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by

**Sanjeev Kumar Jha**

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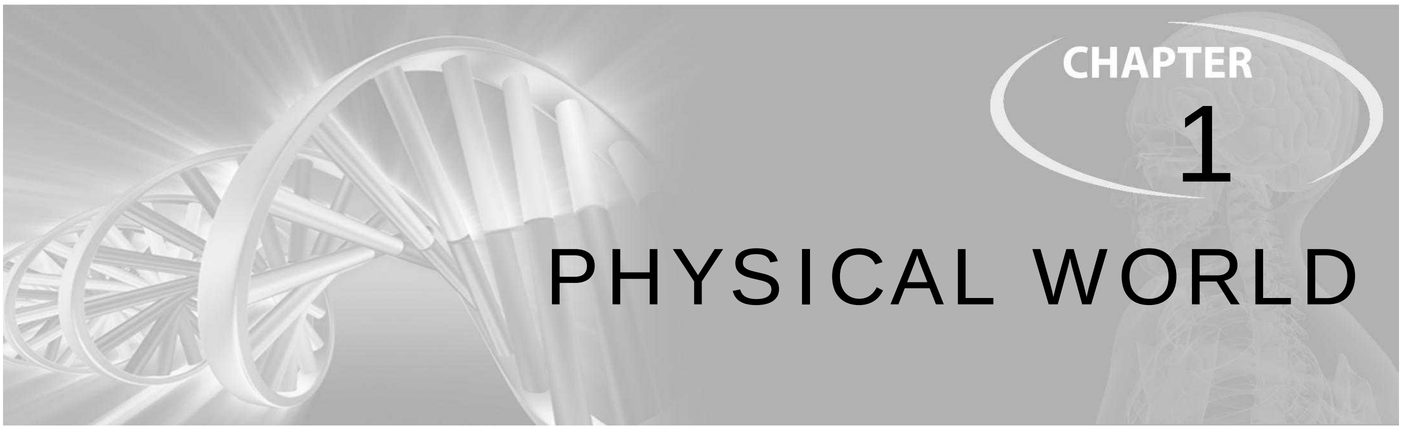


# CHAPTER 1

# PHYSICAL WORLD

## FACT/DEFINITION TYPE QUESTIONS

**1.** The branch of science which deals with nature and natural phenomena is called
(a) Sociology (b) Biology
(c) Civics (d) Physics

**2.** Science is exploring, ...x... and ...y... from what we see around us. Here, x and y refer to
(a) qualitative, modify (b) experiment, predict
(c) verification, predict (d) reasoning, quantitative

**3.** The person who has been awarded the title of the Father of Physics of 20th century is
(a) Madame Curie (b) Sir C.V. Raman
(c) Neils Bohar (d) Albert Einstein

**4.** The man who is known as the Father of Experimental Physics is
(a) Newton (b) Albert Einstein
(c) Galileo (d) Rutherford

**5.** Macroscopic domain includes
(a) phenomena at the laboratory
(b) terrestrial scales
(c) astronomical scales
(d) All of the above

**6.** The man who has won Nobel Prize twice in physics is
(a) Einstein (b) Bardeen
(c) Heisenberg (d) Faraday

**7.** Prof. Albert Einstein got nobel prize in physics for his work on
(a) special theory of relativity
(b) general theory of relativity
(c) photoelectric effect
(d) theory of specific heats

**8.** Which of the following is wrongly matched ?
(a) Barometer-Pressure
(b) Lactometer-Milk
(c) Coulomb’s law-charges
(d) Humidity-Calorimeter

**9.** C.V. Raman got Nobel Prize for his experiment on
(a) dispersion of light (b) reflection of light
(c) deflection of light (d) scattering of light

**10.** Louis de-Broglie is credited for his work on
(a) theory of relativity
(b) electromagnetic theory
(c) matter waves
(d) law of distribution of velocities

**11** Madam Marie Curie won Nobel Prize twice which were in the field of
(a) Physics and chemistry(b) Chemistry only
(c) Physics only (d) Biology only

**12.** A scientific way of doing things involve
(a) identifying the problem
(b) collecting data
(c) hypothesising a possible theory
(d) All of the above

**13.** Two Indian born physicists who have been awarded Nobel Prize in Physics are
(a) H. J. Bhabha and APJ Kalam
(b) C.V. Raman and S. Chandrasekhar
(c) J.C. Bose and M.N. Saha
(d) S. N. Bose and H. J. Bhabha

**14.** Who gave general theory of relativity?
(a) Einstein (b) Marconi
(c) Ampere (d) Newton

**15.** Who discovered X-rays?
(a) Chadwick (b) Roentgen
(c) Thomson (d) Madam Curie

**16.** The field of work of S. Chandrashekar is
(a) theory of black hole (b) Cosmic rays
(c) theory of relativity (d) X-rays

**17.** When we hold a book in our hand, we are balancing the gravitational force on the book due to
(a) normal force provided by our hand
(b) friction force provided by our book
(c) both (a) and (b)
(d) None of these

**18.** Which of the following has infinite range?

(a) Gravitational force (b) Electromagnetic force

(c) Strong nuclear force (d) Both (a) and (b)

**19.** Which of the following is the correct decreasing order of the strengths of four fundamental forces of nature ?

(a) Electromagnetic force > weak nuclear force > gravitational force > strong nuclear force

(b) Strong nuclear force > weak nuclear force > electromagnetic force > gravitational force

(c) Gravitational force > electromagnetic force > strong nuclear force > weak nuclear force

(d) Strong nuclear force > electromagnetic force > weak nuclear force > gravitational force

**20.** The exchange particles for the electromagnetic force are

(a) gravitons (b) gluons

(c) photons (d) mesons

**21.** Which of the following is true regarding the physical science?

(a) They deal with non-living things

(b) The study of matter are conducted at atomic or ionic levels

(c) Both (a) and (b)

(d) None of these

**22.** Which of the following is the weakest force?

(a) Nuclear force (b) Gravitational force

(c) Electromagnetic force (d) None of these

**23.** The scientific principle involves in production of ultra high magnetic fields is

(a) super conductivity (b) digital logic

(c) photoelectric effect (d) laws of thermodynamics

## STATEMENT TYPE QUESTIONS

**24** Consider the following statements and select the correct statement(s).

I. Optics deal with the phenomena involving light.

II. Unification means physical phenomena in terms of few concepts and laws.

III. Macroscopic domain of Physics deals with the constitution and structure of matter at the minute scales of atoms and nuclei.

(a) Only I (b) Only II

(c) I and II (d) II and III

**25.** Which of the following statements is/are correct?

I. Strong nuclear force binds protons and neutrons in a nucleus.

II. In twentieth century, silicon chip triggered a revolutionary changes in technology of computer system.

III. The fossil fuels of the planet are dwindling fast and there is urgent need to discover new source of energy.

(a) Only I (b) Only III

(c) I and II (d) I, II and III

## MATCHING TYPE QUESTIONS

Match the Column I and Column II.

**26.**

| **Column I** | **Column II** |
|---|---|
| (A) Johannes Kepler | (1) Nuclear model of the atom |
| (B) Tycho Brahe | (2) Planetary motion |
| (C) Nicolas Copernicus | (3) Elliptical orbit theory |
| (D) Ernest Rutherford | (4) Circular orbit theory |

(a) (A)→(2); (B)→(4); C→(3); (D)→(1)

(b) (A)→(1); (B)→(2); C→(3); (D)→(4)

(c) (A)→(2); (B)→(1); C→(4); (D)→(3)

(d) (A)→(3); (B)→(2); C→(4); (D)→(1)

**27.**

| **Column I** | **Column II** |
|---|---|
| (A) Galileo Galilei | (1) Explanation of photoelectric effect. |
| (B) JC Bose | (2) Law of inertia. |
| (C) Albert Einstein | (3) Discovery of Ultra short radio waves. |
| (D) JJ Thomson | (4) Discovery of electron. |

(a) (A)→(2); (B)→(3); C→(1); (D)→(4)

(b) (A)→(1); (B)→(2); C→(4); (D)→(3)

(c) (A)→(1); (B)→(2); C→(3); (D)→(4)

(d) (A)→(3); (B)→(4); C→(1); (D)→(2)

**28.**

| **Column I** | **Column II** |
|---|---|
| (A) J.C Maxwell | (1) Verified experimentally the prediction of electromagnetic force. |
| (B) Cario Rubia | (2) Unified electricity, magnetism and optics, showed that light is an EM waves. |
| (C) Isaac Newton | (3) Unified celestial and terrestrial mechanics. |
| (D) Michael Faraday | (4) Showed that electric and magnetic phenomenon i.e., electromagnetism. |

(a) (A)→(1); (B)→(2); C→(4); (D)→(3)

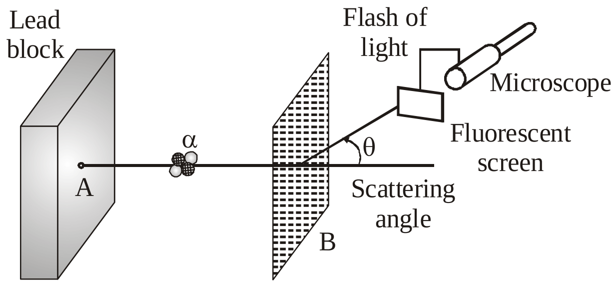
(b) (A)→(2); (B)→(1); C→(3); (D)→(4)

(c) (A)→(2); (B)→(3); C→(4); (D)→(1)

(d) (A)→(2); (B)→(1); C→(4); (D)→(3)

## DIAGRAM TYPE QUESTIONS

**29.** In Rutherford, alpha particle scattering experiment as shown in given figure, A and B refer to



(a) polonium sample and aluminium foil
(b) polonium sample and gold foil
(c) uranium sample and gold foil
(d) uranium sample and aluminium foil

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contains two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

**30.** **Assertion :** The concept of energy is central to Physics and expression for energy can be written for every physical system.

**Reason :** Law of conservation of energy is not valid for all forces and for any kind of transformation between different forms of energy.

**31.** **Assertion :** Electromagnetic force is much stronger than the gravitational farce.

**Reason :** Electromagnetic force dominates all phenomena at atomic and molecular scales.

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(d)**

**2.** **(b)** Science is exploring, experimenting and predicting from what we see around us.

**3.** **(d)** **4.** **(c)**

**5.** **(d)** The macroscopic domain includes phenomena at the laboratory, terrestrial and astronomical scales.

**6.** **(b)** **7.** **(c)** **8.** **(d)** **9.** **(d)**

**10.** **(c)** **11.** **(a)** **12.** **(d)** **13.** **(b)**

**14.** **(a)** **15.** **(b)** **16.** **(a)**

**17.** **(a)** When we hold a book in our hand , we are balancing the gravitational force on the book due to the huge mass of the Earth by the 'normal force' provided by our hand.

**18.** **(d)** **19.** **(d)** **20.** **(c)** **21.** **(c)**

**22.** **(b)** **23.** **(a)**

## STATEMENT TYPE QUESTIONS

**24.** **(a)** Optics deals with the phenomena involving light. The working of telescopes and microscopes, colours exhibited by thin films, etc., are topics in optics.

The microscopic domain of Physics deals with the constitution and structure of matter at the minute scales of atoms and nuclei (and even lower scales of length) and their interaction with different probes such as electrons, photons and other elementary particles.

**25.** **(d)** In a nucleus, strong nuclear force (strongest fundamental force) binds protons and neutrons. The silicon 'chip' triggered the computer revolution the last three decades of the twentieth century.

A most significant area to which Physics has and will contribute is the development of alternative energy resources. The fossil fuels of the planet are dwindling fact and there is an urgent need to discover new and affordable sources of energy.

## MATCHING TYPE QUESTIONS

**26.** **(a)** Johannes Kepler examined the extensive data on planetary motion collected by Tycho Brahe the planetary circular orbits in heliocentric theory (Sun at the centre of the solar system) imagined by Nicolas Copernicus had to be replaced by elliptical orbits to fit the data better.

**27.** **(a)**

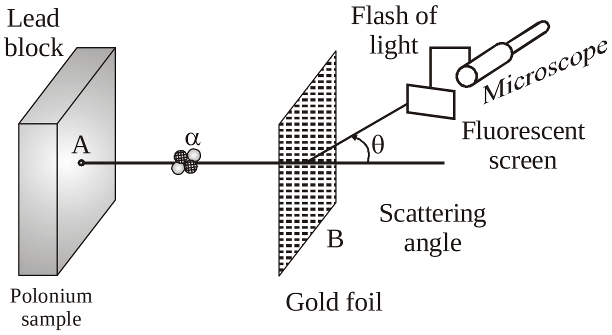
| **Name of the physicist** | **Major contribution /discovery** | **Country of origin** |
|---|---|---|
| Galileo Galilei | Law of inertia | Italy |
| JC Bose | Ultra short radio waves | India |
| JJ Thomson | Electron | Uk |
| Albert Einstein | Explanation of photoelectric effect;<br>Theory of relativity | Germeny |

**28.** **(b)**

| **Name of the Physicist** | **Year** | **Achievement in unification** |
|---|---|---|
| Isaac Newton | 1687 | Unified celestial and terrestrial mechanics, showed that the same laws of motion and the law of gravitation apply to both the domains. |
| Michael Faraday | 1830 | Showed phenomena of electromagnetism. |
| J.C. Maxwell | 1873 | Unified electricity, magnetism and optics, showed that light is an electromagnetic wave. |
| Cario Rubia | 1984 | Verified experimentally the predictions of the theory of electromagnetic force. |

## DIAGRAM TYPE QUESTIONS

**29.** **(b)** The alpha particle scattering experiment of Rutherford gave the nuclear model of the atom as shown in figure



## ASSERTION- REASON TYPE QUESTIONS

**30.** **(c)** The concept of energy is central to Physics and the expressions for energy can be written for every physical system. When all forms of energy e.g., Heat, mechanical energy, electrical energy etc., are counted, it turns out that energy is conserved. The general law of conservation of energy is true for all forces and for any kind of transformation between different forms of energy.

**31.** **(a)** It is mainly the electromagnetic force that governs the structure of atoms and molecules, the dynamics of chemical reactions and the mechanical, thermal and other properties of materials.

# CHAPTER 2

# UNITS AND MEASUREMENTS

## FACT/DEFINITION TYPE QUESTIONS

**1.** Which of the following systems of units is not based on units of mass, length and time alone ?
(a) SI (b) MKS
(b) CGS (d) FPS

**2.** Number of base SI units is
(a) 4 (b) 7
(c) 3 (d) 5

**3.** Second is defined in terms of periods of radiation from Cesiuim 133 because
(a) it is not affected by the change of place
(b) it is not affected by the change of time
(c) it is not affected by the change of Physical conditions
(d) All of these.

**4.** 1° (degree) is equal to
(a) 17 radian
(b) $17.45 \times 10^{-2}$ radian
(c) $17.45 \times 10^{-2}$ radian
(d) $1.745 \times 10^{-2}$ radian

**5.** Very large distances such as the distance of a Planet or a star from Earth can be measured by
(a) Spectrograph
(b) Millikan's oil drop method
(c) Parallax method
(d) All of these.

**6.** One unified atomic mass unit is equal to
(a) 12 times the mass of one carbon-12 atom
(b) $\frac{1}{12}$ of the mass of 12 atoms of C-12
(c) $\frac{1}{12}$ of the mass of one atom of C-12
(d) 12 times the mass of 12 atoms of C-12

**7.** Light year is
(a) light emitted by the sun in one year.
(b) time taken by light to travel from sun to earth.
(c) the distance travelled by light in free space in one year.
(d) time taken by earth to go once around the sun.

**8.** Length cannot be measured by
(a) fermi (b) debye
(c) micron (d) light year

**9.** One yard in SI unit is equal to
(a) 1.9144 metre (b) 0.9144 metre
(c) 0.09144 kilometre (d) 1.0936 kilometre

**10.** Which one of the following is the smallest unit?
(a) millimetre (b) angstrom
(c) fermi (d) metre

**11.** The prototype of the international standard kilogram supplied by the International Bureau of Weights and Measures (BIPM) are available at
(a) National Physics Laboratory
(b) National science centre
(c) CSIR
(d) None of these

**12.** Illuminance of a surface is measured in
(a) lumen
(b) Candela
(c) lux
(d) lux $m^{-2}$

**13.** Which of the following is not the unit of time ?
(a) Micro second (b) Leap year
(c) Lunar month (d) Parallactic second

**14.** Universal time is based on
(a) rotation of the earth on its axis
(b) earth's orbital motion around the Sun
(c) vibrations of cesium atom
(d) oscillations of quartz crystal

**15.** 1 Parsec is equal to
(a) $3.1 \times 10^{-16}$ m. (b) 3.26 ly
(c) $6.3 \times 10^{4}$ Au (d) $1.496 \times 10^{11}$ m.

**16.** Which of the following can measure length upto $10^{-5}$ m ?
(a) Metre scale (b) Vernier callipers
(c) Spherometer (d) None of these

**17.** Systematic errors can be
(a) positive only
(b) negative only
(c) either positive or negative
(d) None of these

**18.** Instrumental errors are due to
(a) imperfect design
(b) zero error in the instrument
(c) Both (a) and (b)
(d) None of these

**19.** ____ is the ratio of the mean absolute error to the mean value of the quantity measured.
(a) Absolute error (b) Relative error
(c) Percentage error (d) None of these

**20.** Random error can be eliminated by
(a) careful observation
(b) eliminating the cause
(c) measuring the quantity with more than one instrument
(d) taking large number of observations and then their mean.

**21.** When two quantities are added or subtracted, the absolute error in the final result is the
(a) sum of the absolute errors in the individual quantities
(b) sum of the relative errors in the individual quantities
(c) can be (a) or (b)
(d) None of these

**22.** Error in the measurement of radius of a sphere is 1%. Then error in the measurement of volume is
(a) 1% (b) 5%
(c) 3% (d) 8%

**23.** The _____ is a measure of how closed the measured value is to the true value of quantity.
(a) Precision (b) accuracy
(c) Error (d) None of these.

**24.** Which of the following is not a systematic error ?
(a) Instrumental error
(b) Imperfection in experimental technique
(c) Personal error
(d) None of these

**25.** The smallest value that can be measured by the measuring instrument is called
(a) least count (b) parallax
(c) accuracy (d) precision

**26.** The _____ is the error associated with the resolution of the instrument.
(a) parallax error (b) systematic error
(c) random error (d) least count error

**27.** Absolute error is always
(a) positive (b) negative
(c) both (a) and (b) (d) None of these

**28.** The magnitude of the difference between the individual measurement and true value of the quantity is called
(a) absolute error (b) relative error
(c) percentage error (d) None of these

**29.** The pitch and the number of circular scale divisions in a screw gauge with least count 0.02 mm are respectively
(a) l mm and 100 (b) 0.5 mm and 50
(c) 1 mm and 50 (d) 0.5 mm and 100

**30.** A student measured the length of a rod and wrote it as 3.50 cm. Which instrument did he use to measure it?
(a) A meter scale.
(b) A vernier calliper where the 10 divisions in vernier scale matches with 9 division in main scale and main scale has 10 divisions in 1 cm.
(c) A screw gauge having 100 divisions in the circular scale and pitch as 1 mm.
(d) A screw gauge having 50 divisions in the circular scale and pitch as 1 mm.

**31.** The unit of percentage error is
(a) same as that of physical quantity
(b) different from that of physical quantity
(c) percentage error is unitless
(d) errors have got their own units which are different from that of physical quantity measured

**32.** If L = 2. 331 cm, B = 2.1 cm, then L + B =
(a) 4.4 cm (b) 4 cm
(c) 4.43 cm (d) 4.431 cm

**33.** When two quantities are divided, the relative error in the result is given by
(a) the product of the relative error in the individual quantities
(b) the quotient of the relative error in the individual quantities
(c) the difference of the relative error in the individual quantities
(d) the sum of the relative error in the individual quantities

**34.** If Z = $A^3$, then $\frac{\Delta Z}{Z}$ = ______
(a) $\frac{\Delta A^3}{A}$ (b) $\left(\frac{\Delta A}{A}\right)^3$
(c) $3\left(\frac{\Delta A}{A}\right)$ (d) $\left(\frac{\Delta A}{A}\right)^{1/3}$

**35.** What is the correct number of significant figures in 0.0003026 ?
(a) Four (b) Seven
(c) Eight (d) Six

**36.** Which of the following is the most accurate?
(a) 200.0 m (b) $20 \times 10^1$ m
(c) $2 \times 10^2$ m (d) $0.2 \times 10^3$ m

**37.** The number of significant figures in 0.00060 m is
(a) 1 (b) 2
(c) 3 (d) 4

**38.** The sum of the numbers 436.32, 227.2 and 0.301 in appropriate significant figures is
(a) 6663.821 (b) 664
(c) 663.8 (d) 663.8

**39.** Number of significant figures in expression $\frac{4.327\,\text{g}}{2.51\,\text{cm}^3}$ is
(a) 2 (b) 4
(c) 3 (d) 5

**40.** The dimensions of force are
(a) $[ML^2T^{-1}]$ (b) $[M^2L^3T^{-2}]$
(c) $[MLT^{-2}]$ (d) None of these

**41.** The dimensions of speed and velocity are
(a) $[L^2T], [LT^{-1}]$ (b) $[LT^{-1}], [LT^{-2}]$
(c) [LT], [LT] (d) $[LT^{-1}], [LT^{-1}]$

**42.** By equating a physical quantity with its dimensional formula we get
(a) dimensional analysis (b) dimensional equation
(c) dimensional formula (d) none of these

**43.** Dimensional analysis can be applied to
(a) check the dimensional consistency of equations
(b) deduce relations among the physical quantities.
(c) to convert from one system of units to another
(d) All of these

**44.** Two quantities A and B have different dimensions which mathematical operation given below is physically meaningful?
(a) A/B (b) A + B
(c) A – B (d) A = B

**45.** Which is dimensionless?
(a) Force/acceleration (b) Velocity/acceleration
(c) Volume/area (d) Energy/work

**46.** Which of the following quantities has a unit but dimensionless?
(a) Strain (b) Reynolds number
(c) Angular displacement (d) Poisson's ratio

**47.** The wrong unit conversion among the following is
(a) 1 angstrom $= 10^{-10}$m
(b) 1 fermi $= 10^{-15}$m
(c) 1 light year $= 9.46 \times 10^{15}$m
(d) 1 astronomical unit $= 1.496 \times 10^{-11}$m

**48.** The physical quantity that does not have the dimensional formula $[ML^{-1}T^{-2}]$ is
(a) force (b) pressure
(c) stress (d) modulus of elasticity

**49.** The dimensions of pressure is equal to
(a) force per unit volume (b) energy per unit volume
(c) force (d) energy

**50.** The dimensional formula of angular velocity is
(a) $[MLT^{-1}]$ (b) $[M^0L^0T]$
(c) $[ML^0T^{-2}]$ (d) $[M^0L^0T^{-1}]$

**51.** The physical quantity that has no dimensions is
(a) strain (b) angular velocity
(c) angular momentum (d) linear momentum

## STATEMENT TYPE QUESTIONS

**52.** Consider the following statements and select the correct statement(s).
I. Light year and year, both measure time.
II. Both have dimension of time.
III. Light year measures length.
(a) I and II (b) II and III
(c) II only (d) III only

**53.** Consider the following statements and select the correct statement(s)?
I. If $l_1 = 0.6$ cm ; $l_2 = 0.60$ cm and $l_3 = 0.600$ cm, then $l_3$ is the most accurate measurement.
II. $l_3 = 0.600$ cm has the least error so it is most accurate
(a) I only (b) II only
(c) Both I and II (d) None of these

**54.** Consider the following statements and select the correct statement(s).
I. 1 calorie = 4.18 *joule*
II. $1\overset{o}{A} = 10^{-10}$ m
III. 1 MeV = $1.6 \times 10^{-13}$ *Joule*
IV. 1 newton = $10^{-5}$ *dyne*
(a) I, II and III (b) III and IV
(c) I only (d) IV only

**55.** Which the following is/are correct?
I. Pressure = energy per unit area
II. Pressure = energy per unit volume
III. Pressure = force per unit volume
IV. Pressure = momentum per unit volume per unit time
(a) I and II (b) II only
(c) III only (d) I, II, III and IV

**56.** Consider the following statements and select the correct option.
I. Every measurement by any measuring instrument has some error
II. Every calculated physical quantity that is based on measured values has some error
III. A measurement can have more accuracy but less precision and vice versa
(a) I and II (b) II and III
(c) II and III (d) I, II and III

**57.** Which of the following statements is/are correct?
I. 345.726 has six significant figures
II. 0.004289 has seven singificant figures
III. 125000 has three significant figures
IV. 9.0042 has five significant figures
(a) I only (b) II only
(c) I, III and IV (d) II, III and IV

**58.** Which of the following statements is/are correct ?
I. Change of units does not change the number of significant digits
II. All the non– zero digits are significant
III. All the zero between two non-zero digits are significant
(a) I only (b) II only
(c) II and III (d) I, II and III

## MATCHING TYPE QUESTIONS

**59.** Match the columns I and II.

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Practical unit | (1) | radian |
| (B) | Base unit | (2) | light year |
| (C) | Derived unit | (3) | kg-ms$^{-1}$ |
| (D) | Complementary unit | (4) | second |

(a) (A)→(4); (B)→(2); C→(1); (D)→(3)
(b) (A)→(2); (B)→(4); C→(3); (D)→(1)
(c) (A)→(3); (B)→(2); C→(4); (D)→(1)
(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

**60.**

| | **Column-I** | | **Column-II** |
|---|---|---|---|
| (A) | Distance between earth & stars | (1) | micron |
| (B) | Inter-atomic distance in a solid | (2) | angstrom |
| (C) | Size of the nucleus | (3) | light year |
| (D) | Wavelength of infrared laser | (4) | fermi |
| | | (5) | kilometre |

(a) (A)→(1); (B)→(3); C→(4); (D)→(2)
(b) (A)→(3); (B)→(2); C→(4); (D)→(1)
(c) (A)→(5); (B)→(2); C→(3); (D)→(1)
(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

**61.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Length | (1) | burette |
| (B) | Volume | (2) | Vernier callipers |
| (C) | Diameter of a thin wire | (3) | screw gauge |
| (D) | Mass | (4) | common balance |

(a) (A)→(4); (B)→(2); C→(1); (D)→(3)
(b) (A)→(3); (B)→(2); C→(4); (D)→(1)
(c) (A)→(4); (B)→(2); C→(3); (D)→(1)
(d) (A)→(2); (B)→(1); C→(3); (D)→(4)

**62.** Match the following column I and II.

| | Column I | | Column II |
|---|---|---|---|
| (A) | 1 Fermi | (1) | $3.08 \times 10^{16}$ m |
| (B) | 1 Astronomical unit | (2) | $9.46 \times 10^{15}$ m |
| (C) | 1 Light year | (3) | $1.496 \times 10^{11}$ m |
| (D) | 1 Parsec | (4) | $10^{-15}$ m |

(a) (A)→(4); (B)→(2); C→(1); (D)→(3)
(b) (A)→(3); (B)→(2); C→(4); (D)→(1)
(c) (A)→(4); (B)→(3); C→(2); (D)→(1)
(d) (A)→(2); (B)→(1); C→(3); (D)→(4)

**63.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Meter scale | (1) | $3.08 \times 10^{16}$ m |
| (B) | Vernier callipers | (2) | $10^{-5}$ m |
| (C) | Screw gauge | (3) | $10^{-3}$m to $10^{2}$m |
| (D) | Parallax method | (4) | $10^{-4}$ m |

(a) (A)→(3); (B)→(4); C→(2); (D)→(3)
(b) (A)→(3); (B)→(2); C→(4); (D)→(1)
(c) (A)→(4); (B)→(3); C→(2); (D)→(1)
(d) (A)→(2); (B)→(1); C→(3); (D)→(4)

**64.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Size of atomic nucleus | (1) | $10^{11}$ m |
| (B) | Distance of the sun from Earth | (2) | $10^{7}$ m |
| (C) | Radius of Earth | (3) | $10^{-15}$ m |
| (D) | Size of proton | (4) | $10^{-14}$ m |

(a) (A)→(3); (B)→(4); C→(1); (D)→(3)
(b) (A)→(4); (B)→(1); C→(2); (D)→(3)
(c) (A)→(4); (B)→(3); C→(2); (D)→(1)
(d) (A)→(2); (B)→(1); C→(3); (D)→(4)

**65.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Rotation period of Earth | (1) | $10^{9}$s |
| (B) | Average human life – span | (2) | $10^{17}$s |
| (C) | Travel time for light from Sun to Earth | (3) | $10^{5}$s |
| (D) | Age of universe | (4) | $10^{2}$s |

(a) (A)→(3); (B)→(4); C→(1); (D)→(3)
(b) (A)→(4); (B)→(1); C→(2); (D)→(3)
(c) (A)→(3); (B)→(1); C→(4); (D)→(2)
(d) (A)→(2); (B)→(1); C→(3); (D)→(4)

**66.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Mean absolute error | (1) | $\Delta\, a_{\text{mean}} /\, a_{\text{mean}}$ |
| (B) | Relative error | (2) | $\left(\frac{\Delta a_{\text{ mean}}}{a_{\text{ mean}}}\right) \times 100$ |
| (C) | Percentage error | (3) | $\sum_{\text{i=1}}^{\text{n}} \lvert \Delta a_i \rvert / n$ |
| (D) | Absolute error | (4) | $a_n - a_{\text{mean}}$ |

(a) (A)→(3); (B)→(1); C→(2); (D)→(4)
(b) (A)→(1); (B)→(2); C→(4); (D)→(3)
(c) (A)→(3); (B)→(2); C→(4); (D)→(1)
(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

**67.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Joule | (1) | $\text{MLT}^{-2}$ |
| (B) | Newton | (2) | $\text{ML}^{-1}\text{T}^{-2}$ |
| (C) | Hertz | (3) | $\text{ML}^{2}\text{T}^{-2}$ |
| (D) | Pascal | (4) | $\text{M}^{0}\text{L}^{0}\text{T}^{-1}$ |

(a) (A)→(4); (B)→(2); C→(1); (D)→(3)
(b) (A)→(1); (B)→(2); C→(4); (D)→(3)
(c) (A)→(3); (B)→(2); C→(4); (D)→(1)
(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

**68.**

| | Column - I | | Column - II |
|---|---|---|---|
| (A) | Force | (1) | $\text{T}^{-1}$ |
| (B) | Angular velocity | (2) | $\text{MLT}^{-2}$ |
| (C) | Torque | (3) | $\text{ML}^{-1}\text{T}^{-2}$ |
| (D) | Stress | (4) | $\text{ML}^{-1}\text{T}^{-1}$ |
| | | (5) | $\text{ML}^{2}\text{T}^{-2}$ |

(a) (A)→(3); (B)→(4); C→(1); (D)→(3)
(b) (A)→(2); B→(1); (C)→(5); (D)→(4)
(c) (A)→(3); (B)→(1); C→(4); (D)→(2)
(d) (A)→(2); (B)→(1); C→(3); (D)→(4)

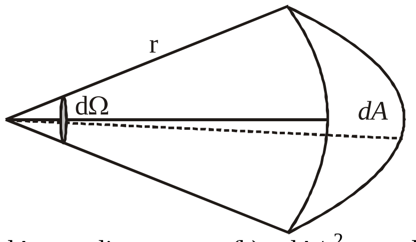
**69.** Match the columns I and II.

| | Column I | | Column II |
|---|---|---|---|
| (A) | Angle | (1) | $\text{ML}^{2}\text{T}^{-3}$ |
| (B) | Power | (2) | $\text{M}^{0}\text{L}^{0}\text{T}^{0}$ |
| (C) | Work | (3) | $\text{ML}^{2}\text{T}^{-2}$ |
| (D) | Force | (4) | $\text{MLT}^{-2}$ |

(a) (A)→(3); (B)→(4); C→(1); (D)→(3)
(b) (A)→(2); B→(1); (C)→(5); (D)→(4)
(c) (A)→(3); (B)→(1); C→(4); (D)→(2)
(d) (A)→(2); (B)→(1); C→(3); (D)→(4)

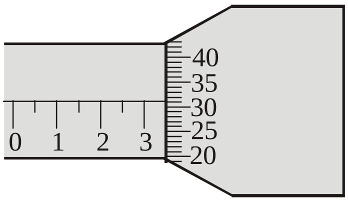
## DIAGRAM TYPE QUESTIONS

**70.** For the given figure solid angle, $d\Omega$ is equal to



(a) $r^2dA$ steradian
(b) $dA/r^2$ steradian
(c) $\frac{r^2}{dA}$ steradian
(d) $dA/r$ steradian

**71.** The accompanying diagram represents a screw gauge. The circular scale is divided into 50 divisions and the linear scale is divided into millimeters. If the screw advances by 1 mm when the circular scale makes 2 complete revolutions, the least count of the instrument and the reding of the instrument in figure are respectively.



(a) 0.01 mm and 3.82 mm
(b) 0.02 mm and 3.70 mm
(c) 0.11 mm and 4.57 mm
(d) 1.0 mm and 5.37 mm

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

**72.** **Assertion :** Now a days a standard *metre* is defined in terms of the wavelength of light.
**Reason :** Light has no relation with length.

**73.** **Assertion :** Parallax method cannot be used for measuring distances of stars more than 100 light years away.
**Reason :** Because parallax angle reduces so much that it cannot be measured accurately.

**74.** **Assertion :** A.U. is much bigger than Å.
**Reason :** A.U. stands for astronomical unit and A stands for Angstrom.

**75.** **Assertion :** When we change the unit of measurement of a quantity, its numerical value changes.
**Reason :** Smaller the unit of measurement smaller is its numerical value.

**76.** **Assertion :** The cesium atomic clocks are very accurate
**Reason :** The vibration of cesium atom regulate the rate of cesium atomic clock.

**77.** **Assertion:** In the measurement of physical quantities direct and indirect methods are used.
**Reason :** The accuracy and precision of measuring instruments along with errors in measurements should be taken into account, while expressing the result.

**78.** **Assertion :** The error in the measurement of radius of the sphere is 0.3%.The permissible error in its surface area is 0.6%.
**Reason :** The permissible error is calculated by the formula $\frac{\Delta A}{A} = \frac{4\Delta r}{r}$

**79.** **Assertion :** Absolute error may be negative or positive.
**Reason :** Absolute error is the difference between the real value and the measured value of a physical quantity.

**80.** **Assertion :** The number of significant figures depends on the least count of measuring instrument.
**Reason :** Significant figures define the accuracy of measuring instrument.

**81.** **Assertion :** Out of three measurements $I = 0.7$ m; $I = 0.70$ m and $I = 0.700$ m, the last one is most accurate.
**Reason :** In every measurement, only the last significant digit is not accurately known.

**82.** **Assertion :** Number of significant figures in 0.005 is one and that in 0.500 is three
**Reason :** This is because zeros are not significant.

**83.** **Assertion:** ‘Light year’ and ‘Wavelength’ both measure distance.
**Reason :** Both have dimension of time.

**84.** **Assertion :** Dimensional constants are the quantities whose values are constant.
**Reason :** Dimensional constants are dimensionless.

**85.** **Assertion :** Avogadro’s number is the number of atoms in one gram mole.
**Reason :** Avogadro’s number is a dimensionless constant.

**86.** **Assertion :** Energy cannot be divided by volume.
**Reason :** Dimensions for energy and volume are different.

**87.** **Assertion :** Angle and strain are dimensionless.
**Reason :** Angle and strain have no unit.

**88.** **Assertion :** In the equation momentum, $P = \frac{\text{mass}}{\text{area}} x$, the dimensional formula of $x$ is $LT^{-2}$.
**Reason :** Quantities with different dimensions can be multiplied.

**89.** **Assertion :** Force cannot be added to pressure.
**Reason :** The dimensions of force and pressure are different.

**90.** **Assertion :** The time period of a pendulum is given by the formula, $T = 2\pi\sqrt{g/\ell}$
**Reason :** According to the principle of homogeneity of dimensions, only that formula is correct in which the dimensions of L.H.S. is equal to dimensions of R.H.S.

**91.** **Assertion:** Formula for kinetic energy is $K = \frac{1}{2} mu^2 = ma$
**Reason :** Both the equation $K = \frac{1}{2} mv^2$ and $k = ma$ are dimensionally incorrect.

## CRITICALTHINKING TYPE QUESTIONS

**92.** If unit of length and force are increased 4 times. The unit of energy
(a) is increased by 4 times
(b) is increased by 16 times
(c) is increased by 8 times
(d) remains unchanged

**93.** The density of a material in CGS system of units is $4\text{g/cm}^3$. In a system of units in which unit of length is 10 cm and unit of mass is 100 g, the value of density of material will be
(a) 0.4 (b) 40 (c) 400 (d) 0.04

**94.** Resistance R = V/I, here V= (100 ± 5)V and I = (100 ± 0.2 ) A. Find percentage error in R.
(a) 5% (b) 2%
(c) 7% (d) 3%

**95.** Find equivalent resistance when $R_1 = (100 \pm 3)\Omega$ and $R_2 = (200 \pm 4)\Omega$ when connected in series
(a) $(300 \pm 7)\Omega$ (b) $(300 \pm 1)\Omega$
(c) $(100 \pm 7)\Omega$ (d) None of these

**96.** In an experiment four quantities a, b, c and d are measured with percentage error 1%, 2%, 3% and 4% respectively. Quantity P is calculated as follows

$P = \dfrac{a^3b^2}{cd}$ % error in P is

(a) 10% (b) 7% (c) 4% (d) 14%

**97.** In a vernier callipers *N* division of vernier coincide with (*N* – 1) divisions of main scale in which length of a division is 1 mm. The least count of the instrument in cm is
(a) $N$ (b) $N-1$
(c) $\dfrac{1}{10N}$ (d) $(1/N)-1$

**98.** The least count of a stop watch is $\dfrac{1}{5}$ s. The time of 20 oscillations of a pendulum is measured to be 25 s. What is the maximum percentage error in this measurement ?
(a) 8 % (b) 1 %
(c) 0.8 % (d) 16 %

**99.** The refractive index of water measured by the relation $\mu = \dfrac{\text{real depth}}{\text{apparent depth}}$ is found to have values of 1.34, 1.38, 1.32 and 1.36; the mean value of refractive index with percentage error is
(a) 1.35 ± 1.48 % (b) 1.35 ± 0 %
(c) 1.36 ± 6 % (d) 1.36 ± 0 %

**100.** A wire has a mass 0.3 ± 0.003 g, radius 0.5 ± 0.005 mm and length 6 ± 0.06 cm. The maximum percentage error in the measurement of its density is
(a) 1 (b) 2
(c) 3 (d) 4

**101.** One centimetre on the main scale of a vernier callipers is divided into 10 equal parts. If 10 divisions of vernier coincide with 8 small divisions of the main scale, the least count of vernier callipers is
(a) 0.01 cm (b) 0.02 cm
(c) 0.05 cm (d) 0.005 cm

**102.** The pitch of the screw gauge is 0.5 mm. Its circular scale contains 50 divisions. The least count of the screw gauge is
(a) 0.001 mm (b) 0.01 mm
(c) 0.02 mm (d) 0.025 mm

**103.** Relative density of a metal may be found with the help of spring balance. In air the spring balance reads (5.00 ± 0.05) N and in water it reads (4.00 ± 0.05) N. Relative density would be
(a) (5.00 ± 0.05)N (b) (5.00 ± 11%)
(c) (5.00 ± 0.10) (d) (5.00 ± 6%)

**104.** A quantity is represented by $X = M^a L^b T^c$. The % error in measurement of M, L and T are a%, b% and g% respectively. The % error in X would be
(a) $(\alpha a + \beta b + \gamma c)\%$ (b) $(\alpha a - \beta b + \gamma c)\%$
(c) $(\alpha a - \beta b - \gamma c) \times 100\%$ (d) None of these

**105.** If $Z = A^4\ B^{1/3}/\ CD^{3/2}$, than relative error in Z. $\dfrac{\Delta Z}{Z}$ is equal to

(a) $\left(\dfrac{\Delta A}{A}\right)^4 + \left(\dfrac{\Delta B}{B}\right)^{1/3} - \left(\dfrac{\Delta C}{C}\right) - \left(\dfrac{\Delta D}{D}\right)^{3/2}$

(b) $4\left(\dfrac{\Delta A}{A}\right) + \left(\dfrac{1}{3}\right)\left(\dfrac{\Delta B}{B}\right) + \left(\dfrac{\Delta C}{C}\right) + \left(\dfrac{3}{2}\right)\left(\dfrac{\Delta D}{D}\right)$

(c) $4\left(\dfrac{\Delta A}{A}\right) + \dfrac{1}{3}\left(\dfrac{\Delta B}{B}\right) - \left(\dfrac{\Delta C}{C}\right) - \left(\dfrac{3}{2}\right)\left(\dfrac{\Delta D}{D}\right)$

(d) $\left(\dfrac{\Delta A}{A}\right)^4 + \dfrac{1}{3}\left(\dfrac{\Delta B}{B}\right) + \left(\dfrac{\Delta C}{C}\right) + \dfrac{3}{2}\left(\dfrac{\Delta D}{D}\right)$

**106.** A force F is applied onto a square plate of side L. If the percentage error in determining L is 2% and that in F is 4%, the permissible percentage error in determining the pressure is
(a) 2% (b) 4%
(c) 6% (d) 8%

**107.** The period of oscillation of a simple pendulum is $T = 2\pi\sqrt{\dfrac{L}{g}}$. Measured value of L is 20.0 cm known to 1 mm accuracy and time for 100 oscillations of the pendulum is found to be 90 s using a wrist watch of 1s resolution. The accuracy in the determination of g is
(a) 1% (b) 5%
(c) 2% (d) 3%

**108.** In a simple pendulum experiment, the maximum percentage error in the measurement of length is 2% and that in the observation of the time-period is 3%. Then the maximum percentage error in determination of the acceleration due to gravity g is

(a) 5%
(b) 6%
(c) 1%
(d) 8%

**109.** Diameter of a steel ball is measured using a Vernier callipers which has divisions of 0.1 cm on its main scale (MS) and 10 divisions of its vernier scale (VS) match 9 divisions on the main scale. Three such measurements for a ball are given below:

| S.No. | MS(cm) | VS divisions |
|---|---|---|
| 1. | 0.5 | 8 |
| 2. | 0.5 | 4 |
| 3. | 0.5 | 6 |

If the zero error is – 0.03 cm, then mean corrected diameter is

(a) 0.52 cm
(b) 0.59 cm
(c) 0.56 cm
(d) 0.53 cm

**110.** The respective number of significant figures for the number 23.023, 0.0003 and $2.1 \times 10^{-3}$ are respectively.

(a) 5, 1 and 2
(b) 5, 1 and 5
(c) 5, 5 and 2
(d) 4, 4 and 2

**111.** The value of resistance is 10.845 Ω and the value of current is 3.23 A. The potential difference is 35.02935 volt. Its value in significant number would be

(a) 35 V
(b) 35.0 V
(c) 35.03 V
(d) 35.029 V

**112.** Mass of a body is 210 gm and its density is 7.981 g/cm$^3$ what will be its volume, with regard to significant digits?

(a) 26.312 cm$^3$
(b) 26 cm$^3$
(c) 27 cm$^3$
(d) 26.3 cm$^3$

**113.** A force is given by $F = at + bt^2$, where t is time, the dimensions of a and b are

(a) $[M L T^{-4}]$ and $[M L T^{-1}]$
(b) $[M L T^{-1}]$ and $[M L T^{0}]$
(c) $[M L T^{-3}]$ and $[M L T^{-4}]$
(d) $[M L T^{-3}]$ and $[M L T^{0}]$

**114.** The frequency of vibration of a string is given by $f = \frac{n}{2L}\sqrt{\frac{T}{m}}$, where T is tension in the string, L is the length, n is number of harmonics. The dimensional formula for m is

(a) $[M^0 L T]$
(b) $[M^1 L^{-1} T^{-1}]$
(c) $[M^1 L^{-1} T^0]$
(d) $[M^0 L T^{-1}]$

**115.** Which of the following pairs has same dimensions?

(a) Angular momentum and Plank's constant
(b) Dipole moment and electric field
(c) Both (a) and (b)
(d) None of these.

**116.** If P,Q, R are physical quantities, having different dimensions, which of the following combinations can never be a meaningful quantity?

(a) $(P - Q) / R$
(b) $PQ - R$
(c) $PQ / R$
(d) $(PR - Q^2) / R$

**117.** Dimensions of specific heat are

(a) $[ML^2 T^{-2} K]$
(b) $[ML^2 T^{-2} K^{-1}]$
(c) $[ML^2 T^2 K^{-1}]$
(d) $[L^2 T^{-2} K^{-1}]$

**118.** The dimensions of torque are

(a) $[MLT^{-2}]$
(b) $[ML^2T^{-2}]$
(c) $[ML^2T^{-1}]$
(d) $[M^2L^2T^{-2}]$

**119.** The ratio of the dimensions of Planck's constant and that of the moment of inertia is the dimensions of

(a) time
(b) frequency
(c) angular momentum
(d) velocity

**120.** Identify the pair whose dimensions are equal.

(a) Torque and work
(b) Stress and energy
(c) Force and stress
(d) Force and work.

**121.** The physical quantities not having same dimensions are

(a) torque and work
(b) momentum and Planck's constant
(c) stress and Young's modulus
(d) speed and $(\mu_0 \varepsilon_0)^{-1/2}$

**122.** Which one of the following represents the correct dimensions of the coefficient of viscosity ?

(a) $[ML^{-1}T^{-1}]$
(b) $[MLT^{-1}]$
(c) $[ML^{-1}T^{-2}]$
(d) $[ML^{-2}T^{-2}]$

**123.** The density of a material in CGS system is 8 g / cm$^3$. In a system of a unit in which unit of length is 5 cm and unit of mass is 20 g. The density of material is

(a) 8
(b) 20
(c) 50
(d) 80

**124.** The dimensional formula for magnetic flux is

(a) $[ML^2T^{-2}A^{-1}]$
(b) $[ML^3T^{-2}A^{-2}]$
(c) $[M^0L^{-2}T^2A^{-2}]$
(d) $[ML^2T^{-1}A^2]$

**125.** If force (F), length (L) and time (T) are assumed to be fundamental units, then the dimensional formula of the mass will be

(a) $[FL^{-1}T^2]$
(b) $[FL^{-1}T^{-2}]$
(c) $[FL^{-1}T^{-1}]$
(d) $[FL^2T^2]$

**126.** Which one of the following represents the correct dimensions of the gravitational constant?

(a) $[M^{-1}L^3T^{-2}]$
(b) $[MLT^{-1}]$
(c) $[ML^{-1}T^{-2}]$
(d) $[ML^{-2}T^{-2}]$

**127.** The dimensions of magnetic field in M, L, T and C (coulomb) is given as

(a) $[MLT^{-1} C^{-1}]$
(b) $[MT^2 C^{-2}]$
(c) $[MT^{-1} C^{-1}]$
(d) $[MT^{-2} C^{-1}]$

**128.** The dimensions of coefficient of self inductance are
(a) $[ML^2T^{-2}A^{-2}]$ (b) $[ML^2T^{-2}A^{-1}]$
(c) $[MLT^{-2}A^{-2}]$ (d) $[MLT^{-2}A^{-1}]$

**129.** In C.G.S. system the magnitude of the force is 100 dynes. In another system where the fundamental physical quantities are in kilogram, metre and minute, the magnitude of the force is
(a) 0.036 (b) 0.36 (c) 3.6 (d) 36

**130.** The division of energy by time is X. The dimensional formula of X is same as that of
(a) momentum (b) power
(c) torque (d) electric field

**131.** The Solar constant is defined as the energy incident per unit area per second. The dimensional formula for solar constant is
(a) $[M^0L^0T^0]$ (b) $[MLT^{-2}]$
(c) $[ML^2T^{-2}]$ (d) $[ML^0T^{-3}]$

**132.** Which of the following is a dimensional constant?
(a) Refractive index (b) Dielectric constant
(b) Relative density (d) Gravitational constant

**133.** If the dimensions of a physical quantity are given by $M^a L^b T^c$, then the physical quantity will be
(a) velocity if a = 1, b = 0, c = – 1
(b) acceleration if a = 1, b = 1, c = – 2
(c) force if a = 0, b = – 1, c = – 2
(d) pressure if a = 1, b = – 1, c = – 2

**134.** $[MLT^{-1}] + [MLT^{-1}] =$ ............
(a) $[M^\circ L^\circ T^\circ]$ (b) $[MLT^{-1}]$
(c) $2[MLT^{-1}]$ (d) None of these

**135.** If energy (E), velocity (V) and time (T) are chosen as the fundamental quantities, the dimensional formula of surface tension will be
(a) $[EV^{-1}T^{-2}]$ (b) $[EV^{-2}T^{-2}]$
(c) $[E^{-2}V^{-1}T^{-3}]$ (d) $[EV^{-2}T^{-1}]$

**136.** The dimensions of mobility are
(a) $[M^{-2}T^2A]$ (b) $[M^{-1}T^2A]$
(c) $[M^{-2}T^3A]$ (d) $[M^{-1}T^3A]$

**137.** If force (F), velocity (V) and time (T) are taken as fundamental units, then the dimensions of mass are
(a) $[F\,V\,T^{-1}]$ (b) $[F\,V\,T^{-2}]$
(c) $[F\,V^{-1}\,T^{-1}]$ (d) $[F\,V^{-1}\,T]$

**138.** If the capacitance of a nanocapacitor is measured in terms of a unit '*u*' made by combining the electric charge '*e*', Bohr radius '$a_0$', Planck's constant 'h' and speed of light '*c*' then
(a) $u = \frac{e^2h}{a_0}$ (b) $u = \frac{hc}{e^2a_0}$
(c) $u = \frac{e^2c}{ha_0}$ (d) $u = \frac{e^2a_0}{hc}$

**139.** If electronic charge e, electron mass m, speed of light in vacuum c and Planck's constant h are taken as fundamental quantities, the permeability of vacuum $\mu_0$ can be expressed in units of
(a) $\left(\frac{h}{me^2}\right)$ (b) $\left(\frac{hc}{me^2}\right)$
(c) $\left(\frac{h}{ce^2}\right)$ (d) $\left(\frac{mc^2}{he^2}\right)$

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(a)** SI is based on seven fundamental units.

**2.** **(b)** **3.** **(d)** **4.** **(c)** **5.** **(c)** **6.** **(c)**

**7.** **(c)** 1 light year = speed of light in vacuum × no. of seconds in one year = $(3\times 10^8)\times(365\times 24\times 60\times 60)$ $= 9.467\times 10^{15}$ m.

**8.** **(b)** **9.** **(b)**

**10.** **(c)** 1 fermi = $10^{-5}$ metre

**11.** **(a)**

**12.** **(c)** Illuminance is intensity of illumination measured in lux.

**13.** **(d)** Parallactic second is the unit of distance.

**14.** **(c)**

**15.** **(b)** 1 parsec = $3.08\times 10^{16}$ m
1 ly = $9.46\times 10^{15}$ m

$$\therefore \frac{1\,\text{Parsec}}{1\,\text{ly}} = \frac{30.8\times 10^{15}}{9.46\times 10^{15}} = 3.26$$

$\therefore$ 1 Parsec = 3.26 ly

**16.** **(c)** **17.** **(c)** **18.** **(c)**

**19.** **(b)** **20.** **(d)** **21.** **(a)**

**22.** **(c)** $V = \frac{4}{3}\pi r^3$;

$$\frac{\Delta V}{V}\times 100 = 3\left(\frac{\Delta r}{r}\right)\times 100 = 3\times 1\% = 3\%$$

**23.** **(b)** **24.** **(d)** **25.** **(a)**

**26.** **(d)** **27.** **(c)** **28.** **(a)**

**29.** **(c)** Least count of a screw gauge

$$= \frac{\text{Pitch}}{\text{Number of circular scale divisions}}$$

$$= \frac{1\text{ mm}}{50} = 0.02\text{ mm}$$

Therefore the pitch and no. of circular scale divisions are 1mm and 50 respectively.

**30.** **(b)** Measured length of rod = 3.50 cm
For vernier scale with 1 Main Scale Division = 1 mm
9 Main Scale Division = 10 Vernier Scale Division,
Least count = 1 MSD –1 VSD = 0.1 mm

**31.** **(c)**

**32.** **(a)** $L + B = 2.331 + 2.1 \cong 4.4$ cm
Since minimum significant figure is 2.

**33.** **(d)** If $z = AB$ then

$$\frac{\Delta z}{z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$$

**34.** **(c)** **35.** **(a)** **36.** **(a)**

**37.** **(b)** According to rules of significant figures.

**38.** **(b)**

**39.** **(c)** In multiplication or division the final result should return as many significant figures as there are in the original number with the least significant figures.

**40.** **(c)** Force, $F = m \times a$ and $a = \frac{L}{T^2}$

**41.** **(d)** speed $= \frac{\text{distance}}{\text{time}}$ and velocity $= \frac{\text{displacement}}{\text{time}}$

**42.** **(b)** **43.** **(d)** **44.** **(a)**

**45.** **(d)** Both energy and work have same unit.
$\therefore$ energy/work is a pure number.

**46.** **(c)** Angular displacement has unit (degree or radian) but it is dimensionless.
**Note :** vice-versa is not possible.

**47.** **(d)** 1 astronomical unit = $1.496\times 10^{11}$m

**48.** **(a)** Force $F = ma = M\left(\frac{v}{t}\right) = MLT^{-2}\left[\because v = \frac{L}{T}\right]$

Force has dimensional formula $[MLT^{-2}]$

**49.** **(b)** $\frac{\text{Energy}}{\text{Volume}} = \frac{ML^2T^{-2}}{L^3}$
$= [ML^{-1}T^{-2}]$ = Pressure

**50.** **(d)** Angular velocity $\omega = \frac{\theta}{t} = [M^0L^0T^{-1}]$

**51.** **(a)** Strain $= \frac{\text{Change in length}}{\text{Original length}}$

Hence no dimension.

## STATEMENT TYPE QUESTIONS

**52.** **(d)** **53.** **(c)**

**54.** **(a)** 1 newton = $10^5$ *dyne*

**55.** **(b)** Pressure $= \frac{\text{force}}{\text{area}} = \frac{\text{energy}}{\text{volume}} = ML^{-1}T^{-2}$

**56.** **(d)** **57.** **(c)** **58.** **(d)**

## MATCHING TYPE QUESTIONS

**59.** **(b)** (A)→(2); (B)→(4); C→(3); (D)→(1)

**60.** **(b)** (A)→(3); (B)→(2); C→(4); (D)→(1)

**61.** **(d)** (A) → (2); (B) → (1); C → (3); (D) → (4)

**62.** **(c)** (A)→(4); (B)→(3); C→(2); (D)→(1)

**63.** **(a)** (A)→(3); (B)→(4); C→(2); (D)→(3)

**64.** **(b)** (A)→(4); (B)→(1); C→(2); (D)→(3)

**65.** **(c)** (A)→(3); (B)→(1); C→(4); (D)→(2)

**66.** **(a)** (A)→(3); (B)→(1); C→(2); (D)→(4)

**67.** **(c)** (A)→(3); (B)→(2); C→(4); (D)→(1)

**68.** **(b)** (A)→ (3); B→(1); (C)→(4); (D)→(2)

**69.** **(d)** (A)→(2); B→(1); C→(3); (D)→(4)

## DIAGRAM TYPE QUESTIONS

**70.** **(b)** **71.** **(a)**

## ASSERTION- REASON TYPE QUESTIONS

**72.** **(c)** Light has well defined relation with length.

**73.** **(a)** As the distance of star increases, the parallax angle decreases, and great degree of accuracy is required for its measurement. Keeping in view the practical limitation in measuring the parallax angle, the maximum distance of a star we can measure is limited to 100 light year.

**74.** **(b)** A.U. (Astronomical unit) is used to measure the average distance of the centre of the sun from the centre of the earth, while angstrom is used to measure very short distances. 1 A.U. = $1.5 \times 10^{11}$m; 1Å =$10^{-10}$m.

**75.** **(c)** We know that Q = $n_1u_1 = n_2u_2$ are the two units of measurement of the quantity Q and $n_1$, $n_2$ are their respective numerical values. From relation $Q_1 = n_1u_1 = n_2u_2$, nu = constant $\Rightarrow n \propto 1/u$ *i.e.*, smaller the unit of measurement, greater is its numerical value.

**76.** **(b)** **77.** **(a)**

**78.** **(c)** Area A = $4\pi r^2$

Fractional error $\frac{\Delta A}{A} = \frac{2\Delta r}{r}$

$$\frac{\Delta A}{A} \times 100 = 2 \times 0.3\% = 0.6\%$$

**79.** **(a)** **80.** **(b)**

**81.** **(b)** The last number is most accurate because it has greatest significant figure (3).

**82.** **(c)** Since zeros placed to the left of the number are never significant, but zeros placed to right of the number are significant

**83.** **(c)** Light year and wavelength both represent the distance, so both have dimension of length not of time.

**84.** **(c)** Dimensional constants are not dimensionless.

**85.** **(c)** Avogadro number (N) represents the number of atoms in 1 gram mole of an element, i.e. it has the dimensions of $\text{mol}^{-1}$.

**86.** **(d)**

**87.** **(c)** Angle is dimensionless, but it has unit radian.

**88.** **(d)** $P = \frac{\text{mass}}{\text{area}} x$

$$\therefore \quad x = \frac{P \times \text{area}}{\text{mass}} = \frac{\text{MLT}^{-1}}{\text{M}} \times \text{L}^2 = \text{L}^3\text{T}^{-1}$$

Quantities with different dimensions can be multiplied.

**89.** **(a)** Addition and subtraction can be done between quantities having same dimensions.

**90.** **(d)** Let us write the dimension of various quantities on two sides of the given relation.

L.H.S. = T = [T]

$$\text{R.H.S.} = 2\pi\sqrt{g/\ell} = \sqrt{\frac{LT^{-2}}{L}} = [T^{-1}]$$

[$\therefore$ 2π has no dimension]. As dimensions of L.H.S is not equal to dimensions of R.H.S. Therefore according to principle of homogeneity the relation

$\text{T} = 2\pi\sqrt{\text{g}/\ell}$ is not valid

**91.** **(d)** Mass × acceleration (ma) = F (force)

## CRITICAL THINKING TYPE QUESTIONS

**92.** **(b)** The work done = force × displacement

$\therefore$ unit, $u_1 = Fs$

and $u_2 = 4F \times 4s = 16u.$

**93.** **(b)** In CGS system, $d = 4\frac{\text{g}}{\text{cm}^3}$

The unit of mass is 100g and unit of length is 10 cm, so

$$\text{density} = \frac{4\left(\frac{100\text{g}}{100}\right)}{\left(\frac{10}{10}\text{cm}\right)^3} = \frac{\left(\frac{4}{100}\right)}{\left(\frac{1}{10}\right)^3}\frac{(100\text{g})}{(10\text{cm})^3}$$

$$= \frac{4}{100} \times (10)^3 \cdot \frac{100\text{g}}{(10\text{cm})^3} = 40 \text{ unit}$$

**94.** **(c)**

**95.** **(a)**

**96.** **(d)** $\text{P} = \frac{\text{a}^3\text{b}^2}{\text{cd}}, \frac{\Delta\text{P}}{\text{P}} \times 100\% = 3\frac{\Delta\text{a}}{\text{a}} \times 100\% + 2\frac{\Delta\text{b}}{\text{b}} \times$

$$100\% + \frac{\Delta\text{c}}{\text{c}} \times 100\% + \frac{\Delta\text{d}}{\text{d}} \times 100\%.$$

$$= 3 \times 1\% + 2 \times 2\% + 3\% + 4\% = 14\%$$

**97.** **(c)** $L.C. = \frac{\text{value of 1division of main scale}}{\text{number of division on main scale}}$

$$= \frac{1}{\text{N}}\text{mm} = \frac{1}{10\text{N}}\text{cm}$$

**98.** **(c)** The percentage error = $\frac{1}{5} \times \frac{100}{25} = 0.8\%$

**99.** **(a)** The mean value of refractive index,

$$\mu = \frac{1.34 + 1.38 + 1.32 + 1.36}{4} = 1.35$$

and

$$\Delta\mu = \frac{|(1.35 - 1.34)| + |(1.35 - 1.38)| + |(1.35 - 1.32)| + |(1.35 - 1.36)|}{4}$$

$$= 0.02$$

Thus $\frac{\Delta\mu}{\mu} \times 100 = \frac{0.02}{1.35} \times 100 = 1.48$

**100. (d)** Density, $\rho = \frac{M}{V} = \frac{M}{\pi r^2 \ell}$

$$\therefore \quad \frac{\Delta\rho}{\rho}\times 100 = \left[\frac{\Delta M}{M}+\frac{2\Delta r}{r}+\frac{\Delta \ell}{\ell}\right]\times 100$$

$$= \left[\frac{0.003}{0.3}+2\frac{0.005}{0.5}+\frac{0.06}{6}\right]\times 100$$

$$= 4$$

**101. (b)** The value of 1 division of main scale = $\frac{1}{10} = 0.1$ cm

The value of 1 division of vernier scale = $\frac{8\times 0.1}{10}$ $= 0.08$ cm

Thus L.C. = 0.1 – 0.08
= 0.02 cm

**102. (b)** Least count $= \frac{0.5}{50} = 0.01$ mm

**103. (d)** Relative density = $\frac{\text{Weight of body in air}}{\text{Loss of weight in water}}$

$$= \frac{5.00}{5.00-4.00} = \frac{5.00}{1.00}$$

$$\frac{\Delta\rho}{\rho}\times 100 = \left(\frac{0.05}{5.00}+\frac{0.05}{1.00}\right)\times 100$$

$$= (0.01 + 0.05) \times 100$$

$$= 0.06 \times 100 = 6\%$$

$\therefore$ Relative density = $5.00 \pm 6\%$

**104. (a)** $X = M^a L^b T^c$;

$$\frac{\Delta X}{X}\times 100 = \left(\frac{a\ \Delta M}{M}+\frac{b\ \Delta L}{L}+\frac{c\ \Delta T}{T}\right)\times 100$$

$$= (a\,\alpha + b\,\beta + c\,\gamma)\%$$

**105. (b)**

**106. (d)** As, pressure $P = \frac{F}{A} = \frac{F}{L^2}$

$$\%\ \text{Error} = \frac{\Delta F}{F}\times 100 + 2\frac{\Delta L}{L}\times 100$$

$$= 4 + 2 \times 2 = 8\%$$

**107. (d)** As, $g = 4\pi^2 \frac{l}{T^2}$

So, $\frac{\Delta g}{g}\times 100 = \frac{\Delta l}{l}\times 100 + 2\frac{\Delta T}{T}\times 100$

$$= \frac{0.1}{20}\times 100 + 2\times\frac{1}{90}\times 100 = 2.72 \simeq 3\%$$

**108. (d)** As we know, time period of a simple pendulum

$$T = 2\pi\sqrt{\frac{L}{g}} \Rightarrow g = \frac{4\pi^2 L}{T^2}$$

The maximum percentage error in $g$

$$\frac{\Delta g}{g}\times 100 = \frac{\Delta L}{L}\times 100 + 2\left(\frac{\Delta T}{T}\times 100\right)$$

$$= 2\% + 2(3\%) = 8\%$$

**109. (b)** Least count $= \frac{0.1}{10}$ = 0.01 cm

$d_1 = 0.5 + 8 \times 0.01 + 0.03 = 0.61$ cm
$d_2 = 0.5 + 4 \times 0.01 + 0.03 = 0.57$ cm
$d_3 = 0.5 + 6 \times 0.01 + 0.03 = 0.59$ cm

Mean diameter = $\frac{0.61 + 0.57 + 0.59}{3}$

= 0.59 cm

**110. (a)** Number of significant figures in 23.023= 5
Number of significant figures in 0.0003 = 1
Number of significant figures in $2.1 \times 10^{-3} = 2$

**111. (b)** The significant number in the potential, $V = iR$; should be the minimum of either $i$ or $R$. So corresponding to $i$ = 3.23 $A$, we have only three significant numbers in $V$ = 35.02935 $V$. Thus the result is $V$ = 35.0 $V$.

**112. (b)**

**113. (c)** $[at] = [F]$ amd $[bt^2] = [F]$
$\Rightarrow [a] = MLT^{-3}$ and $[b] = MLT^{-4}$

**114. (c)** Clearly, $m = \frac{n^2 T}{4f^2 L^2}$ ; $[m] = \frac{MLT^{-2}}{T^{-2}.L^2}$

**115. (a)** **116. (a)**

**117. (d)** $s = \frac{Q}{m\theta} = \frac{ML^2T^{-2}}{MK} = [L^2\,T^{-2}\,K^{-1}]$

**118. (b)** [Torque] = [Force] [distance]

$$= MLT^{-2}.\ L = ML^2T^{-2}$$

**119. (b)** $\frac{\text{Planck's constant}}{\text{Moment of inertia}} = \frac{\frac{2\pi I\omega}{n}}{I}$ $\left[\text{As } \frac{nh}{2\pi} = I\omega\ \right]$

$$= \frac{2\pi I(2\pi f)}{nI} = \left(\frac{4\pi^2}{n}.f\right) = [T^{-1}]$$

**120. (a)** Both have the dimension $M^1L^2T^{-2}$.

**121. (b)** $[\text{momentum}] = [M][L][T^{-1}] = [MLT^{-1}]$

Planck's constant = $\frac{E}{\nu} = \frac{[M][LT^{-1}]^2}{T^{-1}} = ML^2T^{-1}$

**122. (a)** From stokes law

$$F = 6\pi\eta rv \Rightarrow \eta = \frac{F}{6\pi rv}$$

$$\therefore \eta = \frac{MLT^{-2}}{[L][LT^{-1}]} \Rightarrow \eta = [ML^{-1}T^{-1}]$$

**123. (c)** $n_1u_1 = n_2u_2$

$$\therefore \quad n_2 = n_1\frac{u_1}{u_2} = 8\left[\frac{M_1}{M_2}\right]\left[\frac{L_2}{L_1}\right]^3$$

$$= 8\left[\frac{1}{20}\right]\left[\frac{5}{1}\right]^3 = 50.$$

**124. (a)** Dimension of Magnetic flux
= Dimension of voltage × Dimension of time
$= [ML^2T^{-3}A^{-1}]\,[T] = [ML^2T^{-2}A^{-1}]$

$$\because \text{ Voltage} = \frac{\text{Work}}{\text{Charge}}$$

**125. (a)** Let $m = KF^aL^bT^c$
Substituting the dimensions of
$[F] = [MLT^{-2}]$, $[L] = [L]$ and $[T] = [T]$ and comparing both side, we get $m = FL^{-1}T^2$

**126. (a)** $F = \frac{GMm}{R^2}$

$$\therefore G = \frac{FR^2}{Mm} \Rightarrow G = [ML^3T^{-2}]$$

**127. (c)** We know that $F = q\,v\,B$

$$\therefore \quad B = \frac{F}{qv} = \frac{MLT^{-2}}{C \times LT^{-1}} = MT^{-1}C^{-1}$$

**128. (a)** Energy stored in an inductor, $U = \frac{1}{2}LI^2$

$$\Rightarrow L = \frac{2U}{I^2} \quad \therefore [L] = \frac{[ML^2T^{-2}]}{[A]^2} = [ML^2T^{-2}A^{-2}]$$

**129. (c)** $n_2 = n_1\left(\frac{M_1}{M_2}\right)^1\left(\frac{L_1}{L_2}\right)^1\left(\frac{T_1}{T_2}\right)^{-2}$

$$= 100\left(\frac{gm}{10^3 gm}\right)^1\left(\frac{cm}{m}\right)^1\left(\frac{sec}{min}\right)^{-2}$$

$$= 100\left(\frac{gm}{10^3 gm}\right)^1\left(\frac{cm}{10^2 cm}\right)^1\left(\frac{sec}{60\,sec}\right)^{-2}$$

$$n_2 = \frac{3600}{10^3} = 3.6$$

**130. (b)** $\text{Power} = \frac{\text{Energy}}{\text{time}}$

**131. (d)** Energy incident per unit area per second

$$= \frac{\text{Energy}}{\text{area} \times \text{second}} = \frac{ML^2T^{-2}}{L^2T} = MT^{-3}$$

**132. (d)**

**133. (d)** $\text{Pressure} = \frac{MLT^{-2}}{L^2} = [ML^{-1}T^{-2}]$

$\Rightarrow a = 1, b = -1, c = -2.$

**134. (b)**

**135. (b)** Let surface tension
$s = E^aV^bT^c$

$$\frac{MLT^{-2}}{L} = (ML^2T^{-2})^a\left(\frac{L}{T}\right)^b(T)^C$$

Equating the dimension of LHS and RHS
$ML^0T^{-2} = M^aL^{2a+b}T^{-2a-b+c}$
$\Rightarrow a = 1, 2a + b = 0, \quad -2a - b + c = -2$
$\Rightarrow a = 1, b = -2, c = -2$
Hence, the dimensions of surface tension are $[E\,V^{-2}\,T^{-2}]$

**136. (b)** $\text{Mobility } \mu = \frac{\text{drift velocity}}{\text{electric field}}\frac{V_d}{E} = \frac{(ms^{-1})}{(Vm^{-1})} = \frac{m^2s^{-3}}{V}$

$$\left(\because \text{ Volt} = V = \frac{\text{joule(J)}}{\text{coulomb(C)}}\right)$$

$$= \frac{m^2s^{-1}C}{J} = \frac{m^2s^{-1}As}{kg\,m^2s^{-2}} [\text{Coulomb}, c = As]$$

$= kg^{-1}\,s^2\,A = M^{-1}\,T^2\,A$

**137. (d)** Force = mass × acceleration

$$\Rightarrow [\text{Mass}] = \left[\frac{\text{force}}{\text{acceleration}}\right]$$

$$= \left[\frac{\text{force}}{\text{velocity / time}}\right] = [F\,V^{-1}\,T]$$

**138. (d)** Let unit '$u$' related with $e$, $a_0$, $h$ and $c$ as follows.
$[u] = [e]^a\,[a_0]^b\,[h]^c\,[C]^d$
Using dimensional method,
$[M^{-1}L^{-2}T^{+4}A^{+2}] = [A^1T^1]^a[L]^b[ML2T^{-1}]^c[LT^{-1}]^d$
$[M^{-1}L^{-2}T^{+4}A^{+2}] = [M^c\,L^{b+2c+d}\,T^{a-c-d}\,A^a]$
$a = 2, b = 1, c = -1, d = -1$

$$\therefore \quad u = \frac{e^2a_0}{hc}$$

**139. (c)** Let $\mu_0$ related with $e$, $m$, $c$ and $h$ as follows.
$\mu_0 = ke^am^bc^ch^d$
$[MLT^{-2}A^{-2}] = [AT]^a\,[M]^b\,[LT^{-1}]^c\,[ML^2T^{-1}]^d$
$= [M^{b+d}\,L^{c+2d}\,T^{a-c-d}\,A^a]$
On comparing both sides we get
$a = -2$ ...(i)
$b + d = 1$ ...(ii)
$c + 2d = 1$ ...(iii)
$a - c - d = -2$ ...(iv)
By equation (i), (ii), (iii) & (iv) we get,
$a = -2, b = 0, c = -1, d = 1$

$$\therefore [\mu_0] = \left[\frac{h}{ce^2}\right]$$

## CHAPTER 3

# MOTION IN A STRAIGHT LINE

## FACT/DEFINITION TYPE QUESTIONS

**1.** Which of the following is a one dimensional motion ?
(a) Landing of an aircraft
(b) Earth revolving around the sun
(c) Motion of wheels of a moving train
(d) Train running on a straight track

**2.** The numerical ratio of displacement to distance for a moving object is
(a) always less than 1 (b) always equal to 1
(c) always more than 1 (d) equal to or less than 1

**3.** Which of the following can be zero, when a particle is in motion for some time?
(a) Distance (b) Displacement
(c) Speed (d) None of these

**4.** If distance covered by a particle is zero, what can you say about its displacement?
(a) It may or may not be zero
(b) It cannot be zero
(c) It is negative
(d) It must be zero

**5.** The location of a particle has changed. What can we say about the displacement and the distance covered by the particle?
(a) Neither can be zero
(b) One may be zero
(c) Both may be zero
(d) One is +ve, other is –ve

**6.** The displacement of a body is zero. The distance covered
(a) is zero
(b) is not zero
(c) may or may not be zero
(d) depends upon the acceleration

**7.** A body is moving along a straight line path with constant velocity. At an instant of time the distance travelled by it is S and its displacement is D, then
(a) $D < S$ (b) $D > S$
(c) $D = S$ (d) $D \leq S$

**8.** Speed is in general _____ in magnitude than that of the velocity.
(a) equal (b) greater or equal
(c) smaller (c) none of these

**9.** Area under velocity-time curve over a given interval of time represents
(a) acceleration (b) momentum
(c) velocity (d) displacement

**10.** The distance travelled by a body is directly proportional to the time taken. Its speed
(a) increases (b) decreases
(c) becomes zero (d) remains constant

**11.** The slope of velocity-time graph for motion with uniform velocity is equal to
(a) final velocity (b) initial velocity
(c) zero (d) none of these

**12.** The ratio of the numerical values of the average velocity and average speed of a body is
(a) unity (b) unity or less
(c) unity or more (d) less than unity

**13.** The slope of the tangent drawn on position-time graph at any instant is equal to the instantaneous
(a) acceleration (b) force
(c) velocity (d) momentum

**14.** Which of the following is the correct definition for Average speed?

(a) $\text{Average speed} = \dfrac{\text{total displacement}}{\text{total time}}$

(b) $\text{Average speed} = \dfrac{\text{total path length}}{\text{total time}}$

(c) $\text{Average speed} = \dfrac{\text{change in speed}}{\text{total time}}$

(d) $\text{Average speed} = \dfrac{\text{sum of all the speeds}}{\text{total time}}$

**15.** What is the numerical ratio of velocity to speed of an object ?
(a) Always equal to one
(b) Always less than one
(c) Always greater than one
(d) Either less than or equal to one.

**16.** The graph between displacement and time for a particle moving with uniform acceleration is a/an

(a) straight line with a positive slope

(b) parabola

(c) ellipse

(d) straight line parallel to time axis

**17.** The acceleration of a moving body can be found from

(a) area under velocity - time graph

(b) area under distance -time graph

(c) slope of the velocity- time graph

(d) slope of distance-time graph

**18.** What determines the nature of the path followed by the particle?

(a) Speed (b) Velocity

(c) Acceleration (d) Both (b) and (c)

**19.** Acceleration of a particle changes when

(a) direction of velocity changes

(b) magnitude of velocity changes

(c) speed changes

(d) Both (a) and (b)

**20.** The area under acceleration time graph gives

(a) distance travelled (b) change in acceleration

(c) force acting (d) change in velocity

**21.** Acceleration is described as rate of change of

(a) distance with time

(b) velocity with distance

(c) velocity with time

(d) distance with velocity

**22.** Which of the following is the correct expression of instantaneous acceleration ?

(a) $a = \frac{\Delta v}{(\Delta t)^2}$ (b) $a = \frac{dv}{dt}$

(c) $a = \frac{d^2v}{dt^2}$ (d) $a = \left(\frac{\Delta v}{\Delta t}\right)^2$

**23.** If a body travels with constant acceleration, which of the following quantities remains constant ?

(a) Displacement (b) Velocity

(c) Time (d) None of these.

**24.** A body is thrown vertically upwards. If air resistance is to be taken into account, then the time during which the body rises is

(a) equal to the time of fall

(b) less than the time of fall

(c) greater than the time of fall

(d) twice the time of fall

**25.** Velocity time curve for a body projected vertically upwards is

(a) parabola (b) ellipse

(c) hyperbola (d) straight line

**26.** A body is thrown upwards and reaches its maximum height. At that position

(a) its acceleration is minimum

(b) its velocity is zero and its acceleration is also zero

(c) its velocity is zero but its acceleration is maximum

(d) its velocity is zero and its acceleration is the acceleration due to gravity.

**27.** Stopping distance of a moving vehicle is directly proportional to

(a) square of the initial velocity

(b) square of the initial acceleration

(c) the initial velocity

(d) the initial acceleration

**28.** The path of a particle moving under the influence of a force fixed in magnitude and direction is

(a) straight line (b) circle

(c) parabola (d) ellipse

**29.** Velocity-time curve for a body projected vertically upwards is

(a) parabola (b) ellipse

(c) hyperbola (d) straight line

**30.** An object accelerated downward under the influence of force of gravity. The motion of object is said to be

(a) uniform motion

(b) free fall

(c) non uniformly accelerated motion

(d) None of these

**31.** Choose the wrong statement from the following.

(a) The motion of an object along a straight line is a rectilinear motion

(b) The speed in general is less than the magnitude of the velocity

(c) The slope of the displacement-time graph gives the velocity of the body

(d) The area under the velocity-time graph gives the displacement of the body

**32.** Free fall of an object (in vacuum) is a case of motion with

(a) uniform velocity

(b) uniform acceleration

(c) variable acceleration

(d) constant momentum

**33.** A ball thrown vertically upwards after reaching a maximum height h, returns to the starting point after a time of l0 s. Its displacement is

(a) *h* (b) 2 *h*

(c) 10 *h* (d) zero

**34.** If the displacement of a body varies as the square of elapsed time, then its

(a) velocity is constant

(b) velocity varies non-uniformly

(c) acceleration is constant

(d) acceleration changes continuously

**35.** The total distance travelled by the body in the given time is equal to

(a) the area which v– t graph encloses with displacement axis

(b) the area which x – t graph encloses with time axis

(c) the area which v – t graph encloses with time axis

(d) the area which a – t graph encloses with axis

**36.** Choose the correct equation to determine distance in a straight line for a body with uniform motion.

(a) $s = \frac{v}{t}$
(b) $s = v^2t$
(c) $s = ut + \frac{1}{2}gt^2$
(d) $s = v \times t^2$

**37.** If the *v*-*t* graph is a straight line inclined to the time axis, then

(a) $a = 0$
(b) $a \neq 0$
(c) $a = \text{constant} \neq 0$
(d) $a \neq \text{ constant } \neq 0$

**38.** For a moving body at any instant of time

(a) if the body is not moving, the acceleration is necessarily zero
(b) if the body is slowing, the retardation is negative
(c) if the body is slowing, the distance is negative
(d) if displacement, velocity and acceleration at that instant are known, we can find the displacement at any given time in future.

**39.** A particle moves 2m east then 4m north then 5 m west. The distance is

(a) 11m
(b) 10m
(c) –11m
(d) 5m

**40.** The ball is projected up from ground with speed 30 m/sec. What is the average velocity for time 0 to 4 sec?

(a) 10 m/sec
(b) 20 m/sec
(c) 15 m/sec
(d) zero

**41.** A body moves in straight line with velocity $v_1$ for 1/3rd time and for remaining time with $v_2$. Find average velocity.

(a) $\frac{v_1}{3} + \frac{2v_2}{3}$
(b) $\frac{v_1}{3} + \frac{v_2}{3}$
(c) $\frac{2v_1}{3} + \frac{v_2}{3}$
(d) $v_1 + \frac{2v_2}{3}$

**42.** A particle moves in straight line with velocity $v_1$ and $v_2$ for time intervals which are in ratio 1:2. Find average velocity.

(a) $\frac{v_1}{3} + \frac{2v_2}{3}$
(b) $\frac{v_1}{3} + \frac{v_2}{3}$
(c) $\frac{2v_1}{3} + \frac{v_2}{3}$
(d) $v_1 + \frac{2v_2}{3}$

**43.** A particle moves from (2,3) m to (4,1) m. The displacement vector is

(a) 2i + 2jm
(b) –2i – 2jm
(c) 2i – 2jm
(d) –2i + 2jm

**44.** If a train travelling at 20 m/s is to be brought to rest in a distance of 200 m, then its retardation should be

(a) 1 m/s$^2$
(b) 2 m/s$^2$
(c) 10 m/s$^2$
(d) 20 m/s$^2$

**45.** A body starts from rest and travels ‘s’ m in 2nd second, then acceleration is

(a) 2s m/s$^2$
(b) 3s m/s$^2$
(c) $\frac{2}{3}$s m/s$^2$
(d) $\frac{3}{2}$s m/s$^2$

**46.** Two trains, each Xm long are travelling in opposite direction with equal velocity 20 m/s. The time of crossing is

(a) $\frac{X}{40}$s
(b) $\frac{X}{20}$s
(c) $\frac{2X}{20}$s
(d) Zero

## STATEMENT TYPE QUESTIONS

**47.** Consider the following statements and select the incorrect statements.

I. The magnitude of instantaneous velocity of a particle is equal to its instantaneous speed
II. The magnitude of the average velocity in an interval is equal to its average speed in that interval.
III. It is possible to have a situation in which the speed of the particle is never zero but the average speed in an interval is zero.
IV. It is possible to have a situation in which the speed of particle is zero but the average speed is not zero.

(a) II, III and IV
(b) I and II
(c) II and III
(d) IV only

**48.** Select the incorrect statements from the following.

I. Average velocity is path length divided by time interval
II. In general, speed is greater than the magnitude of the velocity.
III. A particle moving in a given direction with a non-zero velocity can have zero speed.
IV. The magnitude of average velocity is equal to the average speed

(a) II and III
(b) I and IV
(c) I, III and IV
(d) I, II, III and IV

**49.** The incorrect statement(s) from the following is/are

I. A body having zero velocity will not necessarily have zero acceleration
II. A body having zero velocity will necessarily have zero acceleration
III. A body having uniform speed can have only uniform acceleration
IV. A body having non-uniform velocity will have zero acceleration

(a) II, III and IV
(b) I and II
(c) II and III
(d) IV only

**50.** Which of the following statements are correct?

I. A body can have zero velocity and still be accelerated
II. A body can have a constant velocity and still have a varying speed
III. A body can have a constant speed and still have a varying velocity
IV. The direction of the velocity of a body cannot change when its acceleration is constant.

(a) I and II
(b) I and III
(c) I, II and III
(d) II, III and IV

**51.** Select the correct statements from the following
I. A body can have constant velocity but variable speed
II. A body can have constant speed but variable velocity
III. A body can have zero velocity but non–zero acceleration
(a) I and II (b) II and III
(c) I and III (d) I, II and III

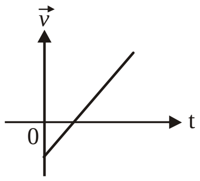
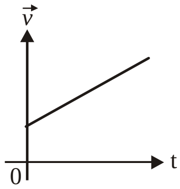
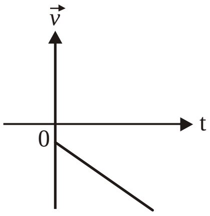
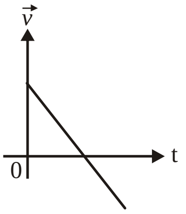
**52.** A body is thrown vertically upwards with a velocity *u*. Select the incorrect statements from the following.
I. Both velocity and acceleration are zero at its highest point
II. Velocity is maximum and acceleration is zero at the highest point.
III. Velocity is maximum and acceleration is *g* downwards at its highest point.
(a) I and II (b) II and III
(c) I and III (d) I, II and III

**53.** Which of the following is/are correct statements ?
I. When a body reaches highest point in vertical motion, its velocity becomes zero but acceleration is non -zero.
II. Average velocity of an object is not equal to the instantaneous velocity in uniform motion.
III. Average speed can be zero but average velocity can never be zero
(a) I and II (b) II and III
(c) I and III (d) I, II and III

**54.** The relative velocity $V_{AB}$ or $V_{BA}$ of two bodies A and B may be
I. greater than velocity of body A
II. greater than velocity of body B
III. less than the velocity of body A
IV. less than the velocity of body B
(a) I and II only (b) III and IV only
(c) I, II and III only (d) I, II, III and IV

## MATCHING TYPE QUESTIONS

**55.** A particle is going along a straight line with constant acceleration a, having initial velocity u. Then match the columns :

| **Column I** | **Column II** |
|---|---|
| (A) $u$ = + ve and $a$ = + ve | (1)  |
| (B) $u$ = – ve, and $a$ = + ve | (2)  |
| (C) $u$ = + ve, and $a$ = – ve | (3)  |
| (D) $u$ = – ve, and $a$ = – ve | (4)  |

(a) (A)→(3); (B)→(2); C→(1); (D)→(1)
(b) (A)→(2); (B)→(1); C→(4); (D)→(3)
(c) (A)→(1); (B)→(2); C→(3); (D)→(4)
(d) (A)→(4); (B)→(3); C→(2); (D)→(1)

**56.** For a particle in one dimensional motion, match the following columns :

| **Column I** | **Column II** |
|---|---|
| (A) Zero speed but non-zero acceleration. | (1) Body which is about to fall |
| (B) Zero speed non-zero velocity. | (2) Extreme position of oscillating body |
| (C) Constant speed non-zero acceleration. | (3) Possible |
| (D) Positive acceleration must speeding up. | (4) Not possible |

(a) (A)→(4); (B)→(2); C→(1); (D)→(3)
(b) (A)→(2); (B)→(1); C→(3); (D)→(4)
(c) (A)→(1, 2, 3); (B)→(3); C→(4); (D)→(1, 3)
(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

**57.**

| **Column I** | **Column II** |
|---|---|
| (A) Physical quantity whose unit is cm $s^{-2}$ in CGS system | (1) Linear motion |
| (B) Negative acceleration | (2) Zero |
| (C) Motion exhibited by body moving in a straight line | (3) Distance |
| (D) Area under a speed time graph | (4) Acceleration |
| (E) Velocity of an upward throwing body at the peak point | (5) Retardation |

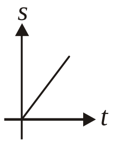
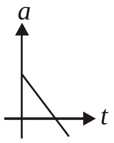
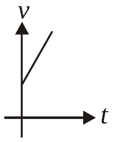
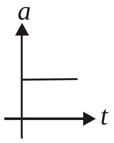
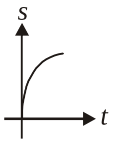
(a) (A)→(4); (B)→(5); C→(1); (D)→(3) ; (E)→(2)
(b) (A)→(2); (B)→(1); C→(3); (D)→(4) ; (E)→(5)
(c) (A)→(5); (B)→(2); C→(3); (D)→(1) ; (E)→(4)
(d) (A)→(2); (B)→(4); C→(1); (D)→(3) ; (E)→(5)

**58.**

| **Column I** | **Column II** |
|---|---|
| (A) Zero acceleration | (1) Retardation |
| (B) Velocity time graph | (2) Speed |
| (C) Speed in a direction | (3) Constant motion |
| (D) Acts in opposite direction of motion | (4) Acceleration |
| (E) Slope of a distance time graph | (5) Velocity |

(a) (A)→(4); (B)→(5); C→(1); (D)→(3) ; (E)→(3)
(b) (A)→(2); (B)→(1); C→(3); (D)→(4) ; (E)→(5)
(c) (A)→(5); (B)→(2); C→(3); (D)→(1) ; (E)→(4)
(d) (A)→(3); (B)→(4); C→(5); (D)→(1) ; (E)→(2)

**59.**

| **Column I** | **Column II** |
|---|---|
| (A) Uniform retardation | (1)  |
| (B) Uniform velocity | (2)  |
| (C) Uniform acceleration with initial velocity | (3)  |
| (D) Constant acceleration | (4)  |
| (E) Decreasing acceleration at steady rate. | (5)  |

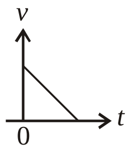
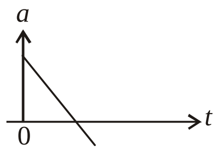
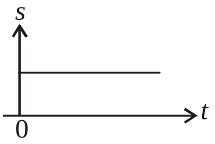
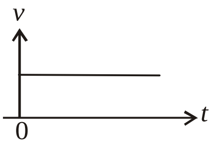
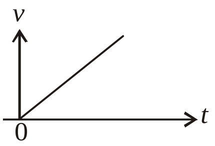
(a) (A)→(2); (B)→(5); C→(1); (D)→(4) ; (E)→(3)
(b) (A)→(5); (B)→(1); C→(3); (D)→(4) ; (E)→(2)
(c) (A)→(5); (B)→(2); C→(3); (D)→(1) ; (E)→(4)
(d) (A)→(3); (B)→(4); C→(5); (D)→(1) ; (E)→(2)

**60.**

| **Column I** | **Column II** |
|---|---|
| (A) Velocity | (1) $m/s^2$ |
| (B) Displacement | (2) vector |
| (C) Speed | (3) m/s |
| (D) Acceleration | (4) scalar |

(a) (A)→(2, 3); (B)→(2); C→(3, 4); (D)→(1)
(b) (A)→(2); (B)→(1); C→(3); (D)→(4)
(c) (A)→(1, 2, 3); (B)→(3); C→(4); (D)→(1, 3)
(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

**61.**

| **Column I** | **Column II** |
|---|---|
| (A) Decreasing acceleration at steady rate | (1)  |
| (B) A body at rest | (2)  |
| (C) Uniform velocity | (3)  |
| (D) Constant motion | (4)  |
| | (5)  |

(a) (A)→(2, 3); (B)→(2); C→(3, 4); (D)→(1, 5)
(b) (A)→(1, 2); (B)→(3); C→(5); (D)→(4)
(c) (A)→(1, 2, 3); (B)→(3); C→(4); (D)→(1, 3)
(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

**62.**

| **Column I** | **Column II** |
|---|---|
| (A) Distance travelled by a body | (1) zero acceleration |
| (B) Uniform velocity | (2) $ut + \frac{1}{2}at^2$ |
| (C) Speedometer | (3) instantaneous speed |
| (D) Height of a vertically thrown body | (4) $\frac{u^2}{2g}$ |

(a) (A)→(2, 3); (B)→(2); C→(3, 4); (D)→(1, 5)
(b) (A)→(1, 2); (B)→(3); C→(5); (D)→(4)
(c) (A)→(1, 5); (B)→(1); C→(3); (D)→(4, 5)
(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

**63.**

| **Column I** | **Column II** |
|---|---|
| (A) $s_n$ | (1) $m/s^2$ |
| (B) $v^2 - u^2$ | (2) $\frac{u+v}{t}$ |
| (C) Average speed | (3) $2gh$ |
| (D) Acceleration | (4) $u+\frac{a}{2}(2n-1)$ |

(a) (A)→(4); (B)→(3); C→(2); (D)→(1)
(b) (A)→(4); (B)→(1); C→(2); (D)→(3)
(c) (A)→(3); (B)→(1); C→(4); (D)→(2)
(d) (A)→(2); (B)→(1); C→(3); (D)→(4)

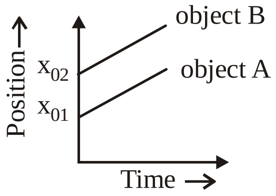
**64.** Match the Column I and Column II.

| | Column I | | Column II |
|---|---|---|---|
| (A) | Displacement | (1) | Slope of $x - t$ graph |
| (B) | Velocity | (2) | Slope of tangent to x – t Curve |
| (C) | Acceleration | (3) | Area under $v - t$ curve |
| (D) | Instantaneous velocity | (4) | Slope of $v - t$ graph |
| | | (5) | Area. under $x - t$ curve |

(a) (A)→(4); (B)→(2); C→(1); (D)→(3)
(b) (A)→(2); (B)→(4); C→(3); (D)→(1)
(c) (A)→(3); (B)→(1); C→(4); (D)→(2)
(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

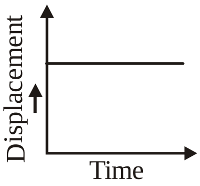
## DIAGRAM TYPE QUESTIONS

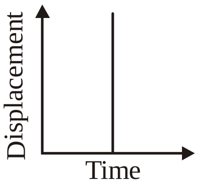
**65.** The graph shown below represent



(a) A and B are moving with same velocity in opposite directions
(b) velocity of B is more than A in same direction
(c) velocity of A is more than B in same direction
(d) velocity of A and B is equal in same direction

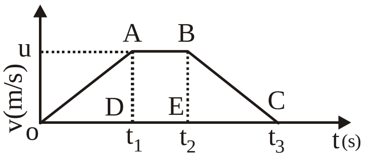
**66.** Which of the following is not possible for a body in uniform motion?

(a)


(b)


(c) Both (a) & (b) (d) None of these

**67.** The velocity time graph of the motion of the body is as shown below



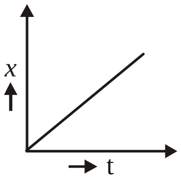
The total distance travelled by the body during the motion is equal to ____.

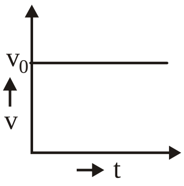
(a) $\frac{1}{2}$ (AD + BE) × OC (b) $\frac{1}{2}$ (OA + BC) × OC

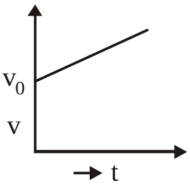
(c) $\frac{1}{2}$ (OC + AB) × AD (d) $\frac{1}{2}$ (OA + AB) × BC

**68.** Which of the following graphs gives the equation

$$x = v_o t + \frac{1}{2} at^2$$

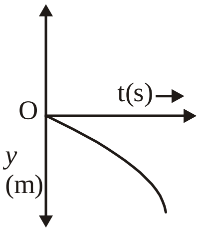
(a)


(b)


(c)


(d) None of these

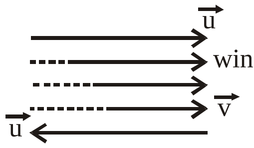
**69.** The equation represented by the graph below is :



(a) $y = \frac{1}{2} gt$ (b) $y = \frac{-1}{2} gt$

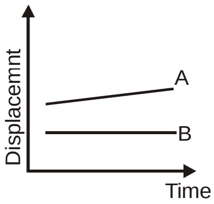
(c) $y = \frac{1}{2} gt^2$ (d) $y = \frac{-1}{2} gt^2$

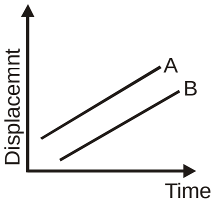
**70.** Wind is blowing west to east along two parallel tracks. Two trains moving with same speed in opposite directions have the relative velocity w.r.t. wind in the ratio 1 : 2. The speed of each train is



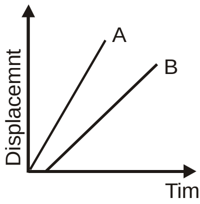
(a) equal to that of wind
(b) double that of wind
(c) three times that of wind
(d) half that of wind

**71.** Which one of the following represents the time-displacement graph of two objects A and B moving with zero relative speed?

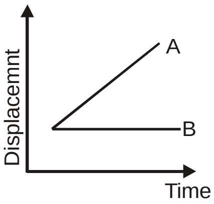
(a)


(b)


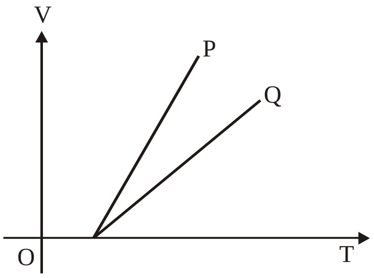
(c)



(d)



**72.** Figure shows the v-t graph for two particles P and Q. Which of the following statements regarding their relative motion is true ?



Their relative velocity is

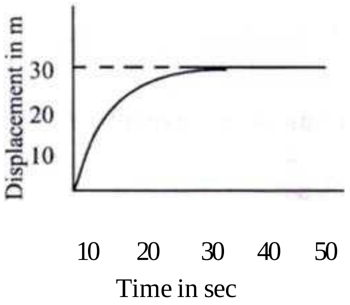
(a) is zero

(b) is non-zero but constant

(c) continuously decreases

(d) continuously increases

**73.** The displacement of a particle as a function of time is shown in figure. It indicates that



(a) the velocity of the particle is constant throughout

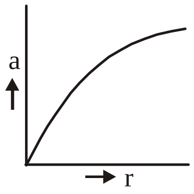
(b) the acceleration of the particle is constant throughout

(c) the particle starts with a constant velocity and is accelerated

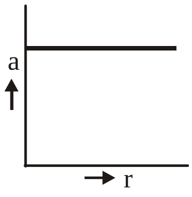
(d) the motion is retarded and finally the particle stops

**74.** If a body moving in circular path maintains constant speed of 10 ms$^{-1}$, then which of the following correctly describes relation between acceleration and radius ?

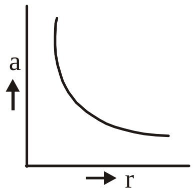
(a)



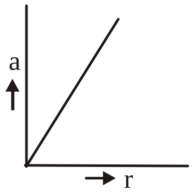
(b)



(c)



(d)



## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

**75.** **Assertion :** Displacement of a body may be zero when distance travelled by it is not zero.

**Reason :** The displacement is the longest distance between initial and final position.

**76.** **Assertion :** Displacement of a body is vector sum of the area under velocity– time graph.

**Reason :** Displacement is a vector quantity.

**77.** **Assertion :** The position-time graph of a uniform motion, in one dimension of a body cannot have negative slope.

**Reason :** In one – dimensional motion the position does not reverse, so it cannot have a negative slope.

**78.** **Assertion :** Position-time graph of a stationary object is a straight line parallel to time axis.

**Reason :** For a stationary object, position does not change with time.

**79.** **Assertion :** Velocity-time graph for an object in uniform motion along a straight path is a straight line parallel to the time axis.

**Reason :** In uniform motion of an object velocity increases as the square of time elapsed.

**80.** **Assertion:** The average velocity of the object over an interval of time is either smaller than or equal to the average speed of the object over the same interval.

**Reason:** Velocity is a vector quantity and speed is a scalar quantity.

**81.** **Assertion :** The speedometer of an automobile measure the average speed of the automobile.

**Reason :** Average velocity is equal to total displacement per total time taken.

**82.** **Assertion :** An object can have constant speed but variable velocity.

**Reason :** Speed is a scalar but velocity is a vector quantity.

**83.** **Assertion :** The position-time graph of a uniform motion in one dimension of a body can have negative slope.

**Reason :** When the speed of body decreases with time, the position-time graph of the moving body has negative slope.

**84.** **Assertion :** position-time graph of a body moving uniformly in a straight line parallel to position axis. Says body is at rest.

**Reason :** The slope of position-time graph in a uniform motion gives the velocity of an object.

**85.** **Assertion :** The average and instantaneous velocities have same value in a uniform motion.

**Reason :** In uniform motion, the velocity of an object increases uniformly.

**86.** **Assertion :** A body may be accelerated even when it is moving uniformly.

**Reason :** When direction of motion of the body is changing, the body must have acceleration.

**87.** **Assertion :** For one dimensional motion the angle between acceleration and velocity must be zero.

**Reason :** One dimensional motion is always on a straight line.

**88.** **Assertion :** A particle starting from rest and moving with uniform acceleration travels' a length of x and 3x in first two and next two-seconds.

**Reason :** Displacement is directly proportional to velocity.

**89.** **Assertion :** A body is momentarily at rest when it reverses the direction.

**Reason :** A body cannot have acceleration if its velocity is zero at a given instant of time.

**90.** **Assertion :** The equation of motion can be applied only if acceleration is along the direction of velocity and is constant.

**Reason :** If the acceleration of a body is zero then its motion is known as uniform motion.

**91.** **Assertion :** A positive acceleration of a body can be associated with '*slowing down*' of the body.

**Reason :** Acceleration is a vector quantity.

**92.** **Assertion :** The speed of a body can never be negative.

**Reason :** The speed of an object is the distance travelled by it in unit time and distance can never be negative.

**93.** **Assertion** : If a passenger stands 'd' aways from a bus and the bus starts moving with a constant acceleration 'a' then the minimum speed of the passenger in order to catch the bus will be $\sqrt{2ad}$

**Reason :** $v^2 = u^2 + 2ad$,

**94.** **Assertion** : When brakes are applied to a moving vehicle the distance it travels before stopping is proportional to the square of initial velocity of the vehicle.

**Reason :** $u^2 = v^2 - 2as, \quad s \propto u^2$

**95.** **Assertion :** In a free fall, weight of a body becomes effectively zero.

**Reason :** Acceleration due to gravity acting on a body having free fall is zero.

**96.** **Assertion :** A body falling freely may do so with constant velocity.

**Reason :** The body falls freely, when acceleration of a body is equal to acceleration due to gravity.

**97.** **Assertion :** A body, whatever its motion is always at rest in a frame of reference which is fixed to the body itself.

**Reason:** The relative velocity of a body with respect to itself is zero.

**98.** **Assertion** : If wind blows west to east and two trains are moving with the same speed in opposite direction and have the stream track of one double than other, then the speed of each train is three times that of the wind.

**Reason :** If u→ speed of each train and v → speed of wind then $(u + v) = 2(u - v) \quad \therefore u = 3v$

## CRITICAL THINKING TYPE QUESTIONS

**99.** A truck and a car are moving with equal velocity. On applying the brakes both will stop after certain distance, then
(a) truck will cover less distance before rest
(b) car will coverless distance before rest
(c) Both will cover equal distance
(d) None of these

**100.** If Position of a particle is given by $x = (4t^2 - 8t)$, then which of the following is true?
(a) Acceleration is zero at t = 0
(b) Velocity is zero at t = 0
(c) Velocity is zero at t = 1s
(d) Velocity and acceleration will never be zero

**101.** A particle located at x=0 at time t=0, starts moving along with the positive x-direction with a velocity 'v' that varies as $v = \alpha\sqrt{x}$ . The displacement of the particle varies with time as
(a) $t^2$ (b) $t$
(c) $t^{1/2}$ (d) $t^3$

**102.** A man leaves his house for a cycle ride. He comes back to his house after half-an-hour after covering a distance of one km. What is his average velocity for the ride ?
(a) zero (b) $2\ \text{km h}^{-1}$
(c) $10\ \text{km s}^{-1}$ (d) $\frac{1}{2}\ \text{km s}^{-1}$

**103.** A point traversed half of the distance with a velocity $v_0$. The half of remaining part of the distance was covered with velocity $v_1$ & second half of remaining part by $v_2$ velocity. The mean velocity of the point, averaged over the whole time of motion is
(a) $\frac{v_0 + v_1 + v_2}{3}$ (b) $\frac{2v_0 + v_1 + v_2}{3}$
(c) $\frac{v_0 + .2v_1 + 2v_2}{3}$ (d) $\frac{2v_0(v_1 + v_2)}{(2v_0 + v_1 + v_2)}$

**104.** A particle moves along a straight line OX. At a time *t* (in second) the distance x (in metre) of the particle from O is given by $x = 40 + 12t - t^3$. How long would the particle travel before coming to rest?
(a) 24m (b) 40m
(c) 56m (d) 16m

**105.** A passenger in a moving train tosses a coin. If the coin falls behind him, the train must be moving with

(a) an acceleration (b) a deceleration

(c) a uniform speed (d) any of the above

**106.** The deceleration experienced by a moving motorboat after its engine is cut off, is given by $dv/dt = -kv^3$ where k is constant. If $v_0$ is the magnitude of the velocity at cut-off, the magnitude of the velocity at a time t after the cut-off is

(a) $\dfrac{v_0}{\sqrt{(2v_0^2 kt + 1)}}$ (c) $v_0 e^{-kt}$

(c) $v_0 / 2$ (d) $v_0$

**107.** A particle moves a distance x in time t according to equation $x = (t + 5)^{-1}$. The acceleration of particle is proportional to

(a) $(\text{velocity})^{3/2}$ (b) $(\text{distance})^2$

(c) $(\text{distance})^{-2}$ (d) $(\text{velocity})^{2/3}$

**108.** A particle is moving eastwards with a velocity of 5 $ms^{-1}$. In 10 seconds the velocity changes to 5 $ms^{-1}$ northwards. The average acceleration in this time is

(a) $\frac{1}{2} ms^{-2}$ towards north

(b) $\frac{1}{\sqrt{2}} ms^{-2}$ towards north - east

(c) $\frac{1}{\sqrt{2}} ms^{-2}$ towards north - west

(d) zero

**109.** It is given that $t = px^2 + qx$, where $x$ is displacement and t is time. The acceleration of particle at origin is

(a) $-\dfrac{2p}{q^3}$ (b) $-\dfrac{2q}{p^3}$ (c) $\dfrac{2p}{q^3}$ (d) $\dfrac{2q}{p^3}$

**110.** An object, moving with a speed of 6.25 m/s, is decelerated at a rate given by: $\dfrac{dv}{dt} = -2.5\sqrt{v}$ where $v$ is the instantaneous speed. The time taken by the object, to come to rest, would be

(a) 2 s (b) 4 s

(c) 8 s (d) 1 s

**111.** The position of a particle along the $x$-axis at certain times is given below

| $t(s)$ | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| $x(m)$ | –2 | 0 | 6 | 16 |

Which of the following describes the motion correctly?

(a) uniform acceleration

(b) uniform retardation

(c) non-uniform acceleration

(d) there is not enough data for generalization

**112.** A car accelerates from rest at a constant rate $\alpha$ for some time after which it decelerates at a constant rate $\beta$ to come to rest. If the total time elapsed is t, the maximum velocity acquired by the car is given by

(a) $\left(\dfrac{\alpha^2 + \beta^2}{\alpha\beta}\right)t$ (b) $\left(\dfrac{\alpha^2 - \beta^2}{\alpha\beta}\right)t$

(c) $\left(\dfrac{\alpha + \beta}{\alpha\beta}\right)t$ (d) $\left(\dfrac{\alpha\beta}{\alpha + \beta}\right)t$

**113.** A metro train starts from rest and in 5 s achieves 108 km/h. After that it moves with constant velocity and comes to rest after travelling 45 m with uniform retardation. If total distance travelled is 395 m, find total time of travelling.

(a) 12.2 s (b) 15.3 s

(c) 9 s (d) 17.2 s

**114.** A car, starting from rest, accelerates at the rate f through a distance S, then continues at constant speed for time t and then decelerates at the rate $\frac{f}{2}$ to come to rest. If the total distance traversed is 15 S , then

(a) $S = \frac{1}{6} ft^2$ (b) $S = f t$

(c) $S = \frac{1}{4} ft^2$ (d) $S = \frac{1}{72} ft^2$

**115.** A body is projected vertically upwards. If $t_1$ and $t_2$ be the times at which it is at height $h$ above the projection while ascending and descending respectively, then $h$ is

(a) $\frac{1}{2} g t_1 t_2$ (b) $g t_1 t_2$

(c) $2 g t_1 t_2$ (d) $2hg$

**116.** Two balls A and B of same mass are thrown from the top of the building. A thrown upward with velocity v and B, thrown down with velocity $v$, then

(a) velocity A is more than B at the ground

(b) velocity of B is more than A at the ground

(c) both A &B strike the ground with same velocity

(d) None of these

**117.** A rocket is fired upward from the earth's surface such that it creates an acceleration of 19.6 $ms^{-2}$. If after 5 s, its engine is switched off, the maximum height of the rocket from earth's surface would be

(a) 980 m (b) 735 m

(c) 490 m (d) 245 m

**118.** A man throws balls with same speed vertically upwards one after the other at an interval of 2 sec. What should be the speed of throw so that more than two balls are in air at any time ?

(a) Only with speed 19.6 m/s

(b) More than 19.6 m/s

(c) At least 9.8 m/s

(d) Any speed less then 19.6 m/s.

**119.** A ball is dropped from a high rise platform at t = 0 starting from rest. After 6 seconds another ball is thrown downwards from the same platform with a speed v. The two balls meet at t = 18s. What is the value of v?

(take $g = 10 \text{ m/s}^2$)

(a) 75 m/s (b) 55 m/s

(c) 40 m/s (d) 60 m/s

**120.** A stone falls freely under gravity. It covers distances $h_1$, $h_2$ and $h_3$ in the first 5 seconds, the next 5 seconds and the next 5 seconds respectively. The relation between $h_1$, $h_2$ and $h_3$ is

(a) $h_1 = \frac{h_2}{3} = \frac{h_3}{5}$ (b) $h_2 = 3h_1$ and $h_3 = 3h_2$

(c) $h_1 = h_2 = h_3$ (d) $h_1 = 2h_2 = 3h_3$

**121.** From a building two balls *A* and *B* are thrown such that *A* is thrown upwards and *B* downwards (both vertically). If $v_A$ and $v_B$ are their respective velocities on reaching the ground, then

(a) $v_A > v_B$

(b) $v_A = v_B$

(c) $v_A < v_B$

(d) their velocities depend on their masses.

**122.** A ball is released from the top of tower of height h metre. It takes T second to reach the ground. What is the position of the ball in T/3 second ?

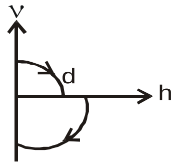
(a) $\frac{h}{9}$ metre from the ground

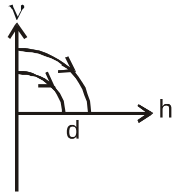
(b) $\frac{7h}{9}$ metre from the ground

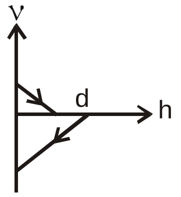
(c) $\frac{8h}{9}$ metre from the ground

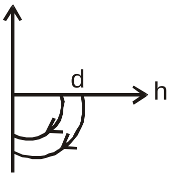
(d) $\frac{17h}{18}$ metre from the ground

**123.** A ball is dropped vertically from a height d above the ground. It hits the ground and bounces up vertically to a height d/2. Neglecting subsequent motion and air resistance, its velocity v varies with the height h above the ground as

(a)


(b)


(c)


(d)


**124.** A stone is dropped into a well in which the level of water is h below the top of the well. If v is velocity of sound, the time T after which the splash is heard is given by

(a) T = 2h/v (b) $T = \sqrt{\left(\frac{2h}{g}\right)} + \frac{h}{v}$

(c) $T = \sqrt{\left(\frac{2h}{v}\right)} + \frac{h}{g}$ (d) $T = \sqrt{\left(\frac{h}{2g}\right)} + \frac{2h}{v}$

**125.** Let A, B, C, D be points on a vertical line such that AB = BC = CD. If a body is released from position A, the times of descent through AB, BC and CD are in the ratio.

(a) $1 : \sqrt{3} - \sqrt{2} : \sqrt{3} + \sqrt{2}$ (b) $1 : \sqrt{2} - 1 : \sqrt{3} - \sqrt{2}$

(c) $1 : \sqrt{2} - 1 : \sqrt{3}$ (d) $1 : \sqrt{2} : \sqrt{3} - 1$

**126.** Water drops fall at regular intervals from a tab which is hm above the ground. After how many seconds does the first drop reach the ground?

(a) $\sqrt{\frac{2h}{g}}$ (b) $\sqrt{\frac{h}{2g}}$

(c) $\frac{h}{2g}$ (d) $\frac{2h}{g}$

**127.** If two balls of masses $m_1$ and $m_2(m_1 = 2m_2)$ are dropped from the same height, then the ratio of the time taken by them to reach the ground will be

(a) $m_1 : m_2$ (b) $2m_2 : m_1$

(c) 1 : 1 (d) 1 : 2

**128.** Two cars A and B approach each other at the same speed, then what will be the velocity of A if velocity of B is 8 m/s ?

(a) 16 m/s (b) 8 m/s

(c) – 8 m/s (d) Can't be determined.

**129.** A train of 150 m length is going towards north direction at a speed of 10 $ms^{-1}$. A parrot flies at a speed of 5 $ms^{-1}$ towards south direction parallel to the railway track. The time taken by the parrot to cross the train is equal to

(a) 12 s (b) 8 s

(c) 15 s (d) 10 s

**130.** Two trains are each 50 m long moving parallel towards each other at speeds 10 m/s and 15 m/s respectively. After what time will they pass each other?

(a) $5\sqrt{\frac{2}{3}}$ sec (b) 4 sec

(c) 2 sec (d) 6 sec

**131.** A particle of unit mass undergoes one-dimensional motion such that its velocity varies according to $v(x) = bx^{-2n}$ where b and n are constants and *x* is the position of the particle. The acceleration of the particle as d function of x, is given by

(a) $-2nb^2x^{-4n-1}$ (b) $-2b^2x^{-2n+1}$

(c) $-2nb^2e^{-4n+1}$ (d) $-2nb^2x^{-2n-1}$

**132.** A ship A is moving Westwards with a speed of 10 km $h^{-1}$ and a ship B 100 km South of A, is moving Northwards with a speed of 10 km $h^{-1}$. The time after which the distance between them becomes shortest, is

(a) 5 h (b) $5\sqrt{2}$ h

(c) $10\sqrt{2}$ h (d) 0 h

**133.** From a balloon moving upwards with a velocity of 12 $ms^{-1}$, a packet is released when it is at a height of 65 m from the ground. The time taken by it to reach the ground is ($g = 10\ ms^{-2}$)

(a) 5 s (b) 8 s

(c) 4 s (d) 7 s

**134.** A bus is moving with a velocity of 10 $ms^{-1}$ on a straight road. A scootorist wishes to overtake the bus in one minute. If the bus is at a distance of 1.2 km ahead, then the velocity with which he has to chase the bus is

(a) 20 $ms^{-1}$ (b) 25 $ms^{-1}$
(c) 60 $ms^{-1}$ (d) 30 $ms^{-1}$

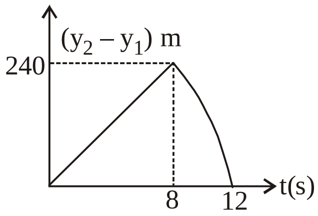
**135.** A ball dropped from a point A falls down vertically to C, through the midpoint B. The descending time from A to B and that from A to C are in the ratio

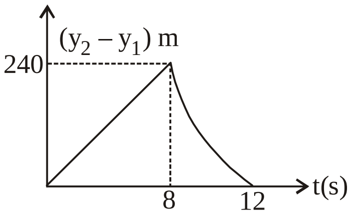
(a) $1:1$ (b) $1:2$
(c) $1:3$ (d) $1:\sqrt{2}$

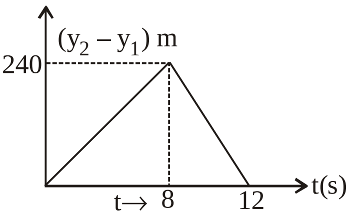
**136.** Two stones are thrown up simultaneously from the edge of a cliff 240 m high with initial speed of 10 m/s and 40 m/s respectively. Which of the following graph best represents the time variation of relative position of the second stone with respect to the first ?

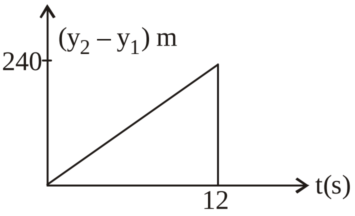
(Assume stones do not rebound after hitting the ground and neglect air resistance, take g = 10 m/ $s^2$)

(*The figures are schematic and not drawn to scale*)

(a)


(b)


(c)


(d)


**137.** A ball is dropped from the top of a tower of height 100 m and at the same time another ball is projected vertically upwards from ground with a velocity 25 $ms^{-1}$. Then the distance from the top of the tower, at which the two balls meet is

(a) 68.4m (b) 48.4m
(c) 18.4m (d) 78.4m

**138.** The ratio of distances traversed in successive intervals of time when a body falls freely under gravity from certain height is

(a) $1:2:3$ (b) $1:5:9$
(c) $1:3:5$ (d) $\sqrt{1}:\sqrt{2}:\sqrt{3}$

**139.** A particle starting with certain initial velocity and uniform acceleration covers a distance of 12 m in first 3 seconds and a distance of 30 m in next 3 seconds. The initial velocity of the particle is

(a) 3 $ms^{-1}$ (b) 2.5 $ms^{-1}$
(c) 2 $ms^{-1}$ (d) 1 $ms^{-1}$

**140 .** From a tower of height H, a particle is thrown vertically upwards with a speed u. The time taken by the particle, to hit the ground, is n times that taken by it to reach the highest point of its path. The relation between H, u and n is

(a) $2gH = n^2u^2$ (b) $gH = (n-2)^2 u^2d$
(c) $2gH = nu^2(n-2)$ (d) $gH = (n-2)u^2$

# HINTS AND SOLUTIONS

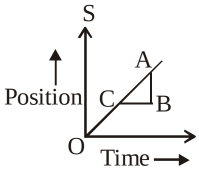
## FACT/DEFINITION TYPE QUESTIONS

1. **(d)** Motion of a body along a straight line is one dimensional motion.
2. **(d)** $\frac{\text{Displacement}}{\text{distance}} \le 1$
3. **(b)**
4. **(d)** Distance covered by a particle is zero only when it is at rest. Therefore, its displacement must be zero.
5. **(a)** When location of a particle has changed, it must have covered some distance and undergone some displacement.
6. **(c)**
7. **(c)** If a body is moving along a straight line path with constant velocity then distance travelled = displacement i.e., D = S
8. **(b)** In general, in magnitude of speed $\ge$ velocity
9. **(d)** Area under velocity-time curve represents displacement.
10. **(d)** When s $\propto$ t, so $\frac{s}{t} = \text{constant}$.
11. **(c)** The velocity-time graph for a uniform motion is a straight. line parallel to time axis. Its slope is zero.
12. **(b)**

$$\frac{|\text{Average velocity}|}{|\text{Average speed}|} = \frac{|\text{displacement}|}{|\text{distance}|}$$

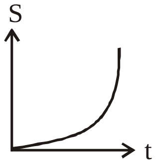
because displacement will either be equal or less than distance. It can never be greater than distance travelled.

13. **(c)** The slope of the tangent drawn on position-time graph at any instant gives instantaneous velocity.



$$AC = \frac{AB}{BC} = V_{inst}$$

14. **(b)**
15. **(d)** $\frac{\text{velocity}}{\text{speed}} \le 1$
16. **(b)** For a particle moving with uniform acceleration the displacement-time graph is a parabola.



17. **(c)** Slope of velocity-time graph shows acceleration.
18. **(d)** The nature of the path is decided by the direction of velocity, and the direction of acceleration. The trajectory can be a straight line, circle or a parabola depending on these factors.
19. **(c)** Because acceleration is a vector quantity.
20. **(d)** 21. **(c)** 22. **(b)** 23. **(d)**
24. **(b)** Let the initial velocity of ball be $u$

Time of rise $t_1 = \frac{u}{g+a}$ and height reached

$$= \frac{u^2}{2(g+a)}$$

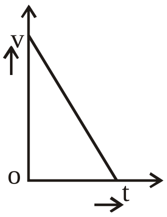
Time of fall $t_2$ is given by

$$\frac{1}{2}(g-a)t_2^2 = \frac{u^2}{2(g+a)}$$

$$t_2 = \frac{u}{\sqrt{(g+a)(g-a)}} = \frac{u}{(g+a)}\sqrt{\frac{g+a}{g-a}}$$

$\therefore$ $t_2 > t_1$ because $\frac{1}{g+a} < \frac{1}{g-a}$

25. **(d)** Velocity time curve will be a straight line as shown:



At the highest point v = 0.

26. **(d)**
27. **(a)** Let s be the distance travelled by the vehicle before it stops.
Final velocity υ = 0, initial velocity = u
Using equation of motion $v^2 - u^2 = 2aS$
$0^2 - u^2 = 2aS$

Stopping distance, $S = -\frac{u^2}{2a}$

28. **(a)**
29. **(d)** Because acceleration due to gravity is constant so the slope of line will be constant i.e. velocity time curve for a body projected vertically upwards is straight line.
30. **(b)**
31. **(b)** The speed in general $\ge$ the magnitude of velocity
32. **(b)** Free fall of an object (in vacuum) is a case of motion with uniform acceleration.

**33.** **(d)** As ball returns to starting point so displacement is zero.

**34.** **(c)** As, $s = \frac{1}{2}at^2$

If $a$ is constant, then $s \propto t^2$

**35.** **(c)** **36.** **(c)** **37.** **(c)** **38.** **(d)** **39.** **(a)**

**40.** **(a)** We should know the displacement in this time.

$$\vec{S} = \vec{u}t + \frac{\vec{a}t^2}{2} \quad \text{(we take upward as positive)}$$

$$S = 30 \times 4 - 10 \times 4 \times \frac{4}{2} = 40\,\text{m.}$$

The average velocity will be 10 m/sec.

**41.** **(a)** $v_{av} = \frac{v_1 t/3 + v_2(2t/3)}{t} = \frac{v_1}{3} + \frac{2v_2}{3}$

**42.** **(a)** $v_{av} = \frac{v_1 t/3 + v_2(2t/3)}{t} = \frac{v_1}{3} + \frac{2v_2}{3}$

**43.** **(c)**

**44.** **(a)** $v^2 - u^2 = 2as \Rightarrow a = \frac{u^2}{2as} = \frac{(20)^2}{2 \times 200} = 1 \text{ m/s}^2$

**45.** **(c)** $S_n = u + \frac{a}{2}(2n - 1)$

or, $S = \frac{a}{2}(2 \times 2 - 1) \Rightarrow a = \frac{2}{3}\text{m/s}^2$

**46.** **(a)** $\text{Time} = \frac{\text{total length}}{\text{relative velocity}} = \frac{X + X}{20 + 20} = \frac{X}{40}\text{s}$

## STATEMENT TYPE QUESTIONS

**47.** **(a)** Instantaneous speed is the distance being covered by the particle per unit time at the given instant. It is equal to the magnitude of the instantaneous velocity at the given instant.

**48.** **(c)** $\text{Average velocity} = \frac{\text{displacement}}{\text{time interval}}$

A particle moving in a given direction with non-zero velocity cannot have zero speed.

In general, average speed is not equal to magnitude of average velocity. However, it can be so if the motion is along a straight line without change in direction.

**49.** **(a)** When the body is projected vertically upward then at the highest point its velocity is zero but acceleration is not equal to zero ($g = 9.8\text{m/s}^2$).

**50.** **(b)** **51.** **(b)**

**52.** **(d)** At highest point $v = 0$ and $H_{\max} = \frac{u^2}{2g}$

**53.** **(a)** Average velocity can be positive, negative or zero.

**54.** **(d)** All options are correct :

(i) When two bodies A & B move in opposite directions then relative velocity between A & B either $V_{AB}$ or $V_{BA}$ both are greater than $V_A$ & $V_B$.

(ii) When two bodies A & B move in same direction

then $V_{AB} = V_A - V_B \Rightarrow V_{AB} < V_A$

$V_{BA} = V_B - V_A \Rightarrow V_{BA} < V_B$

## MATCHING TYPE QUESTIONS

**55.** **(b)** (A)→(2); (B)→(1); C→(4); (D)→(3)
**56.** **(c)** (A)→(1, 2, 3); (B)→(3); C→(4); (D)→(1, 3)
**57.** **(a)** (A)→(4); (B)→(5); C→(1); (D)→(3) ; (E)→(2)
**58.** **(d)** (A)→(3); (B)→(4); C→(5); (D)→(1) ; (E)→(2)
**59.** **(b)** (A)→(5); (B)→(1); C→(3); (D)→(4) ; (E)→(2)
**60.** **(a)** (A)→(2, 3); (B)→(2); C→(3, 4); (D)→(1)
**61.** **(b)** (A)→(1, 2); (B)→(3); C→(5); (D)→(4)
**62.** **(c)** (A)→( 2); (B)→(1); C→(3); (D)→(4)
**63.** **(a)** (A)→(4); (B)→(3); C→(2); (D)→(1)
**64.** **(c)** (A)→(3); (B)→(1); C→(4); (D)→(2)

## DIAGRAM TYPE QUESTIONS

**65.** **(d)** **66.** **(c)** **67.** **(c)** **68.** **(c)** **69.** **(d)**

**70.** **(c)** Let v be velocity of wind and u be velocity of each train.

Rel. vel. of one train w.r.t. wind = 2 × Rel. vel. of other train w.r.t. wind

$u + v = 2\,(u - v)$

$v + 2\,v = 2u - u = u.$

i.e., $u = 3v.$

**71.** **(b)**

**72.** **(d)** The difference in velocities is increasing with time as both of them have different acceleration.

**73.** **(e)** From displacement-time graph, it is clear that in equal intervals of time displacements are not equal infact, decreases and after 40s displacement constant i.e. the particle stops.

**74.** **(c)** Speed, $V$ = constant (from question)

Centripetal acceleration,

$$a = \frac{V^2}{r}$$

$ra$ = constant

Hence graph (c) correctly describes relation between acceleration and radius.

## ASSERTION- REASON TYPE QUESTIONS

**75.** **(c)** The displacement is the shortest distance between initial and final position. When final position of a body coincides with its initial position, displacement is zero, but the distance travelled is not zero.

**76.** **(a)** According to definition, displacement = velocity × time. Since displacement is a vector quantity so its value is equal to the vector sum of the area under velocity-time graph.

**77.** **(c)**

**78.** **(a)** Position-time graph for a stationary object is a straight line parallel to time axis showing that not change in position with time.

**79.** **(c)** In uniform motion the object moves with uniform velocity, the magnitude of its velocity at different instance i.e., at $t = 0$, $t = 1$, sec, $t = 2$sec ..... will always be constant. Thus velocity-time graph for an object in uniform motion along a straight path is a straight line parallel to time axis.

**80.** **(a)** Because displacement ≤ distance and so average velocity ≤ average speed.

**81.** **(d)** Speedometer measures instantaneous speed of automobile.

**82.** **(a)** Since velocity is a vector quantity, hence as its direction changes keeping magnitude constant, velocity is said to be changed. But for constant speed in equal time interval distance travelled should be equal.

**83.** **(c)** Negative slope of position time graph represents that the body is moving towards the negative direction and if the slope of the graph decrease with time then it represents the decrease in speed i.e. retardation in motion.

**84.** **(c)** If the position-time graph of a body moving uniformly in a straight line parallel to position axis, it means that the position of body is changing at constant time. The statement is abrupt and shows that the velocity of body is infinite.

**85.** **(c)** In uniform motion the speed is same at each instant of motion.

**86.** **(a)** In uniform circular motion, there is acceleration of constant magnitude.

**87.** **(d)** One dimensional motion is always along straight line. But acceleration may be opposite of velocity and so angle between them will be 180°.

**88.** **(c)**

**89.** **(c)** Assertion is True, Reason is False.

**90.** **(d)** Equation of motion can be applied if the acceleration is in opposite direction to that of velocity and uniform motion mean the acceleration is zero.

**91.** (b) A body having positive acceleration can be associated with slowing down, as time rate of change of velocity decreases, but velocity increases with time.

**92.** **(a)** **93.** **(a)** **94.** **(a)** **95.** **(c)**

**96.** **(d)** When a body falling freely, only gravitational force acts on it in vertically downward direction. Due to this downward acceleration the velocity of a body increases and will be maximum when the body touches the ground.

**97.** **(a)** A body has no relative motion with respect to itself. Hence, if a frame of reference of body is fixed, then the body will be always at relative rest in this frame of reference.

**98.** **(a)**

## CRITICAL THINKING TYPE QUESTIONS

**99.** **(c)** Stopping distance = $\dfrac{\text{kinetic energy}}{\text{retarding force}} = \dfrac{\frac{1}{2}mu^2}{F}$

$$= \frac{u^2}{2\mu g} \qquad [\because F = \mu mg]$$

So both will cover equal distance.

**100.** **(c)** Velocity $V = \dfrac{dx}{dt}$

**101.** **(a)** $v = \alpha\sqrt{x}$

$$\frac{dx}{dt} = \alpha\sqrt{x}$$

$$\frac{dx}{\sqrt{x}} = \alpha\, dt$$

$$\int_0^x \frac{dx}{\sqrt{x}} = \alpha\int_0^t dt$$

$$\left[\frac{2\sqrt{x}}{1}\right]_0^x = \alpha[t]_0^t$$

$$\Rightarrow 2\sqrt{x} = \alpha t$$

$$\Rightarrow x = \frac{\alpha^2}{4}t^2$$

**102.** **(a)** Since displacement is zero.

**103.** **(d)** Let the total distance be d. Then for first half distance, time $= \dfrac{d}{2v_0}$, next distance. $= v_1 t$ and last half distance $= v_2 t$

$$\therefore \quad v_1 t + v_2 t = \frac{d}{2}; \quad t = \frac{d}{2(v_1 + v_2)}$$

Now average speed

$$t = \frac{d}{\dfrac{d}{2v_0} + \dfrac{d}{2(v_1+v_2)} + \dfrac{d}{2(v_1+v_2)}}$$

$$= \frac{2v_0(v_1+v_2)}{(v_1+v_2) + 2v_0}$$

**104.** **(c)** When particle comes to rest,

$$V = 0 = \frac{dx}{dt} = \frac{d}{dt}(40 + 12t - t^3)$$

$$\Rightarrow \quad 12 - 3t^2 = 0$$

$$\Rightarrow \quad t^2 = \frac{12}{3} = 4 \ \therefore t = 2 \text{ sec}$$

Therefore distance travelled by particle before coming to rest,

$x = 40 + 12t - t^3 = 40 + 12 \times 2 - (2)^3 = 56\text{m}$

**105. (a)** As the coin falls behind him, force due to air must be backwards. Therefore, the train must be accelerating forward.

**106. (a)** $\frac{dv}{dt} = -kv^3$ or $\frac{dv}{v^3} = -k\ dt$

Integrating we get, $-\frac{1}{2v^2} = -kt + c$ ...(1)

At t = 0, v = $v_0$ $\therefore -\frac{1}{2v_o^2} = c$

Putting in (1)

$$-\frac{1}{2v^2} = -kt - \frac{1}{2{v_0}^2} \text{ or } \frac{1}{2v_0^2} - \frac{1}{2v^2} = -kt$$

$$\text{or } \left[\frac{1}{2v_0^2} + kt\right] = \frac{1}{2v^2} \text{ or } \left[1 + 2v_0^2\ kt\right] = \frac{v_0^2}{v^2}$$

$$\text{or } v^2 = \frac{v_0^2}{1 + 2v_0^2\,kt} \text{ or } v = \frac{v_0}{\sqrt{1 + 2v_0^2\,kt}}$$

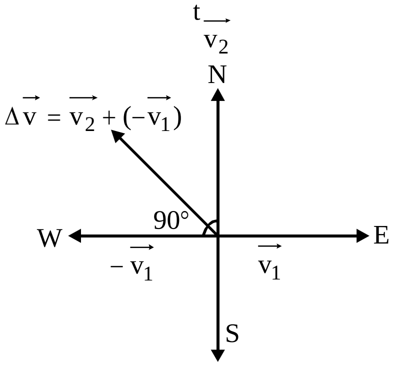
**107. (a)** $x = \frac{1}{t+5}$ $\therefore v = \frac{dx}{dt} = \frac{-1}{(t+5)^2}$

$$\therefore a = \frac{d^2x}{dt^2} = \frac{2}{(t+5)^3} = 2x^3$$

Now $\frac{1}{(t+5)} \propto v^{\frac{1}{2}}$ $\therefore$ $\frac{1}{(t+5)^3} \propto v^{\frac{3}{2}} \propto a$

**108. (c)** Average acceleration = $\frac{\text{change in velocity}}{\text{time interval}}$

$$= \frac{\Delta \vec{v}}{t}$$



$\vec{v_1} = 5\hat{i}, \vec{v_2} = 5\hat{j}$

$$\Delta\vec{v} = (\vec{v}_2 - \vec{v}_1) = \sqrt{v_1^2 + v_2^2 + 2v_1v_2 \cos 90}$$

$= \sqrt{5^2 + 5^2 + 0}$ [As $|\ v_1| = |v_2| = 5$ m/s]

$= 5\sqrt{2}\ \text{m/s}$

Avg. acc. $= \frac{\Delta\vec{v}}{t} = \frac{5\sqrt{2}}{10} = \frac{1}{\sqrt{2}}\text{m/s}^2$

$\tan\theta = \frac{5}{-5} = -1$

which means $\theta$ is in the second quadrant. (towards north-west)

**109. (a)** Differentiate two times and put $x = 0$.

**110. (a)** $\frac{dv}{dt} = -2.5\sqrt{v} \Rightarrow \frac{dv}{\sqrt{v}} = -2.5\,dt$

Integrating,

$$\int_{6.25}^{0} v^{-½}dv = -2.5\int_0^t dt$$

$$\Rightarrow \left[\frac{v^{+½}}{(½)}\right]_{6.25}^{0} = -2.5[t]_0^t$$

$$\Rightarrow -2(6.25)^{½} = -2.5t \Rightarrow t = 2\text{ sec}$$

**111. (a)** $x = x_0 + (ut + \frac{1}{2}at^2)$

At $t = 0, x = -2,$

$\therefore -2 = x_0 + 0$

or $x_0 = -2$

Thus,0 $= -2 + (u \times 1 + \frac{1}{2} \times a \times 1^2)$ ...(i)

and 6 $= -2 + (u \times 2 + \frac{1}{2} \times a \times 2^2)$ ...(ii)

After solving equations, we get $u = 0$, $\boldsymbol{a} = 4$ m/s$^2$. Now for $t = 3$,

$x = -2 + (u \times 3 + \frac{1}{2} \times 4 \times 3^2)$

$= 16$m.

Clearly it represents motion with constant acceleration.

**112. (d)** Let the car accelerates for a time $t_1$ and travels a distance $s_1$. Suppose the maximum velocity attained by the car be v. Then

$s_1 = \frac{1}{2}\alpha\, t_1^2$ and $v = \alpha\, t_1,\ t_1 = v/\alpha,$

$\therefore\ s_1 = \frac{1}{2} \times \alpha \times (v^2/\alpha^2) = \frac{v^2}{2\alpha}$ ...(1)

Let the car decelerates for a time $t_2$ and travels a distances $s_2$. Then

$s_2 = v\,t_2 - \frac{1}{2}\beta\,{t_2}^2$ and $0 = v - \beta\,t_2$ or $t_2 = \frac{v}{\beta}$

$$\therefore\ s_2 = v \times \left(\frac{v}{\beta}\right) - \frac{1}{2}\beta\left(\frac{v^2}{\beta^2}\right)$$

or $s_2 = \frac{v^2}{\beta} - \frac{v^2}{2\beta} = \frac{v^2}{2\beta}$ ...(2)

As per question,

Let max. velocity is v

then $v = \alpha t_1$ & $v - \beta t_2 = 0$, where $t = t_1 + t_2$

Now $t_1 + t_2 = t$ or $\frac{v}{\alpha} + \frac{v}{\beta} = t$

$$\therefore v = \frac{t}{\left(\frac{1}{\alpha} + \frac{1}{\beta}\right)} = \left(\frac{\alpha\beta}{\alpha + \beta}\right) t \text{ and}$$

$$s = s_1 + s_2 = \frac{v^2}{2\alpha} + \frac{v^2}{2\beta} = \frac{v^2}{2}\left(\frac{1}{\alpha} + \frac{1}{\beta}\right)$$

**113. (d)** Given : u = 0, t = 5 sec, v = 108 km/hr = 30m/s

By eq$^n$ of motion

v = u + at

or $a = \frac{v}{t} = \frac{30}{5} = 6\ m/s^2 \quad [\because\ u = 0]$

$$S_1 = \frac{1}{2}at^2$$

$$= \frac{1}{2} \times 6 \times 5^2 = 75\ m$$

Distance travelled in first 5 sec is 75m.

Distance travelled with uniform speed of 30 m/s is $S_2$

$395 = S_1 + S_2 + S_3$

$395 = 75 + S_2 + 45$

$\therefore S_2 = 395 - 120 = 275\ m$

Time taken to travel 275 m = $\frac{275}{30} = 9.2\,sec$

For retarding motion, we have

$0^2 - 30^2 = 2\,(-a) \times 45$

We get, a = 10 m/s$^2$

Now by, $S = ut + \frac{1}{2}at^2$

$$45 = 30t + \frac{1}{2}(-10)t^2$$

$$45 = 30t - 5t^2$$

on solving we get,

t = 3 sec

Total time taken = 5 + 9.2 + 3

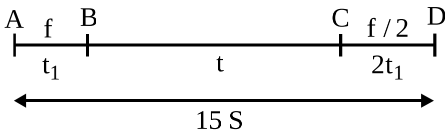
= 17.2 sec.

**114. (d)** Distance from A to B = $S = \frac{1}{2}ft_1{}^2$

Distance from B to C = $(ft_1)\,t$

Distance from C to D = $\frac{u^2}{2a} = \frac{(ft_1)^2}{2(f/2)}$

$$= ft_1{}^2 = 2S$$



$\Rightarrow S + f\,t_1 t + 2S = 15S$

$\Rightarrow f\,t_1 t = 12S$ ............. (i)

$\frac{1}{2} f\,t_1^2 = S$ ............ (ii)

Dividing (i) by (ii), we get $t_1 = \frac{t}{6}$

$$\Rightarrow S = \frac{1}{2} f \left(\frac{t}{6}\right)^2 = \frac{f\,t^2}{72}$$

**115. (a)** $h = ut_1 - \frac{1}{2}gt_1^2$

Also $h = ut_2 - \frac{1}{2}gt_2^2$

After simplify above equations, we get

$$h = \frac{1}{2}gt_1t_2 .$$

**116. (c)** If *h* is the height of the building, then

$$v_A^2 = v^2 + 2gh$$

and $v_B^2 = (-v)^2 + 2gh$.

Clearly $v_A = v_B$.

**117. (b)** Velocity when the engine is switched off

$v = 19.6 \times 5 = 98\,m\,s^{-1}$

$h_{max} = h_1 + h_2$ where $h_1 = \frac{1}{2}at^2$ & $h_2 = \frac{v^2}{2a}$

$h_{max} = \frac{1}{2} \times 19.6 \times 5 \times 5 + \frac{98 \times 98}{2 \times 9.8}$

$= 245 + 490 = 735\,m$

**118. (b)** Height attained by balls in 2 sec is

$= \frac{1}{2} \times 9.8 \times 4 = 19.6m$

the same distance will be covered in 2 second (for descent)

Time interval of throwing balls, remaining same. So, for two balls remaining in air, the time of ascent or descent must be greater than 2 seconds. Hence speed of balls must be greater than 19.6 m/sec.

**119. (a)** Clearly distance moved by 1st ball in 18s = distance moved by 2nd ball in 12s.

Now, distance moved in 18 s by 1st ball

$= \frac{1}{2} \times 10 \times 18^2 = 90 \times 18 = 1620\,m$

Distance moved in 12 s by 2nd ball

$= ut + \frac{1}{2}gt^2 \quad \therefore\ 1620 = 12\,v + 5 \times 144$

$\Rightarrow v = 135 - 60 = 75\ ms^{-1}$

**120. (a)** $\because\ h = \frac{1}{2}\ gt^2$

$\therefore\ h_1 = \frac{1}{2}\ g(5)^2 = 125$

$$h_1 + h_2 = \frac{1}{2} g(10)^2 = 500$$

$$\Rightarrow \; h_2 = 375$$

$$h_1 + h_2 + h_3 = \frac{1}{2} g(15)^2 = 1125$$

$$\Rightarrow \; h_3 = 625$$

$$h_2 = 3h_1 , h_3 = 5h_1$$

$$\text{or} \quad h_1 = \frac{h_2}{3} = \frac{h_3}{5}$$

**121. (b)** As the ball moves down from height 'h' to ground the P.E. at height 'h' is converted to K.E. at the ground (Applying Law of conservation of Energy).

Hence, $\frac{1}{2} m_A v_A{}^2 = m_A g h_A$ or $v_A = \sqrt{2gh}$ ;

Similarly, $v_B = \sqrt{2gh}$ or $v_A = v_B$

**122. (c)** $h = \frac{1}{2} g T^2$

In $\frac{T}{3}$ sec, the distance travelled $= \frac{1}{2} g \left(\frac{T}{3}\right)^2 = \frac{h}{9}$

$\therefore$ Position of the ball from the ground

$$= h - \frac{h}{9} = \frac{8h}{9} m$$

**123. (a)** Before hitting the ground, the velocity $v$ is given by

$$v^2 = 2gd$$

Further, $v'^2 = 2g \times \left(\frac{d}{2}\right) = gd$ ;

$$\therefore \left(\frac{v}{v'}\right) = \sqrt{2} \quad \text{or} \quad v = v'\sqrt{2}$$

As the direction is reversed and speed is decreased and hence graph (a) represents these conditions correctly.

**124. (b)** Time taken by the stone to reach the water level

$$t_1 = \sqrt{\frac{2h}{g}}$$

Time taken by sound to come to the mouth of the well,

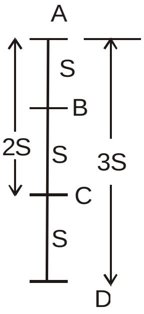
$$t_2 = \frac{h}{v}$$

$$\therefore \quad \text{Total time } t_1 + t_2 = \sqrt{\frac{2h}{g}} + \frac{h}{v}$$

**125. (b)** $S = AB = \frac{1}{2} g t_1{}^2 \Rightarrow 2S = AC = \frac{1}{2} g\,(t_1 + t_2)^2$

and $3S = AD = \frac{1}{2} g\,(t_1 + t_2 + t_3)^2$

$$t_1 = \sqrt{\frac{2S}{g}}$$



$$t_1 + t_2 = \sqrt{\frac{4S}{g}}, \; t_2 = \sqrt{\frac{4S}{g}} - \sqrt{\frac{2S}{g}}$$

$$t_1 + t_2 + t_3 = \sqrt{\frac{6S}{g}}$$

$$t_3 = \sqrt{\frac{6S}{g}} - \sqrt{\frac{4S}{g}}$$

$$t_1 : t_2 : t_3 :: 1 : (\sqrt{2} - \sqrt{1}) : \; (\sqrt{3} - \sqrt{2})$$

**126. (a)** $h = ut + \frac{1}{2} g t^2$

$$h = \frac{1}{2} g t^2 \; [\because u = 0]$$

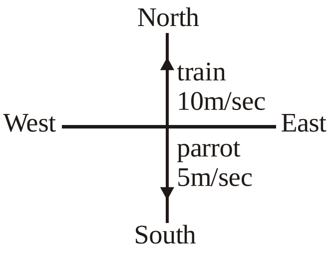
$$\therefore t = \sqrt{2h / g}$$

**127. (c)**

**128. (c)** Velocity of A is same as that of B in magnitude but opposite in direction.

**129. (d)** So by figure the velocity of parrot w.r. t. train is = 5–(–10) = 15m/sec so time taken to cross the train is

$$= \frac{\text{length of train}}{\text{relative velocity}} = \frac{150}{15} = 10 \text{ sec}$$



**130. (b)** Relative speed of each train with respect to each other be, $v = 10 + 15 = 25$ m/s

Here distance covered by each train = sum of their lengths $= 50 + 50 = 100$ m

$$\therefore \text{ Required time} = \frac{100}{25} = 4 \text{ sec} .$$

**131. (a)** According to question,

$V(x) = bx^{-2n}$

So, $\frac{dv}{dx} = -2\,nb\,x^{-2n-1}$

Acceleration of the particle as function of x,

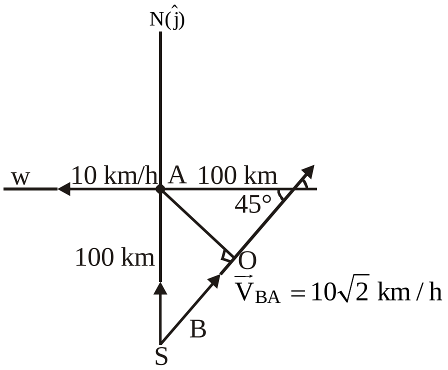
$$a = v \frac{dv}{dx} = bx^{-2n} \left\{ b\,(-2n)\,x^{-2n-1} \right\}$$

$$= -2nb^2 x^{-4n-1}$$

**132. (a)** $\vec{V}_A = 10\left(-\hat{i}\right)$

$$\vec{V}_B = 10\left(\hat{j}\right)$$

$$\vec{V}_{BA} = 10\,\hat{j} + 10\,\hat{i} = 10\sqrt{2} \text{ km / h}$$



Distance OB = 100 cos 45° = $50\sqrt{2}$ km

Time taken to each the shortest distance between

A and B = $\dfrac{\text{OB}}{\overrightarrow{V_{BA}}} = \dfrac{50\sqrt{2}}{10\sqrt{2}} = 5\text{h}$

**133. (a)** $s = ut + \frac{1}{2}at^2$

$-65 = 12t - 5t^2$ on solving we get, $t = 5\text{s}$

**134. (d)** Speed to cover 1200 m by scootarist

$v_r \times 60 = 1200 \Rightarrow v_r = 20$

speed to overtake bus

$v = v_r + 10 = 30$ m/s

**135. (d)** For $A$ to $B$

$S = \frac{1}{2}gt^2$ ...(*i*)

For $A$ to C

$2S = \frac{1}{2}gt'^2$ ...(*ii*)

Dividing (i) by (ii) we get

$\dfrac{t}{t'} = \dfrac{1}{\sqrt{2}}$

**136. (b)** $y_1 = 10t - 5t^2$ ; $y_2 = 40t - 5t^2$

for $y_1 = -240\text{m}, t = 8\text{s}$

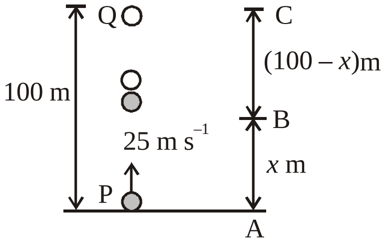
$\therefore$ $y_2 - y_1 = 30t$ for $t \le 8\text{s}$.

for $t > 8\text{s}$,

$y_2 - y_1 = 240 - 40t - \frac{1}{2}gt^2$

**137. (d)** Let the two balls Pand Q meet at height $x$ m from the ground after time $t$ s from the start.

We have to find distance, $BC = (100 - x)$



For ball P

$S = x$ m, $u = 25$ m s$^{-1}$, $a = -g$

From $S = ut + \frac{1}{2}at^2$

$x = 25t - \frac{1}{2}gt^2$ .......... (i)

For ball Q

$S = (100 - x)$ m, $u = 0$, $a = g$

$\therefore\ 100 - x = 0 + \frac{1}{2}gt^2$ .......... (ii)

Adding eqns. (i) and (ii), we get

$100 = 25t$ or $t = 4$ s

From eqn. (i),

$x = 25 \times 4 - \frac{1}{2} \times 9.8 \times (4)^2 = 21.6$ m

Hence distance from the top of the tower

$= (100 - x)$ m $= (100 - 21.6$ m$) = 78.4$ m

**138. (c)** As we know, distance traversed in $n^{\text{th}}$ second

$S_n = u + \frac{1}{2}a(2n - 1)$

Here, $u = 0$, $a = g$

$\therefore\quad S_n = \frac{1}{2}g(2n - 1)$

Distance traversed in 1st second i.e., $n = 1$

$S_1 = \frac{1}{2}g(2 \times 1 - 1) = \frac{1}{2}g$

Distance traversed in 2nd second i.e., $n = 2$

$S_2 = \frac{1}{2}g(2 \times 2 - 1) = \frac{3}{2}g$

Distance traversed in 3rd second i.e., $n = 3$

$S_3 = \frac{1}{2}g(2 \times 3 - 1) = \frac{5}{2}g$

$\therefore S_1 : S_2 : S_3 = \frac{1}{2}g : \frac{3}{2}g : \frac{5}{2}g = 1:3:5$

**139. (d)** Let $u$ be the initial velocity that have to find and $a$ be the uniform acceleration of the particle.

For $t = 3$s, distance travelled $S = 12$ m and

for $t = 3 + 3 = 6$ s distance travelled $S' = 12 + 30 = 42$ m

From, $S = ut + 1/2\, at^2$

$12 = u \times 3 + \frac{1}{2} \times a \times 3^2$

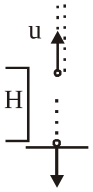
or $24 = 6u + 9a$ ...(i)

Similarly, $42 = u \times 6 + \frac{1}{2} \times a \times 6^2$

or $42 = 6u + 18a$ ...(ii)

On solving, we get $u = 1$ m s$^{-1}$

**140. (c)** Speed on reaching ground $v = \sqrt{u^2 + 2gh}$



Now, $v = u + at$

$\Rightarrow \quad \sqrt{u^2 + 2gh} = -u + gt$

Time taken to reach highest point is $t = \dfrac{u}{g}$,

$\Rightarrow \quad t = \dfrac{u + \sqrt{u^2 + 2gH}}{g} = \dfrac{nu}{g}$ (from question)

$\Rightarrow \quad 2gH = n(n - 2)u^2$

## CHAPTER 4

# MOTION IN A PLANE

## FACT / DEFINITION TYPE QUESTIONS

**1.** A scalar quantity is one that
(a) can never take negative values
(b) has magnitude as well as direction
(c) does not vary from one point to another in space
(d) has the same value for observers with different orientations of axes.

**2.** Which of the following conditions are sufficient and essential for a quantity to be a vector?
(a) Magnitude and direction
(b) Magnitude and addition, subtraction, multiplication by ordinary rules of algebra
(c) Magnitude, direction, and addition, subtraction multiplication and division by vector laws
(d) Magnitude, direction and combination of vectors by ordinary rules of algebra

**3.** If θ is the angle between two vectors, then the resultant vector is maximum, when value of θ is
(a) 0° (b) 90°
(c) 180° (d) Same in all cases.

**4.** How many minimum number of vectors in different planes can be added to give zero resultant?
(a) 2 (b) 3
(c) 4 (d) 5

**5.** The unit vectors along the three co-ordinate axes are related as
(a) $\hat{i} > \hat{j} > \hat{k} > 1$ (b) $\hat{i} = \hat{j} = \hat{k} = 0$
(c) $\hat{i} = -\hat{j} = \hat{k} = 1$ (d) $\hat{i} = \hat{j} = \hat{k} = 1$

**6.** The angle between the direction of $\hat{i}$ and $(\hat{i} + \hat{j})$ is
(a) 90° (b) 0°
(c) 45° (d) 180°

**7.** Consider the quantities pressure, power, energy, impulse, gravitational potential, electric charge, temperature and area. Out of these, the vector quantities are
(a) impulse, pressure and area
(b) impulse and area
(c) area and gravitational potential
(d) impulse and pressure

**8.** Angular momentum is
(a) a scalar (b) a polar vector
(c) an axial vector (d) None of these

**9.** The resultant of $\vec{A} \times 0$ will be equal to
(a) zero (b) A
(c) zero vector (d) unit vector

**10.** In a clockwise system
(a) $\hat{j} \times \hat{k} = \hat{i}$ (b) $\hat{i} \times \hat{k} = 0$
(c) $\hat{j} \times \hat{j} = 1$ (d) $\hat{k} \times \hat{i} = 1$

**11.** The component of a vector *r* along *x*-axis will have maximum value if
(a) *r* is along positive *y*-axis
(b) *r* is along positive *x*-axis
(c) *r* makes an angle of 45° with the *x*-axis
(d) *r* is along negative *y*-axis

**12.** It is found that | A + B | = | A |. This necessarily implies,
(a) B = 0
(b) A and B are antiparallel
(c) A and B are perpendicular
(d) A.B $\le$ 0

**13.** The shape of trajectory of the motion of an object is determined by
(a) acceleration (b) initial position
(c) initial velocity (d) All of these

**14.** The position vector a of particle is

$$\vec{r} = (a\cos\omega t)\hat{i} + (a\sin\omega t)\hat{j}$$

The velocity of the particle is
(a) directed towards the origin
(b) directed away from the origin
(c) parallel to the position vector
(d) perpendicular to the position vector

**15.** If $t_m$ is the time taken by a projectile to achieve the maximum height, then the total time of flight $T_f$ related to $t_m$ as
(a) $t_m = 2\,T_f$ (b) $T_f = t_m$
(c) $T_f = 2t_m$ (d) None of these

**16.** If u is the initial velocity of a projectile and v is the velocity at any instant, then the maximum horizontal range $R_m$ is equal to
(a) $R_m = \frac{u^2 \sin 2\theta}{g}$ (b) $R_m = \frac{v^2}{g}$
(c) $R_m = \frac{v^2 \sin 2\theta}{g}$ (d) $R_m = \frac{u^2}{g}$

**17.** Which of the following is an essential condition for horizontal component of projectile to remain constant?
(a) Acceleration due to gravity should be exactly constant
(b) Angle of projection should be 45°
(c) There should be no air-resistance
(d) All of these

**18.** In the projectile motion, if air resistance is ignored, the horizontal motion is at
(a) constant acceleration (b) constant velocity
(b) variable acceleration (d) constant retardation

**19.** A moves with 65 km/h while B is coming back of A with 80 km/h. The relative velocity of B with respect to A is
(a) 80 km/h (b) 60 km/h
(c) 15 km/h (d) 145 km/h

**20.** A bullet is dropped from the same height when another bullet is fired horizontally. They will hit the ground
(a) one after the other
(b) simultaneously
(c) depends on the observer
(d) None of these

**21.** What determines the nature of the path followed by a particle?
(a) Velocity (b) Speed
(c) Acceleration (d) None of these

**22.** The time of flight of a projectile on an upward inclined plane depends upon
(a) angle of inclination of the plane
(b) angle of projection
(c) the value of acceleration due to gravity
(d) all of the above.

**23.** At the highest point on the trajectory of a projectile, its
(a) potential energy is minimum
(b) kinetic energy is maximum
(c) total energy is maximum
(d) kinetic energy is minimum.

**24.** In a projectile motion, velocity at maximum height is
(a) $\frac{u\cos\theta}{2}$ (b) $u \cos \theta$
(c) $\frac{u\sin\theta}{2}$ (d) None of these

**25.** The angle of projection, for which the horizontal range and the maximum height of a projectile are equal, is:
(a) 45° (b) $\theta = \tan^{-1}4$
(c) $\theta = \tan^{-1}(0.25)$ (d) none of these.

**26.** For an object thrown at 45° to horizontal, the maximum height ($H$) and horizontal range ($R$) are related as
(a) $R = 16$ H (b) $R = 8$ H
(c) $R = 4$ H (d) $R = 2$H

**27.** The vertical component of velocity of a projectile at its maximum height ($u$ - velocity of projection, $\theta$-angle of projection) is
(a) $u \sin\theta$ (b) $u \cos\theta$
(c) $\frac{u}{\sin\theta}$ (d) 0

**28.** For projectile motion, we will assume that the air resistance has ...X... effect on the motion of the projectile. Here, X refers to
(a) sufficient (b) insufficient
(c) negligible (d) proper

**29.** For angle ...X..., the projectile has maximum range and it is equal to ...X.... Here, X and Y refer to
(a) $\frac{\pi}{4}$ and $\frac{v_0^2}{2g}$ (b) $\frac{\pi}{2}$ and $\frac{v_0}{g}$
(c) $\frac{\pi}{4}$ and $\frac{v_0^2}{g}$ (d) $\frac{\pi}{2}$ and $\frac{v_0^2}{g}$

**30.** At the top of the trajectory of a projectile, the acceleration is
(a) maximum (b) minimum
(c) zero (d) $g$

**31.** Centripetal acceleration is
(a) a constant vector
(b) a constant scalar
(c) a magnitude changing vector
(d) not a constant vector

**32.** The force required to keep a body in uniform circular motion is
(a) centripetal force (b) centrifugal force
(c) resistance (d) None of these

**33.** In a vertical circle of radius r at what point in the path a particle has tension equal to zero if it is just able to complete the vertical circle?
(a) Highest point
(b) Lowest point
(c) Any point
(d) At a point horizontally from the centre of circle of radius r

**34.** Two stones are moving with same angular speeds in the radii of circular paths 1 m and 2 m. The ratio of their linear speed is ...X.... Here, X refers to
(a) 2 (b) 1/2
(c) 1/3 (d) 3

**35.** The direction of the angular velocity vector is along
(a) the tangent to the circular path
(b) the inward radius
(c) the outward radius
(d) the axis of rotation

**36.** If $a_r$ and $a_t$ represent radial and tangential accelerations, the motion of particle will be uniformly circular, if
(a) $a_r = 0$ and $a_t = 0$ (b) $a_r = 0$ but $a_t \neq 0$
(c) $a_r \neq 0$ and $a_t = 0$ (d) $a_r \neq 0$ and $a_t \neq 0$

**37.** In uniform circular motion
(a) both velocity and acceleration are constant
(b) acceleration and speed are constant but velocity changes
(c) both acceleration and velocity change
(d) both acceleration and speed are constant

**38.** When a body moves with a constant speed along a circle
(a) no work is done on it
(b) no acceleration is produced in the body
(c) no force acts on the body
(d) its velocity remains constant

**39.** A body is travelling in a circle at a constant speed. It
(a) has a constant velocity
(b) is not accelerated
(c) has an inward radial acceleration
(d) has an outward radial acceleration

**40.** A body is moving with a constant speed v in a circle of radius r. Its angular acceleration is
(a) vr (b) v/r
(c) zero (d) $vr^2$

**41.** A stone of mass m is tied to a string of length $\ell$ and rotated in a circle with a constant speed v, if the string is released the stone flies
(a) radially outward
(b) radially inward
(c) tangentially outward
(d) with an acceleration $mv^2/\ell$

**42.** If a particle moves in a circle describing equal angles in equal interval of time, its velocity vector
(a) remains constant
(b) changes in magnitude
(c) changes in direction
(d) changes both in magnitude and direction

**43.** The circular motion of a particle with constant speed is
(a) periodic but not simple harmonic
(b) simple harmonic but not periodic
(c) periodic and simple harmonic
(d) neither periodic nor simple harmonic

**44.** In uniform circular motion, the velocity vector and acceleration vector are
(a) perpendicular to each other
(b) same direction
(c) opposite direction
(d) not related to each other

**45.** A body of mass m moves in a circular path with uniform angular velocity. The motion of the body has constant
(a) acceleration (b) velocity
(c) momentum (d) kinetic energy

## STATEMENT TYPE QUESTIONS

**46.** Consider the following statements and select the correct statements from the following.
I. Addition and subtraction of scalars make sense only for quantities with same units
II. Multiplication and division of scalars with different units is possible
III. Addition, subtraction, multiplication and division of scalars with same unit is possible
(a) I and II (b) II and III
(c) I and III (d) I, II and III

**47.** Which of the following statements is/are incorrect?
I. A scalar quantity is the one that is conserved in a process.
II. A scalar quantity is the one that can never take negative values.
III. A scalar quantity has the same value for observers with different orientations of the axes.
(a) I and III (b) II only
(c) II and III (d) I and II

**48.** Which of the following is/are correct ?
I. $\vec{A}\times\vec{B} = -\vec{B}\times A$
II. $\vec{A}\times\vec{B} \neq \vec{B}\times A$
III. $\vec{A}\times(\vec{B}+\vec{C}) = (\vec{A}\times\vec{B})+\vec{C}$
(a) I only (b) II and III
(b) I and III (d) I and II

**49.** Three vectors **A, B** and **C** add up to zero. Select the correct statements.
I ($\mathbf{A} \times \mathbf{B}$) . **C** is not zero unless **B**, **C** are parallel
II If **A,B,C** define a plane, ($\mathbf{A} \times \mathbf{B}$) × **C** is in that plane
III $(\mathbf{A} \times \mathbf{B}) .\mathbf{C} = |\mathbf{A}||\mathbf{B}\ |\mathbf{C}| \rightarrow \mathbf{C}^2 = \mathbf{A}^2 + \mathbf{B}^2$
(a) I and II (b) II and III
(c) I and III (d) I, II and III

**50.** In a two dimensional motion, instantaneous speed $v_0$ is a positive constant. Then which of the following statements is/are incorrect?
I. The average velocity is not zero at any time.
II. Average acceleration must always vanish.
III. Equal path lengths are traversed in equal intervals.
(a) I and II (b) II only
(c) III only (d) II and III

**51.** Choose the correct statement(s) from the following.
I. If speed of a body in a curved path is constant it has zero acceleration
II. When a body moves on a curved path with a constant speed, it has acceleration perpendicular to the direction of motion
(a) I only (b) II only
(c) I and II (d) None of these

**52.** Select the correct statements about the football thrown in a parabolic path.
I. At the highest point the vertical component of velocity is zero
II. At the highest point, the velocity of the football, acts horizontally
III. At the highest point, the acceleration of the ball acts vertically downwards
(a) I and II (b) II and III
(c) I and III (d) I, II and III

**53.** Select the incorrect statement(s) from the following.
I. In projectile motion, the range depends on the mass. It is greater for heavier object
II. In projectile motion, the range is independent of the angle of projection.
(a) I only (b) II only
(c) I and II (d) None of these

**54.** A ball is thrown upwards and it returns to ground describing a parabolic path. Which of the following has the same value at the time of throw and the time of return?

I. Kinetic energy of the ball

II. Speed of the ball

III. Vertical component of velocity

(a) I and II (b) II and III

(c) III only (d) I, II and III

**55.** For a particle performing uniform circular motion, select the correct statement(s) from the following.

I. Magnitude of particle velocity (speed) remains constant.

II. Particle velocity remains directed perpendicular to radius vector.

III. Angular momentum is constant.

(a) I only (b) II and III

(c) III only (d) I and II

**56.** Which of the following statements are correct ?

I. Centripetal acceleration is always directed towards the centre.

II. Magnitude of the centripetal acceleration is $\frac{v^2}{R}$.

III. Direction of centripetal acceleration changes pointing always towards the centre.

(a) I and II (b) II and III

(c) I and III (d) I, II and III

## MATCHING TYPE QUESTIONS

**57.** Vector $\vec{A}$ has components $A_x = 2$, $A_y = 3$ and vector $\vec{B}$ has components $B_x = 4$, $B_y = 5$, then match the columns :

| Column I | Column II |
|---|---|
| (A)The components of vector sum $(\vec{A}+\vec{B})$ | (1) 8 |
| (B)The magnitude of $\vec{A}+\vec{B}$ | (2) $-2$ |
| (C)The componet of vector difference $\vec{A}-\vec{B}$ | (3) $2\sqrt{2}$ |
| (D)The magnitude of $(\vec{A}-\vec{B})$ | (4) 10 |

(a) (A)→(1); (B)→(4); C→(2); (D)→(3)

(b) (A)→(2); (B)→(4); C→(3); (D)→(1)

(c) (A)→(3); (B)→(2); C→(4); (D)→(1)

(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

**58.** Given two vectors $\vec{A} = 3\hat{i}+4\hat{j}$ and $\vec{B} = \hat{i}-2\hat{j}$. Then match the following columns :

| Column I | Column II |
|---|---|
| (A) Magnitude of vector $\vec{A}$ or $\vec{B}$ | (1) 5 |
| (B) Unit vector of $\vec{A}$ | (2) $(0.6\hat{i}+0.8\hat{j})$ |
| (C) The magnitude of $\vec{A}+\vec{B}$ | (3) $(2\hat{i}+6\hat{j})$ |
| (D) The difference of vector, $\vec{A}-\vec{B}$ | (4) $\sqrt{20}$ |

(a) (A)→(4); (B)→(1); C→(2); (D)→(3)

(b) (A)→(1); (B)→(2); C→(4); (D)→(3)

(c) (A)→(3); (B)→(2); C→(4); (D)→(1)

(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

**59.** Given two vectors; $\vec{A} = \hat{i}+\hat{j}$ and $\vec{B} = \hat{i}-\hat{j}$. Then match the following columns :

| Column - I | Column - II |
|---|---|
| (A) $(\vec{A}+\vec{B})/2$ | (1) $\hat{i}$ |
| (B) $(\vec{A}-\vec{B})/2$ | (2) $\hat{j}$ |
| (C) $(\vec{A}\cdot\vec{B})/2$ | (3) $-\hat{k}$ |
| (D) $(\vec{A}\times\vec{B})/2$ | (4) 0 |

(a) (A)→(4); (B)→(1); C→(2); (D)→(2)

(b) (A)→(2); (B)→(4); C→(3); (D)→(1)

(c) (A)→(3); (B)→(2); C→(4); (D)→(1)

(d) (A)→(1); (B)→(2); C→(4); (D)→(3)

**60.** The velocity $\vec{v}$ of a particle moving in the *xy* – plane is given by $\vec{v} = (6t-4t^2)\hat{i}+8\hat{j}$, with $\vec{v}$ in m/s and t(>0) in second.

Match the following columns :

| Column - I | Column - II |
|---|---|
| (A) Acceleration magnitude is 10 m/s$^2$ at a time | (1) ¾ s |
| (B) Acceleration zero at time | (2) never |
| (C) velocity zero at time | (3) 1 s |
| (D) The speed 10 m/s at a time | (4) 2 s |

(a) (A)→(4); (B)→(1); C→(2); (D)→(3)

(b) (A)→(2); (B)→(4); C→(3); (D)→(1)

(c) (A)→(3); (B)→(2); C→(4); (D)→(1)

(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

**61.** The equation of trajectory of a particle projected from the surface of the planet is given by the equation $y = x - x^2$. (suppose, $g = 2$ m/s$^2$)

| Column - I | Column - II<br>(magnitude only) |
|---|---|
| (A) angle of projection, tan q | (1) ¼ |
| (B) time of flight, *T* | (2) 1 |
| (C) maximum height attained, *H* | (3) 2 |
| (D) horizontal range, *R* | (4) 4 |

(a) (A)→(4); (B)→(1); C→(2); (D)→(2)

(b) (A)→(2); (B)→(3); C→(1); (D)→(4)

(c) (A)→(3); (B)→(2); C→(4); (D)→(1)

(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

**62.** A particle is projected with some angle from the surface of the planet. The motion of the particle is described by the equation; $x = t,\ y = t - t^2$. Then match the following columns:

| **Column - I**<br>(quantity) | **Column - II**<br>(magnitude only) |
|---|---|
| (A) velocity of projection | (1) 1 |
| (B) acceleration | (2) $\sqrt{2}$ |
| (C) time of flight | (3) 2 |
| (D) maximum height attained | (4) $\frac{1}{4}$ |

(a) (A)→(4); (B)→(1); C→(2); (D)→(2)
(b) (A)→(2); (B)→(3); C→(1); (D)→(2)
(c) (A)→(2); (B)→(3); C→(1); (D)→(4)
(d) (A)→(3); (B)→(4); C→(3); (D)→(2)

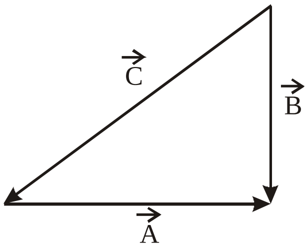
**63.** A ball is thrown at an angle 75° with the horizontal at a speed of 20 m/s towards a high wall at a distance d. If the ball strikes the wall, its horizontal velocity component reverses the direction without change in magnitude and the vertical velocity component remains same. Ball stops after hitting the ground. Match the statement of column I with the distance of the wall from the point of throw in column II .

| **Column I** | **Column II** |
|---|---|
| (A) Ball strikes the wall directly | (1) 8 m |
| (B) Ball strikes the ground at x = 12 m from the wall | (2) 10 m |
| (C) Ball strikes the ground at x = 10m from the wall | (3) 0 m |
| (D) Ball strikes the ground at x = 5 m from the wall | (4) 25 m |

(a) (A)→(1,2); (B)→(1); C→(2); (D)→(4)
(b) (A)→(2); (B)→(3); C→(1); (D)→(2)
(c) (A)→(2); (B)→(3); C→(1); (D)→(4)
(d) (A)→(3); (B)→(4); C→(3); (D)→(2)

## DIAGRAM TYPE QUESTIONS

**64.** For the figure, which of the following is correct?



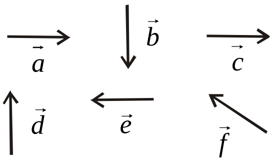
(a) $\vec{A} + \vec{B} = \vec{C}$

(b) $\vec{B} + \vec{C} = \vec{A}$

(c) $\vec{C} + \vec{A} = \vec{B}$

(d) $\vec{A} + \vec{B} + \vec{C} = 0$

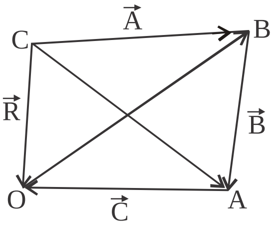
**65.** Six vectors, $\vec{a}$ through $\vec{f}$ have the magnitudes and directions indicated in the figure. Which of the following statements is true?



(a) $\vec{b} + \vec{c} = \vec{f}$ (b) $\vec{d} + \vec{c} = \vec{f}$

(c) $\vec{d} + \vec{e} = \vec{f}$ (d) $\vec{b} + \vec{e} = \vec{f}$

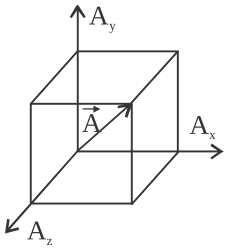
**66.** Which law is governed by the given figure ?

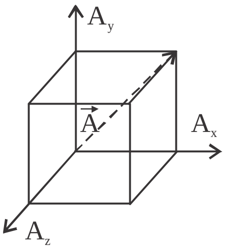


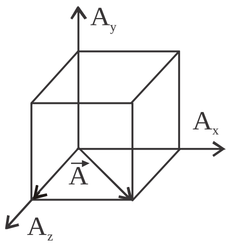
(a) Associative law of vector addition
(b) Commutative law of vector addition
(c) Associative law of vector multiplication
(d) Commutative law of vector multiplication

**67.** Which of the following figures represents

$\vec{A} = AX\hat{i} + Ay\hat{j} \ + A_z \hat{k}$ ?

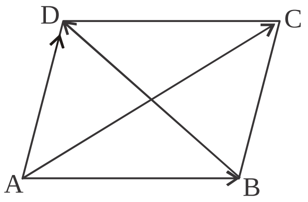
(a)


(b)


(c)


(d) All of these

**68.** Which of the following holds true for the given figure?

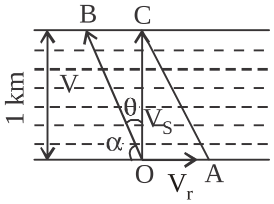


(a) $\overrightarrow{AC} + \overrightarrow{BD} = 2\overrightarrow{BC}$ (b) $\overrightarrow{AB} + \overrightarrow{BC} = 2\overrightarrow{CD}$

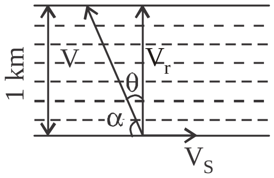
(c) $\overrightarrow{AC} - \overrightarrow{AB} = 2\overrightarrow{BD}$ (d) All of these

**69.** A swimmer wants to cross a river straight. He swim at 5 km/hr in still water. A river 1 km wide flows at the rate of 3 km/hr. Which of the following figure shows the correct direction for the swimmer along which he should strike? ($V_s$ → velocity of swimmer, $V_r$ → velocity of river, V→ resultant velocity)

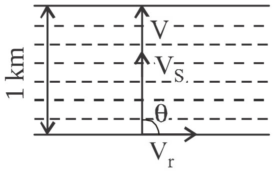
(a)



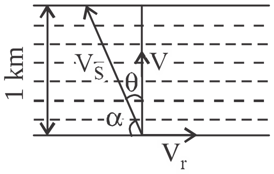
(b)



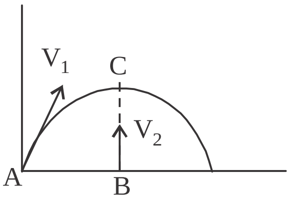
(c)



(d)



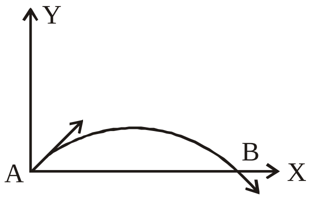
**70.** If $V_1$ is velocity of a body projected from the point A and $V_2$ is the velocity of a body projected from point B which is vertically below the highest point C. if both the bodies collide, then



(a) $V_1 = \frac{1}{2}V_2$ (b) $V_2 = \frac{1}{2}V_1$

(c) $V_1 = V_2$ (d) Two bodies can't collide.

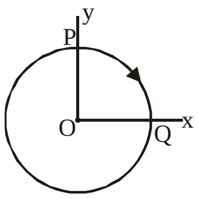
**71.** The velocity of a projectile at the initial point A is $\left(2\hat{i}+3\hat{j}\right)$ m/s its velocity (in m/s) at point B is



(a) $-2\hat{i}+3\hat{j}$ (b) $2\hat{i}-3\hat{j}$

(c) $2\hat{i}+3\hat{j}$ (d) $-2\hat{i}-3\hat{j}$

**72.** A particle moves in a circle of radius 4 cm clockwise at constant speed 2 cm/s. If $\hat{x}$ and $\hat{y}$ are unit acceleration vectors along X and Y-axis respectively (in cm/s$^2$), the acceleration of the particle at the instant half way between P and Q is given by



(a) $-4(\hat{x}+\hat{y})$

(b) $4(\hat{x}+\hat{y})$

(c) $-(\hat{x}+\hat{y})/\sqrt{2}$

(d) $(\hat{x}-\hat{y})/4$

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

**73.** **Assertion:** A physical quantity cannot be called as a vector if its magnitude is zero.
**Reason:** A vector has both magnitude and direction.

**74.** **Assertion :** The scalar product of two vectors can be zero.
**Reason :** If two vectors are perpendicular to each other, their scalar product will be zero.

**75.** **Assertion :** Minimum number of non-equal vectors in a plane required to give zero resultant is three.
**Reason :** If $\vec{A}+\vec{B}+\vec{C}=\vec{0}$, then they must lie in one plane.

**76.** **Assertion :** If $\vec{A}.\vec{B}=\vec{B}.\vec{C}$, then $\vec{A}$ may not always be equal to $\vec{C}$.
**Reason :** The dot product of two vectors involves cosine of the angle between the two vectors.

**77.** **Assertion :** $\vec{\tau}=\vec{r}\times\vec{F}$ and $\vec{\tau}\neq\vec{F}\times\vec{r}$
**Reason :** Cross product of vectors is commutative.

**78.** **Assertion :** If dot product and cross product of $\vec{A}$ and $\vec{B}$ are zero, it implies that one of the vector $\vec{A}$ and $\vec{B}$ must be a null vector
**Reason :** Null vector is a vector with zero magnitude.

**79.** **Assertion :** The magnitude of velocity of two boats relative to river is same. Both boats start simultaneously from same point on one bank may reach opposite bank simultaneously moving along different paths.
**Reason :** For boats to cross the river in same time. The component of their velocity relative to river in direction normal to flow should be same.

**80.** **Assertion :** Two balls of different masses are thrown vertically upward with same speed. They will pass through their point of projection in the downward direction with the same speed.

**Reason :** The maximum height and downward velocity attained at the point of projection are independent of the mass of the ball.

**81.** **Assertion :** If a body of mass m is projected upwards with a speed V making an angle θ with the vertical, than the change in the momentum of the body along X–axis is zero.
**Reason :** Mass of the body remains constant along X–axis

**82.** **Assertion :** The horizontal range is same when the angle of projection is greater than 45° by certain value and less than 45° by the same value.
**Reason:** If θ = 45° + α, then

$$R_1 = \frac{u^2 \sin 2(45° + \alpha)}{g} = \frac{u^2 \cos 2\alpha}{g}$$

If θ = 45° – α, then $R_2 = \dfrac{u^2 \sin 2(45° - \alpha)}{g} = \dfrac{u^2 \cos 2\alpha}{g}$

**83.** **Assertion :** If there were no gravitational force, the path of the projected body always be a straight line.

**Reason :** Gravitational force makes the path of projected body always parabolic.

**84.** **Assertion:** The maximum possible height attained by the projected body is $\frac{u^2}{2g}$, where u is the velocity of projection.

**Reason :** To attain the maximum height, body is thrown vertically upwards.

**85.** **Assertion :** When the range of projectile is maximum, the time of flight is the largest.

**Reason :** Range is maximum when angle of projection is $45^0$.

**86.** **Assertion :** A shell fired from a gun is moving along the parabolic path. If it explodes at the top of the trajectory, then no part of the shell can fly vertically.

**Reason :** The vertical momentum of the shell at the top of the trajectory is zero.

**87.** **Assertion :** A body is thrown with a velocity u inclined to the horizontal at some angle. It moves along a parabolic path and falls to the ground. Linear momentum of the body, during its motion, will remain conserve.

**Reason :** Throughout the motion of the body, a constant force acts on it.

**88.** **Assertion :** Two projectiles having same range must have the same time of flight.

**Reason :** Horizontal component of velocity is constant in projectile motion under gravity.

**89.** **Assertion :** The maximum horizontal range of projectile is proportional to square of velocity.
**Reason :** The maximum horizontal range of projectile is equal to maximum height attained by projectile.

**90.** **Assertion :** The trajectory of projectile is quadratic in *y* and linear in *x*.
**Reason :** *y* component of trajectory is independent of *x*-component.

**91.** **Assertion :** When range of a projectile is maximum, its angle of projection may be 45° or 135°.
**Reason :** Wheather θ is 45° or 135° value of range remains the same, only the sign changes.

**92.** **Assertion :** A body of mass 1 kg is making 1 rps in a circle of radius 1 m. Centrifugal force acting on it is $4\pi^2$ N.

**Reason :** Centrifugal force is given by $F = \dfrac{mv^2}{r}$

**93.** **Assertion :** K.E. of a moving body given by $as^2$ where s is the distance travelled in a circular path a refers to variable acceleration.

**Reason :** Acceleration varies with direction only in this case of circular motion.

**94.** **Assertion :** Centripetal and centrifugal forces cancel each other.

**Reason :** This is because they are always equal and opposite.

## CRITICALTHINKING TYPE QUESTIONS

**95.** For which angle between two equal vectors $\vec{A}$ and $\vec{B}$ will the magnitude of the sum of two vectors be equal to the magnitude of each vector?
(a) θ = 60°
(b) θ = 120°
(c) θ = 0°
(d) θ = 90°

**96.** $\vec{A}$ can be written in terms of components as $\vec{A} = Ax\hat{i} + Ay\hat{j} + Az\hat{k}$. When will $\vec{A}|$ be zero
(a) Ax = Ay = 0 & Az ≠ 0
(b) Ax = Ay = Az ≠ 0
(c) Ax = Ay = Az = 0
(d) $|\vec{A}|$ can never be zero.

**97.** Two vectors *A* and *B* lie in a plane, a third vector *C* lies outside this plane, the sum of these vectors *A* + *B* + *C*
(a) can be zero
(b) can never be zero
(c) lies in a plane containing $\vec{A} + \vec{B}$
(d) lies in a plane containing $\vec{A} \times \vec{B}$

**98.** ABCDEF is a regular hexagon. The centre of hexagon is a point O. Then the value of

$$\overrightarrow{AB} + \overrightarrow{AC} + \overrightarrow{AD} + \overrightarrow{AE} + \overrightarrow{AF} \text{ is}$$

(a) $2\overrightarrow{AO}$
(b) $4\overrightarrow{AO}$
(c) $6\overrightarrow{AO}$
(d) Zero

**99.** For two vectors **A** and **B**, | **A** + **B** | = | **A** – **B**| is always true when
(a) | **A** | = | **B** | ≠ 0
(b) | **A** ⊥ **B**
(c) | **A** | = | **B** | ≠ 0 and A and B are parallel or anti parallel
(d) None of these

**100.** If a vector $2\hat{i}+3\hat{j}+8\hat{k}$ is perpendicular to the vector $4\hat{j}-4\hat{i}+\alpha\hat{k}$, then the value of α is

(a) 1/2 (b) –1/2
(c) 1 (d) –1

**101.** The sum of magnitudes of two forces acting at a point is 16 N and their resultant $8\sqrt{3}$ N is at 90° with the force of smaller magnitude. The two forces (in N) are

(a) 11, 5 (b) 9, 7
(c) 6, 10 (d) 2, 14

**102.** The coordinates of a particle moving in x–y plane at any instant of time t are $x = 4t^2$; $y = 3t^2$. The speed of the particle at that instant is

(a) 10 t (b) 5 t
(c) 3 t (d) 2 t

**103.** If $\vec{r}$ is the position vector of a particle at time t, r′ is the position vector of the particle at time t’, and $\overrightarrow{\Delta r}$ is the displacement vector, then instantaneous velocity is given by

(a) $V = \lim_{\Delta t\to 0}\frac{\Delta r'}{\Delta t}$ (b) $V = \lim_{\Delta t\to 0}\frac{\Delta r}{\Delta t}$

(c) $V = \lim_{\Delta t\to 0}\frac{\Delta r' - \Delta r}{\Delta t}$ (d) $V = \frac{\Delta r}{\Delta t}$

**104.** For motion in two or three dimensions, the angle between velocity and acceleration is

(a) 0°
(b) 90°
(c) 180°
(d) Any angle between 0° & 180°

**105.** A particle crossing the origin of co-ordinates at time t = 0, moves in the xy-plane with a constant acceleration a in the y-direction. If its equation of motion is $y = bx^2$ (b is a constant), its velocity component in the x-direction is

(a) $\sqrt{\frac{2b}{a}}$ (b) $\sqrt{\frac{a}{2b}}$

(c) $\sqrt{\frac{a}{b}}$ (d) $\sqrt{\frac{b}{a}}$

**106.** The position of particle is given by $\vec{r} = 2t^2\hat{i}+3t\hat{j}+4\hat{k}$, where t is in second and the coefficients have proper units for $\vec{r}$ to be in metre. The $\vec{a}(t)$ of the particle at t = 1 s is

(a) 4 m $s^{-2}$ along y-direction
(b) 3 m $s^{-2}$ along x-direction
(c) 4 m $s^{-2}$ along x-direction
(d) 2 m $s^{-2}$ along z-direction

**107.** The position vector of a particle is $\vec{r} = (a\cos\omega t)\hat{i} + (a\sin\omega t)\hat{j}$. The velocity of the particle is

(a) directed towards the origin
(b) directed away from the origin
(c) parallel to the position vector
(d) perpendicular to the position vector

**108.** A body of 3kg. moves in X-Y plane under the action of force given by $6t\hat{i}+4t\hat{j}$. Assuming that the body is at rest at time t = 0, the velocity of body at t = 3 sec is

(a) $9\hat{i}+6\hat{j}$ (b) $18\hat{i}+6\hat{j}$

(c) $18\hat{i}+12\hat{j}$ (d) $12\hat{i}+68\hat{j}$

**109.** The coordinates of a moving particle at any time t are given by $x = a\,t^2$ and $y = b\,t^2$. The speed of the particle is

(a) 2 t (a + b) (b) $2t\sqrt{(a^2+b^2)}$

(c) $2t\sqrt{(a^2-b^2)}$ (d) $\sqrt{(a^2+b^2)}$

**110.** A boat which has a speed of 5 km $h^{-1}$ in still water crosses a river of width 1 km along the shortest possible path in 15 minutes. The velocity of the river water is

(a) 1 km $h^{-1}$ (b) 3 km $h^{-1}$
(c) 4 km $h^{-1}$ (d) $\sqrt{41}\,\text{km}\,\text{h}^{-1}$

**111.** If rain falls vertically with a velocity $V_r$ and wind blows With a velocity $v_w$ from east to west, then a person standing on the roadside should hold the umbrella in the direction

(a) $\tan\theta = \frac{V_w}{V_r}$ (b) $\tan\theta = \frac{V_r}{V_w}$

(c) $\tan\theta = \frac{V_{rw}}{\sqrt{Vr^2+Vw^2}}$ (d) $\tan\theta = \frac{V_r}{\sqrt{Vr^2+Vw^2}}$

**112.** If Vr is the velocity of rain falling vertically and Vm is the velocity of a man walking on a level road, and θ is the angle with vertical at which he should hold the umbrella to protect himself, than the relative velocity of rain w.r.t. the man is given by:

(a) $Vrm = \sqrt{Vr^2+Vm^2+2VrVm\cos\theta}$

(b) $Vrm = \sqrt{Vr^2+Vm^2-2VrVm\cos\theta}$

(c) $Vrm = \sqrt{Vr^2+Vm^2}$

(d) $Vrm = \sqrt{Vr^2-Vm^2}$

**113.** A hunter aims his gun and fires a bullet directly at a monkey on a tree. At the instant the bullet leaves the barrel of the gun, the monkey drops. Pick the correct statement regarding the situation.

(a) The bullet will never hit the monkey
(b) The bullet will always hit the monkey
(c) The bullet may or may not hit the monkey
(d) Can’t be predicted

**114.** A particle moves in a plane with a constant acceleration in a direction different from the initial velocity. The path of the particle is a/an

(a) straight line (b) arc of a circle
(c) parabola (d) ellipse

**115.** A stone is just released from the window of a moving train moving along a horizontal straight track. The stone will hit the ground following a

(a) straight line path (b) circular path

(c) parabolic path (d) hyperbolic path

**116.** Two bullets are fired horizontally with different velocities from the same height. Which will reach the ground first?

(a) Slower one

(b) Faster one

(c) Both will reach simultaneously

(d) It cannot be predicted

**117.** A stone is projected with an initial velocity at an angle to the horizontal. A small piece separates from the stone before the stone reaches its maximum height. Then this piece will

(a) fall to the ground vertically

(b) fly side by side with the parent stone along a parabolic path

(c) fly horizontally initially and will trace a different parabolic path

(d) lag behind the parent stone, increasing the distance from it

**118.** A ball is thrown from rear end of the compartment of train to the front end which is moving at a constant horizontal velocity. An observer A sitting in the compartment and another observer B standing on the ground draw the trajectory. They will have

(a) equal horizontal and equal vertical ranges

(b) equal vertical ranges but different horizontal ranges

(c) different vertical ranges but equal horizontal ranges

(d) different vertical and different horizontal ranges

**119.** Two balls are projected simultaneously in the same vertical plane from the same point with velocities $v_1$ and $v_2$ with angle $\theta_1$ and $\theta_2$ respectively with the horizontal. If $v_1 \cos\theta_1 = v_2 \cos\theta_2$, the path of one ball as seen from the position of other ball is :

(a) parabola

(b) horizontal straight line

(c) vertical straight line

(d) straight line making 45° with the vertical

**120.** Two stones are projected from the same point with same speed making angles $45° + \theta$ and $45° - \theta$ with the horizontal respectively. If $\theta \le 45°$, then the horizontal ranges of the two stones are in the ratio of

(a) 1 : 1 (b) 1 : 2

(c) 1 : 3 (d) 1 : 4

**121.** A missile is fired for maximum range with an initial velocity of 20 m/s. If g = 10 m/s$^2$, the range of the missile is

(a) 40 m (b) 50 m

(c) 60 m (d) 20 m

**122.** A ball is thrown from a point with a speed '$v_0$' at an elevation angle of $\theta$. From the same point and at the same instant, a person starts running with a constant speed $\frac{'v_0'}{2}$ to catch the ball. Will the person be able to catch the ball? If yes, what should be the angle of projection $\theta$ ?

(a) No (b) Yes, 30°

(c) Yes, 60° (d) Yes, 45°

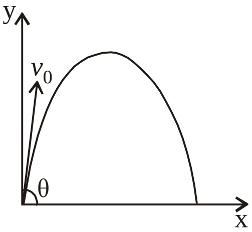
**123.** A projectilel can have the same range R for two angles of projection. If $t_1$ and $t_2$ be the times of flight in two cases, then what is the product of two times of flight?

(a) $t_1t_2 \propto R$ (b) $t_1t_2 \propto R^2$

(c) $t_1t_2 \propto 1/R$ (d) $t_1t_2 \propto 1/R^2$

**124.** A small particle of mass m is projected at an angle θ with the x-axis with an initial velocity $v_0$ in the x-y plane as shown in the figure. At a time $t < \frac{v_0 \sin\theta}{g}$, the angular momentum of the particle is

where $\hat{i}, \hat{j}$ and $\hat{k}$ are unit vectors along *x*, *y* and *z*-axis respectively.



(a) $-mg\, v_0 t^2 \cos\theta\, \hat{j}$ (b) $mg\, v_0 t \cos\theta \hat{k}$

(c) $-\frac{1}{2} mg v_0 t^2 \cos\theta \hat{k}$ (d) $\frac{1}{2} mg v_0 t^2 \cos\theta \hat{i}$

**125.** A particle of mass m is projected with a velocity υ making an angle of 30° with the horizontal. The magnitude of angular momentum of the projectile about the point of projection when the particle is at its maximum height *h* is

(a) $\frac{\sqrt{3}}{2}\frac{m\upsilon^2}{g}$ (b) zero

(c) $\frac{m\upsilon^3}{\sqrt{2}g}$ (d) $\frac{\sqrt{3}}{16}\frac{m\upsilon^3}{g}$

**126.** Two projectiles A and B thrown with speeds in the ratio $1 : \sqrt{2}$ acquired the same heights. If A is thrown at an angle of 45° with the horizontal, the angle of projection of B will be

(a) 0° (b) 60°

(c) 30° (d) 45°

**127.** A body projected at an angle with the horizontal has a range 300 m. If the time of flight is 6 s, then the horizontal component of velocity is

(a) 30 m s$^{-1}$ (b) 50 m s$^{-1}$

(c) 40 m s$^{-1}$ (d) 45 m s$^{-1}$

**128.** A particle of unit mass is projected with velocity *u* at an inclination α above the horizon in a medium whose resistance is *k* times the velocity. Its direction will again make an angle α with the horizon after a time

(a) $\frac{1}{k}\log\left\{1-\frac{2ku}{g}\sin\alpha\right\}$ (b) $\frac{1}{k}\log\left\{1+\frac{2ku}{g}\sin\alpha\right\}$

(c) $\frac{1}{k}\log\left\{1+\frac{ku}{g}\sin\alpha\right\}$ (d) $\frac{1}{k}\log\left\{1+\frac{2ku}{3g}\sin\alpha\right\}$

**129.** The greatest range of a particle, projected with a given velocity on an inclined plane, is $x$ times the greatest vertical altitude above the inclined plane. Find the value of $x$.
(a) 2 (b) 4 (c) 3 (d) 1/2

**130.** A body is projected vertically upwards with a velocity $u$, after time $t$ another body is projected vertically upwards from the same point with a velocity $v$, where $v < u$. If they meet as soon as possible, then choose the correct option

(a) $t=\frac{u-v+\sqrt{u^2+v^2}}{g}$ (b) $t=\frac{u-v+\sqrt{u^2-v^2}}{g}$

(c) $t=\frac{u+v+\sqrt{u^2-v^2}}{g}$ (d) $t=\frac{u-v+\sqrt{u^2-v^2}}{2g}$

**131.** A cricket ball is hit at an angle of 30° to the horizontal with a kinetic energy E. Its kinetic energy when it reaches the highest point is

(a) $\frac{E}{2}$ (b) 0

(c) $\frac{2E}{3}$ (d) $\frac{3E}{4}$

**132.** The range of a projectile is R when the angle of projection is 40°. For the same velocity of projection and range, the other possible angle of projection is
(a) 45° (b) 50°
(c) 60° (d) 40°

**133.** If the angles of projection of a projectile with same initial velocity exceed or fall short of 45° by equal amounts , then the ratio of horizontal ranges is
(a) l : 2 (b) l : 3
(c) 1 : 4 (d) 1 : 1

**134.** A projectile is fired from the surface of the earth with a velocity of 5 ms$^{-1}$ and angle θ with the horizontal. Another projectile fired from another planet with a velocity of 3 ms$^{-1}$ at the same angle follows a trajectory which is identical with the trajectory of the projectile fired from the earth. The value of the acceleration due to gravity on the planet is (in ms$^{-2}$) given g = 9.8 m/s$^2$
(a) 3.5 (b) 5.9
(c) 16.3 (d) 110.8

**135.** For a particle in uniform circular motion, the acceleration $\vec{a}$ at a point P(R,θ) on the circle of radius R is (Here θ is measured from the x-axis )

(a) $-\frac{v^2}{R}\cos\theta\ \hat{i}+\frac{v^2}{R}\sin\theta\ \hat{j}$

(b) $-\frac{v^2}{R}\sin\theta\ \hat{i}+\frac{v^2}{R}\cos\theta\ \hat{j}$

(c) $-\frac{v^2}{R}\cos\theta\ \hat{i}-\frac{v^2}{R}\sin\theta\ \hat{j}$

(d) $\frac{v^2}{R}\hat{i}+\frac{v^2}{R}\hat{j}$

**136.** When a particle is in uniform circular motion it does not have
(a) radial velocity and radial acceleration
(b) radial velocity and tangential acceleration
(c) tangential velocity and radial acceleration
(d) tangential velocity and transverse acceleration

**137.** A particle moves in a circular orbit under the action of a central attractive force inversely proportional to the distance ‘r’. The speed of the particle is
(a) proportional to r$^2$ (b) independent of r
(c) proportional to r (d) proportional to 1/r

**138.** A particle describes uniform circular motion in a circle of radius 2 m, with the angular speed of 2 rad s$^{-1}$. The magnitude of the change in its velocity in $\frac{\pi}{2}$ s is
(a) 0 m s$^{-1}$ (b) $2\sqrt{2}$m s$^{-1}$
(c) 8 m s$^{-1}$ (d) 4 m s$^{-1}$

**139.** A stone of mass 2 kg is tied to a string of length 0.5 m. If the breaking tension of the string is 900 N, then the maximum angular velocity, the stone can have in uniform circular motion is
(a) 30 rad s$^{-1}$ (b) 20 rad s$^{-1}$
(c) 10 rad s$^{-1}$ (d) 25 rad s$^{-1}$

**140.** A particle moves along a circle of radius $\left(\frac{20}{\pi}\right)$m with constant tangential acceleration. It the velocity of particle is 80 m/sec at end of second revolution after motion has begun, the tangential acceleration is
(a) 40 π m/sec$^2$ (b) 40 m/sec$^2$
(c) 640 π m/sec$^2$ (d) 160 π m/sec$^2$

**141.** A stone tied to the end of a string of 1 m long is whirled in a horizontal circle with a constant speed. If the stone makes 22 revolution in 44 seconds, what is the magnitude and direction of acceleration of the stone?
(a) $\pi^2$ m s$^{-2}$ and direction along the radius towards the centre.
(b) $\pi^2$ m s$^{-2}$ and direction along the radius away from the centre.
(c) $\pi^2$ m s$^{-2}$ and direction along the tangent to the circle.
(d) $\pi^2/4$ m s$^{-2}$ and direction along the radius towards the centre.

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(d)** A scalar quantity has only magnitude and the same value for observers with different orientations of axes.

**2.** **(c)** A vector quantity is defined as the quantity which has magnitude and direction and for which all the mathematical operations are possible only through vector laws of algebra.

**3.** **(a)** Resultant vector of two vectors $\vec{A}$ & $\vec{B}$ inclined at an angle θ, is given by

R = $\sqrt{A^2+B^2+2AB\cos\theta}$ ∴ if θ = 0°; cos 0° = 1

∴ R = $\sqrt{A^2+B^2+2AB} = \sqrt{(A+B)^2}$

R = A + B

This is the maximum resultant possible.

**4.** **(c)** The resultant of any three vectors will be cancel out by Fourth vector

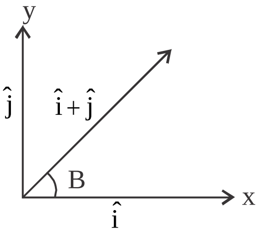
**5.** **(d)** All the three unit vectors have the magnitude as unity

∴ $\hat{i} = \hat{j} = \hat{k} = 1$

**6.** **(c)** $|\hat{i}+\hat{j}| = \sqrt{(1)^2+(1)^2} = \sqrt{2}$

$|\hat{i}| = 1$

$\cos\beta = \frac{1}{\sqrt{2}}$ ∴ β = 45°



**7.** **(b)**

**8.** **(c)**

**9.** **(c)** The resultant of $\vec{A}\times 0$ is a vector of zero magnitude. The product of a vector with a scalar gives a vector.

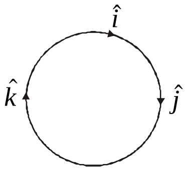
**10.** **(a)** In a clockwise system,

$\hat{i}\times\hat{j} = \hat{k}$, $\hat{j}\times\hat{k} = \hat{i}$ and $\hat{k}\times\hat{i} = \hat{j}$

And $\hat{i}\times\hat{i} = \hat{j}\times\hat{j} = \hat{k}\times\hat{k} = 0$

$\hat{i}\,.\,\hat{i} = \hat{j}\,.\,\hat{j} = \hat{k}\,.\,\hat{k} = 1$

$\hat{i}\,.\,\hat{j} = \hat{j}\,.\,\hat{k} = \hat{k}\,.\,\hat{i} = 0$



Therefore, the right option is $\hat{j}\times\hat{k} = \hat{i}$

**11.** **(b)** **12.** **(b)**

**13.** **(d)** The equation of motion for projectile is $x = x_0 + U_x t + \frac{1}{2} a_x t^2$

∴ The shape of the trajectory depends on the initial position, initial velocity and acceleration.

**14.** **(d)** Position vector, $\vec{r} = (a\cos\omega t)\hat{i} + (a\sin\omega t)\hat{j}$

Velocity vector

$\vec{v} = \frac{d\vec{r}}{dt}$ (– aωsin ωt) $\hat{i}$ + (aωcos ωt) $\hat{j}$

(– aωsin ωt)(a cos ωt) + (– aωcos ωt) + (a cos ωt) = 0

⇒ $\vec{v} \perp \vec{r}$

**15.** **(c)** $V_y = u\sin\theta - gt_m = 0$

∴ $t_m = \frac{u_y\sin\theta}{g}$ (time to reach the maximum height)

Total time of flight $T_f = \frac{2(u\sin\theta)}{g}$

∴ $T_f = 2t_m$

**16.** **(d)** Horizontal range = $\frac{u^2\sin 2\theta}{g}$

For maximum range θ = 45°

∴ $R_{max} = \frac{u^2\sin 90°}{g} = \frac{u^2}{g}$ (∵ sin 90° = 1)

**17.** **(c)** Force due to viscosity, air – resistance are all dissipative forces. Thus in the presence of air – resistance the horizontal component of velocity will decrease, thus for horizontal component of velocity to remain constant, there should be no air-resistance.

**18.** **(b)** If air resistance is ignored, then there is no acceleration in horizontal direction in projectile motion. Hence the particle move with constant velocity in horizontal direction.

**19.** **(c)** $\vec{V}_{BA} = \vec{V}_B - \vec{V}_A$

= 80 – 65 = 15 km/h

**20.** **(b)** In both the cases, the initial velocity in the vertical downward direction is zero. So they will hit the ground simultaneously.

**21.** **(c)** The nature of path is determined by acceleration of particle. For example in uniform circular motion the transverse acceleration is zero & only radial acceleration acts. If $a_R$ (radial acceleration) is zero, then particle go in the direction in which transverse acceleration acts (if it is not zero).

**22.** **(d)** $T = \frac{2u\sin(\theta-\alpha)}{g\cos\alpha}$

**23.** **(d)** Velocity and kinetic energy is minimum at the highest point.

$K.E = \frac{1}{2}mv^2\cos^2\theta$

**24.** **(b)** Only horizontal component of velocity ($u\cos\theta$)

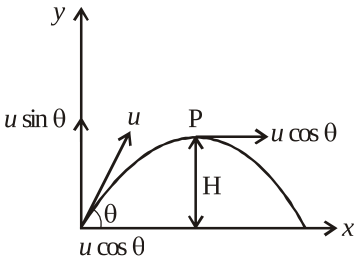
**25.** **(b)** $\frac{u^2\sin 2\theta}{g} = \frac{u^2\sin^2\theta}{2g}$

$\therefore \quad \tan\theta = 4.$

**26.** **(c)** $H = \frac{u^2\sin 45°}{2g} = \frac{u^2}{4g}$

$R = \frac{u^2}{g} = = 4\,H.$

**27.** **(d)** At maximum height ($H$) i.e. at point P the vertical component of the projectile $u\sin\theta = 0$ whereas its horizontal component i.e. $u\cos\theta$ remains the same.



**28.** **(c)** In our discussion, we shall assume that the air resistance has negligible effect on the motion of the projectile.

**29.** **(c)** If the angle of projection is $\frac{\pi}{4}$, then range $= \frac{v_0^2}{g}\sin(\pi/2)$

$\Rightarrow \quad (R)_{\max} = \frac{v_0^2}{g} \qquad [\because \{\sin(\pi/2)\}_{\max} = 1]$

**30.** **(d)** At the highest point of trajectory, the acceleration is equal to g.

**31.** **(d)** Centripetal acceleration, $a_c = \frac{v^2}{R}$

Where $v$ is the speed of an object and $R$ is the radius of the circle. It is always directed towards the centre of the circle. Since $v$ and $R$ are constants for a given uniform circular motions, therefore the magnitude of centripetal acceleration is also constant. However, the direction of centripetal acceleration changes continuously. Therefore, a centripetal acceleration is not a constant vector.

**32.** **(a)** **33.** **(a)**

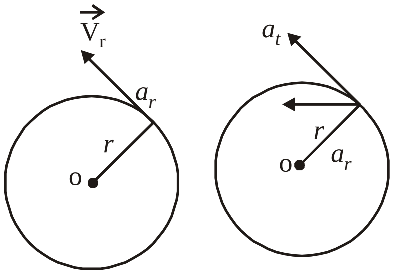
**34.** **(b)** $\frac{v_1}{v_2} = \frac{r_1\omega}{r_2\omega} = \frac{1}{2}$ [v = rω]

**35.** **(d)** $\vec{v} = \vec{\omega} \times \vec{r}$

As linear velocity vector $\vec{v}$ is along the tangent to the circular path and angular velocity vector $\vec{\omega}$ is perpendicular to $\vec{v}$, so $\vec{\omega}$ is along the axis of rotation.

**36.** **(c)** When a particle moves on a circular path with a constant speed, then its motion is said to be a uniform circular motion in a plane. This motion has radial acceleration whose magnitude remains constant but whose direction changes continuously, So $a_r \neq 0$ and $a_t = 0$.

If the circular motion of the particle is not uniform but accelerated then along with the radial acceleration it will have tangential acceleration also and both these acceleration will be mutually perpendicular.

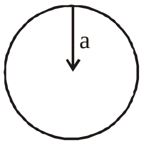


So, $a_r \neq 0$ and $a_t = 0$.

When, $a_r = 0$ and $a_t = 0$ motion is accelerated translatory.

Also, when $a_r = 0$ and then motion is uniform translatory.

**37.** **(c)** In circular motion with constant speed, acceleration is always inward, its magnitude is constant but direction changes, hence acceleration changes, so does velocity. K.E. is constant.



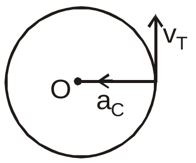
**38.** **(a)** Body moves with constant speed, it means that it performs uniform circular motion. In this motion the direction of motion is always perpendicular to centripetal force. Hence the work done by centripetal force is always zero

(dW = $\vec{F}_c.\vec{dr} = F_c\,dr\cos\theta = 0, \Rightarrow \theta = 90°$)

**39.** **(c)** Body moves with constant speed it means that tangential acceleration $a_T = 0$ & only centripetal acceleration $a_C$ exists whose direction is always towards the centre or inward (along the radius of the circle).

**40.** **(c)** Since the circular motion is uniform, therfore there is no change of angular velocity. Thus angular acceleration is zero.

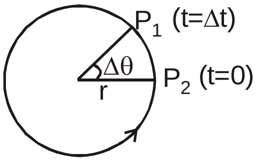
**41.** **(c)** In uniform circular motion, the body move with $v_T$ (tangential velocity) & $a_C$. If $a_C = 0$ then it implies that the body is no longer bound to rotate in circle & so no change in the direction of velocity. Hence it move tangentially to the circle outward with velocity $v_T$.



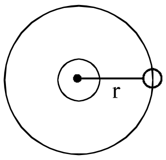
**42.** **(c)** Since velocity is defined as $v = \frac{\Delta s}{\Delta t} = r\frac{\Delta\theta}{\Delta t}$

Where s = r.θ, is an arc to circle, which is swept by the particle in $\Delta t$ time, r is radius of circle which is constant in uniform circular motion & $\Delta\theta$ is angular displacement in $\Delta t$ time.

Hence if particle in a circle describe equal angles in equal intervals of time, its speed (magnitude of velocity vector) remains same but the direction changes due to centripetal acceleration $a_C$.



**43.** **(a)** In circular motion of a particle with constant speed, particle repeats its motion after a regular interval of time but does not oscillate about a fixed point. So, motion of particle is periodic but not simple harmonic.



**44.** **(a)** In uniform circular motion speed is constant. So, no tangential acceleration.

It has only radial acceleration $a_R = \frac{v^2}{R}$ [directed towards center]

and its velocity is always in tangential direction. So these two are perpendicular to each other.

**45.** **(d)**

## STATEMENT TYPE QUESTIONS

**46.** **(d)** Addition and subtraction of scalars make sense only for quantities with same units, however multiplication and division of scalars of different unit is possible.

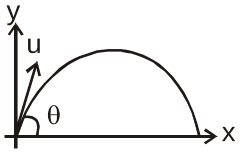
**47.** **(d)** **48.** **(d)** **49.** **(c)** **50.** **(d)**

**51.** **(b)** When a body moves on a curved path with a constant speed, it experiences the centripetal acceleration which along the radius. Since velocity acts along the tangent therefore acceleration is perpendicular to the direction of velocity and hence motion.

**52.** **(d)** While going up, the vertical component of velocity keeps on decreasing due to gravity & thus at highest point it becomes zero. The horizontal component remains constant so at the highest point, if is non-zero. Acceleration due to gravity acts at the heighest point. So it acts vertically downwards.

**53.** **(c)** In projectile motion, the horizontal range is independent of the mass and depends on the angle of projection according to the relation: $R = \frac{u^2 \sin 2\theta}{g}$

**54.** **(a)** If we neglect air resistance, horizontal component of velocity is always same.



To find vertical component use equation,

$v_f^2 = v_i^2 - 2g \times h$ , $\quad v_i = u \sin\theta$ , h = 0,

$v_f^2 = u^2 \sin^2\theta - 0$ , $v_f = u \sin\theta$

hence $\vec{v} = u \cos\theta \hat{i} - u \sin\theta \hat{j}$

$\therefore$ Speed is same, so K.E. is same.

**55.** **(c)**

**56.** **(d)** Centripetal acceleration has a constant magnitude and is always directed towards the centre.

## MATCHING TYPE QUESTIONS

**57.** **(a)** A $\rightarrow$ (1) ; B $\rightarrow$ (4) ; C $\rightarrow$ (2) ; D $\rightarrow$ (3)

(A) $\vec{A} = 2\hat{i} + 3\hat{j}$ and $\vec{B} = 4\hat{i} + 5\hat{j}$ $\therefore$ $\vec{A} + \vec{B} = 6\hat{i} + 8\hat{j}$

(B) $|\vec{A} + \vec{B}| = \sqrt{6^2 + 8^2} = 10$

(C) $\vec{A} - \vec{B} = (2\hat{i} + 3\hat{j}) - (4\hat{i} + 5\hat{j}) = -2\hat{i} - 2\hat{j}$

(D) $|\vec{A} - \vec{B}| = \sqrt{(-2)^2 + (-2)^2} = 2\sqrt{2}$ .

**58.** **(b)** A $\rightarrow$ (2) ; B $\rightarrow$ (2) ; C $\rightarrow$ (4) ; D $\rightarrow$ (3)

(A) $\vec{A} = 3\hat{i} + 4\hat{j}$, $\quad \therefore \quad A = \sqrt{3^2 + 4^2} = 5$

and $\vec{B} = \hat{i} - 2\hat{j}$, $\quad \therefore \quad B = \sqrt{1^2 + (-2)^2} = \sqrt{5}$

(B) $\vec{A} = \frac{\vec{A}}{A} = \frac{3\hat{i} + 4\hat{j}}{5} = 0.6\hat{i} + 0.8\hat{j}$

(C) $\vec{A} + \vec{B} = (3\hat{i} + 4\hat{j}) + (\hat{i} - 2\hat{j}) = 4\hat{i} + 2\hat{j}$

$\therefore$ $|\vec{A} + \vec{B}| = \sqrt{4^2 + 2^2} = \sqrt{20}$

(D) $\vec{A} - \vec{B} = (3\hat{i} + 4\hat{j}) - (\hat{i} - 2\hat{j}) = 2\hat{i} + 6\hat{j}$ .

**59.** **(d)** A $\rightarrow$ (1) ; B $\rightarrow$ (2) ; C $\rightarrow$ (4) ; D $\rightarrow$ (3)

(A) $(\vec{A} + \vec{B})/2 = \frac{(\hat{i} + \hat{j}) + (\hat{i} - \hat{j})}{2} = \hat{i}$

(B) $(\vec{A} - \vec{B})/2 = \frac{(\hat{i} + \hat{j}) - (\hat{i} - \hat{j})}{2} = \hat{j}$

(C) $(\vec{A}.\vec{B})/2 = \frac{(\hat{i} + \hat{j}).(\hat{i} - \hat{j})}{2} = \frac{1-1}{2} = 0$

(D) $\frac{(\vec{A} \times \vec{B})}{2} = \frac{(\hat{i} + \hat{j}) \times (\hat{i} - \hat{j})}{2} = \frac{0 - \hat{k} - \hat{k} + 0}{2} = -\hat{k}$

**60.** **(a)** (A)→(4); (B)→(1); C→(2); (D)→(3)

**61.** **(b)** (A)→(2); (B)→(3); C→(1); (D)→(4)

**62.** **(c)** (A)→(2); (B)→(3); C→(1); (D)→(4)

$$U_x = \frac{dx}{dt} = 1$$

and $$U_y = \frac{dx}{dt} = 1 - 2t$$

$$\therefore U_{t=0} = \sqrt{u_x^2 + y_y^2} = \sqrt{1^2 + 1^2} = \sqrt{2} \text{ m/s.}$$

$$a_x = \frac{d^2x}{dt^2} = 0$$

$$d_y = \frac{d^2y}{dt^2} = -2$$

For time of flight,

$$y = 0$$

or $$0 = t - t^2$$

$$\therefore \quad t = 1s.$$

For maximum height,

$$t = \frac{1}{2} s.$$

$$\therefore \quad H = t - t^2 = \frac{1}{2} - \left(\frac{1}{2}\right)^2 = \frac{1}{4} \text{ m.}$$

**63.** **(a)** (A)→(1,2); (B)→(1); C→(2); (D)→(4)

Range of the ball in absence of the wall

$$= \frac{u^2 \sin 2\theta}{g} = \frac{20^2 \sin 150°}{10} m = 20m$$

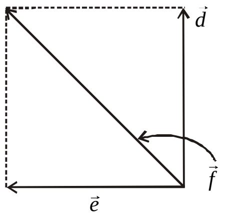
When d < 20m, ball will hit the wall, when d = 25m, ball will fall 5m short of the wall.

When d < 20m, ball will hit the ground, at a distance, x = 20m – d in front of the wall.

## DIAGRAM TYPE QUESTIONS

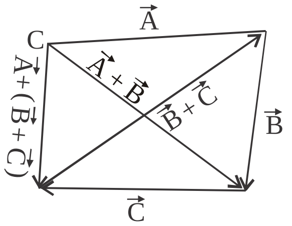
**64.** **(c)** By the triangle law of vector addition $\vec{C} + \vec{A} = \vec{B}$

**65.** **(c)** Using the law of vector addition, $(\vec{d} + \vec{e})$ is as shown in the fig.



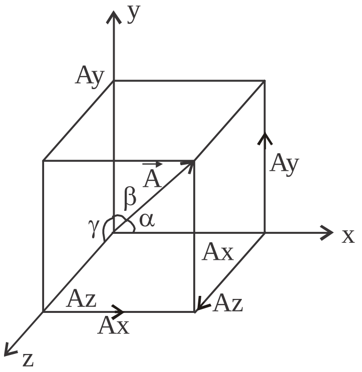
$$\therefore \quad \vec{d} + \vec{e} = \vec{f}$$

**66.** **(a)**

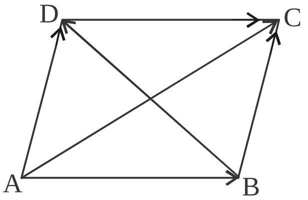


It illustrates the associative law of addition.

**67.** **(a)**



**68.** **(a)**



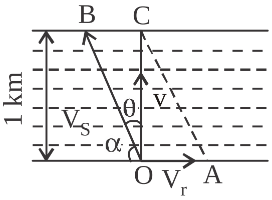
$$\overrightarrow{AC} + \overrightarrow{BD} = (\overrightarrow{AB} + \overrightarrow{BC}) + (\overrightarrow{BC} + \overrightarrow{CD})$$

$$= \overrightarrow{AB} + 2\overrightarrow{BC} + \overrightarrow{CD}$$

$$= \overrightarrow{AB} + 2\overrightarrow{BC} - \overrightarrow{AB}$$

$$= 2\overrightarrow{BC}$$

**69.** **(d)** The swimmer will cross straight if the resultant velocity of river flow and swimmer acts perpendicular to the direction of river flow. It will be so if the swimmer moves making an angle α with the upstream. i.e. goes along OB.



**70.** **(b)** Two bodies will collide at the highest point if both cover the same vertical height in the same time.

$$\text{So } \frac{V_1^2 \sin^2 30°}{2\cancel{g}} = \frac{V_2^2}{2\cancel{g}} \Rightarrow \frac{V_2}{V_1} = \sin 30° = \frac{1}{2}$$

$$\therefore \quad V_2 = \frac{1}{2} V_1$$

**71.** **(b)** At point B the direction of velocity component of the projectile along Y - axis reverses.

Hence, $\vec{V}_B = 2\hat{i} - 3\hat{j}$

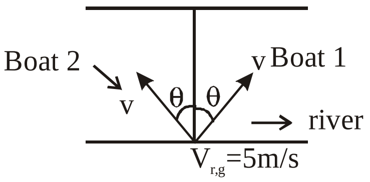
**72.** **(c)** $a = \frac{v^2}{r}$ = 1 cm/s. Centripetal acceleration is directed towards the centre. Its magnitude = 1. Unit vector at the mid point on the path between P and Q is $-(\hat{x}+\hat{y})/\sqrt{2}$ .

## ASSERTION- REASON TYPE QUESTIONS

**73.** **(d)** If a vector quantity has zero magnitude then it is called a null vector. That quantity may have some direction even if its magnitude is zero.

**74.** **(b)** **75.** **(c)** **76.** **(b)** **77.** **(d)** **78.** **(c)**

**79.** **(b)**



If component of velocities of boat relative to river is same normal to river flow (as shown in figure) both boats reach other bank simultaneously.

**80.** **(b)** $h = ut - \frac{1}{2}gt^2$ and $v^2 = u^2 - 2gh$;

These equations are independent of mass.

**81.** **(b)** When a body is projected up making an angle θ the velocity component along-axis remains constant.

∴ Momentum along x-axis is constant.

Along horizontal, mass and velocity both are constant.

**82.** **(a)** $R = \frac{u^2 \sin 2\theta}{g}$ If θ = 45° + α

then $R_1 = \frac{u^2 \sin 2(45°+\alpha)}{g} = \frac{u^2 \sin(90°+\alpha)}{g} = \frac{u^2 \cos\alpha}{g}$

If θ = 45° – α

then $R_2 = \frac{u^2 \sin^2(45°-\alpha)}{g} = \frac{u^2 \sin(90°-\alpha)}{g}$

$= \frac{u^2 \cos\alpha}{g}$ $\therefore R_1 = R_2$

**83.** **(c)** If gravitational force is zero, then $a_y = 0$.

So, $x = u \cos\theta\, t$ and $y = u \sin\theta\, t$

∴ $y = x \tan\theta$. It represent straight line.

The resultant path of the body depends on initial velocities and acceleration.

**84.** **(a)** For maximum height θ = 90°, or body must be projected straight upwards. Then

$0 = u^2 - 2gh,$

$\therefore \quad h = \frac{u^2}{2g}$ .

**85.** **(d)** $T = \frac{2u\sin\theta}{g}$, it will maximum, when θ = 0°.

$R_{max} = \frac{u^2}{g}$, for θ = 45°.

**86.** **(d)** At the highest point of the trajectory,

$v_y = 0,$ and

so, $\vec{P}_y = 0.$

For the two pieces, it is

$\vec{P}_{1y} + \vec{P}_{2y} = 0.$

**87.** **(d)** Linear momentum during parabolic path changes continuously.

**88.** **(d)** Statement-1 is false because angles of projection θ and (90° – θ ) give same range but time of flight will be different. Statement-2 is true because in horizontal direction acceleration is zero.

**89.** **(c)** Maximum horizontal range, $R = \frac{u^2 \sin 2\theta}{g}$ ∴ $R_{max}$

$= \frac{u^2}{g}$ when θ = 45°

$\therefore R_{max} \propto u^2$

Height $H = \frac{u^2 \sin^2\theta}{2g} \Rightarrow H_{max} = \frac{u^2}{2g}$ when θ = 90°

It is clear that $H_{max} = \frac{R_{max}}{2}$

**90.** **(d)** $y = x \tan\theta - \frac{gx^2}{2u^2 \cos^2\theta}$

**91.** **(a)** Range, $R = \frac{u^2 \sin 2\theta}{g}$

when θ = 45°, $R_{max} = \frac{u^2}{g} \sin 90° = \frac{u^2}{g}$

when θ = 135°, $R_{max} = \frac{u^2}{g} \sin 270° = \frac{-u^2}{g}$

Negative sign shows opposite direction.

**92.** **(a)** From relation

$F = \frac{mv^2}{r} = \frac{m(r\omega)^2}{r} = mr\omega^2$ $[\because v = r\omega]$

$= mr\,(2\pi v)^2 = 4\pi^2 mrv^2$

Here, $m$ = 1kg, $v$ = 1 $rps$, $r$ = 1$m$

∴ $F = 4\pi^2 \times 1 \times 1 \times 1^2 = 4\pi^2$ N

**93.** **(c)** **94.** **(d)**

## CRITICALTHINKING TYPE QUESTIONS

**95.** **(b)** $|\vec{A}+\vec{B}| = \sqrt{A^2+B^2+2AB\cos120°}$ $(\theta = 120°)$

$$= \sqrt{A^2+B^2+\cancel{2}AB\left(\frac{-1}{\cancel{2}}\right)} \left(\cos120° = -\frac{1}{2}\right)$$

$$= \sqrt{A^2+B^2-A(A)}$$

$$= \sqrt{B^2} = B \qquad (\therefore A = B)$$

**96.** **(c)** $\vec{A} = Ax\hat{i}+Ay\hat{j}+Az\hat{k}$

$$|\vec{A}| = \sqrt{Ax^2+Ay^2+Az^2}$$

$\therefore$ Even if one component is non – zero the sum $Ax^2 + Ay^2 + Az^2$ can't be zero.

$\therefore$ for $|\vec{A}| = 0$, $Ax = Ay = Az = 0$.

**97.** **(b)** Given $\vec{A}$ and $\vec{B}$ lie in a plane and vector $\vec{C}$ lies outside this plane.

Resultant vector of $\vec{A}$ and $\vec{B}$ lies in the same plane as that vectors $\vec{A}$ and $\vec{B}$.

Resultant vector of $\vec{A}$, $\vec{B}$ and $\vec{C}$ in non. coplanar vector therefore, their resultant can never be zero.

**98.** **(c)** **99.** **(b)**

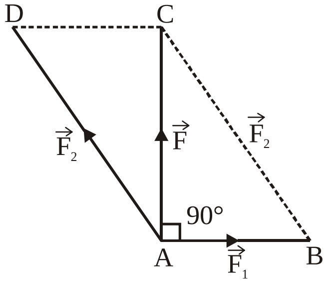
**100.** For two vectors to be perpendicular to each other

$$\vec{A}\cdot\vec{B} = 0$$

$$(2\hat{i}+3\hat{j}+8\hat{k})\cdot(4\hat{j}-4\hat{i}+\alpha\hat{k}) = 0$$

$$-8 + 12 + 8\alpha = 0 \text{ or } \alpha = -\frac{4}{8} = -\frac{1}{2}$$

**101.** **(d)**



In $\Delta ABC$,

$$F_2^2 = F^2 + F_1^2 \text{ or } F^2 = F_2^2 - F_1^2$$

$$(8\sqrt{3})^2 = F_2^2 - F_1^2$$

$$192 = (F_2 + F_1)(F_2 - F_1)$$

$$F_2 - F_1 = \frac{192}{16} = 12N \ [\because F_1 + F_2 = 16N]$$

On solving we get,

$F_1 = 2N$, $F_2 = 14$ N

**102.** **(a)** According to the question, at any instant $t$,

$x = 4t^2$, $y = 3t^2$

$$\therefore v_x = \frac{dx}{dt} = \frac{d}{dt}(4t^2) = 8t$$

and $v_y = \dfrac{dy}{dt} = \dfrac{d}{dt}(3t^2) = 6t$

The speed of the particle at instant t.

$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{(8t)^2 + (6t)^2} = 10t$$

**103.** **(b)** Average velocity $= \dfrac{\text{displacement vector}}{\text{time interval}} = \dfrac{\Delta r}{\Delta t}$

Instantaneous velocity is limiting value of average velocity as the time interval approaches zero.

$$\therefore \vec{V} = \underset{\Delta t \to 0}{\text{lt}} \frac{\Delta r}{\Delta t}$$

**104.** **(d)** Along same straight line, velocity & acceleration can be in the same direction, opposite to each other or perpendicular as in circular motion with uniform speed. Thus θ can be anywhere between 0 & 180°.

**105.** **(b)** $y = bx^2$

Differentiating w.r.t to t an both sides, we get

$$\frac{dy}{dx} = b2x\frac{dx}{dt}$$

$v_y = 2bxv_x$

Again differentiating w.r.t to t on both sides we get

$$\frac{dv_y}{dt} = 2bv_x\frac{dx}{dt} + 2bx\frac{dv_x}{dt} = 2bv_x^2 + 0$$

[$\dfrac{dv_x}{dt}$ = 0, because the particle has constant acceleration along y-direction]

Now, $\dfrac{dv_y}{dt} = a = 2bv_x^2$;

$$v_x^2 = \frac{a}{2b}$$

$$v_x = \sqrt{\frac{a}{2b}}$$

**106.** **(c)** $\vec{r} = 2t^2\hat{i} + 3t\hat{j} + 4\hat{k}$

$$\therefore \vec{v} = \frac{d\vec{r}}{dt} = \frac{d}{dt} = (2t^2\hat{i}+3t\hat{j}+4\hat{k}) = 4t\hat{i}+3\hat{j}$$

$$\vec{a} = \frac{d\vec{v}}{dt} = \frac{d}{dt}(4t\hat{i}+3\hat{j}) = 4\hat{i}$$

$\therefore$ $\vec{a} = 4\,\text{ms}^{-2}$ along x-direction

**107.** **(d)** $\vec{r} = (a\cos\omega t)\hat{i} + (a\sin\omega t)\hat{j}$

$$\vec{v} = \frac{\vec{d}(r)}{dt} = \frac{d}{dt}\{(a\cos\omega t)\hat{i} + (a\sin\omega t)\hat{j}\}$$

$$= (-a\omega\sin\omega t)\hat{i} + (a\omega\cos\omega t)\hat{j}$$

$$= \omega[(-a\sin\omega t)\hat{i} + (a\cos\omega t)\hat{j}]$$

$\vec{r}.\vec{v} = 0$

$\therefore$ velocity is perpendicular to the displacement.

**108. (a)** $F = 6t\hat{i} + 4t\hat{j}$ or $a_x = \frac{6t}{3}, a_y = \frac{4t}{3}$

so $u_x = \int_0^t a_x dt = t^2 \Rightarrow (u_x)_{t=3} = 9\text{m/sec}$

and $u_y = \int_0^t a_y dt = \frac{2t^2}{3} \Rightarrow (u_y)_{t=3} = 6\text{m/sec}$

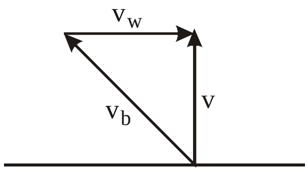
(because $u_x$ & $u_y = 0$ at t = 0 sec)

**109. (b)** $r = \mathbf{i}\, a\, t^2 + \mathbf{j}\, b\, t^2$, $v = \frac{dr}{dt} = i2at + j2bt$

$\therefore$ Magnitude of $v = \sqrt{\left(4a^2 t^2 + 4b^2 t^2\right)}$

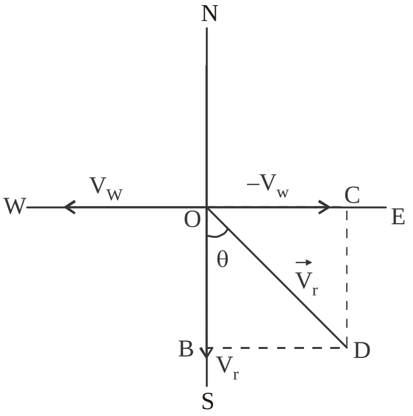
$= 2t\sqrt{\left(a^2 + b^2\right)}$

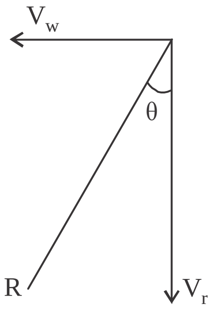
**110. (b)** $v = \frac{1\text{km}}{\frac{1}{4}\text{h}} = 4\,\text{km}\,\text{h}^{-1}$, $v_b = 5\,\text{km}\,\text{h}^{-1}$



$v_w = \sqrt{v_b^2 - v^2} = \sqrt{25-16} = \sqrt{9} = 3\,\text{km}\,\text{h}^{-1}$

**111. (a)** Man should hold the umbrella in the direction of the relative velocity of the rain. If Vr → velocity of rain, $V_W$ → velocity of wind and $V_{rw}$ → relative velocity of rain w.r.t. wind

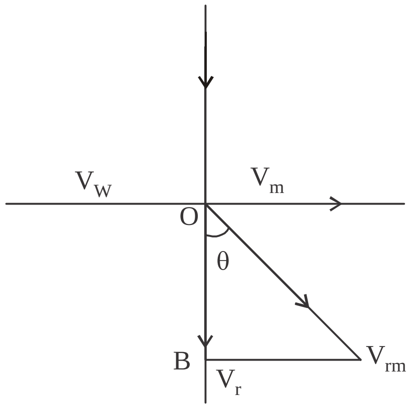




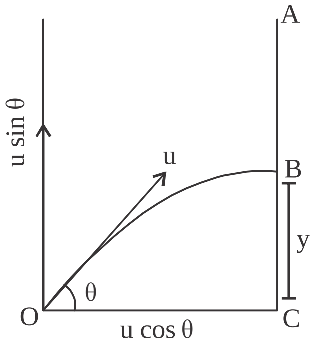
$\therefore \quad \tan\theta = \frac{\vec{V}_w}{\vec{V}_r}$

**112. (c)** According to pythagorus theorem

$$Vrm = \sqrt{Vr^2 + Vm^2}$$



**113. (b)**



$t = \frac{OC}{u\cos\theta} = \frac{x}{u\cos\theta}$

AC = x tan θ

BC = distance travelled by bullet in time t, vertically.

$y = u \sin\theta\, t - \frac{1}{2} gt^2$

$AB = x\tan\theta - (u\sin\theta t - \frac{1}{2} gt^2)$

$= x\tan\theta - (u\sin\theta \times \frac{x}{u\cos\theta} - \frac{1}{2} gt^2)$

$\Rightarrow$ distance trevelled by monkey

$= x\tan\theta - x\tan\theta + \frac{1}{2} gt^2 = \frac{1}{2} gt^2$

($\therefore$ bullet will always hit the monkey)

**114. (c)** Only in case of parabolic motion, the direction and magnitude of the velocity changes, acceleration remains same. Morever, in case of uniform circular motion, the direction changes.

**115.** **(c)** The horizontal velocity of the stone will be the same as that of the train. In this way, the horizontal motion will be uniform. The vertical motion will be controlled by the force of gravity. Hence it is accelerated motion. The resultant motion is a parabolic trajectory.

**116.** **(c)** The time taken to reach the ground depends on the height from which the projectile is fired horizontally. Here height is same for both the bullets and hence they will reach the ground simultaneously.

**117.** **(b)** The piece will fly side by side because the velocity of the piece is the same.

**118.** **(b)**

**119.** **(c)**

**120.** **(a)** Note that the given angles of projection add upto 90°. So, the ratio of horizontal ranges is 1 : 1.

**121.** **(a)** For maximum range, the angle of projection, $\theta = 45°$

$$\therefore R = \frac{u^2 \sin 2\theta}{g} = \frac{(20)^2 \sin(2\times 45°)}{10} = \frac{400\times 1}{10} = 40\text{m}.$$

**122.** **(c)** Yes, the person can catch the ball when horizontal velocity is equal to the horizontal component of ball's velocity, the motion of ball will be only in vertical direction w.r.t person

for that $\frac{v_0}{2} = v_0 \cos\theta$ or $\theta = 60°$

**123.** **(a)** $t_1 = \frac{2u\sin\theta}{g}$ and

$$t_2 = \frac{2u\ \sin(90-\theta)}{g} = \frac{2u\ \cos\theta}{g}$$

$$\therefore\quad t_1 t_2 = \frac{4u^2\ \cos\theta\ \sin\theta}{g^2} = \frac{2}{g}\left[\frac{u^2 \sin\ 2\theta}{g}\right] = \frac{2}{g}R\ ,$$

where R is the range.

Hence $t_1 t_2 \propto R$

**124.** **(c)** $\vec{L} = m(\vec{r}\times\vec{v})$

$$\vec{L} = m\left[v_0 \cos\theta t\,\hat{i} + (v_0 \sin\theta t - \frac{1}{2}gt^2)\hat{j}\right]$$

$$\times\left[v_0 \cos\theta\,\hat{i} + (v_0 \sin\theta - gt)\hat{j}\right]$$

$$= mv_0 \cos\theta t\left[-\frac{1}{2}gt\right]\hat{k} \quad = -\frac{1}{2}mgv_0 t^2 \cos\theta\hat{k}$$

**125.** **(d)** Angular momentum of the projectile

$L = mv_h r_\perp = m\,(v\cos\theta)\,h$

where *h* is the maximum height

$$= m(\upsilon\cos\theta)\left(\frac{\upsilon^2 \sin^2\theta}{2g}\right)$$

$$L = \frac{m\upsilon^3 \sin^2\theta\cos\theta}{2g} = \frac{\sqrt{3}\,m\upsilon^3}{16g}$$

**126.** **(c)** For projectile A

Maximum height, $H_A = \frac{u_A^2 \sin^2 45°}{2g}$

For projectile B

Maximum height, $H_B = \frac{u_B^2 \sin^2\theta}{2g}$

As we know, $H_A = H_B$

$$\frac{u_A^2 \sin^2 45°}{2g} = \frac{u_B^2 \sin^2\theta}{2g}$$

$$\frac{\sin^2\theta}{\sin^2 45°} = \frac{u_A^2}{u_B^2}$$

$$\sin^2\theta = \left(\frac{u_A}{u_B}\right)^2 \sin^2 45°$$

$$\sin^2\theta = \left(\frac{1}{\sqrt{2}}\right)^2\left(\frac{1}{\sqrt{2}}\right)^2 = \frac{1}{4}$$

$$\sin\theta = \frac{1}{2} \Rightarrow \theta = \sin^{-1}\left(\frac{1}{2}\right) = 30°$$

**127.** **(b)** As we know, R = u cosθ × t
Given, R = 300 m, t = 6 s

$$\therefore\quad u\cos\theta = \frac{R}{t} = \frac{300}{6} = 50\text{ms}^{-1}$$

**128.** **(b)** Resistance = *kv* $\left(= k\frac{ds}{dt}\right)$

Equations of motion are

$$\frac{d^2x}{dt^2} = -k\frac{dx}{dt} \qquad ............\ (1)$$

$$\frac{d^2y}{dt^2} = -k\frac{dy}{dt} - g \qquad ............\ (2)$$

Integrating (1) and (2) and using the initial conditions, we get

$$\frac{dx}{dt} = u\cos\alpha.e^{-kt} \qquad ............\ (3)$$

and $k\frac{dy}{dt} + g = (ku\sin\alpha + g).e^{-kt}$

i.e., $\frac{dy}{dt} = \frac{1}{k}[(ku\sin\alpha + g).e^{-kt} - g]$ ......... (4)

$$\frac{dy}{dx} = \frac{dy/dt}{dx/dt} = \frac{[(ku\sin\alpha + g).e^{-kt} - g]}{ku\cos\alpha.e^{-kt}} \quad ....\ (5)$$

Direction of projection was α with the horizontal, when the direction of motion again makes the angle α with the horizontal, it really makes the angle (π – α) with the horizontal in the sense of the direction of projection. If this happens after the time $t$, we have from (5),

$$\tan(\pi-\alpha)=\frac{(ku\sin\alpha+g).e^{-kt}-g}{ku\cos\alpha.e^{-kt}}$$

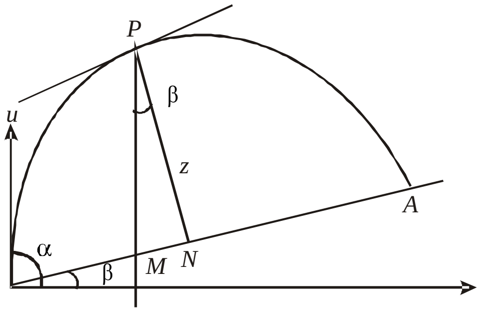
i.e., $$-\tan\alpha=\frac{(ku\sin\alpha+g)-ge^{-kt}}{ku\cos\alpha}$$

i.e., $$-ku\sin\alpha=ku\sin\alpha+g-g.e^{-kt}$$

or $$e^{kt}=1+\frac{2ku}{g}\sin\alpha$$

or $$t=\frac{1}{k}\log\left(1+\frac{2ku}{g}\sin\alpha\right)$$

**129. (b)** $P$ be the point where the tangent is parallel to the inclined plane. If $PN = z$ be perpendicular from $P$ on the inclined plane and $PM$ the vertical altitude of $P$ then evidently for all points on the path, $P$ is the point where $z$ is the greatest and consequently $PM$ is greatest.



Now for the point $P$, velocity perpendicular to the inclined plane is zero. Now the velocity and acceleration perp. to the plane at $O$ is u sin (α – β) and $g$ cos β and this velocity becomes zero at $P$.

∴ $0 = u^2\sin^2(\alpha-\beta) - 2g\cos\beta.z$

$$z=\frac{u^2\sin^2(\alpha-\beta)}{2g\cos\beta}$$

For max. range $\alpha=\frac{\pi}{4}+\frac{\beta}{2}$ or $\alpha-\beta=\frac{\pi}{4}-\frac{\beta}{2}$

Hence, $$z=\frac{u^2}{2g\cos\beta}\sin^2\left(\frac{\pi}{4}-\frac{\beta}{2}\right)$$

$$=\frac{u^2}{4g\cos\beta}\left[1-\cos\left(\frac{\pi}{2}-\beta\right)\right]$$

$$=\frac{u^2}{4g\cos\beta}(1-\sin\beta)$$ or $PM = z\sec\beta$

$$=\frac{u^2}{4g\cos^2\beta}(1-\sin\beta)=\frac{u^2}{4g(1+\sin\beta)}=\frac{1}{4}$$ (max. range)

⇒ Maximum range = 4 × $PM$

**130. (b)** Let the two bodies meet each other at a height $h$ after time $T$ of the projection of second body. Then before meeting, the first body was in motion for time $(t + T)$ whereas the second body was in motion for time $T$.

The distance moved by the first body in time $(t + T)$

$= u(t+T) - \frac{1}{2}g(t+T)^2$.

And the distance moved by the second body in time $T$

$= vT - \frac{1}{2}gT^2 = h$ (supposed above). ........ (1)

∵ The two bodies meet each other,

∴ They are equidistant from the point of projection.

Hence, $u(t+T)-\frac{1}{2}g(t+T)^2 = vT-\frac{1}{2}gT^2$

or $u(t+T)-\frac{1}{2}g(t^2+2tT) = vT$

or $gt^2 + 2t(gT-u) + 2(v-u)T = 0$ ......... (2)

Also from (1) we get, $h = vT - \frac{1}{2}gT^2$

∴ $\frac{dh}{dT}=v-gT$

∴ $h$ increases as $T$ increases

∴ $T$ is minimum when $h$ is minimum i.e., when

$\frac{dh}{dT}=0$, i.e. when $v - gT = 0$ or $T = v/g$.

Substituting this value of $T$ in (2), we get

$gt^2 + 2t(v-u) + 2(v-u)(v/g) = 0$

or $g^2t^2 - 2gt(u-v) + 2v(u-v) = 0$

or $$t=\frac{2g(u-v)+\sqrt{4g^2(u-v)^2+8vg^2(u-v)}}{2g^2}$$

or $$t=\frac{u-v+\sqrt{u^2-v^2}}{g}$$

neglecting the negative sign which gives negative value of $t$.

**131. (d)** Kinetic energy at the highest point is

$$E_{\text{top}}=\frac{1}{2}mu^2\cos^2\theta$$

Here $\frac{1}{2}mu^2=E$

and $\cos\theta=\frac{\sqrt{3}}{2}$ $[\because\theta=30°]$

∴ $E_{\text{top}}=\frac{3}{4}\times E$

**132. (b)** Horizontal range $R = \frac{u^2 \sin 2\theta}{g}$

Range is same for angle of projection θ and (90° – θ)

**133. (d)** For complementary angles of projection (45° + α) and (45° – α) with same initial velocity u, range R is same.

$\theta_1 + \theta_2 = (45° + \alpha) + (45° - \alpha) = 90°$

**134. (a)** Horizontal range = $\frac{u^2 \sin 2\theta}{g}$ so $g \propto u^2$

or $\frac{g_{planet}}{g_{earth}} = \frac{(u_{planet})^2}{(u_{earth})^2}$

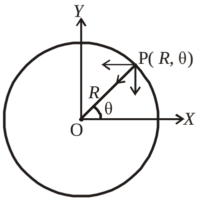
Therefore $g_{planet} = \left(\frac{3}{5}\right)^2 (9.8\ m/s^2)$

$= 3.5\ m/s^2$

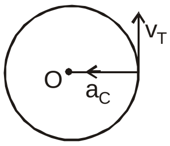
**135. (c)** Clearly

$\vec{a} = a_c \cos\theta(-\hat{i}) + a_c \sin\theta(-\hat{j})$

$= \frac{-v^2}{R}\cos\theta\,\hat{i} - \frac{v^2}{R}\sin\theta\,\hat{j}$



**136. (c)** It has only tangential velocity $v_T$ & radial acceleration or centripetal acceleration $a_C$.



**137. (b)** Centripetal force, $F = \frac{mv^2}{r}$, so, $F \propto \frac{1}{r}$ so v is independent of r.

**138. (c)** Given, $\omega = 2$ rad $s^{-1}$, r = 2 m, $t = \frac{\pi}{2}s$

Angular displacement, $\theta = \omega t = 2 \times \frac{\pi}{2} = \pi$ rad

Linear velocity, $v = r \times \omega = 2 \times 2 = 4\ m\,s^{-1}$

∴ change in velocity, $\Delta v = 2v \sin\frac{\theta}{2} = 2 \times 4 \times \sin\left(\frac{\pi}{2}\right)$

$= 8\ m\ s^{-1}$

**139. (a)** As $T = mr\omega^2$

or $\omega^2 = \frac{T}{mr} = \frac{900}{2 \times 0.5} = 900 \Rightarrow \omega = 30$ rad $s^{-1}$

**140. (b)** Circumference of circle is 2πr = 40m

Total distance travelled in two revolution is 80m. Initial velocity u = 0, final veloctiy v = 80 m/sec

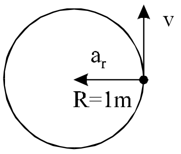
so from

$v^2 = u^2 + 2as$

$\Rightarrow (80)^2 = 0^2 + 2 \times 80 \times a$

$\Rightarrow a = 40 m/sec^2$

**141. (a)** $a_r = \omega^2 R$



$a_r = (2\pi 2)^2 R = 4\pi^2 2^2 R = 4\pi^2 \left(\frac{22}{44}\right)^2 (1)$ $\left[\because v = \frac{22}{44}\right]$

$a_t = \frac{dv}{dt} = 0$

$a_{net} = a_r = \pi^2\ ms^{-2}$ and direction along the radius towards the centre.

# CHAPTER 5

# LAWS OF MOTION

## FACT/DEFINITION TYPE QUESTIONS

**1.** Inertia is the property of a body linked to tendency of a body

(a) to change its position
(b) to change its direction
(c) to change the momentum
(d) to resist any change in its state

**2.** Physical independence of force is a consequence of

(a) third law of motion (b) second law of motion
(c) first law of motion (d) all of these

**3.** Newton's first law of motion describes the

(a) energy (b) work
(c) inertia (d) moment of inertia

**4.** Force depends on

(a) change in momentum
(b) how fast the change in momentum is brought about
(c) Both (a) & (b) (d) None of these

**5.** Which motion does not require force to maintain it ?

(a) Uniform circular motion
(b) Elliptical motion
(c) Uniform straight line motion
(d) Projectile motion

**6.** A ball is travelling with uniform translatory motion. This means that

(a) it is at rest.
(b) the path can be a straight line or circular and the ball travels with uniform speed.
(c) all parts of the ball have the same velocity (magnitude and direction) and the velocity is constant.
(d) the centre of the ball moves with constant velocity and the ball spins about its centre uniformly.

**7.** An object will continue moving uniformly when

(a) the resultant force on it is increasing continuously
(b) the resultant force is at right angles to its rotation
(c) the resultant force on it is zero
(d) the resultant force on it begins to decrease

**8.** External agencies like gravitational and magnetic forces ...X... exerts force on a body from a distance.

Here, X refers to

(a) can (b) cannot
(c) never (d) None of these

**9.** According to Galileo's experiment for a double inclined plane, if slope of second plane is zero and planes are smooth, then a ball is released from rest on one of the planes rolls down and move on the second plane ...X... distance.

Here, X is

(a) zero
(b) infinite
(c) equal to length of first plane
(d) None of these

**10.** When a body is stationary

(a) there is no force acting on it
(b) the force acting on it is not in contact with it
(c) the combination of forces acting on it balances each other
(d) the body is in vacuum

**11.** No force is required for

(a) an object moving in straight line with constant velocity
(b) an object moving in circular motion
(c) an object moving with constant acceleration
(d) an object moving in elliptical path.

**12.** If a stone is thrown out of an accelerated train, then acceleration of the stone at any instant depends on

(a) force acting on it at that instant
(b) acceleration of the train
(c) Both (a) & (b) (d) None of these

**13.** Which of the following expression is correct?

(a) $F = ma$ (b) $F = \frac{m}{a}$
(c) $F = \frac{a}{m}$ (d) None of these

**14.** Newton’s second law measures the

(a) acceleration (b) force
(c) momentum (d) angular momentum

**15.** A reference frame attached to the earth

(a) is an inertial frame by definition
(b) cannot be an inertial frame because earth is revolving round the sun
(c) is an inertial frame because Newton's laws are applicable
(d) is an inertial frame because the earth is rotating about its own axis

**16.** Impulse equals
(a) rate of change of momentum
(b) change in momentum
(c) momentum multiplied by time
(d) rate of change of force

**17.** The direction of impulse is
(a) same as that of the net force
(b) opposite to that of the net force
(c) same as that of the final velocity
(d) same as that of the initial velocity

**18.** A particle of mass m is moving with velocity $v_1$, it is given an impulse such that the velocity becomes $v_2$. Then magnitude of impulse is equal to
(a) $m(\vec{v}_2 - \vec{v}_1)$ (b) $m(\vec{v}_1 - \vec{v}_2)$
(c) $m \times (\vec{v}_2 - \vec{v}_1)$ (d) $0.5m(\vec{v}_2 - \vec{v}_1)$

**19.** Impulse is
(a) a scalar quantity
(b) equal to change in the momentum of a body
(c) equal to rate of change of momentum of a body
(d) a force

**20.** A large force is acting on a body for a short time. The impulse imparted is equal to the change in
(a) acceleration (b) momentum
(c) energy (d) velocity

**21.** China wares are wraped in straw of paper before packing. This is the application of concept of
(a) impulse (b) momentum
(c) acceleration (d) force

**22.** Which one of the following is not a force?
(a) Impulse (b) Tension
(c) Thrust (d) Air resistance

**23.** In which of the following cases, net force acting on the body is zero?
(a) A car moving with uniform velocity
(b) A book lying on the table
(c) Both (a) & (b)
(d) None of these

**24.** If the net external force on a body is ...X..., its acceleration is zero. Acceleration can be ...Y... only, if there is a net external force on the body. Here, X and Y refer to
(a) zero, zero (b) zero, non-zero
(c) non-zero, zero (d) non-zero, non-zero

**25.** The same change in momentum about in ...X... time needs ...Y... force applied. Here, X and Y refer to
(a) longer, lesser (b) shorter, greater
(c) both (a) and (b) (d) longer, greater

**26.** We can derive Newton's
(a) second and third laws from the first law
(b) first and second laws from the third law
(c) third and first laws from the second law
(d) All the three laws are independent of each other

**27.** Swimming is possible on account of
(a) first law of motion
(b) second law of motion
(c) third law of motion
(d) newton's law of gravitation

**28.** Newton's second and third laws of motion lead to the conservation of
(a) linear momentum (b) angular momentum
(c) potential energy (d) kinetic energy

**29.** Rocket engines lift a rocket from the earth surface, because hot gases with high velocity
(a) push against the air
(b) push against the earth
(c) react against the rocket and push it up
(d) heat up the air which lifts the rocket.

**30.** A cannon after firing recoils due to
(a) conservation of energy
(b) backward thrust of gases produced
(c) Newton's third law of motion
(d) Newton's first law of motion

**31.** A man is standing at the centre of frictionless pond of ice. How can he get himself to the shore?
(a) By throwing his shirt in vertically upward direction
(b) By spitting horizontally
(c) He will wait for the ice to melt in pond
(d) Unable to get at the shore

**32.** The acceleration of an astronaut is zero once he steps out of his accelerated spaceship in the intersteller space. this statement is in accordance with
(a) Newton's second law of motion
(b) Newton's first law of motion
(c) Newton's third law of motion
(d) All of these

**33.** Law of conservation of momentum follows from
(a) Newton's first law of motion
(b) Newton's second law of motion
(c) Newton's third law of motion
(d) Both (b) & (c)

**34.** A body whose momentum is constant must have constant
(a) velocity (b) force
(c) acceleration (d) All of the above

**35.** In an explosion, a body breaks up into two pieces of unequal masses. In this
(a) both parts will have numerically equal momentum
(b) lighter part will have more momentum
(c) heavier part will have more momentum
(d) both parts will have equal kinetic energy

**36.** A jet engine works on the principle of
(a) conservation of mass
(b) conservation of energy
(c) conservation of linear momentum
(d) conservation of angular momentum

**37.** Which one of the following motions on a smooth plane surface does not involve force?
(a) Accelerated motion in a straight line
(b) Retarded motion in a straight line
(c) Motion with constant momentum along a straight line
(d) Motion along a straight line with varying velocity

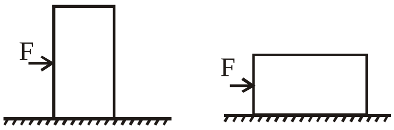
**38.** Identify the correct statement.
(a) Static friction depends on the area of contact
(b) Kinetic friction depends on the area of contact
(c) Coefficient of kinetic friction does not depend on the surfaces in contact
(d) Coefficient of kinetic friction is less than the coefficient of static friction

**39.** If the resultant of all the external forces acting on a system of particles is zero, then from an inertial frame, one can surely say that
(a) linear momentum of the system does not change in time
(b) kinetic energy of the system does not change in time
(c) angular momentum of the system does not change in time
(d) potential energy of the system does not change in time

**40.** Frictional force that opposes relative motion between surfaces in contact is called ...X... and denoted by ...Y.... Here, X and Y refer to
(a) static friction, $f_s$ (b) kinetic friction, $f_s$
(c) kinetic friction, $f_k$ (d) static friction, $f_k$

**41.** The coefficient of static friction between two surfaces depends upon
(a) the normal reaction
(b) the shape of the surface in contact
(c) the area of contact
(d) None of the these

**42.** A rectangular block is placed on a rough horizontal surface in two different ways as shown, then



(a) (b)

(a) friction will be more in case (a)
(b) friction will be more in case (b)
(c) friction will be equal in both the cases
(d) friction depends on the relations among its dimensions.

**43.** If the normal force is doubled, then coefficient of friction is
(a) halved (b) tripled
(c) doubled (d) not changed

**44.** When a box is in stationary position with respect to train moving with acceleration, then relative motion is opposed by the ...X.... Which provides the same acceleration to the box as that of the train, keeping it stationary relative to the train. Here, X refers to
(a) kinetic friction (b) static friction
(c) limiting friction (d) None of these

**45.** If $\mu_s$, $\mu_k$ and $\mu_r$ are coefficients of static friction, kinetic friction and rolling friction, then
(a) $\mu_s < \mu_k < \mu_f$ (b) $\mu_k < \mu_r < \mu_s$
(c) $\mu_r < \mu_k < \mu_s$ (d) $\mu_r = \mu_k = \mu_s$

**46.** It is difficult to move a cycle with brakes on because
(a) rolling friction opposes motion on road
(b) sliding friction opposes motion on road
(c) rolling friction is more than sliding friction
(d) sliding friction is more than rolling friction

**47.** Which of the following statements about friction is true?
(a) Friction can be reduced to zero
(b) Frictional force cannot accelerate a body
(c) Frictional force is proportional to the area of contact between the two surfaces
(d) Kinetic friction is always greater than rolling friction

**48.** A thin cushion of air maintained between solid surfaces in ...X... is another effective way of ...Y... friction. Here, X and Y refer to
(a) relative motion, reducing
(b) motion, increasing
(c) relative motion, increasing
(d) None of these

**49.** What are the effects if force is acting on a moving body in a direction perpendicular to the direction of motion?
(a) The speed changes uniformly
(b) The acceleration changes uniformly
(c) The direction of motion changes
(d) All of these

**50.** When a car moves on a level road, then the centripetal force required for circular motion is provided by ________
(a) weight of the car
(b) normal reaction
(c) component of friction between the road & tyres along the surface.
(d) All of these

**51.** On a banked road, which force is essential to provide the necessary centripetal force to a car to take a turn while driving at the optimum speed?
(a) Component of normal reaction
(b) Component of frictional force
(c) Both (a) & (b) (d) None of these

**52.** Which of the following forces does not act on a body moving in uniform circular motion?
(a) Centripetal force (b) Weight of the body
(c) Normal reaction (d) Force of friction

**53.** A particle revolves round a circular path. The acceleration of the particle is inversely proportional to
(a) radius (b) velocity
(c) mass of particle (d) both (b) and (c)

**54.** A cyclist taking turn bends inwards while a car passenger taking the same turn is thrown outwards. The reason is
(a) car is heavier than cycle
(b) car has four wheels while cycle has only two
(c) difference in the speed of the two
(d) cyclist has to counteract the centrifugal force while in the case of car only the passenger is thrown by this force

**55.** A car takes a circular turn with a uniform speed u. If the reaction at inner and outer wheels be denoted by $R_1$ and $R_2$, then
(a) $R_1 = R_2$ (b) $R_1 < R_2$
(c) $R_1 > R_2$ (d) None of these

**56.** A cyclist bends while taking turn in order to
(a) reduce friction
(b) provide required centripetal force
(c) reduce apparent weight
(d) reduce speed

## STATEMENT TYPE QUESTIONS

**57.** Consider the following statements and select the incorrect statement(s).
I. To move a football at rest, some one must kick it.
II. To throw a stone upwards, one has to give it an upward push.
III. A breeze causes the branches of a tree to become stationary.
IV. A strong wind can move even heavy objects.
(a) Only I (b) Only III
(c) III and IV (d) I and II

**58.** Which of the following statements is/are correct ?
I. Newton's first law of motion defines force
II. Newton's first law of motion defines inertia
III. Newton's first law of motion is a measure of force
(a) I only (b) II and III
(c) I and III (d) I and II

**59.** Choose the incorrect statement(s) from the following.
I. If a body is not in rest position, then the net external force acting on it cannot be zero.
II. If the net force acting on a body be zero then the body will essentially remain at rest.
(a) I only (b) II only
(c) I and II (d) None of these

**60.** There are different types of inertia called
I. Inertia of rest.
II. Inertia of motion.
III. Inertia of direction.
IV. Inertia of shape.
Choose the correct option.
(a) I and II (b) I, II and III
(c) I, II, III and IV (d) None of these

**61.** Which of the following statements is/are correct about action and reaction forces?
I. Action and reaction are simultancous forces
II. There is no cause-effect relation between action and reaction.
III. Action and reaction always on two different body
(a) I only (b) II only
(c) III only (d) I, II and III

**62.** Which of the following statements is/are incorrect, when a person walks on a rough surface?
I. The frictional force exerted by the surface keeps him moving
II. The force which the man exerts on the floor keeps him moving
III. The reaction of the force which the man exerts on floor keeps him moving
(a) I only (b) II only
(c) I and III (d) I and II

**63.** Select the wrong statement(s) from the following.
I. Newton's laws of motion hold good for both inertial and non-inertial frames
II. During explosion, linear momentum is conserved
III. Force of friction is zero when no driving force is applied
(a) I only (b) II only
(c) I and II (d) II and III

**64.** Choose the correct statement(s) from the following.
I. Recoiling of a gun is an application of principle of conservation of linear momentum.
II. Explosion of a bomb is based on second law of motion
(a) I only (b) II only
(c) I and II (d) None of these

**65.** Select the incorrect statement(s) about static friction.
I. Static friction exists on its own
II. In the absence of applied force static friction is maximum
III. Static friction is equal and opposite to the applied force upto a certain limit
(a) I only (b) II and III
(c) I and III (d) I and II

**66.** Select the incorrect statement(s) from the following.
I. Limiting friction is always greater than the kinetic friction
II. Limiting friction is always less than the static friction
III. Coefficient of static fiction is always greater than the coefficient of kinetic fiction
(a) I only (b) I and III
(c) II and III (d) I and II

## MATCHING TYPE QUESTIONS

**67.** Match the column I and II.

| **Column I** | **Column II** |
|---|---|
| (A) Inertia | (1) $10^5$ gcms$^{-1}$ |
| (B) Recoil of gun | (2) kg f |
| (C) 1 kg ms$^{-1}$ | (3) Newton's third law of motion |
| (D) Weight | (4) Newton's first law of motion |

(a) (A)→(4); (B)→(1); C→(2); (D)→(3)
(b) (A)→(4); (B)→(3); C→(1); (D)→(2)
(c) (A)→(3); (B)→(2); C→(4); (D)→(1)
(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

**68.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Unbalanced | (1) | Acts on two different bodies |
| (B) | Action & Reaction | (2) | Inability to change the state |
| (C) | Inertia | (3) | *mv* |
| (D) | Momentum | (4) | Variable velocity |

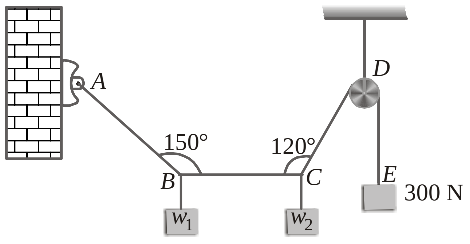
(a) (A)→(4); (B)→(1); C→(2); (D)→(3)
(b) (A)→(1); (B)→(2); C→(4); (D)→(3)
(c) (A)→(3); (B)→(2); C→(4); (D)→(1)
(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

**69.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Accelerated motion | (1) | Newton's 1st law |
| (B) | Impulse | (2) | Mass |
| (C) | Law of inertia | (3) | Force×time |
| (D) | Measure of inertia | (4) | Change in speed and direction |

(a) (A)→(4); (B)→(1); C→(2); (D)→(3)
(b) (A)→(4); (B)→(2); C→(1); (D)→(3)
(c) (A)→(3); (B)→(4); C→(1); (D)→(2)
(d) (A)→(4); (B)→(3); C→(1); (D)→(2)

**70.** A light string *ABCDE* whose extremity *A* is fixed, has weights $W_1$ and $W_2$ attached to it at *B* and *C*. It passes round a small smooth peg at *D* carrying a weight of 300 N at the free end *E* as shown in figure. If in the equilibrium position, *BC* is horizontal and *AB* and *CD* make 150° and 120° with *CB*. Match the columns :



| | Column I | | Column II |
|---|---|---|---|
| (A) | Tension in portion *AB*, $T_{AB}$ | (1) | 150 N |
| (B) | Tension in portion *BC*, $T_{BC}$ | (2) | 173 N |
| (C) | Weight, $W_1$ | (3) | 260 N |
| (D) | Weight, $W_2$ | (4) | 87 N |

(a) (A)→(4); (B)→(1); C→(2); (D)→(3)
(b) (A)→(2); (B)→(1); C→(4); (D)→(3)
(c) (A)→(3); (B)→(4); C→(1); (D)→(3)
(d) (A)→(4); (B)→(3); C→(1); (D)→(2)

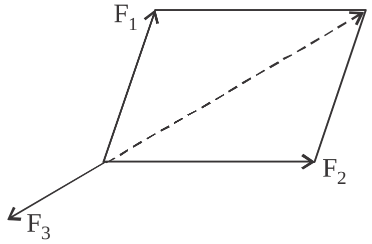
**71.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Rocket's work | (1) | Momentum |
| (B) | $F = ma$ | (2) | Uniform motion |
| (C) | Quantity of motion | (3) | Conservation of momentum |
| (D) | Constant force | (4) | Newton's second law |

(a) (A)→(4); (B)→(1); C→(2); (D)→(3)
(b) (A)→(4); (B)→(3); C→(1); (D)→(2)
(c) (A)→(3); (B)→(4); C→(1); (D)→(2)
(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

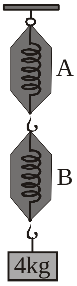
## DIAGRAM TYPE QUESTIONS

**72.** Which equation holds true for the given figure?



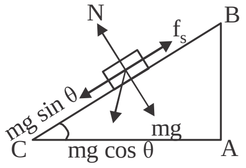
(a) $F_1 - F_2 = F_3$ (b) $F_1 + F_2 = F_3$
(c) $F_1 + F_2 + F_3 = 0$ (d) $F_2 + F_3 = F_1$

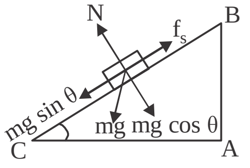
**73.** A block of mass 4 kg is suspended through two light spring balances A and B. Then A and B will read respectively :

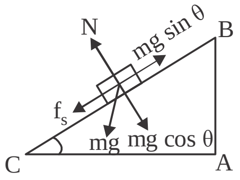


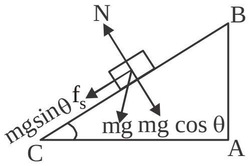
(a) 4 kg and zero kg
(b) zero kg and 4 kg
(c) 4 kg and 4 kg
(d) 2 kg and 2 kg

**74.** Which figure shows the correct force acting on the body sliding down an inclined plane? (m → mass, $f_s$ → force of friction)

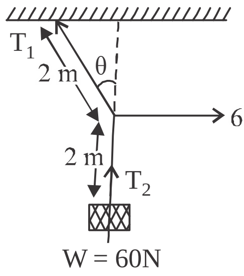
(a)


(b)


(c)


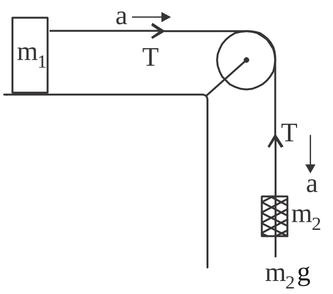
(d)


**75.** For the given situation as shown in the figure, the value of θ to keep the system in equilibrium will be



(a) 30° (b) 45°
(c) 0° (d) 90°

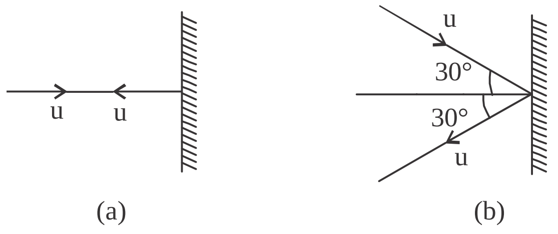
**76.** The acceleration of the system shown in the figure is given by the expression (ignore force of friction)



(a) $a = \frac{m_2 g}{(m_1 + m_2)}$ (b) $a = \frac{m_1 g}{(m_1 + m_2)}$

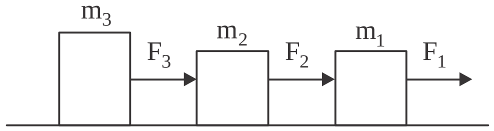
(c) $a = \frac{m_1}{(m_1 + m_2)g}$ (c) $a = \frac{m_2}{(m_1 + m_2)g}$

**77.** What is the direction of force on the wall due to the ball in two cases shown in the figures?



(a) In (a) force is normal to the wall and in (b) force is inclined at 30° to the normal.
(b) In (a) force is normal to the wall and in (b) force is inclined at 60° to the normal.
(c) In (a) the force is along the wall and in (b) force is normal to the wall.
(d) In (a) and (b) both the force is normal to the wall.

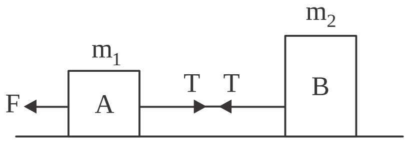
**78.** For the system shown in figure, the correct expression is



(a) $F_3 = F_1 + F_2$ (b) $F_3 = \frac{m_3 F}{F_1 + F_2 + F_3}$

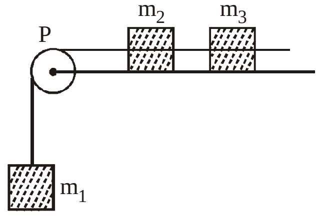
(c) $F_3 = \frac{m_3 F}{m_1 + m_2 + m_3}$ (d) $F_3 = \frac{m_3 F}{m_1 + m_2}$

**79.** Which of the following is true about acceleration, a for the system?



(a) Acceleration is more in A, when force is applied on A.
(b) Acceleration is more in B, when force is applied on B.
(c) Acceleration is same and does not depend on whether the force is applied on $m_1$ or $m_2$
(d) Acceleration depends on the tension in the string.

**80.** A system consists of three masses $m_1$, $m_2$ and $m_3$ connected by a string passing over a pulley P. The mass $m_1$ hangs freely and $m_2$ and $m_3$ are on a rough horizontal table (the coefficient of friction = μ). The pulley is frictionless and of negligible mass. The downward acceleration of mass $m_1$ is : (Assume $m_1 = m_2 = m_3 = m$)



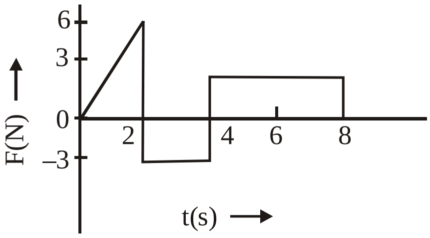
(a) $\frac{g(1 - g\mu)}{g}$

(b) $\frac{2g\mu}{3}$

(c) $\frac{g(1 - 2\mu)}{3}$

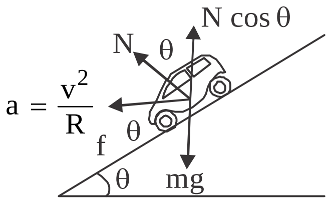
(d) $\frac{g(1 - 2\mu)}{2}$

**81.** The force 'F' acting on a particle of mass 'm' is indicated by the force-time graph shown below. The change in momentum of the particle over the time interval from zero to 8 s is :



(a) 24 Ns (b) 20 Ns
(c) 12 Ns (d) 6 Ns

**82.** The motion of a car on a banked road is shown in the figure. The centripetal force equation will be given by



(a) $N\sin\theta + f\cos\theta = \frac{mv^2}{R}$ (b) $f = \frac{mv^2}{R}$

(c) $N\cos\theta + f = \frac{mv^2}{R}$ (d) $N\sin\theta + f = \frac{mv^2}{R}$

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

**83.** **Assertion :** Mass is a measure of inertia of the body in linear motion.
**Reason :** Greater the mass, greater is the force required to change its state of rest or of uniform motion.

**84.** **Assertion :** An object can move with constant velocity if no net force acts on it.
**Reason :** No net force is needed to move an object with constant velocity.

**85.** **Assertion :** If the net external force on the body is zero, then its acceleration is zero.
**Reason :** Acceleration does not depend on force.

**86.** **Assertion :** For the motion of electron around nucleus, Newton's second law is used.
**Reason :** Newton's second law can be used for motion of any object.

**87.** **Assertion :** Impulse of force and momentum are same physical quantities.
**Reason :** Both quantities have same unit.

**88.** **Assertion:** A cricketer moves his hands forward to catch a ball so as to catch it easily without hurting.
**Reason:** He tries to decrease the distance travelled by the ball so that it hurts less.

**89.** **Assertion:** Same force applied for the same time causes the same change in momentum for different bodies
**Reason:** The total momentum of an isolated system of interacting bodies remains conserved.

**90.** **Assertion :** A bullet is fired from a rifle. If the rifle recoils freely, the kinetic energy of rifle is more than that of the bullet.
**Reason :** In case of rifle bullet system, the law of conservation of momentum violates.

**91.** **Assertion :** A rocket works on the principle of conservation of linear momentum.
**Reason :** Whenever there is change in momentum of one body, the same change occurs in the momentum of the second body of the same system but in the opposite direction.

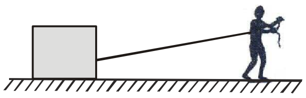
**92.** **Assertion :** The two bodies of masses $M$ and $m$ ($M > m$) are allowed to fall from the same height if the air resistance for each be the same then both the bodies will reach the earth simultaneously.
**Reason :** For same air resistance, acceleration of both the bodies will be same.

**93.** **Assertion :** A block placed on a table is at rest, because action force cancels the reaction force on the block.
**Assertion :** The net force on the block is zero.

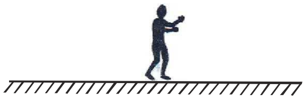
**94.** **Assertion :** On a rainy day, it is difficult to drive a car or bus at high speed.
**Reason :** The value of coefficient of friction is lowered due to wetting of the surface.

**95.** **Assertion :** Frictional forces are conservating forces.
**Reason :** Potential energy can be associated with frictional forces.

**96.** **Assertion :** A man and a block rest on smooth horizontal surface. The man holds a rope which is connected to block. The man cannot move on the horizontal surface.



**Reason :** A man standing at rest on smooth horizontal surface cannot start walking due to absence of friction (The man is only in contact with floor as shown).



**97.** **Assertion:** Friction is a necessary evil
**Reason:** Though friction dissipates power, but without friction we cannot walk.

**98.** **Assertion:** There is a stage when frictional force is not needed at all to provide the necessary centripetal force on a banked road.
**Reason:** On a banked road, due to its inclination the vehicle tends to remain inwards without any chances of skidding.

**99.** **Assertion :** Force is required to move a body uniformly along a circle.
**Reason :** When the motion is uniform, acceleration is zero.

**100.** **Assertion :** Linear momentum of a body changes even when it is moving uniformly in a circle.

**Reason :** In uniform circular motion, velocity remains constant.

**101.** **Assertion :** A cyclist always bends inwards while negotiating a curve.

**Reason :** By bending, cyclist lowers his centre of gravity.

## CRITICALTHINKING TYPE QUESTIONS

**102.** A boy, sitting on the topmost birth in the compartment of a train which is just going to stop on the railway station, drops an apple aiming at the open hand of his brother situated vertically below his own hand at a distance of 2m. The apple will fall

(a) in the hand of his brother

(b) slightly away from the hand of his brother in the direction of motion of the train

(c) slightly away from the hand of his brother opposite to the direction of motion of the train

(d) None of the above

**103.** A person sitting in an open car moving at constant velocity throws a ball vertically up into air. The ball falls

(a) outside the car

(b) in the car ahead of the person

(c) in the car to the side of the person

(d) exactly in the hand which threw it up

**104.** If a stone of mass 0.05 kg is thrown out a window of a train moving at a constant speed of 100 km/h then magnitude of the net force acting on the stone is

(a) 0.5 N (b) zero

(c) 50 N (d) 5 N

**105.** A closed compartment containing gas is moving with same acceleration in horizontal direction. Neglect effect of gravity. Then the pressure in the compartment is

(a) same everywhere (b) lower in front side

(c) lower in rear side (d) lower in upper side

**106.** When an elevator cabin falls down, the cabin and all the bodies fixed in the cabin are accelerated with respect to

(a) ceiling of elevator (b) floor of elevator

(c) man standing on earth

(d) man standing in the cabin

**107.** A monkey is climbing up a rope, then the tension in the rope

(a) must be equal to the force applied by the monkey on the rope

(b) must be less than the force applied by the monkey on the rope.

(c) must be greater than the force applied by the monkey on the rope.

(d) may be equal to, less than or greater the force applied by the monkey on the rope.

**108.** A metre scale is moving with uniform velocity. This implies

(a) the force acting on the scale is zero, but a torque about the centre of mass can act on the scale.

(b) the force acting on the scale is zero and the torque acting about centre of mass of the scale is also zero.

(c) the total force acting on it need not be zero but the torque on it is zero.

(d) neither the force nor the torque need to be zero.

**109.** A body of mass M hits normally a rigid wall with velocity V and bounces back with the same velocity. The impulse experienced by the body is

(a) MV (b) 1.5 MV (c) 2 MV (d) zero

**110.** If rope of lift breaks suddenly, the tension exerted by the surface of lift ($a$ = acceleration of lift)

(a) $mg$ (b) $m(g + a)$

(c) $m(g - a)$ (d) 0

**111.** An explosion breaks a rock into three parts in a horizontal plane. Two of them go off at right angles to each other. The first part of mass 1 kg moves with a speed of 12 $ms^{-1}$ and the second part of mass 2 kg moves with speed 8 $ms^{-1}$. If the third part flies off with speed 4 $ms^{-1}$ then its mass is

(a) 5 kg (b) 7 kg

(c) 17 kg (d) 3 kg

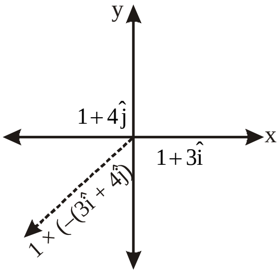
**112.** A stationary body of mass 3 kg explodes into three equal pieces. Two of the pieces fly off in two mutually perpendicular directions, one with a velocity of $3\hat{i}\ ms^{-1}$ and the other with a velocity of $4\hat{j}\ ms^{-1}$. If the explosion occurs in $10^{-4}$ s, the average force acting on the third piece in newton is

(a) $(3\hat{i} + 4\hat{j}) \times 10^{-4}$

(b) $(3\hat{i} - 4\hat{j}) \times 10^{-4}$

(c) $(3\hat{i} - 4\hat{j}) \times 10^{4}$

(d) $-(3\hat{i} + 4\hat{j}) \times 10^{4}$



**113.** A spacecraft of mass 100 kg breaks into two when its velocity is $10^4$ m $s^{-1}$. After the break, a mass of 10 kg of the space craft is left stationary. The velocity of the remaining part is

(a) $10^3$ m $s^{-1}$ (b) $11.11 \times 10^3 ms^{-1}$

(c) $11.11 \times 10^2$ m $s^{-1}$ (d) $10^4$ m $s^{-1}$

**114.** A ball is thrown up at an angle with the horizontal. Then the total change of momentum by the instant it returns to ground is

(a) acceleration due to gravity × total time of flight

(b) weight of the ball × half the time of flight

(c) weight of the ball × total time of flight

(d) weight of the ball × horizontal range

**115.** A spring balance is attached to the ceiling of a lift. A man hangs his bag on the spring and the spring reads 49 N, when the lift is stationary. If the lift moves downward with an acceleration of $5 m/s^2$, the reading of the spring balance will be

(a) 24 N (b) 74 N

(c) 15 N (d) 49 N

**116.** A block of mass *m* is placed on a smooth wedge of inclination θ. The whole system is accelerated horizontally so that the block does not slip on the wedge. The force exerted by the wedge on the block (g is acceleration due to gravity) will be

(a) mg/cos θ (b) mg cos θ

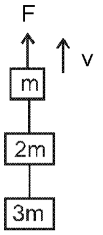
(c) mg sin θ (d) mg

**117.** A person of mass 60 kg is inside a lift of mass 940 kg and presses the button on control panel. The lift starts moving upwards with an acceleration $1.0 m/s^2$. If $g = 10 ms^{-2}$, the tension in the supporting cable is

(a) 8600 N (b) 9680 N

(c) 11000 N (d) 1200 N

**118.** Three blocks with masses m, 2 m and 3 m are connected by strings as shown in the figure. After an upward force F is applied on block m, the masses move upward at constant speed v. What is the net force on the block of mass 2m? (g is the acceleration due to gravity)



(a) 2 mg

(b) 3 mg

(c) 6 mg

(d) zero

**119.** The net force on a rain drop falling down with a constant speed is ________

(a) weight of drop W

(b) viscous drag of air F

(c) W + F + force of buoyany

(d) zero

**120.** If two masses (M & m) are connected on a horizontal plane and a force is applied on the combination, then the tension T depends on

(a) the force applied on the system

(b) whether force is applied on M or m

(c) both (a) and (b)

(d) Can't be predicted.

**121.** A body is imparted motion from rest to move in a straight line. If it is then obstructed by an opposite force, then

(a) the body may necessarily change direction

(b) the body is sure to slow down

(c) the body will necessarily continue to move in the same direction at the same speed

(d) None of these

**122.** The force required to just move a body up the inclined plane is double the force required to just prevent the body from sliding down the plane. The coefficient of friction is μ. The inclination θ of the plane is

(a) $\tan^{-1} \mu$ (b) $\tan^{-1} (\mu/2)$

(c) $\tan^{-1} 2\mu$ (d) $\tan^{-1} 3\mu$

**123.** A hockey player is moving northward and suddenly turns westward with the same speed to avoid an opponent. The force that acts on the player is

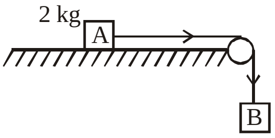
(a) frictional force along westward

(b) muscles force along southward

(c) frictional force along south-west

(d) muscle force along south-west

**124.** The coefficient of static friction $\mu_s$, between block A of mass 2 kg and the table as shown in the figure is 0.2. What would be the maximum mass value of block B so that the two blocks do not move? The string and the pulley are assumed to be smooth and massless. ($g = 10 m/s^2$)



(a) 0.4 kg (b) 2.0 kg

(c) 4.0 kg (d) 0.2 kg

**125.** A conveyor belt is moving at a constant speed of 2m/s. A box is gently dropped on it. The coefficient of friction between them is μ = 0.5. The distance that the box will move relative to belt before coming to rest on it taking $g = 10 ms^{-2}$, is

(a) 1.2 m (b) 0.6 m (c) zero (d) 0.4 m

**126.** The upper half of an inclined plane of inclination θ is perfectly smooth while lower half is rough. A block starting from rest at the top of the plane will again come to rest at the bottom, if the coefficient of friction between the block and lower half of the plane is given by

(a) $\mu = \dfrac{2}{\tan \theta}$ (b) $\mu = 2 \tan \theta$

(c) $\mu = \tan \theta$ (d) $\mu = \dfrac{1}{\tan \theta}$

**127.** A marble block of mass 2 kg lying on ice when given a velocity of 6 m/s is stopped by friction in 10 s. Then the coefficient of friction is (Take $g = 10 ms^{-2}$)

(a) 0.06 (b) 0.03

(c) 0.04 (d) 0.01

**128.** A block rests on a rough inclined plane making an angle of 30° with the horizontal. The coefficient of static friction between the block and the plane is 0.8. If the frictional force on the block is 10 N, the mass of the block (in kg) is (take $g = 10\ m/s^2$)

(a) 1.6 (b) 4.0

(c) 2.0 (d) 2.5

**129.** A given object takes n times as much time to slide down a 45º rough incline as it takes to slide down a perfectly smooth 45º incline. The coefficient of kinetic friction between the object and incline is given by

(a) $\left(1-\frac{1}{n^2}\right)$ (b) $\frac{1}{1-n^2}$

(c) $\sqrt{\left(1-\frac{1}{n^2}\right)}$ (d) $\sqrt{\left(\frac{1}{1-n^2}\right)}$

**130.** The minimum force required to start pushing a body up rough (frictional coefficient $\mu$) inclined plane is $F_1$ while the minimum force needed to prevent it from sliding down is $F_2$. If the inclined plane makes an angle $\theta$ from the horizontal such that $\tan\theta = 2\mu$ then the ratio $\frac{F_1}{F_2}$ is

(a) 1 (b) 2

(c) 3 (d) 4

**131.** A particle is acted upon by a force of constant magnitude which is always perpendicular to the velocity of the particle. The motion of the particle takes place in a plane. It follows that

(a) its velocity is constant
(b) its acceleration is constant
(c) its kinetic energy is constant
(d) it moves in a straight line.

**132.** If *n* bullets each of mass *m* are fired with a velocity *v* per second from a machine gun, the force required to hold the gun in position is

(a) $(n+1)mv$ (b) $\frac{mv}{n^2}$

(c) $\frac{mv}{n}$ (d) $mnv$

**133.** A car moves at a speed of 20 ms$^{-1}$ on a banked track and describes an arc of a circle of radius $40\sqrt{3}$ m. The angle of banking is (g = 10 ms$^{-2}$ )

(a) 25° (b) 60°

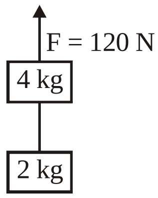
(c) 45° (d) 30°

**134.** A ball of mass 10 g moving perpendicular to the plane of the wall strikes it and rebounds in the same line with the same velocity. If the impulse experienced by the wall is 0.54 Ns, the velocity of the ball is

(a) 27 ms$^{-1}$ (b) 3.7 ms$^{-1}$

(c) 54 ms$^{-1}$ (d) 37 ms$^{-1}$

**135.** Two blocks of masses 2 kg and 4 kg are attached by an inextensible light string as shown in the figure. If a force of 120 N pulls the blocks vertically upward, the tension in the string is (take g = 10 ms$^{-2}$)



(a) 20 N
(b) 15 N
(c) 35 N
(d) 40 N

**136.** A block of mass m is placed on a surface with a vertical cross section given by $y = \frac{x^3}{6}$. If the coefficient of friction is 0.5, the maximum height above the ground at which the block can be placed without slipping is:

(a) $\frac{1}{6}$m (b) $\frac{2}{3}$m

(c) $\frac{1}{3}$m (d) $\frac{1}{2}$m

**137.** Two bodies of masses 1 kg and 2 kg moving with same velocities are stopped by the same force. Then the ratio of their stopping distances is

(a) 1 : 2 (b) 2 : 1

(c) $\sqrt{2}$ : 1 (d) 1 : $\sqrt{2}$

**138.** A block A of mass $m_1$ rests on a horizontal table. A light string connected to it passes over a frictionless pulley at the edge of table and from its other end another block B of mass $m_2$ is suspended. The coefficient of kinetic friction between the block and the table is $\mu_k$. When the block A is sliding on the table, the tension in the string is

(a) $\frac{(m_2 - \mu k\, m_1)g}{(m_1 + m_2)}$ (b) $\frac{m_1 m_2(1+\mu_k)g}{(m_1 + m_2)}$

(c) $\frac{m_1 m_2(1-\mu_k)g}{(m_1 + m_2)}$ (d) $\frac{(m_2 + \mu_k\, m_1)g}{(m_1 + m_2)}$

**139.** The retarding acceleration of 7.35 m s$^{-2}$ due to frictional force stops the car of mass 400 kg travelling on a road. The coefficient of friction between the tyre of the car and the road is

(a) 0.55 (b) 0.75

(c) 0.70 (d) 0.65

**140.** A hammer weighing 3 kg strikes the head of a nail with a speed of 2 ms$^{-1}$ drives it by l cm into the wall. The impulse imparted to the wall is

(a) 6Ns (b) 3Ns

(c) 2Ns (d) 12 Ns

**141.** A balloon with mass ‘m’ is descending down with an acceleration ‘a’ (where a < g). How much mass should be removed from it so that it starts moving up with an acceleration ‘a’?

(a) $\frac{2ma}{g+a}$ (b) $\frac{2ma}{g-a}$

(c) $\frac{ma}{g+a}$ (d) $\frac{ma}{g-a}$

**142.** The time required to stop a car of mass 800 kg, moving at a speed of 20 ms$^{-1}$ over a distance of 25 m is

(a) 2s (b) 2.5s

(c) 4s (d) 4.5s

**143.** A particle rests on the top of a hemisphere of radius R. Find the smallest horizontal velocity that must be imparted to the particle if it is to leave the hemisphere without sliding down is

(a) $\sqrt{gR}$ (b) $\sqrt{2gR}$

(c) $\sqrt{3gR}$ (d) $\sqrt{5gR}$

**144.** A train is moving with a speed of 36 km/hour on a curved path of radius 200 m. If the distance between the rails is 1.5 m, the height of the outer rail over the inner rail is

(a) 1m (b) 0.5m

(c) 0.75m (d) 0.075m

**145.** A car moving on a horizontal road may be thrown out of the road in taking a turn

(a) by the gravitational force

(b) due to the lack of proper centripetal force

(c) due to the rolling frictional force between the tyre and road

(d) due to the reaction of the ground

**146.** A car sometimes overturns while taking a turn. When it overturns, it is

(a) the inner wheel which leaves the ground first

(b) the outer wheel which leaves the ground first

(c) both the wheel leave the ground simultaneously

(d) either wheel will leave the ground first

**147.** On a railway curve the outside rail is laid higher than the inside one so that resultant force exerted on the wheels of the rail car by the tops of the rails will

(a) have a horizontal inward component

(b) be vertical

(c) equilibriate the centripetal force

(d) be decreased

**148.** A sphere is suspended by a thread of length $\ell$. What minimum horizontal velocity has to be imparted to the sphere for it to reach the height of the suspension?

(a) $g\,\ell$ (b) $2\,g\,\ell$

(c) $\sqrt{g\ell}$ (d) $\sqrt{2g\ell}$

**149.** A car when passes through a bridge exerts a force on it which is equal to

(a) $Mg+\frac{Mv^2}{r}$ (b) $\frac{Mv^2}{r}$

(c) $Mg-\frac{Mv^2}{r}$ (d) None of these

**150.** A bridge is in the from of a semi-circle of radius 40m. The greatest speed with which a motor cycle can cross the bridge without leaving the ground at the highest point is ($g = 10\text{ m s}^{-2}$) (frictional force is negligibly small)

(a) 40 m s$^{-1}$ (b) 20 m s$^{-1}$

(c) 30 m s$^{-1}$ (d) 15 m s$^{-1}$

**151.** A particle tied to a string describes a vertical circular motion of radius r continually. If it has a velocity $\sqrt{3\text{ gr}}$ at the highest point, then the ratio of the respective tensions in the string holding it at the highest and lowest points is

(a) 4 : 3 (b) 5 : 4

(c) 1 : 4 (d) 3 : 2

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(d)** Inertia is defined as the ability of a body to oppose any change in its state of rest or of uniform motion.

**2.** **(c)** Newton's first law of motion is related to the physical independence of force.

**3.** **(c)** Newton's first law of motion defines the inertia of body. It states that every body has a tendency to remain in its state (either rest or motion) due to its inertia.

**4.** **(c)** According to Newton's 2nd law of motion

$$F = \frac{\text{change in momentum}}{\text{time}}$$

Thus force depends directly on the rate of change of momentum.

**5.** **(c)** According to Newton's second law of motion, $F = ma$

When body is moving uniformly along a straight line and there is no force of friction, acceleration / retardation of the body $a = 0$,

$\therefore \quad F = ma = 0$

i.e, no external force is required.

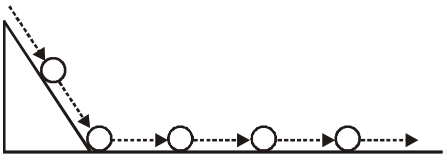
For accelerated motion, force is necessary. In uniform circular motion, elliptical motion and projectile motion direction of velocity changes due to which force is imposed.

**6.** **(c)**

**7.** **(c)** The body will continue accelerating until the resultant force acting on the body becomes zero.

**8.** **(a)** External agencies like gravitational and magnetic forces can exert force on body from distance. When ball is released from some height. Earth exerts gravitational force from distance, ball moves faster with time.

**9.** **(b)**



On second plane ball will move with constant velocity because no external force is there to provide acceleration or retardation.

**10.** **(c)** From Newton's second law if $\Sigma F_i = 0$ then the body is in translational equilibrium.

**11.** **(a)** No force is required for an object moving in straight line with constant velocity or for non acceleration motion.

**12.** **(a)** Since force at a point at any instant is related to the acceleration at that point, at that instant and acceleration is determined only by the instantaneous force and not by any history of the motion of the particle. Therefore, the moment the stone is thrown out of an accelerated train, it has no horizontal force and acceleration, if air resistance is neglected.

**13.** **(a)**

**14.** **(b)** $F = \frac{dp}{dt}$

**15.** **(b)** The frame of reference which are at rest or in uniform motion are called inertial frames while frames which are accelerated with respect to each other are non–inertial frames. Spinning or rotating frames are accelerated frame, hence these are non-inertial frames.

**16.** **(b)** Impulse = Force × time duration. …(1)

According to Newton's second law

$$\text{Force} = \frac{\text{Change in momentum}}{\text{time duration}} \quad \ldots(2)$$

$\therefore$ Force × time = change in momentum

i.e., Impulse = change is momentum.

**17.** **(a)**

**18.** **(a)** Impulse = change in momentum = $m\vec{v}_2 - m\vec{v}_1$

**19.** **(b)** $F = \frac{\Delta P}{\Delta t}$ and impulse = F. $\Delta T$

**20.** **(b)** If a large force F acts for a short time $dt$ the impulse imparted I is

$$I = F.dt = \frac{dp}{dt}.dt$$

I = $dp$ = change in momentum

**21.** **(a)**

**22.** **(a)** Impulse is not a force.

Impulse = Force × Time duration

**23.** **(c)** A book lying on the table is acted by its weight downwards and a reaction upwards.

A car moving on a road, has an applied forward force and force of friction acts backwards. Thus it moves with constant velocity.

Force, F = ma, if a = 0, then $F_{net} = 0$

**24.** **(b)** If the net external force on a body is **zero**, its acceleration is zero.

Acceleration can be **non-zero** only if there is net external force on the body. This is concluded from Newton's first law of motion.

**25.** **(c)** As $f_{ext} = \frac{\Delta P}{\Delta t}$, if $\frac{\Delta P}{\Delta t}$ = constant

i.e, $f_{ext} \propto \Delta t =$ constant. If force is small time taken is more and if force is large time taken is less.

**26.** **(c)**

**27.** **(c)** Swimming is a result of pushing water in the opposite direction of the motion.

**28.** **(a)** Newton's second and third laws of motion leads to the conservation of linear momentum.

**29.** **(c)** Hot gases with high velocity react against the rocket and push it up.

**30.** **(c)** The gun applied a force $F_{12}$ on the bullet in forward direction & according to Newton's third law bullet applies a reaction force on gun $F_{21}$ in backward direction. But the recoil speed of gun is very low in comparison to bullet due to large mass.

**31.** **(b)**

**32.** **(b)** Since no nearby stars are there to exert gravitational force on the astronaut, so the net force acting on him is zero when he moves out of the spaceship. Thus in accordance with first law of motion the acceleration of astronaut will be zero.

**33.** **(d)**

**34.** **(a)** It works on the principle of conservation of linear momentum.

**35.** **(a)** If $m_1$, $m_2$ are masses and $u_1$, $u_2$ are velocity then by conservation of momentum $m_1u_1 + m_2u_2 = 0$ or $|m_1u_1| = |m_2u_2|$

**36.** **(c)**

**37.** **(c)** Motion with constant momentum along a straight line. According to Newton's second law rate of change of momentum is directly proportional to force applied.

**38.** **(d)** $\mu_k < \mu_s$ coefficient of static friction is always greater than kinetic friction.

**39.** **(a)** Since there in no resultant external force, linear momentum of the system remains constant.

**40.** **(c)** Frictional force that opposes relative motion between surfaces in contact is called kinetic friction and denoted by $f_k$.

**41.** **(a)** Coefficient of static friction = $\dfrac{\text{force of friction}}{\text{normal reaction}}$

Therefore, coefficient of static friction depends upon the normal reaction.

**42.** **(c)** Friction does not depend on area of surfaces in contact.

**43.** **(d)** Coefficient of friction is independent of normal force.

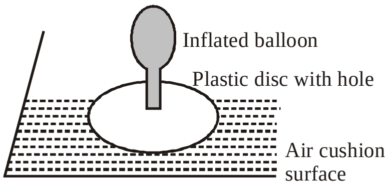
**44.** **(b)** When a box is in stationary position with respect to train moving with acceleration, then relative motion is opposed by the static friction.

**45.** **(c)**

**46.** **(d)** When brakes are on, the wheels of the cycle will slide on the road instead of rolling there. It means the sliding friction will come into play instead of rolling friction. The value of sliding friction is more than that of rolling friction.

**47.** **(d)**

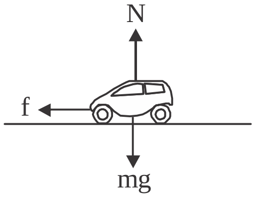
**48.** **(a)** A thin cushion of air maintained between solid surfaces in relative motion is another effective way or reducing friction



Because of air cushion between plastic disc and surface, there is very less friction between plastic disc and surface. So plastic disc can be moved on surface with very less frictional dissipation of energy. This is because friction between solid and air is very small.

**49.** **(c)** When force is applied on a moving body in a direction perpendicular to the direction of motion, then it takes a circular path. Thus the direction of motion changes without changes in the speed.

**50.** **(c)** Normal reaction N = weight mg thus the centripetal force required by the car for circular motion is provided by the component of the force of friction b/w the road and the car tyres.



**51.** **(a)** Optimum speed is given by $V_0 = (Rg \tan\theta)^{1/2}$ on a banked road, the normal reaction's component is enough to provide the necessary centripetal force to a car driven at optimum speed.

**52.** **(a)** Material forces like friction, gravitational force etc. act on the body and provide the centripetal force. The centripetal force cannot be regarded as any kind of force acting externally. It is simple name given to the force that provides inward radial acceleration to a body in circular motion.

**53.** **(a)** Acceleration (centripetal) $a = \dfrac{v^2}{r}$ i.e., $a \propto \dfrac{1}{r}$

**54.** **(d)**

**55.** **(b)** Due to centrifugal force, the inner wheel will be left up when car is taking a circular turn. Due to this, the reaction on outer wheel is more than that on inner wheel.

**56.** **(b)** The cyclist bends while taking turn in order to provide necessary centripetal force.

## STATEMENT TYPE QUESTIONS

**57.** **(b)** A breeze causes branches of tree to swing. In general force is required to put a stationary object in motion.

**58.** **(d)** Newton's 2nd law of motion gives F = ma. Thus it is a measure of force. Newton's first law of motion simply gives a qualitative definition of force.

**59.** **(d)** If a body is moving with a constant velocity then the net force on the body is zero. Also if net force is zero, the body may be moving uniformly along a straight line. Thus both the given statements are false.

**60.** **(b)** There are three types of inertia.

**Inertia of rest :** The resistance of a body to change its state of rest is called inertia of rest.

**Inertia of motion :** The resistance of a body to change its state of motion is called inertia of motion.

**Inertia of direction :** The resistance of a body to change its direction of motion is called inertia of direction.

**61.** **(d)** Action & reaction forces act simultaneously: There is no cause effect relation between action and reaction as any of the two mutual forces can be called action and the other reaction since action & reaction act on different bodies, so they cannot be cancelled out.

**62.** **(c)** When the men push the rough surface on walking, then surface (from Newton' third Law) applies reaction force in forward direction. It occurs because there is friction between men & surface. If surface is frictionless (such as ice), then it is very difficult to move on it.

**63.** **(a)** Newton's laws of motion are applicable only for inertial frames. All refrence frames present on surface of earth are supposed to be inertial frame of refrence.

**64.** **(a)** According to third law of motion bullet experiences a force F then, give experiences an equal and opposite force F. According to second law, FΔt is change in momentum of the bullet, then – FΔt is change in momentum of the gun. Since initially both are at rest, the final momentum = 0. ∴ $P_b + P_g = 0$. Thus the total momentum of (bullet + gun) is conserved.

**65.** **(d)** The static friction comes into play, the moment there is an applied force. As the applied force increases, static friction also increases, remaining equal and opposite to the applied force upto a certain limit. But if the applied force increases so much, it overcomes the static friction and the body starts moving.

**66.** **(c)** Limiting friction is the maximum static friction beyond which the object starts moving. It decreases a little bit before the object comes into motion. Thus limiting friction is less than the kinetic friction.

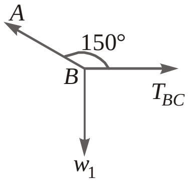
## MATCHING TYPE QUESTIONS

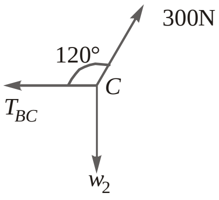
**67.** **(b)** (A)→(4); (B)→(3); C→(1); (D)→(2)

**68.** **(a)** (A)→(4); (B)→(1); C→(2); (D)→(3)

**69.** **(d)** (A)→(4); (B)→(3); C→(1); (D)→(2)

**70.** **(b)** (A) → (2) ; (B) → (1) ; (C) → (4) ; (D) → (3)





Applying Lami's equation, we have

$$\frac{T_{BC}}{\sin 150°} = \frac{W_2}{\sin 120°} = \frac{300}{\sin 90°}$$

and $$\frac{T_{AB}}{\sin 90°} = \frac{W_1}{\sin 150°} = \frac{T_{BC}}{\sin 120°}$$

After simplifying, we get

$T_{AB} = 173$ N, $T_{BC} = 150$ N, $W_1 = 87$ N, $W_2 = 260$ N.

**71.** **(c)** (A)→(3); (B)→(4); C→(1); (D)→(2)

## DIAGRAM TYPE QUESTIONS

**72.** **(c)** Equilibrium under three concurrent forces $F_1$, $F_2$ and $F_3$ requires that vector sum of the three forces is zero.

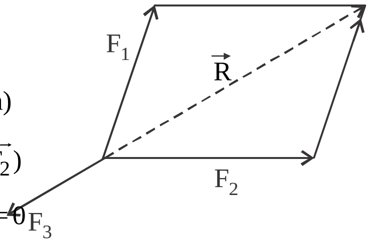
$F_1 + F_2 + F_3 = 0$.

$\vec{R} = \vec{F_1} + \vec{F_2}$

$\vec{F_3} = -\vec{R}$ (In eqbm)

$\therefore \quad \vec{F_3} = -(\vec{F_1} + \vec{F_2})$

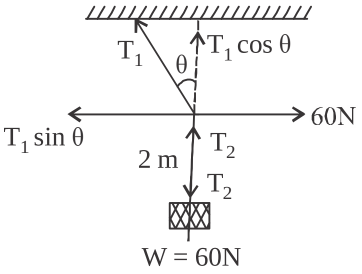
$\therefore \quad \vec{F_1} + \vec{F_2} + \vec{F_3} = 0$



**73.** **(c)** In series each spring will have same force. Here it is 4 kg-wt.

**74.** **(b)** If a body slides down, then the force of friction acts upwards along the plane weight(mg) act vertically downwards.

**75.** **(b)**



In eqbm $T_1 \cos θ = T_2 = 60$N. …(1)

$T_1 \sin θ = 60$ N …(2)

∴ tan θ = 1

θ = 45°.

**76.** **(a)** Equations of motion of $m_1$ & $m_2$ are as:

$T = m_1 a$ …(1)

$m_2 g - T = m_2 a$ …(2)

Adding eqn. (i) and (ii)

$m_2 g = (m_1 + m_2) a$

$$\therefore a = \frac{m_2 g}{m + m_2}$$

**77.** **(d)** Case (a)

$(P_x)_i = mu$ $\qquad P_y(\text{initial}) = 0$

$(P_x)_f = f = -mu$ $\qquad P_y(\text{final}) = 0$

Impulse = $\Delta P = -2mu$ (along $x$–axis)

Impulse = 0 along $y$–axis

parallaly in case (b)

$(P_x)_i = mu \cos 30°$ $\qquad (P_y)_i = -mu \sin 30°$

$(P_x)_f = f = -mu \cos 30°$ $\qquad (P_y)_f = -mu \sin 30°$

$\therefore$ Impulse = $-2mu \cos 30°$ (along $x$-axis)

Impulse = 0 (along $y$–axis)

Force and impulse are in the same direction the force on wall due to the ball is normal to the wall along positive $x$–direction in both (a) & (b) case.

**78.** **(c)** Common acceleration of system is

$$a = \frac{F}{m_1 + m_2 + m_3}$$

$$\therefore \text{ Force on } m_3 \text{ is } F_3 = m_3 \times a = \frac{m_3 F}{m_1 + m_2 + m_3}$$

**79.** **(c)** $a = \dfrac{F}{m_1 + m_2}$

So the acceleration is same whether the force is applied on $m_1$ or $m_2$.

**80.** **(c)** Acceleration

$$= \frac{\text{Net force in the direction of motion}}{\text{Total mass of system}}$$

$$= \frac{m_1 g - \mu(m_2 + m_3)g}{m_1 + m_2 + m_3} = \frac{g}{3}(1 - 2\mu)$$

$(\because\ m_1 = m_2 = m_3 = m \text{ given})$

**81.** **(c)** Change in momentum,

$$\Delta p = \int F dt$$

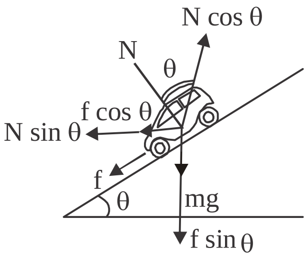
= Area of F-t graph

= ar of Δ – ar of ▭ + ar of ▭

$$= \frac{1}{2} \times 2 \times 6 - 3 \times 2 + 4 \times 3$$

= 12 N-s

**82.** **(a)**



Clearly form the figure, N sinθ and f cosθ contribute to the centripetal force.

$$\therefore N \sin\theta + f \cos\theta = \frac{mv^2}{R}$$

## ASSERTION- REASON TYPE QUESTIONS

**83.** **(a)** According to Newton's second law of motion $a = \dfrac{F}{m}$

*i.e.* magnitude of the acceleration produced by a given force is inversely proportional to the mass of the body. Higher is the mass of the body, lesser will be the acceleration produced i.e. mass of the body is a measure of the opposition offered by the body to change a state, when the force is applied i.e. mass of a body is the measure of its inertia.

**84.** **(a)**

**85.** **(c)** According to Newton's second law

Acceleration = $\dfrac{\text{force}}{\text{mass}}$ i.e. if net external force on the body is zero then acceleration will be zero

**86.** **(c)** Newton's second law can not be used for any object.

**87.** **(d)** Impulse and momentum are different quantities, but both hae same unit ($N$–$s$).

**88.** **(d)** A cricket player moves his hands backward to increase the time interval for reducing the momentum of the ball to zero. Thus the ball does not hit him hard as force is directly proportional to change of momentum.

**89.** **(b)** According to 2nd law of motion;

$$F_1 = \frac{\Delta P_1}{\Delta t_1} \qquad F_2 = \frac{\Delta P_2}{\Delta t_2}$$

$\therefore\ F_1 \times \Delta t_1 = F_2 \times \Delta t_2$

$\Rightarrow\ \Delta P_1 = \Delta P_2$

Thus the same force for the same time causes the same change in momentum for different bodies.

**90.** **(d)** Law of conservation of linear momentum is correct when no external force acts. When bullet is fired form a rifle then both should possess equal momentum but different kinetic energy. $E = \dfrac{p^2}{2m}$ $\therefore$ Kinetic energy of the rifle is less than that of bullet because $E \propto 1/m$

**91.** **(a)**

**92.** **(a)** The force acting on the body of mass M are its weight $Mg$ acting vertically downward and air resistance $F$ acting vertically upward.

$\therefore$ Acceration of the body, $a = g - \dfrac{F}{M}$

Now M > m, therefore, the body with larger mass will have great acceleration and it will reach the ground first.

**93. (d)** The net force on the block is zero, but action cannot cancel the reaction because these two act on different bodies.

**94. (a)** On a rainy day, the roads are wet. Wetting of roads lowers the coefficient of friction between the types and the road. Therefore, grip on a road of car reduces and thus chances of skidding increases.

**95. (d)**

**96. (d)** The man can exert force on block by pulling the rope. The tension in rope will make the man move. Hence statement-1 is false.

**97. (a)** Friction causes wear & tear and loss of energy, so it is an evil but without friction walking. Stopping a vehicle etc. would not be possible. So it is necessary for us.

**98. (c)** The assertion is true for a reason that when the car is driven at optimum speed. Then the normal reaction component is enough to provide the centripetal force.

**99. (b)** When a body is moving in a circle, its speed remains same but velocity changes due to change in the direction of motion of body. According to first law of motion, force is required to change the state of a body. As in circular motion the direction of velocity of body is changing so the acceleration cannot be zero. But for a uniform motion acceleration is zero (for rectilinear motion).

**100. (c)** In uniform circular motion, the direction of motion changes, therefore velocity changes.
As P = mv therefore momentum of a body also changes uniform circular motion.

**101. (c)** The purpose of bending is to acquire centripetal force for circular motion. By doing so component of normal reaction will counter balance the centrifugal force.

## CRITICALTHINKING TYPE QUESTIONS

**102. (b)** The apple will fall slightly away from the hand of his brother in the direction of motion of the train due to inertia of motion. When train is just going to stop, the boy and his brother slows down with train but the apple which is in free fall continue to move with the same speed and therefore, falls slightly away from the hand in the direction of motion of the train.

**103. (d)** Horizontal velocity of ball and person are same so both will cover equal horizontal distance in a given interval of time and after following the parabolic path the ball falls exactly in the hand which threw it up.

**104. (a)** After the stone is thrown out of the moving train, the only force acting on it is the force of gravity i.e. its weight.

$\therefore \quad F = mg = 0.05 \times 10 = 0.5\,N.$

**105. (b)** The pressure on rear side would be more due to fictious force on the rear face. Consequently the pressure in the front side would be lowered.

**106. (c)** When an elevator cabin falls down, it is accelerated down with respect to earth i.e. man standing on earth.

**107. (a)**

**108. (b)**

**109. (c)** Impulse experienced by the body

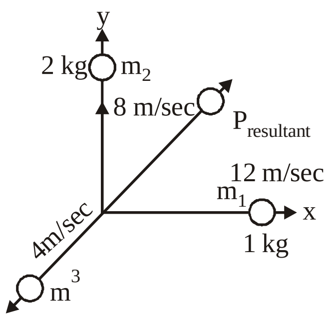
= change in momentum

= MV – (–MV)

= 2MV.

**110. (d)** If rope of lift breaks suddenly, then acceleration becomes equal to g so that tension T = m(g – g) = 0

**111. (a)**



$P_{resultant} = \sqrt{12^2 + 16^2}$

$= \sqrt{144 + 256} = 20$

$m_3 v_3 = 20$ (momentum of third part)

or, $m_3 = \frac{20}{4} = 5\,kg$

**112. (d)** According to law of conservation of momentum the third piece has momentum

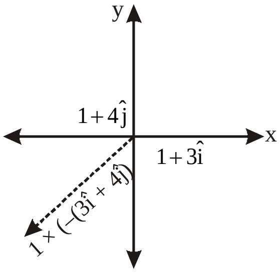
$= 1 \times -(3\hat{i} + 4\hat{j})\ kg\ ms^{-1}$

Impulse = Average force × time

$\Rightarrow$ Average force $= \frac{\text{Impulse}}{\text{time}}$

$= \frac{\text{Change in momentum}}{\text{time}}$

$= \frac{-(3\hat{i} + 4\hat{j})kg\ ms^{-1}}{10^{-4}s}$



**113. (b)** From law of conservation of momentum

$MV = m_1 v_1 + m_2 v_2$

Here, $M = 100$ kg, $v = 10^4\ m\ s^{-1}$

$m_1 = 10$ kg, $v_1 = 0$

$m_2 = 90$ kg, $v_2 = ?$

$\therefore\ 100 \times 10^4 = 10 \times 0 + 90 \times v_2 \quad \therefore\ v_2 = \dfrac{100 \times 10^4}{90}$

$v_2 = 11.11 \times 10^3\ \text{m s}^{-1}$.

**114. (c)** Change in momentum of the ball

$= mv \sin\theta - (-\ mv \sin\ \theta)$

$= 2\ mv \sin\theta$

$= mg \times \dfrac{2v\sin\theta}{g}$

= weight of the ball × total time of flight

**115. (a)** $\text{Mass} = \dfrac{49}{9.8} = 5\ \text{kg}$

When lift is moving downward

Apparent weight = 5(9.8 – 5) = 5 × 4.8 = 24 N

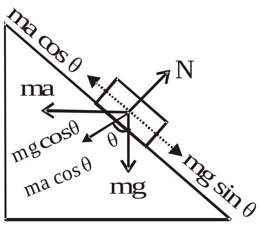
**116. (a)** $N = m\,a \sin\theta + mg \cos\theta$ ......(1)

also $m\,g \sin\theta = m\,a \cos\theta$ ......(2)

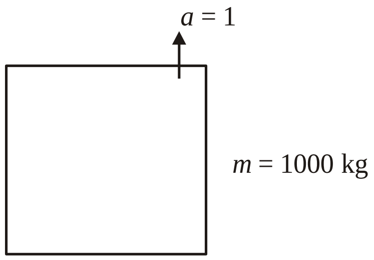
from (2) $a = g \tan\theta$

$\therefore N = mg\dfrac{\sin^2\theta}{\cos\theta} + mg\cos\theta,$

or $N = \dfrac{mg}{\cos\theta}$



**117. (c)**



Total mass = (60 + 940) kg = 1000 kg

Let T be the tension in the supporting cable, then

$T - 1000g = 1000 \times 1$

$\Rightarrow T = 1000 \times 11 = 11000\ \text{N}$

**118. (d)** $\because$ v = constant

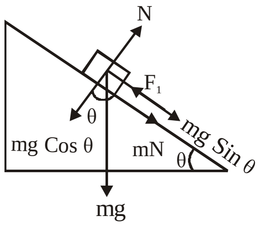
so, a = 0, Hence, $F_{net} = ma = 0$

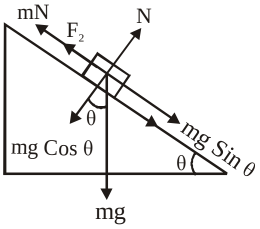
**119. (d)** When a rain drop falls down with the constant speed, its weight is balanced by the upward viscous drag of air and the force of buoyancy. Thus the net force acting on it is zero.

**120. (b)** When force is applied on $m_1$ then $T = m_2a$ and when force is applied on $m_2$, then $T = m_1a$. Thus value of T is different for each case. And it depends on whether the force is applied on $m_1$, or $m_2$.

**121. (b)** Opposite force causes retardation.

**122. (d)** In case (a) In case (b)





$mg \sin\theta = F_1 - \mu N$

$N = mg \cos\theta$

$\therefore\ mg \sin\theta + \mu\, mg \cos\theta = F_1$

In second case (b)

$\mu N + F_2 = mg \sin\theta$

$\mu\, mg \cos\theta - F_2 = mg \sin\theta$

or $F_2 = mg \sin\theta - \mu mg \cos\theta$

but $F_1 = 2F_2$

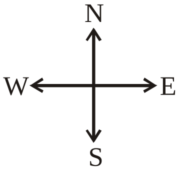
therefore $mg \sin\theta + \mu\, mg \cos\theta$

$= 2(mg \sin\theta - \mu\, mg \cos\theta)$

$mg \sin\theta = 3\, \mu\, mg \cos\theta$

or $\tan\theta = 3\mu$ or $\theta = \tan^{-1}(3\mu)$

**123. (c)** Frictional force is always opposite to the direction of motion



**124. (a)** $m_Bg = \mu_s m_Ag \quad \{\because m_Ag = \mu_s m_Ag\}$

$\Rightarrow m_B = \mu_s m_A$

or $m_B = 0.2 \times 2 = 0.4$ kg

**125. (d)** Frictional force on the box $f = \mu mg$

$\therefore$ Acceleration in the box

$a = \mu g = 5\ \text{ms}^{-2}$

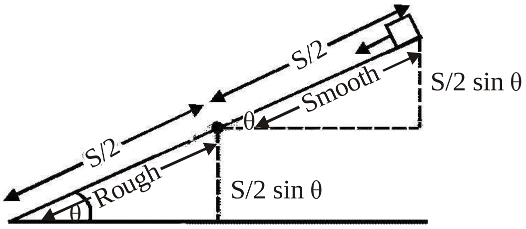
$v^2 = u^2 + 2as$

$\Rightarrow \quad 0 = 2^2 + 2 \times (5)\, s$

$\Rightarrow s = -\dfrac{2}{5}$ w.r.t. belt

$\Rightarrow$ distance = 0.4 m

**126. (b)**



For upper half of inclined plane

$v^2 = u^2 + 2a\, S/2 = 2\,(g \sin\theta)\, S/2 = gS \sin\theta$

For lower half of inclined plane

$0 = u^2 + 2\,g\,(\sin\theta - \mu\cos\theta)\, S/2$

$\Rightarrow -gS \sin\theta = gS\,(\sin\theta - \mu\cos\theta)$

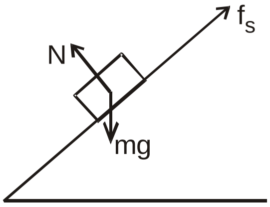
$\Rightarrow 2\sin\theta = \mu\cos\theta$

$$\Rightarrow \mu = \frac{2\sin\theta}{\cos\theta} = 2\tan\theta$$

**127. (a)** $a = \mu g = \frac{6}{10}$ [using v = u + at]

$$\Rightarrow \quad \mu = \frac{6}{10\times g} = \frac{6}{10\times 10} = 0.06$$

**128. (c)**



$mg \sin\theta = f_s$ ( for body to be at rest)

$\Rightarrow m\times 10\times \sin 30° = 10$

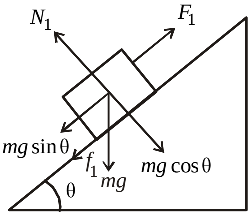
$\Rightarrow m = 2.0\text{ kg}$

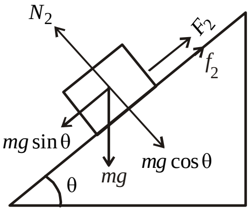
**129. (a)** We have $\sqrt{\frac{2s}{g(\sin\theta - \mu\cos\theta)}} = n\sqrt{\frac{2s}{g\sin\theta}}$

$$\frac{2s}{g(\sin\theta - \mu\cos\theta)} = \frac{2s\times n^2}{g\sin\theta}$$

here $\theta = 45^\circ \Rightarrow \frac{1}{1-\mu} = n^2$ or $\mu = (1 - 1/n^2)$

**130. (c)**





For the upward motion of the body

$mg \sin\theta + f_1 = F_1$

or, $F_1 = mg \sin\theta + \mu mg \cos\theta$

For the downward motion of the body,

$mg \sin\theta - f_2 = F_2$

or $F_2 = mg \sin\theta - \mu mg \cos\theta$

$$\therefore \quad \frac{F_1}{F_2} = \frac{\sin\theta + \mu\cos\theta}{\sin\theta - \mu\cos\theta}$$

$$\Rightarrow \quad \frac{\tan\theta + \mu}{\tan\theta - \mu} = \frac{2\mu + \mu}{2\mu - \mu} = \frac{3\mu}{\mu} = 3$$

**131. (c)** It is a case of uniform circular motion in which velocity and acceleration vectors change due to change in direction. As the magnitude of velocity remains constant, the kinetic energy is constant.

**132. (d)** By Newton's second law of motion

$$F = n(mv) = nmv$$

**133. (d)** Angle of banking is $\tan\theta = \frac{v^2}{rg} = \frac{20^2}{40\sqrt{3}\times 10}$

$$\tan\theta = \frac{1}{\sqrt{3}}$$

$\therefore \quad \theta = 30^\circ$

**134. (a)** As the ball, m = 10 g = 0.01 kg rebounds after striking the wall

$\therefore$ Change in momentum $= mv - (-mv) = 2\,mv$

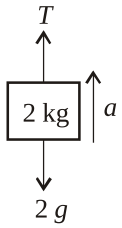
Inpulse = Change in momentum = $2mv$

$$\therefore\ v = \frac{\text{Impulse}}{2m} = \frac{0.54\text{ N s}}{2\times 0.01\text{ kg}} = 27\text{ m s}^{-1}$$

**135. (d)** Acceleration of the system

$$a = \frac{F - 4g - 2g}{4+2} = \frac{120 - 40 - 20}{6}$$

$= 10\text{ ms}^{-2}$



FBD of block

From figure

$T - 2g = 2a$

$T = 2\,(a + g) = 2\,(10 + 10)$

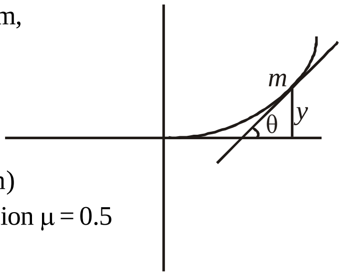
$= 40\text{ N}$

**136. (a)** At limiting equilibrium,

$\mu = \tan\theta$

$$\tan\theta = \mu = \frac{dy}{dx} = \frac{x^2}{2}$$

(from question)



$\because$ Coefficient of friction $\mu = 0.5$

$$\therefore \quad 0.5 = \frac{x^2}{2}$$

$$\Rightarrow \quad x = \pm 1$$

$$\text{Now, } y = \frac{x^3}{6} = \frac{1}{6} m$$

**137. (a)** Energy of both bodies is given by

$KE_1 = F.S_1$

$KE_2 = F.S_2$

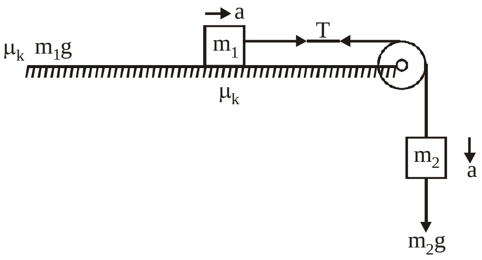
As force is equal

$$\therefore \frac{S_1}{S_2} = \frac{m_1 v_1^2}{m_2 v_2^2} = \frac{m_1}{m_2} = \frac{1}{2} \qquad [\because v_1 = v_2]$$

**138. (b)** For the motion of both the blocks

$m_1 a = T - \mu_k m_1 g$

$m_2 g - T = m_2 a$



$$a = \frac{m_2 g - \mu_k m_1 g}{m_1 + m_2}$$

$$m_2 g - T = (m_2)\left(\frac{m_2 g - \mu_k m_1 g}{m_1 + m_2}\right)$$

solving we get tension in the string

$$T = \frac{m_1 mg\,(1 + \mu_k) g}{m_1 + m_2}$$

**139. (b)** As we know, coefficient of friction $\mu = \frac{F}{N}$

$$\Rightarrow \mu = \frac{ma}{mg} = \frac{a}{g} \quad (a = 7.35 \text{ m s}^{-2} \text{ given})$$

$$\therefore \mu = \frac{7.35}{9.8} = 0.75$$

**140. (a)** As we know, |impulse| = |change in momentum|

$= |p_2 - p_1|$

$= |0 - mv_1| = |0 - 3 \times 2| = 6$ Ns

**141. (a)** Let upthrust of air be $F_a$ then

For downward motion of balloon

$F_a = mg - ma$

$mg - F_a = ma$

For upward motion

$F_a - (m - \Delta m)g = (m - \Delta m)a$

$$\text{Therefore } \Delta m = \frac{2ma}{g + a}$$

**142. (b)** As we know, $S = \left(\frac{u+v}{2}\right)t$

$$\left(\frac{0+20}{2}\right)t = 25 \quad \therefore t = 2.5\text{s}$$

**143. (a)** The velocity should be such that the centripetal acceleration is equal to the acceleration due to gravity

$$\frac{v^2}{R} = g \text{ or } v = \sqrt{gR}$$

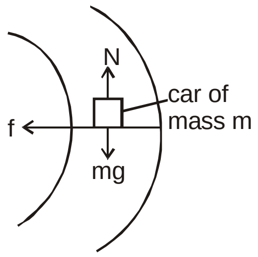
**144. (d)** $\tan\theta = v^2/rg,\ \tan\theta = H/1.5,\ r = 200\text{ m}, b = 1.5\text{ m}$

$v = 36$ km/hour $= 36 \times (5/18) = 10$ m/s.

Putting these values, we get H = 0.075 m.

**145. (b)** It means that car which is moving on a horizontal road & the necessary centripetal force, which is provided by friction (between car & road) is not sufficient.

If $\mu$ is friction between car and road, then max speed of safely turn on horizontal road is determined from figure.



$N = mg$ ...(i)

$$f = \frac{mv^2}{r} \qquad \text{...(ii)}$$

Where f is frictional force between road & car, N is the normal reaction exerted by road on the car. We know that

$f = \mu_s N = \mu_s mg$ ......(iii)

where $\mu_s$ is static friction

so from eq (ii) & (iii) we have

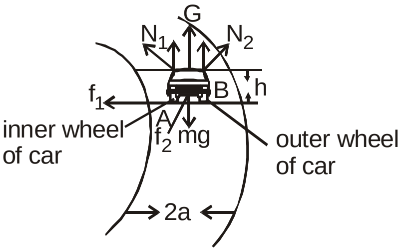
$$\frac{mv^2}{r} \le \mu_s mg \Rightarrow v^2 \le \mu_s rg \text{ or } v \le \sqrt{\mu_s rg}$$

$$\& \ v_{max} = \sqrt{\mu_s rg}$$

If the speed of car is greater than $v_{max}$ at that road, then it will be thrown out from road i.e., skidding.

**146. (a)** The car over turn, when reaction on inner wheel of car is zero, i.e., first the inner wheel of car leaves the ground (where G is C.G of car, h is height of C.G from the ground, $f_1$ & $f_2$ are frictional force exerted by ground on inner &

outer wheel respectively). The max. speed for no over turning is

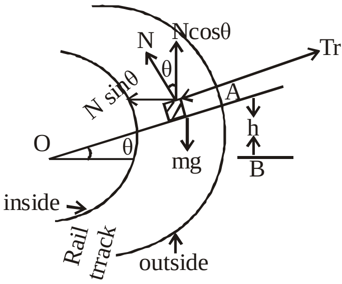


$$v_{\max} = \sqrt{\frac{gra}{h}}$$

where r is radius of the path followed by car for turn & 2a is distance between two wheels of car (i.e., AB)

**147. (a)** If the outside rail is h units higher than inside of rail track as shown in figure then

$N\cos\theta = mg$....................(i)



$$N\sin\theta = \frac{mv^2}{r} \text{ ..................(ii)}$$

$$\& \tan\theta = \frac{v^2}{rg} \text{ ....................(iii)}$$

Where θ is angle of banking of rail track, N is normal reaction exerted by rail track on rail.

It is clear from the equation (i) & (ii) that N cosθ balance the weight of the train & N sinθ provide the necessary centripetal force to turn.

If width of track is $\ell$ (OB) & h (AB) be height of outside of track from the inside, then

$$\tan\theta = \frac{h}{\ell} = \frac{v^2}{rg} \text{ or } h = \frac{v^2\ell}{rg} \text{ .................(iv)}$$

So it is clear from the above analysis that if we increase the height of track from inside by h metre then resultant force on rail is provided by railway track & whose direction is inwards.

**148. (d)** $\frac{1}{2}mv^2 = mg\ell$ or $v = \sqrt{(2g\ell)}$

**149. (c)** Force exerted by a car when passes through a bridge

$$F = Mg - \frac{Mv^2}{r}.$$

**150. (b)** $v = \sqrt{gr} = \sqrt{10 \times 40} = 20 \text{ m s}^{-1}$

**151. (c)** Tension at the highest point

$$T_{top} = \frac{mv^2}{r} - mg = 2mg \quad (\therefore v_{top} = \sqrt{3gr})$$

Tension at the lowest point

$T_{bottom} = 2mg + 6mg = 8mg$

$$\therefore \frac{T_{top}}{T_{bottom}} = \frac{2mg}{8mg} = \frac{1}{4}.$$

## CHAPTER 6

# WORK, ENERGY AND POWER

## FACT/DEFINITION TYPE QUESTIONS

**1.** No work is done if
(a) displacement is zero
(b) force is zero
(c) force and displacement are mutually perpendicular
(d) All of these

**2.** The magnitude of work done by a force
(a) depends on frame of reference
(b) does not depend on frame of reference
(c) cannot be calculated in non-inertial frames.
(d) both (a) and (b)

**3.** Work is always done on a body when
(a) a force acts on it
(b) it moves through a certain distance
(c) it experiences an increase in energy through a mechanical influence
(d) None of these

**4.** A boy carrying a box on his head is walking on a level road from one place to another is doing no work. This statement is
(a) correct (b) incorrect
(c) partly correct (d) cannot say

**5.** When the force retards the motion of body, the work done is
(a) zero
(b) negative
(c) positive
(d) Positive or negative depending upon the magnitude of force and displacement

**6.** In which of the following work is being not done?
(a) Shopping in the supermarket
(b) Standing with a basket of fruit on the head
(c) Climbing a tree
(d) Pushing a wheel barrow

**7.** A man pushes a wall and fails to displace it, he does
(a) negative work
(b) positive but not maximum work
(c) no work at all
(d) maximum positive work

**8.** According to work-energy theorem, the work done by the net force on a particle is equal to the change in its
(a) kinetic energy (b) potential energy
(c) linear momentum (d) angular momentum

**9.** A light and a heavy body have equal momentum. Which one has greater K.E.?
(a) The lighter body
(b) The heavier body
(c) Both have equal K.E.
(d) Data given is incomplete

**10.** A particle of mass $m$ has momentum $p$. Its kinetic energy will be
(a) $mp$ (b) $p^2m$
(c) $\frac{p^2}{m}$ (d) $\frac{p^2}{2m}$

**11.** Kinetic energy, with any reference, must be
(a) zero (b) positive
(c) negative (d) both (b) and (c)

**12.** Total ....$X$.... energy of a system is conserved, if the forces, doing work on it, are .....$Y$..... .
Here, $X$ and $Y$ refer to
(a) conservative, mechanical
(b) mechanical, conservative
(c) mechanical, non-conservative
(d) kinetic, conservative

**13.** A bullet is fired and gets embedded in block kept on table. If table is frictionless, then
(a) kinetic energy gets conserved
(b) potential energy gets conserved
(c) momentum gets conserved
(d) both (a) and (c)

**14.** Unit of energy is
(a) kwh (b) joule
(c) electron volt (d) All of these

**15.** Which of the following is not a conservative force?
(a) Gravitational force (b) Frictional force
(c) Spring force (d) None of these

**16.** If a light body and heavy body have same kinetic energy, then which one has greater linear momentum?
(a) Lighter body (b) Heavier body
(c) Both have same momentum (d) Can't be predicted

**17.** The time rate of change of kinetic energy is equal to

(a) $\frac{1}{2}m\frac{dv}{dt}$ (b) $m\frac{dv}{dt}v$

(c) $m\frac{dv}{dt}$ (d) $\frac{1}{2}mv\frac{dv}{dt}$

**18.** Two bodies of different masses are moving with same kinetic energy. Then the ratio of their momenta is equal to the ratio of their

(a) masses (b) square of masses

(c) square root of masses (d) cube root of masses

**19.** A spring with force constant k is initially stretched by $x_1$ . If it is further stretched by $x_2$, then the increase in its potential energy is

(a) $\frac{1}{2}k(x_2 - x_1)^2$ (b) $\frac{1}{2}kx_2(x_2 + 2x_1)$

(c) $\frac{1}{2}kx_1{}^2 - \frac{1}{2}kx_2{}^2$ (d) $\frac{1}{2}k(x_1 + x_2)^2$

**20.** The speed of an object of mass *m* dropped from an inclined plane (frictionless), at the bottom of the plane, depends on:

(a) height of the plane above the ground

(b) angle of inclination of the plane

(c) mass of the object

(d) All of these

**21.** A particle is taken round a circle by application of force. The work done by the force is

(a) positive non–zero (b) negative non–zero

(c) Zero (d) None of the above

**22.** Four particles given, have same momentum. Which has maximum kinetic energy

(a) Proton (b) Electron

(c) Deutron (d) $\alpha$-particles

**23.** The potential energy of a system increases if work is done

(a) upon the system by a non conservative force

(b) by the system against a conservative force

(c) by the system against a non conservative force

(d) upon the system by a conservative force

**24.** The temperature at the bottom of a high water fall is higher than that at the top because

(a) by itself heat flows from higher to lower temperature

(b) the difference in height causes a difference in pressure

(c) thermal energy is transformed into mechanical energy

(d) mechanical energy is transformed into thermal energy.

**25.** If two particles are brought near one another, the potential energy of the system will

(a) increase (b) decrease

(c) remains the same (d) equal to the K.E

**26.** Which of the following is correct?

(a) $W = FS\cos\theta$

(b) $P.E. = mgh$

(c) $K.E. = \frac{1}{2}mv^2$

(d) All of these

**27.** Work done by a conservative force is positive if

(a) P.E. of the body increases

(b) P.E. of the body decreases

(c) K.E. of the body increases

(d) K.E. of the body decreases

**28.** The potential energy of a system increases if work is done

(a) upon the system by a non conservative force

(b) by the system against a conservative force

(c) by the system against a non conservative force

(d) upon the system by a conservative force

**29.** The ...*X*... energy *V*(*x*) of the spring is said to be zero when block and spring system is in the ...*Y*... position.

Here, *X* and *Y* refer to

(a) potential, equilibrium

(b) kinetic, equilibrium

(c) mechanical, equilibrium

(d) vibrational, left

**30.** For a conservative force in one dimension, potential energy function V(x) is related to the force F(x) as

(a) $F(x) = \frac{-dV(x)}{dx}$ (b) $F(x) = \frac{dV(x)}{dx}$

(c) $F(x) = V(x)dx$ (d) $F(x) = \int\frac{-dV(x)}{dx}$

**31.** The total mechanical energy of a system is conserved if the force, doing work on it is

(a) constant (b) variable

(c) conservative (d) non-conservative

**32.** If stretch in a spring of force constant k is doubled then the ratio of elastic potential energy in the two cases will be

(a) 4 : 1 (b) 1 : 4

(c) 2 : 1 (d) 1 : 2

**33.** The energy stored in wounded spring watch is

(a) Kinetic (b) Potential

(c) Heat (d) chemical

**34.** The work done in stretching a spring of force constant k from length $\ell_1$ and $\ell_2$ is

(a) $k(\ell_2^2 - \ell_1^2)$ (b) $\frac{1}{2}k(\ell_2^2 - \ell_1^2)$

(c) $k(\ell_2 - \ell_1)$ (d) $\frac{k}{2}(\ell_2 + \ell_1)$

**35.** Which of the following force(s) is/are non-conservative?

(a) Frictional force (b) Spring force

(c) Elastic force (d) All of these

**36.** Law of conservation of energy states that

(a) work done is zero

(b) energy is zero

(c) work done is constant

(d) energy of world is constant

**37.** If a force F is applied on a body and it moves with a velocity V, the power will be

(a) F×v (b) F/v

(c) $F/v^2$ (d) $F \times v^2$

**38.** Unit of power is

(a) kilowatt hour (b) kilowatt/hour

(c) watt (d) erg

**39.** Which of the following must be known in order to determine the power output of an automobile?
(a) Final velocity and height
(b) Mass and amount of work performed
(c) Force exerted and distance of motion
(d) Work performed and elapsed time of work

**40.** If a shell fired from a cannon, explodes in mid air, then
(a) its total kinetic energy increases
(b) its total momentum increases
(c) its total momentum decreases
(d) None of these

**41.** Which one of the following statements is true?
(a) Momentum is conserved in elastic collisions but not in inelastic collisions
(b) Total kinetic energy is conserved in elastic collisions but momentum is not conserved in elastic collisions
(c) Total kinetic energy is not conserved but momentum is conserved in inelastic collisions
(d) Kinetic energy and momentum both are conserved in all types of collisions

**42.** When after collision the deformation is not relived and the two bodies move together after the collision, it is called
(a) elastic collision
(b) inelastic collision
(c) perfectly inelastic collision
(d) perfectly elastic collision

**43.** In an inelastic collision, which of the following does not remain conserved?
(a) Momentum
(b) kinetic energy
(c) Total energy
(d) Neither momentum nor kinetic energy

**44.** The coefficient of restitution e for a perfectly elastic collision is
(a) 1 (b) 0
(c) $\infty$ (d) –1

**45.** The coefficient of restitution e for a perfectly inelastic collision is
(a) 1 (b) 0
(c) $\infty$ (d) –1

**46.** When two bodies stick together after collision, the collision is said to be
(a) partially elastic (b) elastic
(c) inelastic (d) perfectly inelastic

**47.** Consider the elastic collision of two bodies A and B of equal mass. Initially B is at rest and A moves with velocity v. After the collision
(a) the body A traces its path back with the same speed
(b) the body A comes to rest and B moves away in the direction of A's approach with the velocity v
(c) both the bodies stick together and are at rest
(d) B moves along with velocity v/2 and A retraces its path with velocity v/2.

**48.** The principle of conservation of linear momentum can be strictly applied during a collision between two particles provided the time of impact
(a) is extremely small
(b) is moderately small
(c) is extremely large
(d) depends on particular case

**49.** In a one-dimensional elastic collision, the relative velocity of approach before collision is equal to
(a) sum of the velocities of the bodies
(b) e times the relative velocity of separation after collision
(c) 1/e times the relative velocity of separation after collision
(d) relative velocity of separation after collision

**50.** In case of elastic collision, at the time of impact.
(a) total K.E. of colliding bodies is conserved.
(b) total K.E. of colliding bodies increases
(c) total K.E. of colliding bodies decreases
(d) total momentum of colliding bodies decreases.

**51.** When two spheres of equal masses undergo glancing elastic collision with one of them at rest, after collision they will move
(a) opposite to one another
(b) in the same direction
(c) together
(d) at right angle to each other

**52.** In an inelastic collision
(a) momentum is not conserved
(b) momentum is conserved but kinetic energy is not conserved
(c) both momentum and kinetic energy are conserved
(d) neither momentum nor kinetic energy is conserved

**53.** In an elastic collision, what is conserved ?
(a) Kinetic energy (b) Momentum
(c) Both (a) and (b) (d) Neither (a) nor (b)

**54.** In elastic collision, 100% energy transfer takes place when
(a) $m_1 = m_2$ (b) $m_1 > m_2$
(c) $m_1 < m_2$ (d) $m_1 = 2m_2$

## STATEMENT TYPE QUESTIONS

**55.** Choose the correct statement(s) from the following.
I. No work is done if the displacement is perpendicular to the direction of the applied force
II. If the angle between the force and displacement vectors is obtuse, then the work done is negative
III. All the central forces are non-conservative
(a) I only (b) I and II
(c) II and III (d) I, II and III

**56.** Consider the following statements and select the incorrect statement(s).
I. If work is done on a body against some force, then kinetic energy has to change.
II. No work done on earth by sun when it revolves around the sun in a perfectly circular orbit
III. K.E. can never be negative
(a) I only (b) II only
(c) I and II (d) I, II and III

**57.** Which of the following statement(s) is/are correct?

I. K.E. of a system can be changed without changing its momentum

II. Momentum of a system can be changed without changing its K.E.

(a) I only (b) II only
(c) I and II (d) None of these

**58.** Which of the following statements are incorrect for an oscillating spring?

I. Kinetic energy is maximum at the extreme position

II. Kinetic energy is minimum at the extreme position

III. Potential energy is maximum at equilibrium position

(a) I and II (b) II and III
(c) I and III (d) I, II and III

**59.** Identify the correct statement(s) from the following.

I. Work-energy theorem is not independent of Newton's second law.

II. Work-energy theorem holds in all inertial frames.

III. Work done by friction over a closed path is zero.

(a) I only (b) II and III
(c) I and II (d) I, II and III

**60.** Which of the following statements are incorrect ?

I. If there were no friction, work need to be done to move a body up an inclined plane is zero.

II. If there were no friction, moving vehicles could not be stopped even by locking the brakes.

III. As the angle of inclination is increased, the normal reaction on the body placed on it increases.

IV. A duster weighing 0.5 kg is pressed against a vertical board with a force of 11 N. If the coefficient of friction is 0.5, the work done in rubbing it upward through a distance of 10 cm is 0.55J.

(a) I and II (b) I, II and IV
(c) I, III and IV (d) I, II, III and IV

**61.** A force $F(x)$ is conservative, if

I. it can be derived from a scalar quantity $V(x)$.

II. it depends only on the end points.

III. work done by $F(x)$ in a closed path is zero.

Which of the following option is correct ?

(a) Only I (b) I and III
(c) Only II (d) I, II and III

**62.** Choose the correct conversion taking place in the generation of electricity by burning of coal in a thermal station in all the stages.

I. Chemical energy to heat energy

II. Heat energy to mechanical energy

III. Mechanical energy to electrical energy

(a) II and III (b) I and II
(c) I and III (d) I, II and III

**63.** Consider the following statements and select the correct statements.

I. Work energy theorem is a scalar form of Newton's second law.

II. Conservation of mechanical energy is a consequence of work energy theorem for conservative forces

III. Work energy theorem holds in all inertial frames

(a) I and II (b) II and III
(c) I and III (d) I, II and III

**64.** In elastic collision,

I. initial kinetic energy is equal to the final kinetic energy.

II. kinetic energy during the collision time $\Delta t$ is constant.

III. total momentum is conserved.

Which of the above statements is/are correct ?

(a) Only I (b) I and III
(c) Only III (d) Only II

## MATCHING TYPE QUESTIONS

**65.** A small block of mass 200*g* is kept at the top of a an incline which is 10 *m* long and 3.2 *m* high. Match the columns

| | Column I | | Column II |
|---|---|---|---|
| (A) | Work done, to lift the block from the ground and put it at the top | (1) | 6.4 J |
| (B) | Work done to slide the block up the incline | (2) | 7.2 J |
| (C) | the speed of the block at the ground when left from the top of the incline to fall vertically | (3) | 4 m/s |
| (D) | The speed of the block at the ground when side along the incline | (4) | 8 m/s |

(a) (A)→(2); (B)→(3); C→(1); (D)→(4)
(b) (A)→(1); (B)→(1); C→(3); (D)→(3)
(c) (A)→(4); (B)→(3); C→(2); (D)→(2)
(d) (A)→(1); (B)→(3); C→(1); (D)→(2)

**66.** If W represents the work done, then match the two columns:

| | Column I | | Column II |
|---|---|---|---|
| (A) | Force is always along the velocity | (1) | $W = 0$ |
| (B) | Force is always perpendicular to velocity | (2) | $W < 0$ |
| (C) | Force is always perpendicular to acceleration | (3) | $W > 0$ |
| (D) | The object is stationary but the point of application of the force moves on the object | | |

(a) (A)→(1); (B)→(2); C→(3); (D)→(2)
(b) (A)→(3); (B)→(1); C→(2,3); (D)→(1)
(c) (A)→(2); (B)→(3); C→(1); (D)→(2)
(d) (A)→(1); (B)→(2); C→(3); (D)→(1)

**67.** Column I represents work done by forces and column II represents change in kinetic energy $\Delta k$, change in potential energy $\Delta U$, change in mechanical energy $\Delta E$. Then match the two columns

| | Column I | | Column II (magnitude only) |
|---|---|---|---|
| (A) | Work done by conservative force | (1) | $\Delta K$ |
| (B) | Work done by non-conservative force | (2) | $\Delta U$ |
| (C) | Work done by internal force | (3) | $\Delta E$ |
| (D) | Work done by external force | | |

(a) (A)→(1,2); (B)→(1,2); C→(1,2); (D)→(1,3)
(b) (A)→(3); (B)→(1); C→(1,2); (D)→(3)
(c) (A)→(3); (B)→(2); C→(1); (D)→(2,3)
(d) (A)→(1,3); (B)→(2,3); C→(2); (D)→(1)

**68.**

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Kinetic energy | (1) | Drilling anail |
| (B) | Potential energy | (2) | Water tank on the roof |
| (C) | Mechanical energy | (3) | Pushing a wall |
| (D) | Muscular energy | (4) | Motion of a car |

(a) (A)→(2); (B)→(3); C→(1); (D)→(4)
(b) (A)→(1); (B)→(1); C→(3); (D)→(3)
(c) (A)→(4); (B)→(2); C→(1); (D)→(3)
(d) (A)→(1); (B)→(3); C→(1); (D)→(2)

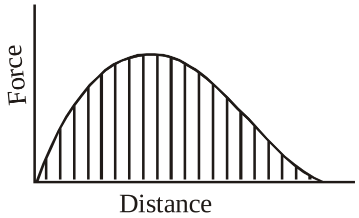
**69.**

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Kinetic Energy | (1) | Stretched spring |
| (B) | Potential Energy | (2) | Watt |
| (C) | Collision | (3) | Elastic or inelastic |
| (D) | Power | (4) | A boy running on the roof |

(a) (A)→(2); (B)→(3); C→(1); (D)→(4)
(b) (A)→(1); (B)→(1); C→(3); (D)→(3)
(c) (A)→(4); (B)→(3); C→(2); (D)→(2)
(d) (A)→(4); (B)→(1); C→(3); (D)→(2)

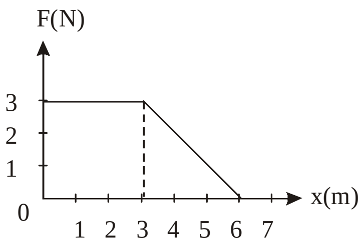
## DIAGRAM TYPE QUESTIONS

**70.** Which one of the following physical quantities is represented by the shaded area in the given graph?



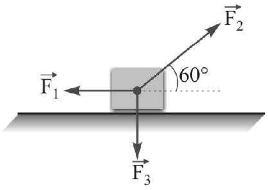
(a) Torque (b) Impulse
(c) Power (d) Work done

**71.** A force F acting on an object varies with distance x as shown here. The force is in N and x in m. The work done by the force in moving the object from x = 0 to x = 6 m is



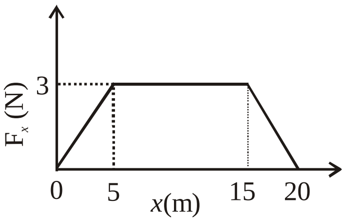
(a) 18.0 J (b) 13.5 J
(c) 9.0 J (d) 4.5 J

**72.** Figure shows three forces applied to a trunk that moves leftward by 3 m over a smooth floor. The force magnitudes are $F_1 = 5N$, $F_2 = 9N$, and $F_3 = 3N$. The net work done on the trunk by the three forces



(a) 1.50 J (b) 2.40 J
(c) 3.00 J (d) 6.00 J

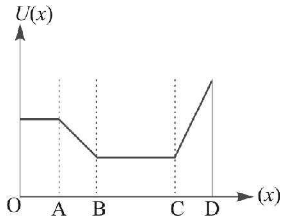
**73.** A force $F_x$ acts on a particle such that its position x changes as shown in the figure.



The work done by the particle as it moves from x = 0 to 20 m is

(a) 37.5 J (b) 10 J
(c) 45 J (d) 22.5 J

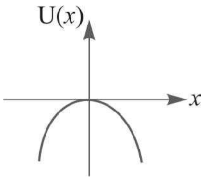
**74.** The figure gives the potential energy function $U(x)$ for a system in which a particle is in one-dimensional motion. In which region the magnitude of the force on the particle is greatest :



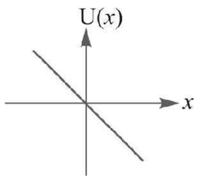
(a) *OA* (b) *AB*
(c) *BC* (d) *CD*

**75.** A particle is placed at the origin and a force $F = kx$ is acting on it (where $k$ is positive constant). If $U(0) = 0$, the graph of $U(x)$ versus $x$ will be (where $U$ is the potential energy function) :

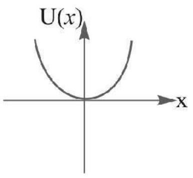
(a)



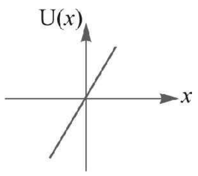
(b)



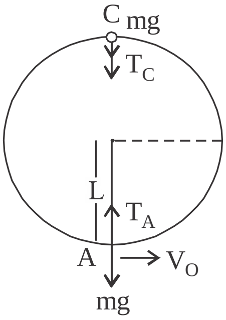
(c)



(d)



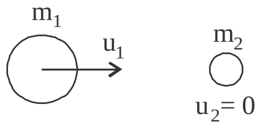
**76.** Figure shows a bob of mass *m* suspended from a string of length L. The velocity is $V_0$ at A, then the potential energy of the system is _______ at the lowest point A.



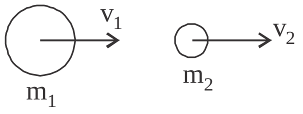
(a) $\frac{1}{2}mv_0^2$ (b) mgh

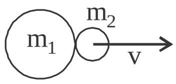
(c) $\frac{-1}{2}mv_0^2$ (d) zero

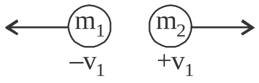
**77.** For the given case which figure is correctly showing the after inelastic collision situation?



Before collision

(a)


(b)


(c)


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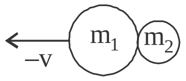
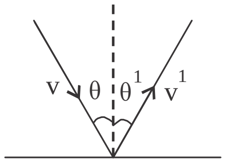


**78.** A ball of mass *m* hits the floor making an angle θ as shown in the figure. If e is the coefficient of restitution, then which relation is true, for the velocity component before and after collision?



(a) $V^1 \sin\theta = V \sin\theta$ (b) $V^1 \sin\theta' = -\sin\theta$

(c) $V^1 \cos\theta' = V \cos\theta$ (d) $V^1 \cos\theta' = -V \cos\theta$

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

**79.** **Assertion :** The work done in moving a body over a closed loop is zero for every force in nature.

**Reason :** Work done depends on nature of force.

**80.** **Assertion :** A force applied on the body always does work on the body.

**Reason :** If a force applied on a body displaces the body along the direction of force work done will be maximum.

**81.** **Assertion :** A man rowing a boat upstream is at rest with respect to the bank. He is doing no external work.

**Reason :** Work done by constant force, $W = F s \cos\theta$.

**82.** **Assertion :** The rate of change of total momentum of a many particle system is proportional to the sum of the internal forces of the system.

**Reason :** Internal forces can change the kinetic energy but not the momentum of the system.

**83.** **Assertion :** A work done by friction is always negative.

**Reason :** If frictional force acts on a body its K.E. may decrease.

**84.** **Assertion :** The change in kinetic energy of a particle is equal to the work done on it by the net force.

**Reason :** Change in kinetic energy of particle is equal to workdone only in case of a system of one particle.

**85.** **Assertion:** Kinetic energy of a body is quadrupled, when its velocity is doubled.

**Reason :** Kinetic energy is proportional to square of velocity. If velocity is doubled the K.E. will be quadrupled

**86.** **Assertion:** If the velocity of a body is tripled, then K.E. becomes 9 times.

**Reason :** Kinetic energy, K.E.= $\frac{1}{2}$ mv$^2$

**87.** **Assertion:** Kinetic energy of a system can be increased or decreased without applying any external force on the system.

**Reason:** This is because K.E. = $\frac{1}{2}$mV$^2$, so it independent of any external forces.

**88.** If two springs $S_1$ and $S_2$ of force constants $k_1$ and $k_2$, respectively, are stretched by the same force, it is found that more work is done on spring $S_1$ than on spring $S_2$.

**Assertion :** If stretched by the same amount work done on $S_1$

**Reason :** $k_1 < k_2$

**89.** **Assertion :** A spring has potential energy, both when it is compressed or stretched.

**Reason :** In compressing or stretching, work is done on the spring against the restoring force.

**90.** **Assertion :** Graph between potential energy of a spring versus the extension or compression of the spring is a straight line.

**Reason :** Potential energy of a stretched or compressed spring, proportional to square of extension or compression.

**91.** **Assertion:** The P.E. of a spring increases when it is compressed and decreases when it is stretched.
**Reason:** During compression work is done on the spring while during stretching work is done by the spring.

**92.** **Assertion :** When a body moves vertically upward, work done by gravitational force is negative.

**Reason :** According to conservation of mechanical energy, $\Delta K + \Delta U = 0$.

**93.** **Assertion :** Mechanical energy is the sum of macroscopic kinetic & potential energies.

**Reason :** Mechanical energy is that part of total energy which always remain conserved.

**94.** **Assertion :** Mass and energy are not conserved separately, but are conserved as a single entity called mass-energy.
**Reason :** Mass and energy are inter-convertible in accordance with Einstein's relation.

$$E = mc^2$$

**95.** **Assertion :** When a machine gun fires n bullets per second each with kinetic energy $K$, the power of a gun is $P = nK$

**Reason :** Power $P$ = work done / time

**96.** **Assertion :** Power developed in circular motion is always zero.
**Reason :** Work done in case of circular motion is not zero.

**97.** **Assertion:** Linear momentum is conserved in both elastic and inelastic collisions but total energy is not conserved in inelastic collision.
**Reason:** Law of conservation of momentum states that momentum has to be conserved in an isolated system.

**98.** **Assertion :** A point particle of mass m moving with speed $\upsilon$ collides with stationary point particle of mass M. If the maximum energy loss possible is given as $f\left(\frac{1}{2}mv^2\right)$ then $f = \left(\frac{m}{M+m}\right)$.
**Reason :** Maximum energy loss occurs when the particles get stuck together as a result of the collision.

**99.** **Assertion :** A quick collision between two bodies is more violent than slow collision, even when initial and final velocities are identical.

**Reason :** The rate of change of momentum determines that the force is small or large.

**100.** **Assertion :** If collision occurs between two elastic bodies their kinetic energy decreases during the time of collision.

**Reason :** During collision intermolecular space decreases and hence elastic potential energy increases.

**101.** **Assertion :** Two particles moving in the same direction do not lose all their energy in a completely inelastic collision.
**Reason :** Principle of conservation of momentum holds true for all kinds of collisions.

**102.** **Assertion :** In an elastic collision of two billiard balls, the total kinetic energy is conserved during the short time of collision of the balls (i.e., when they are in contact).
**Reason :** Energy spent against friction follow the law of conservation of energy.

## CRITICAL THINKING TYPE QUESTIONS

**103.** If a motorcyclist skids and stops after covering a distance of 15 m. The stopping force acting on the motorcycle by the road is 100 N, then the work done by the motorcycle on the road is
(a) 1500 J (b) –1500 J
(c) 750J (d) Zero

**104.** A ball moves in a frictionless inclined table without slipping. The work done by the table surface on the ball is
(a) positive (b) negative
(c) zero (d) None of these

**105.** A force acts on a 30 g particle in such a way that the position of the particle as a function of time is given by $x = 3t - 4t^2 + t^3$, where x is in metres and t is in seconds. The work done during the first 4 seconds is
(a) 576mJ (b) 450mJ
(c) 490mJ (d) 530mJ

**106.** A uniform force of $(3\hat{i} + \hat{j})$ newton acts on a particle of mass 2 kg. The particle is displaced from position $(2\hat{i} + \hat{k})$ meter to position $(4\hat{i} + 3\hat{j} - \hat{k})$ meter. The work done by the force on the particle is
(a) 6 J (b) 13 J
(c) 15 J (d) 9 J

**107.** The position of a particle of mass 4 g, acted upon by a constant force is given by $x = 4t^2 + t$, where $x$ is in metre and $t$ in second. The work done during the first 2 seconds is
(a) 128 mJ (b) 512 mJ
(c) 576 mJ (d) 144 mJ

**108.** An athlete in the olympic games covers a distance of 100 m in 10 s. His kinetic energy can be estimated to be in the range
(a) 200 J - 500 J (b) $2 \times 10^5$ J - $3 \times 10^5$ J
(c) 20,000 J - 50,000 J (d) 2,000 J - 5, 000 J

**109.** At time $t = 0$s particle starts moving along the $x$-axis. If its kinetic energy increases uniformly with time $t$, the net force acting on it must be proportional to
(a) $\sqrt{t}$ (b) constant
(c) $t$ (d) $\frac{1}{\sqrt{t}}$

**110.** Two bodies of masses 4 kg and 5 kg are moving with equal momentum. Then the ratio of their respective kinetic energies is
(a) 4 : 5 (b) 2 : 1
(c) 1 : 3 (d) 5 : 4

**111.** A crate is pushed horizontally with 100 N across a 5 m floor. If the frictional force between the crate and the floor is 40 N, then the kinetic energy gained by the crate is
(a) 200 J (b) 240 J
(c) 250 J (d) 300 J

**112.** An electron and a proton are moving under the influence of mutual forces. In calculating the change in the kinetic energy of the system during motion, one ignores the magnetic force of one on another. This is because,

(a) the two magnetic forces are equal and opposite, so they produce no net effect.

(b) the magnetic forces do no work on each particle.

(c) the magnetic forces do equal and opposite (but non-zero) work on each particle.

(d) the magnetic forces are necessarily negligible.

**113.** A particle moves in a straight line with retardation proportional to its displacement. Its loss of kinetic energy for any displacement $x$ is proportional to

(a) $x^2$ (b) $e^x$

(c) $x$ (d) $\log_e x$

**114.** A weight hangs freely from the end of a spring. A boy then slowly pushes the weight upwards until the spring becomes slack. The gain in gravitational potential energy of the weight during this process is equal to

(a) the work done by the boy against the force of gravity acting on the weight

(b) the loss of stored energy by the spring minus the work done by the tension in the spring

(c) the work done on the weight by the boy plus the stored energy lost by the spring

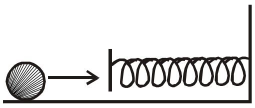
(d) the work done on the weight by the boy minus the work done by the tension in the spring plus the stored energy lost by the spring.

**115.** A rod of mass m and length I is made to stand at an angle of 60° with the vertical. Potential energy of the rod in this position is

(a) mgl (b) $\frac{mgl}{2}$

(c) $\frac{mgl}{3}$ (d) $\frac{mgl}{4}$

**116.** A mass of m kg moving with a speed of 1.5 m/s on a horizontal smooth surface, collides with a nearly weightless spring of force constant k = 50 N/m. If the maximum compression of the spring is 0.15 m, the value of mass m is



(a) 0.5 kg (b) 0.15 kg

(c) 0.12 kg (d) 1.5 kg

**117.** A 2 kg block slides on a horizontal floor with a speed of 4m/s. It strikes a uncompressed spring, and compresses it till the block is motionless. The kinetic friction force is 15N and spring constant is 10,000 N/m. The spring compresses by

(a) 8.5 cm (b) 5.5 cm

(c) 2.5 cm (d) 11.0 cm

**118.** Two spring P and Q of force constant $k_p$ and $k_q \left(k_q = \frac{k_p}{2}\right)$ are stretched by applying forces of equal magnitude. If the energy stored in Q is E, then the energy stored in P is

(a) E (b) 2E

(c) E/8 (d) E/2

**119.** Two springs have their force constant as $k_1$ and $k_2$ ($k_1 > k_2$). When they are stretched by the same force

(a) no work is done in case of both the springs.

(b) equal work is done in case of both the springs

(c) more work is done in case of second spring

(d) more work is done in case of first spring.

**120.** One end of a light spring of spring constant k is fixed to a wall and the other end is tied to a block placed on a smooth horizontal surface. In a displacement, the work done by the spring is $1/2 \text{ k } x^2$. The possible cases are

(a) the spring was initially compressed by a distance x, was finally in its natural length

(b) it was initially stretched by a distance x and was finally in its natural length

(c) it was initially in its natural length and finally in a compressed position

(d) it was initially in its natural length and finally in the stretched position

**121.** If the extension in a spring is increased to 4 times then the potential energy

(a) remains the same (b) becomes 4 times

(c) becomes one fourth (d) becomes 16 times

**122.** Before a rubber ball bounces off from the floor, the ball is in contact with the floor for a fraction of second. Which of the following statements is correct?

(a) Conservation of energy is not valid during this period

(b) Conservation of energy is valid during this period

(c) As ball is compressed, kinetic energy is converted to compressed potential energy

(d) None of these

**123.** A spherical ball of mass 20 kg is stationary at the top of a hill of height 100 m. It rolls down a smooth surface to the ground, then climbs up another hill of height 30 m and finally rolls down to a horizontal base at a height of 20 m above the ground. The velocity attained by the ball is

(a) 20 m/s (b) 40 m/s

(c) $10\sqrt{30}$ m/s (d) 10 m/s

**124.** A rubber ball is dropped from a height of 5m on a plane, where the acceleration due to gravity is not shown. On bouncing it rises to 1.8 m. The ball loses its velocity on bouncing by a factor of

(a) $\frac{16}{25}$ (b) $\frac{2}{5}$

(c) $\frac{3}{5}$ (d) $\frac{9}{25}$

**125.** A body of mass m is accelerated uniformly from rest to a speed v in a time T . The instantaneous power delivered to the body as a function of time is given by

(a) $\frac{mv^2}{T^2}.t^2$ (b) $\frac{mv^2}{T^2}.t$

(c) $\frac{1}{2}\frac{mv^2}{T^2}.t^2$ (d) $\frac{1}{2}\frac{mv^2}{T^2}.t$

**126.** A vehicle is moving with a uniform velocity on a smooth horizontal road, then power delivered by its engine must be

(a) uniform (b) increasing
(c) decreasing (d) zero

**127.** The engine of a vehicle delivers constant power. If the vehicle is moving up the inclined plane then, its velocity,

(a) must remain constant
(b) must increase
(c) must decrease
(d) may increase, decrease or remain same.

**128.** A body projected vertically from the earth reaches a height equal to earth's radius before returning to the earth. The power exerted by the gravitational force is greatest

(a) at the highest position of the body
(b) at the instant just before the body hits the earth
(c) it remains constant all through
(d) at the instant just after the body is projected

**129.** Johnny and his sister Jane race up a hill. Johnny weighs twice as much as jane and takes twice as long as jane to reach the top . Compared to Jane

(a) Johnny did more work and delivered more power.
(b) Johnny did more work and delivered the same amount of power.
(c) Johnny did more work and delivered less power
(d) Johnny did less work and johnny delivered less power.

**130.** A body of mass (4m) is lying in x-y plane at rest. It suddenly explodes into three pieces. Two pieces, each of mass (m) move perpendicular to each other with equal speeds (v). The total kinetic energy generated due to explosion is

(a) $mv^2$ (b) $\frac{3}{2}mv^2$
(c) $2\,mv^2$ (d) $4\,mv^2$

**131.** A particle of mass m is driven by a machine that delivers a constant power of k watts. If the particle starts from rest the force on the particle at time t is

(a) $\sqrt{mk}\,t^{-1/2}$ (b) $\sqrt{2mk}\,t^{-1/2}$
(c) $\frac{1}{2}\sqrt{mk}\,t^{-1/2}$ (d) $\sqrt{\frac{mk}{2}}t^{-1/2}$

**132.** If two persons A and B take 2 seconds and 4 seconds respectively to lift an object to the same height *h*, then the ratio of their powers is

(a) 1 : 2 (b) 1 : 1
(c) 2 : 1 (d) 1 : 3

**133.** If a machine gun fires n bullets per second each with kinetic energy K, then the power of the machine gun is

(a) $nK^2$ (b) $\frac{K}{n}$
(c) $n^2K$ (d) nK

**134.** A block of mass *m* = 0.1 kg is connected to a spring of unknown spring constant k. It is compressed to a distance *x* from its equilibrium position and released from rest. After approaching half the distance $\left(\frac{x}{2}\right)$ from equilibrium position, it hits another block and comes to rest momentarily, while the other block moves with a velocity 3 $ms^{-1}$. The total initial energy of the spring is

(a) 0.3 J (b) 0.6 J
(c) 0.8 J (d) 1.5 J

**135.** A particle is moving in a circle of radius r under the action of a force F = $\alpha r^2$ which is directed towards centre of the circle. Total mechanical energy (kinetic energy + potential energy) of the particle is (take potential energy = 0 for r = 0)

(a) $\frac{1}{2}\alpha r^3$ (b) $\frac{5}{6}\alpha r^3$
(c) $\frac{4}{3}\alpha r^3$ (d) $\alpha r^3$

**136.** When a body is projected vertically up from the ground with certain velocity, its potential energy and kinetic energy at a point A are in the ratio 2 : 3. If the same body is projected with double the previous velocity, then at the same point A the ratio of its potential energy to kinetic energy is

(a) 9 : 1 (b) 2 : 9
(c) 1 : 9 (d) 9 : 2

**137.** The total energy of a solid sphere of mass 300 g which rolls without slipping with a constant velocity of 5 $ms^{-1}$ along a straight line is

(a) 5.25 J (b) 3.25 J
(c) 0.25 J (d) 1.25 J

**138.** A bullet when fired into a target loses half of its velocity after penetrating 20 cm. Further distance of penetration before it comes to rest is

(a) 6.66 cm (b) 3.33 cm
(c) 12.5 cm (d) 10 cm

**139.** When a rubber-band is stretched by a distance x, it exerts restoring force of magnitude $F = ax + bx^2$ where a and b are constants. The work done in stretching the unstretched rubber-band by L is

(a) $aL^2 + bL^3$ (b) $\frac{1}{2}\left(aL^2 + bL^3\right)$
(c) $\frac{aL^2}{2} + \frac{bL^3}{3}$ (d) $\frac{1}{2}\left(\frac{aL^2}{2} + \frac{bL^3}{3}\right)$

**140.** If two equal masses ($m_1 = m_2$) collide elastically in one dimension, where $m_2$ is at rest and $m_1$ moves with a velocity $u_1$, then the final velocities of two masses are

(a) $V_1 = 0; V_2 = u_1$ (b) $V_1 = V_2 = 0$
(c) $V_1 = 0$ and $V_2 = -u_1$ (d) $V_1 = -u_1; V_2 = 0$

**141.** A particle A suffers an oblique elastic collision with a particle B that is at rest initially. If their masses are the same, then after collision

(a) they will move in opposite directions

(b) A continues to move in the original direction while B remains at rest

(c) they will move in mutually perpendicular directions

(d) A comes to rest and B starts moving in the direction of the original motion of A

**142.** Which one of the following statements does hold good when two balls of masses $m_1$ and $m_2$ undergo elastic collision?

(a) When $m_1 < m_2$ and $m_2$ at rest, there will be maximum transfer of momentum

(b) When $m_1 > m_2$ and $m_2$ at rest, after collision the ball of mass $m_2$ moves with four times the velocity of $m_1$

(c) When $m_1 = m_2$ and $m_2$ at rest, there will be maximum transfer of K.E.

(d) When collision is oblique and $m_2$ at rest with $m_1 = m_2$, after collisions the ball moves in opposite direction

**143.** A ball of mass m moving with a constant velocity strikes against a ball of same mass at rest. If e = coefficient of restitution, then what will be the ratio of velocity of two balls after collision?

(a) $\frac{1-e}{1+e}$ (b) $\frac{e-1}{e+1}$

(c) $\frac{1+e}{1-e}$ (d) $\frac{2+e}{e-1}$

**144.** A particle of mass $m_1$ moving with velocity v strikes with a mass $m_2$ at rest, then the condition for maximum transfer of kinetic energy is

(a) $m_1 >> m_2$ (b) $m_2 >> m_2$

(c) $m_1 = m_2$ (d) $m_1 = 2m_2$

**145.** A metal ball of mass 2 kg moving with a velocity of 36 km/h has a head on collision with a stationary ball of mass 3 kg. If after the collision, the two balls move together, the loss in kinetic energy due to collision is

(a) 140 J (b) 100 J

(c) 60 J (d) 40 J

**146.** A ball moving with velocity 2 m/s collides head on with another stationary ball of double the mass. If the coefficient of restitution is 0.5, then their velocities (in m/s) after collision will be

(a) 0, 1 (b) 1, 1

(c) 1, 0.5 (d) 0, 2

**147.** A mass m moving horizontally (along the x-axis) with velocity v collides and sticks to mass of 3m moving vertically upward (along the y-axis) with velocity 2v. The final velocity of the combination is

(a) $\frac{1}{4}v\hat{i}+\frac{3}{2}v\hat{j}$ (b) $\frac{1}{3}v\hat{i}+\frac{2}{3}v\hat{j}$

(c) $\frac{2}{3}v\hat{i}+\frac{1}{3}v\hat{j}$ (d) $\frac{3}{2}v\hat{i}+\frac{1}{4}v\hat{j}$

**148.** A block of mass 0.50 kg is moving with a speed of $2.00\ \text{ms}^{-1}$ on a smooth surface. It strikes another mass of 1.00 kg and then they move together as a single body. The energy loss during the collision is

(a) 0.16 J (b) 1.00 J

(c) 0.67 J (d) 0.34 J

**149.** Two particles A and B, move with constant velocities $\vec{v}_1$ and $\vec{v}_2$. At the initial moment their position vectors are $\vec{r}_1$ and $\vec{r}_2$ respectively. The condition for particles A and B for their collision is

(a) $\vec{r}_1.\vec{v}_1 = \vec{r}_2.\vec{v}_2$

(b) $\vec{r}_1 \times \vec{v}_1 = \vec{r}_2 \times \vec{v}_2$

(c) $\vec{r}_1 - \vec{r}_2 = \vec{v}_1 - \vec{v}_2$

(d) $\frac{\vec{r}_1-\vec{r}_2}{|\vec{r}_1-\vec{r}_2|}=\frac{\vec{v}_2-\vec{v}_1}{|\vec{v}_2-\vec{v}_1|}$

**150.** On a frictionless surface a block of mass M moving at speed v collides elastically with another block of same mass M which is initially at rest. After collision the first block moves at an angle θ to its initial direction and has a speed $\frac{v}{3}$. The second block's speed after the collision is

(a) $\frac{3}{4}v$ (b) $\frac{3}{\sqrt{2}}v$

(c) $\frac{\sqrt{3}}{2}v$ (d) $\frac{2\sqrt{2}}{3}v$

**151.** A ball is thrown vertically downwards from a height of 20 m with an initial velocity $v_0$. It collides with the ground loses 50 percent of its energy in collision and rebounds to the same height. The initial velocity $v_0$ is

(Take $g = 10\ \text{ms}^{-2}$)

(a) $20\ \text{ms}^{-1}$ (b) $28\ \text{ms}^{-1}$

(c) $10\ \text{ms}^{-1}$ (d) $14\ \text{ms}^{-1}$

**152.** A particle of mass m moving in the x direction with speed 2*v* is hit by another particle of mass 2*m* moving in the *y* direction with speed **v**. If the collision is perfectly inelastic, the percentage loss in the energy during the collision is close to

(a) 56% (b) 62%

(c) 44% (d) 50%

# HINTS AND SOLUTIONS

## FACT / DEFINITION TYPE QUESTIONS

**1.** **(d)** $W = FS \cos\theta$

$\therefore$ If $F = 0$; $W = 0$

If $S = 0$; $W = 0$

& if $\theta = 90°$; $\cos 90° = 0$

$\therefore W = 0$.

**2.** **(a)**

**3.** **(c)** (i) Since work $W = \vec{F}.\vec{s} = Fs\cos\theta$

If $\theta = 90^o \Rightarrow W = 0$, but force is acting on it so option (a) is not correct.

(ii) A person carrying a suit case vertically in his hand walks in a horizontal direction, no work is done, because the angle between the direction of force applied by hand on weight & direction of displacement is 90º. So option (b) is also not correct.

(iii) According to work energy theorem

work done on body = change in kinetic energy of the bod

**4.** **(a)** When a person carrying load on his head moves over a horizontal road, work done against gravitational force is zero.

**5.** **(b)**

**6.** **(b)**

**7.** **(c)** When a man pushes a wall and fails to displace it, then displacement of wall = 0

$\therefore$ Work done by man = $F \times 0 = 0$

Therefore, man does no work at all.

**8.** **(a)** Work done by the net force = change in kinetic energy of the particle.

This is according to work energy theorem.

**9.** **(a)** Since momentum of both bodies are equal

So $p_1 = p_2 \Rightarrow \frac{M_1}{M_2} = \frac{u_2}{u_1} \Rightarrow u_2 > u_1$ (let $M_1 > M_2$)

so $\frac{E_{k_1}}{E_{k_2}} = \frac{P_1^2/2M_1}{P_2^2/2M_2} = \frac{M_2}{M_1} \Rightarrow E_{k_1} < E_{k_2}$

It means that light body has greater kinetic energy, if they have equal momentum.

**10.** **(d)** Let the velocity of the particle be $v$ $m/s$.

Momentum of the particle ($p$) = mv

Kinetic energy of the particle

$$(E) = \frac{1}{2}mv^2 = \frac{1}{2}.\frac{(mv)^2}{m}$$

$$E = \frac{p^2}{2m}$$

**11.** **(b)** K. E $= \frac{1}{2}mv^2$

It is always positive

**12.** **(b)** The principle of conservation of total mechanical energy can be stated as, the total mechanical energy of a system is conserved if the forces, doing work on it, are conservative.

**13.** **(c)** Only momentum is conserved. Some kinetic energy is lost when bullet penetrates the block.

**14.** **(d)** 1Kwh = $3.6 \times 10^6$ J

1 ev = $1.6 \times 10^{-19}$ J

$\therefore$ J, Kwh and ev all are units of energy.

**15.** **(b)** As work done by frictional force over a closed path is not zero, therefore, it is non-conservative force.

**16.** **(b)** $E_1 = E_2 \; \therefore \; \frac{1}{2}m_1{v_1}^2 = \frac{1}{2}m_2{v_2}^2$ or $\frac{V_2}{V_1} = \sqrt{\frac{m_1}{m_2}}$

$$\frac{P_2}{P_1} = \frac{m_2 v_2}{m_1 v_1} = \frac{m_2}{m_1}\sqrt{\frac{m_1}{m_2}} = \sqrt{\frac{m_2^2\, m_1}{m_2^2\, m_2}} = \sqrt{\frac{m_2}{m_1}}$$

If $m_2 > m_1$, then $P_2 > P_1$ i.e. heavier body has greater linear momentum.

**17.** **(b)** $\frac{dk}{dt} = \frac{d}{dt}\left(\frac{mv^2}{2}\right)$

$$= \frac{1}{\cancel{2}}m\cancel{2}v\frac{dv}{dt} = \frac{mdv}{dt}v$$

**18.** **(c)** Kinetic energy is given by $k.E = \frac{p^2}{2m}$

$$\therefore \frac{p_1^2}{2m_1} = \frac{p_2^2}{2m_2}$$

or $\frac{p_1}{p_2} = \sqrt{\frac{m_1}{m_2}}$

**19.** **(b)** P.E in case of spring $= \frac{1}{2}kx^2$

Increase in potential energy

$$\frac{1}{2}k(x_1 + x_2)^2 - \frac{1}{2}kx_1^2 = \frac{1}{2}k\left(2x_1x_2 + x_2^2\right)$$

$$= \frac{1}{2}kx_2\left(x_2 + 2x_1\right)$$

**20.** **(a)** If an object of mass m is released from rest from top of a smooth inclined plane, its speed at the bottom is $\sqrt{2gh}$ , independent of angle θ and mass.

**21.** **(c)** Displacement of the particle when it takes a complete round the circular path is zero.

∴ Work done = force × displacement

$W = F \times 0 = 0$

Therefore, work done by the force is zero.

**22.** **(b)** $E = \frac{P^2}{2m} \therefore E \propto \frac{1}{m}$ [If $P$ = constant]

i.e. the lightest particle will possess maximum kinetic energy and in the given option mass of electron is minimum.

**23.** **(d)** When work is done upon a system by a conservative force then its potential energy increases.

**24.** **(d)** By the principle of conservation energy

**25.** **(a)** **26.** **(d)** **27.** **(b)**

**28.** **(d)** When work is done upon a system by a conservative force then its potential energy increases.

**29.** **(a)** We define the potential energy V(x) of the spring to be zero when block and spring system is in the equilibrium position.

**30.** **(a)** Conservative force is negative gradient of potential

$$F(x) = \frac{-dV(x)}{dx}$$

**31.** **(c)** Principle of conservation of energy states that, the total mechanical energy is conserved if the forces doing work on it are conservative.

**32.** **(a)** For a given spring, $u = \frac{1}{2}kx^2$

$$\therefore \frac{u_2}{u_1} = \frac{\frac{1}{2}Kx_2^2}{\frac{1}{2}Kx_1^2} = \frac{(2x)^2}{x^2} = 4:1$$

**33.** **(b)** The energy stored in spring in the form of elastic potential energy. i.e., $(P.E)_{elastic} = \frac{1}{2}kx^2$

Where x is compression or elongation of spring & k is spring constant.

**34.** **(b)** $w = \frac{1}{2}kl_2^2 - \frac{1}{2}kl_1^2 = \frac{1}{2}k\left(l_2^2 - l_1^2\right)$

**35.** **(a)**

**36.** **(d)** According to the law of conservation of energy the total energy of the world (universe) remains constant.

**37.** **(a)**

**38.** **(c)** The S.I. unit of power is watt (*W*)

**39.** **(d)** Power is defined as the rate of doing work. For the automobile, the power output is the amount of work done (overcoming friction) divided by the length of time in which the work was done.

**40.** **(a)**

**41.** **(c)** The law of conservation of momentum is true in all type of collisions, but kinetic energy is conserved only in elastic collision. The kinetic energy is not conserved in inelastic collision but the total energy is conserved in all type of collisions.

**42.** **(c)** In a perfectly inelastic collision, the two bodies move together as one body.

**43.** **(b)** In an inelastic collision, momentum remains conserved, but K.E is changed.

**44.** **(a)** Since $e = \frac{-(v_1 - v_2)}{(u_2 - u_1)} = \frac{\text{-velocity of separation}}{\text{velocity of approach}}$

(i) For perfectly elastic collision e =1

(ii) For perfectly inelastic collision e = 0

(iii) For other collision 0 < e < 1

**45.** **(b)** For a perfectly inelastic collision, e = 0.

**46.** **(d)** When the two bodies stick together after collision, then it is perfectly inelastic collision and in this case, the coefficient of restitution e is equal to zero.

**47.** **(b)** When two bodies of equal mass collide head on elastically, their velocities are mutually exchanged.

**48.** **(a)** In physics, collision does not means that are particle strike another particle. Infact, two particles may not even touch each other & may still said to be colliding.

The necessary requirements of collision are

(i) A large force for a relatively short time (i.e., an impulse) acts on each colliding particle.

(ii) The motion of the particles (at least one of the particle) is changed abruptly.

(iii) The total momentum (as also the total energy) of particles remains conserved.

**49.** **(d)** Coefficient of restitution,

$$e = \frac{-\text{velocity of seperation}}{\text{velocity of approach}}$$

for elastic collision e = 1

**50.** **(c)**

**51.** **(d)** When two spheres of equal masses undergo a glancing elastic collision with one of them at rest, after the collision they will move at right angle to each other.

**52.** **(b)** Momentum is conserved but kinetic energy is not conserved.

**53.** **(c)** In an elastic collision, momentum and K.E. both conserved.

**54.** **(a)** During elastic collision between two equal masses, the velocities get exchanged. Hence energy transfer is maximum when $m_1 = m_2$.

## STATEMENT TYPE QUESTIONS

**55.** **(d)** A conservative force is that force which is independant of path followed e.g. gravitational force, electrostatic force, etc. All of these are central forces. So, all the central forces are conservative.

**56.** **(a)** When a body is moved on a rough horizontal surface with a constant velocity, then work is done against friction but K.E. is constant. So, even if work is done on a body by some force, K.E. remains unchanged

**57.** **(c)** When a bomb explodes; momentum is conserved K.E. changes and in uniform circular motion , K.E remains constant but momentum changes due to change in directions of motion.

**58.** **(c)** When spring oscillates, its velocity is minimum at the mean position & hence KE is maximum at the equilibrium position.

**59.** **(c)** Friction is a non-conservative force. Work done by a non-conservative force over a closed path is not zero.

**60.** **(c)** If there were no friction, moving vehicles could not be stopped by looking the brakes. Vehicles are stopped by air friction only. So, this statement is correct.

**61.** **(d)** A force $F(x)$ is conservative, if it can be derived from a scalar quantity $V(x)$ by the relation given by eq, $\Delta v = -F(x)\,\Delta x$. The work done by the conservative force depends only on the end points.

This can be seen from the relation,

$W = K_f - K_i = V(X_i) - V(X_f)$

which depends on the end points.

A third definition states that the work done by this force in a closed path is zero. This is once again apparent from Eq. $K_i + v(X_i) = K_f + v(X_f)$, since $X_i = X_f$

**62.** **(d)** In burning of coal, chemical energy is converted to heat energy.

**63.** **(d)**

**64.** **(b)** In elastic collision, total momentum and kinetic energy will remain conserved.

## MATCHING TYPE QUESTIONS

**65.** **(b)** $A \to (1); B \to (1); C \to (3); D \to (3)$

**66.** **(b)** $(A)\to(3); (B)\to(1); C\to(2,3); (D)\to(1)$

**67.** **(a)** $(A)\to(1,2); (B)\to(1,2); C\to(1,2); (D)\to(1,3)$

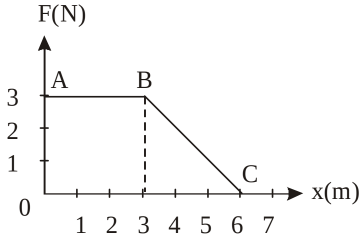
**68.** **(c)** $(A)\to(4); (B)\to(2); C\to(1); (D)\to(3)$

**69.** **(d)** $(A)\to(4); (B)\to(1); C\to(3); (D)\to(2)$

## DIAGRAM TYPE QUESTIONS

**70.** **(d)** Work done $= \int \mathrm{F}dx$

**71.** **(b)**



Work done = area under F-x graph

$$= \text{area of trapezium OABC} = \frac{1}{2}(3+6)(3) = 13.5\text{ J}$$

**72.** **(a)**

$$\vec{F} = -5\hat{i} + 9\cos 60°\hat{i} + 9\sin 60°\hat{j} - 3\hat{j}$$

$$= -5\hat{i} + \frac{9}{2}\hat{i} + \frac{9\sqrt{3}}{2}\hat{j} - 3\hat{j}$$

$$= -\frac{\hat{i}}{2} + \left(\frac{9\sqrt{3}}{2} - 3\right)\hat{j}$$

$$\vec{s} = -3\hat{i}.$$

$$W = \vec{F}.\vec{s} = \left[-\frac{\hat{i}}{2} + \left(\frac{9\sqrt{3}}{2} - 3\right)\hat{j}\right].(-3\hat{i})$$

$$= 1.5\text{ J}.$$

**73.** **(c)** $W$ = area of $F - x$ graph

= area of $\Delta$ + area of rectangle + area of $\Delta$

$$= \frac{5\times3}{2} + 10\times3 + \frac{5\times3}{2} = 45\ J$$

**74.** **(d)** $|F| = \frac{dU}{dx}$, which is greatest in the reagion $CD$.

**75.** **(a)** $U = -\int_0^x F dx = -\int_0^x kx dx = -\frac{1}{2}kx^2.$

It is correctly drawn in (a)

**76.** **(d)** At the lowest point, h = 0 ∴ P.E. = 0 (gravitational P.E.). There is no work done on the **bob** by the tension as it is perpendicular to the displacement.

∴ Potential energy is associated only to the gravitational force.

**77.** **(b)** When $m_1 > m_2$ & $m_2$ at rest then the bodies collide in elastically and move together as one body without changing the direction.

**78.** **(a)** As the floor exerts a force on the ball along the normal, & no force parallel to the surface, therefore the velocity component along the parallel to the floor remains constant. Hence $V \sin\theta = V^1 \sin\theta^1$.

## ASSERTION- REASON TYPE QUESTIONS

**79.** **(b)** In close loop, $s = 0$, and so $W = Fs = 0$.

**80.** **(d)** Work done may be zero, even F is not zero.
$W = Fs\cos 0° = Fs$ (maximum).

**81.** **(a)** In this case, s = 0, and so W = 0.

**82.** **(d)**

**83.** **(d)** When frictional force is opposite to velocity, kinetic energy will decrease.

**84.** **(c)** Change in kinetic energy = work done by net force. This relationship is valid for particle as well as system of particles.

**85.** **(a)** $K = \frac{1}{2}mv^2 \;\therefore\; K \propto v^2$

If velocity is doubled the K.E. will be quadrupled

**86.** **(a)** K.E. = $\frac{1}{2}mv^2$ if V is tripled then K.E. = $v^2 = (3)^2$

**87.** **(c)** K.E. can be increased or decreased without applying any external force, as internal forces can do work e.g., explosion of a bomb.

**88.** **(b)**

**89.** **(a)**

**90.** **(d)** Potential energy $U = \frac{1}{2}kx^2 i.e.\ U \propto x^2$

This is a equation of parabola, so graph between U and x is a parabola not a straight line.

**91.** **(d)** P.E. of a spring either it is compressed or stretched as work is done by us on the spring.

**92.** **(b)** $W = Fs\cos 180° = -mgs$ .

**93.** **(d)**

**94.** **(a)** Both reason and assertion are true and reason is the correct explanation of the assertion.

**95.** **(a)** Power = $\frac{W}{t} = \frac{K}{1/n} = nK$

**96.** **(d)** Work done and power developed one zero in uniform circular motion only.

**97.** **(d)** Total momentum and total energy both are conserved in an inelastic collision. It is the K.E. which changes.

**98.** **(d)** Maximum energy loss = $\frac{P^2}{2m} - \frac{P^2}{2(m+M)}$

$$\left[\because \text{K.E.} = \frac{P^2}{2m} = \frac{1}{2}mv^2\right]$$

$$= \frac{P^2}{2m}\left[\frac{M}{(m+M)}\right] = \frac{1}{2}mv^2\left\{\frac{M}{m+M}\right\}$$

Reason is a case of perfectly inelastic collision.

By comparing the equation given in Assertion with above equation, we get

$$f = \left(\frac{M}{m+M}\right) \text{ instead of } \left(\frac{m}{M+m}\right)$$

Hence Assertion is wrong and Reason is correct.

**99.** **(b)** **100. (b)** **101. (a)**

**102.** **(d)** The billiard balls in an elastic collision are in a deformed state. Their total energy is partly kinetic and partly potential. So K.E. is less than the total energy. The energy spent against friction is dissipated as heat which is not available for doing work.

## CRITICALTHINKING TYPE QUESTIONS

**103.** **(d)** Though an equal and opposite force acts on the road but since road does not undergo any displacement, hence no work is done on the road.

**104.** **(c)** Motion without slipping implies pure rolling. During pure rolling work done by friction force is zero.

**105.** **(a)** $x = 3t - 4t^2 + t^3 \quad \frac{dx}{dt} = 3 - 8t + 3t^2$

Acceleration = $\frac{d^2x}{dt^2} = -8 + 6t$

Acceleration after 4 sec = $-8 + 6 \times 4 = 16$

Displacement in 4 sec = $3 \times 4 - 4 \times 4^2 + 4^3 = 12$ m

∴ Work = Force × displacement

= Mass × acc. × disp. = $3 \times 10^{-3} \times 16 \times 12 = 576$ mJ

**106.** **(d)** Given : $\vec{F} = 3\hat{i} + \hat{j}$

$\vec{r_1} = \left(2\hat{i} + \hat{k}\right)$, $\vec{r_2} = \left(4\hat{i} + 3\hat{j} - \vec{k}\right)$

$\vec{r} = \vec{r_2} - \vec{r_1} = \left(4\hat{i} + 3\hat{j} - \vec{k}\right) - \left(2\hat{i} + \hat{k}\right)$

or $\vec{r} = 2\hat{i} + 3\hat{j} - 2\hat{k}$

So work done by the given force w = $\vec{f}.\vec{r}$

$= \left(3\hat{i} + \hat{j}\right).\left(2\hat{i} + 3\hat{j} - 2\hat{k}\right) = 6 + 3 = 9J$

**107.** **(c)** here, m = 4 , g = $4 \times 10^{-3}$ kg

$x = 4t^2 + t$

$\therefore \frac{dx}{dt} = 8t + 1 \quad \frac{d^2x}{dt^2} = 8$

Work done, $W = \int f dx = \int m \frac{d^2x}{dt^2}\left(\frac{dx}{dt}\right) dt$

$$= \int_0^2 (4\times10^{-3})(8)(8t+1)\,dt$$

$$= 32\times10^{-3}\int_0^2 (8t+1)dt = 32\times10^{-3}\left[\frac{8t^2}{2}+t\right]_0^2$$

$= 32 \times 10^{-3} [4(2)^2 + 2 - 0] = 576\,mJ$

**108. (d)** The average speed of the athelete

$$v = \frac{100}{10} = 10 m/s$$

$$\therefore \quad K.E. = \frac{1}{2}mv^2$$

If mass is 40 kg then, $K.E. = \frac{1}{2}\times 40\times(10)^2 = 2000\,J$

If mass is 100 kg then,

$$K.E. = \frac{1}{2}\times 100\times(10)^2 = 5000\,J$$

**109. (d)** Given, $\frac{dk}{dt}$ = constant

$$\Rightarrow \quad k \propto t \quad \Rightarrow \quad v \propto \sqrt{t}$$

Also, $P = Fv = \frac{dk}{dt}$ = constant

$$\Rightarrow \quad F \propto \frac{1}{v} \quad \Rightarrow F \propto \frac{1}{\sqrt{t}}$$

**110. (d)** Kinetic energy of a body, $K = \frac{p^2}{2m}$

As $p_1 = p_2$ (Given)

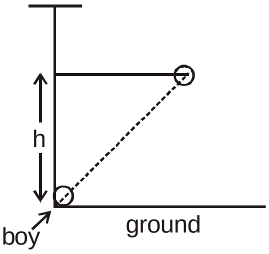
$$\therefore \quad \frac{K_1}{K_2} = \frac{m_2}{m_1} = \frac{5}{4}$$

**111. (d)** Here, F = 100 N, d = 5 m,
frictional force $f_r$ = 40 N
$\therefore F - f_r = ma$
$100 - 40 = ma$
Now kinetic energy gained is = ma × d
$= 60 \times 5 = 300\,J$

**112. (b)**

**113. (a)** This condition is applicable for simple harmonic motion. As particle moves form mean position to extreme position its potential energy increases according to expression $U = \frac{1}{2}kx^2$ and according kinetic energy decreases.

**114. (a)** In this case the boy has done work (see the fig.) against force of gravity acting on the weight and this work is stored in weight in the form of gravitational potential energy (work done on weight = mgh = gravitation P.E of weight).



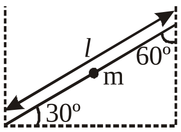
**115. (d)** For any uniform rod, the mass is supposed to be concentrated at its centre.

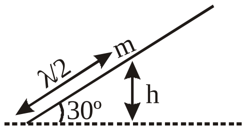
$\therefore$ height of the mass from ground is, h = (*l*/2) sin 30°

$\therefore$ Potential energy of the rod

$$= m\times g\times\frac{\ell}{2}\sin 30^\circ$$

$$= m\times g\times\frac{\ell}{2}\times\frac{1}{2} = \frac{mg\ell}{4}$$





**116. (a)** $\frac{1}{2}mv^2 = \frac{1}{2}kx^2 \Rightarrow mv^2 = kx^2$ or $m\times(1.5)^2 = 50\times(0.15)^2$

$\therefore m = 0.5\,kg$

**117. (b)** Let the blow compress the spring by x before stopping.

Kinetic energy of the block = (P.E of compressed spring) + work done against function.

$$\frac{1}{2}\times 2\times(4)^2 = \frac{1}{2}\times 10,000\times x^2 + (+15)\times x$$

$$10,000\,x^2 + 30x - 32 = 0$$

$$\Rightarrow 5000x^2 + 15x - 16 = 0$$

$$\therefore \quad x = -\frac{15\pm\sqrt{(15)^2 - 4\times(5000)(-16)}}{2\times 5000}$$

$= 0.055m = 5.5cm.$

**118. (d)** According to Hooke's law, $F_P = -k_I x_P$

$$F_Q = -k_Q x_Q \text{ or } \frac{F_P}{F_Q} = \frac{k_P}{k_Q}\frac{x_P}{x_Q}$$

$F_P = F_Q$ (Given) $\quad \therefore \frac{x_P}{x_Q} = \frac{k_Q}{k_P}$

Energy stored in a spring is $U=\frac{1}{2}kx^2$

$$\therefore \frac{U_P}{U_Q}=\frac{k_Px_P^2}{k_Qx_Q^2}=\frac{k_P}{k_Q}\times\frac{k_Q^2}{k_P^2}$$

$$\frac{U_P}{U_Q}=\frac{k_Q}{k_P} \qquad \left(\because k_Q=\frac{k_P}{2}\right)$$

$$=\frac{1}{2}$$

or $U_P=\frac{U_Q}{2}=\frac{E}{2}$ $\qquad (\because U_Q=E)$

**119. (c)** From Hooke's law

$F \propto x \Rightarrow$ F = kx., where k is spring constant

Since force is same in stretching for both spring so $F=k_1x_1=k_2x_2 \Rightarrow x_1<x_2$ because $k_1>k_2$

so work done in case of first spring is $W_1=\frac{1}{2}k_1x_1^2$

and work done in case of second spring is

$$W_2=\frac{1}{2}k_2x_2^2 \text{ so } \frac{W_1}{W_2}=\frac{x_1}{x_2}\Rightarrow W_1<W_2$$

It means that more work is done in case of second spring (work done on spring is equal to stored elastic potential energy of the spring)

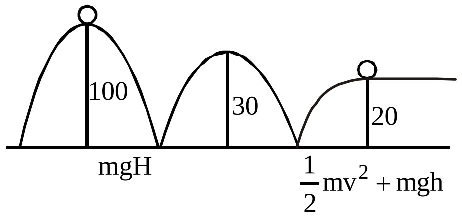
**120. (a)** Stored elastic potential energy of spring =½kx$^2$ where x is compression or elongation of spring from its natural length. In this position the spring can do work on the block tied to it, which is equal to ½kx$^2$, so both option (a) & b are correct.

**121. (d)** $P.E.=\frac{1}{2}kx^2$

$\therefore$ If x = 4x, then $P.E=\frac{1}{2}k(16x^2)=16\left(\frac{1}{2}kx^2\right)$

**122. (b)** The law of conservation of energy is valid at any instant & in all circumstances.

**123. (b)**



Using conservation of energy,

$$m(10\times100)=m\left(\frac{1}{2}v^2+10\times20\right)$$

or $\frac{1}{2}v^2=800$ or $v=\sqrt{1600}=40$ m/s

Alternative method :

Loss in potential energy = gain in kinetic energy

$$m\times g\times80=\frac{1}{2}mv^2$$

$$10\times80=\frac{1}{2}v^2$$

$v^2=1600$ or $v=40$ m/s

**124. (b)** According to principle of conservation of energy

Potential energy = kinetic energy

$$\Rightarrow mgh=\frac{1}{2}mv^2\Rightarrow v=\sqrt{2gh}$$

If $h_1$ and $h_2$ are initial and final heights, then

$$\Rightarrow v_1=\sqrt{2gh_1},v_2=\sqrt{2gh_2}$$

Loss in velocity, $\Delta v=v_1-v_2=\sqrt{2gh_1}-\sqrt{2gh_2}$

$\therefore$ fractional loss in velocity

$$=\frac{\Delta v}{v_1}=\frac{\sqrt{2gh_1}-\sqrt{2gh_2}}{\sqrt{2gh_1}}=1-\sqrt{\frac{h_2}{h_1}}$$

$$=1-\sqrt{\frac{1.8}{5}}=1-\sqrt{0.36}=1-0.6=0.4=\frac{2}{5}$$

**125. (b)** u = 0; v = u + aT; v = aT

Instantaneous power = F × v = m. a. at = $m.a^2.t$

$\therefore$ Instantaneous power = $m\frac{v^2}{T^2}t$

**126. (d)**

**127. (a)**

**128. (b)** Power exerted by a force is given by

P = F.v

When the body is just above the earth's surface, its velocity is greatest. At this instant, gravitational force is also maximum. Hence, the power exerted by the gravitational force is greatest at the instant just before the body hits the earth.

**129. (b)** The work is done against gravity so it is equal to the change in potential energy. $W = E_p = mgh$

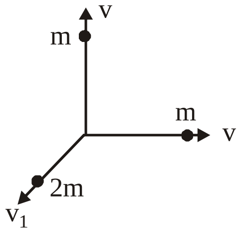
For a fixed height, work is proportional to weight lifted. Since Johnny weighs twice as much as Jane he works twice as hard to get up the hill.

Power is work done per unit time. For Johnny this is $W/\Delta t$. Jane did half the work in half the time,

$(1/2\ W)/(1/2\ \Delta t) =\ W/\Delta t$ which is the same power delivered by Johnny.

**130. (b)** By conservation of linear momentum

$$2mv_1 = \sqrt{2}mv \Rightarrow v_1 = \frac{v}{\sqrt{2}}$$



As two masses of each of mass m move perpendicular to each other.

Total KE generated

$$= \frac{1}{2}mv^2 + \frac{1}{2}mv^2 + \frac{1}{2}(2m)v_1^2$$

$$= mv^2 + \frac{mv^2}{2} = \frac{3}{2}mv^2$$

**131. (d)** As we know power $P = \frac{dw}{dt}$

$$\Rightarrow \quad w = Pt = \frac{1}{2}\ mV^2$$

So, $v = \sqrt{\frac{2Pt}{m}}$

Hence, acceleration $a = \frac{dV}{dt} = \sqrt{\frac{2P}{m}} \cdot \frac{1}{2\sqrt{t}}$

Therefore, force on the particle at time ‘t’

$$= ma = \sqrt{\frac{2Km^2}{m}} \cdot \frac{1}{2\sqrt{t}} = \sqrt{\frac{Km}{2t}} = \sqrt{\frac{mK}{2}}\ t^{-1/2}$$

**132. (c)** Power $= \frac{\text{work done}}{\text{time}}$

Therefore power of A, $P_A = \frac{mgh}{t_A}$

and power of B, $P_B = \frac{mgh}{t_B}$

$$\therefore \quad \frac{P_A}{P_B} = \frac{t_B}{t_A} = \frac{4}{2} = 2:1$$

**133. (d)** Power $= \frac{\text{total work done}}{\text{time}}$

$$= \frac{\frac{1}{2}Mv^2}{t} = \frac{1}{2}(mv^2)n \left(\because \frac{M}{t} = mn\right)$$

$$= kn\left[\because \text{K.E. } K = \frac{1}{2}mv^2\right]$$

**134. (b)** Applying momentum conservation

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$0.1u + m(0) = 0.1(0) + m(3)$

$0.1u = 3m$

$$\frac{1}{2}0.1u^2 = \frac{1}{2}m(3)^2$$

Solving we get, $u = 3$

$$\frac{1}{2}kx^2 = \frac{1}{2}K\left(\frac{x}{2}\right)^2 + \frac{1}{2}(0.1)3^2$$

$$\Rightarrow \quad \frac{3}{4}kx^2 = 0.9$$

$$\Rightarrow \quad \frac{3}{2} \times \frac{1}{2}kx^2 = 0.9$$

$\therefore \quad \frac{1}{2}Kx^2 = 0.6$ J (total initial energy of the spring)

**135. (b)** As we know, $dU = F.dr$

$$U = \int_0^r \alpha r^2 dr = \frac{ar^3}{3} \qquad \text{...(i)}$$

As, $\frac{mv^2}{r} = \alpha r^2$

$m^2v^2 = m\alpha r^3$

or, $2m(KE) = \frac{1}{2}\alpha r^3 \qquad$ ...(ii)

Total energy = Potential energy + kinetic energy

Now, from eqn (i) and (ii)

Total energy = K.E. + P.E.

$$= \frac{\alpha r^3}{3} + \frac{\alpha r^3}{2} = \frac{5}{6}\alpha r^3$$

**136. (c)** Let $E$ be the total energy then

$$\frac{P.E}{K.E} = \frac{mgh}{E - mgh} = \frac{2}{3} \Rightarrow E = \frac{5}{2}\ mgh$$

When velocity is double then inital energy becomes $4E$.

So, $\frac{mgh}{4E-mgh} = NL = \frac{mgh}{10mgh-mgh}$

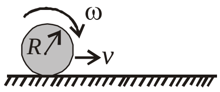
On solving we get $\frac{P.E}{K.E}=\frac{1}{9}$.

**137. (a)** Given, mass of the sphere, $M = 300\text{ g} = 0.3\text{ kg}$

Speed of the sphere $V = 5\text{ m s}^{-1}$

In case of rolling motion without slipping

Total energy, $K = K_{trans} + K_{rot}$



i.e., $K = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2$

$= \frac{1}{2}Mv^2 + \frac{1}{2}\frac{2}{5}MR^2\omega^2 \left(\because I \text{ solid sphere} = \frac{2}{5}MR^2\right)$

$= \frac{1}{2}Mv^2 + \frac{1}{5}Mv^2 \qquad (\because v = R\omega)$

$= \frac{7}{10}Mv^2 = \frac{7}{10}\times 0.3\times 5^2 = 5.25\text{ J}$

**138. (a)** Let the bullet be fired with velocity v.

For 20 cm penetration of bullet

using $v^2 - u^2 = 2as$

$$\left(\frac{v}{2}\right)^2 - (v)^2 = 2a(20)$$

$\Rightarrow \; -\frac{3}{4}v^2 = 40a \text{ or } a = -\frac{3v^2}{160} \qquad \text{.......... (i)}$

For latter part of penetration,

Let before it comes to rest distance travelled by the bullet be $x$

Again, using $v^2 - u^2 = 2as$ we get

$$0 - \left(\frac{v}{2}\right)^2 = 2ax$$

or $x = -\frac{v^2}{8a} = -\frac{v^2}{8}\left(\frac{160}{-3v^2}\right) = 6.66\text{ cm}$ (using eq. (i))

Therefore, the distance travelled by the bullet before it comes to rest = 6.66 cm

**139. (c)** Work done in stretching the rubber-band by a distance $dx$ is

$dW = F\,dx = (ax + bx^2)dx$

Integrating both sides,

$$W = \int_0^L ax\,dx + \int_0^L bx^2\,dx = \frac{aL^2}{2} + \frac{bL^3}{3}$$

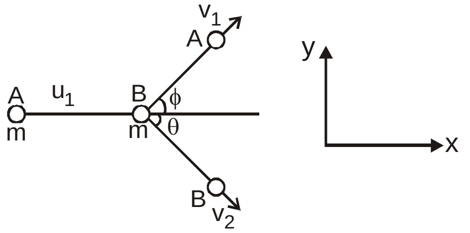
**140. (a)** In an elastic collision

$V_1 = \frac{(m_1 - m_2)}{m_1 + m_2}u_1$

$V_2 = \frac{2m_1u_1}{m_1 + m_2}$

$\therefore$ if $m_1 = m_2$, then $V_1 = 0$; and $V_2 = \frac{2\cancel{m_1}v_1}{2\cancel{m_1}} = u_1$

**141. (c)**



(a) By law of conservation of momentum

(i) along x axis

$mu_1 + 0 = mv_1\cos\phi + mv_2\cos\theta \qquad \text{.........(i)}$

(ii) along y axis

$0 = mv_1\sin\phi - mv_2\sin\phi. \qquad \text{........(ii)}$

(b) By law of conservation of energy

$\frac{1}{2}mu_1^2 = \frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2 \Rightarrow u_1^2 = v_1^2 + v_2^2 \qquad \text{.......(iii)}$

From eq (i) & (ii) we get

$u_1^2 = v_1^2 + v_2^2 + 2v_1v_2\cos(\varphi+\theta) \qquad \text{...... (iv)}$

Now use eq.(iii) in eq.(iv), we get

$\cos(\phi+\theta) = 0 \Rightarrow \theta + \phi = 90^o$

ie, after collision they will move in mutually perpendicular directions.

**142. (c)** When two particles of mass $m_1$ & $m_2$ undergo elastic collision, then

$$v_1 = \frac{(m_1 - m_2)}{m_1 + m_2}u_1 + \frac{2m_2u_2}{(m_1 + m_2)}$$

$$v_2 = \frac{(m_2 - m_1)u_2}{m_1 + m_2} + \frac{2m_1u_1}{m_1 + m_2}$$

Where $u_1$ & $u_2$ are the initial velocity of $m_1$ & $m_2$ respectively and $v_1$ & $v_2$ are the velocity of $m_1$ & $m_2$ respectively after collision. So when $m_1 = m_2$ & $u_2 = 0$

$\Rightarrow v_2 = u_1$ & $v_1 = 0$

It means that $m_1$ ball has zero velocity after collision & ball $m_2$ moves with the velocity $v_2 = u_1$, so maximum transfer of kinetic energy.

**143. (a)** As $u_2 = 0$ and $m_1 = m_2$, therefore from

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ we get $u_1 = v_1 + v_2$

Also, $e = \frac{v_2 - v_1}{u_1} = \frac{v_2 - v_1}{v_2 + v_1} = \frac{1 - v_1 / v_2}{1 + v_1 / v_2}$,

which gives $\frac{v_1}{v_2} = \frac{1-e}{1+e}$

**144. (c)** $K_i = \frac{1}{2} m_1 u_1^2$,

$$K_f = \frac{1}{2} m_1 v_1^2 , v_1 = \frac{m_1 - m_2}{m_1 + m_2} u_1$$

Fractional loss

$$\frac{K_i - K_f}{K_i} = \frac{\frac{1}{2} m_1 u_1^2 - \frac{1}{2} m_1 v_1^2}{\frac{1}{2} m_1 u_1^2}$$

$$= 1 - \frac{v_1^2}{u_1^2} \quad = 1 - \frac{(m_1 - m_2)^2}{(m_1 + m_2)^2} = \frac{4 m_1 m_2}{(m_1 + m_2)^2}$$

$m_2 = m \; ; \; m_1 = nm$ $\qquad 1 - \frac{K_f}{K_i} = \frac{4n}{(1+n)^2}$

Energy transfer is maximum when $K_f = 0$

$$\frac{4n}{(1+n)^2} = 1 \Rightarrow 4n = 1 + n^2 + 2n \Rightarrow n^2 + 1 - 2n = 0$$

$(n-1)^2 = 0 \qquad n = 1$ ie. $m_2 = m$, $m_1 = m$

Transfer will be maximum when both masses are equal and one is at rest.

**145. (c)** Apply conservation of momentum,

$m_1 v_1 = (m_1 + m_2) v$

$$v = \frac{m_1 v_1}{(m_1 + m_2)}$$

Here $v_1$ = 36 km/hr = 10 m/s,

$m_1$ = 2 kg, $m_2$ = 3 kg

$$v = \frac{10 \times 2}{5} = 4 \text{ m/s}$$

$$\text{K.E. (initial)} = \frac{1}{2} \times 2 \times (10)^2 = 100 \text{ J}$$

$$\text{K.E. (Final)} = \frac{1}{2} \times (3+2) \times (4)^2 = 40 \text{ J}$$

Loss in K.E. = 100 – 40 = 60 J

Alternatively use the formula

$$-\Delta E_k = \frac{1}{2} \frac{m_1 m_2}{(m_1 + m_2)} (u_1 - u_2)^2$$

**146. (a)** Clearly $v_1 = 2 \text{ ms}^{-1}$, $v_2 = 0$

$m_1 = m$ (say), $m_2 = 2m$

$v_1' = ?, v'_2 = ?$

$$e = \frac{v_1' - v_2'}{v_2 - v_1} \qquad \text{....(i)}$$

By conservation of momentum,

$2m = mv_1' + 2mv_2'$ ... (ii)

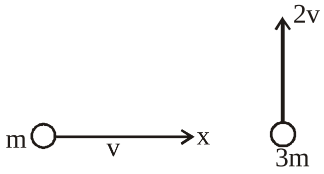
From (i), $0.5 = \frac{v_2' - v_1'}{2}$

$\therefore \quad v_2' = 1 + v_1'$

From (ii), $2 = v_1' + 2 + 2 v_1'$

$\Rightarrow \quad v_1 = 0$ and $v_2 = 1 \text{ ms}^{-1}$

**147. (a)** As the two masses stick together after collision, hence it is inelastic collision. Therefore, only momentum is conserved.



$$\therefore mv\hat{i} + 3m(2v)\hat{j} = (4m)\vec{v}$$

$$\vec{v} = \frac{v}{4}\hat{i} + \frac{6}{4} v\hat{j}$$

$$= \frac{v}{4}\hat{i} + \frac{3}{2} v\hat{j}$$

**148. (c)** Initial kinetic energy of the system

$$\text{K.E}_i = \frac{1}{2} mu^2 + \frac{1}{2} M(0)^2 = \frac{1}{2} \times 0.5 \times 2 \times 2 + 0 = 1\text{J}$$

For collision, applying conservation of linear momentum

$m \times u = (m + M) \times v$

$\therefore \quad 0.5 \times 2 = (0.5 + 1) \times v$

$\Rightarrow \quad v = \frac{2}{3} \text{m/s}$

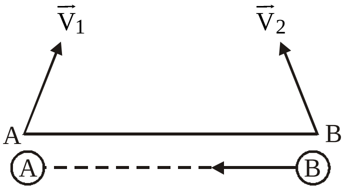
Final kinetic energy of the system is

$$\text{K.E}_f = \frac{1}{2}(m+M)v^2 = \frac{1}{2}(0.5+1) \times \frac{2}{3} \times \frac{2}{3} = \frac{1}{3}\text{J}$$

$\therefore$ Energy loss during collision $= \left(1 - \frac{1}{3}\right)\text{J} = 0.67\text{J}$

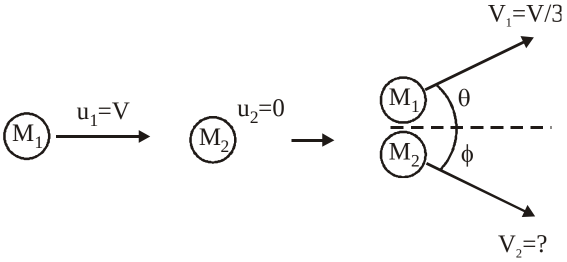
**149. (d)** For collision $\vec{V}_{B/A}$ should be along $\overline{B \rightarrow A}\left(\vec{r}_{A/B}\right)$

So, $\frac{\vec{V}_2-\vec{V}_1}{\left|V_2-V_1\right|}=\frac{\vec{r}_1-\vec{r}_2}{\left|r_1-r_2\right|}$



**150. (d)** Here, $M_1 = M_2$ and $u_2 = 0$

$u_1 = V, \quad V_1 = \frac{V}{3}; \qquad V_2 = ?$



From figure, along x-axis,

$M_1u_1 + M_2u_2 = M_1V_1 \cos\theta + M_2V_2 \cos\phi$ ...(*i*)

Along y-axis

$0 = M_1V_1 \sin\theta - M_2V_s \sin\phi$ ...(*ii*)

By law of conservation of kinetic energy

$\frac{1}{2}M_1u_1^2+\frac{1}{2}M_2u_2^2=\frac{1}{2}M_1V_1^2+\frac{1}{2}M_2V_2^2$ ...(*iii*)

Putting $M_1 = M_2$ and $u_2 = 0$ in equation (*i*), (*ii*) and (*iii*) we get

$\theta+\phi=\frac{\pi}{2}=90°$

and $u_1^2=V_1^2+V_2^2$

$V^2=\left(\frac{V}{3}\right)^2+V_2^2 \qquad \left[\because u_1 = V \text{ and } V_1=\frac{V}{3}\right]$

or, $V^2-\left(\frac{V}{3}\right)^2=V_2^2$

$V^2-\frac{V^2}{9}=V_2^2$

or $V_2^2=\frac{8}{9}V^2 \Rightarrow V_2=\frac{2\sqrt{2}}{3}V$

**151. (a)** When ball collides with the ground it loses its 50% of energy

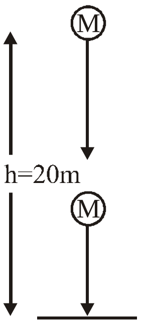
$\therefore \frac{KE_f}{KE_i}=\frac{1}{2} \Rightarrow \frac{\frac{1}{2}mV_f^2}{\frac{1}{2}mV_i^2}=\frac{1}{2}$

or $\frac{V_f}{V_i}=\frac{1}{\sqrt{2}}$

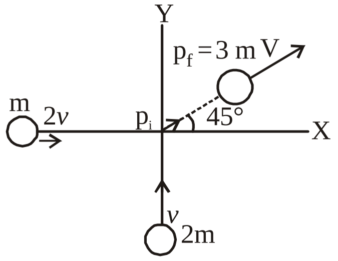
or, $\frac{\sqrt{2gh}}{\sqrt{V_0^2+2gh}}=\frac{1}{\sqrt{2}}$

or, $4gh = V_0^2+2gh$

$\therefore V_0 = 20ms^{-1}$



**152. (a)**



Initial momentum of the system

$p_i=\sqrt{[m(2V)^2\times m(2V)^2]}$

$=\sqrt{2}m\times 2V$

Final momentum of the system = 3mV

By the law of conservation of momentum

$2\sqrt{2}mv = 3mV$

$\Rightarrow \frac{2\sqrt{2}v}{3}=V_{combined}$

Loss in energy

$\Delta E=\frac{1}{2}m_1V_1^2+\frac{1}{2}m_2V_2^2-\frac{1}{2}(m_1+m_2)V_{combined}^2$

$\Delta E = 3mv^2-\frac{4}{3}mv^2=\frac{5}{3}mv^2=55.55\%$

Percentage loss in energy during the collision $\simeq$ 56%

## CHAPTER

## 7

# SYSTEM OF PARTICLES AND ROTATIONAL MOTION

## FACT/DEFINITION TYPE QUESTIONS

**1.** The centre of mass of a body is the average position of its
(a) mass (b) weight
(c) either mass or weight (d) None of these

2. The centre of mass of a body
(a) lies always outside the body
(b) may lie within, outside on the surface of the body
(c) lies always inside the body
(d) lies always on the surface of the body

**3.** Position vector of centre of mass of two particles system is given by

(a) $\vec{R} = \frac{m_1\vec{r}_1 - m_2\vec{r}_2}{m_1 + m_2}$ (b) $\vec{R} = \frac{m_1\vec{r}_1 . m_2\vec{r}_2}{\vec{r}_1 + \vec{r}_2}$

(c) $\vec{R} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{\vec{r}_1 + \vec{r}_2}$ (d) $\vec{R} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{\vec{m}_1 + \vec{m}_2}$

**4.** The motion of the centre of mass depends on
(a) total external forces (b) total internal forces
(c) sum of (a) and (b) (d) None of these

**5.** The centre of mass of a rigid body lies
(a) inside the body (b) outside the body
(c) neither (a) nor (b) (d) either (a) or (b)

**6.** The sum of moments of all the particles in a system about the centre of mass is always
(a) maximum (b) minimum
(c) infinite (d) zero

**7.** The centre of mass of two particles lies on the line
(a) joining the particles
(b) perpendicular to the line joining the particles
(c) at any angle to this line
(d) None of these

**8.** If the resultant of all external forces is zero, then velocity of centre of mass will be
(a) zero (b) constant
(c) either (a) or (b) (d) neither (a) nor (b)

**9.** Centre of mass of the earth and the moon system lies
(a) closer to the earth
(b) closer to the moon
(c) at the mid-point of line joining the earth and the moon
(d) cannot be predicted

**10.** The position of centre of mass of a system of particles does not depend upon the
(a) mass of particles
(b) symmetry of the body
(c) position of the particles
(d) relative distance between the particles

**11.** In rotatory motion, linear velocities of all the particles of the body are
(a) same (b) different
(c) zero (d) cannot say

**12.** Which of the following is invalid equation? (where $\tau$, $\omega$, L and $\alpha$ have their usual meanings)
(a) $\vec{\tau} = I\vec{\omega}$ (b) $\vec{L} = I\vec{\omega}$
(c) $\vec{\tau} = I\vec{\alpha}$ (d) All of these

**13.** The time rate of change of angular momentum of a particle is equal to
(a) force (b) acceleration
(c) torque (d) linear momentum

**14.** Which component of force contributes to the torque?
(a) Radial component
(b) Transverse component
(c) Both (a) and (b)
(d) Either radial or transverse

**15.** The wide handle of screw is based upon
(a) Newton's second law of motion
(b) law of conservation of linear momentum
(c) turning moment of force
(d) None of these

**16.** Which of the following is an expression for power?
(a) $P = \tau\omega$ (b) $P = I\alpha$
(c) $P = I\omega$ (d) $P = \tau\alpha$

**17.** Which of the following statements about angular momentum is correct?
(a) It is directly proportional to moment of inertia
(b) It is a scalar quantity
(c) both (a) and (b)
(d) None of these

**18.** A couple produces
(a) linear motion (b) rotational motion
(c) both (a) and (b) (d) neither (a) nor (b)

**19.** According to the principle of conservation of angular momentum, if moment of inertia of a rotating body decreases, then its angular velocity
(a) decreases (b) increases
(c) remains constant (d) becomes zero

**20.** When a mass is rotating in a plane about a fixed point, its angular momentum is directed along the
(a) radius of orbit
(b) tangent to the orbit
(c) line parallel to plane of rotation
(d) line perpendicular to plane of rotation

**21.** The motion of a rigid body which is not pivoted or fixed in some way is either a pure ...*A*... or a combination of translation and rotation. The motion of a rigid body which is pivoted or fixed in some way is ...*B*...
Here, *A* and *B* refer to
(a) rotation and translation
(b) translation and rotation
(c) translation and the combination of rotation and translation
(d) None of the above

**22.** The moment of inertia of a ...*A*... body about an axis ...*B*... to its plane is equal to the sum of its moments of inertia about two ...*C*... axes concurrent with perpendicular axis and lying in the plane of the body.
Here, *A*, *B* and *C* refer to
(a) three dimensional, perpendicular and perpendicular
(b) planar, perpendicular and parallel
(c) planar, perpendicular and perpendicular
(d) three dimensional, parallel and perpendicular

**23.** During summersault, a swimmer bends his body to
(a) increase moment of Inertia
(b) decrease moment of Inertia
(c) decrease the angular momentum
(d) reduce the angular velocity

**24.** The moment of inertia of a uniform circular disc of radius 'R' and mass 'M' about an axis passing from the edge of the disc and normal to the disc is
(a) $MR^2$ (b) $\frac{1}{2}MR^2$
(c) $\frac{3}{2}MR^2$ (d) $\frac{7}{2}MR^2$

**25.** Rotational analogue of force in linear motion is
(a) weight (b) angular momentum
(c) moment of inertia (d) torque

**26.** A boy comes and sits suddenly on a circular rotating table. What will remain conserved for the table-boy system?
(a) Angular velocity (b) Angular momentum
(c) Linear momentum (d) Angular acceleration

**27.** In rotation of a rigid body about a fixed axis, every ...*A*...of the body moves in a ...*B*..., which lies in a plane ...*C*... to the axis and has its centre on the axis.
Here, *A*, *B* and *C* refer to
(a) particle, perpendicular and circle
(b) circle, particle and perpendicular
(c) particle, circle and perpendicular
(d) particle perpendicular and perpendicular

**28.** Moment of inertia does not depend upon
(a) distribution of mass
(b) axis of rotation
(c) point of application of force
(d) None of these

**29.** Force change the ...*X*... state of motion of a rigid body.
(a) Here X refers to rotational
(b) translational
(c) rotational and translational in general
(d) None of the above

**30.** Moment of inertia of a circular wire of mass *M* and radius *R* about its diameter is
(a) $MR^2/2$ (b) $MR^2$
(c) $2MR^2$ (d) $MR^2/4$.

**31.** Moment of inertia does not depend upon
(a) angular velocity of body
(b) shape and size
(c) mass
(d) position of axis of rotation

**32.** Moment of inertia of a hollow cylinder of mass M and radius r about its own axis is
(a) $\frac{2}{3}Mr^2$ (b) $\frac{2}{5}Mr^2$
(c) $\frac{1}{3}Mr^2$ (d) $Mr^2$

**33.** Which of the following has the highest moment of inertia when each of them has the same mass and the same outer radius
(a) a ring about its axis, perpendicular to the plane of the ring
(b) a disc about its axis, perpendicular to the plane of the ring
(c) a solid sphere about one of its diameters
(d) a spherical shell about one of its diameters

**34.** Radius of gyration of a body depends upon
(a) axis of rotation (b) translational motion
(c) shape of the body (d) area of the body

**35.** The correct relation between moment of inertia I, radius of gyration k and mass M of the body is
(a) $K = I^2M$ (b) $K = IM^2$
(c) $K = \sqrt{\frac{M}{I}}$ (d) $K = \sqrt{\frac{I}{M}}$

**36.** Choose the wrong statement from the following.
(a) The centre of mass of a uniform circular ring is at its geometric centre
(b) Moment of inertia is a scalar quantity
(c) Radius of gyration is a vector quantity
(d) For same mass and radius, the moment of inertia of a ring is twice that of a uniform disc

**37.** If two circular discs A and B are of same mass but of radii r and 2r respectively, then the moment of inertia of A is

(a) the same as that of B (b) twice that of B
(c) four times that of B (d) 1/4 that of B

**38.** Analogue of mass in rotational motion is

(a) moment of inertia (b) angular momentum
(c) torque (d) None of these

**39.** For a given mass and size, moment of inertia of a solid disc is

(a) more than that of a ring
(b) less than that of a ring
(c) equal to that of a ring
(d) depend on the material of ring and disc

**40.** What is the moment of inertia of a solid sphere about its diameter?

(a) $\frac{2}{5}MR^2$ (b) $\frac{1}{5}MR^2$
(c) $\frac{2}{3}MR^2$ (d) $MR^2$

**41.** If $I_{xy}$ is the moment of inertia of a ring about a tangent in the plane of the ring and $I_{x'y'}$ is the moment of inertia of a ring about a tangent perpendicular to the plane of the ring then

(a) $I_{xy} = I_{x'y'}$ (b) $I_{xy} = \frac{1}{2}I_{x'y'}$
(c) $I_{x'y'} = \frac{3}{4}I_{xy}$ (d) $I_{xy} = \frac{3}{4}I_{x'y'}$

**42.** Moment of inertia of a rigid body depends on

(a) Mass of the body (b) Shape of the body
(c) Size of the body (d) All of these

**43.** Which of the following is not the moment of inertia of a uniform circular disc along any axis?

(a) $\frac{1}{2}MR^2$ (b) $\frac{3}{2}MR^2$
(c) $\frac{1}{4}MR^2$ (d) $\frac{3}{4}MR^2$

**44.** Which of the following is/are essential condition for mechanical equilibrium of a body?

(a) Total force on the body should be zero
(b) Total torque on the body should be zero
(c) Both (a) and (b)
(d) Total linear momentum should be zero

**45.** Which of the following is incorrect?

(a) $\vec{v} = \vec{\omega} \times \vec{r}$ (b) $\vec{\tau} = \vec{F} \times \vec{r}$
(c) $\vec{L} = \vec{r} \times \vec{p}$ (d) None of these

**46.** Which of the following is not an expression for kinetic energy?

(a) $k = \frac{1}{2}MR^2\omega^2$ (b) $k = \frac{1}{2}I\omega^2$
(c) $k = \frac{1}{2}mv^2$ (d) None of these

**47.** A particle moving in a circular path has an angular momentum of L. If the frequency of rotation is halved, then its angular momentum becomes

(a) $\frac{L}{2}$ (b) L
(c) $\frac{L}{3}$ (d) $\frac{L}{4}$

**48.** A circular disc A and a ring B have same mass and same radius. If they are rotated with the same angular speed about their own axis, then

(a) A has less moment of inertia than B
(b) A has less rotational kinetic energy than B
(c) A and B have the same angular momentum
(d) A has greater angular momentum than B

**49.** The angular momentum of a system of particle is conserved

(a) when no external force acts upon the system
(b) when no external torque acts upon the system
(c) when no external impulse acts upon the system
(d) when axis of rotation remains same

**50.** Angular momentum of the particle rotating with a central force is constant due to

(a) constant torque
(b) constant force
(c) constant linear momentum
(d) zero torque

**51.** When a body starts to roll on an inclined plane, its potential energy is converted into

(a) translation kinetic energy only
(b) translation and rotational kinetic energy
(c) rotational energy only
(d) None of these

**52.** A body cannot roll without slipping on a

(a) rough horizontal surface
(b) smooth horizontal surface
(c) rough inclined surface
(d) smooth inclined surface

**53.** A fan is moving around its axis, What will be its motion regarded as ?

(a) Pure rolling (b) Rolling with shipping
(c) Skidding (d) Pure rotation

**54.** A sphere rolls on a rough horizontal surface and stops. What does the force of friction do?

(a) It decreases the angular velocity
(b) It decreases the linear velocity
(c) It increases the angular velocity
(d) It decreases both angular and linear velocity

**55.** If a ring, a solid cylinder and a solid sphere roll down the same inclined plane without slipping then

(a) ring has the least velocity of centre of mass at the bottom of inclined plane
(b) sphere has the least velocity of centre of mass at the bottom of the inclined plane
(c) cylinder has the greatest velocity of centre of mass at the bottom of the inclined plane
(d) sphere has the least velocity of centre of mass at the bottom of the inclined plane.

## STATEMENT TYPE QUESTIONS

**56.** Consider the following statements and select the correct statements.

I. The position of centre of mass depends upon the shape of the body
II. The position of centre of mass depends upon the distribution of mass
III. The positon of centre of mass is independent of the co-ordinate system chosen

(a) I and II only (b) II and III only
(c) I and III only (d) I, II and III

**57.** Which of the following statements are incorrect about centre of mass?

I. Centre of mass can coincide with geometrical centre of a body
II. Centre of mass of a system of two particles does not always lie on the line joining the particles
III. Centre of mass should always lie on the body.

(a) II and III (b) I and II
(c) I and III (d) I, II and III

**58.** Consider the following statements and choose the correct option.

I. Position vector of centre of mass of two particles of equal mass is equal to the position vector of either particle.
II. Centre of mass is always at the mid-point of the line joining two particles
III. Centre of mass of a body can lie where there is no mass

(a) I and II (b) II only
(c) III only (d) I, II and III

**59.** Consider the following statements and select the correct statement(s).

I. Angular velocity is a scalar quantity
II. Linear velocity is a vector quantity
III. About a fixed axis, angular velocity has fixed direction
IV. Every point on a rigid rotating body has different angular velocity

(a) I only (b) II only
(c) II and III (d) III and IV

**60.** Consider the following statements and select the correct option.

I. Moment of a couple depends on the point about which moment is taken.
II. Principle of moments holds only when parallel forces $F_1$ and $F_2$ are perpendicular to the lever
III. Centre of mass depends on the gravity
IV. Centre of mass depends on the distribution of mass of the body

(a) I and II (b) III and IV
(c) I, II and III (d) IV only

**61.** Consider the following statements and choose the incorrect statement(s).

I. A body in translatory motion cannot have angular momentum
II. If $\vec{A}$ points vertically upwards and $\vec{B}$ points towards east then, $\vec{A} \times \vec{B}$ points along South

(a) I only (b) II only
(c) I and II (d) None of these

**62.** Select the correct statement(s) from the following.

I. Moment of inertia is a scalar quantity
II. Angular acceleration requires torque
III. The rotational equivalent of distance is radius
IV. State of rest or motion of centre of mass can never be changed

(a) I only (b) II only
(c) I and II (d) II and IV

**63.** Consider the following statements and select the correct statement(s).

I. Two satellites of equal masses orbiting the earth at different heights have equal moments of inertia
II. If earth were to shrink suddenly, length of the day will increase
III. Centre of gravity cannot coincide with centre of mass

(a) I only (b) II only
(c) I and II (d) I, II and III

## MATCHING TYPE QUESTIONS

**64.** Match Column I and Column II

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Moment of inertia | (1) | Twice the product of mass and areal velocity of the particle |
| (B) | Radius of gyration | (2) | The product of masses of the various particles and square of their perpendicular distances |
| (C) | Angular momentum | (3) | The root mean square distance of the particles from the axis of rotation |
| (D) | Torque | (4) | The product of force and its perpendicular distance |

(a) (A)→(2); (B)→(3); C→(1); (D)→(4)
(b) (A)→(1); (B)→(2); C→(4); (D)→(3)
(c) (A)→(2); (B)→(1); C→(4); (D)→(3)
(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

**65.**

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Rolling motion | (1) | Torque |
| (B) | Rate of change of angular momentum | (2) | Rotatory motion |
| (C) | Hollow cylinder about axis | (3) | $I_z + Ma^2$ |
| (D) | Theorem of parallel axes | (4) | $MR^2$ |

(a) (A)→(1); (B)→(3); C→(4); (D)→(2)
(b) (A)→(3); (B)→(2); C→(4); (D)→(1)
(c) (A)→(2); (B)→(1); C→(4); (D)→(3)
(d) (A)→(3); (B)→(1); C→(2); (D)→(4)

**66.**

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Translational equilibrium | (1) | $\Sigma F = 0$ |
| (B) | Moment of inertia of disc | (2) | $MR^2$ |
| (C) | Rotational equilibrium | (3) | $\frac{1}{2}I\omega^2$ |
| (D) | Kinetic energy of rolling body | (4) | $\frac{1}{2}mV_cm^2 + \frac{1}{2}I\omega^2$ |
| | | (5) | $\Sigma\tau = 0$ |
| (E) | Moment of inertia of ring | (6) | $MR^2/2$ |

(a) (A)→(1); (B)→(6); C→(5); (D)→(4); (E)→(2)
(b) (A)→(4); (B)→(3); C→(2); (D)→(1); (E)→(6)
(c) (A)→(6); (B)→(5); C→(3); (D)→(4); (E)→(2)
(d) (A)→(1); (B)→(2); C→(4); (D)→(5); (E)→(6)

**67.** Match Column I and Column II.

| | **Column I**<br>(*Quantity*) | | **Column II**<br>(*Expression*) |
|---|---|---|---|
| (A) | Angular momentum | (1) | $\vec{r}\times(m\vec{v})$ |
| (B) | Impulse | (2) | $\frac{1}{2}I\omega^2$ |
| (C) | Torque | (3) | $\vec{r}\times\vec{F}$ |
| (D) | Rotational energy | (4) | $m\Delta\vec{v}$ |

(a) (A)→(4); (B)→(2); C→(1); (D)→(3)
(b) (A)→(1); (B)→(2); C→(4); (D)→(3)
(c) (A)→(2,4); (B)→(1); C→(5); (D)→(3)
(d) (A)→(1); (B)→(4); C→(3); (D)→(2)

**68.** Match Column I and Column II.

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Moment of Inertia of a solid uniform sphere about the diameter | (1) | $MR^2$ |
| (B) | Moment of inertia of a thin uniform spherical shell about the tangent | (2) | $\frac{1}{2}MR^2$ |
| (C) | Moment of inertia of a uniform disc through centre of a mass and perpendicular to plane of the disc | (3) | $\frac{5}{3}MR^2$ |
| (D) | Moment of inertia of disc about tangent in the plane of disc. | (4) | $\frac{2}{5}MR^2$ |
| | | (5) | $\frac{5}{4}MR^2$ |

(a) (A)→(3,2); (B)→(3); C→(5); (D)→(4)
(b) (A)→(5); (B)→(2); C→(1); (D)→(3)
(c) (A)→(4); (B)→(3); C→(2); (D)→(5)
(d) (A)→(4); (B)→(5); C→(2); (D)→(1)

**69.** Match Column I (Body rolling on a surface without slipping) with Column II (Ratio of Translational energy to Rotational energy.

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Circular ring | (1) | 1/2 |
| (B) | Circular disc | (2) | 1 |
| (C) | Solid sphere | (3) | 3/2 |
| (D) | Spherical shell | (4) | 2 |
| | | (5) | 5/2 |

(a) (A)→(4); (B)→(2); C→(1); (D)→(3)
(b) (A)→(1); (B)→(2); C→(4); (D)→(3)
(c) (A)→(2); (B)→(1); C→(5); (D)→(3)
(d) (A)→(2); (B)→(4); C→(5); (D)→(3)

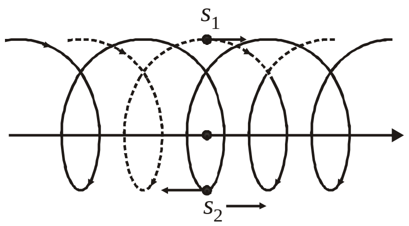
**70.** A rigid body of mass *M* and radius *R* rolls without slipping on an inclined plane of inclination θ, under gravity. Match the type of body Column I with magnitude of the force of friction Column II

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | For ring | (1) | $\frac{Mg\sin\theta}{2.5}$ |
| (B) | For solid sphere | (2) | $\frac{Mg\sin\theta}{3}$ |
| (C) | For solid cylinder | (3) | $\frac{Mg\sin\theta}{3.5}$ |
| (D) | For hollow spherical shell | (4) | $\frac{Mg\sin\theta}{2}$ |

(a) (A)→(4); (B)→(3); C→(2); (D)→(1)
(b) (A)→(1); (B)→(2); C→(4); (D)→(3)
(c) (A)→(2); (B)→(1); C→(5); (D)→(3)
(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

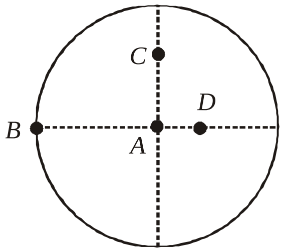
## DIAGRAM TYPE QUESTIONS

**71.** The motion of binary stars , $S_1$ and $S_2$ is the combination of ....*X*.... and ....*Y*.... . Here, *X* and *Y* refer to



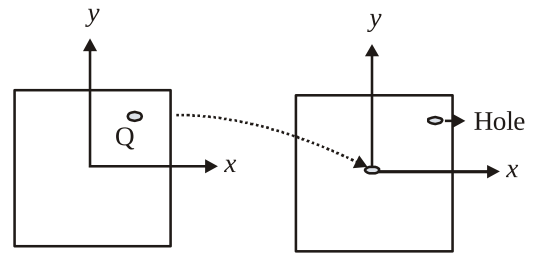
(a) motion of the CM and motion about the CM
(b) motion about the CM and motion of one star
(c) position of the CM and motion of the CM
(d) motion about CM and position of one star

**72.** The moment of inertia of a uniform circular disc (figure) is maximum about an axis perpendicular to the disc and passing through



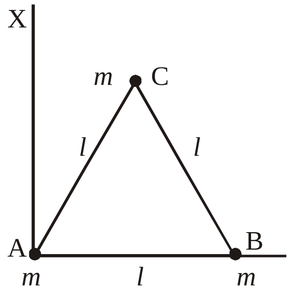
(a) *B* (b) *C*
(c) *D* (d) *A*

**73.** A uniform square plate has a small piece Q of an irregular shape removed and glued to the centre of the plate leaving a hole behind. Then the moment of inertia about the z-axis



(a) increases
(b) decreases
(c) remains same
(d) changed in unpredicted manner.

**74.** Three particles, each of mass *m* gram, are situated at the vertices of an equilateral triangle ABC of side $\ell$ cm (as shown in the figure). The moment of inertia of the system about a line AX perpendicular to AB and in the plane of ABC, in gram-cm$^2$ units will be



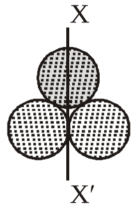
(a) $\frac{3}{2}m\ell^2$

(b) $\frac{3}{4}m\ell^2$

(c) $2\,m\ell^2$

(d) $\frac{5}{4}m\ell^2$

**75.** Three identical spherical shells, each of mass m and radius r are placed as shown in figure. Consider an axis XX' which is touching to two shells and passing through diameter of third shell. Moment of inertia of the system consisting of these three spherical shells about XX' axis is



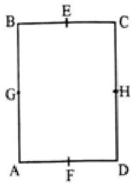
(a) $3mr^2$

(b) $\frac{16}{5}mr^2$

(c) $4mr^2$

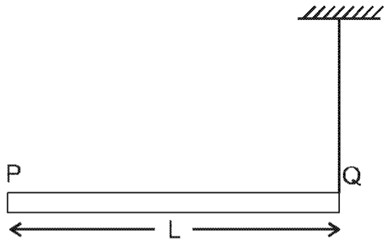
(d) $\frac{11}{5}mr^2$

**76.** The moment of inertia of the rectangular plate ABCD, (AB = 2 BC) is minimum along the axis



(a) GH
(b) EF
(c) BC
(d) AC

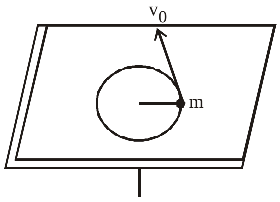
**77.** A rod PQ of mass M and length L is hinged at end P. The rod is kept horizontal by a massless string tied to point Q as shown in figure. When string is cut, the initial angular acceleration of the rod is



(a) g /L (b) 2g/L

(c) $\frac{2g}{3L}$ (d) $\frac{3g}{2L}$

**78.** A mass m moves in a circle on a smooth horizontal plane with velocity $v_0$ at a radius $R_0$. The mass is attached to string which passes through a smooth hole in the plane as shown.

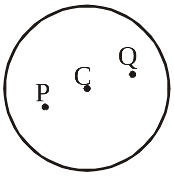


The tension in the string is increased gradually and finally mass *m* moves in a circle of radius $\frac{R_0}{2}$. The final value of the kinetic energy is

(a) $\frac{1}{4}mv_0^2$ (b) $2mv_0^2$

(c) $\frac{1}{2}mv_0^2$ (d) $mv_0^2$

**79.** A disc is rolling (without slipping) on a horizontal surface C is its centre and Q and P are two points equidistant from C. Let $V_p$, $V_q$ and $V_c$ be the magnitude of velocities of points P, Q and C respectively, then



(a) $V_Q > V_C > V_P$ (b) $V_Q < V_C < V_P$

(c) $V_Q = V_P, V_C = \frac{1}{2}V_P$ (d) $V_Q < V_C > V_P$

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

**80.** **Assertion:** Centre of mass of a ring lies at its geometric centre though there is no mass.
**Reason:** Centre of mass is independent of mass.

**81.** **Assertion :** When you lean behind over the hind legs of the chair, the chair falls back after a certain angle.
**Reason :** Centre of mass lying outside the system makes the system unstable.

**82.** **Assertion :** The centre of mass of a two particle system lies on the line joining the two particle, being closer to the heavier particle.
**Reason :** Product of mass of particle and its distance from centre of mass is numerically equal to product of mass of other particle and its distance from centre of mass.

**83.** **Assertion :** The centre of mass of system of *n* particles is the weighted average of the position vector of the n particles making up the system.
**Reason :** The position of the centre of mass of a system in independent of coordinate system.

**84.** **Assertion :** The centre of mass of an isolated system has a constant velocity.
**Reason :** If centre of mass of an isolated system is already at rest, it remains at rest.

**85.** **Assertion :** The centre of mass of a body may lie where there is no mass.
**Reason :** Centre of mass of body is a point, where the whole mass of the body is supposed to be concentrated.

**86.** **Assertion :** The position of centre of mass of body depend upon shape and size of the body.
**Reason :** Centre of mass of a body lies always at the centre of the body

**87.** **Assertion :** If no external force acts on a system of particles, then the centre of mass will not move in any direction.
**Reason :** If net external force is zero, then the linear momentum of the system remains constant.

**88.** **Assertion :** A particle is moving on a straight line with a uniform velocity, its angular momentum is always zero.
**Reason :** The momentum is not zero when particle moves with a uniform velocity.

**89.** **Assertion :** The earth is slowing down and as a result the moon is coming nearer to it.
**Reason :** The angular momentum of the earth moon system is conserved.

**90.** **Assertion :** For a system of particles under central force field, the total angular momentum is conserved.
**Reason :** The torque acting on such a system is zero.

**91.** **Assertion :** It is harder to open and shut the door if we apply force near the hinge.
**Reason :** Torque is maximum at hinge of the door.

**92.** **Assertion :** Torque is equal to rate of change of angular momentum.
**Reason :** Angular momentum depends on moment of inertia and angular velocity.

**93.** **Assertion:** When no external torque acts on a body, its angular velocity remains constant as long as moment of inertia is constant.
**Reason:** Torque $\tau = 0$; $\frac{dL}{dt} = 0$, $L = \text{constant}$.
$L = I\omega = \text{constant}$

**94.** **Assertion:** Torque is a vector quantity directed opposite to the applied force.
**Reason:** Torque $\vec{\tau} = -\vec{r} \times \vec{F}$

**95.** **Assertion:** When axis of rotation passes through the centre of gravity, then the moment of inertia of a rigid body increases.
**Reason:** At the centre of gravity mass gets concentrated and moment of inertia increases.

**96.** **Assertion:** An ice-skater stretches out arms-legs during performance.
**Reason:** Stretching out arms-legs helps the performer to balance his or her body so that he or she does not fall.

**97.** **Assertion :** If polar ice melts, days will be longer.
**Reason :** Moment of inertia decreases and thus angular velocity increases.

**98.** **Assertion :** Moment of inertia of a particle is same, whatever be the axis of rotation
**Reason :** Moment of inertia depends on mass and distance of the particles.

**99.** **Assertion :** Radius of gyration of body is a constant quantity.
**Reason :** The radius of gyration of a body about an axis of rotation may be defined as the root mean square distance of the particle from the axis of rotation.

**100.** **Assertion:** A rigid disc rolls without slipping on a fixed rough horizontal surface with uniform angular velocity. Then the acceleration of lowest point on the disc is zero.
**Reason :** For a rigid disc rolling without slipping on a fixed rough horizontal surface, the velocity of the lowest point on the disc is always zero.

**101.** **Assertion :** A wheel moving down a frictionless inclined plane will slip and not roll on the plane.
**Reason :** It is the frictional force which provides a torque necessary for a body to roll on a surface.

**102.** **Assertion :** When a sphere is rolls on a horizontal table it slows down and eventually stops.
**Reason :** When the sphere rolls on the table, both the sphere and the surface deform near the contact. As a result, the normal force does not pass through the centre and provide an angular declaration.

**103.** **Assertion :** The velocity of a body at the bottom of an inclined plane of given height, is more when it slides down the plane, compared to when it is rolling down the same plane.

**Reason :** In rolling, down, a body acquires both, kinetic energy of translation and rotation.

**104.** **Assertion :** The total kinetic energy of a rolling solid sphere is the sum of translational and rotational kinetic energies.

**Reason :** For all solid bodies total kinetic energy is always twice the translational kinetic energy.

## CRITICALTHINKING TYPE QUESTIONS

**105.** Two particles of mass $m_1$ and $m_2$ ($m_1 > m_2$) attract each other with a force inversely proportional to the square of the distance between them. If the particles are initially held at rest and then released, the centre of mass will

(a) move towards $m_1$ (b) move towards $m_2$

(c) remains at rest (d) None of these

**106.** A shell following a parabolic path explodes somewhere in its flight. The centre of mass of fragments will continue to move in

(a) vertical direction (b) any direction

(c) horizontal direction (d) same parabolic path

**107.** A man stands at one end of a boat which is stationary in water. Neglect water resistance. The man now moves to the other end of the boat and again becomes stationary. The centre of mass of the 'man plus boat' system will remain stationary with respect to water

(a) in all cases

(b) only when the man is stationary initially and finally

(c) only if the man moves without acceleration on the boat

(d) only if the man and the boat have equal masses

**108.** There are some passengers inside a stationary railway compartment. The centre of mass of the compartment itself (without the passengers) is $C_1$, while the centre of mass of the 'compartment plus passengers' system is $C_2$. If the passengers move about inside the compartment then

(a) both $C_1$ and $C_2$ will move with respect to the ground

(b) neither $C_1$ nor $C_2$ will be stationary with respect to the ground

(c) $C_1$ will move but $C_2$ will be stationary with respect to the ground

(d) $C_2$ will move but $C_1$ will be stationary with respect to the ground

**109.** A stick is thrown in the air and lands on the ground at some distance from the thrower. The centre of mass of the stick will move along a parabolic path

(a) in all cases

(b) only if the stick is uniform

(c) only if the stick has linear motion but no rotational motion

(d) only if the stick has a shape such that its centre of mass is located at some point on it and not outside it

**110.** Consider a system of two particles having masses $m_1$ and $m_2$. If the particle of mass $m_1$ is pushed towards the centre of mass particles through a distance d, by what distance would the particle of mass $m_2$ move so as to keep the mass centre of particles at the original position?

(a) $\frac{m_2}{m_1}d$ (b) $\frac{m_1}{m_1+m_2}d$

(c) $\frac{m_1}{m_2}d$ (d) d

**111.** Three masses are placed on the *x*-axis : 300 g at origin, 500 g at $x = 40$ cm and 400 g at $x = 70$ cm. The distance of the centre of mass from the origin is

(a) 40 cm (b) 45 cm

(c) 50 cm (d) 30 cm

**112.** A body A of mass M while falling vertically downwards under gravity breaks into two parts; a body B of mass $\frac{1}{3}$ M and a body C of mass $\frac{2}{3}$ M. The centre of mass of bodies B and C taken together shifts compared to that of body A

(a) does not shift

(b) depends on height of breaking

(c) towards body B

(d) towards body C

**113.** A circular disc of radius R is removed from a bigger circular disc of radius 2R such that the circumferences of the discs coincide. The centre of mass of the new disc is $\alpha$ / R form the centre of the bigger disc. The value of $\alpha$ is

(a) 1/4 (b) 1/3

(c) 1/2 (d) 1/6

**114.** The centre of mass of three bodies each of mass 1 kg located at the points (0, 0), (3, 0) and (0, 4) in the XY plane is

(a) $\left(\frac{4}{3}, 1\right)$ (b) $\left(\frac{1}{3}, \frac{2}{3}\right)$

(c) $\left(\frac{1}{2}, \frac{1}{2}\right)$ (d) $\left(1, \frac{4}{3}\right)$

**115.** The instantaneous angular position of a point on a rotating wheel is given by the equation $\theta(t) = 2t^3 - 6t^2$. The torque on the wheel becomes zero at

(a) t = 1s (b) t = 0.5 s

(c) t = 0.25 s (d) t = 2s

**116.** A tube of length L is filled completely with an incompressible liquid of mass M and closed at both ends. The tube is then rotated in a horizontal plane about one of its ends with uniform angular speed $\omega$. What is the force exerted by the liquid at the other end?

(a) $\frac{ML\omega^2}{2}$ (b) $ML\omega^2$

(c) $\frac{ML\omega^2}{4}$ (d) $\frac{ML\omega^2}{8}$

**117.** A planet is moving around the sun in an elliptical orbit. Its speed is
(a) same at all points of the orbit
(b) maximum when it is nearest to sun
(c) maximum when it is farthest from the sun
(d) cannot say

**118.** A man standing on a rotating table is holding two masses at arm's length. Without moving his arms, he drops the two masses. His angular speed will
(a) increase (b) decrease
(d) become zero (d) remain constant

**119.** When sand is poured on a rotating disc, its angular velocity will
(a) decrease (b) increase
(c) remain constant (d) None of the above

**120.** A disc is given a linear velocity on a rough horizontal surface then its angular momentum is
(a) conserved about COM only
(b) conserved about the point of contact only
(c) conserved about all the points
(d) not conserved about any point.

**121.** Standing on a turn table, you are rotating holding weights in your hands outstretched horizontally, If you suddenly draw your hands and weights towards your chest, you will now
(a) stop rotating (b) rotate as before
(c) rotate slower (d) rotate faster

**122.** Of the two eggs which have identical sizes, shapes and weights, one is raw, and other is half boiled. The ratio between the moment of inertia of the raw to the half boiled egg about central axis is
(a) one (b) greater than one
(c) less than one (d) not comparable

**123.** A gymnast takes turns with her arms and legs stretched. When she pulls her arms and legs in
(a) the angular velocity decreases
(b) the moment of inertia decreases
(c) the angular velocity stays constant
(d) the angular momentum increases

**124.** One solid sphere *A* and another hollow sphere *B* are of same mass and same outer radii, Their moments of inertia about their diameters are respectively $I_A$ and $I_B$, such that
(a) $I_A = I_B$ (b) $I_A > I_B$
(c) $I_A < I_B$ (d) $I_A / I_B = \rho_A = \rho_B$
Here $\rho_A$ and $\rho_B$ represent their densities.

**125.** A diver in a swimming pool bends his head before diving. It
(a) increases his linear velocity
(b) decreases his angular velocity
(c) increases his moment of inertia
(d) decreases his moment of inertia

**126.** A ring of mass *m* and radius *r* is melted and then moulded into a sphere. The moment of inertia of the sphere will be
(a) more than that of the ring
(b) less than that of the ring
(c) equal to that of the ring
(d) None of these

**127.** A wheel having moment of inertia 2 kg-m$^2$ about its vertical axis, rotates at the rate of 60 rpm about this axis, The torque which can stop the wheel's rotation in one minute would be
(a) $\frac{\pi}{18}$Nm (b) $\frac{2\pi}{15}$Nm
(c) $\frac{\pi}{12}$Nm (d) $\frac{\pi}{15}$Nm

**128.** A round disc of moment of inertia $I_2$ about its axis perpendicular to its plane and passing through its centre is placed over another disc of moment of inertia $I_1$ rotating with an angular velocity ω about the same axis. The final angular velocity of the combination of discs is
(a) $\frac{(I_1 + I_2)\omega}{I_1}$ (b) $\frac{I_2\omega}{I_1 + I_2}$
(c) ω (d) $\frac{I_1\omega}{I_1 + I_2}$

**129.** The ratio of the radii of gyration of a circular disc about a tangential axis in the plane of the disc and of a circular ring of the same radius about a tangential axis in the plane of the ring is
(a) $1:\sqrt{2}$ (b) $1:3$
(c) $2:1$ (d) $\sqrt{5}:\sqrt{6}$

**130.** Two bodies have their moments of inertia I and 2I respectively about their axis of rotation. If their kinetic energies of rotation are equal, their angular momenta will be in the ratio
(a) $2:1$ (b) $1:2$
(c) $\sqrt{2}:1$ (d) $1:\sqrt{2}$

**131.** The moment of inertia of a thin uniform rod of mass M and length L about an axis passing through its midpoint and perpendicular to its length is $I_0$. Its moment of inertia about an axis passing through one of its ends and perpendicular to its length is
(a) $I_0 + ML^2/2$ (b) $I_0 + ML^2/4$
(c) $I_0 + 2ML^2$ (d) $I_0 + ML^2$

**132.** Four point masses, each of value m, are placed at the corners of a square ABCD of side $\ell$. The moment of inertia of this system about an axis passing through A and parallel to BD is

(a) $2m\ell^2$ (b) $\sqrt{3}m\ell^2$

(c) $3m\ell^2$ (d) $m\ell^2$

**133.** Consider a uniform square plate of side 'a' and mass 'm'. The moment of inertia of this plate about an axis perpendicular to its plane and passing through one of its corners is

(a) $\frac{5}{6}ma^2$ (b) $\frac{1}{12}ma^2$

(c) $\frac{7}{12}ma^2$ (d) $\frac{2}{3}ma^2$

**134.** Point masses 1, 2, 3 and 4 kg are lying at the points (0, 0, 0), (2, 0, 0), (0, 3, 0) and (–2, –2, 0) respectively. The moment of inertia of this system about X-axis will be

(a) 43 kg $m^2$ (b) 34 kg $m^2$

(c) 27 kg $m^2$ (d) 72 kg $m^2$

**135.** The moment of inertia of a circular disc of mass M and radius R about an axis passing through the centre of mass is $I_0$. The moment of inertia of another circular disc of same mass and thickness but half the density about the same axis is

(a) $\frac{I_0}{8}$ (b) $\frac{I_0}{4}$

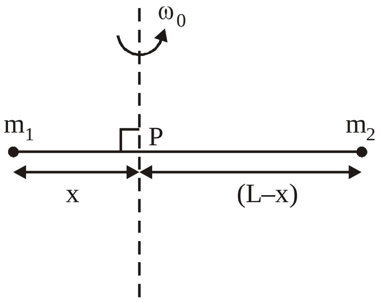
(c) $8I_0$ (d) $2I_0$

**136.** An automobile moves on a road with a speed of 54 km $h^{-1}$. The radius of its wheels is 0.45 m and the moment of inertia of the wheel about its axis of rotation is 3 kg $m^2$. If the vehicle is brought to rest in 15s, the magnitude of average torque transmitted by its brakes to the wheel is :

(a) 8.58 kg $m^2$ $s^{-2}$ (b) 10.86 kg $m^2$ $s^{-2}$

(c) 2.86 kg $m^2$ $s^{-2}$ (d) 6.66 kg $m^2$ $s^{-2}$

**137.** Point masses $m_1$ and $m_2$ are placed at the opposite ends of a rigid rod of length L, and negligible mass. The rod is to be set rotating about an axis perpendicular to it. The position of point P on this rod through which the axis should pass so that the work required to set the rod rotating with angular velocity $\omega_0$ is minimum, is given by



(a) $x = \frac{m_1}{m_2}L$ (b) $x = \frac{m_2}{m_1}L$

(c) $x = \frac{m_2 L}{m_1 + m_2}$ (d) $x = \frac{m_1 L}{m_1 + m_2}$

**138.** A force $\vec{F} = \alpha\hat{i} + 3\hat{j} + 6\hat{k}$ is acting at a point $\vec{r} = 2\hat{i} - 6\hat{j} - 12\hat{k}$. The value of $\alpha$ for which angular momentum about origin is conserved is

(a) 2 (b) zero

(c) 1 (d) –1

**139.** A solid cylinder of mass 50 kg and radius 0.5 m is free to rotate about the horizontal axis. A massless string is wound round the cylinder with one end attached to it and other hanging freely. Tension in the string required to produce an angular acceleration of 2 revolutions $s^{-2}$ is

(a) 25 N (b) 50 N

(c) 78.5 N (d) 157 N

**140.** A rod of weight W is supported by two parallel knife edges A and B and is in equilibrium in a horizontal position. The knives are at a distance d from each other. The centre of mass of the rod is at distance x from A. The normal reaction on A is

(a) $\frac{Wd}{x}$ (b) $\frac{W(d-x)}{x}$

(c) $\frac{W(d-x)}{d}$ (d) $\frac{Wx}{d}$

**141.** A uniform solid cylindrical roller of mass 'm' is being pulled on a horizontal surface with force F parallel to the surface and applied at its centre. If the acceleration of the cylinder is 'a' and it is rolling without slipping then the value of 'F' is

(a) ma (b) $\frac{5}{3}ma$

(c) $\frac{3}{2}ma$ (d) 2 ma

**142.** Consider a thin uniform square sheet made of a rigid material. If its side is '*a*' mass *m* and moment of inertia I about one of its diagonals, then

(a) $I > \frac{ma^2}{12}$ (b) $\frac{ma^2}{24} < I < \frac{ma^2}{12}$

(c) $I = \frac{ma^2}{24}$ (d) $I = \frac{ma^2}{12}$

**143.** A particle of mass 2 kg is on a smooth horizontal table and moves in a circular path of radius 0.6 m. The height of the table from the ground is 0.8 m. If the angular speed of the particle is 12 rad $s^{-1}$, the magnitude of its angular momentum about a point on the ground right under the centre of the circle is

(a) 14.4 kg $m^2s^{-1}$ (b) 8.64 kg $m^2s^{-1}$

(c) 20.16 kg $m^2s^{-1}$ (d) 11.52 kg $m^2s^{-1}$

**144.** A uniform thin rod AB of length L has linear mass density $\mu(x) = a + \frac{bx}{L}$, where x is measured from A. If the CM of the rod lies at a distance of $\left(\frac{7}{12}\right)L$ from A, then $a$ and $b$ are related as :

(a) $a = 2b$ (b) $2a = b$

(c) $a = b$ (d) $3a = 2b$

**145.** Two objects P and Q initially at rest move towards each other under mutual force of attraction. At the instant when the velocity of P is v and that of Q is 2v, the velocity of centre of mass of the system is

(a) v (b) 3v

(c) 2v (d) zero

**146.** A body rolls down an inclined plane. If its kinetic energy of rotation is 40% of its kinetic energy of translation motion, then the body is

(a) hollow cylinder (b) ring

(c) solid disc (d) solid sphere

**147.** From a solid sphere of mass M and radius R a cube of maximum possible volume is cut. Moment of inertia of cube about an axis passing through its center and perpendicular to one of its faces is

(a) $\frac{4MR^2}{9\sqrt{3}\pi}$ (b) $\frac{4MR^2}{3\sqrt{3}\pi}$

(c) $\frac{MR^2}{32\sqrt{2}\pi}$ (d) $\frac{MR^2}{16\sqrt{2}\pi}$

**148.** Two discs rotating about their respective axis of rotation with angular speeds 2 $\text{rads}^{-1}$ and 5 $\text{rads}^{-1}$ are brought into contact such that their axes of rotation coincide. Now, the angular speed of the system becomes 4 $\text{rads}^{-1}$. If the moment of inertia of the second disc is $1 \times 10^{-3}$ kg $m^2$, then the moment of inertia of the first disc (in kg $m^2$) is

(a) $0.25 \times 10^{-3}$ (b) $1.5 \times 10^{-3}$

(c) $1.25 \times 10^{-3}$ (d) $0.5 \times 10^{-3}$

**149.** A wheel is rotating at 1800 rpm about its own axis. When the power is switched off, it comes to rest in 2 minutes. Then the angular retardation in rad $s^{-1}$ is

(a) $2\pi$ (b) $\pi$

(c) $\frac{\pi}{2}$ (d) $\frac{\pi}{4}$

**150.** If the angular momentum of a particle of mass $m$ rotating along a circular path of radius r with uniform speed is $L$, the centripetal force acting on the particle is

(a) $\frac{L^2}{mr^2}$ (b) $\frac{L^2}{mr}$

(c) $\frac{L}{mr}$ (d) $\frac{L^2 m}{r}$

**151.** A bob of mass m attached to an inextensible string of length $l$ is suspended from a vertical support. The bob rotates in a horizontal circle with an angular speed $\omega$ rad/s about the vertical. About the point of suspension:

(a) angular momentum is conserved.

(b) angular momentum changes in magnitude but not in direction.

(c) angular momentum changes in direction but not in magnitude.

(d) angular momentum changes both in direction and magnitude.

**152.** A solid cylinder of mass 2 kg and radius 0.1 m rolls down an inclined plane of height 3m without slipping. Its rotational kinetic energy when it reaches the foot of the plane would be :

(a) 22.7 J (b) 19.6 J

(c) 10.2 J (d) 9.8 J

**153.** A solid sphere and a hollow sphere of the same material and of a same size can be distinguished without weighing

(a) by determining their moments of inertia about their coaxial axes

(b) by rolling them simultaneously on an inclined plane

(c) by rotating them about a common axis of rotation

(d) by applying equal torque on them

**154.** A solid sphere rolls down two different inclined planes of same height, but of different inclinations. In both cases

(a) speed and time of descent will be same

(b) speed will be same, but time of descent will be different

(c) speed will be different, but time of descent will be same

(d) speed and time of descent both are different

**155.** The ratio of the accelerations for a solid sphere (mass 'm' and radius 'R') rolling down an incline of angle '$\theta$' without slipping and slipping down the incline without rolling is

(a) 5 : 7 (b) 2 : 3

(c) 2 : 5 (d) 7 : 5

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(a)**

**2.** **(b)** Depends on the distribution of mass in the body.

**3.** **(d)** By definition, position vector of centre of mass of two particle system is such that the product of total mass of the system and position vector of centre of mass is equal to the sum of products of masses of two particles and their respective position vectors i.e.

$$(m_1 + m_2)\vec{R} = m_1 \vec{r}_2 + m_r \vec{r}_2$$

**4.** **(a)** **5.** **(d)** **6.** **(d)** **7.** **(a)**

**8.** **(c)** **9.** **(a)**

**10.** **(d)** The position of centre of mass of a system depends upon mass, relative distance, position and symmetry of the body.

$$R_{CM} = \frac{\sum m_i r_i}{\sum m_i}$$

**11.** **(b)** From v = r ω, linear velocities (v) for particles at different distances (r) from the axis of rotation are different.

**12.** **(a)** Since torque $\vec{\tau}$ is rotational analogue of force $\vec{F}$ and $\vec{F}$ = mass × acceleration, therefore torque $\vec{\tau}$ = moment of inertia xangular acceleration ($I \propto$ ) as moment of inertia is rotational analogue of mass.

**13.** **(c)** In analogy to Newton's second law of motion in linear motion,
Force = rate of charge of linear momentum, in angular motion
Torque = rate of change of angular momentum

**14.** **(b)** Only the transverse component contributes to the torque.

**15.** **(c)** Turning moment of force = Force × distance from the axis of rotation.
Thus a small force is required to produce a given turning moment, when distance is large. That is why handle of a screw is made wider.

**16.** **(a)** $P = \tau\omega$. ($P = FV$ in translational motion)
Since $\tau = I\alpha$
$\therefore \quad P = I\omega\alpha$

**17.** **(a)** From $L = I\,\omega$, we find that angular momentum is directly proportional to the moment of inertia.

**18.** **(b)** A couple can produce rotational motion only and not linear motion.

**19.** **(b)** As $L = I\,\omega$ = constant, therefore, when I decreases, ω will increase.

**20.** **(d)** As angular momentum, $\vec{L} = \vec{r} \times \vec{p}$, therefore, direction of $\vec{L}$ is along a line perpendicular to the plane of rotation.

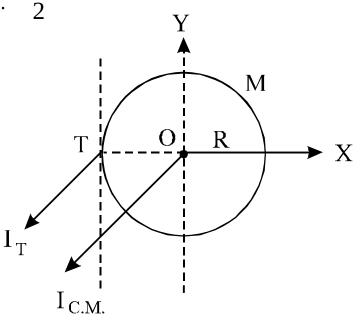
**21.** **(b)** The motion of a rigid body which is not pivoted or fixed in some way is either a pure **translation** or a combination of translation and rotation. The motion of a rigid body which is pivoted or fixed in some way is rotation.

**22.** **(c)** Planar, perpendicular and perpendicular. The moment of inertia of a planar body about an axis perpendicular to its plane is equal to the sum of its moments of inertia about two perpendicular axes concurrent with perpendicular axis and lying in the plane of the body.

**23.** **(b)** By bending his body, he decreases his moment of inertia. This would increase his angular velocity.

**24.** **(c)** M.I. of a uniform circular disc of radius 'R' and mass 'M' about an axis passing through C.M. and normal to the disc is

$$I_{C.M.} = \frac{1}{2}MR^2$$



From parallel axis theorem

$$I_T = I_{C.M.} + MR^2 = \frac{1}{2}MR^2 + MR^2 = \frac{3}{2}MR^2$$

**25.** **(d)** Force in linear motion corresponds to torque in rotational motion.

**26.** **(b)** Angular momentum will remain conserved as no torque is exerted by the boy.

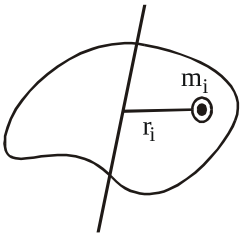
**27.** **(c)** In rotation of a rigid body about a fixed axis, every particle of the body moves in a circle, which lies in a plane perpendicular to the axis and has its centre on the axis.

**28.** **(c)**

**29.** **(c)** Force changes the linear momentum of the body. The external force (or force) change the translational motion of the rigid body. But this is not the only effect of the force. The total torque due to the force on the body changes the rotational state of motion of the rigid body.

**30.** **(a)**

**31.** **(a)** Basic equation of moment of inertia is given by $I = \sum_{i=1}^{n} m_i r_i^2$



where $m_i$ is the mass of $i^{th}$ particle at a distance of $r_i$ from axis of rotation.
Thus it does not depend on angular velocity.

**32.** **(d)** Moment of inertia of a hollow cylinder of mass $M$ and radius $r$ about its own axis is $Mr^2$.

**33.** **(a)**

(a) Moment of inertia of a ring about its axis and perpendicular to its plane = $Mr^2$

(b) Moment of inertia of disc about its axis and perpendicular to its plane = $\frac{1}{2}Mr^2$ = 0.5 $Mr^2$

(c) Moment of inertia of a solid sphere about one of its diameter = $\frac{2}{5}Mr^2$ = 0.4 $Mr^2$

(d) Moment of inertia of a spherical shell about one of its diameter = $\frac{2}{3}Mr^2$ = 0.66 $Mr^2$

Therefore, the moment of inertia of the ring is highest

**34.** **(a)** Radius of gyration of a body depends on the axis of rotation.

**35.** **(d)**

**36.** **(b)** Moment of inertia is a tensor quantity.

**37.** **(d)** Ratio of M.I is

$$\frac{M_A r^2}{M_B (2r)^2} = \frac{I_A}{I_B}$$

$$\frac{I_A}{I_B} = \frac{1}{4} \quad [\because M_A = M_B]$$

$$\text{or,} \quad I_A = \frac{I_B}{4}$$

**38.** **(a)**

**39.** **(b)** Because the entire mass of a ring is at its periphery i.e. at maximum distance from the centre and I = $Mr^2$

**40.** **(a)**

**41.** **(d)** $I_{xy}$, moment of inertia of a ring about its tangent in the plane of ring $I_{x^1y} = \frac{3}{2}MR^2$

Moment of inertia about a tangent perpendicular to the plane of ring $I_{xy} = 2MR^2$

$$\therefore \quad I_{xy} = \frac{3}{4}(2MR^2) = \frac{3}{2}MR^2$$

$$\text{or} \quad I_{xy} = \frac{3}{4}I_{x^1y^1}$$

**42.** **(d)** From $I = MR^2$, moment of inertia depends on the mass and size of the body. It also depends on the distribution of mass, thus it depends on the shape of the body as well.

**43.** **(d)**

**44.** **(c)** A rigid body is in mechanical equilibrium if

(i) it is in translational equilibrium and

(ii) it is in rotational equilibrium.

**45.** **(b)** Torque $\vec{\tau} = \vec{r} \times \vec{F}$

**46.** **(d)** K.E. = $\frac{1}{2}mV^2$

Since $V = \omega r$

$$\therefore \quad \text{K.E.} = \frac{1}{2}mV^2 = \frac{1}{2}m\omega^2 r^2$$

$$= \frac{1}{2}I\omega^2 \qquad (\because mr^2 = I)$$

**47.** **(a)** Angular momentum of particle is given by :

$$L = I\omega = mr^2\omega = 2\pi mr^2 f \qquad [\because W = 2\pi f]$$

If frequency is halved then,

$$L' = I\omega' = mr^2\frac{\omega}{2} = \pi mr^2 f$$

$$\therefore L' = \frac{L}{2}$$

**48.** **(a)** Moment of inertia of ring is greater than disc. About a diameter

$$1_{\text{ring}} = \frac{1}{2}MR^2$$

$$\text{and} \quad I_{disc} = \frac{1}{4}MR^2$$

**49.** **(b)** We know that $\tau_{ext} = \frac{dL}{dt}$

if angular momentum is conserved, it means change in angular momentum = 0

or, dL = 0

$$\frac{dL}{dt} = 0 \Rightarrow \tau_{ext} = 0$$

Thus total external torque = 0.

**50.** **(d)** We know that $\vec{\tau}_c = \frac{d\vec{L}_c}{dt}$

where $\vec{\tau}_c$ Torque about the center of mass of the body

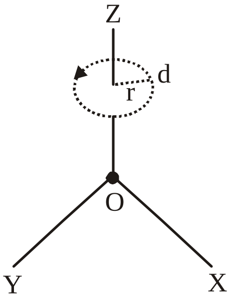
and $\vec{L}_c$ = Angular momentum about the center of mass of the body. Central forces act along the center of mass. Therefore torque about center of mass is zero.

When $\vec{\tau}_c = 0$ then $\vec{L}_c$ = constt.

**51.** **(b)** P.E. of the body is converted into both translational KE and rotational K.E i.e., $P.E = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2$

**52.** **(d)**

**53.** **(d)** A rigid body performs a pure rotational motion of every particle of the body moves in a circle and the centres of all the circles lie on a straight line called the axis of rotation. Particles lying on the axis of rotation remain stationary. Hence, motion of fan moving around the axis satisfies this criteria is purely rotational.



**54.** **(c)** Frictional force acts upwards forming a couple and hence creating torque on the body which increases the angular velocity of the body.

**55.** **(a)** Kinetic energy of a rolling body k = $\frac{1}{2}mv^2\left(1+\frac{k}{R^2}\right)$.

According to law of conservation of energy, potential energy lost by rolling body is equal to the final kinetic energy of the body.

$$\therefore \quad \cancel{m}gh = \frac{1}{2}\cancel{m}v^2\left(1+\frac{k^2}{R^2}\right)$$

$$\therefore \quad v^2 = \frac{2gh}{\left(1+\frac{k^2}{R^2}\right)}$$

Thus it is independent of the mass of the bodies.
For ring, $k^2 = R^2$

$$\therefore \quad V = \sqrt{gh}$$

For cylinder, $k^2 = R^2/2$

$$\therefore \quad V = \sqrt{\frac{4gh}{3}}$$

For solid sphere, $k^2 = 2R^2/5$

$$\therefore \quad V = \sqrt{\frac{10gh}{7}}$$

Thus sphere has greatest and ring has least velocity of centre of mass at the bottom of the inclined plane.

## STATEMENT TYPE QUESTIONS

**56.** **(d)**

**57.** **(a)** Centre of mass of a body can coincide with its geometrical centre when the body has a uniform mass density.

**58.** **(c)** Centre of mass does not necessarily lie only where there is mass. It can lie outside the body as well. For e.g. Centre of mass of circular ring lies in the centre of the ring where there is no mass.

**59.** **(c)** Linear velocity has magnitude and direction both therefore it is a vector quantity. Angular velocity has a fixed direction when a body rotates about a fixed axis.

**60.** **(d)** Centre of mass depends on the distribution of mass.

**61.** **(c)**

I. A body in translatory motion shall have angular momentum unless the fixed point about which angular momentum is taken lies on the line of motion of the body.

II. If $\vec{A}$ points vertically upwards and $\vec{B}$ points towards east then $\vec{A} \times \vec{B}$ points towards north.

**62.** **(b)** Moment of inertia is a tensor quantity.
$\tau = I\alpha$ $\quad\therefore\quad$ for constant I
$\alpha$ can change only if torque acts.

**63.** **(b)** If Earth shrinks suddenly, its radius R would decrease and I = $\frac{2}{5}MR^2$ would decrease. Thus, $\omega$ increases to keep angular momentum constant. Hence the length of the day will decrease.

## MATCHING TYPE QUESTIONS

**64.** **(a)** (A)→(2); (B)→(3); C→(1); (D)→(4)

**65.** **(c)** (A)→(2); (B)→(1); C→(4); (D)→(3)
Rolling motion → combination of translatory and rotatory motion
Rate of change of angular momentum → torque

$$\frac{dL}{dt} = \tau$$

Moment of inertia of a hollow cylinder about axis $= MR^2$
Theorem of parallel axis $I_Z{}^1 = I_Z + Ma^2$

**66.** **(a)** (A)→(1); (B)→(6); C→(5); (D)→(4); (E)→(2)
For translational equilibrium, total ext force = 0
$\Sigma F = 0$

Moment of inertia of disc = $\frac{MR^2}{2}$

For rotational equilibrium, net external torque =0
$\Sigma\tau = 0$
Kinetic energy of rolling body = K. E. of translation + K. E. of rotation.

$$K = \frac{1}{2}mVcm^2 + \frac{1}{2}I\omega^2$$

Moment of inertia of a ring = $MR^2$

**67.** **(d)** (A)→(1); (B)→(4); C→(3); (D)→(2)

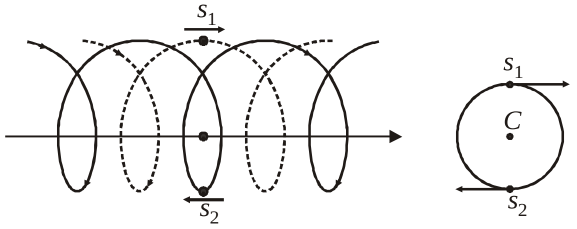
**68.** **(c)** (A)→(4); (B)→(3); C→(2); (D)→(5)

**69.** **(d)** (A)→(2); (B)→(4); C→(5); (D)→(3)

**70.** **(a)** (A)→(4); (B)→(3); C→(2); (D)→(1)

## DIAGRAM BASED QUESTIONS

**71.** **(a)** When no external force acts on the binary star, its CM will move like a free particle [Fig. (a)]. From the CM frame, the two stars will seems to move in a circle about the CM with diametrically opposite positions.



(a) (b)

(a) Trajectories of two stars. $S_1$ (dotted line) and $S_2$ (solid line) forming a binary system with their centre of mass C in uniform motion

(b) The same binary system, with the centre of mass C at rest.

So, to understand the motion of a complicated system, we can separate the motion of the system into two parts. So, the combination of the motion of the CM and motion about the CM could described the motion of the system.

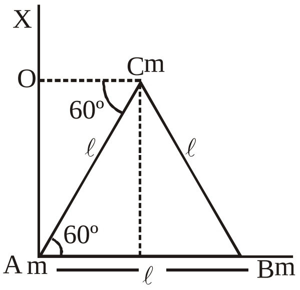
**72.** **(a)** According to parallel axis theorem of the moment of Inertia

$$I = I_{cm} + md^2$$

*d* is maximum for point *B* so $I_{max}$ about *B*.

**73.** **(b)**

**74.** **(d)** $I_{AX} = m(AB)^2 + m(OC)^2 = m\ell^2 + m\,(\ell \cos 60^o)^2$
$= m\ell^2 + m\ell^2/4 = 5/4\, m\ell^2$

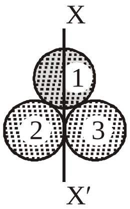


**75.** **(c)** Moment of inertia of shell 1 along diameter

$$I_{diameter} = \frac{2}{3}MR^2$$

Moment of inertia of shell 2 = m. i of shell 3

$$= I_{tengential} = \frac{2}{3}MR^2 + MR^2 = \frac{5}{3}MR^2$$



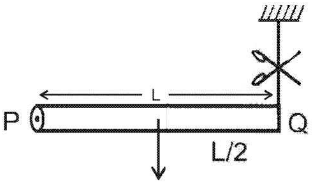
So, I of the system along x x$^1$
$= I_{diameter} + (I_{tengential}) \times 2$

or, $I_{total} = \frac{2}{3}MR^2 + \left(\frac{5}{3}MR^2\right) \times 2$

$$= \frac{12}{3}MR^2 = 4MR^2$$

**76.** **(b)** The distribution of mass about axis EF is minimum so radius of gyration is minimum and therefore moment of inertia is minimum about EF.

**77.** **(d)**



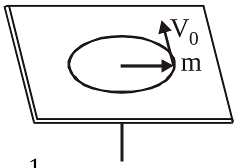
Weight of the rod will produce the torque

$$\tau = mg\frac{L}{2} = I\,\alpha = \frac{mL^2}{3}\alpha \quad \left[\because\ I_{rod} = \frac{ML^2}{3}\right]$$

Hence, angular acceleration $\alpha = \frac{3g}{2L}$

**78.** **(b)** Applying angular momentum conservation

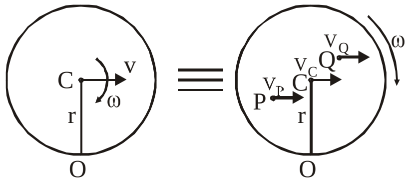
$$mV_0R_0 = (m)\,(V^1)\left(\frac{R_0}{2}\right)$$



$\therefore \quad v^1 = 2V_0$

Therefore, new KE = $\frac{1}{2}m\,(2V_0)^2 = 2mv_0^2$

**79.** **(a)**



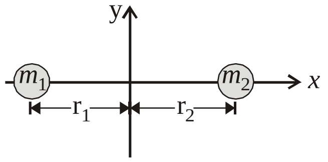
(I) (II)

From Fig. (I), we have OC = r (radius)
Therefore, $v = r\omega$
Since , $\omega$ = constant, therefore $v \propto r$
Now, form Fig (II), it is clear that the distance,
$OP < OC < OQ \Rightarrow V_P < V_C < V_Q$ or $V_Q > V_C > V_P$.

## ASSERTION- REASON TYPE QUESTIONS

**80.** **(b)** **81.** **(c)**

**82.** **(a)** If centre of mass of system lies at origin then $\vec{r}_{cm} = 0$



$$\vec{r}_{cm} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1 + m_2}$$

$\therefore \quad m_1\vec{r}_1 + m_2\vec{r}_2 = 0$

or $m_1r_1 = m_2r_2$

**83.** **(b)**

**84.** **(b)** External force on the system $F_{ext} = M\frac{d}{dt}\left(\vec{v}_{cm}\right)$

If system is isolated i.e. $F_{ext} = 0$ then $\vec{v}_{cm}$ constant

If initially the velocity of centre of mass is zero then it will remain zero.

**85.** **(a)** As the concept of centre of mass is only theoretical, therefore in practice no mass may lie at the centre of mass. For example, centre of mass of a uniform circular ring is at the centre of the ring where there is no mass.

**86.** **(c)** The position of centre of mass of a body depends on shape, size and distribution of mass of the body. The centre of mass does not lie necessarily at the centre of the body.

**87.** **(a)**

**88.** **(d)** When particle moves with constant velocity $\vec{v}$ then its linear momentum has some finite value $(\vec{P} = m\vec{v})$.

Angular momentum ($L$) = Linear momentum ($P$) × Perpendicular distance of line of action of linear momentum form the point of rotation ($d$)

So if $d \neq 0$ then $L \neq 0$, but if d = 0 then $L$ may be zero. So we can conclude that angular momentum of a particle moving with constant velocity is not always zero.

**89.** **(d)** The earth is not slowing down. The angular momentum of the earth – moon system is conserved.

**90.** **(a)** Both the assertion and reason are true.

For central forces,

$$\tau = \frac{dL}{dt} = 0$$

$\therefore$ L = constant

**91.** **(c)** Torque = Force × perpendicular distance of line of action of force from the axis of rotation (d).

Hence for a given applied force, torque or true tendency of rotation will be high for large value of d. If distance d is smaller, then greater force is required to cause the same torque, hence it is harder to open or shut down the door by applying a force near the hinge.

**92.** **(b)** $\vec{\tau} = \frac{d\vec{L}}{dt}$ and $L = I\omega$

**93.** **(a)** Torque $\tau = \frac{dL}{dt}$ $\therefore$ $\tau = 0$, L = constant.

$I\omega$ = constant

$\therefore$ $\omega$ is constants as long as I is constant.

**94.** **(d)** Torque is a vector whose direction is perpendicular to F since $\vec{\tau} = \vec{r} \times \vec{F}$.

**95.** **(d)** The moment of inertia of a rigid body reduces to its minimum value, when the axis of rotation passes through its centre of gravity because the weight of a rigid body always acts through its centre of gravity.

**96.** **(c)** An ice-skater stretches out arms and legs during performance to take advantage of principle of conservation of angular momentum. As on doing so, their moment of inertia increases or decreases respectively and hence the angular velocity of spin motion decreases or increases accordingly.

**97.** **(c)** As the polar ice melts, water so formed flows towards the equator. The moment of inertia of the earth increases. To conserve angular momentum, angular velocity decreases. This increases the length (T = 2 $\pi/\omega$) of the day.

**98.** **(d)** The moment of inertia of a particle about an axis of rotation is given by the product of the mass of the particle and the square of the perpendicular distance of the particle from the axis of rotation. For different axis, distance would be different, therefore moment of inertia of a particle changes with the change in axis of rotation.

**99.** **(d)** Radius of gyration of body is not a constant quantity. Its value changes with the change in location of the axis of rotation. Radius of gyration of a body about a given axis is given as

$$K = \sqrt{\frac{r_1^2 + r_2^2 + .....r_n^2}{n}}$$

**100.** **(d)** For a disc rolling without slipping on a horizontal rough surface with uniform angular velocity, the acceleration of lowest point of disc is directed vertically upwards and is not zero (Due to translation part of rolling, acceleration of lowest point is zero. Due to rotational part of rolling, the tangential acceleration of lowest point is zero and centripetal acceleration is non-zero and upwards). Hence assertion is false.

**101.** **(b)**

**102.** **(b)**

**103.** **(a)** In sliding down, the entire potential energy is converted into kinetic energy. While in rolling down some part of potential energy is converted into K.E. of rotation. Therefore linear velocity acquired is less.

**104.** **(c)** $K_N = K_R + K_T$

This equation is correct for any body which is rolling with slipping

For the ring and hollow cylinder only $K_R = K_T$ i.e. $K_N = 2K_T$

## CRITICALTHINKING TYPE QUESTIONS

**105.** **(c)** **106.** **(d)** **107.** **(a)** **108.** **(c)** **109.** **(a)**

**110.** **(c)** $m_1 d = m_2\, d_2 \Rightarrow d_2 = \frac{m_1 d}{m_2}$

**111.** **(a)**

$$X_{cm} = \frac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3}$$

$$X_{cm} = \frac{300 \times (0) + 500(40) + 400 \times 70}{300 + 500 + 400}$$

$$X_{cm} = \frac{500 \times 40 + 400 \times 70}{1200}$$

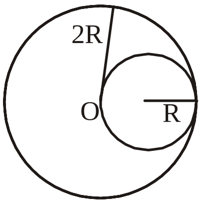
$$X_{cm} = \frac{50 + 70}{3} = \frac{120}{3} = 40\,\text{cm}$$

**112.** **(a)** Does not shift as no external force acts. The centre of mass of the system continues its original path. It is only the internal forces which comes into play while breaking.

**113.** **(b)** Let the mass per unit area be $\sigma$.

Then the mass of the complete disc

$$= \sigma[\pi(2R)^2] = 4\pi\sigma R^2$$



The mass of the removed disc $= \sigma(\pi R^2) = \pi\sigma R^2$

Let us consider the above situation to be a complete disc of radius 2R on which a disc of radius R of negative mass is superimposed. Let O be the origin. Then the above figure can be redrawn keeping in mind the concept of centre of mass as :

$$\underset{O}{\overset{4\pi\sigma R^2}{\bullet}} \xleftrightarrow{R} \underset{\pi\sigma R^2}{\bullet}$$

$$X_{c.m} = \frac{\left(4\pi\sigma R^2\right)\times 0 + \left(-\pi\sigma R^2\right)R}{4\pi\sigma R^2 - \pi\sigma R^2}$$

$$\therefore \quad x_{c.m} = \frac{-\pi\sigma R^2 \times R}{3\pi\sigma R^2}$$

$$\therefore \quad x_{c.m} = -\frac{R}{3}$$

$$\Rightarrow \alpha = \frac{1}{3}$$

**114. (d)** $X_{CM} = \dfrac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3}$

$$= \frac{1\times 0 + 1\times 3 + 1\times 0}{1+1+1} = 1$$

$$Y_{CM} = \frac{m_1y_1 + m_2y_2 + m_3y_3}{m_1 + m_2 + m_3}$$

$$= \frac{1\times 0 + 1\times 0 + 1\times 4}{1+1+1} = \frac{4}{3}$$

Therefore the coordinates of centre of mass are $\left(1, \dfrac{4}{3}\right)$.

**115. (a)** When angular acceleration (α) is zero then torque on the wheel becomes zero.

$\theta(t) = 2t^3 - 6t^2$

$$\Rightarrow \frac{d\theta}{dt} = 6t^2 - 12t$$

$$\Rightarrow \alpha = \frac{d^2\theta}{dt^2} = 12t - 12 = 0$$

$\therefore t = 1$ sec.

**116. (a)** Tube may be treated as a particle of mass M at distance L/2 from one end.

Centripetal force $= Mr\omega^2 = \dfrac{ML}{2}\omega^2$

**117. (b)** Since no external torque is applied on planet + sun system, hence the angular momentum of the planet about the sun is constant.

since L = mrv

(i) At the nearest point, r is minimum, so v is maximum to conserve L.

(ii) At the farthest point, r is maximum, so v is minimum to conserve L.

**118. (a)** As mass decreases, moment of inertia I decreases. Since L = I ω is constant, therefore ω increases.

**119. (a)** When sand is poured on a rotating disc, the effective mass of the disc increases.

According to the law of conservation of angular momentum

$L = I\omega =$ constant

As the mass of the disc increases, its moment of inertia increases and therefore, its angular velocity decreases.

**120. (b)**

**121. (d)** When person suddenly draw his hands and weights towards his chest, the moment of inertia ($I = mr^2$) of the person decreases.

According to law of conservation of angular momentum if no external torque acts on a system, then the angular momentum of the system remains conserved, *ie*,

$L = I\omega =$ constant

or $\quad I_1\omega_1 = I_2\omega_2$

As the moment of inertia decreases, the angular velocity will increase and therefore, person will rotate faster.

**122. (b)** A raw egg behaves like a spherical shell and a half boiled egg behaves like a solid sphere

$$\therefore \quad \frac{I_r}{I_s} = \frac{2/3\, mr^2}{2/5\, mr^2} = \frac{5}{3} > 1$$

**123. (b)** Since no external torque act on gymnast, so angular momentum (L=I ω) is conserved. After pulling her arms & legs, the angular velocity increases but moment of inertia of gymnast, decreases in, such a way that angular momentum remains constant.

**124. (c)** In a hollow sphere, the mass is distributed away from the axis of rotation. So, its moment of inertia is greater than that of a solid sphere.

**125. (d)** It decreases his moment of inertia and increases his angular velocity.

**126. (b)** Because radius of the sphere will be very less in comparison to ring (although mass is equal).

**127. (d)** $\tau \times \Delta t = L_0 \qquad \{\because \text{ since } L_f = 0\}$

$\Rightarrow \tau \times \Delta t = I\omega$

or $\tau \times 60 = 2 \times 2 \times 60\pi/60$

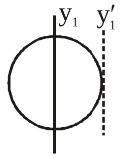
$$\left(\because \quad f = 60\text{rpm} \therefore \quad \omega = 2\pi f = 2\pi \times \frac{60}{60}\right)$$

$$\tau = \frac{\pi}{15}\,N - m$$

**128. (d)** Angular momentum will be conserved

$$I_1\omega = I_1\omega' + I_2\omega' \Rightarrow \omega' = \frac{I_1\omega}{I_1 + I_2}$$

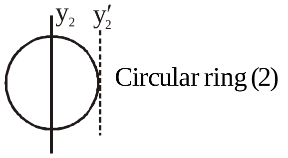
**129. (d)**



Circular disc (1)

$$I_{y_1} = \frac{MR^2}{4}$$

$$\therefore I'_{y_1} = \frac{MR^2}{4} + MR^2 = \frac{5}{4}MR^2$$



$$I_{y_2} = \frac{MR^2}{2}$$

$$\therefore I'_{y_2} = \frac{MR^2}{2} + MR^2 = \frac{3}{2}MR^2$$

$$I'_{y_1} = MK_1^2,\ I'_{y_2} = MK_2^2$$

$$\therefore \frac{K_1^2}{K_2^2} = \frac{I'_{y_1}}{I'_{y_2}} \Rightarrow K_1 : K_2 = \sqrt{5} : \sqrt{6}$$

**130. (d)** $K = \frac{L^2}{2I} \Rightarrow L^2 = 2KI \Rightarrow L = \sqrt{2KI}$

$$\frac{L_1}{L_2} = \sqrt{\frac{K_1}{K_2} \cdot \frac{I_1}{I_2}} = \sqrt{\frac{K}{K} \cdot \frac{I}{2I}} = \frac{1}{\sqrt{2}}$$

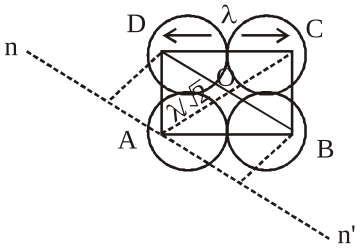
$L_1 : L_2 = 1 : \sqrt{2}$

**131. (b)** By theorem of parallel axes,

$I = I_{cm} + Md^2$

$I = I_0 + M(L/2)^2 = I_0 + ML^2/4$

**132. (c)**

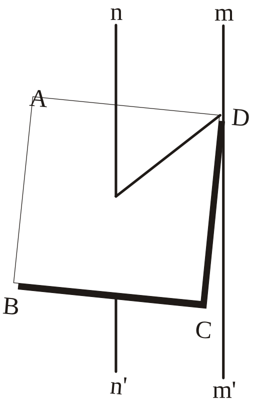


$I_{nn'}$ = M.I due to the point mass at B +
M.I due to the point mass at D +
M.I due to the point mass at C.

$$I_{nn'} = 2 \times m\left(\frac{\ell}{\sqrt{2}}\right)^2 + m(\sqrt{2}\ell)^2$$

$$= m\ell^2 + 2m\ell^2 = 3m\ell^2$$

**133. (d)** $I_{nn'} = \frac{1}{12}M(a^2 + a^2) = \frac{Ma^2}{6}$



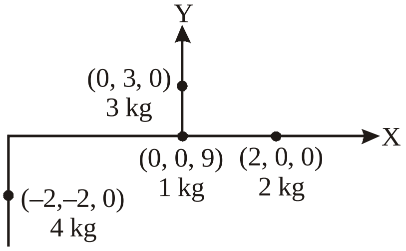
Also, $DO = \frac{DB}{2} = \frac{\sqrt{2}a}{2} = \frac{a}{\sqrt{2}}$

According to parallel axis theorem

$$I_{mm'} = I_{nn'} + M\left(\frac{a}{\sqrt{2}}\right)^2 = \frac{Ma^2}{6} + \frac{Ma^2}{2}$$

$$= \frac{Ma^2 + 3Ma^2}{6} = \frac{2}{3}Ma^2$$

**134. (a)** Moment of inertia of the whole system about the axis of rotation will be equal to the sum of the moments of inertia of all the particles.



$\therefore\ I = I_1 + I_2 + I_3 + I_4$
$= 0 + 0 + 27 + 16 = 43\ kg\ m^2$

**135. (d)** For circular disc 1

mass = M, radius $R_1 = R$

moment of inertia $I_1 = I_0$

For circular disc 2, of same thickness *t*,

mass = M, density = $\frac{\rho}{2}$

then $\pi R_2{}^2 t \times \frac{\rho}{2} = \pi R_1{}^2 t \times \rho = M$

$R_2{}^2 = 2R_1{}^2$

$R_2 = \sqrt{2}R_1 = \sqrt{2}R$

As we know, moment of inertia $I \propto (\text{Radius})^2$

$$\therefore \frac{I_1}{I_2} = \left(\frac{R_1}{R_2}\right)^2$$

$$\frac{I_0}{I_2} = \left(\frac{R}{\sqrt{2}R}\right)^2 \Rightarrow I_2 = 2I_0$$

**136. (d)** Given : speed $V = 54\ kmh^{-1} = 15\ ms^{-1}$

Moment of inertia, $I = 3\ kgm^2$

Time t = 15s

$$\omega_i = \frac{V}{r} = \frac{15}{0.45} = \frac{100}{3} \quad \omega_f = 0$$

$\omega_f = \omega_i + \alpha t$

$0 = \frac{100}{3} + (-\alpha)(15) \qquad \Rightarrow \alpha = \frac{100}{45}$

Average torque transmitted by brakes to the wheel

$\tau = (I)(\alpha) = 3 \times \frac{100}{45} = 6.66 \text{ kgm}^2\text{s}^{-2}$

**137. (c)** Work required to set the rod rotating with angular velocity $\omega_0$

$\text{K.E.} = \frac{1}{2} I\omega^2$

Work is minimum when I is minimum.
I is minimum about the centre of mass
So, $(m_1)(x) = (m_2)(L - x)$
or, $m_1 x = m_2 L - m_2 x$

$\therefore x = \frac{m_2 L}{m_1 + m_2}$

**138. (d)** From Newton's second law for rotational motion,

$\vec{\tau} = \frac{d\vec{L}}{dt}$, if $\vec{L}$ = constant then $\vec{\tau} = 0$

So, $\vec{\tau} = \vec{r} \times \vec{F} = 0$

$\left(2\hat{i} - 6\hat{j} - 12\hat{k}\right) \times (\alpha\hat{i} + 3\hat{j} + 6\hat{k}) = 0$

Solving we get $\alpha = -1$

**139. (d)** Here $\alpha$ = 2 revolutions/s² = 4π rad/s² (given)

$I_{\text{cylinder}} = \frac{1}{2} MR^2 = \frac{1}{2}(50)(0.5)^2$

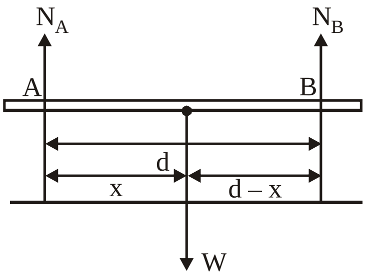
$= \frac{25}{4}$ Kg-m²

As $\tau = I\alpha$ so $TR = I\alpha$

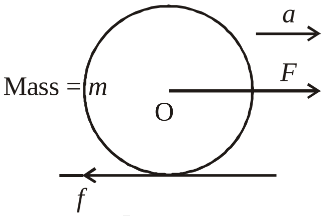
$\Rightarrow T = \frac{I\alpha}{R} = \frac{\left(\frac{25}{4}\right)(4\pi)}{(0.5)} N = 50\pi N = 157 N$

**140. (c)** By torque balancing about B
$N_A(d) = W(d - x)$

$N_A = \frac{W(d - x)}{d}$



**141. (c)** From figure,
$ma = F - f \qquad \text{....(i)}$



And, torque $\tau = I\alpha$

$\frac{mR^2}{2}\alpha = fR$

$\frac{mR^2}{2}\frac{a}{R} = fR \quad \left[\because \alpha = \frac{a}{R}\right]$

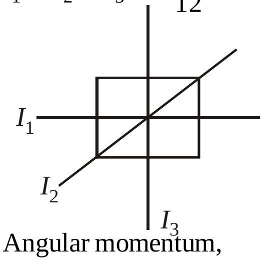
$\frac{ma}{2} = f \qquad \text{...(ii)}$

Put this value in equation (i),

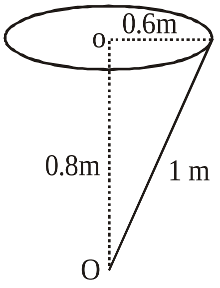
$ma = F - \frac{ma}{2}$ or $F = \frac{3ma}{2}$

**142. (d)** For a thin uniform square sheet

$I_1 = I_2 = I_3 = \frac{ma^2}{12}$



**143. (a)** Angular momentum,
$L_0$ = mvr sin 90°
= 2 × 0.6 × 12 × 1 × 1
[As $V = r\omega$, Sin 90° = 1]
So, $L_0 = 14.4$ kgm²/s



**144. (b)** Centre of mass of the rod is given by:

$$x_{cm} = \frac{\int_0^L (ax + \frac{bx^2}{L})dx}{\int_0^L (a + \frac{bx}{L})dx}$$

$$= \frac{\frac{aL^2}{2} + \frac{bL^2}{3}}{aL + \frac{bL}{2}} = \frac{L\left(\frac{a}{2} + \frac{b}{3}\right)}{a + \frac{b}{2}}$$

Now $\frac{7L}{12} = \frac{\frac{a}{2}+\frac{b}{3}}{a+\frac{b}{2}}$

On solving we get, $b = 2a$

**145. (d)** Centre of mass is at rest

$\therefore V_{CM} = 0$

**146. (d)** $\frac{KE_{rot}}{KE_{trans}} = \frac{\frac{1}{2}mv^2\left(\frac{k^2}{R^2}\right)}{\frac{1}{2}mv^2} = \frac{K^2}{R^2} = 0.4 = \frac{2}{5}$

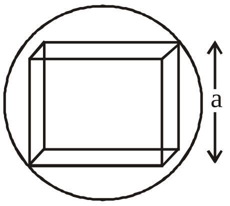
$\Rightarrow \quad k^2 = \frac{2}{5}R^2$

Therefore it is a solid sphere.

**147. (a)** Here $a = \frac{2}{\sqrt{3}}R$

Now, $\frac{M}{M'} = \frac{\frac{4}{3}\pi R^3}{a^3}$

$= \frac{\frac{4}{3}\pi R^3}{\left(\frac{2}{\sqrt{3}}R\right)^3} = \frac{\sqrt{3}}{2}\pi.$



$M' = \frac{2M}{\sqrt{3}\pi}$

Moment of inertia of the cube about the given axis,

$I = \frac{M'a^2}{6}$

$= \frac{\frac{2M}{\sqrt{3}\pi}\times\left(\frac{2}{\sqrt{3}}R\right)^2}{6} = \frac{4MR^2}{9\sqrt{3}\pi}$

**148. (d)** According to law of conservation of angular momentum,

$I_1\omega_1 + I_2\omega_2 = (I_1 + I_2)\omega$

Substituting the values of $\omega_1 = 2$ rad s$^{-1}$

$\omega_2 = 5$ rad s$^{-1}$

$I_2 = I \times 10^{-3}$ kg m$^2$

$I_1 \times 2 + 1 \times 10^{-3}, \times 5 = (I_1 + 1 \times 10^{-3}) \times 4$

$\Rightarrow \; 2I_1 + 5 \times 10^{-3} = 4I_1 + 4 \times 10^{-3}$

$\Rightarrow \; 2I_1 = 1 \times 10^{-3}$

$\Rightarrow \; I_1 = \frac{1 \times 10^{-3}}{2} = 0.5 \times 10^{-3}$ kg m$^2$

**149. (c)** Given, no. of rotation $n = 1800$ rpm $= 1800$ rps

Time, $t = 2$ minutes $= 120$s

$\therefore$ Initial angular speed $\omega_0 = \frac{2\pi \times 1800}{60}$ rad s$^{-1}$

$= 60\pi$ rad s$^{-1}$

Final angular speed (as wheel comes to rest)

$\omega = 0$

$\therefore$ Angular retardation $= \frac{\omega_0 - \omega}{t}$

$= \frac{60\pi - 0}{120} = \frac{\pi}{2}$ rad s$^{-2}$

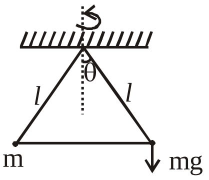
**150. (a)** From the relation, angular momentum, $L = mvr$

$v = \frac{L}{mr}$

$\therefore$ Centripetal force acting on the particle

$F = \frac{mv^2}{r} = \frac{m\left(\frac{L}{mr}\right)^2}{r} = \frac{L^2}{mr^3}$

**151. (c)** Torque working on the bob of mass m is, $\tau = mg \times \ell \sin\theta$. (Direction parallel to plane of rotation of particle)



As $\tau$ is perpendicular to $\vec{L}$, direction of L changes but magnitude remains same.

**152. (b)** $mgh = \frac{1}{2}mv^2 + \frac{1}{2}Iw^2$

$= \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{MR^2}{2}\right)\left(\frac{V}{R}\right)^2$

$= \frac{1}{2}mv^2 + \frac{1}{4}mv^2 = \frac{3}{4}mv^2$

Rotation K.E. $= \frac{1}{4}mv^2 = \frac{1}{4} \times \frac{4}{3}mgh$

$= \frac{mgh}{3} = 2 \times 9.8 \times (3/3) = 19.6$J

**153. (b)** Time of descent will be less for solid sphere. i.e., solid, sphere will reach first at the bottom of inclined plane.

**154. (b)** In pure rolling, mechanical energy remains conserved. Therefore, when heights of inclines are equal, speed of sphere will be same in both the case. But as acceleration down the plane, $a \propto \sin\theta$. Therefore, acceleration and time of descent will be different.

**155. (a)** For solid sphere rolling without slipping on inclined plane, acceleration

$a_1 = \frac{g\sin\theta}{1 + \frac{K^2}{R^2}}$

For solid sphere slipping on inclined plane without rolling, acceleration

$a_2 = g\sin\theta$

Therefore required ratio $= \frac{a_1}{a_2}$

$= \frac{1}{1 + \frac{K^2}{R^2}} = \frac{1}{1 + \frac{2}{5}} = \frac{5}{7}$

CHAPTER

# 8

# GRAVITATION

## FACT/DEFINITION TYPE QUESTIONS

**1.** Newton's universal law of gravitation applies to
(a) small bodies only
(b) planets only
(c) both small and big bodies
(d) only valid for solar system

**2.** For a particle inside a uniform spherical shell, the gravitational force on the particle is
(a) infinite (b) zero
(c) $\frac{-G m_1 m_2}{r^2}$ (d) $\frac{G m_1 m_2}{r^2}$

**3.** The value of G varies with
(a) height above the earth's surface
(b) depth below the ground
(c) radius of the planet
(d) None of these

**4.** Force of gravitational attraction is least
(a) at the equator
(b) at the poles
(c) at a point in between equator and any pole
(d) None of these

**5.** The ratio of the inertial mass to gravitational mass is equal to
(a) 0.5 (b) 1
(c) 2 (d) no fixed number

**6.** Who among the following gave first the experimental value of G
(a) Cavendish (b) Copernicus
(c) Brok Taylor (d) None of these

**7.** Mass of the Earth has been determined through
(a) use of Kepler's $\frac{T^2}{R^3}$ constancy law and Moon's period
(b) sampling the density of Earth's crust and using Earth's radius
(c) Cavendish's determination of G and using Earth radius and g at its surface
(d) use of periods of satellites at different heights above Earth's surface and known radius of Earth

**8.** Two spheres of masses m and M are situated in air and the gravitational force between them is F. The space around the masses is now filled with a liquid of specific gravity 3. The gravitational force will now be
(a) 3 F (b) F
(c) $\frac{F}{3}$ (d) $\frac{F}{9}$

**9.** Consider Earth to be a homogeneous sphere. Scientist A goes deep down in a mine and scientist B goes high up in a balloon. The gravitational field measured by
(a) A goes on decreasing and that by B goes on increasing
(b) B goes on decreasing and that by A goes on increasing
(c) each decreases at the same rate
(d) each decreases at different rates

**10.** In some region, the gravitational field is zero. The gravitational potential in this region.
(a) must be variable (b) must be constant
(c) cannot be zero (d) must be zero

**11.** Where will it be profitable to purchase one kilogram sugar?
(a) At poles (b) At equator
(c) At 45° latitude (d) At 40° latitude

**12.** At sea level, a body will have minimum weight at
(a) pole (b) equator
(c) 42° south latitude (d) 37° north latitude

**13.** Earth is flattened at poles, bulged at the equator. This is due to
(a) the angular velocity of spinning about its axis is less at equator
(b) the angular velocity of spinning about its axis is more at equator
(c) the centrifugal force is more at the equator than at the poles
(d) earth revolves round the sun in an elliptical orbit

**14.** In a gravitational field, at a point where the gravitational potential is zero
(a) the gravitational field is necessarily zero
(b) the gravitational field is not necesarily zero
(c) any value between one and infinite
(d) None of these

**15.** There are _______ gravitational lines of force inside a spherically symmetric shell.
(a) infinitely many
(b) zero
(c) varying number depending upon surface area
(d) varying number depending upon volume

**16.** Intensity of the gravitational field inside the solid sphere is
(a) variable (proportional to distance from centre)
(b) constant
(c) variable (does not depend on distance from the centre)
(d) zero

**17.** Intensity of the gravitational field inside the hollow spherical shell is
(a) variable (b) minimum
(c) maximum (d) zero

**18.** The value of acceleration due to gravity on moving from equator to poles will
(a) decrease (b) increase
(c) remain same (d) become half

**19.** The weight of a body at the centre of the earth is
(a) zero
(b) infinite
(c) same as on the surface of earth
(d) None of these

**20.** In motion of an object under the influence of gravitational force of another object, which of the following quantity is not conserved?
(a) Linear momentum
(b) Angular momentum
(c) Total mechanical energy
(d) None of these

**21.** As we go down below the earth's surface, the acceleration due to gravity decreases by a factor (d → distance, R → radius of earth)
(a) $1+\frac{d}{R}$ (b) $1-\frac{R}{d}$
(c) $1-\frac{d}{R}$ (d) remains constant

**22.** There is no atmosphere on moon, because of
(a) smaller value of G (b) smaller value of g
(c) smaller value of R (d) smaller value of m

**23.** If measured by a spring balance, then 1 kg of salt will weigh more at
(a) equator (b) poles
(c) centre of earth (d) same at all places

**24.** The gravitational potential energy associated with two particles separated by a distance r, when $r \to \infty$, is given by
(a) $\frac{G m_1 m_2}{r}$ (b) $\frac{-G m_1 m_2}{r}$
(c) zero (d) infinity

**25.** For elliptical orbits, in the equation $T^2 = \left(\frac{4\pi^2}{GM_s}\right)R^3$
R refers to
(a) radius of orbit (b) major axis
(c) semi-minor axis (d) semi-major axis

**26.** If the distance of earth is halved from the sun, then the no. of days in a year will be
(a) 365 (b) 182.5
(c) 730 (d) 129

**27.** In planetary motion
(a) the angular speed remains constant
(b) the total angular momentum remains constant
(c) the linear speed remains constant
(d) neither the angular momentum nor angular speed remains constant

**28.** Kepler's second law regarding constancy of areal velocity of a planet is a consequence of the law of conservation of
(a) energy (b) angular momentum
(c) linear momentum (d) None of these

**29.** In planetary motion, the angular momentum conservation leads to the law of
(a) orbits
(b) areas
(c) periods
(d) conservation of kinetic energy

**30.** Weightlessness experienced while orbiting the earth in spaceship is the result of
(a) inertia
(b) acceleration
(c) zero gravity
(d) centre of gravity

**31.** If the earth is at one-fourth of its present distance from the sun, the duration of the year will be
(a) half the present year
(b) one-eighth the present year
(c) one-sixth the present year
(d) one-tenth the present year

**32.** Time period of a simple pendulum inside a satellite orbiting earth is
(a) zero (b) $\infty$
(c) T (d) 2 T

**33.** Which of the following is always positive?
(a) Potential energy of an object
(b) Total energy of a satellite
(c) Kinetic energy (d) None of these

**34.** The distance of neptune and saturn from the sun is nearly $10^{13}$ and $10^{12}$ meter respectively. Assuming that they move in circular orbits, their periodic times will be in the ratio
(a) 10 (b) 100
(c) $10\sqrt{10}$ (d) 1000

**35.** A person sitting in a chair in a satellite feels weightless because
(a) the earth does not attract the objects in a satellite
(b) the normal force bythe chair on the person balances the earth's attraction
(c) the normal force is zero
(d) the person in satellite is not accelerated.

**36.** The relay satellite transmits the TV programme continuously from one part of the world to another because its
(a) period is greater than the period of rotation of the earth
(b) period is less than the period of rotation of the earth about its axis
(c) period has no relation with the period of the earth about its axis
(d) period is equal to the period of rotation of the earth about its axis

**37.** To an astronaut in a spaceship the sky appears black due to
(a) absence of atmosphere in his neighbourhood
(b) light from the sky is absorbed by the medium surrounding him
(c) the fact at that height, sky radiations are only in the infra-red and the ultraviolet region
(d) None of these

**38.** To have an earth synchronous satellite it should be launched at the proper height moving from
(a) north to south in a polar plane
(b) east to west in an equatorial plane
(c) south to north in a polar plane
(d) west to east in an equatorial plane

**39.** A missile is launched with a velocity less than escape velocity. The sum of its kinetic and potential energies is
(a) zero
(b) negative
(c) positive
(d) may be positive, negative or zero.

**40.** The orbital speed of Jupiter is
(a) greater than the orbital speed of earth
(b) less than the orbital speed of earth
(c) equal to the orbital speed of earth
(d) zero

**41.** The total energy of a circularly orbiting satellite is
(a) twice the kinetic energy of the satellite
(b) half the kinetic energy of the satellite
(c) twice the potential energy of the satellite
(d) half the potential energy of the satellite

**42.** Geo-stationary satellite is one which
(a) remains stationary at a fixed height from the earth's surface
(b) revolves like other satellites but in the opposite direction of earth's rotation
(c) revolves round the earth at a suitable height with same angular velocity and in the same direction as earth does about its own axis
(d) None of these

**43.** An artificial satellite orbiting the earth does not fall down because the earth's attraction
(a) is balanced by the attraction of the moon
(b) vanishes at such distances
(c) is balanced by the viscous drag produced by the atmosphere
(d) produces the necessary acceleration of its motion in a curved path

**44.** The period of a satellite in a circular orbit near a planet is independent of
(a) the mass of the planet
(b) the radius of the planet
(c) the mass of the satellite
(d) All of the above

**45.** If a satellite is orbiting the earth very close to its surface, then the orbital velocity mainly depends on
(a) the mass of the satellite
(b) the radius of earth
(c) the orbital radius
(d) the mass of earth

**46.** Two satellites of masses $m_1$ and $m_2$ ($m_1 > m_2$) are revolving round the earth in circular orbits of radii $r_1$ and $r_2$ ($r_1 > r_2$) respectively. Which of the following statements is true regarding their velocities $v_1$ and $v_2$?
(a) $v_1 = v_2$ (b) $v_1 < v_2$
(c) $v_1 > v_2$ (d) $(v_1 / r_2) = (v_2 / r_2)$

**47.** The escape velocity of a body depends upon mass as
(a) $m^0$ (b) $m^1$
(c) $m^2$ (d) $m^3$.

**48.** The minimum velocity of projection to go out from the earth's gravitational pull is called
(a) terminal velocity (b) escape velocity
(c) angular velocity (d) orbital velocity

**49.** There is no atmosphere on the moon because
(a) it is closer to the earth
(b) it revolves round the earth
(c) it gets light from the sun
(d) the escape velocity of gas molecules is lesser than their root mean square velocity

**50.** The escape velocity of a projectile from the earth is approximately
(a) 7 km/sec (b) 112 km/sec
(c) 11.2 km/sec (d) 1.1 km/sec

**51.** The escape velocity of an object projected from the surface of a given planet is independent of
(a) radius of the planet
(b) the direction of projection
(c) the mass of the planet
(d) None of these

**52.** Escape speed on the moon is _______ than escape speed on the earth.
(a) five times smaller (b) five times greater
(c) six times greater (d) six times smaller

**53.** The orbit traced by planet around a star is in general
(a) a circle (b) an ellipse
(c) a parabola (d) a straight line

**54.** If $V_e$ is escape speed from the earth and $V_p$ is that from a planet of half the radius of earth, then

(a) $V_e = V_p$ (b) $V_e = \frac{V_p}{2}$

(c) $V_e = 2V_p$ (d) $V_e = \frac{V_p}{4}$

**55.** In which of the following cases, a person feels weightless?

(a) A person standing on the moon
(b) A person sitting in an artificial satellite of earth
(c) Both (a) & (b)
(d) None of these

**56.** When does the object in a satellite escapes to infinity?

(a) When the total energy is positive
(b) When total energy is zero
(c) Both (a) & (b)
(d) None of these

**57.** In case of a circular orbiting satellite which option is correct for its energies?

(a) Kinetic energy is negative
(b) Potential energy is positive
(c) Total energy is positive
(d) None of these

**58.** What is the distance of a geostationary satellite from the earth's centre?

(a) $4.22 \times 10^4$ km (b) $4.22 \times 10^4$ m
(c) $4.22 \times 10^6$ km (d) $4.22 \times 10^6$ m

**59.** Persons sitting in artificial satellite of the earth have

(a) zero mass (b) zero weight
(c) certain definite weight (d) infinite weight

## STATEMENT TYPE QUESTIONS

**60.** Consider the following statements and select the correct statement(s).

I. Gravitational force may be attractive or repulsive
II. Gravitational force between two particles is independent of presence of other particles
III. Gravitational force is a short-range force

(a) I only (b) II only
(c) II and III (d) I, II and III

**61.** For a body taken to the moon which of the following statements is/are true?

I. Weight of the body will become 1\6 of that on earth
II. Inertial mass remains the same
III. Gravitational mass remains the same

(a) I only (b) II only
(c) I and II (d) I, II and III

**62.** Which of the given statements is/are true?

I. Motion of a particle under a central force is always confined to a plane
II. Under the influence of central force, position vector sweeps out equal areas in equal intervals of time

(a) I only (d) II only
(c) Both (I) and (II) (d) None of these

**63.** Let V and E be the gravitational potential and gravitational field at a distance r from the centre of a uniform spherical shell. Consider the following two statements and select the correct statement(s).

I. The plot of V against r is discontinuous
II. The plot of E against r is discontinuous.

(a) Both I and II (b) I only
(c) II only (d) None of these

**64.** Select the incorrect statements from the following.

I. The orbital velocity of a satellite increases with the radius of the orbit
II. Escape velocity of a particle from the surface of the earth depends on the speed with which it is fired
III. The time period of a satellite does not depend onthe radius of the orbit
IV. The orbital velocity is inversely proportional to the sequare root of the radius of the orbit.

(a) I and II (b) I and IV
(c) I, II and IV (d) I, II and III

**65.** Which of the following is/are not a relevant statement(s) to Kepler's laws of planetary motion?

I. Kepler's second law is based on law of conservation of angular momentum.
II. Every planet revolves around the sun in circular orbits with sun at the centre of the orbit.
III. Planets situated at larger distances from the sun take longer time to complete one rotation

(a) I only (b) II only
(c) II and III (d) I, II and III

**66.** Consider the following statements and select the incorrect statement(s) from the following.

I. When height of a satellite is increased, its potential energy increases & kinetic energy decrease
II. When speed of satellite increases, the total energy increases & it starts orbiting in a circular path
III. For a satellite orbiting in circular orbit, the kinetic energy is always greater than potential energy

(a) I and II (b) II and III
(c) III only (d) I, II and III

## MATCHING TYPE QUESTIONS

**67.** Match the columns I and II.

| | Column I | | Column II |
|---|---|---|---|
| (A) | Force between any two bodies | (1) | Maximum at the earth's surface |
| (B) | Acceleration due to gravity | (2) | Always attractive |
| (C) | Escape velocity | (3) | $\sqrt{gR}$ |
| (D) | Orbital velocity | (4) | $\sqrt{2}.\sqrt{gR}$ |

(a) (A) → (2) ; (B) → (1) ; (C) → (3) ; (D) → (4)
(b) (A) → (2) ; (B) → (2) ; (C) → (4) ; (D) → (3)
(c) (A) → (4) ; (B) → (3) ; (C) → (2) ; (D) → (1)
(d) (A) → (2) ; (B) → (1) ; (C) → (4) ; (D) → (3)

**68.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Gravitational force $F_g$ | (1) | $g\left(1-\frac{2h}{R}\right)$ |
| (B) | $g_{\text{surface of earth}}$ | (2) | $G\frac{Mm}{R^2}$ |
| (C) | Escape velocity | (3) | $\sqrt{2gR}$ |
| (D) | $g_{\text{height}}$ | (4) | $GM/R^2$ |

(a) $(A)\to(2);\ (B)\to(1);\ (C)\to(3);(D)\to(4)$

(b) $(A)\to(2);\ (B)\to(2);\ (C)\to(4);(D)\to(3)$

(c) $(A)\to(4);\ (B)\to(3);\ (C)\to(2);(D)\to(1)$

(d) $(A)\to(2);\ (B)\to(4);\ (C)\to(3);(D)\to(1)$

**69.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Gravitational constant | (1) | Law of periods |
| (B) | $g_h$ | (2) | 24 Hrs |
| (C) | $T^2 \propto R^3$ | (3) | $6.67\times10^{-11}\ \text{Nm}^2\text{kg}^{-2}$ |
| (D) | Time period of a geostationary satellite | (4) | $g_0\left(1-\frac{2h}{R}\right)$ |

(a) $(A)\to(2);\ (B)\to(1);\ (C)\to(3);(D)\to(4)$

(b) $(A)\to(3);\ (B)\to(4);\ (C)\to(1);(D)\to(2)$

(c) $(A)\to(4);\ (B)\to(3);\ (C)\to(2);(D)\to(1)$

(d) $(A)\to(3);\ (B)\to(4);\ (C)\to(2);(D)\to(1)$

**70.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Weight | (1) | Minimum |
| (B) | $g_{\text{equator}}$ | (2) | Zero |
| (C) | $g_{\text{poles}}$ | (3) | Vector |
| (D) | $g_{\text{centre}}$ | (4) | Maximum |

(a) $(A)\to(2);\ (B)\to(1);\ (C)\to(3);(D)\to(4)$

(b) $(A)\to(2);\ (B)\to(2);\ (C)\to(4);(D)\to(3)$

(c) $(A)\to(3);\ (B)\to(1);\ (C)\to(4);(D)\to(2)$

(d) $(A)\to(4);\ (B)\to(3);\ (C)\to(1);(D)\to(2)$

**71.** On the surface of earth acceleration due to gravity is g and gravitational potential is V. Match the following:

| | Column I | | Column -II |
|---|---|---|---|
| (A) | At height $h = R$, value of $g$ | (1) | decreases by a factor 1/4 |
| (B) | At depth $h = R/2$, value of $g$ | (2) | decreases by a factor 1/2 |
| (C) | At height $h = R/2$, value of $g$ | (3) | decreases by a factor 3/4 |
| (D) | At depth $h = R/4$, value of $g$ | (4) | decreases by a factor 2/3 |

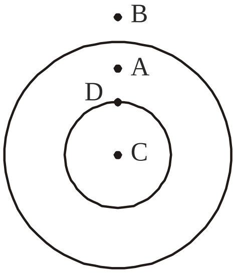
(a) $(A)\to(2);\ (B)\to(1);\ (C)\to(3);(D)\to(4)$

(b) $(A)\to(2);\ (B)\to(2);\ (C)\to(4);(D)\to(3)$

(c) $(A)\to(4);\ (B)\to(3);\ (C)\to(2);(D)\to(1)$

(d) $(A)\to(4);\ (B)\to(3);\ (C)\to(1);(D)\to(2)$

**72.** Two concentric spherical shells are as shown in figure. Match the following:



| | Column I | | Column II |
|---|---|---|---|
| (A) | Potential at $A$ | (1) | greater than $B$ |
| (B) | Gravitational field at $A$ | (2) | less than $B$ |
| (C) | As one moves from $C$ to $D$ | (3) | potential remains constant |
| (D) | As one moves from $D$ to $A$ | (4) | gravitational field decreases |
| | | (5) | None |

(a) $(A)\to(2);\ (B)\to(5);\ (C)\to(3);(D)\to(4)$

(b) $(A)\to(3);\ (B)\to(2);\ (C)\to(1);(D)\to(4)$

(c) $(A)\to(4);\ (B)\to(3);\ (C)\to(2);(D)\to(1)$

(d) $(A)\to(5);\ (B)\to(3);\ (C)\to(1);(D)\to(2)$

**73.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Acceleration due to gravity | (1) | $\sqrt{2\text{g}\,\text{R}_\text{E}}$ |
| (B) | Escape speed | (2) | $\frac{-\text{Gm}_1\text{m}_2}{\text{r}}$ |
| (C) | Total energy of a satellite | (3) | $\text{Gm/R}^2$ |
| (D) | Gravitational potential energy. | (4) | $\frac{-\text{Gm}_1\text{m}_2}{2(\text{R}+\text{h})}$ |

(a) (A)→(4); (B)→(2); C→(1); (D)→(3)

(b) (A)→(3); (B)→(1); C→(4); (D)→(2)

(c) (A)→(3); (B)→(2); C→(4); (D)→(1)

(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

**74.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Potential energy of satellite | (1) | Positive |
| (B) | Total energy of satellite | (2) | Negative |
| (C) | kinetic energy of satellite | (3) | Zero |
| (D) | Gravitational potential energy of satellite at infinity | (4) | Infinite |

(a) (A)→(4); (B)→(2); C→(1); (D)→(3)

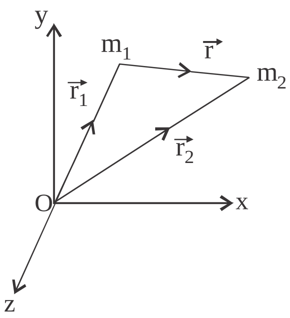
(b) (A)→(3); (B)→(1); C→(4); (D)→(2)

(c) (A)→(2); (B)→(2); C→(1); (D)→(3)

(d) (A)→(2); (B)→(4); C→(1); (D)→(3)

## DIAGRAM TYPE QUESTIONS

**75.** In the figure, the direction of gravitational force on $m_1$ due to $m_2$ is along

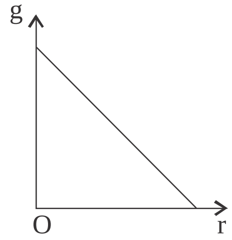


(a) $\vec{r}_1$ (b) $\vec{r}_2$

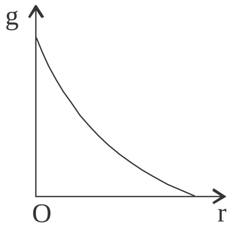
(c) $\vec{r}$ (d) $-\vec{r}$

**76.** Which of the following graphs shows the correct variation of acceleration due to gravity with the height above the earth's surface?

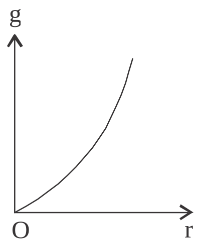
(a)



(b)

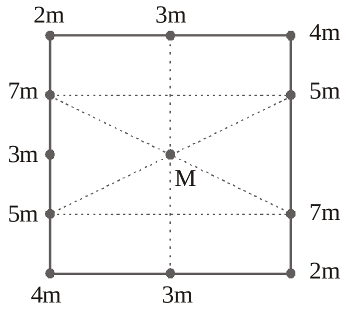


(c)



(d) None of these

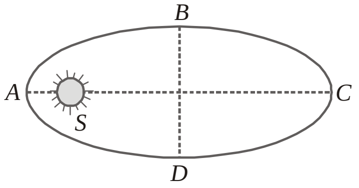
**77.** A central particle *M* is surrounded by a square array of other particles, separated by either distance *d* or distance *d*/2 along the perimeter of the square. The magnitude of the gravitational force on the central particle due to the other particles is



(a) $\frac{9\,GMm}{d^2}$ (b) $\frac{5\,GMm}{d^2}$

(c) $\frac{3\,GMm}{d^2}$ (d) $\frac{GMm}{d^2}$

**78.** A planet is revolving around the sun as shown in elliptical path



The correct option is

(a) the time taken in travelling DAB is less than that for BCD

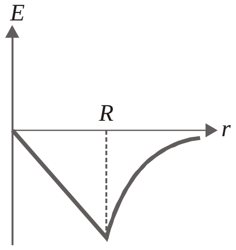
(b) the time taken in travelling DAB is greater than that for ABC

(c) the time taken in travelling CDA is less than that for ABC

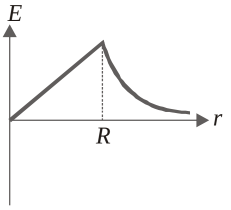
(d) the time taken in travelling CDA is greater than that for ABC

**79.** The gravitational field strength due to a solid sphere (mass *M*, radius *R*) varies with distance *r* from centre as

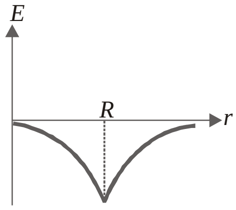
(a)



(b)



(c)



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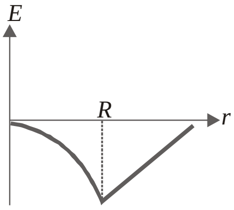
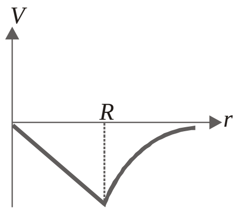
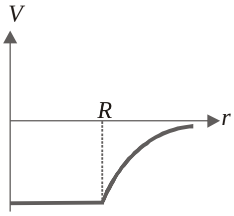


**80.** The gravitational potential due to a hollow sphere (mass *M*, radius *R*) varies with distance *r* from centre as

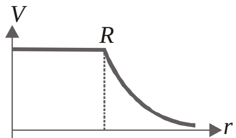
(a)



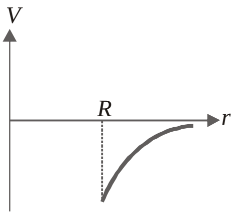
(b)



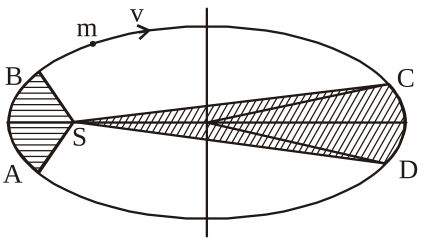
(c)



(d)



**81.** The figure shows elliptical orbit of a planet m about the sun S. The shaded area SCD is twice the shaded area SAB. If $t_1$ is the time for the planet to move from C to D and $t_2$ is the time to move from A to B then



(a) $t_1 = 4t_2$ (b) $t_1 = 2t_2$
(c) $t_1 = t_2$ (d) $t_1 > t_2$

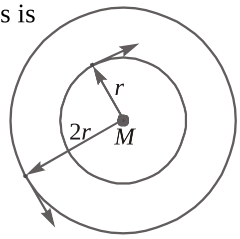
**82.** Two satellites of masses *m* and 2*m* are revolving around a planet of mass *M* with different speeds in orbits of radii *r* and 2*r* respectively. The ratio of minimum and maximum forces on the planet due to satellites is

(a) $\frac{1}{2}$

(b) $\frac{1}{4}$

(c) $\frac{1}{3}$

(d) None of these



## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

**83.** **Assertion :** Gravitational force between two particles is negligibly small compared to the electrical force.
**Reason :** The electrical force is experienced by charged particles only.

**84.** **Assertion :** A body becomes massless at the centre of earth.
**Reason :** This follows from $g' = g\left(1-\frac{d}{R}\right)$

**85.** **Assertion :** If earth suddenly stops rotating about its axis, then the value of acceleration due to gravity will become same at all the places.
**Reason :** The value of acceleration due to gravity depends upon the rotation of the earth.

**86.** **Assertion :** Space rockets are usually launched in the equatorial line from west to east.
**Reason :** The acceleration due to gravity is minimum at the equator.

**87.** **Assertion:** The value of acceleration due to gravity i.e. 'g' is different at different places on the surface of earth.
**Reason:** Earth is flattened at poles and bulging out at the equator. Therefore radius is smaller at poles and larger at equator and $g \propto \frac{1}{R^2}$, so, g is smaller at equator than at poles.

**88.** **Assertion:** A body loses weight when it is at the centre of the earth.
**Reason:** At the centre of earth, g = 0
$\therefore$ weight = mg = 0.

**89.** **Assertion:** The gain in potential energy of an object of mass m raised to height equal to the radius of earth is $\frac{1}{2}$ mg R
**Reason:** Kinetic energy at surface = P.E at the top $\frac{1}{2}mv^2$ and at the top $v = \sqrt{gR}$ . $\therefore$ PE = $\frac{1}{2}$mgR.

**90.** **Assertion :** The tidal waves in sea are primarily due to the gravitational effect of earth.
**Reason :** The intensity of gravitational field of earth is maximum at the surface of earth.

**91.** **Assertion :** Smaller the orbit of the planet around the sun, shorter is the time it takes to complete one revolution.
**Reason :** According to Kepler's third law of planetary motion, square of time period is proportional to cube of mean distance from sun.

**92.** **Assertion :** Moon travellers tie heavy weight at their back before landing on the moon.
**Reason :** The acceleration due to gravity on moon is smaller than that of earth.

**93.** **Assertion :** Generally, the path of a projectile from the earth is parabolic but it is elliptical for projectiles going to a very large height.
**Reason :** The path of a projectile is independent of the gravitational force of earth.

**94.** **Assertion :** Gravitational potential is maximum at infinity.
**Reason :** Gravitational potential is the amount of work done to shift a unit mass from infinity to a given point in gravitational attraction force field.

**95.** **Assertion :** Gravitational potential of earth at every place on it is negative.
**Reason :** Every body on earth is bound by the attraction of earth.

**96.** **Assertion :** For the planets orbiting around the sun, angular speed, linear speed and K.E. changes with time, but angular momentum remains constant.
**Reason :** No torque is acting on the rotating planet. So its angular momentum is constant.

**97.** **Assertion:** Planets appear to move slower when they are farther from the sun than when they are nearer.
**Reason:** All planets move in elliptical orbits with sun at one of the foci of the ellipse.

**98.** **Assertion:** The escape velocity on the moon is much higher than that on the earth.

**Reason:** $V_e = \sqrt{2g / R}$

Thus for lower R, $V_e$ on moon is higher.

**99.** **Assertion :** The escape speed does not depend on the direction in which the projectile is fired.

**Reason :** Attaining the escape speed is easier if a projectile is fired in the direction the launch site is moving as the earth rotates about its axis.

**100.** **Assertion :** If an object is projected from earth surface with escape velocity path of object will be parabola.

**Reason :** When object is projected with velocity less than escape velocity from horizontal surface and greater than orbital velocity path of object will be ellipse.

**101.** **Assertion :** The atmosphere of Jupiter contains light gases, where as earth's atmosphere has little amount of hydrogen gas.

**Reason :** The escape velocity from the Jupiter is smaller than the escape velocity from the earth.

**102.** **Assertion :** An astronaut in an orbiting space station above the earth experiences weightlessness.

**Reason :** An object moving around earth under the influence of earth′s gravitational force is in a state of free fall.

**103.** **Assertion :** Space rocket are usually launched in the equatorial line from west to east

**Reason :** The acceleration due to gravity is minimum at the equator.

**104.** **Assertion :** Orbital velocity of a satellite is greater than its escape velocity.

**Reason :** Orbit of a satellite is within the gravitational field of earth whereas escaping is beyond the gravitational field of earth.

**105.** **Assertion :** Escape velocity is independent of the angle of projection.

**Reason :** Escape velocity from the surface of earth is $\sqrt{2gR}$ where $R$ is radius of earth.

**106.** **Assertion :** If the total energy of a satellite moving around earth is $E$, its potential energy is $2E$.

**Reason :** Total energy $E$ = KE + PE.

**107.** **Assertion :** The speed of satellite always remains constant in an orbit.

**Reason :** The speed of a satellite depends on its path.

**108.** **Assertion :** A person sitting in an artificial satellite revolving around earth feels weightless.

**Reason :** There is no gravitational force on the satellite.

## CRITICALTHINKING TYPE QUESTIONS

**109.** If three equal masses $m$ are placed at the three vertices of an equilateral triangle of side $1/m$ then what force acts on a particle of mass 2m placed at the centroid?

(a) $Gm^2$ (b) $2Gm^2$
(c) Zero (d) $-Gm^2$

**110.** Both earth and moon are subject to the gravitational force of the sun. As observed from the sun, the orbit of the moon

(a) will be elliptical
(b) will not be strictly elliptical because the total gravitational force on it is not central.
(c) is not elliptical but will necessarily be a closed curve.
(d) deviates considerably from being elliptical due to influence of planets other than earth.

**111.** Two identical spheres of gold are in contact with each other. The gravitational attraction between them is

(a) directly proportional to the square of the radius
(b) directly proportional to the cube of the radius
(c) directly proportional to the fourth power of the radius
(d) inversely proportional to the square of the radius

**112.** Two air bubbles in water

(a) attract each other
(b) repel each other
(c) neither attract nor repel
(d) None of these

**113.** If suddenly the gravitational force of attraction between earth and a satellite revolving around it becomes zero, then the satellite will

(a) continue to move in its orbit with same velocity
(b) move tangentialy to the original orbit in the same velocity
(c) become stationary in its orbit
(d) move towards the earth

**114.** Two particles of equal mass '$m$' go around a circle of radius $R$ under the action of their mutual gravitational attraction. The speed of each particle with respect to their centre of mass is

(a) $\sqrt{\frac{Gm}{4R}}$ (b) $\sqrt{\frac{Gm}{3R}}$
(c) $\sqrt{\frac{Gm}{2R}}$ (d) $\sqrt{\frac{Gm}{R}}$

**115.** The change in the value of 'g' at a height 'h' above the surface of the earth is the same as at a depth 'd' below the surface of earth. When both 'd' and 'h' are much smaller than the radius of earth, then which one of the following is correct ?

(a) $d = \frac{3h}{2}$ (b) $d = \frac{h}{2}$
(c) $d = h$ (d) $d = 2h$

**116.** The height at which the acceleration due to gravity becomes $\frac{g}{9}$ (where $g$ = the acceleration due to gravity on the surface of the earth) in terms of $R$, the radius of the earth, is

(a) $\frac{R}{\sqrt{2}}$ (b) $R/2$
(c) $\sqrt{2}R$ (d) $2R$

**117.** The density of a newly discovered planet is twice that of earth. The acceleration due to gravity at the surface of the planet is equal to that at the surface of the earth. If the radius of the earth is R, the radius of the planet would be
(a) ½ R (b) 2 R
(c) 4 R (d) 1/4 R

**118.** Imagine a new planet having the same density as that of earth but it is 3 times bigger than the earth in size. If the acceleration due to gravity on the surface of earth is g and that on the surface of the new planet is g', then
(a) g' = g/9 (b) g' = 27g
(c) g'= 9g (d) g' = 3g

**119.** Average density of the earth
(a) is a complex function of g
(b) does not depend on g
(c) is inversely proportional to g
(d) is directly proportional to g

**120.** A uniform spherical shell gradually shrinks maintaining its shape. The gravitational potential at the centre
(a) increases (b) decreases
(c) remains constant (d) cannot say

**121.** If the earth were to rotates faster than its present speed, the weight of an object will
(a) increase at the equator but remain unchanged at the poles
(b) decrease at the equator but remain unchanged at the poles
(c) remain unchanged at the equator but decrease at the poles
(d) remain unchanged at the equator but increase at the poles

**122.** At what height from the ground will the value of g be the same as that in 10 km deep mine below the surface of earth?
(a) 20 km (b) 10 km
(c) 15 km (d) 5 km

**123.** The earth is an approximate sphere. If the interior contained matter which is not of the same density everywhere, then on the surface of the earth, the acceleration due to gravity
(a) will be directed towards the centre but not the same everywhere.
(b) will have the same value everywhere but not directed towards the centre.
(c) will be same everywhere in magnitude and directed towards the centre.
(d) Cannot be zero at any point.

**124.** If a person goes to height equal to the radius of the earth, from its surface, then his weight (w′) relative to the weight on earth (w) will be
(a) $W' = \frac{W}{4}$ (b) W′ = 2W
(c) $W' = \frac{W}{2}$ (d) W′ = W

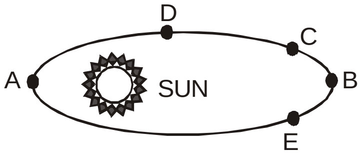
**125.** The gravitational potential at the centre of a square of side 'a' and four equal masses (m each) placed at the corners of a square is
(a) Zero (b) $4\sqrt{2}\,\frac{Gm}{a}$
(c) $-4\sqrt{2}\,\frac{Gm}{a}$ (d) $-4\sqrt{2}\,\frac{Gm^2}{a}$

**126.** If value of acceleration due to gravity is 'g' at a height 50 km above the surface of earth, then at what depth inside the earth will the acceleration due to gravity be same as 'g'?
(a) 100 km (b) 50 km
(c) 25 km (d) 75 km

**127.** The tail of the comet Halley is directed away from the sun due to the fact that
(a) the comet rotates around the sun the lighter mass of the comet is pushed away due to centrifugal force only
(b) the comet rotates the lighter mass of the comet is attracted by some star situated in the direction of the tail
(c) the radiation emitted by the sun exerts a radiation pressure of the comet throwing its tail away from the sun
(d) the tail of the comet always exists in the same orientation

**128.** The time period T of the moon of planet Mars (mass $M_m$) is related to its orbital radius R (G = Gravitational constant) as
(a) $T^2 = \frac{4\pi^2 R^3}{GM_m}$ (b) $T^2 = \frac{4\pi^2 GR^3}{M_m}$
(c) $T^2 = \frac{2\pi R^3 G}{M_m}$ (d) $T^2 = 4\pi M_m GR^3$

**129.** The planet mercury is revolving in an elliptical orbit around the sun as shown in fig. The kinetic energy of mercury will be greatest at
(a) A
(b) B
(c) C
(d) D



**130.** A geostationary satellite is orbiting the earth at a height of 5*R* above that surface of the earth, *R* being the radius of the earth. The time period of another satellite in hours at a height of 2*R* from the surface of the earth is
(a) 5 (b) 10
(c) $6\sqrt{2}$ (d) $\frac{6}{\sqrt{2}}$

**131.** A particle of mass *M* is situated at the centre of a spherical shell of same mass and radius *a*. The gravitational potential at a point situated at $\frac{a}{2}$ distance from the centre, will be
(a) $-\frac{3GM}{a}$ (b) $-\frac{2GM}{a}$
(c) $-\frac{GM}{a}$ (d) $-\frac{4GM}{a}$

**132.** The mass of a spaceship is 1000 kg. It is to be launched from the earth's surface out into free space. The value of $g$ and $R$ (radius of earth) are 10 m/s$^2$ and 6400 km respectively. The required energy for this work will be

(a) $6.4 \times 10^{11}$J (b) $6.4 \times 10^{8}$ J
(c) $6.4 \times 10^{9}$ J (d) $6.4 \times 10^{10}$ J

**133.** A particle of mass m is thrown upwards from the surface of the earth, with a velocity u. The mass and the radius of the earth are, respectively, M and R. G is gravitational constant and g is acceleration due to gravity on the surface of the earth. The minimum value of u so that the particle does not return back to earth, is

(a) $\sqrt{\frac{2GM}{R}}$ (b) $\sqrt{\frac{2GM}{R^2}}$
(c) $\sqrt{2gR^2}$ (d) $\sqrt{\frac{2GM}{R^2}}$

**134.** A planet in a distant solar system is 10 times more massive than the earth and its radius is 10 times smaller. Given that the escape velocity from the earth is 11 km s$^{-1}$, the escape velocity from the surface of the planet would be

(a) 1.1 km s$^{-1}$ (b) 11 km s$^{-1}$
(c) 110 km s$^{-1}$ (d) 0.11 km s$^{-1}$

**135.** For a satellite moving in an orbit around the earth, the ratio of kinetic energy to potential energy is

(a) $\frac{1}{2}$ (b) $\frac{1}{\sqrt{2}}$
(c) 2 (d) $\sqrt{2}$

**136.** The radii of circular orbits of two satellites A and B of the earth, are 4R and R, respectively. If the speed of satellite A is 3 V, then the speed of satellite B will be

(a) 3 V/4 (b) 6 V
(c) 12 V (d) 3 V/2

**137.** What is the minimum energy required to launch a satellite of mass m from the surface of a planet of mass M and radius R in a circular orbit at an altitude of 2R?

(a) $\frac{5GmM}{6R}$ (b) $\frac{2GmM}{3R}$
(c) $\frac{GmM}{2R}$ (d) $\frac{GmM}{2R}$

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(c)** It is applicable to both small & big bodies.

**2.** **(b)** Various regions of spherical shell attract the point mass inside it in various directions. These forces cancel each other completely. Therefore the gravitational force on the particle is zero.

**3.** **(d)** G is a universal gravitational constant as the value of G is same for all pairs of bodies situated anywhere in the universe.

**4.** **(a)** The gravitational force of attraction on a body of mass *m* is given by

$$F = \frac{GMm}{R^2}$$

Therefore, $F \propto \frac{1}{R^2}$

The radius of earth is maximum at equator, therefore, gravitational force of attraction is least at equator.

**5.** **(c)** The inertial mass & gravitational mass are equivalent & ratio of inertial mass to gravitational mass = 1 to a high degree of accuracy (experimental finding).

**6.** **(a)** **7.** **(c)**

**8.** **(b)** It will remain the same as the gravitational force is independent of the medium separating the masses.

**9.** **(d)** Both decreases but variation are different.

**10.** **(b)** $I = \frac{-dV}{dr}$. If I = 0 then V = constant

**11.** **(a)**

**12.** **(b)** At poles, the effect of rotation is zero and also the distance from the centre of earth is least.

**13.** **(c)** Because of the centrifugal force, earth stretches out and so bulges at the equator.

**14.** **(a)** $I = \frac{-dV}{dx}$

**15.** **(b)** There is no gravitational field in the shell.

**16.** **(a)** The gravitational field intensity inside the solid sphere is given by $E_g = -\frac{GMr}{R^3}$. ie, $E_g \infty r$

**17.** **(d)** At a point inside a spherical shell, the value of gravitational intensity, I = 0.
If V = 0 then gravitational field is necessarily zero.

**18.** **(b)** Acceleration due to gravity (*g*) is given by

$$g = \frac{GM}{R^2} \Rightarrow g \propto \frac{1}{R^2}$$

As one moves from the equator to the poles, the radius of the earth decreases, hence *g* increases.

**19.** **(a)** The weight (= mg) of the body at the centre of the earth is zero, because the value of g at centre is zero.

**20.** **(a)** In the motion of an object under gravitational influence of another object, angular momentum and total mechanical energy is conserved but linear momentum is not conserved.

**21.** **(c)** Acceleration due to gravity g varies with dpth as

$$g' = g\left(1 - \frac{d}{R_E}\right)$$

**22.** **(b)** Because of smaller value of acceleration due to gravity on moon, the value of escape velocity is small there. The molecules of atmospheric gases have thermal speeds much greater than the escape velocity. So all the molecules have escaped and there is no atmosphere.

**23.** **(b)** Value of g is larger at poles than the equator so, if salt is weighed by a spring balance 1 kg will weigh more at poles.

**24.** **(c)** Gravitational potential energy associated with two particles of masses $m_1$ & $m_2$ separated by distance r is given by

$$V = -\frac{G\,m_1m_2}{r} \qquad \therefore \text{ if } r \to \infty. \;\; \therefore \;\; \frac{1}{\infty} = 0.$$

$\Rightarrow \quad V = 0.$

**25.** **(d)** Kepler's third law states that the square of time period of revolution of a planet around the sun is directly proportional to the cube of semi-major axis of its elliptical orbit.

**26.** **(d)** From Kepler's law of periods,

$$T_2 = T_1\left(\frac{R_2}{R_1}\right)^{3/2} = 365\left(\frac{\cancel{R}\,/\,2}{\cancel{R}}\right)^{3/2}$$

$$= 365 \times \frac{1}{2\sqrt{2}} = 129 \text{ days.}$$

**27.** **(b)** In planetary motion, there is no external torque. Hence from the equation $\frac{\overrightarrow{dL}}{dt} = \vec{\tau}_{ext.}$, if $\vec{\tau}_{ext.} = 0 \Rightarrow L = \text{constant}$

**28.** **(b)** Since areal velocity $\vec{A}$ & angular momentum $\vec{L}$ of a planet are related by equation $\vec{A} = \frac{\vec{L}}{2M}$, where M is the mass of planet. Since in planetary motion $\vec{L}$ is constant ($\vec{\tau}_{ext.} = 0$), hence $\vec{A}$ is also constant.

**29.** **(b)** In planetary motion, the angular momentum conservation leads to the law of areas. Which means it sweeps out equal area in equal internals of tine or areal velocity is constant.

**30.** **(c)** Weightlessness means that there is no reaction on a body from the floor. Since both the artificial satellite & the astronaut have same centripetal acceleration (as in a lift; which is falling freely, we does not feel any weight, because both lift & we fall with same acceleration). so the astronaut does not feel any weight inside the space craft.

**31.** **(b)** $\frac{T_1^2}{T_2^2} = \frac{r_1^3}{r_2^3} = (4)^3$

$\therefore \quad T_2 = T_1/8.$

**32.** **(b)** Since $T = 2\pi\sqrt{\frac{l}{g}}$

but inside the satellite g = 0

So $T = \infty$

**33.** **(c)** Kinetic energy = $\frac{1}{2}mv^2$ is always positive but potential energy and total energy are negative for a satellite.

**34.** **(c)** $T^2 \propto R^3$ (According to Kepler's law)

$T_1^2 \propto (10^{13})^3$ and $T_2^2 \propto (10^{12})^3$

$\therefore \frac{T_1^2}{T_2^2} = (10)^3$ or $\frac{T_1}{T_2} = 10\sqrt{10}$.

**35.** **(c)**

**36.** **(d)** Because, the period of satellite is equal to period of rotation of earth about its own axis & it seems to be at one point about the equator and so is able to transmit the signals from one part to other.

**37.** **(a)**

**38.** **(d)** The sense of synchronous satellite must be same as the sense of rotation of earth i.e., from west to east.

**39.** **(b)**

**40.** **(b)** orbital speed $v \propto \frac{1}{\sqrt{r}}$; As Jupiter is farther than earth from sun, so its orbital speed is less than orbital speed of earth.

**41.** **(d)** Total energy of satellite is half the potential energy i.e.,

$E = \frac{U}{2}$

**42.** **(c)** Geo-stationary satellites are also called synchronous satellite. They always remain about the same path on equater, i.e., it has a period of exactly one day (86400 sec)

So orbit radius $\left(T = 2\pi\sqrt{\frac{r^3}{GM}}\right)$ comes out to be 42400 km, which is nearly equal to the circumference of earth. So height of Geostationary satellite from the earth surface is 42,400 – 6400 = 36,000 km.

**43.** **(d)**

**44.** **(c)** The orbital velocity of satellite moving in circular orbit near a planet is $v_0 = \sqrt{\frac{GM}{R}}$

so period $T = \frac{2\pi R}{v_0} = 2\pi R\sqrt{\frac{R}{GM}} = 2\pi\sqrt{\frac{R^3}{GM}}$

Where R & M are the radius & mass of that planet. Since satellite moves very near to planet, hence the radius of its circular orbit is approximately equal to radius of the planet.

**45.** **(b)** When satellite is orbiting close to the surface of earth, orbital velocity, $v_o = \sqrt{\frac{GM}{R}}$ where M and R are the mass and radius of earth.

**46.** **(b)** Since $v_0$ (orbital velocity) $= \sqrt{\frac{GM}{r}}$

So $\frac{v_{01}}{v_{02}} = \sqrt{\frac{r_2}{r_1}} \Rightarrow v_{01} < v_{02} \because r_1 > r_2$

**47.** **(a)** $v_{esc} = \sqrt{2gR}$, where R is radius of the planet. Hence escape velocity is independent of m.

**48.** **(b)** It is called escape velocity $(v_e = \sqrt{2gR_e})$

**49.** **(d)** There is no atmosphere at moon, because escape velocity is less than the root mean square velocity of the molecules at moon. Hence all molecules escape.

**50.** **(c)** The escape velocity of projectile from earth is $v_e = \sqrt{2gR_e}$, where $R_e$ is radius of earth

since $g = 9.8 m/sec^2$, $R_e = 6.4\times10^6$ metre

$\Rightarrow v_e = 11.2$ km/sec

**51.** **(b)** The escape veloctiy of an object from any planet is $v_{escape} = \sqrt{2gR} = \sqrt{2GM/R}$

where R & M are the radius & mass of the planet.

**52.** **(a)** Since 'g' on moon is smaller than earth and radius of moon is also smaller, therefore escape velocity on moon is just 2.3 km/s, which is approximately five times smaller than earth 11.2 km/s.

**53.** **(b)** According to Kepler's law of planetary motion all the planets revolve around the sun in elliptical orbit. Therefore, the orbit traced by planet around a star is an ellipse.

**54.** **(c)** Escape speed, $V_e = R\sqrt{\frac{8}{3}\pi G s}$

$\therefore V_e \propto R.$

**55.** **(b)** When a person is sitting in an artificial satellite of earth, the gravitational pull on the person due to earth is counterbalanced by the centrifugal force acting on the person. Thus the net force acting on the person in the satellite is zero & the person feels weightless but on the moon his weight is due to the gravitational pull of the moon.

**56.** **(c)** Since total energy of a body is positive or zero, when it is at infinity from the earth therefore, the satellite will escape to infinity if its total energy becomes zero or positive.

**57.** **(d)** For a satellite in circular orbit the kinetic energy is positive, potential energy and total energy is negative. Hence none of the given options is correct.

**58.** **(a)** A geostationary satellite moves in a circular orbit in the equatorial plane at an approx. distance of $4.22 \times 10^4$ km from zero the earth's centre.

**59.** **(b)** The reaction force of the artificial satellite acting on the person sitting in satellite is zero. Therefore, the weight of the person is zero in artificial satellite is zero.

## STATEMENT TYPE QUESTIONS

**60.** **(b)** Gravitational force is always attractive and a long range force. It is independent of the presence of other bodies.

**61.** **(d)** All the three statements are true.

**62.** **(c)** **63.** **(c)**

**64.** **(d)** Orbital velocity $v_0 = \sqrt{\frac{GM}{r}}$

**65.** **(b)** Every planet revolves around the sun in elliptical orbit and not in circular orbit.

**66.** **(c)** For a satellite orbiting in circular orbit the potential energy is always greater than the kinetic energy.

## MATCHING TYPE QUESTIONS

**67.** **(d)** $(A)\to(2);\ (B)\to(1);\ (C)\to(4);(D)\to(3)$

**68.** **(d)** $(A)\to(2);\ (B)\to(4);\ (C)\to(3);(D)\to(1)$

**69.** **(b)** $(A)\to(3);\ (B)\to(4);\ (C)\to(1);(D)\to(2)$

**70.** **(c)** $(A)\to(3);\ (B)\to(1);\ (C)\to(4);(D)\to(2)$

**71.** **(b)** $(A)\to(2);\ (B)\to(2);\ (C)\to(4);(D)\to(3)$

$g = \frac{GM}{R^2}$,

At height $h = R$: $g' = \frac{g}{1+\frac{h}{R}} = \frac{g}{2}$

i.e., $g'$ decreases by a factor $\frac{1}{2}$.

Similarly, at height h = R/2, $g' = \frac{2}{3}g$.

At depth $h = \frac{R}{2}$: $g' = g\left(1-\frac{h}{R}\right) = \left(1-\frac{1}{2}\right) = \frac{g}{2}$

Similarly at h = R/4, $g' = \frac{3}{4}g$

**72.** **(a)** $(A)\to(2);\ (B)\to(5);\ (C)\to(3);(D)\to(4)$

Inside a shell $V = -\frac{GM}{R}$ = constant and $E = 0$

Outside the shell, $V = -\frac{GM}{r}$ and $E = \frac{GM}{r^2}$

As $r$ increases, $V$ increases and $E$ decreases.

**73.** **(b)** (A)→(3); (B)→(1); C→(4); (D)→(2)

Acceleration due to gravity, $g = Gm/R^2$

Escape velocity, $V_E = \sqrt{2gR_E}$

Total energy of a satellite at a height, h above the earth surface $= \frac{-G\,m_1 m_2}{2(R+h)}$

Gravitational potential energy $= \frac{-G\,m_1 m_2}{r}$

**74.** **(c)** (A)→(2); (B)→(2); C→(1); (D)→(3)

Potential energy of a satellite = Negative

Total energy of a satellite = Negative

Kinetic energy of a satellite = Positive

Grav P.E of a satellite at infinity = zero.

## DIAGRAM TYPE QUESTIONS

**75.** **(c)** As $m_2$ attracts $m_1$ towards itself, ∴ force is along $r^3$.

**76.** **(b)** Acceleration due to gravity with height h varies as $g \propto \frac{1}{r^2}$

(when r = R + h). Thus variation of g and r is a parabolic curve.

**77.** **(c)** $F = \frac{GM(3m)}{d^2} = \frac{3GMm}{d^2}$.

**78.** **(a)** The speed of the planet is faster in region DAB in comparision to the region BCD.

**79.** **(a)** $\vec{g}' = -\frac{g\vec{r}}{R}$ for $r \le R$ and $g' = \frac{g}{(1+r/R)^2}$ for $r \ge R$

so option (a) is correct.

**80.** **(b)** $v_g = -\frac{GM}{R}$ for $r \le R$ and $v_g = -\frac{GM}{r}$, for $r > R$, and so option ($b$) is correct.

**81.** **(b)** According to Kepler's law, the areal velocity of a planet around the sun always remains constant.

SCD : $A_1 - t_1$ (areal velocity constant)

SAB : $A_2 - t_2$

$\frac{A_1}{t_1} = \frac{A_2}{t_2}$,

$t_1 = t_2 \cdot \frac{A_1}{A_2}$, (given $A_1 = 2A_2$)

$= t_2 \cdot \frac{2A_2}{A_2}$ ∴ $t_1 = 2t_2$

**82.** **(c)** $$F_{\min} = \frac{GMm}{r^2} - \frac{GM(2m)}{(2r)^2} = \frac{GMm}{2r^2}$$

and $$F_{\max} = \frac{GMm}{r^2} + \frac{GM(2m)}{(2r)^2} = \frac{3}{2}\frac{GMm}{r^2}.$$

$$\therefore \quad \frac{F_{\min}}{F_{\max}} = \frac{1}{3}.$$

## ASSERTION- REASON TYPE QUESTIONS

**83.** **(b)** For two electron $\frac{F_g}{F_e} = 10^{-43}$ i.e., gravitational force is negligible in comparison to electrostatic force of attraction.

**84.** **(d)** At the centre of the earth, weight is zero but mass cannot be and never zero.

**85.** **(c)** **86.** **(c)** **87.** **(a)** **88.** **(a)**

**89.** **(c)** Work done in raising the body

$$= \int_R^{2R} \frac{GMm}{x^2} dx$$

$$= \int_R^{2R} \frac{gR^2}{x^2} m dx = mgR^2 . \left[\frac{-1}{x}\right]_R^{2R}$$

$$= mgR^2\left[\frac{-1}{2R} + \frac{1}{R}\right]$$

$$= mgR^2\left[\frac{-1+2}{2R}\right] = \frac{1}{2}mgR$$

**90.** **(d)** The tidal effect is due to the gravitation effect of moon and earth both. $g' = \frac{g}{\left(1+\frac{h}{R}\right)^2}$, for $h = 0$, $g' = g$.

**91.** **(a)** According to Kepler's third law $T^2 \propto r^3$
if r is small then T will also be small.

**92.** **(a)** To counter balance the effect of gravity.

**93.** **(c)** **94.** **(b)**

**95.** **(a)** Because gravitational force is always attractive in nature and every body is bound by this gravitational force of attraction of earth.

**96.** **(a)**

**97.** **(b)** Both assertion and reason are true, but reason is not correct explanation of the assertion.
From Kepler's laws of period $T^2 \alpha r^3$
$\therefore$ For more r, T is more.

**98.** **(d)** Escape velocity on the moon is five times smaller than on the earth 11.2 km/s.

**99.** **(c)** **100.** **(c)**

**101.** **(c)** Escape velocity for Jupiter is greater than escape velocity for earth.

**102.** **(a)** Freely faling body experiences weightlessness.

**103.** **(b)** Space rocket are usually launched from west to east to take the advantage of rotation of earth.
Also $g' = g - \omega^2 R\cos^2\lambda$, at equator $\lambda = 0$, and so $\cos\lambda = 1$, and $g'$ is least.

**104.** **(d)** **105.** **(a)**

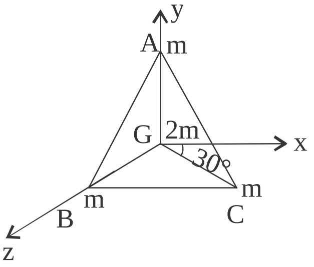
**106.** **(a)** $K = -E = -\frac{U}{2}$.

**107.** **(d)** If the orbital path of a satellite is circular, then its speed is constant and if the orbital path of a satellite is elliptical, then its speed in its orbit is not constant. In that case its areal velocity is constant.

**108.** **(c)** Gravitational force on the person in satellite is not zero, but normal reaction of the satellite on the person is zero.

## CRITICALTHINKING TYPE QUESTIONS

**109.** **(c)**



$$F_{GA} = \frac{Gm(2m)}{1}\hat{j}$$

$$F_{GB} = \frac{Gm(2m)}{1}(-\hat{i}\cos 30° - \hat{j}\sin 30°)$$

$$F_{GC} = \frac{Gm(2m)}{1}(\hat{i}\cos 30° - \hat{j}\sin 30°)$$

$\therefore$ Resultant force on (2m) is $F_R = F_{GA} + F_{GB} + F_{GC}$

$$= 2Gm^2\hat{j} + 2Gm^2\hat{i}(-\cancel{\cos} 30° + \cancel{\cos 30°})$$
$$+ 2Gm^2\hat{j}(-\sin 30° - \sin 30°)$$

$$= 2Gm^2\hat{j} . 2Gm^2\hat{j}\left(-\cancel{2} \times \frac{1}{\cancel{2}}\right)$$

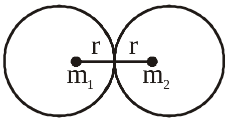
$$= 2Gm^2\hat{j} - 2Gm^2\hat{j} = 0 .$$

**110.** **(b)**

**111.** **(c)** The gravitational force of attraction between two identical spheres of radius r is

$$F = \frac{Gm_1m_2}{r^2} = \frac{G\frac{4}{3}\pi r^3\rho \times \frac{4}{3}\pi r^3\rho}{(2r)^2}$$

$$= \frac{4}{9}\pi^2 p^2 r^4$$



ie. $F \propto r^4$

**112. (a)** The two air bubbles in water attract each other. The mass of air bubble in water (denser medium in comparision to air) behave like a negative mass as far as gravitational attraction is concerned. The absolute value of mass of bubble in water is equal to the mass of an equal volume of water. So by Newton' Law of gravitation

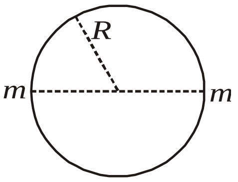
$$\vec{F} = G\frac{m_1 m_2}{r^2}\hat{r}$$

but in water $\vec{F} = \frac{G(-m_1)(-m_2)}{r^2}\hat{r} = \frac{Gm_1m_2}{r^2}\hat{r}$

It means that force has attractive nature between two air bubble in water.

**113. (b)** When gravitational force becomes zero, centripetal force on satellite becomes zero so satellite will move tangentially to the original orbit with same velocity.

**114. (a)** Here, centripetal force will be given by the gravitational force between the two particles.



$$\frac{Gm^2}{(2R)^2} = m\omega^2 R$$

$$\Rightarrow \frac{Gm}{4R^3} = \omega^2$$

$$\Rightarrow \omega = \sqrt{\frac{Gm}{4R^3}}$$

If the velocity of the two particles with respect to the centre of gravity is v then $v = \omega R$

$$v = \sqrt{\frac{Gm}{4R^3}} \times R = \sqrt{\frac{Gm}{4R}}$$

**115. (d)** Variation of g with altitude is,

$$g_h = g\left[1 - \frac{2h}{R}\right];$$

variation of g with depth is,

$$g_d = g\left[1 - \frac{d}{R}\right]$$

Equating $g_h$ and $g_d$, we get d = 2h

**116. (d)** We know that $\frac{g'}{g} = \frac{R^2}{(R+h)^2}$

$$\therefore \frac{g/9}{g} = \left[\frac{R}{R+h}\right]^2$$

$$\therefore \frac{R}{R+h} = \frac{1}{3}$$

$$\therefore h = 2R$$

**117. (a)** $g = \frac{GM}{R^2}$ also $M = d \times \frac{4}{3}\pi R^3$

$\therefore g = \frac{4}{3}d\pi R$ at the surface of planet

$$g_p = \frac{4}{3}(2d)\pi R',\ g_e = \frac{4}{3}(d)\pi R$$

$g_e = g_p \Rightarrow dR = 2d\,R'$

$\Rightarrow R' = R/2$

**118. (d)** We know that

$$g = \frac{GM}{R^2} = \frac{G\left(\frac{4}{3}\pi R^3\right)\rho}{R^2} = \frac{4}{3}\pi GR\rho$$

$$\frac{g'}{g} = \frac{R'}{R} = \frac{3R}{R} = 3 \quad \therefore g' = 3g$$

**119. (d)** $g = \frac{GM}{R^2} = \frac{G\rho \times V}{R^2} \Rightarrow g = \frac{G \times \rho \times \frac{4}{3}\pi R^3}{R^2}$

$g = \frac{4}{3}\rho\pi G.R$ where $\rho \rightarrow$ average density

$$\rho = \left(\frac{3g}{4\pi GR}\right)$$

$\Rightarrow \rho$ is directly proportional to g.

**120. (a)** The gravitational potential at the centre of uniform spherical shell is equal to the gravitational potential at the surface of shell i.e.,

$V = \frac{-GM}{a}$, where a is radius of spherical shell

Now, if the shell shrinks then its radius decrease then density increases, but mass is constant. so from above expression if a decreases, then V increases.

**121. (b)** At the equator, $g' = g - R\omega^2$

As $\omega$ increases, g' decreases and hence weight decreases.

At the pole, g' = g.

So weight remain unchanged.

**122. (d)** $g'\left(1 - \frac{d}{R}\right) = g'\left(1 - \frac{2h}{R}\right)$

$\Rightarrow \quad d = 2h \Rightarrow 10 = 2h$

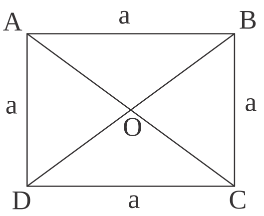
$\Rightarrow \quad h = 5\,km$

**123. (d)**

**124. (a)** $Wr = mg = GMm/R^2$; at a height h, $W_h = \frac{GMm}{(R+R)^2}$

$$= \frac{GMm}{(2R)^2} = \frac{1}{4}W_E. \quad \therefore w_h^1 = \frac{w}{4}$$

**125. (c)**



$$OA = OB = OC = OD = \frac{a\sqrt{2}}{2} = \frac{a}{\sqrt{2}}$$

Total gravitational potential at the centre of the square

$$= \frac{-Gm \times 4}{OA} = \frac{-4Gm}{a/\sqrt{2}} = \frac{-4\sqrt{2}Gm}{a}$$

**126. (a)** As we know, $g' = g\left(1-\frac{2h}{R}\right) = g\left(1-\frac{d}{R}\right)$

$\therefore \frac{2h}{R} = \frac{d}{R}$ $\quad\therefore h = \frac{d}{2}$ or $d = 2h.$

$\therefore d = 2 \times 50 = 100$ km.

**127. (c)** A comet consists of solid mass of rocks surrounded by large volume of combustible gases. The gravitational force acting between the sun and comet attracts the comet's mass, due to which head of comet points towards the sun. The radiations emitted by the sun exerts a radiation pressure on the comet throwing its tail away from the sun.

**128. (a)** Time period of satellite is given by :

$$= \frac{\text{circumference of an orbit}}{\text{Velocity in orbit}} = \frac{2\pi R}{v_0}$$

$$= \frac{2\pi R}{\sqrt{\frac{GM_m}{R}}} = \frac{2\pi R^{3/2}}{\sqrt{GM_m}}$$

Squaring both sides, we get

$$T^2 = \frac{4\pi^2 R^3}{GM_m}$$

**129. (a)** Angular momentum is conserved. At A, the moment of inertia is least and hence angular speed is maximum. Thus the K.E. at A is maximum.

**130. (c)** According to Kepler's law of period $T^2 \propto R^3$

$$\frac{T_1^2}{T_2^2} = \frac{R_1^3}{R_2^3} = \frac{(6R)^3}{(3R)^3} = 8$$

$$\frac{24 \times 24}{T_2^2} = 8$$

$$T_2^2 = \frac{24 \times 24}{8} = 72 = 36 \times 2$$

$$T_2 = 6\sqrt{2}$$

**131. (a)** Potential at the given point = Potential at the point due to the shell + Potential due to the particle

$$= -\frac{GM}{a} - \frac{2GM}{a} = -\frac{3GM}{a}$$

**132. (d)** Potential energy on earth surface is – mgR while in free space it is zero. So, to free the spaceship, minimum required energy is

$K = mgR = 10^3 \times 10 \times 6400 \times 10^3$ J

$= 6.4 \times 10^{10}$ J

**133. (a)** The velocity u should be equal to the escape velocity.

That is, $u = \sqrt{2gR}$

But $g = \frac{GM}{R^2}$

$$\therefore u = \sqrt{2 \cdot \frac{GM}{R^2} \cdot R} \Rightarrow \sqrt{\frac{2GM}{R}}$$

**134. (c)** $$\frac{(v_e)_p}{(v_e)_e} = \frac{\sqrt{\frac{2GM_p}{R_p}}}{\sqrt{\frac{2GM_e}{R_e}}} = \sqrt{\frac{M_p}{M_e} \times \frac{R_e}{R_p}}$$

$$= \sqrt{\frac{10M_e}{M_e} \times \frac{R_e}{R_e/10}} = 10$$

$\therefore (v_e)_p = 10 \times (v_e)_e = 10 \times 11 = 110$ km/s

**135. (a)** K.E. of satellite moving in an orbit around the earth is

$$K = \frac{1}{2}mv^2 = \frac{1}{2}m\left(\sqrt{\frac{GM}{r}}\right)^2 = \frac{GMm}{2r}$$

P.E. of satellite and earth system is

$$U = \frac{GMm}{r} \Rightarrow \frac{K}{U} = \frac{\frac{GMm}{2r}}{\frac{GMm}{r}} = \frac{1}{2}$$

**136. (b)** Orbital velocity of a satellite in a circular orbit of radius a is given by

$$v = \sqrt{\frac{GM}{a}} \Rightarrow v \,\alpha\, \sqrt{\frac{1}{a}} \Rightarrow \frac{v_2}{v_1} = \sqrt{\frac{a_1}{a_2}}$$

$$\therefore \quad v_2 = v_1\sqrt{\frac{4R}{R}} = 2\,v_1 = 6\text{V}$$

**137. (a)** As we know,

Gravitational potential energy $= \frac{-GMm}{r}$

and orbital velocity, $v_0 = \sqrt{GM/R+h}$

$$E_f = \frac{1}{2}mv_0^2 - \frac{GMm}{3R} = \frac{1}{2}m\frac{GM}{3R} - \frac{GMm}{3R}$$

$$= \frac{GMm}{3R}\left(\frac{1}{2}-1\right) = \frac{-GMm}{6R}$$

$$E_i = \frac{-GMm}{R} + K$$

$$E_i = E_f$$

Therefore minimum required energy, $K = \frac{5GMm}{6R}$

## CHAPTER 9

# MECHANICAL PROPERTIES OF SOLIDS

## FACT/DEFINITION TYPE QUESTIONS

**1.** The property of a body by virtue of which it tends to regain its original size and shape when the applied force is removed is called
(a) elasticity (b) plasticity
(c) rigidity (d) compressibility

**2.** Which of the following materials is most elastic?
(a) Steel (b) Rubber
(c) Copper (d) Glass

**3.** When forces are applied on a body such that it is still in static equilibrium, then the extent to which the body gets deformed, depends on
(a) nature of the material
(b) magnitude of deforming force
(c) Both (a) & (b)
(d) None of these

**4.** The restoring force per unit area is known as
(a) strain (b) elasticity
(c) stress (d) plasticity

**5.** In magnitude hydraulic stress is equal to
(a) hydraulic force (b) hydraulic pressure
(c) restoring force (d) hydraulic strain

**6.** Substances which can be stretched to cause large strains are called
(a) brittle (b) ductile
(c) plastic (d) elastomer

**7.** Shearing stress change _______ of the body.
(a) length (b) breadth
(c) shape (d) volume

**8.** The reason for the change in shape of a regular body is
(a) volume stress (b) shearing strain
(c) longitudinal strain (d) metallic strain

**9.** Shearing strain is expressed by
(a) angle of shear (b) angle of twist
(c) decrease in volume (d) increase in volume

**10.** Which of the following substance has the lowest elasticity?
(a) Steel (b) Copper
(c) Rubber (d) wood

**11.** Which of the following affects the elasticity of a substance?
(a) Hammering and annealing
(b) Change in temperature
(c) Impurity in substance
(d) All of the above

**12.** Which of the following is not a type of stress?
(a) Tensile stress (b) Compressive stsress
(c) Hydraulic stress (d) None of these

**13.** If the load is increased beyond the _______ point, the strain increases rapidly for even a small change in the stress.
(a) elastic point (b) yield point
(c) plastic point (d) fracture point

**14.** What is the phenomenon of temporary delay in regaining the original configuration by an elastic body, after the removel of a deforming force?
(a) Elastic fatigue (b) Elasticity
(c) Plasticity (d) Elastic after effect

**15.** Which of the following types of stress causes no chang in shape?
(a) Compressive stress (b) Hydraulic stress
(c) Shearing stress (d) None of these

**16.** Which of the following elastic moduli is used to describe the elastic behaviour of object as they respond to the deforming forces acting on them?
(a) Young's modulus (b) Shear modulus
(c) Bulk modulus (d) All of these

**17.** If a mass M produces an elongation of $\Delta L$ in a wire of radius r and length L, then the young's modulus of the material of the wire is given by
(a) $Y=\frac{Mg}{(\pi r^2\times\Delta L)}$ (b) $Y=\frac{Mg\times\Delta L}{(\pi r^2\times L)}$
(c) $Y=\frac{Mg\times L}{(\pi r^2\times\Delta L)}$ (d) $Y=\frac{M\times\Delta L}{(\pi r^2\times L)}$

**18.** Which is relevant only for solids?
(a) Young's modulus (b) Shear modulus
(c) Bulk modulus (d) Both (a) & (b)

**19.** When a fluid compresses an object, then the Hooke's law is expressed as
(a) $F=kV$ (b) $P=\frac{\Delta V}{V}$
(c) $P=B\left(\frac{\Delta V}{V}\right)$ (d) $F=B\left(\frac{\Delta V}{V}\right)$

**20.** Which of the following is the correct relation? Y = Young's modulus & G = modulus of rigidity?
(a) $Y < G$ (b) $Y > G$
(c) $Y = G$ (d) None of these

**21.** The expression of force constant for a spring following Hooke's law is given by

(a) $k = \frac{ya}{\ell}$ (b) $k = \frac{ya}{\Delta\ell}$

(c) $k = \frac{ya\,\Delta\ell}{\ell}$ (d) $k = \frac{ya\,\ell}{\Delta\ell}$

**22.** How is modulus of rigidity related to young's modulus?

(a) $Y = \frac{G}{3}$ (b) $G = \frac{Y}{3}$

(c) $G = Y$ (d) $G = \frac{Y}{2}$

**23.** For an equal stretching force F, the young's modulus ($Y_s$) for steel and rubber ($Y_r$) are related as

(a) $Y_s = Y_r$ (b) $Y_s < Y_r$

(c) $Y_s > Yr$ (d) $Y_s \geq Y_r$

**24.** A 2 m long rod of radius 1 cm which is fixed from one end is given a twist of 0.8 radians. The shear strain developed will be

(a) 0.002 (b) 0.004 (c) 0.008 (d) 0.016

**25.** The isothermal bulk modulus of a gas at atmospheric pressure is

(a) 1 mm of Hg (b) 13.6 mm of Hg

(c) $1.013 \times 10^5$ N/m$^2$ (d) $2.026 \times 10^5$ N/m$^2$

**26.** Hooke's law states that

(a) stress is directly proportional to strain

(b) stress is inversely proportional to strain

(c) stress is equal to strain

(d) stress and strain are independent of each other

**27.** The ratio of stress and strain is called

(a) elastic limit (b) plastic deformation

(c) modulus of elasticity (d) tensile strength

**28.** The ratio of tensile stress to the longitudinal strain is defined as

(a) modulus of elasticity (b) Yong's modulus

(c) bulk modulus (d) None of these

**29.** The correct increasing order of coefficient of elasticity of Copper, Steel, Glass and Rubber is

(a) Steel, Rubber, Copper, Glass

(b) Rubber, Copper, Glass, Steel

(c) Rubber, Glass, Steel, Copper

(d) Rubber, Glass, Copper, Steel

**30.** If the length of a wire is reduced to half, then it can hold the

(a) half load (b) same load

(c) double load (d) one fourth load

**31.** The ratio of shearing stress to the corresponding shearing strain is called

(a) bulk modulus (b) Young's modulus

(c) modulus of rigidity (d) None of these

**32.** The Young's modulus of a perfectly rigid body is

(a) unity

(b) zero

(c) infinity

(d) some finite non-zero constant

**33.** The only elastic modulus that applies to fluids is

(a) Young's modulus (b) modulus of rigidity

(c) bulk modulus (d) shear modulus

**34.** The reciprocal of the bulk modulus is called

(a) modulus of rigidity (b) volume stress

(c) volume strain (d) compressibility

**35.** Modulus of rigidity of a liquid is

(a) constant (b) infinite

(c) zero (d) cannot be predicted

**36.** According to Hook's law of elasticity, if stress is increased, then the ratio of stress to strain

(a) becomes zero (b) remains constant

(c) decreases (d) increases

## STATEMENT TYPE QUESTIONS

**37.** Which of the following statements are correct ?

I. Elastic fatigue is the property by virtue of which behavior becomes less elastic under the action of repeated alternating deforming forces.

II. Elasticity is the property due to which the body regains its original configuration, when deforming forces are removed.

III. Plasticity is the property due to which the regain in original shape is delayed after the removal of deforming forces.

(a) I and II (b) II and III

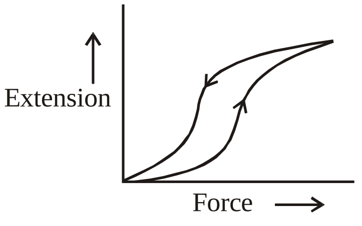
(c) I and III (d) I, II and III

**38.** The diagram shows a force - extension graph for a rubber band. Consider the following statements :

I. It will be easier to compress this rubber than expand it

II. Rubber does not return to its original length after it is stretched

III. The rubber band will get heated if it is stretched and released



Which of these can be deduced from the graph?

(a) III only (b) II and III

(c) I and III (d) I only

**39.** Which of the following statements is/are true?

I. Stress is not a vector quantity

II. Deforming force in one direction can produce strains in other directions also.

(a) I only (b) II only

(c) Both I and II (d) None of these

**40.** Which of the following is/are correct statement(s) about shearing strain?

I Shearing strain is produced by applying normal force.

II Shearing strain = tan θ

(a) I only (b) II only

(c) Both I and II (d) None of these

**41.** Consider the following statements and select the correct statements from the following.

I. A material which stretches to a lesser exent for a load is more elastic

II. A material which undergoes compression is most elastic

III. A material which stretches to greater extent is more elastic

(a) I and II (b) II and III

(c) I and III (d) I, II and III

**42.** Which of the following statements is/are true?

I. Water is more elastic than air

II. Modulus of elasticity is more for steel than that of copper.

III. Young's modulus of elasticity for a perfectly rigid body is infinte

(a) I only (b) II only

(c) I and II only (d) I, II and III

**43.** Consider the following statements and select the correct option.

I. Young's modulus for a perfectly rigid body is zero

II. Rubber is less elastic than steel

III. Bulk modulus is relevant for solids, liquids and gases

IV. The young's modulus and shear modulus are relevant for solids

(a) I only (b) II only

(c) III and IV (d) I, II, III and IV

**44.** Which of the following statements is/are wrong ?

I. Hollow shaft is much stronger than a solid rod of same length and same mass.

II. Reciprocal of bulk modulus of elasticity is called compressibility.

III. It is difficult to twist a long rod as compared to small rod.

(a) I and II (b) II and III

(c) III only (d) I only

**45.** Which of the following is/are false?

I Normal stress = force/area

II Young's modulus = $\frac{\text{force} \times \text{change in length}}{\text{area} \times \text{original length}}$

(a) I only (b) II only

(c) Both I and II (d) None of these

**46.** Select the correct statement(s) from the following.

I. Modulus of rigidity for a liquid is zero

II. Young's modulus of a material decreases with rise in temperature

III. Poisson's ratio is unitless

(a) I only (b) II only

(c) I and II (d) I, II and III

## MATCHING TYPE QUESTIONS

**47.** Match the column - I and Column - II.

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Mud | (1) | Elastic |
| (B) | Steel | (2) | Elastomer |
| (C) | Rubber | (3) | Plastic |
| (D) | Copper | (4) | Compressible |

(a) (A)→(2), (B)→(3), (C)→(4), (D)→(1)

(b) (A)→(3), (B)→(1), (C)→(2), (D)→(1)

(c) (A)→(1), (B)→(2), (C)→(3), (D)→(4)

(d) (A)→(2), (B)→ (1), (C)→(3), (D)→(4)

**48.**

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Young's modulus of elasticity | (1) | Rubber |
| (B) | Hooke's law | (2) | Solids |
| (C) | Hydraulic stress | (3) | Sraight line |
| (D) | Elastomers | (4) | Solids, liquids & gases |

(a) (A)→(2), (B)→(3), (C)→(4), (D)→(1)

(b) (A)→(4), (B)→(2), (C)→(3), (D)→(1)

(c) (A)→(1), (B)→(2), (C)→(3), (D)→(4)

(d) (A)→(2), (B)→ (1), (C)→(3), (D)→(4)

**49.**

| | **Column -I** | | **Column-II** |
|---|---|---|---|
| (A) | Equal force acting perpendicular to each point on a spherical surface | (1) | Balance the net weight to be supported |
| (B) | Cross-sectional area of the rope used in giant structures | (2) | Higher modulus of elasticity |
| (C) | Steel in structural designs | (3) | Reduction in volume without change in shape |
| (D) | Stress-strain curve | (4) | Inversely depends on the yeild strength |

(a) (A) → (4); (B) → (1, 3); (C) → (2) ; (D) → (1)

(b) (A) → (3); (B) → (1, 2); (C) → (4) ; (D) → (3, 4)

(c) (A) → (2); (B) → (1) ; (C) → (4) ; (D) → (3)

(d) (A) → (3); B → (1, 4) ; (C) → (2) ; (D) → (2)

**50.** A copper wire ($Y = 10^{11}$ N/m$^2$) of length 8 m and steel wire ($Y = 2 \times 10^{11}$ N/m$^2$) of length 4 m each of 0.5 cm$^2$ cross-section are fastened end to end and stretched with a tension of 500 N.

| | **Column-I** | | **Column-II** |
|---|---|---|---|
| (A) | Elongation in copper wire in mm | (1) | 0.25 |
| (B) | Elongation in steel wire in mm | (2) | 1.0 |
| (C) | Total elongation in mm | (3) | 0.8 |
| (D) | Elastic potential energy of the system in joules | (4) | $\frac{1}{4}$th the elongation in copper wire |

(a) (A)→(3), (B)→(4), (C)→(2), (D)→(1)

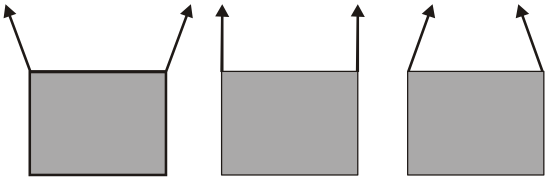
(b) (A)→(4), (B)→(2), (C)→(3), (D)→(1)

(c) (A)→(1), (B)→(2), (C)→(3), (D)→(4)

(d) (A)→(2), (B)→ (1), (C)→(3), (D)→(4)

## DIAGRAM TYPE QUESTIONS

**51.** A rectangular frame is to be suspended symmetrically by two strings of equal length on two supports . It can be done in one of the following three ways

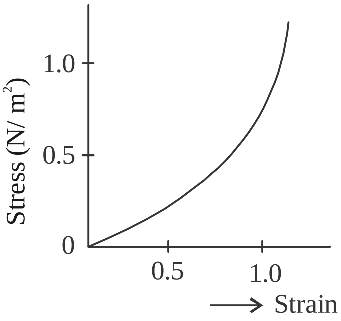


(a) (b) (c)

The tension in the strings will be

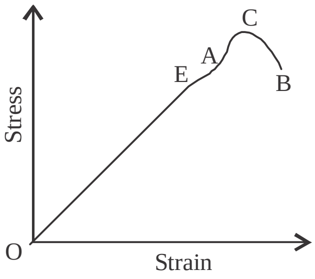
(a) the same in all cases
(b) least in (a)
(c) least in (b)
(d) least in (c)

**52.** The graph given is a stress-strain curve for



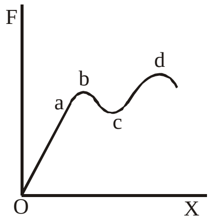
(a) elastic objects (b) plastics
(c) elastomers (d) None of these

**53.** For the given graph, Hooke's law is obeyed in the region



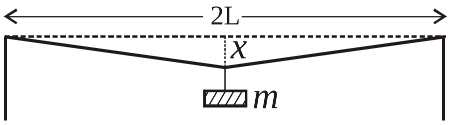
(a) OA (b) C
(c) OE (d) OB

**54.** The diagram shown below represents the applied forces per unit area with the corresponding change X (per unit length) produced in a thin wire of uniform cross section in the curve shown. The region in which the wire behaves like a liquid is



(a) ab (b) bc
(c) cd (d) Oa

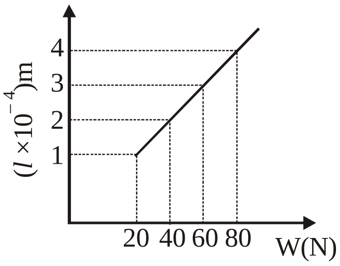
**55.** A mild steel wire of length 2L and cross-sectional area A is stretched, well within elastic limit, horizontally between two pillars. A mass m is suspended from the mid point of the wire. Strain in the wire is



(a) $\frac{x^2}{2L}$ (b) $\frac{x}{L}$

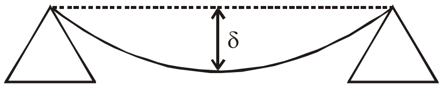
(c) $\frac{x^2}{L}$ (d) $\frac{x^2}{2L}$

**56.** The adjacent graph shows the extension ($\Delta l$) of a wire of length 1m suspended from the top of a roof at one end with a load $W$ connected to the other end. if the corss-sectional area of the wire is $10^{-6}m^2$, calculate the Young's modulus of the material of the wire



(a) $2 \times 10^{11}$ N/m$^2$ (b) $2 \times 10^{-11}$ N/m$^2$
(c) $2 \times 10^{-12}$ N/m$^2$ (d) $2 \times 10^{-13}$ N/m$^2$

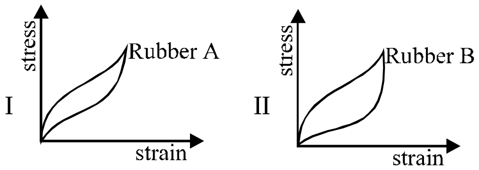
**57.** A beam of metal supported at the two edges is loaded at the centre. The depression at the centre is proportional to



(a) $Y^2$ (b) Y (c) 1/Y (d) $1/Y^2$

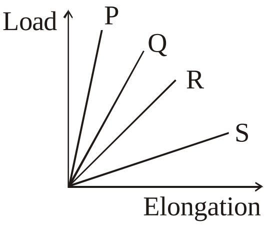
**58.** Two different types of rubber are found to have the stress-strain curve as shown :

I. To absorb vibrations one would prefer rubber A
II. For manufacturing car tyre one would prefer B



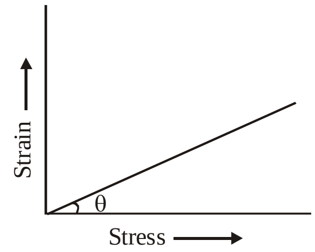
(a) I, II are true (b) I is true, II is false
(c) I is false, II is true (d) I, II are false

**59.** The load versus elongation graph for four wires is shown. The thinnest wire is



(a) *P* (b) *Q* (c) *R* (d) *S*

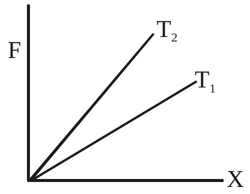
**60.** The value of tan (90° – θ) in the graph gives



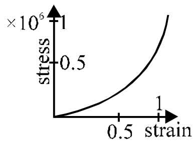
(a) Young's modulus of elasticity
(b) compressibility
(c) shear strain
(d) tensile strength

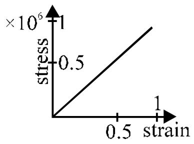
**61.** The diagram below shows the change in the length X of a thin uniform wire caused by the application of stress F at two different temperatures $T_1$ and $T_2$. The variation shown suggests that

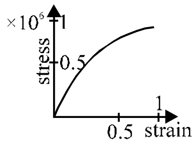
(a) $T_1 > T_2$
(b) $T_1 < T_2$
(c) $T_2 > T_1$
(d) $T_1 \geq T_2$

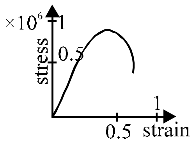


**62.** Stress vs strain curve for the elastic tissue of the aorta, the large tube (vessel) carrying blood from the heart, will be : [stress is proportional to square of the strain for the elastic tissue of the aorta]

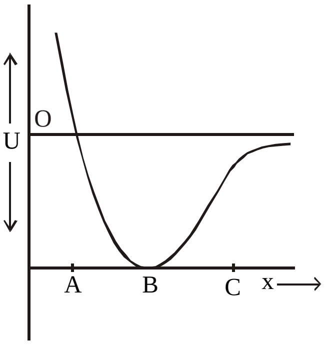
(a)


(b)


(c)


(d)


**63.** The potential energy U between two atoms in a diatomic molecules as a function of the distance x between atoms has been shown in the figure. The atoms are



(a) attracted when x lies between A and B and are repelled when x lies between B and C
(b) attracted when x lies between B and C and are repelled when x lies between A and B
(c) are attracted when they reach B from C
(d) are repelled when they reach B from A

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

**64.** **Assertion:** Solids are least compressible and gases are most compressible.
**Reason:** solids have definite shape and volume but gases do not have either definite shape or definite volume.

**65.** **Assertion:** Rubber is more elastic than lead
**Reason:** If same load is attached to lead and rubber, then the strain produced is much less in rubber than in lead.

**66.** **Assertion:** Hollow shaft is found to be stronger than a solid shaft made of same equal material.
**Reason:** Torque required to produce a given twist in hollow cylinder is greater than that required to twist a solid cylinder of same length and material.

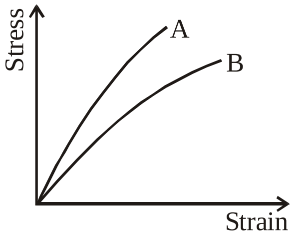
**67.** **Assertion :** Bulk modulus of elasticity (k) represents incompressibility of the material.
**Reason :** Bulk modulus of elasticity is proportional to change in pressure.

**68.** **Assertion :** Stress is the internal force per unit area of a body.
**Reason :** Rubber is less elastic than steel.

**69.** **Assertion :** Young's modulus for a perfectly plastic body is zero.
**Reason :** For a perfectly plastic body, restoring force is zero.

**70.** **Assertion :** Identical springs of steel and copper are equally stretched. More work will be done on the steel spring
**Reason :** Steel is more elastic than copper.

**71.** **Assertion :** The stress-strain graphs are shown in the figure for two materials A and B are shown in figure. Young's modulus of A is greater than that of B.



**Reason :** The Young's modules for small strain is,

$$Y = \frac{\text{stress}}{\text{strain}} = \text{slope of linear portion, of graph; and slope of}$$

A is more than slope that of B.

**72.** **Assertion :** Strain causes the stress in an elastic body.
**Reason :** An elastic rubber is more plastic in nature.

**73.** **Assertion:** Girders are given I shape.
**Reason:** To bear more pressure, depth is increased as per P = hρg

## CRITICALTHINKING TYPE QUESTIONS

**74.** If the ratio of radii of two wires of same material is 2 : 1 and ratio of their lengths is 4 : 1, then the ratio of the normal forces that will produce the same extension in the length of two wires is
(a) 2 : 1 (b) 4 : 1
(c) 1 : 4 (d) 1 : 1

**75.** A and B are two wires. The radius of A is twice that of B. They are stretched by the same load. Then the stress on B is
(a) equal to that on A (b) four times that on A
(c) twice that on A (d) half that on A

**76.** An iron bar of length $\ell$ cm and cross section A $cm^2$ is pulled by a force of F dynes from ends so as to produce an elongation $\Delta\ell$ cm. Which of the following statement is correct ?
(a) Elongation is inversely proportional to length
(b) Elongation is directly proportional to cross section A
(c) Elongation is inversely proportional to cross-section
(d) Elongation is directly proportional to Young's modulus

**77.** Two wires of equal lengths are made of the same material. Wire A has a diameter that is twice as that of wire B. If identical weights are suspended from the ends of these wires, the increase in length is
(a) four times for wire A as for wire B
(b) twice for wire A as for wire B
(c) half for wire A as for wire B
(d) one-fourth for wire A as for wire B

**78.** A steel ring of radius *r* and cross-section area 'A' is fitted on to a wooden disc of radius R(R > r). If Young's modulus be E, then the force with which the steel ring is expanded is
(a) $AE\frac{R}{r}$ (b) $AE\left(\frac{R-r}{r}\right)$
(c) $\frac{E}{A}\left(\frac{R-r}{A}\right)$ (d) $\frac{Er}{AR}$

**79.** If a spring extends by x on loading, then the energy stored by the spring is (if *T* is tension in the spring and *k* is spring constant)
(a) $\frac{T^2}{2x}$ (b) $\frac{T^2}{2k}$ (c) $\frac{2x}{T^2}$ (d) $\frac{2T^2}{k}$

**80.** A steel wire of length 'L' at 40°C is suspended from the ceiling and then a mass 'm' is hung from its free end. The wire is cooled down from 40°C to 30°C to regain its original length 'L'. The coefficient of linear thermal expansion of the steel is $10^{-5}$/° C, Young's modulus of steel is $10^{11}$ N/$m^2$ and radius of the wire is 1 mm. Assume that L >>diameter of the wire. Then the value of 'm' in kg is nearly
(a) 1 (b) 2 (c) 3 (d) 5

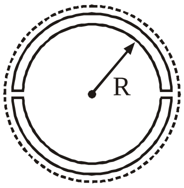
**81.** When a pressure of 100 atmosphere is applied on a spherical ball, then its volume reduces to 0.01%. The bulk modulus of the material of the rubber in dyne/$cm^2$ is
(a) $10 \times 10^{12}$ (b) $100 \times 10^{12}$
(c) $1 \times 10^{12}$ (d) $10 \times 10^{12}$

**82.** From a steel wire of density ρ is suspended a brass block of density $\rho_b$. The extension of steel wire comes to e. If the brass block is now fully immersed in a liquid of density $\rho_l$, the extension becomes e'. The ratio $\frac{e}{e'}$ will be
(a) $\frac{\rho_b}{\rho_b-\rho_l}$ (b) $\frac{\rho_b-\rho_l}{\rho_b}$
(c) $\frac{\rho_b-\rho}{\rho_l-\rho}$ (d) $\frac{\rho_l}{\rho_b-\rho_l}$

**83.** An iron rod of length 2m and cross-sectional area of 50 $mm^2$ stretched by 0.5 mm, when a mass of 250 kg is hung from its lower end. Young's modulus of iron rod is
(a) $19.6\times10^{20}\ N/m^2$ (b) $19.6\times10^{18}\ N/m^2$
(c) $19.6\times10^{10}\ N/m^2$ (d) $19.6\times10^{15}\ N/m^2$

**84.** What per cent of length of wire increases by applying a stress of 1 kg weight/$mm^2$ on it?
(Y = 1 × $10^{11}$ N/$m^2$ and 1 kg weight = 9.8 newton)
(a) 0.0067% (b) 0.0098%
(c) 0.0088% (d) 0.0078%

**85.** A wooden wheel of radius *R* is made of two semicircular parts (see figure). The two parts are held together by a ring made of a metal strip of cross-sectional area *S* and length *L*. *L* is slightly less than 2π*R*. To fit the ring on the wheel, it is heated so that its temperature rises by Δ*T* and it just steps over the wheel. As it cools down to surrounding temperature, it presses the semicircular parts together. If the coefficient of linear expansion of the metal is α and its Young's modulus is *Y*, the force that one part of the wheel applies on the other part is



(a) $2\pi SY\alpha\Delta T$ (b) $SY\alpha\Delta T$
(c) $\pi SY\alpha\Delta T$ (d) $2SY\alpha\Delta T$

**86.** The extension in a string obeying Hooke's law is *x*. The speed of sound in the stretched string is *v*. If the extension in the string is increased to 1.5 *x*, the speed of sound will be
(a) 1.22 *v* (b) 0.61 *v* (c) 1.50 *v* (d) 0.75 *v*

**87.** An elevator cable is to have a maximum stress of 7 x $10^7$ N/$m^2$ to allow for appropriate safety factors. Its maximum upward acceleratiom is 1.5 m/$s^2$. If the cable has to support the total weight of 2000 kg of a loaded elevator, the area of cross–section of the cable should be
(a) 3.28 $cm^2$ (b) 2.38 $cm^2$
(c) 0.328 $cm^2$ (d) 8.23 $cm^2$

**88.** A steel wire is suspended vertically from a rigid support. When loaded with a weight in air, it extends by $\ell_a$ and when the weight is immersed completely in water, the extension is reduced to $\ell_w$. Then the relative density of material of the weight is

(a) $\ell_a / \ell_w$ (b) $\dfrac{\ell_a}{\ell_a - \ell_w}$

(c) $\ell_w / (\ell_a - \ell_w)$ (d) $\ell_w / \ell_a$

**89.** If a rubber ball is taken at the depth of 200 m in a pool, its volume decreases by 0.1%. If the density of the water is $1 \times 10^3$ kg/m$^3$ and g = 10m/s$^2$, then the volume elasticity in *N/m*$^2$ will be

(a) $10^8$ (b) $2 \times 10^8$
(c) $10^9$ (d) $2 \times 10^9$

**90.** A uniform cube is subjected to volume compression. If each side is decreased by 1%, then bulk strain is

(a) 0.01 (b) 0.06
(c) 0.02 (d) 0.03

**91.** To break a wire, a force of $10^6$ N/m$^2$ is required. If the density of the material is $3 \times 10^3$ kg/m$^3$, then the length of the wire which will break by its own weight will be

(a) 34m (b) 30m
(c) 300m (d) 3m

**92.** When a 4 kg mass is hung vertically on a light spring that obeys Hooke's law, the spring stretches by 2 cms. The work required to be done by an external agent in stretching this spring by 5 cms will be (g = 9.8 m/sec$^2$)

(a) 4.900 joule (b) 2.450 joule
(c) 0.495 joule (d) 0.245 joule

**93.** A rubber cord catapult has cross-sectional area 25 mm$^2$ and initial length of rubber cord is 10 cm. It is stretched to 5 cm and then released to project a missile of mass 5 gm. Taking $Y_{\text{rubber}} = 5 \times 10^8$ N/m$^2$. Velocity of projected missile is

(a) 20 ms$^{-1}$ (b) 100 ms$^{-1}$
(c) 250 ms$^{-1}$ (d) 200 ms$^{-1}$

**94.** The Young's modulus of steel is twice that of brass. Two wires of same length and of same area of cross section, one of steel and another of brass are suspended from the same roof. If we want the lower ends of the wires to be at the same level, then the weights added to the steel and brass wires must be in the ratio of :

(a) 2 : 1 (b) 4 : 1
(c) 1 : 1 (d) 1 : 2

**95.** Copper of fixed volume 'V; is drawn into wire of length '*l*'. When this wire is subjected to a constant force 'F', the extension produced in the wire is '$\Delta l$'. Which of the following graphs is a straight line?

(a) $\Delta l$ versus $\dfrac{1}{l}$ (b) $\Delta l$ versus $l^2$

(c) $\Delta l$ versus $\dfrac{1}{l^2}$ (d) $\Delta l$ versus $l$

**96.** The approximate depth of an ocean is 2700 m. The compressibility of water is $45.4 \times 10^{-11}$ Pa$^{-1}$ and density of water is $10^3$ kg/m$^3$.What fractional compression of water will be obtained at the bottom of the ocean ?

(a) $1.0 \times 10^{-2}$ (b) $1.2 \times 10^{-2}$
(c) $1.4 \times 10^{-2}$ (d) $0.8 \times 10^{-2}$

**97.** Consider four steel wires of dimensions given below (*d* = diameter and *l* = length) :

(a) *l* = 1m, *d* = 1mm (b) *l* = 2m, *d* = 2 mm
(c) *l* = 2m, *d* = 1mm (d) *l* = 1m, *d* = 2 mm

If same force is applied to all the wires then the elastic potential energy stored will be maximum in wire :

(a) A (b) B
(c) C (d) D

**98.** If in a wire of Young's modulus *Y*, longitudinal strain *X* is produced, then the value of potential energy stored in its unit volume will be

(a) $YX^2$ (b) $2YX^2$
(c) $Y^2X/2$ (d) $YX^2/2$

**99.** A steel ring of radius *r* and cross sectional area A is fitted onto a wooden disc of radius *R* (*R* > *r*). If the Young's modulus of steel is *Y*, then the force with which the steel ring is expanded is

(a) $AY(R/r)$ (b) $AY(R-r)/r$
(c) $(Y/A)[(R-r)/r]$ (d) $Yr/AR$

**100.** For the same cross-sectional area and for a given load, the ratio of depressions for the beam of a square cross-section and circular cross-section is

(a) $3 : \pi$ (b) $\pi : 3$
(c) $1 : \pi$ (d) $\pi : 1$

**101.** The length of a metal is $\ell_1$ when the tension in it is $T_1$ and is $\ell_2$ when the tension is $T_2$. The original length of the wire is

(a) $\dfrac{\ell_1 + \ell_2}{2}$ (b) $\dfrac{\ell_1 T_2 + \ell_2 T_1}{T_1 + T_2}$

(c) $\dfrac{\ell_1 T_2 - \ell_2 T_1}{T_2 - T_1}$ (d) $\sqrt{T_1 T_2 \ell_1 \ell_2}$

**102.** A wire elongates by *l* mm when a load W is hanged from it. If the wire goes over a pulley and two weights W each are hung at the two ends, the elongation of the wire will be (in mm)

(a) *l* (b) 2*l*
(c) zero (d) *l*/2

**103.** A thick rope of density ρ and length *L* is hung from a rigid support. The Young's modulus of the material of rope is *Y*. The increase in length of the rope due to its own weight is

(a) $(1/4)\,\rho g L^2/Y$ (b) $(1/2)\,\rho g L^2/Y$
(c) $\rho g L^2/Y$ (d) $\rho g L/Y$

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

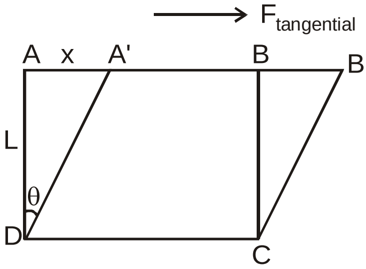
**1.** **(a)**

**2.** **(a)** Young's modulus of elasticity is highest for steel and Greater the young's modulus larger is its elasticity.

**3.** **(c)** The deformation of a body on application of a force depends on the nature of the material and the magnitude of the applied force.

**4.** **(c)** **5.** **(b)** **6.** **(d)** **7.** **(c)** **8.** **(b)**

**9.** **(a)** $\tan\theta = \frac{x}{L}$ = angle of shear = shearing strain



ABCD is the shape of body, before we apply tangential force and A′B′CD is the shape of body after applying tangential force.

**10.** **(a)**

**11.** **(d)** The hammering increases elasticity while annealing decreases it. The increase in temperature increases the elasticity while decrease in temperature decreases it. The impurity in the substance increases the elasticity.

**12.** **(d)** A cylinder stretched by two equal forces applied normal to its cross-sectional area, it experiences tensile stress; & if cylinder is compressed under the action of applied forces, the restoring force per unit area is known as compressive stress.

A body immersed in a fluid develops restoring force equal & opposite to the forces applied by fluid. This restoring force per unit area is hydraulic stress.

**13.** **(b)** Yield point is the point, beyond which the wire starts showing increase in strain without any increase in stress.

**14.** **(d)** Elastic after effect is defined as the temporary delay in regaining the original configuration by an elastic body after the removal of a deforming force.

**15.** **(b)** Hydraulic stress is relevant to volumetric strain, ΔV/V, but there is no change in shape.

**16.** **(d)** The three elastic moduli viz young's modulus, shear modulus and bulk modulus are used to describe the elastic behavior of objects as they respond to deforming forces acting on them.

**17.** **(c)** Young's modulus $= \frac{\text{normal stress}}{\text{longitudinal strain}} = \frac{F/A}{\Delta L/L}$

$$= \frac{F\times L}{A\times\Delta L} = \frac{Mg\times L}{\pi r^2\times\Delta L}$$

**18.** **(d)** Young's modulus $= \frac{\text{normal stress}}{\text{longitudinal stran}}$

Shear modulus $= \frac{\text{Tangential stress}}{\text{Shearing strain}}$

Longitudinal & shearing strains are possible only in solids.

**19.** **(c)** When an object undergoes hydraulic compression due to a stress exerted by a surrounding liquid the Hooke's law takes the form P = B (Δv/v)

**20.** **(b)** Young's modulus Y = 2G(1 – σ)
G = modulus of rigidity and σ = poissons's ratio

**21.** **(a)** $Y = \frac{F}{A}.\frac{\ell}{\Delta\ell}$ or $\frac{F}{\Delta L} = \frac{YA}{\ell}$

Hence force constant $= \frac{F}{\Delta\ell} = \frac{YA}{\ell}$

**22.** **(b)** Modulus of rigidity is, generally less than that of young's modulus of a solid. For most of the solids, value of shear modulus is one-third of the young's modulus i.e.
G = Y/3.

**23.** **(c)** Young's modulus of steel is highest.

**24.** **(b)** $r\theta = L\phi \Rightarrow 10^{-2}\times 0.8 = 2\times\phi \Rightarrow \phi = 0.004$

**25.** **(c)** Isothermal elasticity $K_1 = P = 1\text{atm} = 1.013\times 10^5\ \text{N/m}^2$

**26.** **(a)** **27.** **(c)** **28.** **(b)**

**29.** **(d)** Elasticity is maximum for steel and minimum for rubber.

**30.** **(b)** **31.** **(c)**

**32.** **(c)** For a perfectly rigid body strain produced is zero for the given force applied, so
Y = stress/strain = ∞

**33.** **(c)** Bulk modulus = change in volume

**34.** **(d)** Compressibility $= \frac{1}{\text{Bulk modulus}}$

**35.** **(c)**

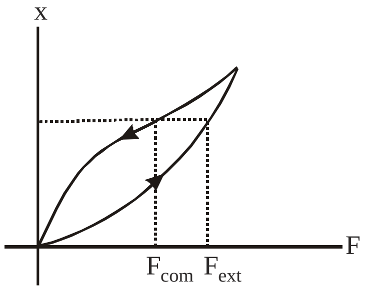
**36.** **(b)** The ratio of stress to strain is always constant. If stress is increased, strain will also increase so that their ratio remains constant.

## STATEMENT TYPE QUESTIONS

**37.** **(d)**

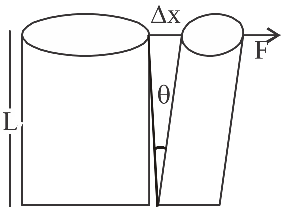
**38.** **(c)** From the figure, it is clear that

$F_{com} < F_{ext.}$



**39.** **(c)**

**40.** **(b)** Shearing strain = $\frac{\Delta x}{L} = \tan\theta$.



**41.** **(a)** A material for which strain is less for a given load is more elastic.

**42.** **(d)** **43.** **(b)** **44.** **(c)**

**45.** **(b)** Young's modulus Y = $\frac{\text{normal stress}}{\text{longitudinal strain}}$

$$= \frac{\frac{\text{force}}{\text{area}}}{\frac{\text{chage in length}}{\text{original length}}} = \frac{\text{Force} \times \text{original length}}{\text{Area} \times \text{change in length}}$$

**46.** **(d)**

## MATCHING TYPE QUESTIONS

**47.** **(b)** (A)→(3), (B)→(1), (C)→(2), (D)→(1)

Mud is a completely plastic material.

Steel is perfect elastic.

Rubber is elastomer.

Copper is elastic.

**48.** **(a)** Young's modulus of elasticity exists only for solids. Hooke's law refers to a straight line on stress strain curve.

Hydraulic stress exists for all the three states, rubber is an elastomer.

**49.** **(d)** (A) → (3); B → (1, 4) ; (C) → (2) ; (D) → (2)

**50.** **(a)** (A)→(3), (B)→(4), (C)→(2), (D)→(1)

(A) $\Delta\ell_{copper} = \frac{F\ell}{AY} = \frac{500 \times 8}{0.5 \times 10^{-4} \times 10^{11}} = 0.8$ mm

(B) $\Delta\ell_{steel} = \frac{F\ell}{AY} = \frac{500 \times 4}{0.5 \times 10^{-4} \times 2 \times 10^{11}} = 0.2$ mm

(C) $\Delta\ell = \Delta\ell_{copper} + \Delta\ell_{steel} = 1.0$ mm

(D) $U = \left[\frac{e^2 Y_{copper}}{2} + \frac{e^2 Y_{steel}}{2}\right] \times \text{Vol} = 0.25$ J

## DIAGRAM TYPE QUESTIONS

**51.** **(c)**

**52.** **(c)** The given graph does not obey Hooke's law. and there is no well defined plastic region. So the graph represents elastomers.

**53.** **(c)** Since OE is a straight line so, stress $\propto$ strain.

$\therefore$ Hooke's law is obeyed in the region OE of the graph.

**54.** **(b)** The wire starts behaving like a liquid at point b. It behaves like a viscous liquid in the region bc of the graph.

**55.** **(a)**

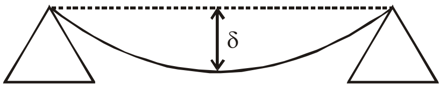
**56.** **(a)** From the graph $l = 10^{-4}$m, $F = 20$ N

$A = 10^{-6}\text{m}^2, L = 1\text{m}$

$$\therefore \; Y = \frac{FL}{Al} = \frac{20 \times 1}{10^{-6} \times 10^{-4}}$$

$$= 20 \times 10^{10} = 2 \times 10^{11} \text{N/m}^2$$

**57.** **(c)**



For a beam, the depression at the centre is given by,

$$\delta = \left(\frac{f\,L}{4Ybd^3}\right)$$

[f, L, b, d are constants for a particular beam]

i.e. $\delta \propto \frac{1}{Y}$

**58.** **(d)**

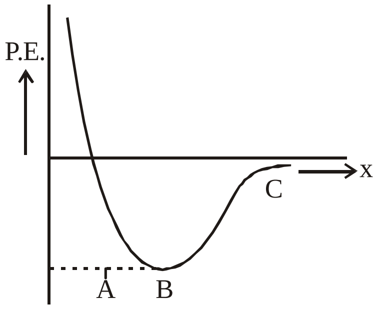
**59.** **(b)**

**60.** **(a)** $\tan(90° - \theta) = \frac{\text{stress}}{\text{strain}}$

**61.** **(a)** When same stress is applied at two different temperatures, the increase in length is more at higher temperature. Thus $T_1 > T_2$.

**62.** **(a)** As stress $\propto$ strain$^2$ hence graph (a) correctly dipicts.

**63.** **(b)** The atoms when brought from infinity are attracted due to interatomic electrostatic force of attraction. At point B, the potential energy is minimum and force of attraction is maximum. But if we bring atoms closer than x = B, force of repulsion between two nucleii starts and P.E. increases.



## ASSERTION- REASON TYPE QUESTIONS

**64.** **(b)** The incompressibility of solids is primarily due to the tight coupling between the neighbouring atoms. Molecules in gases are very poorly coupled to their neighbours.

**65.** **(d)** Lead is more elastic than rubber because for same load strain produced is much less in lead than rubber.

**66.** **(a)** Torque required to produce a given twist in hollow cylinder is greater than solid cylinder thus both are true.

**67.** **(a)**

**68.** **(b)** Stress is defined as internal force (restoring force) per unit area of a body. Also, rubber is less elastic than steel, because restoring force is less for rubber than steel.

**69.** **(a)** Young's modulus of a material, $Y = \frac{\text{stress}}{\text{strain}}$

Here, stress $= \frac{\text{restoring force}}{\text{area}}$

As restoring force is zero $\therefore$ $Y = 0$.

**70.** **(a)** Work done $= \frac{1}{2} \times \text{Stress} \times \text{Strain} = \frac{1}{2} \times Y \times (\text{Strain})^2$.
Since, elasticity of steel is more than copper, hence more work has to be done in order to stretch the steel.

**71.** **(d)** **72.** **(a)**

**73.** **(b)** The most effective method to reduce depression in a beam of given length & material is to make depth of the beam large as compared to its breadth. But on increasing the depth too much, the beam bends. To check this buckling, a compromise between breadth & depth of a beam is made by using I-shaped girder.

## CRITICALTHINKING TYPE QUESTIONS

**74.** **(d)** $\mathrm{Y} = \frac{\mathrm{F}\ell}{\mathrm{A}\Delta\ell}; \Rightarrow \quad \mathrm{F} = \frac{\mathrm{YA}\Delta\ell}{\ell}$

$$\frac{\mathrm{F}_1}{\mathrm{F}_2} = \frac{\mathrm{A}_1}{\mathrm{A}_2} \times \frac{\mathrm{l}_2}{\mathrm{l}_1} = \frac{\mathrm{r}_1^2}{\mathrm{r}_2^2} \times \frac{\mathrm{l}_2}{\mathrm{l}_1} = \frac{4}{1} \times \frac{1}{4} = 1:1.$$

**75.** **(b)** $\text{Stress} = \frac{\mathrm{F}}{\mathrm{A}} = \frac{\mathrm{F}}{\pi \mathrm{r}^2}$

**76.** **(c)** According to Hooke's law

Stress $\propto$ strain i.e., $\frac{\mathrm{F}}{\mathrm{A}} \propto \frac{\Delta l}{l}$

$\Rightarrow$ For same F & $l$, $\Delta l \propto \frac{1}{\mathrm{A}}$

**77.** **(d)** $l = \frac{FL}{AY} \Rightarrow l \propto \frac{1}{r^2}$ (F, L and Y are same)

$$\frac{l_A}{l_B} = \left(\frac{r_B}{r_A}\right)^2 = \left(\frac{r_B}{2r_B}\right)^2 = \frac{1}{4} \Rightarrow l_A = 4l_B$$

or $l_B = \frac{l_A}{4}$

**78.** **(b)** Initial length (circumference) of the ring = $2\pi r$
Final length (circumference) of the ring = $2\pi R$
Change in length = $2\pi R - 2\pi r$

$$\text{strain} = \frac{\text{change in length}}{\text{original length}} = \frac{2\pi(R-r)}{2\pi r} = \frac{R-r}{r}$$

Now Young's modulus $E = \frac{F/A}{l/L} = \frac{F/A}{(R-r)/r}$

$$\therefore \ F = AE\left(\frac{R-r}{r}\right)$$

**79.** **(b)** $U = \frac{F^2}{2K} = \frac{T^2}{2K}$

**80.** **(c)** We know that

$$Y = \frac{mg/A}{\Delta\ell/\ell} = \frac{mg\ell}{A\Delta\ell} \qquad \text{....(1)}$$

Also $\Delta\ell = \ell \, \alpha \, \Delta T$ ...(2)

From (1) and (2)

$$Y = \frac{mg\ell}{A\ell\,\alpha\,\Delta T} = \frac{mg}{A\,\alpha\,\Delta T}$$

$$\therefore \ m = \frac{YA\,\alpha\,\Delta T}{g} = \frac{10^{11} \times \pi(10^{-3})^2 \times 10^{-5} \times 10}{10} = \pi \approx 3$$

**81.** **(c)** Bulk modulus $K = \frac{P}{\frac{\Delta V}{V}} = \frac{100}{0.01/100} = 10^6$ atm

$= 10^{11}$ N/m$^2$ = $10^{12}$ dyne/cm$^2$

**82.** **(a)** Weights without and with liquid proportional to $\rho_b$ and $\rho_b - \rho_l$.

**83.** **(c)** $$\mathrm{Y} = \frac{\mathrm{F}/\mathrm{A}}{\Delta\ell/\ell} = \frac{\frac{250 \times 9.8}{50 \times 10^{-6}}}{\frac{0.5 \times 10^{-3}}{2}}$$

$$= \frac{250 \times 9.8}{50 \times 10^{-6}} \times \frac{2}{0.5 \times 10^{-3}} \Rightarrow 19.6 \times 10^{10}\ \mathrm{N/m^2}$$

**84.** **(b)** Stress $= 1$ kg wt/mm$^2$ $= 9.8$ N/mm$^2$

$= 9.8 \times 10^6$ N/m$^2$.

$$Y = 1\times10^{11}\,\text{N}/\text{m}^2, \quad \frac{\Delta\ell}{\ell}\times100 = ?$$

$$Y = \frac{\text{Stress}}{\text{Strain}} = \frac{\text{Stress}}{\Delta\ell/\ell}$$

$$\therefore \frac{\Delta\ell}{\ell} = \frac{\text{Stress}}{\text{Y}} = \frac{9.8\times10^6}{1\times10^{11}}$$

$$\frac{\Delta\ell}{\ell}\times100 = 9.8\times10^{-11}\times100\times10^6$$

$= 9.8 \times 10^{-3} = 0.0098$ %

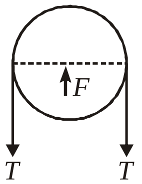
**85.** **(d)** Elongation due to change in temperature,

$\Delta l = L\alpha\Delta T$

Which is compensated by elastic strain,
When temperature becomes normal, i.e.,

$$\Delta l = \frac{TL}{YS}$$

Thus, $\frac{TL}{YS} = L\alpha\Delta T$



$\Rightarrow T = VS\alpha\Delta T$

At equilibrium force exerted by one half on other,

$F = 2T = 2YS\alpha\Delta T$

**86.** **(a)** Speed of sound in a stretched string $v = \sqrt{\frac{T}{\mu}}$ …(i)

Where T is the tension in the string and $\mu$ is mass per unit length.

According to Hooke's law, $F \propto x \ \therefore\ T \propto x$ …(ii)

From (i) and (ii), $v \propto \sqrt{x} \ \therefore\ v' = \sqrt{1.5}\ v = 1.22v$

**87.** **(a)** Given, the breaking strength of cable $f_u = 7\times10^7$ N/m$^2$

The force carried by the cable,

$$F = m(g+a)$$
$$= 2000(9.8+1.5) = 22600\text{ N}$$

The area of cross-section, $A = \frac{F}{f_u} = \frac{22600}{7\times10^7}$

$= 3.28\times10^{-4}$ m$^2$.

**88.** **(b)** Let V be the volume of the load and $\rho$ its relative density

So, $Y = \frac{F L}{A\,\ell_a} = \frac{V\rho g L}{A\,\ell_a}$ .....(1)

When the load is immersed in the liquid, then

$Y = \frac{F' L}{A\,\ell_w} = \frac{(V\rho g - V\times1\times g)L}{A\,\ell_w}$ ....(2)

($\because$ Now net weight = weight – upthrust)

From eqs. (1) and (2), we get

$$\frac{\rho}{\ell_a} = \frac{(\rho-1)}{\ell_w} \text{ or } \rho = \frac{\ell_a}{(\ell_a - \ell_w)}$$

**89.** **(d)** $K = \frac{\Delta P}{\Delta V/V} = \frac{h\rho g}{\Delta V/V} = \frac{200\times10^3\times10}{0.1/100} = 2\times10^9$

**90.** **(d)** If side of the cube is L. then $V = L^3 \Rightarrow \frac{dV}{V} = 3\frac{dL}{L}$

$\therefore$ % change in volume = 3 × (% change in length)

= 3 × 1% = 3%

$\therefore$ Bulk strain $\frac{\Delta V}{V} = 0.03$

**91.** **(a)** $L = \frac{S}{dg} = \frac{10^6}{3\times10^3\times10} = \frac{100}{3} = 34\,m$

**92.** **(b)** $K = \frac{F}{x} = \frac{4\times9.8}{2\times10^{-2}} = 19.6\times10^2$

Work done $= \frac{1}{2}19.6\times10^2\times(0.05)^2 = 2.45\,J$

**93.** **(c)** Young's modulus of rubber, $Y_{\text{rubber}}$

$$= \frac{F}{A}\times\frac{\ell}{\Delta\ell} \Rightarrow F = YA.\frac{\Delta\ell}{\ell}$$

On putting the values from question,

$$F = \frac{5\times10^8\times25\times10^{-6}\times5\times10^{-2}}{10\times10^{-2}}$$

$= 25\times25\times10^{2-1} = 6250$N

kinetic energy = potential energy of rubber

$$\frac{1}{2}mv^2 = \frac{1}{2}F\Delta\ell$$

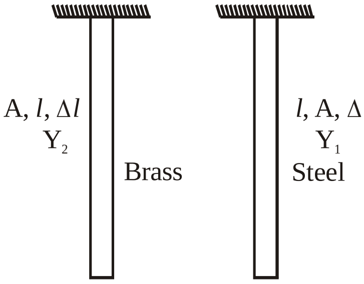
$$v = \sqrt{\frac{F\Delta\ell}{m}} = \sqrt{\frac{6250\times5\times10^{-2}}{5\times10^{-3}}} = \sqrt{62500}$$

= 25 × 10 = 250 m/s

**94.** **(a)** Young's modulus $Y = \frac{W}{A}.\frac{l}{\Delta l}$

$$\frac{W_1}{Y_1} = \frac{W_2}{Y_2}$$

[$\because$ A, $l$, $\Delta l$ same for both brass and steel]



$\frac{W_1}{W_2} = \frac{Y_1}{Y_2} = 2$ [$Y_{\text{steel}}/Y_{\text{brass}} = 2$ given]

**95.** **(b)** As $\mathrm{Y}=\frac{\frac{\mathrm{F}}{\mathrm{A}}}{\frac{\Delta l}{l}} \Rightarrow \Delta l=\frac{\mathrm{F}l}{\mathrm{AY}}$

But $\mathrm{V}=\mathrm{A}l$ so $\mathrm{A}=\frac{\mathrm{V}}{l}$

Therefore $\Delta l=\frac{\mathrm{F}l^2}{\mathrm{VY}} \propto l^2$

Hence graph of $\Delta l$ versus $l^2$ will give a straight line.

**96.** **(b)** Compressibility of water,
$\mathrm{K} = 45.4 \times 10^{-11}\ \mathrm{Pa}^{-1}$
density of water $\mathrm{P} = 10^3\ \mathrm{kg/m^3}$
depth of ocean, h = 2700 m

We have to find $\frac{\Delta \mathrm{V}}{\mathrm{V}}=?$

As we know, compressibility,

$\mathrm{K}=\frac{1}{\mathrm{B}}=\frac{(\Delta \mathrm{V}/\mathrm{V})}{\mathrm{P}}\ (\mathrm{P}=\mathrm{Pgh})$

So, $(\Delta\mathrm{V}/\mathrm{V}) = \mathrm{KPgh}$
$= 45.4 \times 10^{-11} \times 10^3 \times 10 \times 2700 = 1.2258 \times 10^{-2}$

**97.** **(c)** We have, $U=\frac{F^2}{2k}$

where $k=\frac{Yl}{A}=\frac{Yl}{\frac{1}{4}\pi d^2}$

$\therefore\ U \propto \frac{d^2}{l}$

**98.** **(d)** $\text{P.E.}=\frac{1}{2}\times \text{stress} \times \text{strain} \times \text{volume}$

or $(\text{P.E./volume})=\frac{1}{2}\times(Y\times\text{strain})\ (\text{strain})$

$=\frac{1}{2}Y(\text{strain})^2=\frac{1}{2}YX^2$

**99.** **(b)** Let $T$ be the tension in the ring, then

$$Y=\frac{T.2\pi r}{A.2\pi(R-r)}=\frac{Tr}{A(R-r)}$$

$$\therefore\ T=\frac{YA(R-r)}{r}$$

**100.** **(a)** $\delta=\frac{W\ell^3}{3YI}$, where $W$ = load, $\ell$ = length of beam and $I$ is geometrical moment of inertia for rectangular beam,

$I=\frac{bd^3}{12}$ where $b$ = breadth and $d$ = depth

For square beam $b = d$

$\therefore\ I_1=\frac{b^4}{12}$

For a beam of circular cross-section, $I_2=\left(\frac{\pi r^4}{4}\right)$

$\therefore\ \delta_1=\frac{W\ell^3\times 12}{3Yb^4}=\frac{4W\ell^3}{Yb^4}$

(for sq. cross section)

and $\delta_2=\frac{W\ell^3}{3Y(\pi r^4/4)}=\frac{4W\ell^3}{3Y(\pi r^4)}$

(for circular cross-section)

Now $\frac{\delta_1}{\delta_2}=\frac{3\pi r^4}{b^4}=\frac{3\pi r^4}{(\pi r^2)^2}=\frac{3}{\pi}$

$(\because b^2=\pi r^2$ i.e., they have same cross-sectional area)

**101.** **(c)** If $\ell$ is the original length of wire, then change in length of first wire,

$\Delta\ell_1=(\ell_1-\ell)$

Change in length of second wire,

$\Delta\ell_2=(\ell_2-\ell)$

Now, $Y=\frac{T_1}{A}\times\frac{\ell}{\Delta\ell_1}=\frac{T_2}{A}\times\frac{\ell}{\Delta\ell_2}$

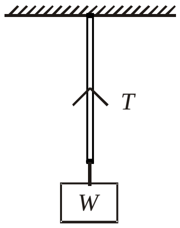
or $\frac{T_1}{\Delta\ell_1}=\frac{T_2}{\Delta\ell_2}$ or $\frac{T_1}{\ell_1-\ell}=\frac{T_2}{\ell_2-\ell}$

or $T_1\ell_2-T_1\ell=T_2\ell_1-\ell T_2$

or $\ell=\frac{T_2\ell_1-T_1\ell_2}{T_2-T_1}$

**102.** **(a)** Case (i)
At equilibrium, $T = W$

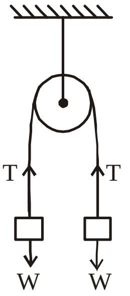
$Y=\frac{W/A}{\ell/L}$ .....(1)



Case (ii)
At equilibrium $T = W$

$\therefore Y=\frac{W/A}{\frac{\ell/2}{L/2}}\Rightarrow Y=\frac{W/A}{\ell/L}$

$\Rightarrow$ Elongation is the same.



**103.** **(b)** $\Delta\ell=\frac{F(L/2)}{AY}=\frac{(AL\rho g)(L/2)}{AY}$

$=\left(\frac{1}{2}\right)\rho g L^2/Y$

## CHAPTER
## 10

# MECHANICAL PROPERTIES OF FLUIDS

## FACT/DEFINITION TYPE QUESTIONS

**1.** The most characteristic property of a liquid is
(a) elasticity (b) fluidity
(c) formlessness (d) volume conservation

**2.** _________ and _________ play the same role in case of fluids as force and mass play in case of solids.
(a) Thrust and density (b) Pressure and density
(c) Pressure and thrust (d) thrust and volume

**3.** Which of the following is a unit of pressure?
(a) atm (b) pascal
(c) bar (d) All of these

**4.** Which of the following pressure-measuring device measures the guage pressure?
(a) Mercury barometer (b) Sphygmomanometer
(c) Both (a) & (b) (d) None of these

**5.** Liquid pressure depends upon
(a) area of the liquid surface
(b) shape of the liquid surface
(c) height of the liquid column
(d) directions

**6.** Hydraulic lifts and hydraulic brakes are based on
(a) Archimedes' principle (b) Bernoulli's principle
(c) Stoke's law (d) Pascal's law

**7.** According to archimedes' principle, loss of weight of a body immersed in a liquid is equal to
(a) weight of the liquid displaced
(b) weight of the total liquid
(c) weight of the body
(d) None of these

**8.** Specific gravity of a body is numerically equal to
(a) weight of the body in air
(b) weight of the body in water
(c) relative density of the body
(d) density of body in water

**9.** Which of the following parameters decrease as we go up?
(a) Density of air (b) Acceleration due to gravity
(c) Atmospheric pressure (d) All of these

**10.** Which liquid is used in an open-tube manometer for measuring small pressure differences?
(a) Oil (b) Mercury
(c) Water (d) None of these

**11.** If a solid floats with 1/4th of its volume above the surface of water, then density of the solid ($\rho_s$) is related to density of water ($\rho_w$) as
(a) $\rho_s = \rho_w$ (b) $\rho_s = \frac{1}{4}\rho_w$
(c) $\rho_s = \frac{3}{4}\rho_w$ (d) $\rho_s = \frac{4}{3}\rho_w$

**12.** Smaller the area on which the force acts, greater is the impact. This concept is known as
(a) impulse (b) pressure
(c) surface tension (d) magnus effect

**13.** Pressure in a fluid at rest is same at all points which are at the same height. This is known as
(a) Archemedes'. Principle (b) Bernoulli's principle
(c) Stoke's law (d) Pascal's law

**14.** The excess pressure at depth below the surface of a liquid open to the atmosphere is called
(a) atmospheric pressure (b) hydrostatic paradox
(c) gauge pressure (d) None of these

**15.** A pressure equivalent to 1 mm is called
(a) 1 Pa (b) 1 torr
(c) 1 atm (d) 1 N/m$^2$

**16.** When a body is wholly or partially immersed in a fluid at rest, the force working on it in upward direction is called
(a) buoyant force (b) surface tension
(c) viscous force (d) None of these

**17.** Pressure applied to enclosed fluid is
(a) increased and applied to every part of the fluid
(b) diminished and transmitted to wall of container
(c) increased in proportion to the mass of the fluid and then transmitted
(d) transmitted unchanged to every portion of the fluid and wall of containing vessel.

**18.** The pressure at the bottom of a tank containing a liquid does not depend on
(a) acceleration due to gravity
(b) height of the liquid column
(c) area of the bottom surface
(d) nature of the liquid

**19.** Streamline flow is more likely for liquids with
(a) high density and low viscosity
(b) low density and high viscosity
(c) high density and high viscosity
(d) low density and low viscosity

**20.** Beyond the critical speed, the flow of fluids becomes
(a) streamline (b) turbulent
(c) steady (d) very slow

**21.** For flow of a fluid to be turbulent
(a) fluid should have high density
(b) velocity should be large
(c) reynold number should be less than 2000
(d) both (a) and (b)

**22.** In a stream line (laminar flow) the velocity of flow at any point in the liquid
(a) does not vary with time
(b) may vary in direction but not in magnitude
(c) may vary in magnitude but not in direction
(d) may vary both in magnitude and direction

**23.** In Bernoulli's theorem which of the following is conserved?
(a) Mass (b) Linear momentum
(c) Energy (d) Angular momentum

**24.** Bernoulli's equation is important in the field of
(a) electrical circuits (b) magnetism
(c) flow of fluids (d) photoelectric effect

**25.** Paint-gun is based on
(a) Bernoulli's theorem (b) Archimedes' principle
(c) Boyle's law (d) Pascal's law

**26.** Magnus effect is very near to the
(a) magnetic field (b) electric field
(c) bernoulli's theorem (d) magnetic effect of current

**27.** A liquid is allowed to flow into a tube of truncated cone shape. Identify the correct statement from the following:
(a) the speed is high at the wider end and high at the narrow end.
(b) the speed is low at the wider end and high at the narrow end.
(c) the speed is same at both ends in a stream line flow.
(d) the liquid flows with uniform velocity in the tube.

**28.** Toricelli's theorem is used to find
(a) the velocity of efflux through an orifice.
(b) the velocity of flow of liquid through a pipe.
(c) terminal velocity
(d) critical velocity

**29.** The device which measures the flow speed of incompressible fluid is
(a) sphygmomanometer (b) open-tube manometer
(c) venturimeter (d) mercury barometer

**30.** As the temperature of a liquid is raised, the coefficient of viscosity
(a) decreases (b) increases
(c) remains the same
(d) may increase or decrease depending on the nature of liquid

**31.** After terminal velocity is reached, the acceleration of a body falling through a fluid is
(a) equal to g (b) zero
(c) less than g (d) greater than g

**32.** Choose the correct statement from the following.
(a) Terminal velocities of rain drops are proportional to square of their radii
(b) Water proof agents decrease the angle of contact between water and fibres
(c) Detergents increase the surface tension of water
(d) Hydraulic machines work on the principle of Torricelli's law

**33.** According to stokes law, the relation between terminal velocity ($v_t$) and viscosity of the medium (n) is
(a) $v_t = n$ (b) $v_t \propto n$
(c) $v_t \propto \frac{1}{n}$ (d) $v_t$ is independent of n.

**34.** When the temperature increases, the viscosity of
(a) gases decreases and liquid increases
(b) gases increases and liquid decreases
(c) gases and liquids increases
(d) gases and liquids decreases

**35.** Fevicol is added to paint to be painted on the walls, because
(a) it increases adhesive force between paint and wall.
(b) it decreases adhesive force between paint and wall molecules.
(c) it decreases cohesive force between paint molecules
(d) None of these

**36.** A rectangular glass plate is held vertically with long side horizontal and half the plate immersed in water. Which of the following forces is acting on the plate?
(a) Weight of the plate acting vertically upwards
(b) Force of surface tension acting vertically downwards
(c) Force of viscosity acting horizontally
(d) All of these

**37.** Which of the following expressions represents the excess of pressure inside the soap bubble?
(a) $P_i - P_o = \frac{s}{r}$ (b) $P_i - P_o = \frac{2s}{r}$
(c) $P_i - P_o = \frac{2s}{r} + h\rho g$ (d) $P_i - P_o = \frac{4s}{r}$

**38.** For a given volume which of the following will have minimum energy?
(a) Cube (b) Cone
(c) Sphere (d) All have same energy

**39.** If a soap bubble formed at the end of the tube is blown very slowly, then the graph between excess pressure inside the bubble with time will be a
(a) straight line sloping up
(b) straight line sloping down
(c) parabolic curve sloping down
(d) parabolic curve sloping up

**40.** Surface tension of a liquid is due to
(a) gravitational force between molecules
(b) electrical force between molecules
(c) adhesive force between molecules
(d) cohesive force between molecules

**41.** Surface tension may be defined as
(a) the work done per unit area in increasing the surface area of a liquid under isothermal conditions
(b) the work done per unit area in increasing the surface area of a liquid under adiabatic conditions
(c) the work done per unit area in increasing the surface area of a liquid under adiabatic conditions
(d) free surface energy per unit volume

**42.** At critical temperature, the surface tension of a liquid is
(a) zero
(b) infinity
(c) the same as that at any other temperature
(d) None of these

**43.** If two soap bubbles of different radii are in communication with each other then
(a) air flows from the larger bubble into the smaller one until the two bubbles are of equal size
(b) the size of the bubbles remains the same
(c) air flows from the smaller bubble into the larger one and the larger one grows at the expense of the smaller one
(d) the air flows from the larger into the smaller bubble until the radius of the smaller one becomes equal to that of the larger one and of the larger one equal to that of the smaller one.

**44.** Two water droplets merge with each other to form a larger droplet. In this process
(a) energy is liberated
(b) energy is absorbed
(c) energy is neither liberated nor absorbed
(d) some mass is converted into energy

**45.** When a pinch of salt or any other salt which is soluble in water is added to water, its surface tension
(a) increases
(b) decreases
(c) may increase or decrease depending upon salt
(d) None of these

**46.** If more air is pushed in a soap bubble, the pressure in it
(a) decreases (b) becomes zero
(c) remains same (d) increases

**47.** A drop of oil is placed on the surface of water. Which of the following is correct?
(a) It will remain on it as a sphere
(b) It will spread as a thin layer
(c) It will partly be a spherical droplet and partly a thin film
(d) It will float as a distorted drop on the water surface

**48.** For which of the following liquids, the liquid meniscus in the capillary tube is, convex?
(a) Water (b) Mercury
(c) Both (a) & (b) (d) None of these

**49.** Kerosene oil rises up in a wick of a lantern because of
(a) diffusion of the oil through the wick
(b) capillary action
(c) buoyant force of air
(d) the gravitational pull of the wick

**50.** Due to capillary action, a liquid will rise in a tube if angle of contact is
(a) acute (b) obtuse
(c) $90^o$ (d) zero

**51.** With the increase in temperature, the angle of contact
(a) decreases
(b) increases
(c) remains constant
(d) sometimes increases and sometimes decreases

## STATEMENT TYPE QUESTIONS

**52.** Which of the following statements are true about streamline flow?
I. Path taken by a fluid particle under a steady flow is a streamline
II. No two streamlines can cross each other
III. Velocity increases at the narrower portions where the streamlines are closely spaced
(a) I & II only (b) II & III only
(c) I & III only (d) I, II & III

**53.** Select the correct statements from the following.
I. Bunsen burner and sprayers work on Bernoulli's principle
II. Blood flow in arteries is explained by Bernoulli's principle
III. A siphon works on account of atmospheric pressure.
(a) I & II only (b) II & III only
(c) I & III only (d) I, II & III

**54.** Consider the following statements : In a streamline flow of a liquid
I. the kinetic energies of all particles arriving at a given point are same.
II. the momenta of all particles arriving at a given point are same.
III. the speed of particles are below the critical velocity.
Which of the statements given above are correct?
(a) I & II only (b) II & III only
(c) I &III only (d) I, II & III

**55.** Consider the following statements :
I. Magnus effect is a consequence of Bernoulli's principle.
II. A cricketer, while spinning a ball makes it to experience magnus effect.
Which of the statements given above is/are correct?
(a) I only (b) II only
(c) Both I & II (d) Neither I nor II

**56.** Consider the following statements :
There is a small hole near the bottom of an open tank filled with water. The speed of water ejected depends on
I. area of the hole
II. density of liquid
III. height of liquid from the hole
IV acceleration due to gravity
Which of the statements given above are correct
(a) I & II only (b) I, III & IV
(c) III & IV only (d) II, III & IV

**57.** Which of the following statement(s) is/are true?
I. For gases, in general, viscosity increases with temperature
II. For liquids, viscosity varies directly with pressure
III. For gases, viscosity is independent of pressure
(a) I & II (b) II & III
(c) I & III (d) I, II, & III

**58.** Which of the following statements is/are true?

I. Solid friction is independent of area of surface in contact and viscous drag is also independent of area of layers in contact.

II. Solid friction depends on the relative velocity of one body on the surface of another body while viscous drag is independent of the relative velocity between two layers of the liquid.

III. Solid friction is directly proportional to the normal reaction while viscosity is independent of the normal reaction between two layers of the liquid.

(a) I, II & III (b) I & II
(c) III only (d) II only

**59.** Which of the following are incorrect statement(s) about viscosity of liquids?

I. Viscosity decreases with increase in density

II. Viscosity decreases with increase in temperature

III. Viscosity of liquids (except water) decreases with increase in pressure

(a) I only (b) II only
(c) III only (d) I & III

**60.** Select the false statement(s) about surface tension from the following?

I. Surface tension is the extra energy that the molecules at the interface have as compared to the molecules in the interior

II. The value of surface tension is independent of the temperature

III. Surface tension causes capillary action

(a) I only (b) II only
(c) I & II (d) I, II & III

**61.** Consider the following statements and select the true statement(s)?

I. A large soap bubble shrinks while a small soap bubble expands when they are connected to each other by a capillary tube, in order to gain equilibrium

II. The raindrops fall on the surface of earth with the same constant velocity

III. A hydrogen filled balloon stops rising after it has attained a certain height in the sky

(a) I only (b) II only
(c) III only (d) I & III

## MATCHING TYPE QUESTIONS

**62.** Match column I and column II.

| **Column I** | **Column II** |
|---|---|
| (A) Barometer | (1) Law of conservation of energy |
| (B) Hydrometer | (2) To measure density |
| (C) Bernoulli's Principle | (3) To measure atmospheric pressure |
| (D) Archimedes' Principle | (4) upthrust |

(a) (A) → (3) ; (B) → (2) ; (C) → (1) ; (D) → (4)
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(c) (A) → (2) ; (B) → (1) ; (C) → (4) ; (D) → (3)
(d) (A) → (3) ; (B) → (4) ; (C) → (2) ; (D) → (1)

**63.**

| **Column I** | **Column II** |
|---|---|
| (A) Stoke's law | (1) Pressure energy |
| (B) Turbulence | (2) Hydraulic lift |
| (C) Bernoulli's principle | (3) Viscous drag |
| (D) Pascal's law | (4) Reynold's number |

(a) (A) → (3) ; (B) → (4) ; (C) → (1) ; (D) → (2)
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(c) (A) → (2) ; (B) → (1) ; (C) → (2) ; (D) → (3)
(d) (A) → (3) ; (B) → (4) ; (C) → (2) ; (D) → (1)

**64.**

| **Column I** | **Column II** |
|---|---|
| (A) Terminal velocity | (1) Average density becomes less than that of liquid |
| (B) Objects of high density can also float | (2) Upthrust is zero |
| (C) A beaker having a solid iron under free fall | (3) Varies with velocity |
| (D) Viscous drag | (4) Upthrust and viscous force |

(a) (A) → (4) ; (B) → (2) ; (C) → (3) ; (D) → (1)
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(c) (A) → (4) ; (B) → (1) ; (C) → (2) ; (D) → (3)
(d) (A) → (3) ; (B) → (4) ; (C) → (2) ; (D) → (1)

**65.**

| **Column I** | **Column II** |
|---|---|
| (A) Bernoullis theorem | (1) Narrower pipes have less pressure |
| (B) Ball moving with spin | (2) Paint gun |
| (C) Artificial high pressure | (3) Non-viscous fluids |
| (D) Streamline flow | (4) Conservation of energy |
| | (5) Uplift due to pressure difference |

(a) (A) → (3,4) ; (B) → (5) ; (C) → (2) ; (D) → (1,3)
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(c) (A) → (2) ; (B) → (5) ; (C) → (4) ; (D) → (3)
(d) (A) → (3) ; (B) → (5) ; (C) → (2) ; (D) → (1)

**66.**

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Magnus effect | (1) | Pascal's law |
| (B) | Loss of energy | (2) | Archimede's principle |
| (C) | Pressure is same at the same level in a liquid | (3) | Viscous force |
| (D) | Hydraulic machines | (4) | Lifting of Asbestos roofs |

(a) $(A)\rightarrow(4);(B)\rightarrow(2);(C)\rightarrow(5);(D)\rightarrow(1)$

(b) $(A)\rightarrow(1);(B)\rightarrow(2);(C)\rightarrow(3);(D)\rightarrow(4)$

(c) $(A)\rightarrow(2);(B)\rightarrow(5);(C)\rightarrow(4);(D)\rightarrow(3)$

(d) $(A)\rightarrow(4);(B)\rightarrow(3);(C)\rightarrow(1);(D)\rightarrow(2)$

**67.**

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Water proofing agents | (1) | Increase in terminal velocity |
| (B) | Sphygmomanometer | (2) | Gauge pressure |
| (C) | More than gauge pressure | (3) | Actual pressure |
| (D) | Mixing of drops of smaller dimension | (4) | Increase the angle of contact |

(a) $(A)\rightarrow(4);(B)\rightarrow(2);(C)\rightarrow(5);(D)\rightarrow(1)$

(b) $(A)\rightarrow(1);(B)\rightarrow(2);(C)\rightarrow(3);(D)\rightarrow(4)$

(c) $(A)\rightarrow(4);(B)\rightarrow(2);(C)\rightarrow(3);(D)\rightarrow(1)$

(d) $(A)\rightarrow(3);(B)\rightarrow(5);(C)\rightarrow(2);(D)\rightarrow(1)$

**68.**

| | **Column I** | | **Column II** |
|---|---|---|---|
| **(A)** | Capillaries of smaller radii | (1) | Flat meniscus |
| (B) | $F_c > \sqrt{2}F_a$ where $F_c$ and $F_a$ are cohesive and adhesive force | (2) | Greater height difference |
| (C) | Angle of contact is zero | (3) | Drop in level |
| (D) | Lower angle of contact | (4) | Welding agents |

(a) $(A)\rightarrow(4);(B)\rightarrow(2);(C)\rightarrow(3);(D)\rightarrow(1)$

(b) $(A)\rightarrow(3);(B)\rightarrow(4);(C)\rightarrow(1);(D)\rightarrow(2,3)$

(c) $(A)\rightarrow(2);(B)\rightarrow(1);(C)\rightarrow(4);(D)\rightarrow(3)$

(d) $(A)\rightarrow(3);(B)\rightarrow(4);(C)\rightarrow(2);(D)\rightarrow(1)$

**69.** Match the column I and column II

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Floating bodies | (1) | Torricelli's law |
| (B) | Capillarity | (2) | Bernoulli's principle |
| (C) | Energy conservation | (3) | Archimedes principle |
| (D) | Speed of efflux | (4) | Pascal's law |

(a) $(A)\rightarrow(4);(B)\rightarrow(2);(C)\rightarrow(3);(D)\rightarrow(1)$

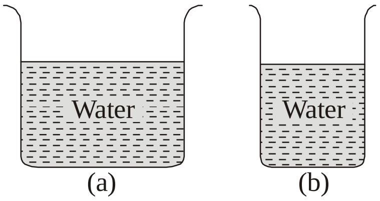
(b) $(A)\rightarrow(3);(B)\rightarrow(4);(C)\rightarrow(2);(D)\rightarrow(1)$

(c) $(A)\rightarrow(2);(B)\rightarrow(1);(C)\rightarrow(4);(D)\rightarrow(3)$

(d) $(A)\rightarrow(3);(B)\rightarrow(4);(C)\rightarrow(2);(D)\rightarrow(1)$

## DIAGRAM TYPE QUESTIONS

**70.** From the figure, the correct observation is



(a) (b)

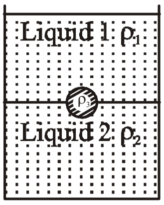
(a) the pressure on the bottom of tank (a) is greater than at the bottom of (b)

(b) the pressure on the botttom of the tank (a) is smaller than at the bottom (b)

(c) the pressure depend on the shape of the container

(d) the pressure on the bottom of (a) and (b) is the same.

**71.** A jar is filled with two non-mixing liquids 1 and 2 having densities $\rho_1$ and, $\rho_2$ respectively. A solid ball, made of a material of density $\rho_3$, is dropped in the jar. It comes to equilibrium in the position shown in the figure.Which of the following is true for $\rho_1$, $\rho_1$and $\rho_3$?



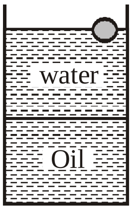
(a) $\rho_3 < \rho_1 < \rho_2$

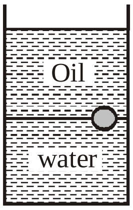
(b) $\rho_1 > \rho_3 > \rho_2$

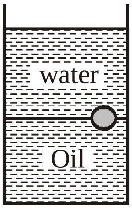
(c) $\rho_1 < \rho_2 < \rho_3$

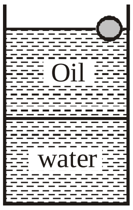
(d) $\rho_1 < \rho_3 < \rho_2$

**72.** A ball is made of a material of density $\rho$ where $\rho_{oil} < \rho < \rho_{water}$ with $\rho_{oil}$ and $\rho_{water}$ representing the densities of oil and water, respectively. The oil and water are immiscible. If the above ball is in equilibrium in a mixture of this oil and water, which of the following pictures represents its equilibrium position?

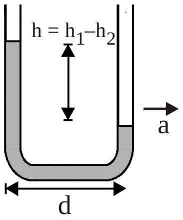
(a) 

(b) 

(c) 

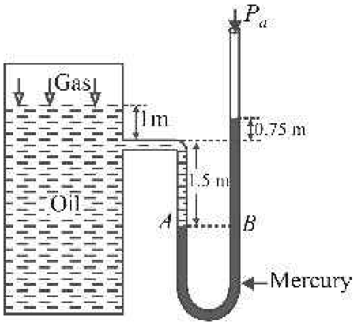
(d) 

**73.** Figure shows a U-tube of uniform cross-sectional area A, accelerated with acceleration a as shown. If d is the separation between the limbs, then what is the difference in the levels of the liquid in the U-tube is



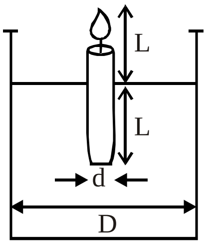
(a) $\frac{ad}{g}$
(b) $\frac{ag}{d}$
(c) $\frac{a}{d}$
(d) $\frac{dg}{a}$

**74.** What is the absolute pressure of the gas above the liquid surface in the tank shown in fig. Density of oil = 820 kg/m$^3$, density of mercury = 13.6 × 10$^3$ kg/m$^3$. Given 1 atmospheric pressure = 1.01× 10$^5$ N/m$^2$.



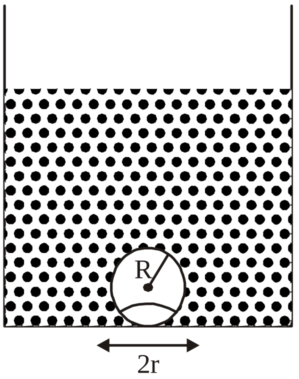
(a) $3.81 \times 10^5$ N/m$^2$
(b) $6 \times 10^6$ N/m$^2$
(c) $5 \times 10^7$ N/m$^2$
(d) $4.6 \times 10^2$ N/m$^2$

**75.** A candle of diameter d is floating on a liquid in a cylindrical container of diameter D (D >> d) as shown in figure. If it is burning at the rate of 2 cm/hour then the top of the candle will
(a) remain at the same height
(b) fall at the rate of 1 cm/hour
(c) fall at the rate of 2 cm/hour
(d) go up at the rate of 1 cm/hour



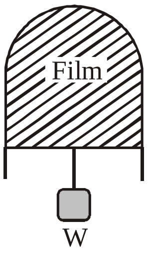
**76.** On heating water, bubbles being formed at the bottom of the vessel detach and rise. Take the bubbles to be spheres of radius R and making a circular contact of radius r with the bottom of the vessel. If r ≪ R and the surface tension of water is T, value of r just before bubbles detach is:

(density of water is $\rho_w$)



(a) $R^2\sqrt{\frac{\rho_w g}{3T}}$
(b) $R^2\sqrt{\frac{2\rho_w g}{3T}}$
(c) $R^2\sqrt{\frac{\rho_w g}{T}}$
(d) $R^2\sqrt{\frac{3\rho_w g}{T}}$

**77.** A thin liquid film formed between a U-shaped wire and a light slider supports a weight of 1.5 × 10$^{-2}$ N (see figure). The length of the slider is 30 cm and its weight negligible. The surface tension of the liquid film is
(a) 0.0125 Nm$^{-1}$
(b) 0.1 Nm$^{-1}$
(c) 0.05 Nm$^{-1}$
(d) 0.025 Nm$^{-1}$



## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.
(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

**78.** **Assertion:** Mercury is preferred as a barometric substance over water.
**Reason:** Mercury is opaque and shiny so it is easier to note the observation.

**79.** **Assertion:** A small iron needle sinks in water while a large iron ship floats.
**Reason:** The shape of iron needle is like a flat surface while the shape of a ship is that which makes it easier to float.

**80.** **Assertion:** The apparent weight of a floating body is zero.
**Reason:** The weight of the block acting vertically downwards is balanced by the buoyant force acting on the block upwards.

**81. Assertion :** Pascal's law is the working principle of a hydraulic lift.

**Reason :** Pressure is equal to the thrust per unit area.

**82. Assertion :** Imagine holding two identical bricks under water. Brick A is completely submerged just below the surface of water, while Brick B is at a greater depth. The magnitude of force exerted by the person (on the brick) to hold brick B in place is the same as magnitude of force exerted by the person (on the brick) to hold brick A in place.

**Reason :** The magnitude of buoyant force on a brick completely submerged in water is equal to magnitude of weight of water it displaces and does not depend on depth of brick in water.

**83. Assertion :** The blood pressure in humans is greater at the feet than at the brain

**Reason :** Pressure of liquid at any point is proportional to height, density of liquid and acceleration due to gravity

**84. Assertion :** Hydrostatic pressure is a vector quantity.

**Reason :** Pressure is force divided by area, and force is vector quantity.

**85. Assertion :** The velocity of flow of a liquid is smaller when pressure is larger and vice-versa.

**Reason :** According to Bernoulli's theorem, for the stream line flow of an ideal liquid, the total energy per unit mass remains constant

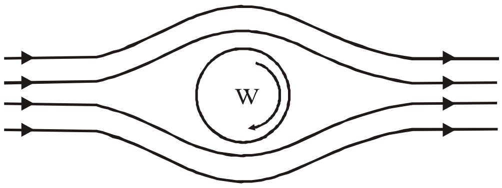
**86. Assertion :** A bubble comes from the bottom of a lake to the top.

**Reason :** Its radius increases.

**87. Assertion :** Sudden fall of pressure at a place indicates storm.

**Reason :** Air flows from higher pressure to lower pressure.

**88. Assertion :** As wind flows left to right and a ball is spinned as shown, there will be a lift of the ball.



**Reason :** Decreased velocity of air below the ball increases the pressure more than that above the ball.

**89. Assertion :** Lifting of aircraft is caused by pressure difference brought by varying speed of air molecules.

**Reason :** As the wings/ aerofoils move against the wind, the streamlines crowd more above them than below, causing higher velocity above than below.

**90. Assertion:** The pressure of water reduces when it flows from a narrow pipe to a wider pipe.

**Reason:** Since for wider pipe area is large, so flow of speed is small and pressure also reduces proportionately.

**91. Assertion :** Falling raindrops acquire a terminal velocity.

**Reason :** A constant force in the direction of motion and a velocity dependent force opposite to the direction of motion, always result in the acquisition of terminal velocity.

**92. Assertion:** Surface tension of all lubricating oils and paints is kept high.

**Reason:** Due to high value of surface tension the fluids don't get damaged.

**93. Assertion :** If a body is floating in a liquid, the density of liquid is always greater than the density of solid.

**Reason :** Surface tension is the property of liquid surface.

**94. Assertion :** Smaller the droplets of water, spherical they are.

**Reason :** Force of surface tension is equal, and opposite to force of gravity.

**95. Assertion :** A large force is required to draw apart normally two glass plates enclosing a thin water film.

**Reason :** Water works as glue and sticks two glass plates.

**96. Assertion :** It is better to wash the clothes in cold soap solution.

**Reason :** The surface tension of cold solution is more than the surface tension of hot solution.

**97. Assertion :** The concept of surface tensiton is held only for liquid

**Reason :** Surface tension does not hold for gases.

**98. Assertion :** When height of a tube is less than liquid rise in the capillary tube, the liquid does not overflow

**Reason :** Product of radius of meniscus and height of liquid in capillary tube always remains constant.

## CRITICAL THINKING TYPE QUESTIONS

**99.** Consider an iceberg floating in sea water. The density of sea water is 1.03 g/cc and that of ice is 0.92 g/cc. The fraction of total volume of iceberg above the level of sea water is near by

(a) 1.8% (b) 3%
(c) 8% (d) 11%

**100.** A block of ice floats on a liquid of density 1.2 in a beaker then level of liquid when ice completely melt

(a) remains same (b) rises
(c) lowers (d) either (b) or (c)

**101.** The total weight of a piece of wood is 6 kg. In the floating state in water its $\frac{1}{3}$ part remains inside the water. On this floating piece of wood what maximum weight is to be put such that the whole of the piece of wood is to be drowned in the water?

(a) 15 kg (b) 14 kg
(c) 10 kg (d) 12 kg

**102.** A vessel contains oil (density = 0.8 gm/cm$^3$) over mercury (denisty = 13.6 gm/cm$^3$). A homogeneous sphere floats with half of its volume immersed in mercury and the other half in oil. The density of the material of the sphere in gm/cm$^3$ is

(a) 3.3 (b) 6.4
(c) 7.2 (d) 12.8

**103 .** In a hydraulic lift, compressed air exerts a force $F_1$ on a small piston having a radius of 5 cm. This pressure is transmitted to a second piston of radius 15 cm. If the mass of the load to be lifted is 1350 kg, find the value of $F_1$ ? The pressure necessary to accomplish this task is

(a) $1.4 \times 10^5$ Pa  (b) $2 \times 10^5$ Pa
(c) $1.9 \times 10^5$ Pa  (d) 1.9 Pa

**104.** The two thigh bones, each of cross - sectional area 10 $cm^2$ support the upper part of a human body of mass 40 kg. Estimate the average pressure sustained by the bones. Take $g$ = 10 $m/s^2$

(a) $2 \times 10^5$ $N/m^2$  (b) $5 \times 10^4$ $N/m^2$
(c) $2 \times 10^7$ $N/m^2$  (d) $3 \times 10^6$ $N/m^2$

**105.** A hemispherical bowl just floats without sinking in a liquid of density $1.2 \times 10^3$ $kg/m^3$. If outer diameter and the density of the bowl are 1 m and $2 \times 10^4$ $kg/m^3$ respectively then the inner diameter of the bowl will be

(a) 0.94m  (b) 0.97m
(c) 0.98m  (d) 0.99m

**106.** A uniform rod of density ρ is placed in a wide tank containing a liquid of density $\rho_0(\rho_0 > \rho)$. The depth of liquid in the tank is half the length of the rod. The rod is in equilibrium, with its lower end resting on the bottom of the tank. In this position the rod makes an angle θ with the horizontal

(a) $\sin\theta = \frac{1}{2}\sqrt{\rho_0 / \rho}$  (b) $\sin\theta = \frac{1}{2}.\frac{\rho_0}{\rho}$
(c) $\sin\theta = \sqrt{\rho / \rho_0}$  (d) $\sin\theta = \rho_0 / \rho$

**107.** Air flows horizontally with a speed v = 106 km/hr. A house has plane roof of area A = 20$m^2$. The magnitude of aerodynamic lift of the roof is

(a) $1.127 \times 10^4$ N  (b) $5.0 \times 10^4$ N
(c) $1.127 \times 10^5$ N  (d) $3.127 \times 10^4$ N

**108.** A spherical solid ball of volume $V$ is made of a material of density $\rho_1$. It is falling through a liquid of density $\rho_2$ ($\rho_2 < \rho_1$). Assume that the liquid applies a viscous force on the ball that is proportional to the square of its speed $v$, i.e., $F_{viscous} = -kv^2$ $(k > 0)$. The terminal speed of the ball is

(a) $\sqrt{\frac{Vg(\rho_1 - \rho_2)}{k}}$  (b) $\frac{Vg\rho_1}{k}$
(c) $\sqrt{\frac{Vg\rho_1}{k}}$  (d) $\frac{Vg(\rho_1 - \rho_2)}{k}$

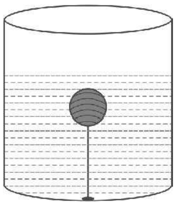
**109.** When a ball is released from rest in a very long column of viscous liquid, its downward acceleration is 'a' (just after release). Its acceleration when it has acquired two third of the maximum velocity is a/X. Find the value of X.

(a) 2  (b) 3
(c) 4  (d) 5

**110.** A tiny spherical oil drop carrying a net charge q is balanced in still air will a vertical uniform electric field of strength $\frac{81\pi}{7} \times 10^5$ $Vm^{-1}$. When the field is switched off, the drop is observed to fall with terminal velocity $2 \times 10^{-3}$ $ms^{-1}$.(Given : g = 9.8 $ms^{-2}$, viscosity of the air = $1.8 \times 10^{-5}$ $Nsm^{-2}$ and the density of oil = 900 $kgm^{-3}$) the magnitude of q is

(a) $1.6 \times 10^{-19}$ C  (b) $3.2 \times 10^{-19}$ C
(c) $4.8 \times 10^{-19}$ C  (d) $8.0 \times 10^{-19}$ C

**111.** A solid sphere of density $\eta\,(>1)$ times lighter than water is suspended in a water tank by a string tied to its base as shown in fig. If the mass of the sphere is $m$, then the tension in the string is given by



(a) $\left(\frac{\eta-1}{\eta}\right)mg$  (b) $\eta mg$
(c) $\frac{mg}{\eta-1}$  (d) $(\eta-1)mg$

**112.** An air bubble of radius 1 cm rises with terminal velocity 0.21 cm/s in liquid column. If the density of liquid is $1.47 \times 10^3$ kg/$m^3$. Then the value of coefficient of viscosity of liquid ignoring the density of air, will be

(a) $1.71 \times 10^4$ poise  (b) $1.82 \times 10^4$ poise
(c) $1.78 \times 10^4$ poise  (d) $1.52 \times 10^4$ poise

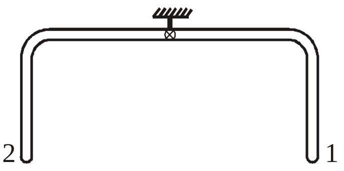
**113.** The relative velocity of two parallel layers of water is 8 cm/sec. If the perpendicular distance between the layers is 0.1 cm. Then velocity gradient will be

(a) 80/sec  (b) 60 /sec
(c) 50/sec  (d) 40/sec

**114.** If a ball of steel (density ρ = 7.8 g $cm^{-3}$) attains a terminal velocity of 10 $cms^{-1}$ when falling in a tank of water (coefficient of viscosity $\eta_{water} = 8.5 \times 10^{-4}\,Pa-s$ ) then its terminal velocity in glycerine ( $\rho = 12gcm^{-3}, \eta = 13.2Pa-s$) would be nearly

(a) $1.6 \times 10^{-5}$ $cms^{-1}$  (b) $6.25 \times 10^{-4}$ $cms^{-1}$
(c) $6.45 \times 10^{-4}$ $cms^{-1}$  (d) $1.5 \times 10^{-5}$ $cms^{-1}$

**115.** A glass tube of uniform internal radius (r) has a valve separating the two identical ends. Initially, the valve is in a tightly closed position. End 1 has a hemispherical soap bubble of radius r. End 2 has sub-hemispherical soap bubble as shown in figure. Just after opening the valve



(a) air from end 1 flows towards end 2. No change in the volume of the soap bubbles
(b) air from end 1 flows towards end 2. Volume of the soap bubble at end 1 decreases
(c) no change occurs
(d) air from end 2 flows towards end 1. Volume of the soap bubble at end 1 increases

**116.** A liquid is filled upto a height of 20 cm in a cylindrical vessel. The speed of liquid coming out of a small hole at the bottom of the vessel is (g = 10 ms$^{-2}$)

(a) 1.2 ms$^{-1}$ (b) 1 ms$^{-1}$

(c) 2 ms$^{-1}$ (d) 3.2 ms$^{-1}$

**117.** Two soap bubbles each with radius $r_1$ and $r_2$ coalesce in vacuum under isothermal conditions to form a bigger bubble of radius $R$. Then $R$ is equal to

(a) $\sqrt{r_1^2 + r_2^2}$ (b) $\sqrt{r_1^2 - r_2^2}$

(c) $r_1 - r_2$ (d) $\frac{\sqrt{r_1^2 + r_2^2}}{2}$

**118.** A boy can reduce the pressure in his lungs to 750 mm of mercury. Using a straw he can drink water from a glass upto the maximum depth of (atmospheric pressure = 760 mm of mercury; density of mercury = 13.6 gcm$^{-3}$)

(a) 13.6 cm (b) 9.8 cm

(c) 10 cm (d) 76 cm

**119.** An open glass tube is immersed in mercury in such a way that a length of 8 cm extends above the mercury level. The open end of the tube is then closed and sealed and the tube is raised vertically up by additional 46 cm. What will be length of the air column above mercury in the tube now? (Atmospheric pressure = 76 cm of Hg)

(a) 16 cm (b) 22 cm

(c) 38 cm (d) 6 cm

**120.** A boat carrying a few number of big stones floats in a water tank. If the stones are unloaded into water, the water level

(a) rises till half the number of stones are unloaded and then begins to fall

(b) remains unchanged

(c) rises

(d) falls

**121.** A solid ball of volume V experiences a viscous force F when falling with a speed $v$ in a liquid. If another ball of volume 8 V with the same velocity $v$ is allowed to fall in the same liquid, it experiences a force

(a) F (b) l6 F

(c) 4 F (d) 2 F

**122.** A beaker of radius 15 cm is filled with a liquid of surface tension 0.075 N/m. Force across an imaginary diameter on the surface of the liquid is

(a) 0.075 N (b) $1.5 \times 10^{-2}$ N

(c) 0.225 N (d) $2.25 \times 10^{-2}$ N

**123.** A water film is formed between two straight parallel wires of 10 cm length 0.5 cm apart. If the distance between wires is increased by 1 mm. What will be the work done ? (surface tension of water = 72 dyne/cm)

(a) 36 erg (b) 288 erg

(c) 144 erg (d) 72 erg

**124.** The work done in increasing the size of a soap film from 10 cm × 6 cm to 10 cm × 11 cm is $3 \times 10^{-4}$J. The surface tension of the film is

(a) $11 \times 10^{-2}$ N/m (b) $6 \times 10^{-2}$ N/m

(c) $3 \times 10^{-2}$ N/m (d) $1.5 \times 10^{-2}$ N/m

**125.** A mercury drop of radius 1 cm is sprayed into $10^6$ drops of equal size. The energy expressed in joule is (surface tension of Mercury is $460 \times 10^{-3}$ N/m)

(a) 0.057 (b) 5.7

(c) $5.7 \times 10^{-4}$ (d) $5.7 \times 10^{-6}$

**126.** Work done in increasing the size of a soap bubble from radius 3 cm to 5 cm is nearly (surface tension of soap solution = 0.03 Nm$^{-1}$)

(a) $0.2\pi$mJ (b) $2\pi mJ$

(c) $0.4\pi$ mJ (d) $4\pi\, mJ$

**127.** Two soap bubbles A and B are kept in a closed chamber where the air is maintained at pressure 8 N/m$^2$. The radii of bubbles A and B are 2 cm and 4 cm, respectively.Surface tension of the soap-water used to make bubbles is 0.04 N/m. Find the ratio $n_B/n_A$, where $n_A$and $n_B$ are the number of moles of air in bubbles A and B, respectively. [Neglect the effect of gravity]

(a) 2 (b) 9

(c) 8 (d) 6

**128.** An isolated and charged spherical soap bubble has a radius r and the pressure inside is atmospheric. If T is the surface tension of soap solution, then charge on drop is $X\,\pi r\sqrt{2rT\varepsilon_0}$ then find the value of X.

(a) 8 (b) 9

(c) 7 (d) 2

**129.** Two parallel glass plates are dipped partly in the liquid of density 'd' keeping them vertical . If the distance between the plates is 'x', surface tension for liquids is $T$ and angle of contact is θ, then rise of liquid between the plates due to capillary will be

(a) $\frac{T\cos\theta}{xd}$ (b) $\frac{2T\cos\theta}{xdg}$

(c) $\frac{2T}{xdg\cos\theta}$ (d) $\frac{T\cos\theta}{xdg}$

**130.** A 20 cm long capillary tube is dipped in water. The water rises up to 8 cm. If the entire arrangement is put in a freely falling elevator the length of water column in the capillary tube will be

(a) 10 cm (b) 8 cm

(c) 20 cm (d) 4 cm

**131.** In a capillary tube, water rises to 3 mm. The height of water that will rise in another capillary tube having one-third radius of the first is

(a) 1mm (b) 3mm

(c) 6mm (d) 9mm

**132.** A wind with speed 40 m/s blows parallel to the roof of a house. The area of the roof is 250 $m^2$. Assuming that the pressure inside the house is atmospheric pressure, the force exerted by the wind on the roof and the direction of the force will be ($\rho_{air} = 1.2\ kg/m^3$)

(a) $4.8 \times 10^5$ N, upwards
(b) $2.4 \times 10^5$ N, upwards
(c) $2.4 \times 10^5$ N, downwards
(d) $4.8 \times 10^5$ N, downwards

**133.** In a surface tension experiment with a capillary tube water rises upto 0.1 m. If the same experiment is repeated on an artificial satellite, which is revolving around the earth, water will rise in the capillary tube upto a height of

(a) 0.1m
(b) 0.2m
(c) 0.98m
(d) full length of the capillary tube

**134.** Water rises in a capillary tube to a certain height such that the upward force due to surface tension is balanced by $7.5 \times 10^{-4}$N force due to the weight of the liquid. If the surface tension of water is $6 \times 10^{-2}Nm^{-1}$, the inner circumference of the capillary tube must be

(a) $1.25 \times 10^{-2}$m (b) $0.50 \times 10^{-2}$m
(c) $6.5 \times 10^{-2}$m (d) $12.5 \times 10^{-2}$m

**135.** Radius of a capillary tube is $2 \times 10^{-3}$m. A liquid of weight $6.28 \times 10^{-4}$ N may remain in the capillary then the surface tension of liquid will be

(a) $5 \times 10^3$ N/m (b) $5 \times 10^{-2}$ N/m
(c) 5 N/m (d) 50 N/m

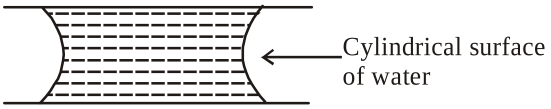
**136.** If the surface tension of water is 0.06 $Nm^{-1}$, then the capillary rise in a tube of diameter 1 mm is ($\theta = 0°$)

(a) 1.22 cm (b) 2.44 cm
(c) 3.12 cm (d) 3.68 cm

**137.** The height upto which liquid rises in a capillary tube is given by $h = \dfrac{2S\cos\theta}{h\rho g}$ this is for which of the following cases, water will be depressed in such a tube?

(a) $\theta$ is acute (b) $\theta$ is a right angle
(c) $\theta$ is zero (d) $\theta$ is obtuse

**138.** If two glass plates have water between them and are separated by very small distance (see figure), it is very difficult to pull them apart. It is because the water in between forms cylindrical surface on the side that gives rise to lower pressure in the water in comparison to atmosphere. If the radius of the cylindrical surface is R and surface tension of water is T then the pressure in water between the plates is lower by



(a) $\dfrac{2T}{R}$ (b) $\dfrac{4T}{R}$
(c) $\dfrac{T}{4R}$ (d) $\dfrac{T}{R}$

**139.** Water rises to a height 'h' in a capillary tube. If the length of capaillary tube above the surface of water is made less than 'h' then

(a) water rises upto the top of capillary tube and stays there without overflowing
(b) water rises upto a point a little below the top and stays there
(c) water does not rise at all.
(d) Water rises upto the tip of capillary tube and then starts overflowing like fountain.

**140.** The cylindrical tube of a spray pump has radius, R, one end of which has n fine holes, each of radius r. If the speed of the liquid in the tube is V, the speed of the ejection of the liquid through the holes is

(a) $\dfrac{VR^2}{nr^2}$ (b) $\dfrac{VR^2}{n^3r^2}$
(c) $\dfrac{V^2R}{nr}$ (d) $\dfrac{VR^2}{n^2r^2}$

**141.** A certain number of spherical drops of a liquid of radius 'r' coalesce to form a single drop of radius 'R' and volume 'V'. If 'T' is the surface tension of the liquid, then :

(a) energy = $4VT\left(\dfrac{1}{r} - \dfrac{1}{R}\right)$ is released
(b) energy = $3VT\left(\dfrac{1}{r} + \dfrac{1}{R}\right)$ is absorbed
(c) energy = $3VT\left(\dfrac{1}{r} - \dfrac{1}{R}\right)$ is released
(d) energy is neither released nor absorbed

**142.** Two capillary tubes A and B of diameter 1 mm and 2 mm respectively are dipped vertically in a liquid. If the capillary rise in A is 6 cm, then the capillary rise in B is

(a) 2 cm (b) 3 cm
(c) 4 cm (d) 6 cm

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(d)** **2.** **(b)**

**3.** **(d)** 1 atm = $1.01 \times 10^5$ Pa; 1 bar = $10^5$ Pa
$\therefore$ Pa, atm, Bar, all are the units of pressure.

**4.** **(b)** Sphygmomanometer is the blood pressure gauge and it measures the gauge pressure.

**5.** **(c)** Liquid pressure depends upon the height of liquid column and is independent of the shape of liquid surface and the area of liquid surface. The liquid at rest exerts equal pressure in all directions.

**6.** **(d)** Hydraulic machines & lifts are based on

$$P_1 = P_2 \; ; \; \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

**7.** **(a)** Archimedes's principle states that when a body is immersed in a liquid, it loses it weight and the loss in weight of body is equal to the weight of the liquid displaced by the immersed part of the body.

**8.** **(c)** Specific gravity of a body is defined as ratio of weight of body in air to the loss of weight of body in water at 4°C.

$$= \frac{Vsg}{Vswg} = \frac{s}{sw} = \text{Relative density of the body.}$$

**9.** **(d)** As we go up the density of air decreases and so does the value of g. since $P = h\rho g$
$\therefore$ P also decreases.

**10.** **(a)** In open-tube manometer, low-density liquid such as oil is used for measuring small pressure differenes.

**11.** **(c)** Weight of water displaced

(Below the water volum = $\frac{3}{4}$v)

$= V\rho g$

$= \frac{3}{4} Vs_w g$

For a floating body weight of body
= weight of water displaced by it

**12.** **(b)** **13.** **(d)** **14.** **(c)**

**15.** **(b)** **16.** **(a)**

**17.** **(d)** Pressure applied to enclosed fluid is transmitted equally in all direction according to Pascal law.

**18.** **(c)** $P = h\rho g$ i.e. pressure does not depend upon the area of bottom surface.

**19.** **(b)**

**20.** **(b)** Beyond the critical speed, the flow of fluids becomes turbulent as the flow loses its steadiness.

**21.** **(d)** Reynold's number N for turbulent motion is more than 3000 and $N = \frac{v\rho r}{\eta}$ i.e., $N \propto v\rho$

**22.** **(a)** In stream line flow velocity of flow at any point in the liquid does not vary with time.

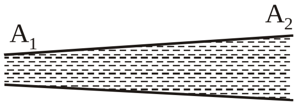
**23.** **(c)** In Bernoulli's theorem only law of conservation of energy is obeyed.

**24.** **(c)** Bernoulli's equation is a indespensable tool for the analysis of flow of liquids.

**25.** **(a)**

**26.** **(c)** Magnus effect of the ball can be explained easily by Bernoulli's theorem.

**27.** **(b)** The theorem of continuity is valid.
$\therefore A_1 v_1 \rho = A_2 v_2 \rho$ as the density of the liquid can be taken as uniform.



$\therefore A_1 v_1 = A_2 v_2$

$\Rightarrow$ Smaller the area, greater the velocity.

**28.** **(a)** **29.** **(c)**

**30.** **(a)** As the temperature rises the atoms of the liquid become more mobile and the coefficient of viscosity falls.

**31.** **(b)** When terminal velocity is reached then body moves with constant velocity hence, accelesation is zero.

**32.** **(a)** Terminal velocities of rain drops are proportional to square of their radii.

Terminal velocity of a body is given by

$$v_T = \frac{2R^2}{9\eta}(d - \sigma)g. \text{ or, } V \propto R^2$$

**33.** **(c)** **34.** **(b)** **35.** **(a)**

**36.** **(b)** The various forces acting on the plate are,
(i) Weight of the plate acting vertically downward
(ii) Surface tension acting vertically downwards
(iii) Upthrust due to liquid acting vertically upward

**37.** **(d)** **38.** **(c)**

**39.** **(c)** Excess pressure inside the soap bubble

$$p = \frac{4s}{r} \quad \therefore \quad p \propto \frac{1}{r}$$

**40.** **(d)** Surface tension of a liquid is due to force of attraction between like molecules of a liquid i.e., cohesive force between the molecules.

**41.** **(a)** Surface tension = workdone per unit area in increasing the surface area of a liquid under isothermal condition.

**42.** **(a)** The surface tension of liquid at critical temperature is zero.

**43.** **(c)** Excess of pressure in a soap bubble, P = 4T/r i.e., $P \propto \frac{1}{r}$ therefore pressure in a smaller bubble is more than that of a bigger bubble. When two bubbles of different radii are in communication, then the air flows from higher pressure to lower pressure i.e. from smaller bubble into larger one.

**44.** **(a)** When two drops merge together to form one drop, the surface area of drop will decrease, due to which the energy of bigger drop is less than the sum of the energy of two smaller drops. Due to it, the energy is released.

**45.** **(a)** When a highly soluble salt (like sodium chloride) is dissolved in water, the surface tension of water increases.

**46.** **(b)** When a sparingly soluble salt (like detergent) added to water, the surface tension of water decreases.

**47.** **(b)** The surface tension of oil is less than that of water, so the oil spreads as a thin layer.

**48.** **(b)** The contact angle between water & glass is acute but that of water & mercury is obtuse.

$\therefore$ the liquid meniscus is common for mercury.

**49.** **(b)** Kerosene oil rises up in wick of a lantern because of capillary action. If the surface tension of oil is zero, then it will not rise, so oil rises up in a wick of a lantern due to surface tension.

**50.** **(a)** $h = \frac{2\ T\cos\theta}{r\rho g}$ ; The liquid will rise i.e., h is positive if cosθ is +ve; It is so if $\theta < 90^\circ$ or θ is acute.

**51.** **(a)** With the increase in temperature, the surface tension of liquid decreases and angle of contact also decreases.

## STATEMENT TYPE QUESTIONS

**52.** **(d)**

**53.** **(d)** According to Bernoulli's theorem, when velocity of liquid flow increases, the pressure decreases. As the two boats moving in parallel directions close to each other, the stream of water between the boats is set into vigorous motion. As a result the presssure exerted by water in between the boats becomes less than the pressure of water outside the boats. Due to this pressure difference the boats are pulled towards each other.

**54.** **(d)** For streamline flow, all are correct.

**55.** **(c)**

**56.** **(c)** Velocity of efflux, $v_e = \sqrt{2gh}$ , clearly $v_e$ depends on $g$ and $h$.

**57.** **(d)** For gases, $\eta \propto \sqrt{T}$ ; for liquids, η increases with increase in pressure, whereas for gases, η is independent of pressure.

**58.** **(c)** **59.** **(d)**

**60.** **(b)** Surface tension depends on the temperature like viscosity, surface tension decreases with rise in temperature.

**61.** **(c)**

## MATCHING TYPE QUESTIONS

**62.** **(a)** (A)→(3) ; (B)→(2) ; (C)→(1) ; (D)→ (4)

**63.** **(a)** **64.** **(c)** **65.** **(a)** **66.** **(d)**

**67.** **(c)** **68.** **(b)** **69.** **(b)**

## DIAGRAM TYPE QUESTIONS

**70.** **(d)** Pressure = hρg i.e. pressure at the bottom is independent of the area of the bottom of the tank. It depends onthe height of water upto which the tank is filled with water. As is both the tanks, the levels of water are the same, pressure at the bottom is also the same.

**71.** **(d)** From the figure it is clear that liquid 1 floats on liquid 2. The lighter liquid floats over heavier liquid. Therefore we can conclude that $\rho_1 < \rho_2$

Also $\rho_3 < \rho_2$ otherwise the ball would have sink to the bottom of the jar.

Also $\rho_3 > \rho_1$ otherwise the ball would have floated in liquid 1. From the above discussion we conclude that

$$\rho_1 < \rho_3 < \rho_2.$$

**72.** **(b)** $\rho_{oil} < \rho < \rho_{water}$

Oil is the least dense of them so it should settle at the top with water at the base. Now the ball is denser than oil but less denser than water. So it will sink through oil but will not sink in water. So it will stay at the oil-water interface.

**73.** **(a)** Mass of liquid in horizontal portion of U-tube = Adρ

Pseudo force on this mass = Adρa

Force due to pressure difference in the two limbs

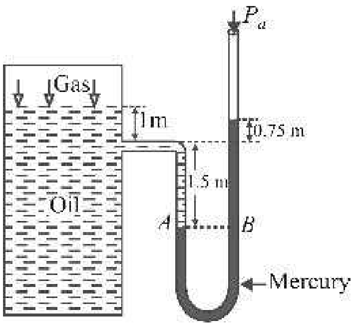
$$= (h_1\rho g - h_2\rho g)\ A$$

Equating both the forces

$$(h_1 - h_2)\ \rho gA = Ad\rho a$$

$$\Rightarrow \quad (h_1 - h_2) = \frac{Ad\rho a}{\rho gA} = \frac{ad}{g}$$

**74.** **(a)**



Suppose $P_{gas}$ is the pressure of the gas on the oil. As the points $A$ and $B$ are at the same level in the mercury columns, so

$$P_A = P_B$$

$$\text{or} \quad P_{gas} + \rho_{oil}\, gh_{oil} = P_a + \rho_{Hg}\, g\, h_{Hg}$$

or $P_{gas} + 820 \times 9.8 \times (1 + 1.50) =$

$$P_a + 13.6 \times 10^3 \times 9.8 \times (1.5 + 0.75)$$

or $P_{gas} + 20.09 \times 10^3 = P_a + 299.88 \times 10^3$

$\therefore \quad P_{gas} - Pa = 299.88 \times 10^3 - 20.09 \times 10^3$

or $[P_{gas}]_{gauge} = 279.8 \times 10^3 \text{ N/m}^2$

$= 2.8 \times 10^5 \text{ N/m}^2$

Absolute pressure of gas

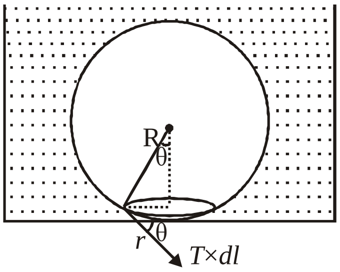
$[P_{gas}]_{\text{absolute}} = [P_{gas}]_{gauge} + P_a$

$= 2.8 \times 10^5 + 1.01 \times 10^5$

$= 3.81 \times 10^5 \text{ N/m}^2$

**75.** **(b)** The candle floats on the water with half its length above and below water level. Let its length be 10 cm. with 5 cm. below the surface and 5 cm. above it. If its length is reduced to 8 cm, it will have 4 cm. above water surface. So we see tip going down by 1 cm. So rate of fall of tip = 1 cm/hour.

**76.** **(b)** None of the given option is correct.
When the bubble gets detached,
Bouyant force = force due to surface tension



Force due to excess pressure = upthrust

Access pressure in air bubble = $\frac{2T}{R}$

$$\frac{2T}{R}(\pi r^2) = \frac{4\pi R^3}{3T}\rho_w g$$

$$\Rightarrow \quad r^2 = \frac{2R^4 \rho_w g}{3T} \Rightarrow r = R^2\sqrt{\frac{2\rho_w g}{3T}}$$

**77.** **(d)** At equilibrium, weight of the given block is balanced by force due to surface tension, i.e.,
2L. S = W

or $S = \frac{W}{2L} = \frac{1.5 \times 10^{-2}\, N}{2 \times 0.3\, m} = 0.025 Nm^{-1}$

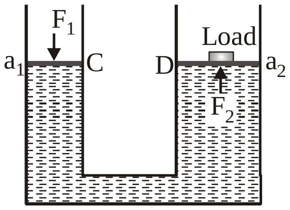
## ASSERTION- REASON TYPE QUESTIONS

**78.** **(b)** Since mercury is a most dense liquid available therefore by using it, barometric arrangement will be of very convinient size.

**79.** **(c)** In case of iron needle, the weight of water displaced by the needle is much less than the weight of the needle, hence it sinks but in case of a large iron ship the weight of water displaced by the ship is higher than the weight of the ship, hence it floats in water.

**80.** **(a)**

**81.** **(b)** According to Pascal's law, if gravity effect is neglected, the pressure at every point of liquid in equilibrium of rest is same



$P_1 = P_2$ i.e., $\frac{F_1}{a_1} = \frac{F_2}{a_2}$ or $F_2 = \frac{a_2}{a_1} F_1$

As $a_2 >> a_1 \therefore F_2 >> F_1$
This shows that small force ($F_1$) applied onthe smaller piston (of area $a_1$) will be appearing as a very large force onthe larger piston.

**82.** **(a)** Since the net buoyant force on the brick completely submerged in water is independent of its depth below the water surface, the man will have to exert same force on both the bricks. Hence statement 1 is true, statement 2 is a correct explanation for statement 1.

**83.** **(a)** Height of the blood column in the human body is more at feet than at the brain. As P = hρg. therefore the blood exerts more pressure at the feet than at the brain.

**84.** **(d)** Since due to applied force on liquid, the pressure is transmitted equally in all directions inside the liquid. That is why there is no fixed direction for the pressure due to liquid. Hence hydrostatic pressure is a scalar quantity.

**85.** **(a)**

**86.** **(a)** Since, the fluid move from higher pressure to lower pressure and in a fluid, the pressure increase with increase of depth. Hence, the pressure $p_0$ will be lesser at the top than that at the bottom ($p_0$ + hρg). So, the air bubble moves from the bottom to the top and does not move sideways, since the pressure is same at the same level. Further in coming from bottom to top the pressure decreases. According to Boyle's law pV = constant.

Therefore, if pressure decreases the volume increses, it means radius increases

**87.** **(a)** **88.** **(a)** **89.** **(a)**

**90.** **(d)** Pressure of water reduces when it comes from wide pipe to narrow pipe. According to equation of continuity, av = constant. As the water flows from wider tube to narrow tube, its velocity increases. According to Bernouli prinicple, where velocity is large pressure is less.

**91.** **(a)**

**92.** **(d)** Surface tension of oils and paints is kept low so that it can spread over larger area.

**93.** **(d)** **94.** **(c)**

**95.** **(c)** The two glass plates stick together due to surface tension.

**96.** **(d)** The soap solution, has less surface tension as compared to ordinary water and its surface tension decreases further on heating. The hot soap solution can, therefore spread over large surface area and also it has more wetting power. It is on account of this property that hot soap solution can penetrate and clean the clothes better than the ordinary water.

**97.** **(b)** We know that the intermolecular distance between the gas molecules is large as compared to that of liquid. Due to it the forces of cohesion in the gas molecules are very small and these are quite large for liquids. Therefore, the concept of surface tension is applicable to liquid but not to gases.

**98.** **(a)** $h = \frac{2T}{Rdg} \Rightarrow hR = \frac{2T}{dg} \quad \therefore hR = \text{constant}$

Hence when the tube is of insufficient length, radius of curvature of the liquid meniscus increases, so as to maintain the product hR a finite constant.

i.e., as h decreases, R increases and the liquid meniscus becomes more and more flat, but the liquid does not overflow.

## CRITICALTHINKING TYPE QUESTIONS

**99.** **(d)** Let $V_i$ be the volume of the iceberg inside sea water and V is the total volume of iceberg.

Total weight of iceberg

= weight of water displaced by iceberg.

$$V.\rho_{ice}\, g = V_i.\rho_{water}.g \Rightarrow \frac{V_i}{V} = \frac{\rho_{ice}}{\rho_{water}} = \frac{0.92}{1.03}$$

Thus the fraction of total volume of iceberg above the sea level

$$= \left(\frac{V - V_i}{V}\right) \times 100\% = \frac{\left[V - \left(\frac{0.92}{1.03}\right)V\right]}{V} \times 100\%$$

$$= \left(1 - \frac{0.92}{1.03}\right) \times 100\% = \frac{0.11}{1.03} \times 100\% \approx 11\%$$

**100.** **(b)** The volume of liquid displaced by floating ice $V_D = \frac{M}{\sigma_L}$

Volume of water formed by melting ice, $V_F = \frac{M}{\sigma_w}$

If $\sigma_L > \sigma_w$, then $\frac{M}{\sigma_L} < \frac{M}{\sigma_w}$ i.e., $V_D < V_F$

i.e., volume of liquid displaced by floating ice will be lesser than water formed and so the level if liquid will rise.

**101.** **(d)** Weight of submerged part of the block

$$W = \frac{1}{3} v \text{ (Density of water) g} \qquad ...(i)$$

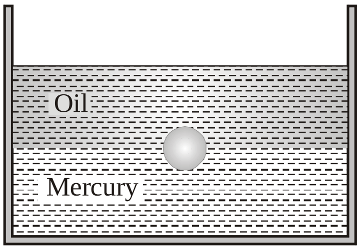
Excess weight, = weight of water having $\frac{2}{3}$ volume of the block.

$$W' = \frac{2}{3} v \text{ (Density of water) g} \qquad ...(ii)$$

Dividing (ii) by (i),

$$\frac{W'}{W} = \frac{2/3}{1/3} \quad \therefore \; W' = 2W \Rightarrow W' = 2 \times 6 = 12 \text{ kg}$$

**102.** **(c)**



As the sphere floats in the liquid. Therefore its weight will be equal to the upthrust force on it

$$\text{Weight of sphere} = \frac{4}{3}\pi R^3 \rho g \qquad \ldots(i)$$

Upthrust due to oil and mercury

$$= \frac{2}{3}\pi R^3 \times \sigma_{oil}\, g + \frac{2}{3}\pi R^3 \sigma_{Hg}\, g \qquad \ldots(ii)$$

Equating (i) and (ii)

$$\frac{4}{3}\pi R^3 \rho g = \frac{2}{3}\pi R^3 0.8g + \frac{2}{3}\pi R^3 + 13.6g$$

$$\Rightarrow 2\rho = 0.8 + 13.6 = 14.4 \Rightarrow \rho = 7.2$$

**103.** **(c)** Since pressure is transmitted undiminished throughout the fluid (Pascal's law)

$$F_1 = \frac{A_1}{A_2} F_2 = \frac{\pi\,(5 \times 5)}{\pi\,(15 \times 15)}(1350 \times 9.81)$$

$$\approx 1.5 \times 10^3 \text{ N}$$

The air pressure that will produce this force is

$$P = \frac{F_1}{A_1} = \frac{1.5 \times 10^3}{\pi\,(5 \times 10^{-2}\,\text{m})^2} = 1.9 \times 10^5 \text{ Pa}$$

**104.** **(a)** Total cross-sectional area of the thigh bones

$A \;\; = 2\,(10 \times 10^{-4}) = 2 \times 10^{-3}\,\text{m}^2$

Force acting on the bones = $mg = 40 \times 10$

= 400 N

$$\therefore \; P_{av} = \frac{F}{A} = \frac{400}{2 \times 10^{-3}} = 2 \times 10^5 \text{ N/m}^2$$

**105. (c)** Weight of the bowl = mg

$$= V\rho g = \frac{4}{3}\pi\left[\left(\frac{D}{2}\right)^3 - \left(\frac{d}{2}\right)^3\right]\rho g$$

Where D = Outer diameter

d = Inner diameter , ρ = Density of bowl

Weight of the liquid diplaced by the bowl

$$= V\sigma g = \frac{4}{3}\pi\left(\frac{D}{2}\right)^3 \sigma g$$

where σ is the density of the liquid
For the floation

$$\frac{4}{3}\pi\left(\frac{D}{2}\right)^3 \sigma g = \frac{4}{3}\pi\left[\left(\frac{D}{2}\right)^3 - \left(\frac{d}{2}\right)^3\right] pg$$

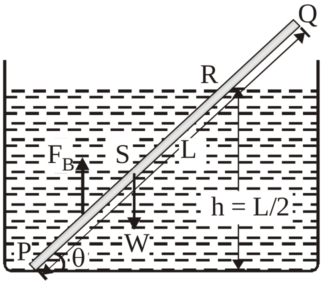
$$\Rightarrow \left(\frac{1}{2}\right)^3 \times 1.2 \times 10^3 = \left[\left(\frac{1}{2}\right)^3 - \left(\frac{d}{2}\right)^3\right] 2 \times 10^4$$

By solving we get d = 0.98 m.

**106. (a)** Let L = PQ = length of rod

$\therefore$ SP = SQ = $\frac{L}{2}$

Weight of rod, W = A$l$ρg. acting
At point S



And force of buoyancy,

$F_B = Al\rho_0 g$ . [$l$ = PR]
Which acts at mid-point of PR.
For rotational equilibrium.

$$Al\rho_0 g \times \frac{\ell}{2}\cos\theta = AL\rho g \times \frac{L}{2}\cos\theta$$

$$\Rightarrow \frac{l^2}{L^2} = \frac{\rho}{\rho_0} \Rightarrow \frac{l}{L} = \sqrt{\frac{\rho}{\rho_0}}$$

From figure, $\sin\theta = \frac{h}{l} = \frac{L}{2l} = \frac{1}{2}\sqrt{\frac{\rho_0}{\rho}}$

**107. (a)** Air flows just above the roof and there is no air flow just below the roof inside the room. Therefore $v_1 = 0$ and $v_2$ = v. Applying Bermaulli's theorem at the points inside and outside the roof, we obtain.

$(1/2)\ \rho v_1^2 + \rho g h_1 + P_1 = (1/2)\ \rho v_2^2 + \rho g h_2 + P_2$.
Since $h_1 = h_2 = h$, $v_1 = 0$ and $v_2 = v_1$

$P_1 = P_2 + 1/2\ \rho v^2$
$P_1 - P_2 = \Delta P = 1/2\ \rho v^2$.
Since the area of the roof is A, the aerodynamic lift exerted on it = F = (ΔP) A

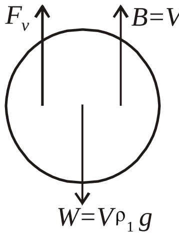
$\Rightarrow$ F = 1/2 $\rho A v^2$

where ρ = density of air = 1.3 kg/$m^3$

A = 20 $m^2$, v = 29.44 m/sec.

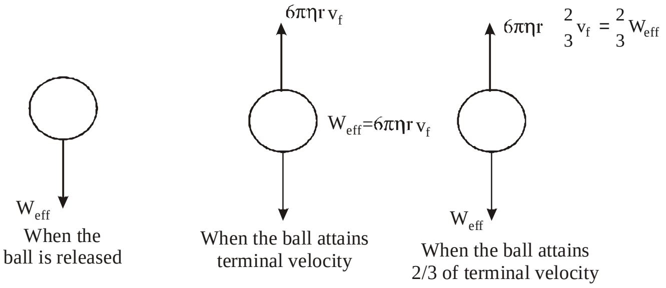
$\Rightarrow$ F = {1/2 × 1.3 × 20 × $(29.44)^2$} N = 1.127 × $10^4$ N.

**108. (a)** The condition for terminal speed ($v_t$) is
Weight = Buoyant force + Viscous force



$$\therefore V\rho_1 g = V\rho_2 g + kv_t^2 \qquad \therefore v_t = \sqrt{\frac{Vg(\rho_1 - \rho_2)}{k}}$$

**109. (b)**



When the ball is just released, the net force on ball is $W_{eff}$ (= mg – buoyant force)

The terminal velocity $v_f$ of the ball is attained when net force on the ball is zero.

$\therefore$ Viscous force $6\pi\eta r\ v_f = W_{eff}$

When the ball acquires $\frac{2}{3}$rd of its maximum velocity

$v_f$ the viscous force is = $\frac{2}{3}W_{eff}$

Hence net force is $W_{eff} - \frac{2}{3}W_{eff} = \frac{1}{3}W_{eff}$

$\therefore$ required acceleration is a/3

**110. (d) When the electric field is on**

Force due to electric field = weight

$$qE = mg \Rightarrow qE = \frac{4}{3}\pi R^3 \rho g$$

$$\therefore q = \frac{4\pi R^3 \rho g}{3E} \qquad ...(i)$$

**When the electric field is switched off**

Weight = viscous drag force

$$mg = 6\pi\eta R v_t$$

$$\frac{4}{3}\pi R^3 \rho g = 6\pi\eta R v_t$$

$$\therefore R = \sqrt{\frac{9\eta v_t}{2\rho g}} \qquad \text{...(ii)}$$

From (i) & (ii) $g = \frac{4}{3}\pi\left[\frac{9\eta v_t}{2\rho g}\right]^{\frac{3}{2}} \times \frac{\rho g}{E}$

$$= \frac{4}{3}\times\pi\left[\frac{9\times1.8\times10^{-5}\times2\times10^{-3}}{2\times900\times9.8}\right]^{\frac{3}{2}}\times\frac{900\times9.8\times7}{81\pi\times10^5}$$

$= 7.8 \times 10^{-19}$ C

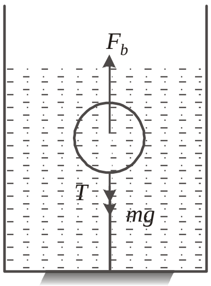
**111. (d)** $T + mg = F_b$

$\therefore \quad T = F_b - mg$

$= V\rho_w g - mg$

$= \frac{m}{(\rho_w/\eta)}\rho_w g - mg$

$= (\eta - 1)mg$ .



**112. (d)** Using the formula of the terminal velocity of a body falling through a viscous medium,

$$V = \frac{2r^2(\rho-\sigma)g}{9\eta} \Rightarrow \eta = \frac{2r^2(\rho-\sigma)g}{9v}$$

Where ρ is the density of material of body and σ is the density of medium.

In case of the air bubble ρ = 1 and σ = 1.47 × $10^3$ kg/ms and the air bubble rises up.

$$\eta = \frac{2r^2\sigma g}{9V}$$

$$= \frac{2\times(10^{-2})^2\times1.47\times10^3\times9.8}{9\times0.21\times10^{-2}} = \frac{2\times1.47\times9.8\times10}{9\times0.21}$$

= 1.52 × $10^3$ decapoise = 1.52 × $10^4$ Poise

**113. (a)** dv = 8 cm/s and dx = 0.1 cm

Velocity gradient = $\frac{dv}{dx} = \frac{8}{0.1} = 80/s.$

**114. (b)** $v \propto \frac{\rho - \rho_0}{\eta}$

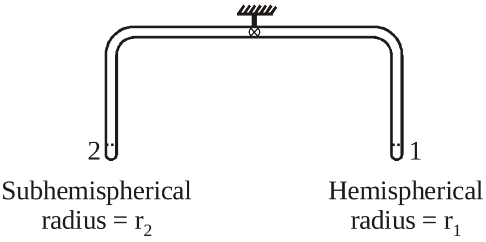
$$\therefore \frac{v_2}{v_1} = \frac{\rho-\rho_{02}}{\rho-\rho_{01}}\times\frac{\eta_1}{\eta_2} = \frac{7.8-1.2}{7.8-1}\times\frac{8.5\times10^{-4}\times10}{13.2}$$

$= 6.25 \times 10^{-4}$ cms$^{-1}$

**115. (b)** Pressure inside tube = $P = P_0 + \frac{4T}{r}$

$\therefore P_2 < P_1$ (since $r_2 > r_1$)

Hence pressure on side 1 will be greater than side 2. So air from end 1 flows towards end 2



**116. (c)** Velocity of efflux v = $\sqrt{2gh}$

$$= \sqrt{2\times10\times0.2} = 2 \text{ ms}^{-1}$$

**117. (a)** Volumes of two soap bubbles

$$V_1 = \frac{4}{3}\pi r_1^3 \text{ and } V_2 = \frac{4}{3}\pi r_2^3$$

where $r_1$ and $r_2$ are the radii of soap bubbles.

Let s be the surface tension of the soap solution. The excess pressure inside the two soap bubbles, then

$$P_1 = \frac{4S}{r_1} \text{ and } P_2 = \frac{4S}{r_2}$$

When these two bubbles coalesce under isothermal conditions a bigger bubble of radius $R$ is formed. If $V$ and $P$ be the volume and excess pressure inside this bigger bubble, then

$$V = \frac{4}{3}\pi R^3 \text{ and } P = \frac{4S}{R}$$

Here Boyle's law holds as the bigger bubble is formed under isothermal conditions

i.e., $P_1V_1 + P_2V_2 = PV$

$$\frac{4S}{r_1}\times\frac{4}{3}\pi r_1^3 + \frac{4S}{r_2}\times\frac{4}{3}\pi r_2^3 = \frac{4S}{R}\times\frac{4}{3}\pi R^3$$

$$\Rightarrow \quad r_1^2 + r_2^2 = R^2 \text{ or } R = \sqrt{r_1^2 + r_2^2}$$

**118. (a)** Pressure difference between lungs and atmosphere

= (760 – 750) mm of Hg

= 10 mm of Hg = 1 cm of Hg

Let the boy can suck water from depth $h$. Then

Pressure difference = $h\rho_{\text{water}}g$ = 1 cm of Hg

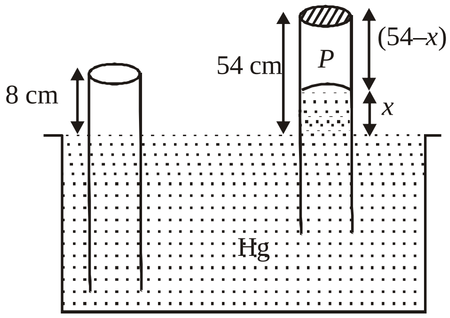
or, $h$ × 1g cm$^{-3}$ × 980 cm s$^{-2}$

= 1 cm × 13.6g cm$^{-3}$ × 980 cm s$^{-2}$

$\therefore \quad h$ = 13.6 cm

The boy can suck water from the depth of 13.6 cm

**119. (a)**



Length of the air column above mercury in the tube is,

$P + x = P_0$

$\Rightarrow \quad P = (76 - x)$

$\Rightarrow \quad 8 \times A \times 76 = (76 - x) \times A \times (54 - x)$

$\therefore \quad x = 38$

Thus, length of air column = 54 – 38 = 16 cm.

**120. (d)** When stones are inside and float, water displacement = V.p

When inside water displacement is V only.

Then water level falls.

**121. (d)** From stoke's law, $F = 6\pi\eta R_1 v$, and $V = \frac{4}{3}\pi R^3$

$F' = 6\pi\eta R_2 v, \left(\text{volume } 8\text{ V} = \frac{4}{3}\pi(2R)^3\right)$

$= 6\pi\eta(2R)v$

$= 2F$

**122. (d)** Surface tension = 0.075 N/m; diameter = 30 cm = 0.30 m

$\therefore$ Force = 0.075 × 0.30 = 0.0225 N = $2.25 \times 10^{-2}$N.

**123. (c)** Work done = Surface tension × increase in area of the film

$W = S \times \Delta A$

Increase in area = Final area – initial area

$= 10 \times (0.5 + 0.1) - 10 \times 0.5 = 1\text{ cm}^2$

$\therefore \quad W = 72 \times 2 \times 1 = 144$ erg

[$\because$ There are 2 free surfaces; $\therefore \ \Delta A = 2 \times 1$].

**124. (c)** Work done, W = S [2 × (Change in area)]

[$\because$ there are two free surface]

$$\text{Surface tension, } S = \frac{W}{2 \times (\text{change in area})}$$

$$= \frac{3 \times 10^{-4}}{2 \times 10(11 - 6) \times (10^{-2})^2} = 3 \times 10^{-2}\text{ N/m}$$

**125. (a)** $W = T\Delta A = 4\pi R^2 T(n^{1/3} - 1)$

$= 4 \times 3.14 \times (10^{-2})^2 \times 460 \times 10^{-3}\,[(10^6)^{1/3} - 1] = 0.057$

**126. (c)** Work done = Change in surface energy

$\Rightarrow W = 2T \times 4\pi\,(R_2^2 - R_1^2)$

$= 2 \times 0.03 \times 4\pi[(5)^2 - (3)^2] \times 10^{-4}\text{J} = 0.4\,\pi\,\text{mJ}$

**127. (d)** Excess pressure inside the soap bubble = $\frac{4S}{r}$

So the pressure inside the soap bubble = $P_{atm} + \frac{4S}{r}$

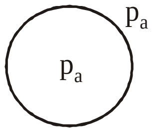
From ideal gas equation $PV = nRT$

$$\frac{P_A V_A}{P_B V_B} = \frac{n_A}{n_B} \Rightarrow \frac{\left(8 + \frac{4S}{r_A}\right)\frac{4}{3}\pi(r_A)^3}{\left(8 + \frac{4S}{r_B}\right)\frac{4}{3}\pi(r_B)^3} = \frac{n_A}{n_B}$$

Substituting S = 0.04 N/m, $r_A$ = 2cm, $r_B$ = 4 cm.

$\frac{n_A}{n_B} = \frac{1}{6} \qquad \therefore \quad \frac{n_B}{n_A} = 6$.

**128. (a)** Inside pressure must be $\frac{4T}{r}$ greater than outside pressure in bubble.

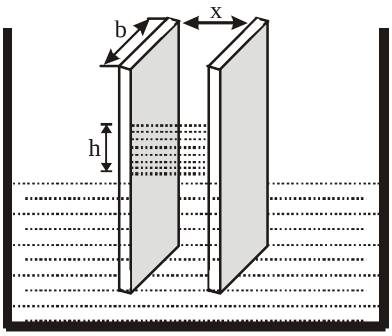


This excess pressure is provided by charge on bubble.

$$\frac{4T}{r} = \frac{\sigma^2}{2\varepsilon_0}; \quad \frac{4T}{r} = \frac{Q^2}{16\pi^2 r^4 \times 2\varepsilon_0} \left[\sigma = \frac{Q}{4\pi r^2}\right]$$

$$Q = 8\pi r\sqrt{2rT\varepsilon_0}$$

**129. (b)**



Let the width of each plate is b and due to surface tension liquid will rise upto height h then upward force due to surface tension.

$= 2Tb\cos\theta$ ...(i)

Weight of the liquid rises in between the plates

$= Vdg = (bxh)dg$ ...(ii)

Equating (i) and (ii) we get, $2T\cos\theta = xhdg$

$\therefore \ h = \frac{2T\cos\theta}{xdg}$

**130. (c)** Water fills the tube entirely in gravity less condition i.e., 20 cm.

**131. (d)** For rise in capillary, the formula is $h = \frac{2T}{r\rho g}$

So, for first capillary tube $h_1 = \frac{2T}{r_1 \rho g}$

For second, $h_2 = \frac{2T}{r_2\rho g}$

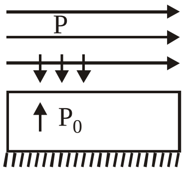
$$\frac{h_1}{h_2} = \frac{r_2}{r_1} \Rightarrow \frac{3}{h_2} = \frac{r_1}{3\times r_1} \quad \left[r_2 = \frac{r_1}{3}\right]$$

$h_2 = 9\text{mm}$

**132. (b)** According to Bernoulli's theorem,

$$P + \frac{1}{2}\rho v^2 = P_0 + 0$$

So, $\Delta P = \frac{1}{2}\rho v^2$



$F = \Delta PA = \frac{1}{2}\rho v^2 A$

$= \frac{1}{2} \times 1.2 \times 40 \times 40 \times 250$

$= 2.4 \times 10^5$ N (upwards)

**133. (d)** In the satellite , the weight of the liquid column is zero. So the liquid will rise up to the top of the tube.

**134. (a)** Weight of the liquid column = T cosθ × 2πr.
For water θ= 0°. Here weight of liquid column W = 7.5 × $10^{-4}$N and T = 6 × $10^{-2}$N/m. Then circumference, 2πr = W/T = 1.25 × $10^{-2}$m

**135. (b)** $T = \frac{F}{2\pi r} = \frac{6.28\times10^{-4}}{2\times3.14\times2\times10^{-3}} = 5\times10^{-2}\ \text{N/m}$

**136. (b)** $h = \frac{2T}{rdg} = \frac{2\times6\times10^{-2}}{5\times10^{-4}\times10^{3}\times10} = 2.4\times10^{-2}\ \text{m} = 2.4\text{cm}$

**137. (d)** Since $h = \frac{2s\cos\theta}{h\rho g}$

if θ is obtuse, cos θ is negative. Hence h is negative and water is depressed in the tube.

**138. (d)** Here excess pressure, $P_{\text{excess}} = \frac{T}{r_1} + \frac{T}{r_2}$

$$P_{\text{excess}} = \frac{T}{R} \qquad \because \begin{pmatrix} r_1 = R \\ r_2 = O \end{pmatrix}$$

**139. (a)** Water rises upto the top of capillary tube and stays there without overflowing.

**140. (a)** Inflow rate of volume of the liquid = Outflow rate of volume of the liquid

$$\pi R^2V = n\pi r^2(v) \Rightarrow v = \frac{\pi R^2 V}{n\pi r^2} = \frac{VR^2}{nr^2}$$

**141. (c)** As surface area decreases so energy is released.
Energy released = $4\pi R^2T[n^{1/3} - 1]$
where $R = n^{1/3}r$

$$= 4\pi R^3T\left[\frac{1}{r} - \frac{1}{R}\right] = 3VT\left[\frac{1}{r} - \frac{1}{R}\right]$$

**142. (b)** For capillary rise, according, to zurin's law
$h_1r_1 = h_2r_2$
$6 \times 1 = h_2 \times 2 \Rightarrow h_2 = 3$ cm

# CHAPTER 11

# THERMAL PROPERTIES OF MATTER

## FACT/DEFINITION TYPE QUESTIONS

**1.** Heat is associated with
(a) kinetic energy of random motion of molecules
(b) kinetic energy of orderly motion of molecules
(c) total kinetic energy of random and orderly motion of molecules
(d) None of these

**2.** Heat content of a body depends on
(a) mass of the body (b) temperature of the body
(c) specific heat capacity (d) all of the above

**3.** Which of the following is not a unit of heat energy ?
(a) joule (b) kelvin
(c) calorie (d) None of these

**4.** Choose the correct equation for interconversion of temperature scales.
(a) $\frac{T_C - 0}{100} = \frac{T_F - 32}{180}$
(b) $\frac{T_F - 32}{180} = \frac{T_K + 273.15}{100}$
(c) $\frac{T_F - 32}{180} = \frac{T_K - 273.15}{180}$
(d) $\frac{T_C - 0}{180} = \frac{T_F - 32}{100}$

**5.** Which of the following pairs may give equal numerical values of the temperature of a body?
(a) Fahrenheit and Celsius
(b) Celsius and Kelvin
(c) Kelvin and Reaumur
(d) None of these

**6.** Expansion during heating
(a) occurs only in solids
(b) increases the weight of a material
(c) generally decreases the density of a material
(d) occurs at the same rate for all liquids and solids

**7.** When water is heated from 0°C to 4°C, its volume
(a) increases
(b) decreases
(c) does not change
(d) first decreases and then increases

**8.** 4200 J of work is required for
(a) increasing the temperature of 10 g of water through 10°C
(b) increasing the temperature of 100 g of water through 10°C
(c) increasing the temperature of 1 kg of water through 10°C
(d) increasing the temperature of 10 g of water through 10°C

**9.** Triple point of water is
(a) 273.16°F (b) 273.16 K
(c) 273.16°C (d) 273.16 R

**10.** The reading of Centigrade thermometer coincides with that of Fahrenheit thermometer in a liquid. The temperature of the liquid is
(a) – 40°C (b) 313°C
(c) 0°C (d) 100°C

**11.** Which of the following will expand the most for same rise in temperature?
(a) Aluminium (b) Glass
(c) Wood (d) All will expand same

**12.** Which of the following is an expression for heat capacity?
(a) $S = \frac{1}{m}\frac{\Delta Q}{\Delta T}$ (b) $S = \frac{\Delta Q}{\Delta T}$
(c) $S = \frac{1}{\mu}\frac{\Delta Q}{\Delta T}$ (d) All of the above

**13.** Which of the following is a poor conductor of heat ?
(a) Copper (b) Concrete
(c) Mercury (d) Air

**14.** If α, β and γ are coefficient of linear, area and volume expansion respectively, then
(a) $\gamma = 3\alpha$ (b) $\alpha = 3\gamma$
(c) $\beta = 3\alpha$ (d) $\gamma = 3\beta$

**15.** If two rods A and B of equal length L, and different areas of cross-section $A_1$ and $A_2$ have one end each at temperature $T_1$ and $T_2$, have equal rates of flow of heat, then

(a) $A_1 = A_2$ (b) $\frac{A_1}{A_2} = \frac{K_1}{K_2}$

(c) $\frac{A_1}{A_2} = \frac{K_2}{K_1}$ (d) $K_1 = K_2$

**16.** Mass of water which absorbs or emits the same amount of heat as is done by the body for the same rise or fall in temperature is known as

(a) thermal capacity of the body
(b) specific heat capacity of the body
(c) latent heat capacity of the body
(d) water equivalent of the body

**17.** Which of the following is the unit of specific heat

(a) J kg°C$^{-1}$ (b) J/kg°C
(c) kg°C/J (d) J/kg°C$^{-2}$

**18.** The equation $\frac{T_F - 32}{180} = \frac{T_c}{100}$, relates the Fahrenheit and Celsius scale temperature. The $T_F$ versus $T_c$ graph will be a

(a) straight line parallel to *x*-axis
(b) straight line parallel to *y*-axis
(c) straight line inclined to *x*-axis
(d) parabolic curve

**19.** Which of the following undergo sublimation ?

(a) Dry ice (b) Iodine
(c) Both (a) and (b) (d) None of these

**20.** The phenomenon of refreezing the water into ice on removing the increased pressure is called

(a) freezing (b) fusion
(c) sublimation (d) regelation

**21.** The value of molar heat capacity at constant temperature is

(a) zero (b) infinity
(c) unity (d) 4.2

**22.** The latent heat of vaporization of a substance is always

(a) greater than its latent heat of fusion
(b) greater than its latent heat of sublimation
(c) equal to its latent heat of sublimation
(d) less than its latent heat of fusion

**23.** A quantity of heat required to change the unit mass of a solid substance, from solid state to liquid state, while the temperature remains constant, is known as

(a) latent heat (b) sublimation
(c) hoar frost (d) latent heat of fusion

**24.** A bubble of n mole of helium is submerged at a certain depth in water. The temperature of water increases by Δt°C. How much heat is added approximately to helium during expansion?

(a) $nc_v\Delta t$ (b) $\frac{nc_p}{\Delta t}$

(c) $\frac{n^2c_v}{\Delta t}$ (d) $nc_p\Delta t$

**25.** Which of the following is used as a coolent in automobile radiator as well as a heater in hot water bags?

(a) Ice (b) Sand
(c) Water (d) All of these

**26.** ... A... and ...B... of heat energy required some material as a transport medium.
Hear, A and B refer to

(a) conduction, radiation
(b) radiation, convection
(c) conduction, convection
(d) radiation, evaporation

**27.** Which law is obeyed when temperature difference between the body and the surroundings is small?

(a) Stefan's law (b) Newton's law of cooling
(c) Planck's law (d) All of these

**28.** Heat is transmitted from higher to lower temperature through actual mass motion of the molecules in

(a) conduction (b) convection
(c) radiation (d) None of these

**29.** Good absorbers of heat are

(a) poor emitters (b) non-emitters
(c) good emitters (d) highly polished

**30.** Three bodies A, B and C have equal area which are painted red, yellow and black respectively. If they are at same temperature, then

(a) emissive power of A is maximum.
(b) emissive power of B is maximum.
(c) emissive power of C is maximum.
(d) emissive power of A, B and C are equal.

**31.** Sweet makers do not clean the bottom of cauldron because

(a) emission power of black and bright surface is more.
(b) absorption power of black and bright surface is more.
(c) black and rough surface absorbs more heat.
(d) transmission power of black and rough surface is more.

**32.** Lamp black absorbs radiant heat which is near about

(a) 90% (b) 98%
(c) 100% (d) 50%

**33.** At temperature T, the emissive power and absorption power of a body for certain wavelength are $e_\lambda$ and $a_\lambda$ respectively, then

(a) $e_\lambda = a_\lambda$
(b) $e_\lambda > a_\lambda$
(c) $e_\lambda < a_\lambda$
(d) there will not be any difinite relation between $e_\lambda$ and $a_\lambda$

**34.** Newton's law of cooling is applicable for

(a) any excess of temperature over the surrounding.
(b) small excess of temperature over the surrounding.
(c) large excess of temperature over the surrounding.
(d) very large excess of temperature over the surrounding.

**35.** Newton's law of cooling is also applicable to
(a) convection losses.
(b) natural convection losses.
(c) forced convection losses.
(d) conduction losses.

## STATEMENT TYPE QUESTIONS

**36.** A body *A* is at a temperature $T_A$ and a body *B* is at temperature $T_B$ such that $T_A > T_B$. Bodies *A* and *B* are connected. Which of the following statements is/are true related to two bodies ?
I. Body *A* is hotter than body *B*.
II. Heat flows from *A* to *B*.
III. Heat flows from *B* to *A*.
(a) I and II (b) Only I
(c) II and III (d) I and III

**37.** Consider the following statements and select the incorrect statements.
I. Water expands on heating between 0°C & 4°C
II. The density of water is minimum at 4°C
III. Density of water increases on heating above 4°C
IV. Water contracts on heating between 0°C & 4°C
(a) I and II only (b) III and IV only
(c) I , II and III (d) I, II, III and IV

**38.** Which of the following statements regarding specific heat capacity of a substance are correct ? It depends on
I. mass of substance.
II. nature of substance.
III. temperature of substance.
IV. volume of substance.
(a) I and II (b) II and III
(c) III and IV (d) I and IV

**39.** Consider the following statements and select the correct statement(s).
I. Water and ice have same specific heats
II. Water and ice have different specific heats
III. Specific heat of water is more than that of ice
IV. Specific heat of ice is more than that of water
(a) I only (b) II only
(c) II and III (d) III and IV

**40.** Consider the following statements and select the correct statement(s).
I. Copper is a better conductor of heat than glass.
II. Silver is the best condutor of heat
III. Thermal conductivity of steel is greater than that of copper.
(a) I only (b) II only
(c) I and II (d) II and III

**41.** Which of the following statements is/are correct ?
I. Gases are poor thermal conductors.
II. Liquids have conductivities intermediate between solids and gases
III. Heat conduction can be take less from old body to hotter body.
(a) Only I (b) Only II
(c) Only III (d) I and II

**42.** During vapourisation
I. change of state from liquid to vapour state occurs.
II. temperature remains constant.
III. both liquid and vapour states coexist inequilibrium.
IV. specific heat of substance increases.
Correct statements are
(a) I, II and IV (b) II, III and IV
(c) I, III and IV (d) I , II and III

**43.** Consider the following statements and select the correct statement(s).
I. Water can never be boiled without heating.
II. Water can be boiled below room temperature by lowering the pressure.
III. On releasing the excess pressure water refreezes into ice.
(a) I only (b) II only
(c) I and II (d) II and III

**44.** Which of the following statements is/are true ?
I. Steam causes more severe burns than boiling water.
II. Specific heat capacity of water is maximum
(a) I only (b) II only
(c) I and II (d) None of these

**45.** Which of the following statements is/ are false about mode of heat transfer?
I. In radiation, heat is transfered from one medium to another without affecting the intervening medium
II. Radiation and convection are possible in vaccum while conduction requires material medium.
III. Conduction is possible in solids while convection occurs in liquids and gases.
(a) I only (b) II only
(c) II and III (d) I, II and III

**46.** Which of the following statements is/are correct ?
I. Convection is a mode of heat transfer by actual motion of matter.
II. Convection is possible only in gases.
III. Convection can be natural or forced process in nature.
(a) Only I (b) I and III
(c) Only II (d) I, II and III

## MATCHING TYPE QUESTIONS

**47.** Match the quantities in column-I with the units in column-II.

| | **Column-I** | | **Column-II** |
|---|---|---|---|
| (A) | Amount of substance | (1) | J $kg^{-1}$ $K^{-1}$ |
| (B) | Coefficient of volume expansion | (2) | J $s^{-1}$ $K^{-1}$ |
| (C) | Specific heat | (3) | $K^{-1}$ |
| (D) | Thermal conductivity | (4) | mol |

(a) (A) → (4) ; (B) → (2) ; (C) → (3) ; (D) → (1)
(b) (A) → (4) ; (B) → (3) ; (C) → (1) ; (D) → (2)
(c) (A) → (2) ; (B) → (1) ; (C) → (4) ; (D) → (3)
(d) (A) → (2) ; (B) → (1) ; (C) → (4) ; (D) → (3)

**48.**

| | **Column-I** | | **Column-II** |
|---|---|---|---|
| (A) | Bimetalic strip | (1). | Change in length |
| (B) | Steam engine | (2) | Energy conversion |
| (C) | Linear expansion | (3) | Change in area |
| (D) | Area expansion | (4) | Thermal expansion |

(a) (A) → (4) ; (B) → (2) ; (C) → (3) ; (D) → (1)
(b) (A) → (4) ; (B) → (2) ; (C) → (1) ; (D) → (3)
(c) (A)→ (2) ; (B) → (1) ; (C) → (4) ; (D) → (3)
(d) (A) → (3) ; (B) → (4) ; (C) → (2) ; (D) → (1)

**49.** Match the column I and column II.

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | $PV = \mu RT$ | (1) | Molar specific heat |
| (B) | $\gamma = 3\alpha$ | (2) | Newton's law of cooling |
| (C) | $C = \frac{1}{\mu}\frac{\Delta Q}{\Delta T}$ | (3) | Ideal gas equation |
| (D) | $\frac{dQ}{dt} = -k(T_2 - T_1)$ | (4) | Coefficient of expansion |

(a) (A) → (4) ; (B) → (2) ; (C) → (3) ; (D) → (1)
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(c) (A)→ (3) ; (B) → (4) ; (C) → (1) ; (D) → (2)
(d) (A) → (3) ; (B) → (4) ; (C) → (2) ; (D) → (1)

**50.**

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Lowest temperature of water in a lake | (1) | Less than 4°C |
| (B) | Rate of variation of density (r) is zero | (2) | Coexistence of three phases of a substance. |
| (C) | Least volume of water | (3) | Surface tension is zero |
| (D) | Triple point | (4) | Equal to 4°C |

(a) (A) → (4) ; (B) → (2) ; (C) → (3) ; (D) → (1)
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(c) (A)→ (3) ; (B) → (4) ; (C) → (4) ; (D) → (2)
(d) (A) → (3) ; (B) → (4) ; (C) → (4) ; (D) → (2)

**51.**

| | **Column-I** | | **Column-II** |
|---|---|---|---|
| (A) | Specific heat capacity S | (1) | $l_1 - l_2$ = constant for $l_1\alpha_1 = l_2\alpha_2$ |
| (B) | Two metals $(l_1, a_1)$ and $(l_2, a_2)$ are heated uniformly | (2) | Y is same |
| (C) | Thermal stress | (3) | $S = \infty$ for $\Delta T = 0$ |
| (D) | Four wires of same material | (4) | $Y \propto \Delta t$ |

(a) (A) → (3) ; (B) → (1) ; (C) → (4) ; (D) → (2)
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(c) (A)→ (2) ; (B) → (1) ; (C) → (4) ; (D) → (3)
(d) (A) → (3) ; (B) → (4) ; (C) → (2) ; (D) → (1)

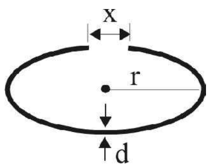
**52.** Three liquids A, B and C having same specific heat and mass m, 2m and 3m have temperatures 20°C, 40°C and 60°C respectively. Temperature of the mixture when

| | **Column-I** | | **Column-II** |
|---|---|---|---|
| (A) | A and B are mixed | (1). | 33.3°C |
| (B) | A and C are mixed | (2) | 52°C |
| (C) | B and C are mixed | (3) | 50°C |
| (D) | A, B and C all three are mixed | (4) | 46.67°C |

(a) (A) → (1) ; (B) → (3) ; (C) → (2) ; (D) → (4)
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(c) (A)→ (2) ; (B) → (1) ; (C) → (4) ; (D) → (3)
(d) (A) → (3) ; (B) → (4) ; (C) → (2) ; (D) → (1)

## DIAGRAM TYPE QUESTIONS

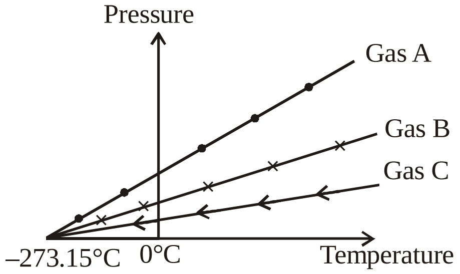
**53.** A cylindrical metal rod is shaped into a ring with a small gap as shown. On heating the system :



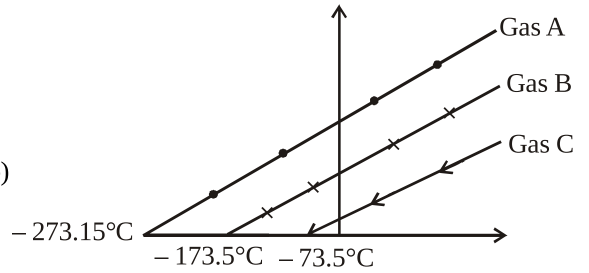
(a) *x* decreases, *r* and *d* increase
(b) *x* and *r* increase, *d* decreases
(c) *x*, *r* and d all increase
(d) *x* and *r* decreased, *d* remains constant

**54.** Which of the following graphs is correct for pressure versus temperature, for low density gases?

(a)

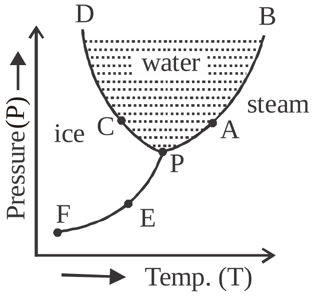


(b)



(c) Both (a) & (b) (d) None of these

**55.** In the given pressure-temperature diagram, for water, which point indicates triple point ?



(a) A

(b) C

(c) P

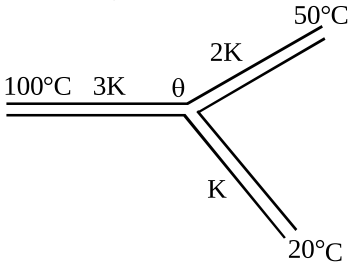
(d) E

**56.** In the diagram given above, the CD curve is known as

(a) hoarfrost line (b) steam line

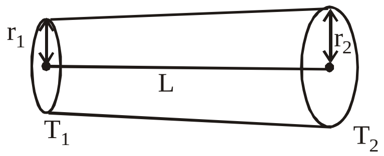
(c) vapourisation line (d) ice line

**57.** There rods of the same dimensions have thermal conductivities 3K, 2K and K. They are arranged as shown in fig. with their ends at 100°C, 50°C and 20°C. The temperature of their junction is



(a) 60° (b) 70° (c) 50° (d) 35°

**58.** The rate of heat flow through the cross-section of the rod shown in figure is ($T_2 > T_1$ and thermal conductivity of the material of the rod is K)



(a) $\frac{K\pi r_1 r_2 (T_2 - T_1)}{L}$ (b) $\frac{K\pi (r_1 + r_2)^2 (T_2 - T_1)}{4L}$

(c) $\frac{K\pi (r_1 + r_1)^2 (T_2 - T_1)}{L}$ (d) $\frac{K\pi (r_1 + r_1)^2 (T_2 - T_1)}{2L}$

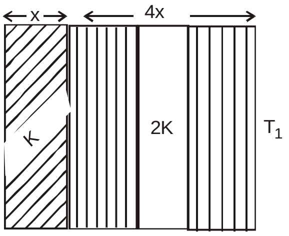
**59.** The temperature of the two outer surfaces of a composite slab, consisting of two materials having coefficients of thermal conductivity *K* and 2*K* and thickness *x* and 4*x*, respectively, are $T_2$ and $T_1 (T_2 > T_1)$. The rate of heat transfer through the slab, in a steady state is $\left(\frac{A(T_2 - T_1)K}{x}\right) f$, with f equal to

(a) $\frac{2}{3}$

(b) $\frac{1}{2}$

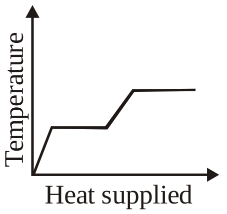
(c) 1

(d) $\frac{1}{3}$

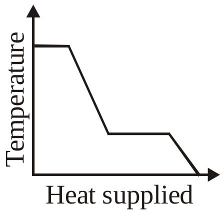


**60.** A block of ice at – 10°C is slowly heated and converted to steam at 100°C. Which of the following curves represents the phenomenon qualitatively

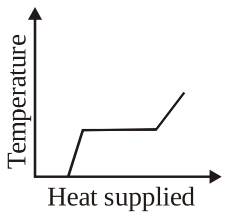
(a)



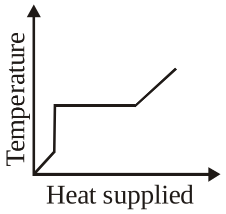
(b)



(c)



(d)



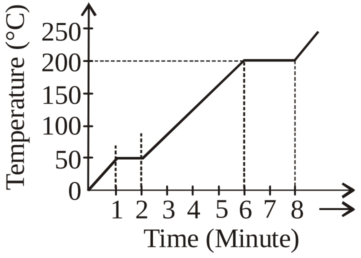
**61.** A student takes 50gm wax (specific heat = 0.6 kcal/kg°C) and heats it till it boils. The graph between temperature and time is as follows. Heat supplied to the wax per minute and boiling point are respectively

(a) 500 cal, 50°C

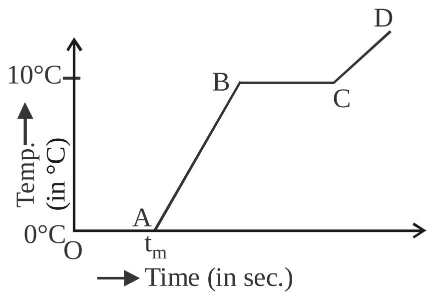
(b) 1000 cal, 100°C

(c) 1500 cal, 200°C

(d) 1000 cal, 200°C



**62.** In the plot of temperature versus time showing changes in the state of ice on heating, which part represents constant temperature ?



(a) OA (b) AB

(c) CD (d) All of these

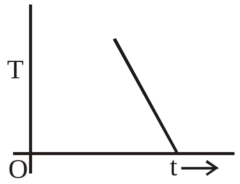
**63.** Which portion of the graph above indicates that two states co-exist in thermal equilibrium ?

(a) OA (b) BC

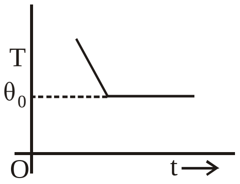
(c) Both (a) & (b) (d) None of these

**64.** If a piece of metal is heated to temperature θ and then allowed to cool in a room which is at temperature $\theta_0$, the graph between the temperature T of the metal and time t will be closest to

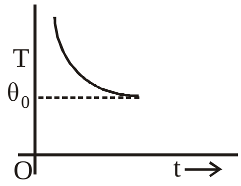
(a)



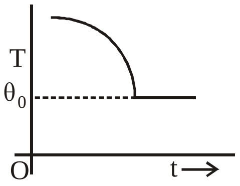
(b)



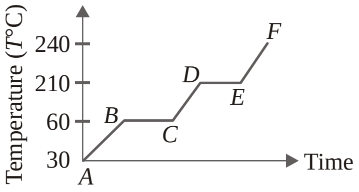
(c)



(d)



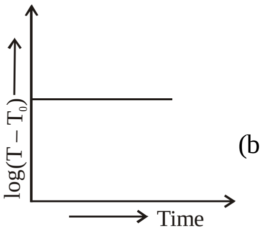
**65.** A solid substance is at 30°C. To this substance heat energy is supplied at a constant rate. Then temperature versus time graph is as shown in the figure. The substance is in liquid state for the portion (of the graph)



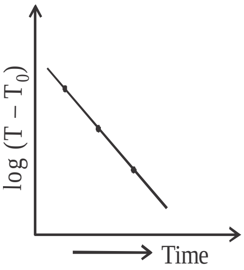
(a) *BC* (b) *CD*
(c) *ED* (d) *EF*

**66.** Which of the given graphs proves Newton's law of cooling?

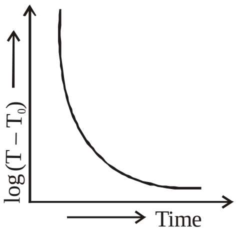
(a)



(b)



(c)



(d) None of these

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

**67.** **Assertion** : Fahrenheit is the smallest unit measuring temperature.

**Reason :** Fahrenheit was the first temperature scale used for measuring temperature.

**68.** **Assertion** : The temperature at which Centigrade and Fahrenheit thermometers read the same is –40°

**Reason :** There is no relation between Faherenheit and Centigrade temperature.

**69.** **Assertion :** It is hotter over the top of a fire than at the same distance on the sides.

**Reason :** Air surrounding the fire conducts more heat upwards.

**70.** **Assertion:** The triple point of water is a standard fixed point in modern thermometry.

**Reason:** The triple point of a substance is unique i.e. it occurs at one particular set of values of pressure and temperature.

**71.** **Assertion:** Copper expands five times more than glass for same rise in temperature.

**Reason:** Copper is five times far better conductor of heat than glass.

**72.** **Assertion:** In insulators electrons do not contribute to their conductivity.

**Reason:** In insulators, no free electrons are present, they cannot conduct heat.

**73.** **Assertion** : Specific heat capacity is the cause of formation of land and sea breeze.

**Reason :** The specific heat of water is more than land

**74.** **Assertion :** Specific heat of a body is always greater than its thermal capacity.

**Reason :** Specific heat capacity is required for raising temperature of unit mass of the body through unit degree.

**75.** **Assertion** : Two bodies at different temperature if brought in thermal contact do not necessary settle to the mean temperature.

**Reason :** The two bodies may have different thermal capacities.

**76.** **Assertion** : A beaker is completely filled with water at 4°C. It will overflow, both when heated or cooled.

**Reason :** There is expansion of water below and above 4°C.

**77.** **Assertion** : Water kept in an open vessel will quickly evaporate onthe surface of the moon.

**Reason :** The temperature at the surface of the moon is much higher than boiling point of the water.

**78.** **Assertion** : The melting point of ice decreases with increase of pressure.

**Reason :** Ice contracts on melting.

**79.** **Assertion** : The molecules at 0°C ice and 0°C water will have same potential energy.

**Reason :** Potential energy depens on temperature of the system.

**80.** **Assertion :** Melting of solid causes no change in internal energy.

**Reason :** Latent heat is the heat required to melt a unit mass of solid.

**81.** **Assertion:** The rate of cooling and the rate of loss of heat are same thing.

**Reason:** In both the cases, the material has to cool down and for a given material, rate of cooling and rate of loss of heat will be same.

## CRITICALTHINKING TYPE QUESTIONS

**82.** A metal sheet with a circular hole is heated. The hole

(a) gets larger

(b) gets smaller

(c) remains of the same size

(d) gets deformed

**83.** A solid ball of metal has a spherical cavity inside it. The ball is heated. The volume of cavity will

(a) decrease (b) increase

(c) remain unchanged (d) have its shape changed

**84.** On a linear temperature scale Y, water freezes at – 160° Y and boils at – 50° Y. On this Y scale, a temperature of 340 K would be read as : (water freezes at 273 K and boils at 373 K)

(a) – 73.7° Y (b) – 233.7° Y

(c) – 86.3° Y (d) – 106.3° Y

**85.** On heating a liquid of coefficient of cubical expansion $\gamma$ in a container having coefficient of linear expansion $\gamma/3$, the level of liquid in the container will

(a) rise

(b) fall

(c) remain almost stationary

(d) It is difficult to say

**86.** An iron tyre is to be fitted on to a wooden wheel 1m in diameter. The diameter of tyre is 6 mm smaller than that of wheel. The tyre should be heated so that its temperature increases by a minimum of (the coefficient of cubical expansion of iron is $3.6 \times 10^{-5}$/°C)

(a) 167°C (b) 334°C (c) 500°C (d) 1000°C

**87.** Water of volume 2 litre in a container is heated with a coil of 1 kW at 27°C. The lid of the container is open and energy dissipates at rate of 160 J/s. In how much time temperature will rise from 27°C to 77°C? [Given specific heat of water is 4.2 kJ/kg]

(a) 8 min 20 s (b) 6 min 2 s

(c) 7 min (d) 14 min

**88.** A beaker is filled with water at 4°C. At one time the temperature is increased by few degrees above 4°C and at another time it is decreased by a few degrees below 4°C. One shall observe that:

(a) the level remains constant in each case

(b) in first case water flows while in second case its level comes down

(c) in second case water over flows while in first case its comes down

(d) water overflows in both the cases

**89.** Assuming no heat losses, the heat released by the condensation of *x g* of steam at 100°C can be used to convert *y g* of ice at 0°C into water at 100°C, the ratio *x* : *y* is :

(a) 1 : 1 (b) 1 : 2

(c) 1 : 3 (d) 3 : 1

**90.** A glass flask is filled up to a mark with 50 cc of mercury at 18°C. If the flask and contents are heated to 38°C, how much mercury will be above the mark? ($\alpha$ for glass is $9 \times 10^{-6}$/°C and coefficient of real expansion of mercury is $180 \times 10^{-6}$/°C)

(a) 0.85 cc (b) 0.46 cc (c) 0.153 cc (d) 0.05 cc

**91.** A bar of iron is 10 cm at 20°C. At 19°C it will be ($\alpha$ of iron $= 11 \times 10^{-6}$/°C)

(a) $11 \times 10^{-6}$ cm longer (b) $11 \times 10^{-6}$ cm shorter

(c) $11 \times 10^{-5}$ cm shorter (d) $11 \times 10^{-5}$ cm longer

**92.** The coefficient of apparent expansion of mercury in a glass vessel is $153 \times 10^{-6}$/°C and in a steel vessel is $144 \times 10^{-6}$/°C. If $\alpha$ for steel is $12 \times 10^{-6}$/°C , then that of glass is

(a) $9 \times 10^{-6}$/°C (b) $6 \times 10^{-6}$/°C

(c) $36 \times 10^{-6}$/°C (d) $27 \times 10^{-6}$/°C

**93.** A lead bullet strikes against a steel plate with a velocity 200 m $s^{-1}$. If the impact is perfectly inelastic and the heat produced is equally shared between the bullet and the target, then the rise in temperature of the bullet is (specific heat capacity of lead = 125 J $kg^{-1}$ $K^{-1}$)

(a) 80°C (b) 60°C

(c) 160°C (d) 40°C

**94.** Certain amount of heat is given to 100 g of copper to increase its temperature by 21° C. If the same amount of heat is given to 50 g of water, then the rise in its temperature is

(Specific heat capacity of copper = 400 J $kg^{-1}$ $K^{-1}$ and that for water = 4200 J $kg^{-1}$ $K^{-1}$)

(a) 4° C (b) 5.25° C

(c) 8° C (d) 6° C

**95.** A hammer of mass 1 kg having speed of 50 m/s, hit a iron nail of mass 200 gm. If specific heat of iron is 0.105 cal/gm°C and half the energy is converted into heat. the raise in temperature of nail is

(a) 7.1°C (b) 9.2°C

(c) 10.5°C (d) 12.1°C

**96.** In an energy recycling process, 100 g of steam at 100°C becomes water at 100°C which converts y g of ice at 0°C into water at 100°C. The numeric value of y is

(a) 100 (b) 200 (c) 300 (d) 400

**97.** In a water-fall the water falls from a height of 100 m. If the entire K.E. of water is converted into heat, the rise in temperature of water will be

(a) 0.23°C (b) 0.46°C

(c) 2.3°C (d) 0.023°C

**98.** 19 g of water at 30°C and 5 g of ice at – 20°C are mixed together in a calorimeter. What is the final temperature of the mixture? Given specific heat of ice = 0.5 cal $g^{-1}(°C)^{-1}$ and latent heat of fusion of ice = 80 cal $g^{-1}$

(a) 0°C (b) –5°C

(c) 5°C (d) 10°C

**99.** Steam is passed into 22 g of water at 20°C . The mass of water that will be present when the water acquires a temperature of 90°C is (Latent heat of steam is 540 cal/gm)

(a) 24.8 gm (b) 24 gm (c) 36.6 gm (d) 30 gm

**100.** A 2 kg copper block is heated to 500°C and then it is placed on a large block of ice at 0°C. If the specific heat capacity of copper is 400 J/kg°C and latent heat of fusion of water is 3.5 × $10^5$ J/kg, the amount of ice that can melt is

(a) (7/8) kg (b) (7/5) kg
(c) (8/7) kg (d) (5/7) kg

**101.** Two spheres of different materials one with double the radius and one-fourth wall thickness of the other are filled with ice. If the time taken for complete melting of ice in the larger sphere is 25 minute and for smaller one is 16 minute, the ratio of thermal conductivities of the materials of larger spheres to that of smaller sphere is

(a) 4 : 5 (b) 5 : 4 (c) 25 : 8 (d) 8 : 25

**102.** Ice starts forming in a lake with water at 0ºC when the atomspheric temperature is –10ºC. If the time taken for the first 1 cm of ice to be formed is 7 hours, then the time taken for the thickness of ice to change from 1 cm to 2 cm is

(a) 7 hours (b) 14 hours
(c) 21 hours (d) 3.5 hours

**103.** A kettle with 2 litre water at 27°C is heated by operating coil heater of power 1 kW. The heat is lost to the atmosphere at constant rate 160J/sec, when its lid is open. In how much time will water heated to 77°C with the lid open? (specific heat of water = 4.2 kJ/kg)

(a) 8 min 20 sec (b) 6 min 2 sec
(c) 14min (d) 7min

**104.** Steam at 100°C is passed into 20 g of water at 10°C. When water acquires a temperature of 80°C, the mass of water present will be:

[Take specific heat of water = 1 cal $g^{-1}$ °$C^{-1}$ and latent heat of steam = 540 cal $g^{-1}$]

(a) 24 g (b) 31.5 g
(c) 42.5 g (d) 22.5 g

**105.** Certain quantity of water cools from 70°C to 60°C in the first 5 minutes and to 54°C in the next 5 minutes. The temperature of the surroundings is:

(a) 45°C (b) 20°C
(c) 42°C (d) 10°C

**106.** On observing light from three different stars P, Q and R, it was found that intensity of violet colour is maximum in the spectrum of P, the intensity of green colour is maximum in the spectrum of R and the intensity of red colour is maximum in the spectrum of Q. If $T_P$, $T_Q$ and $T_R$ are the respective absolute temperature of P, Q and R, then it can be concluded from the above observations that

(a) $T_P > T_R > T_Q$ (b) $T_P < T_R < T_Q$
(c) $T_P < T_Q < T_R$ (d) $T_P > T_Q > T_R$

**107.** The two ends of a metal rod are maintained at temperatures 100°C and 110°C. The rate of heat flow in the rod is found to be 4.0 J/s. If the ends are maintained at temperatures 200°C and 210°C, the rate of heat flow will be

(a) 16.8 J/s (b) 8.0 J/s
(c) 4.0 J/s (d) 44.0 J/s

**108.** The value of coefficient of volume expansion of glycerine is 5 × $10^{-4}$ $K^{-1}$. The fractional change in the density of glycerine for a rise of 40°C in its temperature, is:

(a) 0.020 (b) 0.025
(c) 0.010 (d) 0.015

**109.** Four identical rods of same material are joined end to end to form a square. If the temperature difference between the ends of a diagonal is 100°C, then the temperture difference between the ends of other diagonal will be

(a) 0°C (b) $\frac{100}{l}$°C (c) $\frac{100}{2l}$°C (d) 100°C

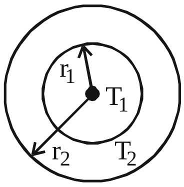
(where *l* is the length of each rod)

**110.** Three very large plates of same area are kept parallel and close to each other. They are considered as ideal black surfaces and have very high thermal conductivity. The first and third plates are maintained at temperatures 2*T* and 3*T* respectively. The temperature of the middle (i.e. second) plate under steady state condition is

(a) $\left(\frac{65}{2}\right)^{1/4} T$ (b) $\left(\frac{97}{4}\right)^{1/4} T$

(c) $\left(\frac{97}{2}\right)^{1/4} T$ (d) $(97)^{1/4}T$

**111.** The figure shows a system of two concentric spheres of radii $r_1$ and $r_2$ are kept at temperatures $T_1$ and $T_2$, respectively. The radial rate of flow of heat in a substance between the two concentric spheres is proportional to



(a) $In\left(\frac{r_2}{r_1}\right)$

(b) $\frac{(r_2 - r_1)}{(r_1 r_2)}$

(c) $(r_2 - r_1)$

(d) $\frac{r_1 r_2}{(r_2 - r_1)}$

**112.** 300 gm of water at 25°C is added to 100 g of ice at 0°C. The final temperature of the mixture is

(a) $-\frac{5}{3}$°C (b) $-\frac{5}{2}$°C (c) 5°C (d) 0°C

**113.** A slab of stone of area 0.36 $m^2$ and thickness 0.1 m is exposed on the lower surface to steam at 100°C. A block of ice at 0°C rests on the upper surface of the slab. In one hour 4.8 kg of ice is melted. The thermal conductivity of slab is :

(Given latent heat of fusion of ice = 3.36 × $10^5$ J $kg^{-1}$.) :

(a) 1.24 J/m°C (b) 1.29 J/m°C
(c) 2.05 J/m°C (d) 1.02 J/m°C

**114.** A partition wall has two layers of different materials A and B in contact with each other. They have the same thickness but the thermal conductivity of layer A is twice that of layer B. At steady state the temperature difference across the layer B is 50 K, then the corresponding difference across the layer A is

(a) 50 K (b) 12.5 K
(c) 25 K (d) 60 K

**115.** The length of a metallic rod is 5 m at 0°C and becomes 5.01 m, on heating upto 100°C. The linear expansion of the metal will be

(a) $2.33 \times 10^{-5}$/°C (b) $6.0 \times 10^{-5}$/°C
(c) $4.0 \times 10^{-5}$/°C (d) $2.0 \times 10^{-5}$/°C

**116.** A pendulum clock is 5 seconds fast at temperature of 15ºC and 10 seconds slow at a temperature of 30ºC. At what temperature does it give the correct time? (take time interval = 24 hours)

(a) 18ºC (b) 20ºC
(c) 22ºC (d) 25ºC

**117.** The tempertaure of equal masses of three different liquids A, B and C are 12°C, 19°C and 28°C respectively. The temperature when A and B are mixed is 16°C and when B and C are mixed is 23°C . The temperature when A and C are mixed is

(a) 18.2ºC (b) 22ºC (c) 20.2ºC (d) 25.2ºC

**118.** A solid copper cube of edges 1 cm each is suspended in an evacuated enclosure. Its temperture is found to fall from 100°C to 99°C in 100 s. Another solid copper cube of edges 2 cm, with similar surface nature, is suspended in a similar manner. The time required for this cube to cool from 100°C to 99°C will be approximately

(a) 25 s (b) 50 s (c) 200 s (d) 400 s

**119.** A body cools from 50.0°C to 49.9°C in 5s. How long will it take to cool from 40.0°C to 39.9°C? Assume the temperature of surroundings to be 30.0°C and Newton’s law of cooling to be valid

(a) 2.5 s (b) 10 s (c) 20 s (d) 5 s

**120.** In a room where the temperature is 30°C, a body cools from 61°C to 59°C in 4 minutes. The time (in minutes) taken by the body to cool from 51°C to 49°C will be

(a) 8 (b) 5 (c) 6 (d) 4

**121.** In a surrounding medium of temperature 10°C, a body takes 7 min for a fall of temperature from 60°C to 40°C. In what time the temperature of the body will fall from 40°C to 28°C?

(a) 7 min (b) 11 min
(c) 14 min (d) 21 min

**122.** A container contains hot water at 100°C. If in time $T_1$ temperature falls to 80° C and the time $T_2$ temperature falls to 60°C form 80°C, then

(a) $T_1 = T_2$ (b) $T_1 > T_2$
(c) $T_1 < T_2$ (d) None of these

**123.** Consider two hot bodies $B_1$ and $B_2$ which have temperatures 100°C and 80°C respectively at $t = 0$. The temperature of the surroundings is 40°C. The ratio of the respective rates of cooling $R_1$ and $R_2$ of these two bodies at $t = 0$ will be

(a) $R_1 : R_2 = 3 : 2$ (b) $R_1 : R_2 = 5 : 4$
(c) $R_1 : R_2 = 2 : 3$ (d) $R_1 : R_2 = 4 : 5$

# HINTS AND SOLUTIONS

## FACT / DEFINITION TYPE QUESTIONS

**1.** **(a)** **2.** **(d)**

**3.** **(b)** Kelvin is a unit of temperature.

**4.** **(a)** Temperature on celsius scale ($T_C$), kelvin scale ($T_K$) and Fahrenheit scale ($T_F$) are related as

$$\frac{T_C - 0}{100} = \frac{T_F - 32}{180} = \frac{T_K - 273.15}{100}$$

**5.** **(a)** The normal temperature of a person is 98.6°F or 37°C.

**6.** **(c)** Solids, liquids and gases all expand on being heated, as a result density (=mass/volume) decreases.

**7.** **(d)**

**8.** **(b)** Work done to raise the temperature of 100 gm water through 10°C is

$W = JQ = 4.2 \times (100 \times 10^{-3} \times 1000 \times 10) = 4200$ J

**9.** **(b)** Triple point of water is 273.16 K

**10.** **(a)** Let the readings of two thermometers coincide at $C = F = x$

As $\frac{C}{5} = \frac{F - 32}{9}$

$\therefore \frac{x}{5} = \frac{x - 32}{9}$

or $9x = 5x - 160$

$4x = -160, x = -40°C$

**11.** **(a)** Among glass, wood and metals, metals expand more for same rise in temperature.

**12.** **(b)** Heat capacity is the amount of heat absorbed by a substance for a unit rise in temperature.

$\Delta Q \propto \Delta T$

$\Delta Q = S\Delta T \Rightarrow S = \frac{\Delta Q}{\Delta T}$

**13.** **(d)** Thermal conductivity of air is very-very low 0.024.

**14.** **(a)** $V + \Delta V = (L + \Delta L)^3 = (L + \alpha L \Delta T)^3$

$= L^3 + (1 + 3\alpha\Delta T + 3\alpha^2\Delta T^2 + \alpha^3\Delta T^3)$

$\Rightarrow$ $\alpha^2$ and $\alpha^3$ terms are neglected.

$\therefore$ $V(1 + \gamma\Delta T) = V(1 + 3\alpha\Delta T)$

$1 + \gamma\Delta T = 1 + 3\alpha\Delta T$

$\therefore \gamma = 3\alpha$.

**15.** **(c)** $\frac{\Delta Q_1}{\Delta t} = \frac{\Delta Q_2}{\Delta t}$

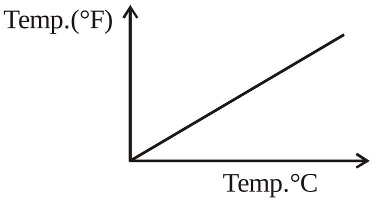
$$K_1A_1\frac{T_1 - T_2}{L_1} = K_2A_2\frac{T_1 - T_2}{L_2} \qquad (L_1 = L_2)$$

$\therefore \frac{A_1}{A_2} = \frac{K_2}{K_1}$

**16.** **(d)** Water equivalent is the quantity of water whose thermal capacity is same as the heat capacity of the body.

**17.** **(b)** $c = \frac{Q}{m\Delta\theta} \to \frac{J}{kg \times °C}$

**18.** **(c)**



**19.** **(c)** Dry ice and iodine pass from solid to vapour state without going into the liquid state.

**20.** **(d)**

**21.** **(b)** At constant temperature molar heat capacity

$C_T = \frac{\Delta Q}{n\Delta T}$

$T$ is const. $\Rightarrow \Delta T = 0$

$\therefore \quad C_T = \frac{\Delta Q}{0} = \infty$

**22.** (a) The latent heat of vaporization is always greater than latent heat of fusion because in liquid to vapour phase change there is a large increase in volume. Hence more heat is required as compared to solid to liquid phase change

**23.** **(d)**

**24.** **(d)** $H = nc_p\Delta t$

**25.** **(c)** Water has highest specific heat capacity and hence it is used as a coolant in car radiators as well as heater in hot water bags.

**26.** **(c)** Conduction and convection require some material as a transport medium. These modes of heat transfer cannot operate between bodies separated by distance in vacuum. But the Earth does receive heat from the Sun across a huge distance and we quickly feel the warmth of the fire near by even though air conducts poorly and before convection can set in. We receive heat from Sun by radiation. Radiation can occur in vacuum.

**27.** **(b)** When the temperature difference between the body and surroundings is small, then Newton's law of cooling is obeyed.

**28.** **(b)** **29.** **(c)** **30.** **(c)** **31.** **(c)** **32.** **(b)**
**33.** **(a)** **34.** **(b)** **35.** **(c)**

## STATEMENT TYPE QUESTIONS

**36.** **(a)** If $T_A > T_B$ body '*A*' is hotter than body B and heat flows from A to B i.e., from body at higher temperature to body at lower temperature till the temperature becomes same.

**37.** **(c)**

**38.** **(b)** Specific heat capacity is given by $C = \frac{S}{m} = \frac{1}{m}\frac{\Delta Q}{\Delta T}$

It is defined as the amount of heat per unit mass absorbed or rejected by the substance to change its temperature by one unit. It depends on the nature of the substance and its temperature. It is independent of mass of substance.

**39.** **(b)** Water and ice have different specific heats. Specific heat of water is 1 $Jg^{-1}°C^{-1}$ while that of water ice is 0.5 $Jg^{-1}°C^{-1}$.

**40.** **(c)** Thermal conductivity of copper is more than that of steel, hence stainless steel cooking pans are provided with extra copper bottoms.

**41.** **(d)** Gases are poor thermal conductors while liquids have conductive intermediate between solids and gases. Heat conduction may be described quantitatively as the time rate of heat flow in a material for a given temperature difference.

**42.** **(d)** The change of state from liquid to vapour (for gas) is called **vapourisation**. It is observed that when liquid is heated, the temperature remains constant untill the entire amount of the liquid is converted into vapour.

The temperature at which the liquid and the vapour states of the substance coexists is called its **boiling point**.

**43.** **(d)** Water can be boiled, even at low temperature on releasing the excess pressure, water refreezes into ice called regelation.

**44.** **(c)** **45.** **(b)**

**46.** **(b)** Convection is mode of heat transfer by actual motion of mater. It is possible only through its. Convection can be natural or forced. In natural convection, gravity plays an important part.

## MATCHING TYPE QUESTIONS

**47.** **(b)** **48.** **(b)**

**49.** **(c)** Ideal gas equation $PV = \mu RT$.

$\gamma = 3\alpha$, relation for coefficient of expansions

$c = \frac{1}{\mu}\frac{\Delta\theta}{\Delta T}$ gives molar specific heat

Newton's law of cooling

$$\frac{d\theta}{dT} = -k\,(T_2 - T_1)$$

**50.** **(c)** **51.** **(a)** **52.** **(a)**

## DIAGRAM TYPE QUESTIONS

**53.** **(b)** Material expands outward and so *x*, *r* increases. Due to linear expansion diameter of rod will increase.

**54.** **(a)** The graph refers to absolute zero which is same for low density gases.

**55.** **(c)** The three curves AB, CD and EF meet at point P which is called the triple point of water. It is the point where all three states solid, liquid and gas of water co-exists.

**56.** **(d)** Line CD is the border between ice and water. At every point of line CD, the temperature and pressure values are such that substance co-exist in solid and liquid phase.

**57.** **(b)** $\frac{dQ}{dt} = KA\frac{\Delta T}{L}$

For the first rod, $\left(\frac{dQ}{dt}\right)_1 = \frac{3KA}{L}(100-\theta)$

Similarly, $\left(\frac{dQ}{dt}\right)_2 = 2K\frac{A}{L}(\theta-50)$

$\left(\frac{dQ}{dt}\right)_3 = K\frac{A}{L}(\theta-20)$

Now, $\left(\frac{dQ}{dt}\right)_1 = \left(\frac{dQ}{dt}\right)_2 + \left(\frac{dQ}{dt}\right)_3$

$\Rightarrow\ 3\,(100-\theta) = 2\,(\theta-50) + (\theta-20)$

$\Rightarrow\ \theta = 70°$

**58.** **(a)** $r_{eff} = \sqrt{r_1 r_2}$

$$\frac{dQ}{dt} = \frac{KA(T_2-T_1)}{L} = \frac{K\pi r_1 r_2 (T_2-T_1)}{L}$$

**59.** **(d)** The thermal resistance is given by

$$\frac{x}{KA} + \frac{4x}{2KA} = \frac{x}{KA} + \frac{2x}{KA} = \frac{3x}{KA}$$

$$\therefore \frac{dQ}{dt} = \frac{\Delta T}{\frac{3x}{KA}} = \frac{(T_2-T_1)KA}{3x} = \frac{1}{3}\left\{\frac{A(T_2-T_1)K}{x}\right\}$$

$$\therefore f = \frac{1}{3}$$

**60.** **(a)** Initially, on heating temperature rises from – 100°C to 0°C. then ice melts and temperature does not rise. After the whole ice has melted, temperature beigins to rise until it reaches 100°C. then it becomes constant, as at the boiling point will not rise.

**61.** **(c)** Since specific heat = 0.6 $kcal/g \times °C = 0.6\ cal/g \times °C$

From graph it is clear that in a minute, the temperature is raised from 0°C to 50°C.

$\Rightarrow$ Heat required for a minute = 50 × 0.6 × 50 = 1500 *cal*.

Also from graph, Boiling point of wax is 200°C.

**62.** **(a)** OA refers to change of state from ice to water without change of temperature.

**63.** **(c)** At OA and BC, there is a change of state from ice to water and water to steam respectively. During this both the state co-exist in thermal equilibirium.

**64.** **(c)** According to Newton's law of cooling, the temperature goes on decreasing with time non-linearly.

**65.** **(b)** At *C*, solid completely will convert into liquid.

**66.** **(b)** When hot water temperature ($T$) and surrounding temparature ($T_0$) readings are noted, and $\log(T - T_0)$ is plotted versus time, we get a straight line having a negative slope; as a proof of Newton's law of cooling.

## ASSERTION- REASON TYPE QUESTIONS

**67.** **(c)** **68.** **(c)**

**69.** **(c)** Heat is carried away from a fire sideways mainly by radiations. Above the fire, heat is carried by both radiation and by convection of air. The latter process carries much more heat.

**70.** **(a)**

**71.** **(a)** Metals generally have higher coefficient of linear expansion. Since copper has 1.7 $K^{-1}$ and glass has 0.32 $K^{-1}$ coefficient of linear expansion so, copper expands five times more than glass.

**72.** **(a)** **73.** **(a)** **74.** **(d)** **75.** **(a)** **76.** **(a)**

**77.** **(c)** **78.** **(a)** **79.** **(d)** **80.** **(d)**

**81.** **(d)** Rate of cooling a body at a temperature is defined as the fall in temperature per second at that temperature, while rate of loss of heat from a body is the quantity of heat lost per second from the body.

## CRITICALTHINKING TYPE QUESTIONS

**82.** **(a)** The area of circular hole increases when we heat the metal sheet & expansion of metal sheet will be independent of shape & size of the hole.

**83.** **(b)** The volume of cavity inside the solid ball increases when it is heated.

**84.** **(c)** $\dfrac{\text{Reading on any scale} - \text{LFP}}{\text{UFP} - \text{LFP}}$

= constant for all scales

$$\frac{340-273}{373-273} = \frac{°\text{y} - (-160)}{-50-(-160)}$$

$$\Rightarrow \frac{67}{100} = \frac{\text{y}+160}{110}$$

$\therefore$ y = – 86.3° y

**85.** **(c)** As coefficient of cubical expansion of liquid equals coefficient of cubical expansion of vessel, the level of liquid will not change on heating.

**86.** **(c)** Initial diameter of tyre = (1000 – 6) *mm* = 994 *mm*, so

initial radius of tyre $R = \dfrac{994}{2} = 497\,mm$

and change in diameter $\Delta D = 6\,mm$ so $\Delta R = \dfrac{6}{2} = 3\,mm$

After increasing temperature by $\Delta\theta$ tyre will fit onto wheel

Increment in the length (circumference) of the iron tyre

$$\Delta L = L \times \alpha \times \Delta\theta = L \times \frac{\gamma}{3} \times \Delta\theta \qquad [\text{As } \alpha = \frac{\gamma}{3}]$$

$$2\pi\Delta R = 2\pi R\left(\frac{\gamma}{3}\right)\Delta\theta \Rightarrow \Delta\theta = \frac{3}{\gamma}\frac{\Delta R}{R} = \frac{3\times 3}{3.6\times10^{-5}\times 497}$$

$\Rightarrow \Delta\theta \simeq 500°C$

**87.** **(a)** Heat gained by the water = (Heat supplied by the coil) – (Heat dissipated to environment)

$\Rightarrow mc\,\Delta\theta = P_{\text{Coil}}\,t - P_{\text{Loss}}\,t$

$\Rightarrow 2 \times 4.2 \times 10^3 \times (77 - 27) = 1000\,t - 160\,t$

$\Rightarrow t = \dfrac{4.2\times10^5}{840} = 500\text{ s} = 8\text{ min }20\text{ s}$

**88.** **(d)** water expands on both sides of 4 °C.

**89.** **(c)** The heat lost in condensation = $x \times 540$ cal.

$\therefore \quad x \times 540 = y \times 80 + y \times 1 \times (100 - 0)$

or $\quad \dfrac{x}{y} = \dfrac{1}{3}$.

**90.** **(c)** Due to volume expansion of both mercury and flask, the change in volume of mercury relative to flask is

given by $\Delta V = V_0\left[\gamma_L - \gamma_g\right]\Delta\theta = V\left[\gamma_L - 3\alpha_g\right]\Delta\theta$

$= 50\,[\,180 \times 10^{-6} - 3\times9\times10^{-6}]\,(38 - 18) = 0.153$ cc

**91.** **(c)** $L = L_0\,(1 + \alpha\Delta\theta) \Rightarrow \dfrac{L_1}{L_2} = \dfrac{1+\alpha(\Delta\theta)_1}{1+\alpha(\Delta\theta)_2}$

$$\Rightarrow \frac{10}{L_2} = \frac{1+11\times10^{-6}\times 20}{1+11\times10^{-6}\times19} \Rightarrow L_2 = 9.99989$$

$\Rightarrow$ Length is shorten by

$10 - 9.99989 = 0.00011 = 11 \times 10^{-5}$ cm.

**92.** **(a)** $\gamma_{\text{real}} = \gamma_{\text{app.}} + \gamma_{\text{vessel}}$

So $(\gamma_{\text{app.}} + \gamma_{\text{vessel}})_{\text{glass}} = (\gamma_{\text{app}} + \gamma_{\text{vessel}})_{\text{steel}}$

$\Rightarrow 153\times10^{-6} + (\gamma_{\text{vessel}})_{\text{glass}} = 144\times10^{-6} + (\gamma_{\text{vessel}})_{\text{steel}}$

Further,

$(\gamma_{\text{vessel}})_{\text{steel}} = 3\alpha = 3\times(12\times10^{-6}) = 36\times10^{-6}\,/°C$

$\Rightarrow 153\times10^{-6} + (\gamma_{\text{vessel}})_{\text{glass}} = 144\times10^{-6} + 36\times10^{-6}$

$\Rightarrow (\gamma_{\text{vessel}})_{\text{glass}} = 3\alpha = 27\times10^{-6}\,/°C$

$\Rightarrow \alpha = 9\times10^{-6}\,/°C$

**93. (a)** Heat produced = msΔT = $\frac{1}{2}\left(\frac{1}{2}mv^2\right)$

$$\Rightarrow \Delta T = \frac{v^2}{4s} = \frac{(200)^2}{4\times125} = \frac{4\times10^4}{4\times125} = 80°C$$

**94. (a)** The amount of heat required to increase the temperature of copper by 21ºC is

$$Q = m_{Cu}s_{Cu}\Delta T = 100\times10^{-3}\times400\times21\text{ J}$$

The amount of heat required to increase the temperature of water by $\Delta T_1{}^0C$ is

$$Q_1 = m_w s_w \Delta T_1 = 50\times10^{-3}\times4200\times\Delta T_1$$

According to question, $Q = Q_1$

$\therefore 100\times10^{-3}\times400\times21 = 50\times10^{-3}\times4200\times\Delta T_1$

$$\Rightarrow \Delta T_1 = \frac{2\times21\times4}{42} = 4°C$$

**95. (a)** $W = JQ \Rightarrow \frac{1}{2}\left(\frac{1}{2}Mv^2\right) = J(m.c.\Delta\theta)$

$$\Rightarrow \frac{1}{4}\times1\times(50)^2 = 4.2[200\times0.105\times\Delta\theta] \Rightarrow \Delta\theta = 7.1°C$$

**96. (c)** Specific heat of water = 4200 J/kg-K

Latent heat of fusion = $3.36\times10^5$ J/kg

Latent heat of vapourisation = $22.68\times10^5$ J/kg

$$x\times10^{-3}\times22.68\times10^5\text{ J} = y\times10^{-3}\times3.36\times10^5\text{ J} + y\times10^{-3}\times4200\times100$$

$$\therefore \frac{x}{y} = \frac{7.56}{22.68} = \frac{1}{3}$$

**97. (a)** $\Delta\theta = 0.0023h = 0.0023\times100 = 0.23°C$

**98. (c)** Here, specific heat of ice, $S_{ice} = 0.5\text{ cal g}^{-1}°C^{-1}$

Specific heat of water, $S_{water} = 1\text{ cal g}^{-1}°C^{-1}$

Latent heat of fusion of ice $L_{lice} = 80\text{ cal g}^{-1}$

Here ice will absorb heat while hot water will release it.

Let T be the final temperature of the mixture.

Assuming water equivalent of calorimeter to be neglected.

Heat given by water, $Q_1 = m_{water}S_{water}\Delta T$

$= 19\times1\times(30-T) = 570-19T$ ...(i)

Heat absorbed by ice.

$$Q_2 = m_{ice}\times S_{ice}\times[0-(-20)] + m_{ice}\times L_{f\ ice} + m_{ice}\times S_{water}\times(T-0)$$

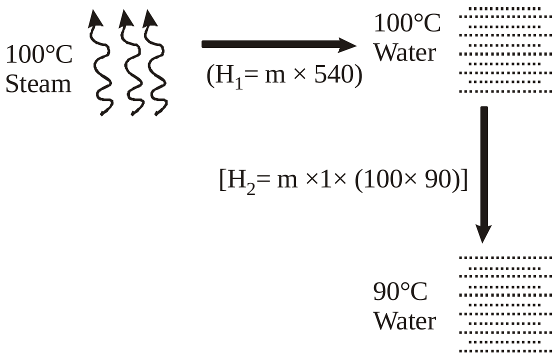
$= 5\times0.5\times20 + 5\times80 + 5\times1\times T$

$= 450 + 5T$

According to principle of calorimetry, $Q_1 = Q_2$

i.e., $570 - 19T = 450 + 5T \Rightarrow T = \frac{120}{24} = 5°C$

**99. (a)** Let m g of steam get condensed into water (By heat loss). This happens in following two steps.



Heat gained by water (20°C) to raise it's temperature upto 90°C = 22 × 1× (90 – 20)

Hence , in equilibrium, heat lost = Heat gain

$\Rightarrow m\times540 + m\times1\times(100-90) = 22\times1\times(90-20)$

$\Rightarrow m = 2.8$ gm

The net mass of the water present in the mixture = 22 +2.8 =24.8 gm.

**100. (c)** Let x kg of ice can melt

Using law of Calorimetry,

Heat lost by copper = Heat gained by ice

$2\times400\times(500-0) = x\times3.5\times10^5$

or $x = \frac{2\times400\times500}{3.5\times10^5} = \frac{8}{7}$ kg

**101. (d)** Radius of small sphere = r

Thickness of small sphere = t

Radius of bigger sphere = 2r

Thickness of bigger sphere = t/4

Mass of ice melted = (volume of sphere) × (density of ice)

Let $K_1$ and $K_2$ be the thermal conductivities of larger and smaller sphere.

For bigger sphere,

$$\frac{K_1 4\pi\,(2r)^2\times100}{t/4} = \frac{\frac{4}{3}\pi(2r)^3\rho L}{25\times60}$$

For smaller sphere,

$$\frac{K_2\times4\pi r^2\times100}{t} = \frac{\frac{4}{3}\pi r^3\rho L}{16\times60} \quad \therefore \frac{K_1}{K_2} = \frac{8}{25}$$

**102. (c)**

**103. (a)** By the law of conservation of energy, energy given by heater must be equal to the sum of energy gained by water and energy lost from the lid.

Pt = ms Δθ + energy lost

$1000t = 2\times4.2\times10^3\times50 + 160t$

$840t = 8.4\times10^3\times50 = 500$ sec = 8 min 20 sec

**104. (d)** According to the principle of calorimetry.

Heat lost = Heat gained

$mL_v + ms_w\Delta\theta = m_w s_w \Delta\theta$

$\Rightarrow m \times 540 + m \times 1 \times (100 - 80)$

$= 20 \times 1 \times (80 - 10)$

$\Rightarrow m = 2.5$ g

Therefore total mass of water at 80°C

$= (20 + 2.5)$ g $= 22.5$ g

**105. (a)** Let the temperature of surroundings be $\theta_0$

By Newton's law of cooling

$$\frac{\theta_1 - \theta_2}{t} = k\left[\frac{\theta_1 + \theta_2}{2} - \theta_0\right]$$

$$\Rightarrow \frac{70 - 60}{5} = k\left[\frac{70 + 60}{2} - \theta_0\right]$$

$$\Rightarrow 2 = k[65 - \theta_0] \quad \text{...(i)}$$

Similarly, $$\frac{60 - 54}{5} = k\left[\frac{60 + 54}{2} - \theta_0\right]$$

$$\Rightarrow \frac{6}{5} = k[57 - \theta_0] \quad \text{...(ii)}$$

By dividing (i) by (ii) we have

$$\frac{10}{6} = \frac{65 - \theta_0}{57 - \theta_0} \Rightarrow \theta_0 = 45°$$

**106. (a)** From Wein's displacement law, $\lambda_m \times T$ = constant

P – max. intensity is at violet $\Rightarrow \lambda_m$ is minimum $\Rightarrow$ temp maximum

R – max. intensity is at green $\Rightarrow \lambda_m$ is moderate $\Rightarrow$ temp moderate

Q – max. intensity is at red $\Rightarrow \lambda_m$ is maximum $\Rightarrow$ temp minimum i.e., $T_p > T_R > T_Q$

**107. (c)** As the temperature difference $\Delta T = 10°C$ as well as the thermal resistance is same for both the cases, so thermal current or rate of heat flow will also be same for both the cases.

**108. (a)** From question,

Rise in temperature $\Delta t = 40°C$

Fractional change in the density $\frac{\Delta\rho}{\rho_0} = ?$

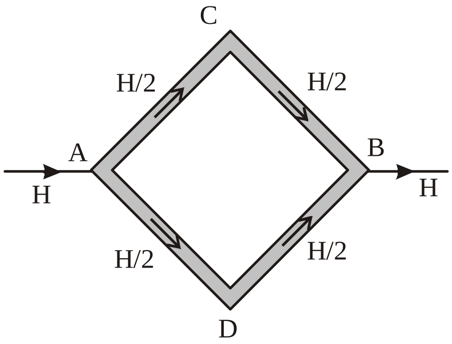
Coefficient of volume expansion

$\gamma = 5 \times 10^{-4} K^{-1}$

$\rho = \rho_0 (1 - \gamma\Delta t)$

$$\Rightarrow \frac{\Delta\rho}{\rho_0} = \gamma\Delta T = (5 \times 10^{-4})(40) = 0.02$$

**109. (a)** Suppose temperature difference between A and B is 100°C and $\theta_A > \theta_B$



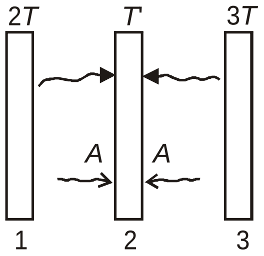
Heat current will flow from A to B via path ACB and ADB. Since all the rod are identical, so, $(\Delta\theta)_{AC} = (\Delta\theta)_{AD}$

(Because heat current $H = \frac{\Delta\theta}{R}$; here $R$ = same for all)

$$\Rightarrow \theta_A - \theta_C = \theta_A - \theta_D \Rightarrow \theta_C = \theta_D$$

i.e., temperature difference between C and D will be zero.

**110. (c)** Under steady conditions, the heat gained per second by a plate is equal to the heat released per second by the plate.



$$\frac{\text{Heat gained}}{\text{Second}} [\text{by (2) from (1)}] + \frac{\text{Heat gained}}{\text{Second}}$$

$$[(\text{by ((2) from (3)}] = \frac{\text{Heat gained}}{\text{Second}} (\text{by 2})$$

$$\therefore \sigma A(2T)^4 + \sigma A(3T)^4 = \sigma(2A)(T')^4$$

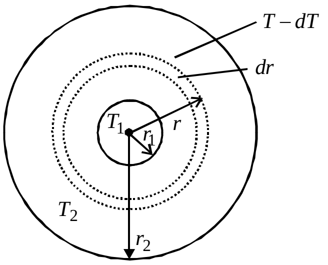
$$\therefore T' = \left[\frac{97}{2}\right]^{1/4} T$$

**111. (d)** Consider a shell of thickness ($dr$) and of radii ($r$) and the temperature of inner and outer surfaces of this shell be $T$, $(T - dT)$

$\frac{dQ}{dt}$ = rate of flow of heat through it

$$= \frac{KA[(T - dT) - T]}{dr} = \frac{-KAdT}{dr}$$

$$= -4\pi Kr^2 \frac{dT}{dr} \quad (\because A = 4\pi r^2)$$



To measure the radial rate of heat flow, integration technique is used, since the area of the surface through which heat will flow is not constant.

Then, $\left(\frac{dQ}{dt}\right)\int_{r_1}^{r_2}\frac{1}{r^2}dr = -4\pi K\int_{T_1}^{T_2} dT$

$$\frac{dQ}{dt}\left[\frac{1}{r_1}-\frac{1}{r_2}\right] = -4\pi K\left[T_2 - T_1\right]$$

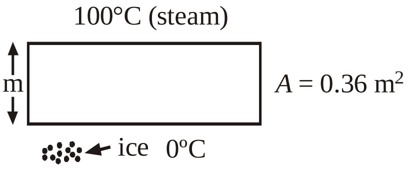
or $\frac{dQ}{dt} = \frac{-4\pi K r_1 r_2 (T_2 - T_1)}{(r_2 - r_1)}$ $\quad\therefore\quad \frac{dQ}{dt} \propto \frac{r_1 r_2}{(r_2 - r_1)}$

**112. (d)** $\theta_{mix} = \frac{m_W\theta_W - \frac{m_i L_i}{S_W}}{m_i + m_W}$

$$= \frac{300\times 25 - \frac{100\times 80}{1}}{100+300} = -1.25°C$$

Which is not possible. Hence $\theta_{mix}$ = 0°C

**113. (a)**



Rate of heat given by steam = Rate of heat taken by ice

where $K$ = Thermal conductivity of the slab

$m$ = Mass of the ice

$L$ = Latent heat of melting/fusion

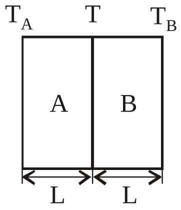
$A$ = Area of the slab

$$\frac{dQ}{dt} = \frac{KA(100-0)}{1} = m\frac{dL}{dt},$$

$$\frac{K\times 100\times 0.36}{0.1} = \frac{4.8\times 3.36\times 10^5}{60\times 60}$$

$K$=1.24 J/m/s/°C

**114. (c)**



Let T be temperature of the junction

Here, $K_A = 2K_B,\ T - T_B = 50K$

At the steady state,

$$H_A = H_B$$

$$\therefore\ \frac{K_A A(T_A - T)}{L} = \frac{K_B A(T - T_B)}{L}$$

$$2K_B(T_A - T) = K_B(T - T_B)$$

$$T_A - T = \frac{T - T_B}{2}$$

$$= \frac{50K}{2} = 25K$$

**115. (d)** $\ell = 5m \quad t_1 = 0°C$

$\ell_2 = 5.01m \quad t_2 = 100°C$

$$\alpha = \frac{\ell_2 - \ell_1}{\ell_1(t_2 - t_1)} = \frac{5.01-5}{5\times 100} = 2\times 10^{-5}/°C.$$

**116. (c)** $\Delta t = \frac{1}{2}\alpha\,\Delta T\times t$

$$\therefore\quad 5 = \frac{1}{2}\alpha\,(T-15)\times 86400$$

and $10 = \frac{1}{2}\alpha(30 - T)\times 86400$

**117. (c)** Heat gain = heat lost

$$C_A(16-12) = C_B(19-16) \Rightarrow \frac{C_A}{C_B} = \frac{3}{4}$$

and $C_B(23-19) = C_c(28-23) \Rightarrow \frac{C_B}{C_C} = \frac{5}{4}$

$$\Rightarrow \frac{C_A}{C_C} = \frac{15}{16} \qquad ...(i)$$

If θ is the temperature when A and C are mixed then,

$$C_A(\theta-12) = C_C(28-\theta) \Rightarrow \frac{C_A}{C_C} = \frac{28-\theta}{\theta-12} \qquad ...(ii)$$

On solving equations (i) and (ii) θ = 20.2°C

**118. (c)** Rate of cooling $\frac{\Delta\theta}{t} = \frac{A\varepsilon\sigma(T^4 - T_0^4)}{mc}$

$$\Rightarrow t \propto \frac{m}{A}\ [\Delta\theta, t, \sigma, (T^4 - T_0^4)\text{ are constant}]$$

$$\Rightarrow t \propto \frac{m}{A} \propto \frac{\text{Volume}}{\text{Area}} \propto \frac{a^3}{a^2} \Rightarrow t \propto a \Rightarrow \frac{t_1}{t_2} = \frac{a_1}{a_2}$$

$$\Rightarrow \frac{100}{t_2} = \frac{1}{2} \Rightarrow t_2 = 200\,\text{sec}$$

**119. (b)** $$\frac{50-49.9}{5}=K\left(\frac{50+49.9}{2}-30\right) \qquad \text{....(i)}$$

$$\frac{40-39.9}{t}=K\left[\frac{40+39.9}{2}-30\right] \qquad \text{....(ii)}$$

From equations (i) and (ii), we get $t \approx 10$ s.

**120. (c)** From Newtwon's law of cooling

$$\frac{dQ}{dt}=-KA\frac{dT}{dx}$$

Area of cross-section A and thickness dx is the same.

Also $dQ = mCd\theta$

Thus in first case

$$\frac{m\times C\times(61°-59°)}{4}=\frac{-KA}{dx}\left[\left(\frac{61°+51°}{2}\right)-30°\right] \quad \text{(i)}$$

In second case,

$$\frac{m\times C\times(51°-49°)}{t}=\frac{-KA}{dx}\left[\left(\frac{51°+49°}{2}\right)-30°\right] \quad \text{(ii)}$$

Dividing equation (i) by equation (ii)

$$\frac{t}{4}=\frac{30}{20} \quad \text{or} \quad t = 6 \text{ minutes.}$$

**121. (a)** According to Newton's law of cooling,

$$\frac{\theta_1-\theta_2}{t}=K\left[\frac{\theta_1+\theta_2}{2}-\theta_0\right]$$

where $\theta_0$ is the surrounding temperature.

$$\therefore \quad \frac{60-40}{7}=K\left(\frac{60+40}{2}-10\right)$$

$$\Rightarrow \quad \frac{20}{7}=40K \;\Rightarrow\; K=\frac{1}{14}$$

$$\therefore \quad \frac{40-28}{t}=K\left[\frac{40+28}{2}-10\right] \Rightarrow \frac{12}{t}=24K$$

$$\text{or} \quad t=\frac{12}{24K}=\frac{12\times14}{24}=7\,\text{min}$$

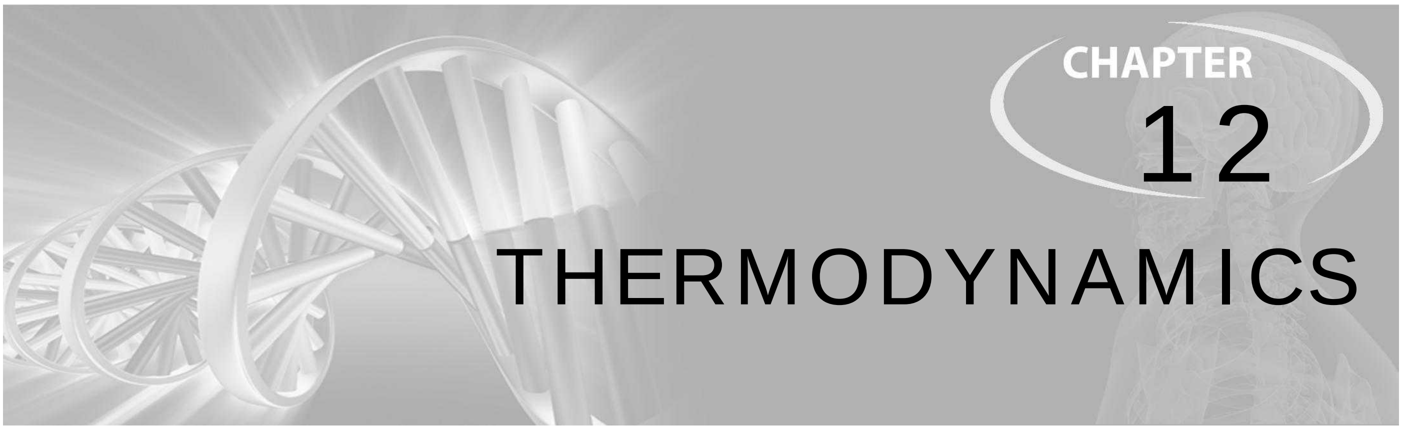
**122. (c)** Rate of colling $=\frac{-d\theta}{dt}\propto\left(\frac{\theta_1+\theta_2}{2}-\theta_0\right)$

In second case average temperature will be less hence rate of colling will be less. Therefore time taken will be more than 4 minutes.

**123. (a)** Initially at $t = 0$

Rate of cooling (R) $\propto$ Fall in temperature of body $(\theta-\theta_0)$

$$\Rightarrow \quad \frac{R_1}{R_2}=\frac{\theta_1-\theta_0}{\theta_2-\theta_0}=\frac{100-40}{80-40}=\frac{3}{2}$$



## CHAPTER

## 12

# THERMODYNAMICS

## FACT/DEFINITION TYPE QUESTIONS

**1.** The branch of physics that deals with the concepts of heat and temperature and the interconversion of heat and other forms of energy is called

(a) calorimetry (b) thermometry

(c) thermodynamics (d) Pyrometry

**2.** Thermodynamics is concerned in part with transformations between

(a) different forms of heat energy

(b) internal energy at various temperatures

(c) one form of mechanical energy into other forms

(d) heat, internal energy and mechnical work

**3.** A system *X* is neither in thermal equilibrium with *Y* nor with *Z*. The systems *Y* and *Z*

(a) must be in thermal equilibrium

(b) cannot be in thermal equilibrium

(c) may be in thermal equilibrium

(d) None of these

**4.** When two bodies A and B are in thermal equilibrium

(a) the kinetic energies of all the molecules of A and B will be equal

(b) the potential energies of all the molecules of A and B will be equal

(c) the internal energies of the two bodies will be equal

(d) the average kinetic energy of the molecules of the two bodies will be equal

**5.** Temperature is a measurement of coldness or hotness of an object. This definition is based on

(a) Zeroth law of thermodynamics

(b) First law of thermodynamics

(c) Second law of thermodynamics

(d) Newton's law of cooling

**6.** The first law of thermodynamics expresses

(a) law of conservation of momentum

(b) law of conservation of energy

(c) law of conservation of mass

(d) All of the above

**7.** The first law of thermodynamics is a special case of

(a) Newton's law

(b) the law of conservation of energy

(c) Charle's law

(d) the law of heat exchange

**8.** Energy transfer brought about by moving the piston of a cylinder containing the gas is known as

(a) work (b) heat

(c) pressure (d) temperature

**9.** Which of the following macroscopic variable is not measurable ?

(a) Pressure (b) Volume

(c) Mass (d) None of these

**10.** Which of the following is a state variable ?

(a) Heat (b) Work

(c) Internal energy (d) All of these

**11.** The internal energy of an ideal gas is a function of

(a) pressure (b) volume

(c) temperature (d) All of the above

**12.** The internal energy of an ideal gas depends upon

(a) specific volume (b) pressure

(c) temperature (d) density

**13.** At a given temperature the internal energy of a substance

(a) in liquid state is equal to that in gaseous state.

(b) in liquid state is less than that in gaseous state.

(c) in liquid state is more than that in gaseous state.

(d) is equal for the three states of matter.

**14.** The variable defined by Zeroth law of thermodynamics is

(a) temperature (b) internal energy

(c) work (d) All of these

**15.** The internal energy of an ideal gas does not depend upon

(a) temperature of the gas

(b) pressure of the gas

(c) atomicity of the gas

(d) number of moles of the gas.

**16.** If ΔQ and ΔW represent the heat supplied to the system and the work done on the system respectively, then the first law of thermodynamics can be written as

(a) $\Delta Q = \Delta U + \Delta W$ (b) $\Delta Q = \Delta U - \Delta W$

(c) $\Delta Q = \Delta W - \Delta U$ (d) $\Delta Q = -\Delta W - \Delta U$

**17.** Which of the following is incorrect regarding first law of thermodynamics?

(a) It is a restatement of principle of conservation of energy.

(b) It is applicable to cyclic processes

(c) It introduces the concept of entropy

(d) It introduces the concept of internal energy

**18.** First law of thermodynamics states that

(a) system can do work

(b) system has temperature

(c) system has pressure

(d) heat is a form of energy

**19.** Which of the following statements is correct for any thermodynamic system ?

(a) The change in entropy can never be zero

(b) Internal energy and entropy are state functions

(c) The internal energy changes in all processes

(d) The work done in an adiabatic process is always zero.

**20.** For one mole of solid, at constant pressure how is $C$ related to $R$ ? ($C \rightarrow$ moler specific heat, $R \rightarrow$ universal gas constant)

(a) $C = \frac{3R}{T}$ (b) $C = 3R$

(c) $C = \frac{1}{3}RT$ (d) $C = \frac{1}{3}R$

**21.** If $C_P$ and $C_V$ are specific heat capacities at constant pressure and constant volume respectively, then for an adiabatic process of an ideal gas

(a) $PV$ = constant (b) $PV^{-\gamma}$ = constant

(c) $PV^{\gamma}$ = constant (d) $\frac{P}{V^{\gamma}}$ = constant

**22.** For an ideal gas, the molar specific heat capacities at constant pressure and volume satisfy the relation

(a) $C_P + C_V = R$ (b) $C_P - C_V = R$

(c) $\frac{C_P}{C_V} = R$ (d) $\frac{C_V}{C_P} = R$

**23.** Which of the following formula is wrong?

(a) $C_v = \frac{R}{\gamma - 1}$ (b) $C_p = \frac{\gamma R}{\gamma - 1}$

(c) $C_p / C_v = \gamma$ (d) $C_p - C_v = 2R$

**24.** γ for a gas is always

(a) negative (b) zero

(c) between zero and one (d) more than one

**25.** The specific heat of a gas at constant pressure is greater than the specific heat of the same gas at constant volume because

(a) work is done in the expansion of the gas at constant pressure.

(b) work is done in the expansion of the gas at constant volume.

(c) the attraction between the molecules increases at constant pressure.

(d) the molecular attraction increases at constant volume.

**26.** Which of the following holds good for an isochoric process?

(a) No work is done on the gas

(b) No work is done by the gas

(c) Both (a) and (b)

(d) None of these

**27.** Which process will increase the temperature of the system without heating it ?

(a) Adiabatic compression

(b) Adiabatic expansion

(c) Isothernal compression

(d) Isothernal expansion

**28.** The state of a thermodynamic system is represented by

(a) Pressure only

(b) Volume only

(c) Pressure, volume and temperature

(d) Number of moles

**29.** Which of the following is not a thermodynamics co-ordinate?

(a) P (b) T

(c) V (d) R

**30.** The specific heat of a gas in an isothermal process is

(a) infinite (b) zero

(c) negative (d) remains constant

**31.** The work done in an adiabatic change in a particular gas depends only upon

(a) change in volume

(b) change in temperature

(c) change in pressure

(d) None of these

**32.** Which one of the following is an isoentropic process?

(a) Isothermal (b) Adiabatic

(c) Isochoric (d) Isobaric

**33.** In all natural processes, the entropy of the universe
(a) remains constant
(b) always decreases
(c) always increases
(d) may increase or decrease

**34.** During isothermal expansion, the slope of *P-V* graph
(a) decreases (b) increases
(c) remains same (d) may increase or decrease

**35.** Which of the following processes is adiabatic ?
(a) Melting of ice
(b) Bursting of tyre
(c) Motion of piston of an engine with constant speed
(d) None of these

**36.** For adiabatic processes (Letters have usual meanings)
(a) $P^{\gamma}V$ = constant (b) $T^{\gamma}V$ = constant
(c) $TV^{\gamma-1}$ = constant (d) $TV^{\gamma}$ = constant

**37.** We consider a thermodynamic system. If ΔU represents the increase in its internal energy and W the work done by the system, which of the following statements is true?
(a) $\Delta U = -W$ in an adiabatic process
(b) $\Delta U = W$ in an isothermal process
(c) $\Delta U = -W$ in an isothermal process
(d) $\Delta U = W$ in an adiabatic process

**38.** Ice contained in a beaker starts melting when
(a) the specific heat of the system is zero
(b) internal energy of the system remains constant
(c) temperature remains constant
(d) entropy remains constant

**39.** Which of the following parameters does not characterize the thermodynamic state of matter?
(a) Temperature (b) Pressure
(c) Work (d) Volume

**40.** A point on P – V diagram represents
(a) the condition of a system
(b) work done on or by the system
(c) work done in a cyclic process
(d) a thermodynamic process

**41.** The slopes of isothermal and adiabatic curves are related as
(a) isothermal curve slope = adiabatic curve slope
(b) isothermal curve slope = γ × adiabatic curve slope
(c) adiabatic curve slope = γ × isothermal curve slope
(d) adiabatic curve slope = $\frac{1}{2}\times$ isothermal curve slope

**42.** A sample of gas expands from volume $V_1$ to $V_2$. The amount of work done by the gas is greatest when the expansion is
(a) isothermal (b) isobaric
(c) adiabatic (d) equal in all cases

**43.** Choose the incorrect statement related to an isobaric process.
(a) $\frac{V}{T}$ = constant
(b) $W = P\Delta V$
(c) Heat given to a system is used up in raising the temperature only.
(d) $\Delta Q > W$

**44.** In thermodynamic processes which of the following statements is not true?
(a) In an isochoric process pressure remains constant
(b) In an isothermal process the temperature remains constant
(c) In an adiabatic process $PV^{\gamma}$ = constant
(d) In an adiabatic process the system is insulated from the surroundings

**45.** When heat is given to a gas in an isothermal change, the result will be
(a) external work done
(b) rise in temperature
(c) increase in internal energy
(d) external work done and also rise in temperature

**46.** Which of the following statements about a thermodynamic process is wrong ?
(a) For an adiabatic process $\Delta E_{int} = -W$
(b) For a constant volume process $\Delta E_{int} = +Q$
(c) For a cyclic process $\Delta E_{int} = 0$
(d) For free expansion of a gas $\Delta E_{int} > 0$

**47.** No heat flows between the system and surrounding. Then the thermodynamic process is
(a) isothermal (b) isochoric
(c) adiabatic (d) isobaric

**48.** The coefficient of performance of a refrigerator is given by
(a) $\frac{\theta_2}{\theta_1-\theta_2}$ (b) $\frac{\theta_1}{\theta_1-\theta_2}$
(c) $\frac{\theta_1-\theta_2}{\theta_2}$ (d) $\frac{\theta_1-\theta_2}{\theta_1}$

**49.** A refrigerator is a
(a) heat engine
(b) an electric motor
(c) heat engine working in backward direction
(d) air cooler

**50.** Air conditioner is based on the principle of
(a) Carnot cycle
(b) refrigerator
(c) first law of thermodynamics
(d) None of these

**51.** "Heat cannot by itself flow from a body at lower temperature to a body at higher temperature" is a statement or consequence of

(a) second law of thermodynamics

(b) conservation of momentum

(c) conservation of mass

(d) first law of thermodynamics

**52.** The second law of thermodynamics implies

(a) whole of the heat can be converted into mechanical energy

(b) no heat engine can be 100% efficient

(c) every heat engine has an efficiency of 100%

(d) a refrigerator can reduce the temperature to absolute zero

**53.** In a cyclic process, work done by the system is

(a) zero

(b) equal to heat given to the system

(c) more than heat given to the system

(d) independent of heat given to the system

**54.** Which of the following processes is reversible?

(a) Transfer of heat by conduction

(b) Transfer of heat by radiation

(c) Isothermal compression

(d) Electrical heating of a nichrome wire

**55.** Which of the following processes is irreversible?

(a) Transfer of heat by radiation

(b) Adiabatic changes performed slowly

(c) Extremely slow extension of a spring

(d) Isothermal changes performed slowly

**56.** In a reversible cyclic process of a gaseous system

(a) $\Delta Q = \Delta U$ (b) $\Delta U = \Delta W$

(c) $\Delta W = 0$ (d) $\Delta U = 0$

**57.** Choose the correct relation between efficiency $\eta$ of a Carnot engine and the heat absorbed $(\theta_1)$ and released by the working substance $(\theta_2)$.

(a) $\eta = 1+\frac{\theta_2}{\theta_1}$ (b) $\eta = 1+\frac{\theta_1}{\theta_2}$

(c) $\eta = 1-\frac{\theta_1}{\theta_2}$ (d) $\eta = 1-\frac{\theta_2}{\theta_1}$

**58.** Universal relation in a Carnot cycle is

(a) $\frac{\theta_1}{\theta_2} = \frac{T_2}{T_1}$ (b) $\frac{\theta_1}{\theta_2} = \frac{T_1}{T_2}$

(c) $\frac{\theta_1}{\theta_2} = \frac{P_1}{P_2}$ (d) All of these

**59.** The correct relation between coefficient of performance and efficiency of refrigerator is

(a) $\beta = \frac{1+\eta}{\eta}$ (b) $\beta = \frac{1-\eta}{\eta}$

(c) $\beta = 1 + \eta$ (d) None of these

**60.** A Carnot engine works between a source and a sink maintained at constant temperatures $T_1$ and $T_2$. For efficiency to be the greatest

(a) $T_1$ and $T_2$ should be high

(b) $T_1$ and $T_2$ should be low

(c) $T_1$ should be low and $T_2$ should be high

(d) $T_1$ should be high and $T_2$ should be low

**61.** Efficiency of carnot engine is 100% if

(a) $T_2 = 273\,k$ (b) $T_2 = 0\,k$

(c) $T_1 = 273\,k$ (d) $T_1 = 0\,k$

**62.** The first operation involved in a Carnot cycle is

(a) isothermal expansion

(b) adiabatic expansion

(c) isothermal compression

(d) adiabatic compression

**63.** Which of the following statements is incorrect?

(a) All reversible cycles have same efficiency

(b) Reversible cycle has more efficiency than an irreversible one

(c) Carnot cycle is a reversible one

(d) Carnot cycle has the maximum efficiency in all cycles

**64.** Even Carnot engine cannot give 100% efficiency because we cannot

(a) prevent radiation

(b) find ideal sources

(c) reach absolute zero temperature

(d) eliminate friction

**65.** Heat engine is a device by which a system is made to undergo a ...*X*... process that result in conversion of ...*Y*... into work.

Here, *X* and *Y* refer to

(a) isothermal and heat (b) cyclic and heat

(c) cyclic and work (d) adiabatic and heat

**66.** A thermodynamic process is reversible if the process can be turned back such that both the system and the surrounding return to their ...X... with no other ...Y... any where in the universe. Here, *X* and *Y* respectively refer to

(a) normal states and change

(b) original states and change

(c) final states and change

(d) None of these

**67.** An ideal gas is compressed to half its initial volume by means of several processes. Which of the process results in the maximum work done on the gas?

(a) Isobaric (b) Isochoric

(c) Isothermal (d) Adiabatic

**68.** A measure of the degree of disorder of a system of a system is known as

(a) enthalpy (b) isotropy

(c) entropy (d) None of these

## STATEMENT TYPE QUESTIONS

**69.** Which of the following statements are incorrect ?

I. If $Q > 0$, heat is added to the system.

II. If $W > 0$, work is done by the system.

III. If $W = 0$, work is done by the system.

(a) II and III (b) I, II and III

(c) I and II (d) I and III

**70.** Choose the false statement(s) from the following.

I. Specific heat of a substance depends on the mass of substance.

II. Specific heat of substance depends on the temperature of the substance.

III. Specific heat depends on the nature of material.

(a) I only (b) II only

(c) I and II (d) I, II and III

**71.** Which of the following statements is/are true about internal energy ?

I. Internal energy of a gas does not change in an isothermal process.

II. Internal energy of a gas does not change in an adiabatic process

III. Internal energy of a gas change in an isothermal process

(a) I only (b) II only

(c) III only (d) II and III

**72.** Select the false statement(s) from the following.

I. Two isothermal curves can never intersect each other.

II. When air rises up it cools.

III. A gas gets cooled on compression.

(a) I only (b) II only

(c) III only (d) I and II

**73.** Which of the following statements are correct about isothermal and adiabatic changes ?

I. Isothermal system is thermally conducting to the surroundings.

II. Adiabatic system is thermally insulated from the surroundings.

III. Internal energy changes in isothermal process.

(a) I and II (b) II and III

(c) I and II (d) I, II and III

**74.** Which of the following is/are the statements of Second law of thermodynamics ?

I. No process is possible whose sole result is the absorption of heat from a reservoir and complete conversion of heat into work.

II. No process is possible whose sole result is the transfer of heat from a colder object to a hotter object.

(a) I only (b) II only

(c) I and II (d) None of these

**75.** Consider the following statements and select the correct option.

I. A real engine has efficiency greater than that of Carnot engine.

II. A real engine can't have efficiency greater than that of Carnot engine.

III. Working substance in Carnot engine is an ideal gas.

(a) I only (b) II only

(c) I and II (d) I, II and III

**76.** Choose the correct statements from the following.

I. Efficeincy of Carnot engine cannot be 100%.

II. Two systems in thermal equilibrium with a third system are in equiliburium with each other.

III. Change in internal energy in the melting process is due to change in internal potential energy.

(a) I and II (b) II and III

(c) I and III (d) I, II and III

**77.** Which of the following statements are incorrect ?

I. Carnot cycle consists of three isothermal process connected by one adiabatic process.

II. Carnot engine is a reversible engine.

III. Efficiency of Carnot engine is 100%.

(a) II and III (b) I, II and III

(c) I and II (d) I and III

**78.** Internal energy

I. is microscopic state variable.

II. is microscopic state variable.

III. depends on the state of the system, not how that state is achieved.

IV. is a thermodynamics state variable

Choose the correct option regarding above statements.

(a) I and III (b) II, III and IV

(c) I, III and IV (d) I and IV

**79.** Choose the correct statements from the following.

I. Free expansion of gas is an irreversible process.

II. The combustion reaction of a mixture of petrol and air ignited by a spark is irreversible.

III. The leaking of a gas from the kitchen cylinder cannot be reversed by itself.

IV. The transfer of heat from one heated part of a liquid to the other colder part is a irreversible process.

(a) I, II and IV

(b) III and IV

(c) II, III and IV

(d) I, II, III and IV

## MATCHING TYPE QUESTIONS

**80.** Match columns I and II.

| | **Column-I** | | **Column-II** |
|---|---|---|---|
| (A) | Isothermal | (1) | $\Delta Q = 0$ |
| (B) | Isobaric | (2) | Volume constant |
| (C) | Isochoric | (3) | Pressure constant |
| (D) | Adiabatic | (4) | Temperature constant |

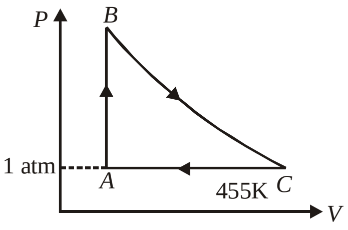
(a) (A) – (4), (B) – (3), (C) – (2), D – (1)
(b) (A) – (1), (B) – (4), (C) – (3), D – (2)
(c) (A) – (2), (B) – (3), (C) – (1), (D) – (4)
(d) (A) – (3), (B) – (1), (C) – (2), (D) – (4)

**81.**

| | **Column-I** | | **Column-II** |
|---|---|---|---|
| (A) | The coefficient of volume expansion at constant pressure | (1) | decrease in pressure |
| (B) | At constant temperature, an increase in volume results in | (2) | at all temperature |
| (C) | An ideal gas obeys Boyle's and Charle's law | (3) | same for all gases |
| (D) | A real gas behaves as an ideal gas at low pressure | (4) | at high temperature |

(a) (A) – (3), (B) – (1), (C) – (2), D – (4)
(b) (A) – (4), (B) – (3), (C) – (2), D – (1)
(c) (A) – (1), (B) – (2), (C) – (3), (D) – (4)
(d) (A) – (2), (B) – (4), (C) – (3), (D) – (1)

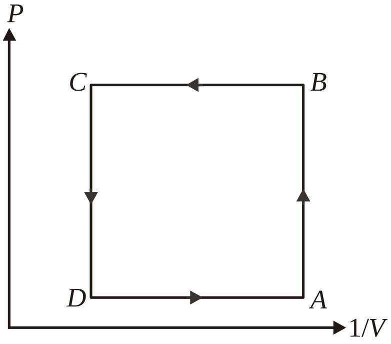
**82.** The P-V diagram of 0.2 mol of a diatomic ideal gas is shown in figure. Process BC is adiabatic, $\gamma = 1.4$.



| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | $\Delta Q_{AB}$ (J) | (1) | 602 |
| (B) | $\Delta W_{BC}$ (J) | (2) | – 644 |
| (C) | $\Delta U_{CA}$ (J) | (3) | 1246 |
| (D) | $\Delta U_{BC}$ (J) | (4) | – 602 |

(a) (A) – (1), (B) – (3), (C) – (4), D – (2)
(b) (A) – (3), (B) – (1), (C) – (2), D – (4)
(c) (A) – (3, 4), (B) – (3), (C) – (2), (D) – (1)
(d) (A) – (1), (B) – (2), (C) – (3), (D) – (4)

**83.** A gas undergoes a process according to the graph. $P$ is pressure, $V$ is volume, $W$ is work done by the gas, $\Delta U$ is change in internal energy of the gas and $\Delta Q$ is heat given to the system. Matchf the two columns.

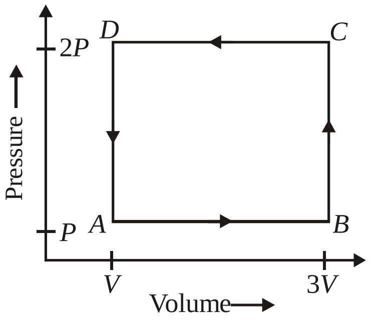


| | **Column-I** | | **Column -II** |
|---|---|---|---|
| (A) | For process $AB$ | (1) | $\Delta U > 0, \Delta Q > 0$ |
| (B) | For process $BC$ | (2) | $\Delta U < 0, \Delta Q < 0$ |
| (C) | For process $CD$ | (3) | $\Delta Q \times \Delta U \times W = 0$ |
| (D) | For process $DA$ | (4) | $\Delta Q \times \Delta U < 0$ |

(a) (A) – (1), (B) – (2), (C) – (4), D – (3)
(b) (A) – (3), (B) – (1), (C) – (2), D – (2)
(c) (A) – (2), (B) – (1), (C) – (4), (D) – (3)
(d) (A) – (4), (B) – (3), (C) – (2), (D) – (1)

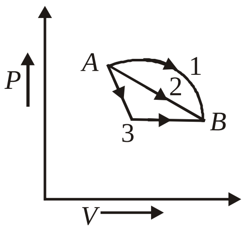
## DIAGRAM TYPE QUESTIONS

**84.** A thermodynamic system is taken through the cycle $ABCD$ as shown in figure. Heat rejected by the gas during the cycle is



(a) 2PV (b) 4PV
(c) $\frac{1}{2}$ PV (d) PV

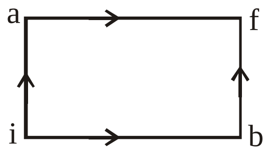
**85.** An ideal gas goes from state $A$ to state $B$ via three different processes as indicated in the $P$-$V$ diagram



If $Q_1$, $Q_2$, $Q_3$ indicate the heat absorbed by the gas along the three processes and $\Delta U_1$, $\Delta U_2$, $\Delta U_3$ indicate the change in internal energy along the three processes respectively, then

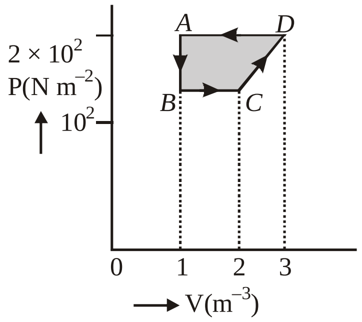
(a) $Q_1 > Q_2 > Q_3$ and $\Delta U_1 = \Delta U_2 = \Delta U_3$
(b) $Q_3 > Q_2 > Q_1$ and $\Delta U_1 = \Delta U_2 = \Delta U_3$
(c) $Q_1 = Q_2 = Q_3$ and $\Delta U_1 > \Delta U_2 > \Delta U_3$
(d) $Q_3 > Q_2 > Q_1$ and $\Delta U_1 > \Delta U_2 > \Delta U_3$

**86.** When a system is taken from state i to state f along the path iaf, it is found that Q =50 cal and W = 20 cal. Along the path ibf Q = 36 cal. W along the path ibf is



(a) 14 cal (b) 6 cal
(c) 16 cal (d) 66 cal

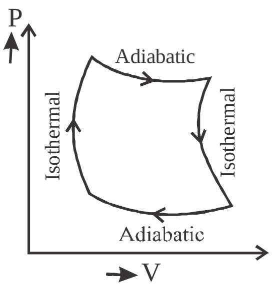
**87.** The *P-V* diagram of a gas system undergoing cyclic process is shown here. The work done during isobaric compression is



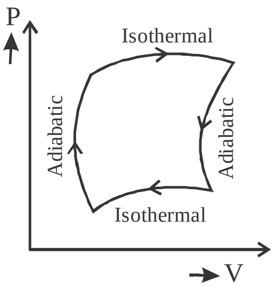
(a) 100 J (b) 200 J
(c) 600 J (d) 400 J

**88.** Which of the following is the *P-V* curve for isothermal and adiabatic process of an ideal gas ?

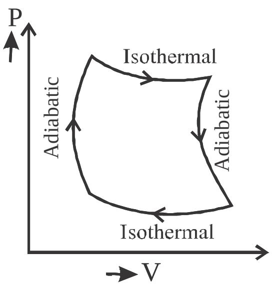
(a)



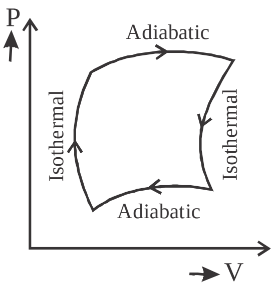
(b)



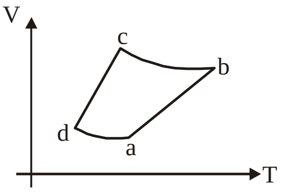
(c)



(d)

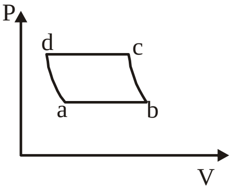


**89.** An ideal gas goes through a reversible cycle a→b→c→d has the V - T diagram shown below. Process d→a and b→c are adiabatic.

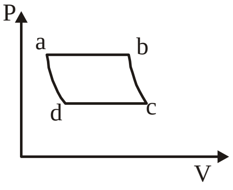


The corresponding P - V diagram for the process is

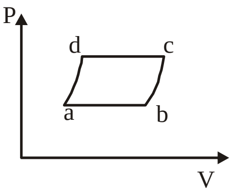
(a)



(b)



(c)



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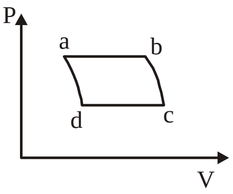
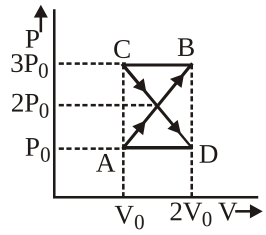
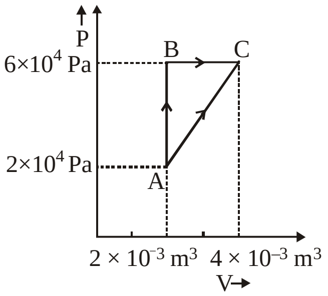


**90.** A thermodynamic system undergoes cyclic process ABCDA as shown in fig. The work done by the system in the cycle is

(a) $P_0V_0$
(b) $2P_0V_0$
(c) $\frac{P_0V_0}{2}$
(d) Zero



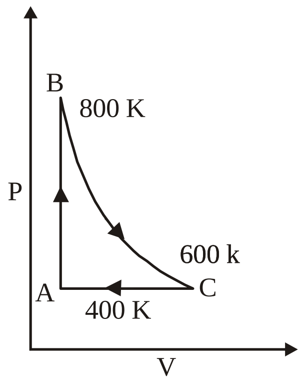
**91.** Figure below shows two paths that may be taken by a gas to go from a state A to a state C.



In process AB, 400 J of heat is added to the system and in process BC, 100 J of heat is added to the system. The heat absorbed by the system in the process AC will be

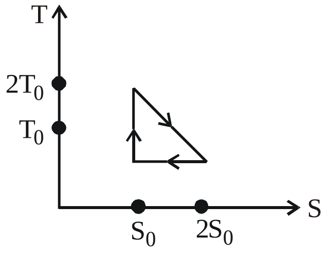
(a) 500 J (b) 460 J
(c) 300 J (d) 380 J

**92.** One mole of a diatomic ideal gas undergoes a cyclic process ABC as shown in figure. The process BC is adiabatic. The temperatures at A, B and C are 400 K, 800 K and 600 K respectively. Choose the correct statement:



(a) The change in internal energy in whole cyclic process is 250 R.
(b) The change in internal energy in the process CA is 700 R.
(c) The change in internal energy in the process AB is -350 R.
(d) The change in internal energy in the process BC is – 500 R.

**93.** The temperature-entropy diagram of a reversible engine cycle is given in the figure. Its efficiency is



(a) $\frac{1}{4}$ (b) $\frac{1}{2}$

(c) $\frac{2}{3}$ (d) $\frac{1}{3}$

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

**94.** **Assertion :** Zeroth law of thermodynamics explain the concept of energy.
**Reason :** Energy depends on temperature.

**95.** **Assertion:** Mass of a body will increase when it is heated.
**Reason:** The internal energy of a body increases on heating.

**96.** **Assertion:** Heat cannot be added to a system without increasing its temperature.
**Reason:** Adding heat will increase the temperature in every situation.

**97.** **Assertion :** The heat supplied to a system is always equal to the increase in its internal energy.
**Reason :** When a system changes from one thermal equilibrium to another, some heat is absorbed by it.

**98.** **Assertion :** In isothermal process whole of the heat energy supplied to the body is converted into internal energy.
**Reason :** According to the first law of thermodynamics $\Delta Q = \Delta U + W$.

**99.** **Assertion :** First law of thermodynamics is a restatement of the principle of conservation
**Reason :** Energy is fundamental quantity

**100.** **Assertion :** At a given temperature the specific heat of a gas at constant volume is always greater than its specific heat at constant pressure.
**Reason :** When a gas is heated at constant volume some extra heat is needed compared to that at constant pressure for doing work in expansion.

**101.** **Statement-1 :** The specific heat of a gas in an adiabatic process is zero but it is infinite in an isothermal process.
**Statement-2 :** Specific heat of a gas directly proportional to heat exchanged with the system and inversely proportional to change in temperature.

**102.** **Assertion :** Adiabatic expansion is always accompanied by fall in temperature.
**Reason :** In adiabatic process, volume is inversely proportional to temperature.

**103.** **Assertion :** When a bottle of cold carbonated drink is opened a slight fog forms around the opening.
**Reason :** Adiabatic expansion of the gas causes lowering of temperature and condensation of water vapours.

**104.** **Assertion :** In an adiabatic process, change in internal energy of a gas is equal to work done on or by the gas in the process.
**Reason :** Temperature of gas remains constant in an adiabatic process.

**105.** **Assertion :** The isothermal curves intersect each other at a certain point.
**Reason :** The isothermal change takes place slowly, so the isothermal curves have very little slope

**106.** **Assertion :** In an isolated system the entropy increases.
**Reason :** The processes in an isolated system are adiabatic.

**107.** **Assertion:** In an adiabatic process, change in internal energy of a gas is equal to work done on/by the gas.
**Reason:** Because adiabatic process is a variable process and so internal energy depends on the work done.

**108. Assertion:** Two isothermal curves can never intersect each other.

**Reason:** At the intersection point, at two different temperatures, volume and pressures of gas will be same which is not possible.

**109. Assertion :** The temperature of the surface of the sun is approximately 6000 K. If we take a bigh lens and focus the sunrays, we can produce a temperature of 8000 K.

**Reason :** The highest temperature can be produced according to second law of thermodynamics

**110. Assertion :** When a glass of hot milk is placed in a room and allowed to cool, its entropy decreases

**Reason :** Allowing hot object to cool does not violate the second law of thermodynamics.

**111. Assertion:** The efficiency of a reversible engine is maximum.

**Reason:** In such a device no dissipation of energy takes place.

**112. Assertion :** Reversible systems are difficult to find in real world.

**Reason :** Most processes are dissipative in nature.

**113. Assertion :** Thermodynamic processes in nature are irreversible

**Reason :** Dissipative effects can not be eliminated.

**114. Assertion :** In cyclic process, initial and final state are same. Therefore net work done is zero.

**Reason :** Initial and final temperature is equal, therefore change in internal energy is zero.

**115. Assertion :** Efficiency of a Carnot engine increase on reducing the temperature of sink.

**Reason :** Efficiency of a Carnot engine is defined as the ratio of net mechanical work done per cycle by the gas to the amount of heat energy absorbed per cycle from the source.

**116. Assertion :** The Carnot cycle is useful in understandsing the performance of heat engines.

**Reason :** The Carnot cycle provides a way of determining the maximum possible efficiency achievable with reservoirs of given temperatures.

## CRITICAL THINKING TYPE QUESTIONS

**117.** When the state of a gas adiabatically changed from an equilibrium state A to another equilibrium state B an amount of work done on the stystem is 35 J. If the gas is taken from state A to B via process in which the net heat absorbed by the system is 12 cal, then the net work done by the system is (1 cal = 4.19 J)

(a) 13.2 J (b) 15.4 J
(c) 12.6 J (d) 16.8 J

**118.** The internal energy change in a system that has absorbed 2 kcals of heat and done 500 J of work is

(a) 6400 J (b) 5400 J
(c) 7900 J (d) 8900 J

**119.** The specific heat at constant pressure of an ideal gas, $C_p = \frac{5R}{2}$. The gas is kept in a closed vessel of volume 0.0083 $m^3$ at 300 K and a pressure of $1.6 \times 10^6$ N/$m^2$. $2.49 \times 10^4$ J of heat energy is supplied to the gas. The final temperature and the pressure respectively are

(a) 567.2 K and $6.3 \times 10^6$ N/$m^2$
(b) 675.2 K and $3.6 \times 10^6$ N/$m^2$
(c) 275.2 K and $2.3 \times 10^6$ N/$m^2$
(d) 465.6 K and $4.2 \times 10^6$ N/$m^2$

**120.** The specific heat capacity of a metal at low temperature ($T$) is given as $C_p(\text{kJK}^{-1}\text{kg}^{-1}) = 32\left(\frac{T}{400}\right)^3$. A 100 g vessel of this metal is to be cooled from 20 K to 4 K by a special refrigerator operating at room temperature (27°C). The amount of work required to cool in vessel is

(a) equal to 0.002 kJ
(b) greater than 0.148 kJ
(c) between 0.148 kJ and 0.028 kJ
(d) less than 0.028 kJ

**121.** The amount of heat supplied to $4 \times 10^{-2}$ kg of nitorgen at room temperature to rise its temperature by 50°C at constant pressure is (Molecular mass of nitrogen is 28 and R = 8.3 J $\text{mol}^{-1}\text{K}^{-1}$)

(a) 2.08 kJ (b) 3.08 kJ
(c) 4.08 kJ (d) 5.08 kJ

**122.** When 1 kg of ice at 0°C melts to water at 0°C, the resulting change in its entropy, taking latent heat of ice to be 80 cal/°C, is

(a) 273 cal/K (b) 8 × 104 cal/K
(c) 80 cal/K (d) 293 cal/K

**123.** A mass of diatomic gas ($\gamma$ = 1.4) at a pressure of 2 atmospheres is compressed adiabatically so that its temperature rises from 27°C to 927°C. The pressure of the gas in final state is

(a) 28 atm (b) 68.7 atm
(c) 256 atm (d) 8 atm

**124.** A diatomic gas initially at 18ºC is compressed adiabatically to one eighth of its original volume. The temperature after compression will be

(a) 18ºC (b) 668.4ºK
(c) 395.4ºC (d) 144ºC

**125.** 2 k mol of hydrogen at NTP expands isobarically to twice its initial volume. The change in its internal energy is ($C_v$ = 10 kJ/kg.K and atm pressure = $1 \times 10^5$ N/$m^2$)

(a) 10.9 MJ (b) 9.10 MJ
(c) 109 MJ (d) 1.09 MJ

**126.** What will be the final pressure if an ideal gas in a cylinder is compressed adiabatically to $\frac{1}{3}$rd of its volume?
- (a) Final pressure will be three times less than initial pressure.
- (b) Final pressure will be three times more than initial pressure.
- (c) Change in pressure will be more than three times the initial pressure.
- (d) Change in pressure will be less than three times the initial pressure.

**127.** In a heat engine, the temperature of the source and sink are 500 K and 375 K. If the engine consumes $25 \times 10^5$ J per cycle, the work done per cycle is
- (a) $6.25 \times 10^5$ J  (b) $3 \times 10^5$ J
- (c) $2.19 \times 10^5$J  (d) $4 \times 10^4$ J

**128.** A refrigerator with coefficient of performance $\frac{1}{3}$ releases 200 J of heat to a hot reservoir. Then the work done on the working substance is
- (a) $\frac{100}{3}$J  (b) 100 J
- (c) $\frac{200}{3}$J  (d) 150 J

**129.** If the co-efficient of performance of a refrigerator is 5 and operates at the room temperature 27°C, the temperature inside the refrigerator is
- (a) 240 K  (b) 250 K
- (c) 230 K  (d) 260 K

**130.** By running a refrigerator with open door in a room
- (a) the temperature of the room will reduce a little
- (b) the room can be cooled considerably but this will take a long time
- (c) the room will get a little hotter
- (d) None of these

**131.** If an air conditioner is put in the middle of a room and started working
- (a) the room can be cooled slightly
- (b) the temperature of the room will not change
- (c) the room will become slightly warmer
- (d) the same temperature will be attained in the room as by putting it on the window in the standard position

**132.** A monoatomic gas at a pressure P, having a volume V expands isothermally to a volume 2V and then adiabatically to a volume 16V. The final pressure of the gas is : (take $\gamma = \frac{5}{3}$)
- (a) 64P  (b) 32P
- (c) $\frac{P}{64}$  (d) 16P

**133.** A spring stores 1 J of energy for a compression of 1 mm. The additional work to be done to compress it further by 1 mm is
- (a) 1 J  (b) 2 J
- (c) 3 J  (d) 4 J

**134.** The change in internal energy of a thermodynamical system which has absorbed 2 kcal of heat and done 400 J of work is (1 cal = 4.2 J)
- (a) 2 kJ  (b) 8 kJ
- (c) 3.5 kJ  (d) 5.5 kJ

**135.** In an air condition room, the heat exchange between the room and the space outside the room
- (a) will be more when the air conditioner is off
- (b) will be more rapid when the air conditioner is on
- (c) will not take place at all
- (d) will depend upon the floor area of the room

**136.** If internal energy of a box is U and the box is moving with some velocity, then which of the following is not to be included in U ?
- (a) Kinetic energy of the box
- (b) Translational kinetic energy of molecules of the gas
- (c) Rotational kinetic energy of molecules of the gas
- (d) Vibrational kinetic energy of the molecules of the gas

**137.** If the temperatures of source and sink of a Carnot engine having efficiency $\eta$ are each decreased by 100 K, then the efficiency
- (a) remains constant  (b) becomes 1
- (c) decreases  (d) increases

**138.** A Carnot engine takes $3 \times 10^6$ cal. of heat from a reservoir at 627°C, and gives it to a sink at 27°C. The work done by the engine is
- (a) $4.2 \times 10^6$ J  (b) $8.4 \times 10^6$ J
- (c) $16.8 \times 10^6$ J  (d) zero

**139.** A Carnot engine, having an efficiency of $\eta = 1/10$ as heat engine, is used as a refrigerator. If the work done on the system is 10 J, the amount of energy absorbed from the reservoir at lower temperature is
- (a) 100 J  (b) 99 J
- (c) 90 J  (d) 1 J

**140.** A diatomic ideal gas is used in a car engine as the working substance. If during the adiabatic expansion part of the cycle, volume of the gas increases from *V* to 32 V, the efficiency of the engine is
- (a) 0.5  (b) 0.75
- (c) 0.99  (d) 0.25

**141.** A Carnot engine operating between temperatures $T_1$ and $T_2$ has efficiency $\frac{1}{6}$. When $T_2$ is lowered by 62 K its efficiency increases to $\frac{1}{3}$. Then $T_1$ and $T_2$ are, respectively

(a) 372 K and 330 K (b) 330 K and 268 K

(c) 310 K and 248 K (d) 372 K and 310 K

**142.** In a Carnot engine, the temperature of reservoir is 927°C and that of sink is 27°C. If the work done by the engine when it transfers heat from reservoir to sink is $12.6 \times 10^6$J, the quantity of heat absorbed by the engine from the reservoir is

(a) $16.8 \times 10^6$ J (b) $4 \times 10^6$ J

(c) $7.6 \times 10^6$ J (d) $4.2 \times 10^6$ J

**143.** The coefficient of performance of a refrigerator is 5. If the inside temperature of freezer is -20°C, then the temperature of the surroundings to which it rejects heat is

(a) 41°C (b) 11°C

(c) 21°C (d) 31°C

**144.** A Carnot engine, having an efficiency of $\eta = \frac{1}{10}$ as heat engine, is used as a refrigerator. If the work done on the system is 10 J, the amount of energy absorbed from the reservoir at lower temperature is

(a) 99 J (b) 90 J

(c) 1 J (d) 100 J

**145.** A Carnot engine operating between temperatures $T_1$ and $T_2$ has efficiency 0.2. When $T_2$ is reduced by 50 K, its efficiency increases to 0.4. Then $T_1$ and $T_2$ are respectively

(a) 200 K, 150 K (b) 250 K, 200 K

(c) 300 K, 250 K (d) 300 K, 200 K

**146.** If the energy input to a Carnot engine is thrice the work it performs then, the fraction of energy rejected to the sink is

(a) $\frac{1}{3}$ (b) $\frac{1}{4}$

(c) $\frac{2}{5}$ (d) $\frac{2}{3}$

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(c)** **2.** **(d)** **3.** **(c)** **4.** **(c)**

**5.** **(a)** **6.** **(b)** **7.** **(b)**

**8.** **(a)** Work is energy transfer brought about by moving piston of a cylinder containing the gas, by raising or lowering some weight connected to it.

**9.** **(d)** Pressure, volume, temperature and mass are all macroscopic variables which can be measured.

**10.** **(c)** Heat and work are not state variables. They are energy, transfer to a system which change the internal energy of a system, which is a state variable.

**11.** **(c)** Internal energy of an ideal gas depends only on the temperature.

**12.** **(c)** **13. (b)**

**14.** **(a)** Zeroth law defines temperature and first law defines internal energy.

**15.** **(b)**

**16.** **(b)** From FLOT $\Delta Q = \Delta U + \Delta W$

$\because$ Heat supplied to the system so

$\Delta Q \to$ Positive

and work is done on the system so

$\Delta W \to$ Negative

Hence $+\Delta Q = \Delta U - \Delta W$

**17.** **(c)**

**18.** **(d)** Heat always refers to energy transmitted from one body to another because of temperature difference.

**19.** **(b)** Internal energy and entropy are state function, they do not depend upon path but on the state.

**20.** **(b)** For one mole of a solid, the total energy.

$$U = 3K_BT \times N_A = 3RT$$

At constant pressure, $\Delta Q = \Delta U + P\Delta V \cong \Delta U$, since for a solid $\Delta V$ is negligible

$$\therefore \quad C = \frac{\Delta Q}{\Delta T} = \frac{\Delta U}{\Delta T} = 3R$$

**21.** **(c)** For an adiabatic process of an ideal gas.

$$PV^{\gamma} = \text{const} \qquad \text{where} \quad \gamma = \frac{C_P}{C_V}$$

**22.** **(b)** **23. (d)**

**24.** **(d)** $\gamma = \frac{C_P}{C_V}$ & it is always larger than unity, even if gas is mono, dia or polyatomic.

$\gamma = 1.67$ monatomic gas

$\gamma = 1.40$ dia-atomic gas

$\gamma = 1.33$ polyatomic gas

**25.** **(a)** $C_p - C_v$ = work done

**26.** **(c)** In an isochoric process, no work is done on or by the gas. $V$ is constant

**27.** **(a)** **28. (c)**

**29.** **(d)** R is the universal gas constant.

**30.** **(a)** In isothermal process temperature remains constnat. i.e., $\Delta T = 0$. Hence according to

$$C = \frac{Q}{m\Delta T} \Rightarrow C_{iso} = \infty$$

**31.** **(b)** In adiabatic process, no heat is taken or given by the system i.e., $\Delta Q = 0 \Rightarrow \Delta U = -\Delta W$

If $\Delta W$ is negative (work done on system), then $\Delta U$ increases & temperature increases and vice-versa. So work done in adiabatic change in particular gas (ideal gas) depends on change in temperature.

**32.** **(a)** **33. (c)** **34. (a)** **35. (b)** **36. (c)**

**37.** **(a)** From first law of thermodynamics,

$$\Delta H = \Delta u + w$$

In adiabatic process $\Delta H = 0$

$\therefore \quad \Delta u = -w$

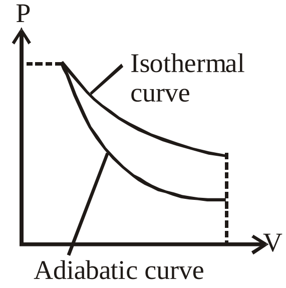
**38.** **(c)** During melting temperature remains constant

**39.** **(c)**

**40.** **(a)** Every point on this isothermal curve represents the condition of a system.

**41.** **(c)** $\dfrac{\text{Slope of adiabatic curve}}{\text{Slope of isothermal curve}} = \dfrac{(dP/dV)_{adi}}{(dP/dV)_{iso}} = +\gamma$

So slope to adiabatic curve is $\gamma\left(=\frac{C_P}{C_V}\right)$ times of isothermal curve, as clear also from figure.



**42.** **(a)** **43. (c)**

**44.** **(a)** In an isochoric process volume remains constant whereas pressure remains constant in isobaric process.

**45.** **(a)**

**46.** **(a)** For adiabatic process Q = 0.
By first law of thermodynamics,
$Q = \Delta E + W$
$\Rightarrow \Delta E_{int} = -W.$

**47.** **(c)** In an adiabatic process $\Delta Q = 0$.

**48.** **(a)** **49.** **(c)** **50.** **(b)**

**51.** **(a)** External amount of work must be done in order to flow heat from lower temperature to higher temperature. This is according to second law of thermodynamics.

**52.** **(b)**

**53.** **(b)**

**54.** **(c)** For process to be reversible it must be quasi-static. For quasi static process all changes take place infinitely slowly. Isothermal process occur very slowly so it is quasi-static and hence it is reversible.

**55.** **(a)** Slow isothermal expansion or compression of an ideal gas is reversible process, while the other given processes are irreversible in nature.

**56.** **(d)** In reversible cyclic Process
$\Delta U = 0$

**57.** **(d)** Efficiency $\eta = \frac{W}{\theta_1}$ and $W = \theta_1 - \theta_2$

$\therefore \quad \eta = \frac{\theta_1 - \theta_2}{\theta_1} = 1 - \frac{\theta_2}{\theta_1}$

**58.** **(b)**

**59.** **(b)**

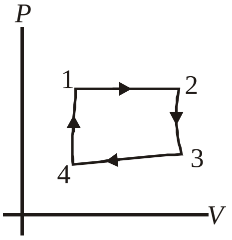
**60.** **(d)** $\eta = 1 - \frac{T_2}{T_1}$ So for $\eta$ be high $T_1$ must be high and $T_2$ must be low.

**61.** **(b)**

**62.** **(a)** **63.** **(a)**

**64.** **(c)** Absolute zero temperature is practically not reachable.

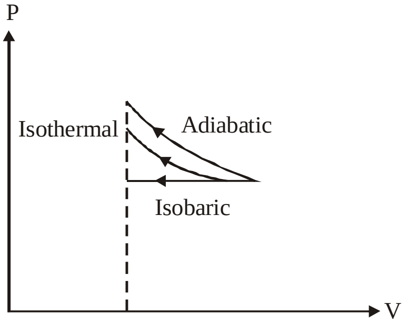
**65.** **(b)** Heat engine is device by which a system is made to undergo cyclic process that result in conversion of heat into work.



When gas (system) in heat engine undergoes process 1 → 2 → 3 → 4 → 1, then work done by gas = area enclosed by figure formed by joining 1, 2 , 3 , 4.
Work is positive if arrows move clockwise.

**66.** **(b)** A thermodynamic process is reversible process can be turned back such that both the system and the surroundings return to their original states, with no other change anywhere in the universe.

**67.** **(d)** Since area under the curve is maximum for adiabatic process so, work done (W = PdV) on the gas will be maximum for adiabatic process



**68.** **(c)**

## STATEMENT TYPE QUESTIONS

**69.** **(a)**

**70.** **(a)** Specific heat of a substance does not depend on mass. It depends only on temperature and nature of the material.

**71.** **(a)** In isothermal process, the temperature remains constant so the internal energy does not change but in adiabatic process, the temperature changes and hence the internal energy also changes.

**72.** **(c)** Work done in compressing the gas increases the internal energy of the gas.

**73.** **(c)**

**74.** **(c)** is Kelvin-Planck's statement and (b) is clauss statement of second law of thermodynamics. Both the statements are completely equivalent.

**75.** **(a)** For a Carnot engine, (i) there is absolutely no friction between the walls of cylinder and the piston. (ii) Woking substance is an ideal gas. In a real engine, these conditions cannot fullfilled and hence no heat engine working between the same two temperatures can have efficiency greater than that of Carnot engine.

**76.** **(d)** **77.** **(c)**

**78.** **(c)** Internal energy is a macroscopic state variable that depend on the state of the system not how that state is achieved. It is thermodynamic state variable.

**79.** **(d)** All the five statements are correct and so that in nature irreversibility is a rule.

## MATCHING TYPE QUESTIONS

**80.** **(a)**

| Type of processes | Feature |
|---|---|
| Isothermal | Temperature constant |
| Isobaric | Pressure constant |
| Isochoric | Volume constant |
| Adiabatic | $\Delta Q = 0$ |

**81.** **(a)** **(A) → 3** $C_v = \frac{1}{273}$ / °C same for all gases

**(B) → 1** $PV = \cos A \Rightarrow P \propto \frac{1}{V}$

**(C) → 2** Ideal gas obey gas law at each range of temperature.

**(D) → 4** At high temperature, intermolecular forces become zero and so real gas behaves like ideal gas.

**82.** **(b)** A → r; B → p; C → q; D → s

**83.** () A → (3); B → (1); C → (2); D → (2)

## DIAGRAM TYPE QUESTIONS

**84.** **(a)** ∵ Internal energy is the state function.

∴ In cyclie process; $\Delta U = 0$

According to 1st law of thermodynamics

$$\boxed{\Delta Q = \Delta U + W}$$

So heat absorbed

$\Delta Q = W$ = Area under the curve

$= -\ (2V)(P) = -\ 2PV$

So heat rejected = 2PV

**85.** **(a)** Initial and final condition is same for all process

$\Delta U_1 = \Delta U_2 = \Delta U_3$

from first law of thermodynamics

$\Delta Q = \Delta U + \Delta W$

Work done

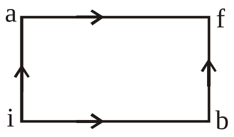
$\Delta W_1 > \Delta W_2 > \Delta W_3$ (Area of P.V. graph)

So $\Delta Q_1 > \Delta Q_2 > \Delta Q_3$

**86.** **(b)** For path iaf,

Q = 50 cal

W = 20 cal



By first law of thermodynamics,

$\Delta U = Q - W = 50 - 20 = 30$ cal.

For path ibf

Q' = 36 cal

W' = ?

or, $W' = Q' - \Delta U'$

Since, the change in internal energy does not depend on the path, therefore

$\Delta U' = 30$ cal

∴ $W' = Q' - \Delta U' = 36 - 30 = 6$ cal.

**87.** **(d)** Isobaric compression is represented by curve AO

Work done = area under AD

$= 2 \times 10^2 \times (3 - 1)$

$= 4 \times 10^2 = 400$ J.

**88.** **(c)**

**89.** **(b)** In *VT* graph

ab-process : Isobaric, temperature increases.

bc process : Adiabatic, pressure decreases.

cd process : Isobaric, volume decreases.

da process : Adiabatic, pressure increases.

The above processes correctly represented in *P-V* diagram (b).

**90.** **(d)** Work done by the system in the cycle

= Area under P-V curve and V-axis

$$= \frac{1}{2}(2P_0 - P_0)(2V_0 - V_0) + \left[-\left(\frac{1}{2}\right)(3P_0 - 2P_0)(2V_0 - V_0)\right]$$

$$= \frac{P_0V_0}{2} - \frac{P_0V_0}{2} = 0$$

**91.** **(b)** In cyclic process ABCA

$Q_{cycle} = W_{cycle}$

$Q_{AB} + Q_{BC} + Q_{CA}$ = ar. of ΔABC

$$+ 400 + 100 + Q_{C \to A} = \frac{1}{2}(2 \times 10^{-3})(4 \times 10^4)$$

$\Rightarrow \quad Q_{C \to A} = -\,460$ J

$\Rightarrow \quad Q_{A \to C} = +\,460$ J

**92.** **(d)** In cyclic process, change in total internal energy is zero.

$\Delta U_{cyclic} = 0$

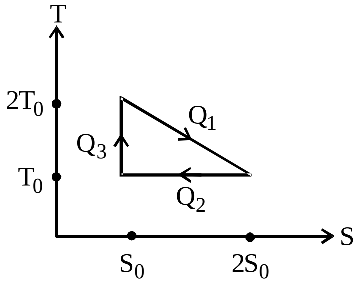
$$\Delta U_{BC} = nC_v\Delta T = 1 \times \frac{5R}{2}\Delta T$$

Where, $C_v$ = molar specific heat at constant volume.

For BC, $\Delta T = -200$ K

∴ $\Delta U_{BC} = -500R$

**93.** **(d)**



$$Q_1 = T_0S_0 + \frac{1}{2}T_0S_0 = \frac{3}{2}T_0S_0$$

$$Q_2 = T_0(2S_0 - S_0) = T_0S_0 \text{ and } Q_3 = 0$$

$$\eta = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1}$$

$$= 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_0S_0}{\frac{3}{2}T_0S_0} = \frac{1}{3}$$

## ASSERTION- REASON TYPE QUESTIONS

**94. (d)** Zeroth law of thermodynamics tells about thermal equilibrium.

**95. (b)** On heating a body it absorbs energy, so, its mass will increase accordingly as per the equation

$$E = mc^2$$

**96. (d)** Heat can be added to a system without increasing its temperature e.g. melting and boiling.

**97. (d)** According to first law of thermodynamics, $\Delta Q = \Delta U + \Delta W = \Delta U + P\Delta V$. If heat is supplied in such a manner that volume does not change $\Delta V = 0$,i.e., isochoric process, then whole of the heat energy supplied to the system will increase internal energy only. But, in any other process it is not possible.

Also heat may be adsorbed or evolved when state of thermal equilibrium changes.

**98. (d)** In isothermal process, $\Delta T = 0$ and so $\Delta U = 0$.

Thus $Q = 0 + W = W$.

**99. (c)** First law of thermodynamics is restatement of the principal of conservation of energy as applied to heat energy.

**100. (a)** **101. (b)** **102. (d)**

**103. (a)** The opening of bottle is the rapid or adiabatic process. In the process temperature falls.

**104. (c)** In adiabatic process, $Q = 0$

$\therefore\ 0 = \Delta U + W$ or $\Delta U = -W$.

Temperature will change in adiabatic process.

**105. (e)** As isothermal processes are very slow and so the different isothermal curves have different slopes so they cannot intersect each other.

**106. (b)** **107. (c)** **108. (a)**

**109. (d)** According to second law of thermodynamics, this is not possible to transfer heat from a body at lower temperature to a body at higher temperature without the aid of an external agent. Since, the given information produces a contradiction in second law of thermodynamics, therefore it is not possible to produce temperature of 8000 K by collecting the sun rays with a lens.

**110. (b)** When milk cools, its energy content decreases.

**111. (a)** **112. (a)** **113. (a)** **114. (a)**

**115. (a)** $\eta = 1 - \frac{T_2}{T_1}$; clearly when $T_2$ is decreases $\eta$ will increase.

**116. (a)** Carnot cycle has maximum efficiency.

## CRITICALTHINKING TYPE QUESTIONS

**117. (b)** In the first-case adiabatic change,

$\Delta Q = 0, \Delta W = -35$ J

From 1st law of thermodynamics,

$\Delta Q = \Delta U + \Delta W$,

or $0 = \Delta U - 35$

$\therefore \Delta U = 35$ J

In the second case

$\Delta Q = 12$ cal $= 12 \times 4.2$ J $= 50.4$ J

$\Delta W = \Delta Q - \Delta U = 50.4 - 35 = 15.4$ J

**118. (c)** According to first law of thermodynamics

$$Q = \Delta U + W$$

$$\Delta U = Q - W$$

$$= 2 \times 4.2 \times 1000 - 500$$

$$= 8400 - 500$$

$$= 7900 \text{ J}$$

**119. (b)**

$$n = \frac{PV}{RT}$$

$$= \left[\frac{1.6 \times 10^6 \times 0.0083}{8.31 \times 300}\right] = 5.33$$

$$Q = nC_v\Delta T$$

or $$2.49 \times 10^4 = 5.33 \times \left(\frac{3 \times 8.31}{2}\right) \times \Delta T$$

or $$\Delta T = 375 \text{ K}$$

$\therefore$ $$T_f = T_i + 375 = 675 \text{ K.}$$

**120. (c)** Heat required to change the temperature of vessel by a small amount $dT$

$$-dQ = mC_p dT$$

Total heat required

$$-Q = m\int_{20}^{4} 32\left(\frac{T}{400}\right)^3 dT = \frac{100 \times 10^{-3} \times 32}{(400)^3}\left[\frac{T^4}{4}\right]_{20}^{4}$$

$\Rightarrow\ Q = 0.001996$ kJ

Work done required to maintain the temperature of sink to $T_2$

$$W = Q_1 - Q_2 = \frac{Q_1 - Q_2}{Q_2}Q_2 = \left(\frac{T_1}{T_2} - 1\right)Q_2$$

$$\Rightarrow W = \left(\frac{T_1 - T_2}{T_2}\right)Q_2$$

For $T_2 = 20$ K

$$W_1 = \frac{300 - 20}{20} \times 0.001996 = 0.028 \text{ kJ}$$

For $T_2 = 4$ K

$$W_2 = \frac{300 - 4}{4} \times 0.001996 = 0.148 \text{ kJ}$$

As temperature is changing from 20k to 4 k, work done required will be more than $W_1$ but less than $W_2$.

**121. (a)** Given, $m = 4 \times 10^{-2}$ kg $= 40$ g, $\Delta T = 50°C$

Number of moles, $n = \frac{m}{M} = \frac{40}{28} = 1.43$

As nitrogen is a diatomic gas, molar specific heat at constant pressure is

$$C_p = \frac{7}{2}R = \frac{7}{2}\times 8.3\,\text{Jmol}^{-1}\text{K}^{-1} = 29.05\,\text{J mol}^{-1}\text{K}^{-1}$$

As $\Delta Q = nC_p\Delta T$

$\therefore\ \Delta Q = 1.43 \times 29.05 \times 50$

$= 2.08 \times 10^3\ \text{J} = 2.08\ \text{kJ}$

**122. (d)** Change in entropy is given by

$$dS = \frac{dQ}{T} \text{ or } \Delta S = \frac{\Delta Q}{T} = \frac{mL_f}{273}$$

$$\Delta S = \frac{1000 \times 80}{273} = 293\,\text{cal/K}.$$

**123. (c)** $T_1 = 273 + 27 = 300\text{K}$

$T_2 = 273 + 927 = 1200\text{K}$

For adiabatic process,

$P^{1-\gamma}\ T^{\gamma} = \text{constant}$

$\Rightarrow P_1^{1-\gamma}\ T_1^{\gamma} = P_2^{1-\gamma}\ T_2^{\gamma}$

$$\Rightarrow \left(\frac{P_2}{P_1}\right)^{1-\gamma} = \left(\frac{T_1}{T_2}\right)^{\gamma}$$

$$\Rightarrow \left(\frac{P_1}{T_2}\right)^{1-\gamma} = \left(\frac{T_2}{T_1}\right)^{\gamma}$$

$$\left(\frac{P_1}{P_2}\right)^{1-1.4} = \left(\frac{1200}{300}\right)^{1.4}$$

$$\left(\frac{P_1}{P_2}\right)^{-0.4} = (4)^{1.4}$$

$$\left(\frac{P_2}{P_1}\right)^{0.4} = 4^{1.4}$$

$$P_2 = P_1\ 4^{\left(\frac{1.4}{0.4}\right)} = P_1\ 4^{\left(\frac{7}{2}\right)}$$

$= P_1\ (2^7) = 2 \times 128 = 256\ \text{atm}$

**124. (b)** Initial temperature $(T_1) = 18°\text{C} = 291\ \text{K}$

Let Initial volume $(V_1) = V$

Final volume $(V_2) = \dfrac{V}{8}$

According to adiabatic process,

$TV^{\gamma-1} = \text{constant}$

According to question, $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$

$$\Rightarrow T_2 = 293\left(\frac{V_1}{V_2}\right)^{\gamma-1}$$

$$\Rightarrow T_2 = 293(8)^{\frac{7}{5}-1} = 293 \times 2.297 = 668.4\text{K}$$

$$\left[\text{For diatomic gas } \gamma = \frac{C_p}{C_v} = \frac{7}{5}\right]$$

**125. (a)**
$$\Delta U = nC_v\Delta T$$
$$= 2 \times 10^3 \times 20 \times 273$$
$$= 10.9\ \text{MJ.}$$

**126. (c)** $P_1V_1^{\gamma} = P_2V_2^{\gamma}$ (Adiabatic change)

$$P_2 = P_1\left(\frac{V_1}{V_2}\right)^{\gamma} = P_1\left(\frac{V_1}{V_1/3}\right)^{\gamma} = P_2(3)^{\gamma}$$

**127. (a)** Here, $T_1 = 500\ \text{K}, T_2 = 375\ \text{K}$

$Q_1 = 25 \times 10^5\ \text{J}$

$$\therefore\ \eta = 1 - \frac{T_2}{T_1} = 1 - \frac{375}{500} = 0.25$$

$W = \eta Q = 0.25 \times 25 \times 10^5 = 6.25 \times 10^5\ \text{J}$

**128. (d)** The coefficient of performance of a refrigerator is given by

$$\alpha = \frac{Q_2}{W} = \frac{Q_2}{Q_1 - Q_2}$$

Substituting the given values, we get

$$\frac{1}{3} = \frac{Q_2}{200 - Q_2}$$

$\Rightarrow\ 200 - Q_2 = 3Q_2 \Rightarrow 4Q_2 = 200$

or $\quad Q_2 = \dfrac{200}{4}\text{J} = 50\text{J}$

$\therefore\ \ W = Q_1 - Q_2 = 200\ \text{J} - 50\ \text{J} = 150\ \text{J}$

**129. (b)** Here, Coefficient of performance $(\beta) = 5$

$T_1 = 27°\text{C}$

$= (27 + 273)\text{K}$

$= 300\ \text{K}$

$$\text{As, } \beta = \frac{T_2}{T_1 - T_2} \Rightarrow 5 = \frac{T_2}{300 - T_2}$$

or $1500 - 5T_2 = T_2$ or $6T_2 = 1500$

$$\therefore\ T_2 = \frac{1500}{6} = 250\ \text{K}$$

**130. (c)** By running a refrigerator with open door in a room. The room will get a little hotter because now compressor will do more work which in turn increases the room's temperature.

**131. (c)** The working of an air coditioner is similar to the working of a refrigerator. An air conditioner removes heat from the room, does some work and rejects the heat to the surroundings. As air conditioner is put in the middle of the room then due to continuous, external work the room will become slightly warmer.

**132. (c)** For isothermal process $P_1V_1 = P_2V_2$

$$\Rightarrow \; PV = P_2(2V) \;\Rightarrow\; P_2 = \frac{P}{2}$$

For adiabatic process

$$P_2V_2^{\gamma} = P_3V_3^{\gamma}$$

$$\Rightarrow \; \left(\frac{P}{2}\right)(2v)^{\gamma} = P_3 16v)^{\gamma}$$

$$\Rightarrow \; P_3 = \frac{3}{2}\left(\frac{1}{8}\right)^{5/3} = \frac{P}{64}$$

**133. (c)** As we know, energy stored in a spring

$$U = \frac{1}{2}kx^2$$

$x$ = extension (or compression) in the spring.

$k$ = spring constant of the spring

As per question, for $x = 1\text{mm} = 1 \times 10^{-3m}$

$$U = \frac{1}{2}k(1\times10^{-3}\text{m})^2 = 1\,\text{J} \qquad \text{.......(i)}$$

If spring is further compressed by 1 mm then

$$U' = \frac{1}{2}k(2\times10^{-3}\text{m})^2 \qquad \text{.......(ii)}$$

Dividing eqn. (ii) by (i), we get

$$\frac{U'}{U} = 4 \text{ or } U' = 4U$$

Work done

$W = U' - U = 4U - U$

$= 3U = 3 \times 1\text{ J} = 3\text{J}$

**134. (b)** According to first law of thermodynamics

$Q = \Delta U + W$

Given : $Q = 2\text{ kcal} = 2000 \times 4.2 = 8400\text{ J}$

$W = 400\text{ J}$

$\therefore \; \Delta U = Q - W$

$= 8400 - 400$

$= 8000\text{ J}$

**135. (c)** The heat exchange between the air conditioned room and the space outside the room will not take place at all.

**136. (a)** Kinetic energy of box is not included in the internal energy of the gas.

**137. (d)** Efficiency, $\eta = \left(1 - \frac{T_2}{T_1}\right) \times 100$

$$\eta' = 1 - \frac{(T_2 - 100)}{(T_1 - 100)} \times 100$$

$$= \frac{(T_1 - 100 - T_2 + 100)}{T_1 - 100} \times 100$$

$$\eta' = \left(\frac{T_1 - T_2}{T_1 - 100}\right) \times 100.$$

Comparing with $\eta$ we get, the efficiency increases.

**138. (b)** $\eta = \dfrac{(627 + 273) - (273 + 27)}{627 + 273}$

$$= \frac{900 - 300}{900} = \frac{600}{900} = \frac{2}{3}$$

$$\text{work} = (\eta) \times \text{Heat} = \frac{2}{3} \times 3 \times 10^6 \times 4.2\text{ J}$$

$= 8.4 \times 10^6\text{ J}$

**139. (c)** The efficiency ($\eta$) of a Carnot engine and the coefficient of performance ($\beta$) of a refrigerator are related as

$$\beta = \frac{1 - \eta}{\eta}$$

Here, $\eta = \dfrac{1}{10}$

$$\therefore \quad \beta = \frac{1 - \frac{1}{10}}{\left(\frac{1}{10}\right)} = 9.$$

Also, Coefficient of performance ($\beta$) is given by $\beta = \dfrac{Q_2}{W}$, where $Q_2$ is the energy absorbed from the reservoir.

or, $\quad 9 = \dfrac{Q_2}{10}$

$\therefore \quad Q_2 = 90\text{ J}.$

**140. (b)** The efficiency of cycle is

$$\eta = 1 - \frac{T_2}{T_1}$$

For adiabatic process

$T\,V^{\gamma-1}$ = constant

For diatomic gas $\gamma = \dfrac{7}{5}$

$$T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$$

$$T_1 = T_2 \left(\frac{V_2}{V_1}\right)^{\gamma-1}$$

$$T_1 = T_2 (32)^{\frac{7}{5}-1} = T_2 (2^5)^{2/5} = T_2 \times 4$$

$$T_1 = 4T_2$$

$$\therefore \quad \eta = \left(1 - \frac{1}{4}\right) = \frac{3}{4} = 0.75$$

**141. (d)** $\eta_1 = 1 - \frac{T_2}{T_1} \Rightarrow \frac{1}{6} = 1 - \frac{T_2}{T_1} \Rightarrow \frac{T_2}{T_1} = \frac{5}{6} \ldots \text{(i)}$

$$\eta_2 = 1 - \frac{T_2 - 62}{T_1} \Rightarrow \frac{1}{3} = 1 - \frac{T_2 - 62}{T_1} \quad \ldots\text{(ii)}$$

On solving Eqs. (i) and (ii)

$T_1 = 372$ K and $T_2 = 310$ K

**142. (a)** As we know $\eta = \frac{W}{Q_1} = 1 - \frac{T_2}{T_1}$

$$\Rightarrow \quad \eta = 1 - \frac{300\,K}{1200K} = \frac{3}{4}$$

$$\frac{3}{4} = \frac{W}{Q_1} \Rightarrow Q_1 = W \times \frac{4}{3} \Rightarrow Q_1 = 12.6 \times 10^6 \times \frac{4}{3}$$

$Q_1 = 16.8 \times 10^6$J.

**143. (d)** Coefficient of performance,

$$\text{Cop} = \frac{T_2}{T_1 - T_2}$$

$$5 = \frac{273 - 20}{T_1 - (273 - 20)} = \frac{253}{T_1 - 253}$$

$$5T_1 - (5 \times 253) = 253$$
$$5T_1 = 253 + (5 \times 253) = 1518$$

$$\therefore T_1 = \frac{1518}{5} = 303.6$$

or, $T_1 = 303.6 - 273 = 30.6 \cong 31°C$

**144. (b)** Efficiency of carnot engine

$$n = 1 - \frac{T_2}{T_1} \text{ i.e., } \frac{1}{10} = 1 - \frac{T_2}{T_1}$$

$$\Rightarrow \quad \frac{T_2}{T_1} = 1 - \frac{1}{10} = \frac{9}{10} \Rightarrow \frac{T_1}{T_2} = \frac{10}{9}$$

$$\therefore \quad w = Q_2 \,.\, \left(\frac{T_1}{T_2} - 1\right)$$

$$\text{i.e., } 10 = Q_2 \left(\frac{10}{9} - 1\right) 10 = Q_2 \left(\frac{1}{9}\right)$$

$\Rightarrow Q_2 = 90$J

So, 90 J heat is absorbed at lower temperature.

**145. (b)** When efficiency of carnot engine, $\eta = 0.2$

Efficiency of a Carnot engine,

$$\eta = 1 - \frac{T_2}{T_1} \text{ or, } 0.2 = 1 - \frac{T_2}{T_1}$$

$$\text{or } \frac{T_2}{T_1} = 0.8 \qquad \text{...(i)}$$

When $T_2$ is reduced by 50 K, its efficiency becomes 0.4

$$\therefore \quad 0.4 = 1 - \frac{T_2 - 50}{T_1}$$

$$\text{or } \frac{T_2 - 50}{T_1} = 0.6 \qquad \text{...(ii)}$$

Dividing eqn. (i) by (ii)

$$\frac{T_2}{T_2 - 50} = \frac{0.8}{0.6} = \frac{4}{3}$$

$\Rightarrow 3T_2 = 4T_2 - 200$ or $T_2 = 200$ K

From eqn. (ii), $T_1 = \frac{T_2 - 50}{0.6} = \frac{200 - 50}{0.6} = 250K$

**146. (d)** Efficiency $\eta = \frac{W_{output}}{Heat_{input}} = \frac{w}{3w} = \frac{1}{3}$

$$\eta = 1 - \frac{Q_2}{Q_1} = \frac{1}{3}$$

$$\therefore \quad \frac{Q_2}{Q_1} = \frac{2}{3}$$

# CHAPTER
# 13
# KINETIC THEORY

## FACT/DEFINITION TYPE QUESTIONS

**1.** According to the kinetic theory of gases, the pressure exerted by a gas on the wall of the container is measured as
- (a) rate of change of momentum imparted to the walls per second per unit area.
- (b) momentum imparted to the walls per unit area
- (c) change of momentum imparted to the walls per unit area.
- (d) change in momentum per unit volume

**2.** According to kinetic theory of matter, a molecule is the smallest particle of a substance and it possesses
- (a) all the properties of the substance
- (b) some of the properties of the substance
- (c) none of the properties of the substance
- (d) either (b) or (c)

**3.** When a gas is in thermal equilibrium, its molecules
- (a) have the same average kinetic energy of molecules
- (b) have different energies which remain constant
- (c) have a certain constant energy
- (d) do not collide with one another

**4.** The pressure exerted on the walls of container by a gas is due to the fact that gas molecules are
- (a) losing their kinetic energy
- (b) sticking to the walls
- (c) changing their momenta due to collision with the walls
- (d) getting accelerated towards the wall

**5.** According to kinetic theory of gases, at absolute zero temperature
- (a) water freezes
- (b) liquid helium freezes
- (c) molecular motion stops
- (d) liquid hydrogen freezes

**6.** The temperature of a gas is a measure of
- (a) the average kinetic energy of the gaseous molecules
- (b) the average potential energy of the gaseous molecules
- (c) the average distance between the molecules of the gas
- (d) the size of the molecules of the gas

**7.** The absolute temperature of a gas determines
- (a) the average momentum of the molecule
- (b) the velocity of sound in the gas
- (c) the number of molecules in the gas
- (d) the mean square velocity of the molecules

**8.** At a given temperature the force between molecules of a gas as a function of intermolecular distance is
- (a) always constant
- (b) always decreases
- (c) always increases
- (d) first decreases and then increases

**9.** The temperature of gas is produced by
- (a) the potential energy of its molecules
- (b) the kinetic energy of its molecules
- (c) the attractive force between its molecules
- (d) the repulsive force between its molecules

**10.** Kinetic theory of gases provide a base for
- (a) Charle's law
- (b) Boyle's law
- (c) Both Charle's law and Boyle's law
- (d) None of these

**11.** In kinetic theory of gases, it is assumed that molecules
- (a) have same mass but can have different volume
- (b) have same volume but mass can be different
- (c) have different mass as well as volume
- (d) have same mass but negligible volume.

**12.** The internal energy of a gram-molecule of an ideal gas depends on
- (a) pressure alone
- (b) volume alone
- (c) temperature alone
- (d) both on pressure as well as temperature

**13.** The phenomenon of Browninan movement may be taken as evidence of
- (a) kinetic theory of matter
- (b) electromagnetic theory of radiation
- (c) corpuscular theory of light
- (d) photoelectric phenomenon

**14.** At 0K which of the following of a gas will be zero?
(a) Kinetic energy (b) Potential energy
(c) Vibrational energy (d) Density

**15.** Which of the following molecular properties is the same for all ideal gases at a given temperature
(a) momentum (b) rms velocity
(c) mean kinetic energy (d) mean free path

**16.** When do real gases approach the ideal gas behaviour ?
(a) At low pressure and low temperature
(b) At low pressure and high temperature
(c) At high pressure and high temperature
(d) At high pressure and low temperature

**17.** When temperature is constant, the pressure of a given mass of gas varies inversely with volume. This is the statement of
(a) Boyle's law (b) Charle's law
(c) Avogadro's law (d) None of these

**18.** The equation which should be satisfied exactly at all pressures and temperatures to be an ideal gas is
(a) $PV = \mu RT$ (b) $PV = k_B NT$
(c) $P = k_B nT.$ (d) All of these

**19.** In a diatomic molecules, the rotational energy at a given temperature
(a) obeys Maxwell's distribution
(b) have the same volue for all molecules
(c) equals the translational kinetic energy for each molecule.
(d) None of these

**20.** The average kinetic energy per molecule of any ideal gas is always equal to
(a) $\frac{2}{3}k_B T$ (b) $\frac{3}{4}k_B T$
(c) $\frac{3}{2}k_B T$ (d) $3k_B T$

**21.** In a mixture of gases at a fixed temperature
(a) heavier molecule has higher average speed
(b) lighter molecule has lower average speed
(c) heavier molecule has lower average speed
(d) None of these

**22.** The average kinetic energy of gas molecules depends upon which of the following factor?
(a) Nature of the gas (b) Temperature of the gas
(c) Volume of the gas (d) Both (b) & (c)

**23.** Cooking gas containers are kept in a lorry moving with uniform speed. The temperature of the gas molecules inside will.
(a) increase
(b) decrease
(c) remains the same
(d) decrease for some and increase for others

**24.** Molecules of a ideal gas behave like
(a) inelastic rigid sphere
(b) perfectly elastic non-rigid sphere
(c) perfectly elastic rigid sphere
(d) inelastic non-rigid sphere

**25.** If the pressure and the volume of certain quantity of ideal gas are halved, then its temperature
(a) is doubled (b) becomes one-fourth
(c) remains constant (d) is halved

**26.** In kinetic theory of gases, one assumes that the collisions between the molecules are
(a) perfectly elastic
(b) perfectly inelastic
(c) partly inelastic
(d) may be perfectly elastic or perfectly inelastic depending on nature of gas

**27.** Pressure exerted by a gas is
(a) independent of density of the gas
(b) inversely proportional to the density of the gas
(c) directly proportional to the square of the density of the gas
(d) directly proportional to the density of the gas

**28.** The internal energy of a gram-molecule of an ideal gas depends on
(a) pressure alone
(b) volume alone
(c) temperature alone
(d) both on pressure as well as temperature

**29.** The relation PV = RT can describe the behaviour of a real gas at
(a) high temperature and high pressure
(b) high temperature and low pressure
(c) low temperature and low pressure
(d) low temperature and high pressure

**30.** For Boyle's law to hold, the gas should be
(a) perfect and of constant mass and temperature
(b) real and of constant mass and temperature
(c) perfect and constant temperature but variable mass
(d) real and constant temperature but variable mass

**31.** Boyle' law is applicable for an
(a) adiabatic process. (b) isothermal process.
(c) isobaric process. (d) isochoric process

**32.** The deviation of gases from the behaviour of ideal gas is due to
(a) colourless molecules
(b) covalent bonding of molecules
(c) attraction of molecules
(d) absolute scale of temp.

**33.** In Boyle's law what remains constant ?
(a) PV (b) TV
(c) $\frac{V}{T}$ (d) $\frac{P}{T}$

**34.** At a given temperature which of the following gases possesses maximum r.m.s. velocity?

(a) Hydrogen (b) Oxygen

(c) Nitrogen (d) Carbon dioxide

**35.** Pressure exerted by a perfect gas is equal to

(a) mean kinetic energy per unit volume

(b) half of mean kinetic energy per unti volume

(c) two third of mean kinetic energy per unit volume

(d) one third of mean kinetic energy per unit volume

**36.** The ratio of molar specific heat at constant pressure $C_P$, to molar specific heat at constant volume $C_v$ for a monoatomic gas is

(a) $\frac{C_P}{C_V}=\frac{3}{5}$ (b) $\frac{C_P}{C_V}=\frac{5}{3}$

(c) $\frac{C_P}{C_V}=\frac{7}{9}$ (d) $\frac{C_P}{C_V}=\frac{9}{7}$

**37.** The average velocity of the molecules in a gas in equilibrium is proportional to

(a) $\sqrt{T}$ (b) T

(c) $T^2$ (d) $\frac{1}{\sqrt{T}}$

**38.** According to the kinetic theory of gases, the r.m.s. velocity of gas molecules is directly proportional to

(a) T (b) $\sqrt{T}$

(c) $T^2$ (d) $1/\sqrt{T}$

**39.** The average kinetic energy of a molecule of a perfect gas is

(a) (2/3) kT (b) 1.5 kT

(c) 2.5 kT (d) None of these

**40.** The internal energy of an ideal gas is

(a) the sum of total kinetic and potential energies.

(b) the total translational kinetic energy.

(c) the total kinetic energy of randomly moving molecules.

(d) the total kinetic energy of gas molecules.

**41.** The root mean square speed of a group of n gas molecules, having speed $v_1, v_2, v_3,..., v_n$ is

(a) $\frac{1}{n}\sqrt{(v_1+v_2+v_3+...+v_n)^2}$

(b) $\frac{1}{n}\sqrt{(v_1^2+v_2^2+v_3^2+...+v_n^2)}$

(c) $\sqrt{\frac{1}{n}(v_1^2+v_2^2+v_3^2+...+v_n^2)}$

(d) $\sqrt{\left[\frac{(v_1+v_2+v_3+...\ v_n)^2}{n}\right]}$

**42.** The ratio of the molar heat capacities of a diatomic gas at constant pressure to that a constant volume is

(a) $\frac{7}{2}$ (b) $\frac{3}{2}$ (c) $\frac{3}{5}$ (d) $\frac{7}{5}$

**43.** The specific heat of a gas

(a) has only two values $c_p$ and $c_v$

(b) has a unique value at a given temperature

(c) can have any value between 0 and ∞

(d) depends upon the mass of the gas

**44.** The mean kinetic energy of a perfect monatomic gas molecule at the temperature T°K is

(a) $\frac{1}{2}kT$ (b) kT (c) $\frac{3}{2}kT$ (d) 2kT

**45.** The total internal energy of one mole of rigid diatomic gas is

(a) $\frac{3}{2}RT$ (b) $\frac{7}{2}RT$

(c) $\frac{5}{2}RT$ (d) $\frac{9}{2}RT$

**46.** The specific heats at constant pressure is greater than that of the same gas at constant volume because

(a) at constant pressure work is done in expanding the gas

(b) at constant volume work is done in expanding the gas

(c) the molecular attraction increases more at constant pressure

(d) the molecular vibration increases more at constant pressure

**47.** If $E$ is the translational kinetie energy, then which of the following relation holds good ?

(a) $PV = E$ (b) $PV = \frac{3}{2}E$

(c) $PV = 3E$ (d) $PV = \frac{2}{3}E$

**48.** Which of the following formula is wrong?

(a) $C_V = \frac{R}{\gamma-1}$ (b) $C_P = \frac{\gamma R}{\gamma-1}$

(c) $C_p / C_V = \gamma$ (d) $C_p - C_V = 2R$

**49.** As per the law of equi-partition of energy each vibrational mode gives how many degrees of freedom ?

(a) 1 (b) 2

(c) 3 (d) 0

**50.** A fly moving in a room has ...X... degree of freedom. Here, $X$ refers to

(a) one (b) two

(c) three (d) four

**51.** The number of degrees of freedom for each atom of a monatomic gas is

(a) 3 (b) 5 (c) 6 (d) 1

**52.** The total number of degree of freedom of a $CO_2$ gas molecule is

(a) 3 (b) 6

(c) 5 (d) 4

**53.** A polyatomic gas with n degrees of freedom has a mean energy per molecule given by

(a) $\frac{nkT}{N}$ (b) $\frac{nkT}{2N}$

(c) $\frac{nkT}{2}$ (d) $\frac{3kT}{2}$

**54.** The degree of freedom of a molecule of a triatomic gas is

(a) 2 (b) 4

(c) 6 (d) 8

**55.** If a gas has 'n' degrees of freedom, the ratio of the specific heats $\gamma$ of the gas is

(a) $\frac{1+n}{2}$ (b) $1+\frac{n}{2}$ (c) $1+\frac{1}{n}$ (d) $1+\frac{2}{n}$

**56.** How is the mean free path ($\lambda$) in a gas related to the interatomic distance ?

(a) $\lambda$ is 10 times the interatomic distance

(b) $\lambda$ is 100 times the interatomic distance

(c) $\lambda$ is 1000 times the interatomic distance

(d) $\lambda$ is $\frac{1}{10}$ times of the interatomic distance

**57.** Mean free path of a gas molecule is

(a) inversely proportional to number of molecules per unit volume

(b) inversely proportional to diameter of the molecule

(c) directly proportional to the square root of the absolute temperature

(d) directly proportional to the molecular mass

**58.** Maxwell's laws of distribution of velocities shows that

(a) the number of molecules with most probable velocity is very large

(b) the number of molecules with most probable velocity is very small

(c) the number of molecules with most probable velocity is zero

(d) the number of molecules with most probable velocity is exactly equal to 1

**59.** If the pressure in a closed vessel is reduced by drawing out some gas, the mean-free path of the molecules

(a) is decreased

(b) is increased

(c) remains unchanged

(d) increases or decreases according to the nature of the gas

## STATEMENT TYPE QUESTIONS

**60.** In the kinetic theory of gases, which of these statements is/are true ?

I. The pressure of a gas is proportional to the mean speed of the molecules.

II. The root mean square speed of the molecules is proportional to the pressure.

III. The rate of diffusion is proportional to the mean speed of the molecules.

IV. The mean translational kinetic energy of a gas is proportional to its kelvin temperature.

(a) II and III only (b) I, II and IV

(c) I and III only (d) III and IV only

**61.** From the following statements, concerning ideal gas at any given temperature $T$, select the correct one(s)

I. The coefficient of volume expansion at constant pressure is same for all ideal gas

II. The average translational kinetic energy per molecule of oxygen gas is $3\,KT$ ($K$ being Boltzmann constant)

III. In a gaseous mixture, the average translational kinetic energy of the molecules of each component is same

IV. The mean free path of molecules increases with decrease in pressure

(a) I, II and III (b) III and IV only

(c) I, III and IV (d) I, II, III and IV

**62.** Which of the given statement(s) is/are false ?

I. All molecules in a gas do not have same velocity.

II. For a gas there is distribution of velocities of the molecules.

III. There is no preferred direction of velocity of the molecules.

(a) I and II (b) II and III

(c) I and III (d) I, II and III

**63.** Which of the following statements is/are true ?

I. Average kinetic energy of a molecule is independent of the pressure of the gas.

II. Average kinetic energy of a molecule is independent of the volume of the gas.

III. Average kinetic energy of a molecule is independent of the nature of the gas.

(a) I and II (b) II and III

(c) I and III (d) I, II and III

**64.** For mean kinetic energy per molecule, a vessel filled with two different gases.

I. Mean kinetic energy per molecule for both gases will be equal

II. Mean kinetic energy per molecule of gas with higher mass will be more

III. Mean kinetic energy per moleculers of gas with lower mass will be more

Select the correct statement(s).

(a) I only (b) II only

(c) I and II (d) I, II and III

**65.** Consider the following statements and select the correct option from the following.

I. At room temperature the specific heats are independent of temperature.

II. At low temperature i.e. as $T \to 0$, specific heat approach zero.

III. At low temp, the degrees of freedom get frozen

(a) I and II (b) II and III

(c) I and III (d) I, II and III

**66.** The root mean square value of the speed of the molecules in a fixed mass of an ideal gas is increased by increasing

I. the temperature while keeping the volume constant

II. the pressure while keeping the volume constant

III. the temperature while keeping the pressure constant

IV. the pressure while keeping the temperature constant.

Select the correct statements.

(a) I and II (b) II and III

(c) I and III (d) I, III and IV

**67.** Consider the following statements and select the correct option.

I. The ratio of $C_P / C_V$ for a diatomic gas is more than that of a monoatomic gas.

II. The ratio of $C_P / C_V$ is more for helium gas than for hydrogen

(a) I only (b) II only

(c) I and II (d) None of these

**68.** Choose the false statement(s) from the following.

I. $C_P - C_V = R$ is true for monoatomic gases only.

II. Specific heat of a gas at constant pressure is greater than specific heat at constant volume.

III. Mean free path of molecules of a gas decrease with increase in number density of the molecules.

(a) I only (b) II only

(c) I and II (d) I, II and III

**69.** Which of the following is/are incorrect statement(s) regarding the law of equipartition of energy ?

I. The gas possess equal energies in all the three directions *x*,*y* and *z*-axis.

II. The total energy of a gas is equally divided between kinetic and potential energies.

III. The total kinetic energy of a gas molecules is equally divided among translational and rotational kinetic energies.

(a) I only (b) II and III

(c) I and III (d) I, II and III

## MATCHING TYPE QUESTIONS

**70.** Match the Column I and II.

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | $P \propto T$ | (1) | Ideal gas equation |
| (B) | $V \propto T$ | (2) | Boyle's law |
| (C) | $PV = K_B NT$ | (3) | Charle's law |
| (D) | $P = nRT / M$ | (4) | V - Constant |

(a) (A) → (4) ; (B) → (2) ; (C) → (3) ; (D) → (1)

(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)

(c) (A) → (4) ; (B) → (3) ; (C) → (1) ; (D) → (2)

(d) (A) → (3) ; (B) → (4) ; (C) → (2) ; (D) → (2)

**71.** Match **Column I** (Physical Variables) with **Column II** (Expressions) . ($n$ = number of gas molecules present per unit volume, $k$ = Boltzmann constant, $T$ = absolute temperature, $m$ = mass of the particle) :

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Most probable velocity | (1) | $nkT$ |
| (B) | Energy per degree of freedom | (2) | $\sqrt{(3kT/m)}$ |
| (C) | Pressure | (3) | $\sqrt{(2kT/m)}$ |
| (D) | R.M.S. velocity | (4) | $kT/2$ |

(a) (A) → (3) ; (B) → (4) ; (C) → (1) ; (D) → (2)

(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)

(c) (A) → (4) ; (B) → (3) ; (C) → (1) ; (D) → (2)

(d) (A) → (3) ; (B) → (4) ; (C) → (2) ; (D) → (2)

**72.**

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Average speed $v_{av}$ | (1) | $\sqrt{\frac{3RT}{M}}$ |
| (B) | Root mean square speed $v_{rms}$ | (2) | $\sqrt{\frac{8RT}{\pi M}}$ |
| (C) | Most probable speed $v_{mp}$ | (3) | $\frac{\sqrt{\gamma Rt}}{M}$ |
| (D) | Speed of sound $v_{sound}$ | (4) | $\sqrt{\frac{2RT}{M}}$ |

(a) (A) → (4) ; (B) → (2) ; (C) → (3) ; (D) → (1)

(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)

(c) (A) → (2) ; (B) → (1) ; (C) → (4) ; (D) → (3)

(d) (A) → (3) ; (B) → (4) ; (C) → (2) ; (D) → (1)

**73.**

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | An ideal gas obeys gas equation | (1) | with decrease in pressure |
| (B) | A real gas behaves as an ideal gas at low pressure | (2) | at all temperature |
| (C) | Mean free path of molecules increases | (3) | at high temperature |
| (D) | Charle's law | (4) | pressure constant |

(a) (A) → (3) ; (B) → (4) ; (C) → (1) ; (D) → (2)

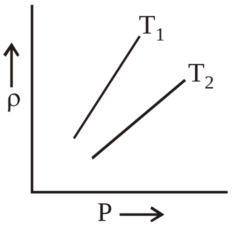
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)

(c) (A) → (4) ; (B) → (3) ; (C) → (1) ; (D) → (4)

(d) (A) → (2) ; (B) → (3) ; (C) → (1) ; (D) → (4)

## DIAGRAM TYPE QUESTIONS

**74.** The density (ρ)versus pressuure (P) of a given mass of an ideal gas is shown at two temperatures $T_1$ and $T_2$



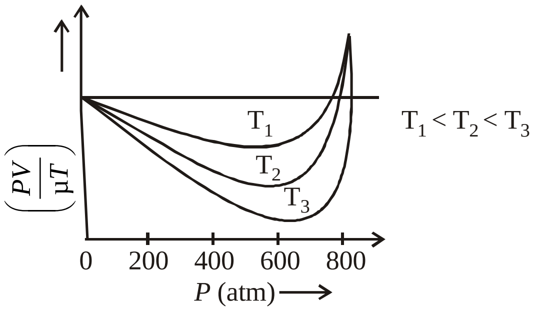
Then relation between $T_1$ and $T_2$ may be

(a) $T_1 > T_2$ (b) $T_2 > T_1$

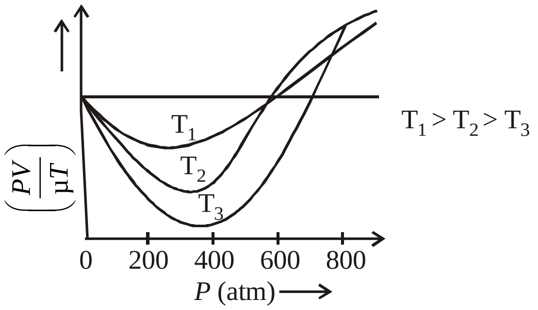
(c) $T_1 = T_2$ (d) All the three are possible

**75.** Which of the following graphs represents the real gas approaching ideal gas behaviour ?

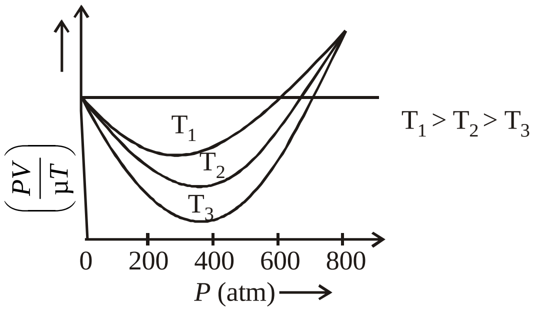
(a)



(b)

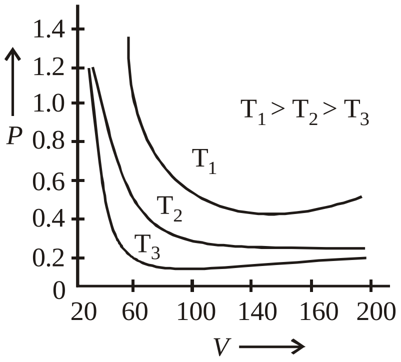


(c)



(d) None of these

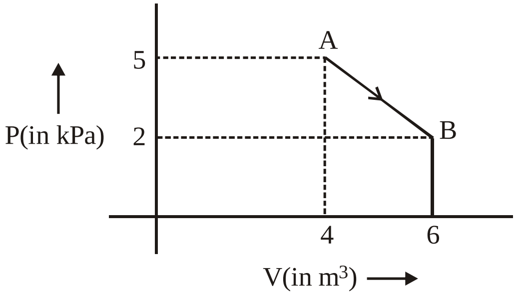
**76.** The given *P-V* curve is predicted by



(a) Boyle's law (b) Charle's law

(c) Avogadro's law (d) Gaylussac's law

**77.** One mole of an ideal diatomic gas undergoes a transition from A to B along a path AB as shown in the figure.

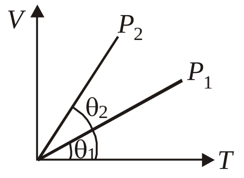


The change in internal energy of the gas during the transition is

(a) – 20 kJ (b) 20 J

(c) –12 kJ (d) 20 kJ

**78.** The figure shows the volume *V* versus temperature *T* graphs for a certain mass of a perfect gas at two constant pressures of $P_1$ and $P_2$. What inference can you draw from the graphs?



(a) $P_1 > P_2$

(b) $P_1 < P_2$

(c) $P_1 = P_2$

(d) No inference can be drawn due to insufficient information.

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

**79.** **Assertion:** On reducing the volume of the gas at constant temperature, the pressure of the gas increases.

**Reason:** It happens because on reducing the volume, the no. of molecules per unit volume increases and as a result more collisions with walls exert greater pressure on the walls.

**80.** **Assertion:** Internal energy of an ideal gas does not depend upon the volume of the gas.

**Reason:** Internal inergy of an ideal gas depends on temperature of the gas.

**81.** **Assertion:** At low temperature and high pressure, the real gases obey more strictly the gas equation $PV = RT$

**Reason:** At low temperature, the molecular motion ceases and due to high pressure, volume decreases and $PV$ becomes constant.

**82.** **Assertion:** One mole of any substance at any temperature or volume always contains $6.02 \times 10^{23}$ molecules.

**Reason:** One mole of a substance always refers to S.T.P. conditions.

**83.** **Assertion :** The total translational kinetic energy of all the molecules of a given mass of an ideal gas is 1.5 times the product of its pressure and its volume.

**Reason :** The molecules of a gas collide with each other and the velocities of the molecules change due to the collision.

**84.** **Assertion :** When we place a gas cylinder on a moving train, its internal kinetic energy increases.

**Reason :** Its temperature remains constant.

**85.** **Assertion :** If a gas container in motion is suddenly stopped, the temperature of the gas rises.

**Reason :** The kinetic energy of ordered mechanical motion is converted in to the kinetic energy of random motion of gas molecules.

**86.** **Assertion :** The internal energy of a real gas is function of both, temperature and volume.

**Reason :** Internal kinetic energy depends on temperature and internal potential energy depends on volume.

**87.** **Assertion :** Each vibrational mode gives two degrees of freedom

**Reason :** By law of equipartition of energy, the energy for each degree of freedom in thermal equilibrium is $2k_B T$.

**88.** **Assertion :** For an ideal gas, at constant temperature, the product of pressure and volume is constant.

**Reason :** The mean square velocity of the molecules is inversely proportional to mass.

**89.** **Assertion :** Air pressure in a car tyre increases during driving.

**Reason :** Absolute zero temperature is not zero energy temperature.

**90.** **Assertion :** A gas can be liquified at any temperature by increase of pressure alone.

**Reason :** On increasing pressure the temperature of gas decreases.

**91.** **Assertion :** At low density, variable of gases $P$, $V$ and $T$ follows the equation $PV = \mu RT$.

**Reason :** At low density real gases are more closely to ideal gases.

**92.** **Assertion :** A gas has unique value of specific heat.

**Reason :** Specific heat is defined as the amount of heat required to raise the temperature of unit mass of the substance through one degree centrigrade.

**93.** **Assertion :** Specific heat of a gas at constant pressure ($C_p$) is greater than its specific heat at constant volume ($C_v$).

**Reason :** At constnat pressure, some heat is spent in expansion of the gas.

**94.** **Assertion :** The ratio $\frac{C_V}{C_P}$ for a monatomic gas is less than for a diatomic gas.

**Reason :** The molecules of a monatomic gas have more degrees of freedom than those of a diatomic gas.

**95.** **Assertion :** For an atom the number of degrees of freedom is 3.

**Reason :** The ratio of specific heats at constant pressure and volume is a constant. i.e., $\frac{C_p}{C_v} = \gamma$ .

**96.** **Assertion :** Maxwell speed distribution graph is symmetric about most probable speed

**Reason :** rms speed of ideal gas, depends upon it's type (monoatomic, diatomic and polyatomic)

**97.** **Assertion :** Mean free path of a gas molecules varies inversely as density of the gas.

**Reason :** Mean free path varies inversely as pressure of the gas.

## CRITICALTHINKING TYPE QUESTIONS

**98.** A gas is enclosed in a cube of side $l$. What will be the change in momentum of the molecule, if it suffers an elastic collision with the plane wall parallel to $yz$-plane and rebounds with the same velocity ?

[($V_x$, $V_y$ & $V_z$) initial velocities of the gas molecules]

(a) $mv_x$ (b) zero

(c) $-mv_x$ (d) $-2mv_x$.

**99.** A flask contains a monoatomic and a diatomic gas in the ratio of 4 : 1 by mass at a temperature of 300 K. The ratio of average kinetic energy per molecule of the two gases is

(a) 1 : 1 (b) 2 : 1

(c) 4 : 1 (d) 1 : 4

**100.** What will be the ratio of number of molecules of a monoatomic and a diatomic gas in a vessel, if the ratio of their partial pressures is 5 : 3 ?

(a) 5 : 1 (b) 3 : 1

(c) 5 : 3 (d) 3 : 5

**101.** If two vessels A and B contain the same gas but the volume of vessel A is twice that of B and temperature and pressure of gas A is twice that of gas in B, then the ratio of gas molecules in A and B is

(a) 1 : 2 (b) 1 : 4
(c) 4 : 1 (d) 2 : 1

**102.** At constant volume, temperature is increased then

(a) collision on walls will be less
(b) number of collisions per unit time will increase
(c) collisions will be in straight lines
(d) collisions will not change.

**103.** If a gas is heated at constant pressure, its isothermal compressibility

(a) remains constant
(b) increases linearly with temperature
(c) decreases linearly with temperature
(d) decreases inversely with temperature

**104.** A gas in a container A is in thermal equilibrium with antoher gas of the same mass in container B. If we denote the corresponding pressures and volumes by the suffixes A and B, then which of the following statement is most likely to be true?

(a) $P_A = P_B,\ V_A \neq V_B$ (b) $P_A \neq P_B,\ V_A = V_B$
(c) $P_A / V_A = P_B / V_B$ (d) $P_A V_A = P_B V_B$

**105.** In a cubical vessel are enclosed n molecules of a gas each having a mass m and an average speed v. If $\ell$ is the length of each edge of the cube, the pressure exerted by the gas will be

(a) $\dfrac{n m v^2}{\ell^3}$ (b) $\dfrac{n m^2 v}{2\ell^3}$ (c) $\dfrac{m n v^2}{3\ell^3}$ (d) $\dfrac{n m v}{2\ell}$

**106.** *P, V, T* respectively denote pressure, volume and temperature of two gases. On mixing, new temperature and volume are respectively *T and V*. Final pressure of the mixture is

(a) *P* (b) 2*P*
(c) zero (d) 3*P*

**107.** Gas at a pressure $P_0$ is contained in a vessel. If the masses of all the molecules are halved and their speeds are doubled, the resulting pressure *P* will be equal to

(a) $4P_0$ (b) $2P_0$
(c) $P_0$ (d) $\dfrac{P_0}{2}$

**108.** The temperature at which the average transitional kinetic energy of a gas molecule is equal to the energy gained by an electron in accelerating from rest through a potential difference of 1 volt is

(a) $4.6 \times 10^3$ K (b) $11.6 \times 10^3$ K
(c) $23.2 \times 10^3$ K (d) $7.7 \times 10^3$ K

**109.** 4.0 g of a gas occupies 22.4 litres at NTP. The specific heat capacity of the gas at constant volume is 5.0JK$^{-1}$. If the speed of sound in this gas at NTP is 952 ms$^{-1}$, then the heat capacity at constant pressure is (Take gas constant R = 8.3 JK$^{-1}$ mol$^{-1}$)

(a) 7.5 JK$^{-1}$ mol$^{-1}$ (b) 7.0 JK$^{-1}$ mol$^{-1}$
(c) 8.5 JK$^{-1}$ mol$^{-1}$ (d) 8.0 JK$^{-1}$ mol$^{-1}$

**110.** Two vessels separately contain two ideal gases A and B at the same temperature. The pressure of A being twice that of B. Under such conditions, the density of A is found to be 1.5 times the density of B. The ratio of molecular weight of A and B is :

(a) $\dfrac{3}{4}$ (b) 2
(c) $\dfrac{1}{2}$ (d) $\dfrac{2}{3}$

**111.** The ratio of the specific heats $\dfrac{C_p}{C_v} = \gamma$ in terms of degrees of freedom (n) is given by

(a) $\left(1+\dfrac{n}{3}\right)$ (b) $\left(1+\dfrac{2}{n}\right)$
(c) $\left(1+\dfrac{n}{2}\right)$ (d) $\left(1+\dfrac{1}{n}\right)$

**112.** For hydrogen gas $C_p - C_v = a$ and for oxygen gas $C_p - C_v = b$. So, the relation between a and b is given by

(a) a = 16 b (b) 16 a = b
(c) a = 4 b (d) a = b

**113.** The temperature at which protons in hydrogen gas would have enough energy to overcome Coulomb barrier of $4.14 \times 10^{-14}$ J is
(Boltzmann constant = $1.38 \times 10^{-23}$ JK$^{-1}$)

(a) $2 \times 10^9$ K (b) $10^9$ K
(c) $6 \times 10^9$ K (d) $3 \times 10^9$ K

**114.** The temperature at which oxygen molecules have the same root mean square speed as that of hydrogen molecules at 300 K is

(a) 600 K (b) 2400 K
(c) 4800 K (d) 300 K

**115.** If the root mean square velocity of the molecules of hydrogen at NTP is 1.84 km/s. Calculate the root mean square velocity of oxygen molecule at NTP, molecular weight of hydrogen and oxygen are 2 and 32 respectively

(a) 1.47 km/sec (b) 0.94 km/s
(c) 1.84 km/s (d) 0.47 km/sec

**116.** The average transitional energy and the rms speed of molecules in a sample of oxygen gas at 300 K are $6.21 \times 10^{-21}$ J and 484 m/s respectively. The corresponding values at 600 K are nearly (assuming ideal gas behaviour)

(a) $12.42 \times 10^{-21}$ J, 968 m/s (b) $8.78 \times 10^{-21}$ J, 684 m/s
(c) $6.21 \times 10^{-21}$ J, 968 m/s (d) $12.42 \times 10^{-21}$ J, 684 m/s

**117.** If $R$ is universal gas constant, the amount of heat needed to raise the temperature of 2 moles of an ideal monoatomic gas from 273 K to 373 K, when no work is done, is

(a) 100 $R$ (b) 150 $R$
(c) 300 $R$ (d) 500 $R$

**118.** One kg of a diatomic gas is at a pressure of $8 \times 10^4$ N/m$^2$. The density of the gas is 4 kg/m$^3$. What is the energy of the gas due to its thermal motion?

(a) $3 \times 10^4$ J (b) $5 \times 10^4$ J
(c) $6 \times 10^4$ J (d) $7 \times 10^4$ J

**119.** If $C_P$ and $C_V$ denote the specific heats of nitrogen per unit mass at constant pressure and constant volume respectively, then

(a) $C_P - C_V = 28R$ (b) $C_P - C_V = R/28$
(c) $C_P - C_V = R/14$ (d) $C_P - C_V = R$

**120.** If one mole of monoatomic gas $\left(\gamma = \frac{5}{3}\right)$ is mixed with one mole of diatomic gas $\left(\gamma = \frac{7}{5}\right)$, the value of $\gamma$ for the mixture is

(a) 1.40 (b) 1.50
(c) 1.53 (d) 3.07

**121.** The molar specific heat at constant pressure of an ideal gas is (7/2)R. The ratio of specific heat at constant pressure to that at constant volume is

(a) 5/7 (b) 9/7 (c) 7/5 (d) 8/7

**122.** The molar specific heats of an ideal gas at constant pressure and volume are denoted by $C_p$ and $C_v$, respectively. If $\gamma = \frac{C_p}{C_v}$ and R is the universal gas constant, then $C_v$ is equal to

(a) $\frac{R}{(\gamma - 1)}$ (b) $\frac{(\gamma - 1)}{R}$
(c) $\gamma R$ (d) $\frac{1+\gamma}{1-\gamma}$

**123.** A gaseous mixture consists of 16 g of helium and 16 g of oxygen. The ratio $\frac{C_p}{C_v}$ of the mixture is

(a) 1.62 (b) 1.59
(c) 1.54 (d) 1.4

**124.** Half mole of helium gas is contained at STP. The heat energy needed to double the pressure of the gas keeping the volume constant (specific heat of the gas = 3J/g –K) is

(a) 3276 J (b) 1638 J
(c) 819 J (d) 409.5 J

**125.** A thermally insulated vessel contains an ideal gas of molecular mass $M$ and ratio of specific heats $\gamma$. It is moving with speed $v$ and it suddenly brought to rest. Assuming no heat is lost to the surroundings, its temperature increases by

(a) $\frac{(\gamma - 1)}{2\gamma R} Mv^2 K$ (b) $\frac{\gamma Mv^2}{2R} K$
(c) $\frac{(\gamma - 1)}{2R} Mv^2 K$ (d) $\frac{(\gamma - 1)}{2(\gamma + 1)R} Mv^2 K$

**126.** A cylinder rolls without slipping down an inclined plane, the number of degrees of freedom it has, is

(a) 2 (b) 3
(c) 5 (d) 1

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1. (a)** **2. (a)** **3. (a)** **4. (c)** **5. (c)**
**6. (a)** **7. (d)** **8. (d)** **9. (b)**
**10. (c)** Boyle's and Charle's law follow kinetic theory of gases.
**11. (d)** **12. (a)** **13. (a)** **14. (a)**

**15. (c)** $E = \frac{3}{2}RT$, so it is same for all ideal gases at same temperature.

**16. (b)** At low pressure and high temperature the molecules are far apart and molecular interactions are negligible. Without interactions the gas behaves like an ideal one.

**17. (a)**

**18. (c)** Perfect gas equation is $PV = \mu RT$.
$\mu$ is the number of moles, $R = N_A k_B$

$$\mu = \frac{M}{M_0} = \frac{N}{N_A}$$

$\therefore \quad PV = k_B NT \qquad$ or $\qquad P = k_B nT$

**19. (a)**

**20. (c)** In equilibrium, the average kinetic energy of molecules of different gases will be equal. That is

$$\frac{1}{2}m_1 v_1^{-2} = \frac{1}{2}m_2 v_2^{-2} = \left(\frac{3}{2}k_B T\right)$$

**21. (c)** Lighter the molecule, higher the average speed.

**22. (b)** Average kinetic energy of gas molecues depends on the temperature of the gas as

$$\frac{1}{2}mv^2 = \frac{3}{2}k_B T$$

**23. (c)** The centre of mass of the gas molecules moves with uniform speed along with lorry. As there is no change in relative motion, the translational kinetic energy and hence the temperature of the gas molecules will remain same.

**24. (c)** molecules of ideal gas behaves like perfectly elastic rigid sphere.

**25. (b)** According to ideal gas law

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \text{ or } T_2 = T_1\frac{P_2V_2}{P_1V_1}$$

$$\therefore T_2 = \frac{T\left(\frac{P}{2}\right)\left(\frac{V}{2}\right)}{PV} \quad T_2 = \frac{T}{4}$$

**26. (a)** According to kinetic theory of gases there is no loss of energy during the collisions between the molecules. Therefore, collision between the molecules is perfectly elastic.

**27.** (d) Pressure exerted by a gas is given by

$$P = \frac{1}{3}\frac{mn}{V}v^2$$

or $\quad P = \frac{1}{3}\rho v^{-2} \qquad \therefore \quad P \propto \rho$

Therefore, pressure exerted by a gas is directly proportional to the density of the gas.

**28. (c)** **29. (b)** **30. (a)**

**31. (b)** According to boyle's law, at constant temperature.

$$P \propto \frac{1}{V} \quad \text{or} \quad P_1V_1 = P_2V_2$$

**32. (c)**

**33. (a)** According to Boyle's law PV = constant.

**34. (a)** $V_{rms} = \sqrt{\frac{3RT}{M}}$ M is least for hydrogen among the hydrogen, oxygen, nitrogen and carbon dioxide.

**35. (c)** Pressure, $P = \frac{2E}{3}$

**36. (b)** For a monoatomic gas, the average energy of a molecule at temperature $T$ is $\frac{3}{2}k_B T$.

$\therefore \quad$ Internal energy $U = \frac{3}{2}RT$

$$C_V = \frac{dU}{dT} = \frac{3}{2}R$$

For an ideal gas, $C_P - C_V = R$

$$\therefore \quad C_P = \frac{5}{2}R \text{ and } \gamma = \frac{C_P}{C_V} = \frac{5}{3}$$

**37. (a)** Average velocity $v_{avg.} = \sqrt{\frac{8kT}{\pi m}}$

**38. (b)** RMS velocity $V_{rms} = \sqrt{\frac{3RT}{M}}$

**39. (b)** **40. (d)** **41. (c)**

**42. (d)** For a diatomic gas,
Molar heat capacity at constant pressure,

$$C_P = \frac{7}{2}R$$

Molar heat capacity at constant volume,

$$C_V = \frac{5}{2}R \therefore \frac{C_P}{C_V} = \frac{\frac{7}{2}R}{\frac{5}{2}R} = \frac{7}{5}$$

**43.** **(c)** $C = \frac{Q}{m\Delta T}$; If $\Delta T = 0$, $C = \infty$ and if $Q = 0$, then $C = 0$

**44.** **(c)**

**45.** **(c)** A rigid diatomic molecule has 5 degrees of freedom total internal energy of one mole of rigid diatomic gas is

$$U = \frac{5}{2}k_B T \times N_A = \frac{5}{2}RT \qquad (\because\ R = k_B N_A)$$

**46.** **(a)** Work done is to be done in expanding the gas at constant pressure.

**47.** **(d)** Translational kinetic enegy $E = \frac{3}{2}k_B NT$

$$\therefore\ PV = \frac{2}{3}E \qquad [\because k_B\ NT = PV]$$

**48.** **(d)** The difference of $C_P$ and $C_V$ is equal to $R$, not $2R$.

**49.** **(b)** Law of equipartition of energy states that the energy for each degree of freedom in thermal equilibrium is $\frac{1}{2}k_B T$. Thus each vibrational mode gives 2 degrees of freedom (kinetic and potential energy modes) corresponding to the energy $2\times\frac{1}{2}k_B T = k_B T$

**50.** **(c)** A fly moving in a room has three degrees of freedom, because it is free to move in space.

**51.** **(a)** **52.** **(c)**

**53.** **(c)** According to law of equipartition of energy, the energy per degree of freedom is $\frac{1}{2}kT$.

For a polyatomic gas with n degrees of freedom, the mean energy per molecule $= \frac{1}{2}nkT$

**54.** **(c)** No. of degree of freedom = $3K - N$

where $K$ is no. of atom and $N$ is the number of relations between atoms. For triatomic gas,

$K = 3, N = {}^3C_2 = 3$

No. of degree of freedom = 3 (3) – 3 = 6

**55.** **(d)**

**56.** **(b)** Mean free path in a gas is 100 times the interatomic distance.

**57.** **(a)** Mean free path, $\lambda = \frac{1}{\sqrt{2}\pi d^2 n}$

where,

n = number of molecules per unit volume,

d = diameter of the molecules

**58.** **(a)** Based on Maxwell's velocity distribution curve.

**59.** **(b)**

## STATEMENT TYPE QUESTIONS

**60.** **(d)**

**61.** **(c)** Coefficient of volume expansion at constant pressure is $\frac{1}{273}$ for all gases. The average transnational K.E. is same for molecules of all gases and for each molecules it is $\frac{3}{2}kT$

Mean free path $\lambda = \frac{kT}{\sqrt{2}\ \pi d^2 P}$ (as $P$ decreases, λ increases)

**62.** **(d)** **63.** **(d)**

**64.** **(a)** Mean kinetic energy per molecule will be equal for both the gases because it depends only upon the temperature. ($E = \frac{3}{2}k_B\ T$)

**65.** **(d)** **66.** **( c)**

**67.** **(b)** Helium is monoatomic and hydrogen is diatomic. Helium has smaller number of degrees of freedom than hydrogen. So $C_P / C_V$ for helium is more than that for hydrogen.

**68.** **(a)** $C_P - C_V = R$ is true for any gas.

**69.** **(b)** In all the three directions x, y and z gas possess equal energies.

## MATCHING TYPE QUESTIONS

**70.** **(c)** (A)→(4) ; (B)→(3) ; (C)→(1) ; (D)→ (2)

**71.** **(a)** (A)→(3) ; (B)→ (4) ; (C)→(1) ; (D)→(2)

**72.** **(c)** (A)→(2); (B)→(1); (C)→(4) ; (D)→(3)

**73.** **(d)** (A)→(2) ; (B)→(3) ; (C)→(1) ; (D)→(4)

## DIAGRAM TYPE QUESTIONS

**74.** **(b)** According to ideal gas equation

PV = nRT

$$PV = \frac{m}{M}RT,\ P = \frac{\rho}{M}RT \text{ or } \frac{\rho}{P} = \frac{M}{RT} \text{ or } \frac{\rho}{P} \propto \frac{1}{T}$$

Here, $\frac{\rho}{P}$ represent the slope of graph

Hence $T_2 > T_1$

**75.** **(c)** **76.** **(a)**

**77.** **(a)** Change in internal energy from A → B

$$\Delta U = \frac{f}{2}\ nR\Delta T = \frac{f}{2}\ nR\,(T_f - T_i)$$

$$= \frac{5}{2}\ \{P_f V_f - P_i V_i\}$$

(As gas is diatomic ∴ f = 5)

$$= \frac{5}{2}\{2 \times 10^3 \times 6 - 5 \times 10^3 \times 4\}$$

$$= \frac{5}{2}\{12 - 20\} \times 10^3 \text{ J} = 5 \times (-4) \times 10^3 \text{ J}$$

$\Delta U = -20$ KJ

**78.** **(a)** $\because \theta_1 < \theta_2 \Rightarrow \tan\theta_1 < \tan\theta_2 \Rightarrow \left(\frac{V}{T}\right)_1 < \left(\frac{V}{T}\right)_2$

From $PV = \mu RT$ ; $\frac{V}{T} \propto \frac{1}{P}$

Hence $\left(\frac{1}{P}\right)_1 < \left(\frac{1}{P}\right)_2 \Rightarrow P_1 > P_2$ .

## ASSERTION- REASON TYPE QUESTIONS

**79.** **(a)** **80.** **(d)**

**81.** **(d)** The real gases obey the gas equation at low pressure and high temperature as, at high temperature the intermolecular force is negligible due to increased volume of the gas.

**82.** **(c)** The number $6.02 \times 10^{23}$ is Avogadro's number and one mole of a substance contains Avogadro's number of molecules.

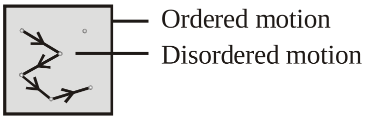
**83.** **(b)** Total translational kinetic energy $= \frac{3}{2}nRT = \frac{3}{2}PV$

In an ideal gas all molecules moving randomly in all direction collide and their velocity changes after collision.

**84.** **(c)** Internal energy can be increased when molecules of gas will get greater velocity w.r.t. container.

**85.** **(a)** The motion of the container is known as the ordered motion of the gas and zigzag motion of gas molecules within the container is called disordered motion

When the container suddenly stops, ordered kinetic energy gets converted into disordered kinetic energy which is turn increases the temperature of the gas.



**86.** **(a)** In real gas, intermolecular force exist. Work has to be done in changing the distance between the molecules. Therefore, internal energy of real gas is sum of internal kinetic and internal potential energy which are function of temperature and volume respectively. Also change in internal energy of a system depends only on initial and final sates of the system.

**87.** **(c)** By law of equipartition of energy, the energy for each degree of freedom in thermal equilibrium is $\frac{1}{2}k_BT$ . Each quadratic term form in the total energy expression of a molecules is to be counted as a degree of freedom. Thus each vibrational mode gives 2 degree of freedom i.e, kinetic and potential energy modes, corresponding to the energy $2\left(\frac{1}{2}k_BT\right) = k_BT$ .

**88.** **(b)** $PV = \text{constant}$ and $v_{rms} = \sqrt{\frac{3kT}{m}}$

**89.** **(b)** When a person is driving a car then the temperature of air inside the tyre is increased because of motion. From the Gay Lussac's law,

$P \propto T$

Hence, when temperature increases the pressure also increase.

**90.** **(d)** A vapour above the critical temperature is a gas and gas below the critical temperature for the substance is a vapour. As gas cannot be liquidfied by the application of pressure alone, how so ever large the pressure may be while vapour can be liquified under pressure alone. To liquify a gas it must be cooled upto or below its critical temperature.

**91.** **(a)** At high temperature and low pressure (low density), real gas behaves like an ideal gas.

**92.** **(d)** The specific heat of a gas can be from 0 to $\infty$ .

**93.** **(a)** $C_v$ is used in increasing the internal energy of the gas while $C_p$ is used in two ways (i) to change the internal energy and (ii) to do expansion of gas. Hence $C_p > C_v$.

**94.** **(c)** For monatomic gas, f = 3,

$$C_v = \frac{3R}{2}, C_p = \frac{5R}{2} \ ; \ \frac{C_v}{C_p} = \frac{3}{5}$$

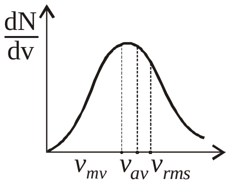
For diatomic gas, f = 5

$$C_v = \frac{5R}{2}, C_p = \frac{7R}{2} \ ; \ \frac{C_v}{C_p} = \frac{5}{7}$$

**95.** **(b)** An atom can have only translatory motion, so its degrees of freedom can be $\frac{1}{2}mv_x^2$ , $\frac{1}{2}mv_y^2$ , $\frac{1}{2}mv_z^2$ .

**96.** **(d)** Maxwell speed distribution graph is asymmetric graph, because it has a long 'tail' that extends to infinity.

Also $U_{rms}$ depends upon nature of gas and it's temperature.



**97.** **(a)** The mean free path of a gas molecule is the averge distance between two successive collisions. It is represented by λ.

$$\lambda = \frac{1}{\sqrt{2}}\frac{kT}{\pi\sigma^2 P} \text{ and } \lambda = \frac{m}{\sqrt{2}\cdot\pi\sigma^2 d}$$

Here, σ = 0 diameter of molecule and

$k$ = Boltzmann's constant.

$\Rightarrow \lambda \propto 1/d,\ \lambda \propto T \text{ and } \lambda \propto 1/P.$

Hence, mean free path varies inversely as density of the gas. It can easily proved that the mean free path varies directly as the temperature and inversely as the pressure of the gas.

## CRITICALTHINKING TYPE QUESTIONS

**98. (d)** Since it hits the plane wall parallel to *y* z – plane and it rebounds with same velocity, its *y* and *z* components of velocity do not change, but the *x*-component reverses the sign.

∴ Velocity after collision is $(-v_x, v_y \text{ and } v_z)$.

The change in momentum is

$$-mv_x - mv_x = -2mv_x$$

**99. (a)** The average kinetic energy per molecule of any ideal gas is always equal to $\left(\frac{3}{2}\right)k_BT$. It depends only on the temperature and is independent of the mass and nature of the gas.

**100. (c)** *V* and *T* will be same for both gases.

$$P_1V = \mu_1RT \quad \text{and} \quad P_2V = \mu_2RT$$

$$(P_1/P_2) = \frac{5}{3} \qquad \therefore \left(\frac{\mu_1}{\mu_2}\right) = \frac{5}{3}$$

By definition, $\mu_1 = \frac{N_1}{N_A}$ and $\mu_2 = \frac{N_2}{N_A}$

$$\therefore \frac{N_1}{N_2} = \frac{\mu_1}{\mu_2} = \frac{5}{3}$$

**101. (d)** $V_A = 2V_B\,;\ T_A = 2T_B\,;\ P_A = 2P_B$

$$\frac{P_AV_A}{TA} = \frac{P_BV_B}{T_B} = n_AR = n_BR$$

$$\therefore \frac{\eta_A}{\eta_B} = \frac{P_AV_AT_B}{P_BV_BT_A}$$

$$= \frac{(2P_B)(2V_B)(T_B)}{P_B\,V_B\,(2T_B)} = 2$$

**102. (b)** As the temperature increases, the average velocity increases. So, the collisions are faster.

**103. (a)**

**104. (d)** Apply Boyle's law, at constant temperature

$$P \propto \frac{1}{V}$$

**105. (c)**

**106. (b)** Let $n_1$ and $n_2$ be the number of moles of each gas. Then

$$n_1 = \frac{PV}{RT} \text{ and } n_2 = \frac{PV}{RT}$$

When the two gases are mixed, total number of moles,

$$n = n_1 + n_2$$

$$\Rightarrow \frac{P'V}{RT} = \frac{PV}{RT} + \frac{PV}{RT}$$

(where *P*′ is the pressure of the mixture.)

$$\Rightarrow \quad P' = 2P$$

**107. (b)** $P_0 = \frac{1}{3}\frac{mnc^2}{V}$ and $P' = \frac{1}{3}\left(\frac{m}{2}\right)\times n\times(2c)^2 = 2\,P_0$.

**108. (d)**

$$1\,\text{eV} = \frac{3}{2}kT$$

or

$$1.6\times10^{-19} = \frac{3}{2}\times1.38\times10^{-23}T$$

$$\therefore \quad T = 7.7\times10^3 \text{ K.}$$

**109. (d)** Molar mass of the gas = 4g/mol

Speed of sound

$$V = \sqrt{\frac{\gamma RT}{m}} \Rightarrow 952 = \sqrt{\frac{\gamma\times3.3\times273}{4\times10^{-3}}}$$

$$\Rightarrow \gamma = 1.6 = \frac{16}{10} = \frac{8}{5}$$

Also, $\gamma = \frac{C_P}{C_V} = \frac{8}{5}$

So, $C_P = \frac{8\times5}{5} = 8\text{JK}^{-1}\text{mol}^{-1}\ [C_V = 5.0\ \text{JK}^{-1} \text{ given}]$

**110. (a)** From PV = nRT

$$P_A = \frac{\rho_AM_A}{RT} \text{ and } P_B = \frac{\rho_BM_B}{RT}$$

From question,

$$\frac{P_A}{P_B} = \frac{\rho_A}{\rho_B}\frac{M_A}{M_B} = 2\frac{M_A}{M_B} = \frac{3}{2}$$

So, $\frac{M_A}{M_B} = \frac{3}{4}$

**111. (b)** Let 'n' be the degree of freedom

$$\gamma = \frac{C_p}{C_v} = \frac{\left(\frac{n}{2}+1\right)R}{\left(\frac{n}{2}\right)R} = \left(1+\frac{2}{n}\right)$$

**112. (d)** Both are diatomic gases and $C_p - C_v = R$ for all gases.

**113. (a)** $\frac{3}{2}k_BT = K_{av}$ ...(i)

where $K_{av}$ is the average kinetic energy of the proton.

$$\therefore \quad T = \frac{2K_{av}}{3k_B}$$

$$T = \frac{2\times4.14\times10^{-14}\text{ J}}{3\times1.38\times10^{-23}\text{JK}^{-1}} = 2\times10^9\text{K.}$$

**114. (c)** According to given problem

$$(v_{rms})_{O_2} = (v_{rms})_{H_2}$$

$$\sqrt{\frac{3RT_{O_2}}{M_{O_2}}} = \sqrt{\frac{3R(300)}{M_{H_2}}}$$

$$T_{O_2} = 300\times\frac{M_{O_2}}{M_{H_2}} = 300\times\frac{32}{2} = 4800\text{ K}$$

**115. (d)** $(c_{rms})_{H_2} = 1.84$ km/s, $(c_{rms})_{O_2} = ?$

$M_{H_2} = 2,\ M_{O_2} = 32$

⇒ Rms velocity,

$$c_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\therefore \frac{c_{H_2}}{c_{O_2}} = \sqrt{\frac{M_{O_2}}{M_{H_2}}}$$

$$\Rightarrow \frac{1.84}{C_{O_2}} = \sqrt{\frac{32}{2}} = 4$$

$$\Rightarrow C_{O_2} = \frac{1.84}{4} = 0.46 \text{ km/s}$$

**116. (d)** $E = \frac{3}{2}\times 300$; $E' = \frac{3}{2}R(600) = 2E = 2\times 6.21\times 10^{-21}$

$= 12.42 \times 10^{-21}$ J.

$$v_{rms} = \sqrt{\frac{3R\times 300}{M}};\ v'_{rms} = \sqrt{\frac{3R\times 600}{M}} = \sqrt{2}\,v_{rms}$$

$= 682.44$ m/s

**117. (c)** If a gas is heated at constant volume then no work is done. The heat supplied is given by

$$dQ = nC_v dT$$

But $C_v = \frac{f}{2}R$ where $f$ is the degree of freedom of the gas

$$\therefore dQ = \frac{nfRdT}{2}$$

$$= \frac{2\times 3\times R\times(373-273)}{2} = 300\,R$$

**118. (b)** For 1kg gas energy, $E = \frac{f}{2}rT$

As $P = \rho rT$ therefore $rT = P/\rho$

$E = \frac{5}{2}\times\frac{8\times 10^4}{4}$ [$f = 5$ for diatomic gas]

$E = 5\times 10^4$ Joule.

**119. (b)** According to Mayer's relationship

$$C_p - C_v = R$$

$$\therefore \frac{C_p}{M} - \frac{C_v}{M} = \frac{R}{M}$$

Here M = 28.

**120. (b)**

$$\frac{n_1+n_2}{\gamma-1} = \frac{n_1}{\gamma_1-1} + \frac{n_2}{\gamma_2-1}$$

or

$$\frac{2}{\gamma-1} = \frac{1}{\frac{5}{3}-1} + \frac{1}{\frac{7}{5}-1}$$

$$\therefore \gamma = \frac{3}{2}.$$

**121. (c)** Molar specific heat at constant pressure $C_P = \frac{7}{2}R$

Since, $C_P - C_V = R \Rightarrow C_V - C_P - R = \frac{7}{2}R - R = \frac{5}{2}R$

$$\therefore \frac{C_P}{C_V} = \frac{(7/2)R}{(5/2)R} = \frac{7}{5}.$$

**122. (a)** $C_p - C_v = R \Rightarrow C_p = C_v + R$

$$\because \gamma = \frac{C_p}{C_v} = \frac{C_v + R}{C_v} = \frac{C_v}{C_v} + \frac{R}{C_v}$$

$$\Rightarrow \gamma = 1 + \frac{R}{C_v} \Rightarrow \frac{R}{C_v} = \gamma - 1 \Rightarrow C_v = \frac{R}{\gamma-1}$$

**123. (a)** For mixture of gas,

$$C_v = \frac{n_1C_{v_1} + n_2C_{v_2}}{n_1+n_2}$$

$$= \frac{4\times\frac{3}{2}R + \frac{1}{2}\times\frac{5}{2}R}{\left(4+\frac{1}{2}\right)} = \frac{6R + \frac{5}{4}R}{\frac{9}{2}}$$

$$= \frac{29R\times 23}{9\times 4} = \frac{29R}{18}$$

and $$C_p = \frac{n_1C_{p_1} + n_2C_{p_2}}{(n_1+n_2)} = \frac{4\times\frac{5R}{2} + \frac{1}{2}\times\frac{7R}{2}}{\left(4+\frac{1}{2}\right)}$$

$$= \frac{10R + \frac{7}{4}R}{\frac{9}{2}} = \frac{47R}{18}$$

$$\therefore \frac{C_p}{C_v} = \frac{47R}{18}\times\frac{18}{29R} = 1.62$$

**124. (b)** $C_v = Mc_v = 4\times 3 = 12$ J/mol-K

To doubling the pressure, the temperature will be doubled, so

$$\Delta T = T_2 - T_1 = 273\,K$$

Thus $Q = nC_v\Delta T = \frac{1}{2}\times 12\times 273 = 1638$ J

**125. (c)** As no heat is lost,

Loss of kinetic energy = gain of internal energy of gas

$$\frac{1}{2}mv^2 = nC_V\Delta T \Rightarrow \frac{1}{2}mv^2 = \frac{m}{M}\cdot\frac{R}{\gamma-1}\Delta T$$

$$\Rightarrow \Delta T = \frac{mv^2(\gamma-1)}{2R}K$$

**126. (a)** As degree of freedom is defined as the number of independent variables required to define body's motion completely. Here f = 2(1 Translational + 1 Rotational).

# CHAPTER 14

# OSCILLATIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** A periodic to-and-fro motion is called
(a) Periodic motion (b) orbital motion
(c) oscillatory motion (d) rectilinear motion

**2.** A particle moves in a circular path with a uniform speed. Its motion is
(a) periodic (b) oscillatory
(c) simple harmonic (d) angular simple harmonic

**3.** Force acting in simple harmonic motion is always
(a) directly proportional to the displacement
(b) inversely proportional to the displacement
(c) directly proportional to the square of displacement
(d) inversely proportional to the square of displacement

**4.** For which of the following conditions will there be an effect on the periodic-time of the swing, if a girl is sitting on the swing ?
(a) Another girl sits by her side
(b) The girl sitting on the swing stands up
(c) Both (a) and (b)
(d) None of these

**5.** A simple harmonic motion is represented by $y(t) = 10 \sin (20t + 0.5)$. The frequency is
(a) $\frac{20}{2\pi}$ Hz (b) $\frac{10}{2\pi}$ Hz
(c) $\frac{\pi}{2\pi}$ Hz (d) $2\pi$Hz

**6.** Which of the following expressions is that of a simple harmonic progressive wave ?
(a) $a \sin \omega t$ (b) $a \sin (\omega t)$ *cox kx*
(c) $a \sin (\omega t - kx)$ (d) $a \cos kx$

**7.** Oscillation and vibration both are ...X... .
Here, *X* refers to
(a) different concepts (b) same concepts
(c) straight line motions (d) None of these

**8.** Which of the following is a simple harmonic motion?
(a) Particle moving through a string fixed at both ends.
(b) Wave moving through a string fixed at both ends.
(c) Earth spinning about its axis.
(d) Ball bouncing between two rigid vertical walls.

**9.** The displacement of a particle is given by $\vec{r} = A(\vec{i} \cos \omega t + \vec{j} \sin \omega t)$. The motion of the particle is
(a) simple harmonic
(b) on a straight line
(c) on a circle
(d) with constant acceleration.

**10.** The displacement of a particle in simple harmonic motion in one time period is
(a) A (b) 2 A
(c) 4 A (d) Zero

**11.** In a periodic motion, displacement is a periodic function of time given by
(a) $f(t) = A \cos \omega t$
(b) $f(t) = \sin \omega t$
(c) $f(t) = A \sin \omega t + A \cos \omega t$
(d) All of these

**12.** Which of the following is a non-periodic motion as represented by the equation? ($\omega$ is any positive constant and *t* is time)
(a) $A \sin (\omega t + \phi)$ (b) $A \cos (\omega t + \phi)$
(c) $e^{-2\omega t}$ (d) All of these

**13.** The function $\sin^2(\omega t)$ represents
(a) a periodic, not simple harmonic motion with a period $\frac{\pi}{\omega}$
(b) a periodic, not simple harmonic motion with a period $\frac{2\pi}{\omega}$
(c) a simple harmonic motion with a period $\frac{\pi}{\omega}$
(d) a simple harmonic motion with a period $\frac{2\pi}{\omega}$

**14.** A child swinging on swing in sitting position stands up. The time period of the swing will
(a) increase
(b) decrease
(c) remain same
(d) increase if the child is tall and decrease if the child is short.

**15.** A particle moves on the X-axis according to the equation $x = A + B \sin \omega t$. The motion is simple harmonic with amplitude
(a) A (b) B
(c) A + B (d) $\sqrt{A^2 + B^2}$

**16.** The physical quantity which remains constant in simple harmonic motion is
(a) kinetic energy (b) potential energy
(c) restoring force (d) frequency

**17.** In simple harmonic motion force is directly proportional to ...X... of the body from the mean position. Here, *A* refers to
(a) path length
(b) displacement
(c) square of displacement
(d) None of the above

**18.** If in a motion $\mathbf{F} \propto \boldsymbol{x}$ it is known as ...*X*... motion. Here, *X* refers, to (with negative constant of proportionality)
(a) linear harmonic (b) non-linear harmonic
(c) cubic harmonic (d) projectile

**19.** Suppose a tunnel is dug along a diameter of the earth. A particle is dropped from a point, a distance h directly above the tunnel, the motion of the particle is
(a) simple harmonic (b) parabolic
(c) oscillatory (d) non-periodic

**20.** A particle moves in a circular path with a continuously increasing speed. Its motion is
(a) periodic (b) oscillatory
(c) simple harmonic (d) None of these

**21.** The motion of a particle is given by $x = A \sin\omega t + B \cos\omega t$. The motion of the particle is
(a) not simple harmonic
(b) simple harmonic with amplitude (A–B)/2
(c) simple harmonic with amplitude (A + B)/2
(d) simple harmonic with amplitude $\sqrt{A^2 + B^2}$

**22.** A system exhibiting SHM must possess
(a) inertia only
(b) elasticity as well as inertia
(c) elasticity, inertia and an external force
(d) elasticity only

**23.** For a body executing simple harmonic motion, which parameter comes out to be non-periodic ?
(a) Displacement (b) Velocity
(c) Acceleration (d) None of these

**24.** In SHM, the acceleration is directly proportional to :
(a) time (b) linear velocity
(c) displacement (d) frequency

**25.** Velocity of a body moving in SHM is
(a) $\omega\sqrt{a^2 + y^2}$ (b) $\omega^2\sqrt{a^2 + y^2}$
(c) $\omega\sqrt{a^2 - y^2}$ (d) $\omega^2\sqrt{a^2 - y^2}$

**26.** The average acceleration in one time period in a simple harmonic motion is
(a) $A\,\omega^2$ (b) $A\,\omega^2/2$
(c) $A\,\omega^2/\sqrt{2}$ (d) zero

**27.** The graph plotted between the velocity and displacement from mean position of a particle executing SHM is
(a) circle (b) ellipse
(c) parabola (d) straight line

**28.** Acceleration of a particle executing SHM, at it's mean position is
(a) infinity (b) variable
(c) maximum (d) zero

**29.** The phase difference between the instantaneous velocity and acceleration of a particle executing simple harmonic motion is
(a) $\pi$ (b) $0.707\,\pi$
(c) zero (d) $0.5\,\pi$

**30.** Which one of the following equations of motion represents simple harmonic motion?
(a) Acceleration = $-k(x + a)$
(b) Acceleration = $k(x + a)$
(c) Acceleration = $kx$
(d) Acceleration = $-k_0x + k_1x^2$
where k, $k_0$, $k_1$ and a are all postive.

**31.** Which of the following quantities are always negative in a simple harmonic motion ?
(a) $\vec{F}.\vec{r}.$ (b) $\vec{v}.\vec{r}.$
(c) $\vec{a}.\vec{r}.$ (d) Both (a) & (c)

**32.** Which of the following is true about total mechanical energy of SHM ?
(a) It is zero at mean position.
(b) It is zero at extreme position.
(c) It is always zero.
(d) It is never zero.

**33.** If *a* is the amplitude of SHM, then K.E. is equal to the P.E. at ............ distance from the mean position.
(a) $\frac{a}{\sqrt{2}}$ (b) $\frac{a}{2}$
(c) $\frac{a}{4}$ (d) $a$

**34.** Energy of a particle in simple harmonic motion depends on
(a) $a^2$ (b) $\omega$
(c) $\frac{1}{a^2}$ (d) $\frac{1}{\omega^2}$

**35.** The total energy of a particle, executing simple harmonic motion is
(a) independent of x (b) $\propto x^2$
(c) $\propto x$ (d) $\propto x^{1/2}$

**36.** The potential energy of a particle ($U_x$) executing S.H.M. is given by
(a) $U_x = \frac{k}{2}(x - a)^2$ (b) $U_x = k_1x + k_2x^2 + k_3x^3$
(c) $U_x = A\,e^{-bx}$ (d) $U_x$ = a constant

**37.** A body executes simple harmonic motion. The potential energy (P.E.), the kinetic energy (K.E.) and total energy (T.E.) are measured as a function of displacement *x*. Which of the following statement is true?
(a) P.E. is maximum when $x = 0$.
(b) K.E. is maximum when $x = 0$.
(c) T.E. is zero when $x = 0$.
(d) K.E. is maximum when x is maximum.

**38.** If $< E >$ and $< U >$ denote the average kinetic and the average potential energies respectively of mass describing a simple harmonic motion, over one period, then the correct relation is

(a) $< E > = < U >$ (b) $< E > = 2 < U >$
(c) $< E > = -2 < U >$ (d) $< E > = - < U >$

**39.** The total energy of a particle executing S.H.M. is proportional to

(a) Displacement from equilibrium position
(b) Frequency of oscillation
(c) Velocity in equilibrium position
(d) Square of amplitude of motion

**40.** For a particle executing simple harmonic motion, which of the following statement is not correct ?

(a) The total energy of the particle always remains the same.
(b) The restoring force of always directed towards a fixed point.
(c) The restoring force is maximum at the extreme positions.
(d) The acceleration of the particle is maximum at the equilibrium position.

**41.** If a body is executing simple harmonic motion, then

(a) at extreme positions, the total energy is zero
(b) at equilibrium position, the total energy is in the form of potential energy
(c) at equilibrium position, the total energy is in the form of kinetic energy
(d) at extreme positions, the total energy is infinite

**42.** In a simple harmonic oscillator, at the mean position

(a) kinetic energy is minimum, potential energy is maximum
(b) both kinetic and potential energies are maximum
(c) kinetic energy is maximum, potential energy is minimum
(d) both kinetic and potential energies are minimum

**43.** A spring-mass system oscillates with a frequency $\nu$. If it is taken in an elevator slowly accelerating upward, the frequency will

(a) increase (b) decrease
(c) remain same (d) become zero

**44.** Two springs of spring constants $k_1$ and $k_2$ are joined in series. The effective spring constant of the combination is given by

(a) $k_1k_2 /(k_1 + k_2)$ (b) $k_1k_2$
(c) $(k_1 + k_2) /2$ (d) $k_1 + k_2$

**45.** Identify the wrong statement from the following

(a) If the length of a spring is halved, the time period of each part becomes $\frac{1}{\sqrt{2}}$ times the original
(b) The effective spring constant K of springs in parallel is given by $\frac{1}{\mathrm{K}} = \frac{1}{\mathrm{K}_1} + \frac{1}{\mathrm{K}_2} + \ldots$
(c) The time period of a stiffer spring is less than that of a soft spring
(d) The spring constant is inversely proportional to the spring length

**46.** The period of oscillation of a simple pendulum swinging through small angles is given by

(a) $T = \pi\sqrt{\frac{L}{g}}$ (b) $T = 2\pi\sqrt{\frac{L}{g}}$

(c) $T = \sqrt{\frac{2\pi L}{g}}$ (d) $T = 2\pi\sqrt{\frac{g}{L}}$

**47.** For an oscillating simple pendulum, the tension in the string is

(a) maximum at extreme position
(b) maximum at mean position
(c) constant throughout the motion
(d) Cannot be predicted

**48.** The ratio of energies of oscillations of two exactly identical pendulums oscillating with amplitudes 5 cm and 10 cm is :

(a) 1 : 2 (b) 2 : 1
(c) 1 : 4 (d) 4 : 1

**49.** The period of vibration for a simple pendulum of length $I$ is

(a) $T = 2\pi\frac{l}{g}$ (b) $T = 2\pi\sqrt{\frac{l}{g}}$

(c) $T = \frac{1}{2}\pi\frac{l}{g}$ (d) $T = \frac{1}{2}\pi\sqrt{\frac{l}{g}}$

**50.** The potential energy of a simple pendulum is maximum when it is

(a) at the turning points of the oscillations
(b) at the equilibrium
(c) in between the above two cases
(d) at any position, it has always a fixed value

**51.** Motion of an oscillating liquid column in a U-tube is

(a) periodic but not simple harmonic
(b) non-periodic
(c) simple harmonic and time period is independent of the density of the liquid.
(d) simple harmonic and time-period is directly proportional to the density of the liquid.

**52.** The necessary condition for the bob of a pendulum to execute SHM is

(a) the length of pendulum should be small
(b) the mass of bob should be small
(c) amplitude of oscillation should be small
(d) the velocity of bob should be small

**53.** The motion which is not simple harmonic is

(a) vertical oscillations of a spring
(b) motion of simple pendulum
(c) motion of a planet around the Sun
(d) oscillation of liquid column in a U-tube

**54.** The tension in the string of a simple pendulum is

(a) constant
(b) maximum in the extreme position
(c) zero in the mean position
(d) None of these

**55.** The bob of a simple pendulum of mass m and total energy E will have maximum linear momentum equal to

(a) $\sqrt{\frac{2E}{m}}$ (b) $\sqrt{2mE}$
(c) 2mE (d) $mE^2$

**56.** How does the time period of pendulum vary with length

(a) $\sqrt{L}$ (b) $\sqrt{\frac{L}{2}}$
(c) $\frac{1}{\sqrt{L}}$ (d) 2L

**57.** The time period of a simple pendulum of infinite length is ($R_e$ = radius of Earth)

(a) $T = 2\pi\sqrt{\frac{R_e}{g}}$ (b) $T = 2\pi\sqrt{\frac{2R_e}{g}}$
(c) $T = 2\pi\sqrt{\frac{R_e}{2g}}$ (d) $T = \infty$

**58.** A simple pendulum is set into vibrations. The bob of the pendulum comes to rest after some time due to
(a) Air friction
(b) Moment of inertia
(c) Weight of the bob
(d) Combination of all the above

**59.** A simple pendulum oscillates in air with time period T and amplitude A. As the time passes
(a) T and A both decrease
(b) T increases and A is constant
(c) T remains same and A decreases
(d) T decreases and A is constant

**60.** Choose the correct statement
(a) Time period of a simple pendulum depends on amplitude
(b) Time shown by a spring watch varies with acceleration due to gravity g.
(c) In a simple pendulum time period varies linearly with the length of the pendulum
(d) The graph between length of the pendulum and time period is a parabola.

**61.** Which of the following will change the time period as they are taken to moon?
(a) A simple pendulum (b) A physical pendulum
(c) A torsional pendulum (d) A spring-mass system

**62.** The total mechanical energy of a harmonic oscillator is given as

(a) $\frac{1}{4}m\omega^2 A^2$ (b) $\frac{1}{4}m^2\omega^2 A^2$
(c) $\frac{1}{2}m\omega^2 A^2$ (d) $\frac{1}{2}m^2\omega^2 A^2$

**63.** In case of sustained forced oscillations the amplitude of oscillations
(a) decreases linearly
(b) decreases sinusoidally
(c) decreases exponentially
(d) always remains constant

**64.** A particle oscillating under a force $\vec{F} = -k\vec{x} - b\vec{\upsilon}$ is a (k and b are constants)
(a) simple harmonic oscillator
(b) non linear oscillator
(c) damped oscillator
(d) forced oscillator

**65.** The frequency of the simple harmonic motion attained in forced oscillations, after the forced oscillation die out, is
(a) the natural frequency of the particle
(b) the frequency of the driving force
(c) double the frequency of the driving force
(d) double the natural frequency of the particle

**66.** If a body oscillates at the angular frequency $\omega_d$ of the driving force, then the oscillations are called
(a) free oscillations (b) coupled oscillations
(c) forced oscillations (d) maintained oscillations

**67.** In case of a forced vibration, the resonance wave becomes very sharp when the
(a) quality factor is small
(b) damping force is small
(c) restoring force is small
(d) applied periodic force is small

**68.** What is the amplitude of simple harmonic motion at resonance in the ideal case of zero damping?
(a) Zero (b) – 1
(c) 1 (d) Infinite

**69.** Resonance is an example of
(a) tuning fork (b) forced vibration
(c) free vibration (d) damped vibration

## STATEMENT TYPE QUESTIONS

**70.** Select the incorrect statement(s) from the following.
I. A simple harmonic motion is necessarily periodic.
II. A simple harmonic motion may be oscillatory
III. An oscillatory motion is necessarily periodic
(a) I only (b) II and III
(c) I and III (d) I and II

**71.** Select the true statement(s) about SHM.
I. Acceleration $\propto$ displacement is a sufficient condition for SHM.
II. Restoring force $\propto$ displacement is a sufficient condition for SHM.
(a) I only (b) II only
(c) I and II (d) None of these

**72.** Select the false statement(s) from the following.
I. In SHM, the acceleration of the body is in the direction of velocity of the body.
II. In SHM, the velocity and displacement of particle are in same phase.
(a) I only (b) II only
(c) I and II (d) None of these

**73.** Consider the following statements and select the correct option from the following.
I. PE becomes maximum twice and KE becomes maximum once in one vibration.

II. KE becomes maximum twice and PE become maximum once in one vibration.

III. Both KE and PE becomes maximum twice in one vibration.

(a) I only (b) II only

(c) III only (d) I and II

**74.** Select the correct statement(s) from the following

I. Motion of a satellite and a planet is periodic as well as SHM.

II. Mass suspended by a spring executes SHM.

III. Motion of a simple pendulum is always SHM.

(a) I only (b) II only

(c) I and II (d) I, II and III

**75.** Choose the false statement(s) for a forced oscillation.

I. Displacement amplitude of an oscillator is independent of the angular frequency of the driving force.

II. The amplitude tends to infinity when the driving frequency equals the natural frequency.

III. Maximum possible amplitude for a given driving frequency is governed by the driving frequency and the damping.

(a) I only (b) II only

(c) I and II (d) I, II and III

**76.** Select the correct statement(s) from the following.

I. In sitar, guitar the strings vibrate and produce sound.

II. Sound waves propagate due to vibration of air molecules.

III. In solids, atoms oscillate to produce the temperature sensation.

(a) I only (b) II only

(c) I and II (d) I, II and III

**77.** Choose the false statement(s) from the following.

I. Natural frequency of a body depends upon the elastic properties of material of the body.

II. Natural frequency of a body depends on the dimensions of the body.

(a) I only (b) II only

(c) I and II (d) None of these

**78.** Consider the following statements

I. $(\omega t + \phi)$ is known as phase constant.

II. $\phi$ is known as phase constant.

III. $\phi$ is the value of phase at $t = 0$

Choose the correct statement(s)

(a) I only (b) II only

(c) I and II (d) I, II and III

**79.** Consider the following statements

I. Time period of a spring mass system depends on its amplitude.

II. Time period of a spring mass system depends on its mass.

III. Time period of a spring mass system depends on spring constant.

Choose the correct statements.

(a) I and II (b) I and III

(c) II and III (d) I, II and III

## MATCHING TYPE QUESTIONS

**80.** Match the column I and column II.

| **Column I** | **Column II** |
|---|---|
| (A) Max. positive displacement | (1) 0 |
| (B) Max. positive velocity | (2) $\frac{T}{2}$ |
| (C) Min. acceleration | (3) $\frac{T}{4}$ |
| (D) Max. positive acceleration | (4) $T$ |
| (E) Min. displacement | (5) $\frac{3T}{4}$ |

(a) (A) - (2), (B) - (4), (C) - (3), (D) - (5), (E) - (1)

(b) (A) - (1), (B) - (4), (C) - (5), (D) - (3), (E) - (2)

(c) (A) - (5), (B) - (1, 4), (C) - (3), (D) - (5), (E) - (1, 2, 4)

(d) (A) - (1, 3), (B) - (3, 4), (C) - (5), (D) - (1, 2), (E) - (5, 4)

**81.** A particle of mass 2 kg is moving on a straight line under the action of force $F = (8 - 2x)$ N. The particle is released at rest from $x$ = 6m. For the subsequent motion match the following (All the values in the column II are in their S.I. units)

| **Column I** | **Column II** |
|---|---|
| (A) Equilibrium position at $x$ | (1) $\pi/4$ |
| (B) Amplitude of SHM is | (2) $\pi/2$ |
| (C) Time taken to go directly from $x = 2$ to $x = 4$ | (3) 4 |
| (D) Energy of SHM is | (4) 2 |

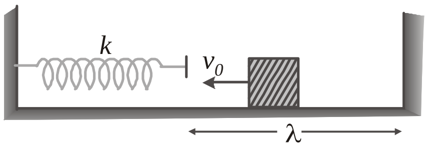
(a) (A) - (3), (B) - (4), (C) - (2), (D) - (3)

(b) (A) - (4), (B) - (3), (C) - (2), (D) - (1)

(c) (A) - (1), (B) - (2), (C) - (3), (D) - (4)

(d) (A) - (2), (B) - (4), (C) - (1), (D) - (3)

**82.** A block of mass $m$ is projected towards a spring with velocity $v_0$. The force constant of the spring is $k$. The block is projected from a distance $\ell$ from the free end of the spring. The collision between block and the wall is completely elastic. Match the following columns :



| **Column-I** | **Column-II** |
|---|---|
| (A) Maximum compression of the spring | (1) $-\sqrt{\frac{kv_0^2}{m}}$ |
| (B) Energy of oscillations of block | (2) $\sqrt{\frac{mv_0{}^2}{k}}$ |
| (C) Time period of oscillations | (3) $\frac{1}{2}mv_0^2$ |
| (D) Maximum acceleration of the block | (4) $\left[\frac{2\ell}{v_0} + \pi\sqrt{\frac{m}{k}}\right]$ |

(a) (A) - (2), (B) - (3), (C) - (1), (D) - (4)

(b) (A) - (2), (B) - (3), (C) - (4), (D) - (1)

(c) (A) - (1), (B) - (4), (C) - (3), (D) - (2)

(d) (A) - (1), (B) - (2), (C) - (3), (D) - (4)

**83.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | $\frac{d^2y}{dt^2} = v^2 \frac{d^2y}{dx^2}$ | (1) | Resonant vibration |
| (B) | $\frac{d^2y}{dt^2} + \omega^2 y = 0$ | (2) | Free vibration |
| (C) | $\frac{d^2y}{dt^2} + 2k\frac{dy}{dt} + \omega^2 y = 0$ | (3) | Damped vibration |
| (D) | $\frac{d^2y}{dt^2} + 2k\frac{dy}{dt} + \omega^2 y = F \sin pt$ | (4) | Forced vibration |
| | | (5) | Progressive wave |

(a) (A) - (1), (B) - (3), (C) - (2, 4), (D) - (5)
(b) (A) - (1, 3), (B) - (2, 5), (C) - (3), (D) - (4, 5)
(c) (A) - (5), (B) - (2), (C) - (3), (D) - (1, 4)
(d) (A) - (1), (B) - (2), (C) - (3), (D) - (4)

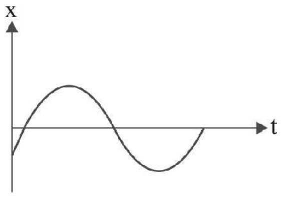
**84.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Motion of a satellite | (1) | Damped oscillations |
| (B) | Motion of a simple pendulum | (2) | Resonant oscillations |
| (C) | Oscillation of stretched string in air | (3) | Periodic motion |
| (D) | Flying off of a paper rider placed on the stretched string | (4) | Simple harmonic motion |

(a) (A) - (2), (B) - (3), (C) - (4), (D) - (1)
(b) (A) - (3), (B) - (2), (C) - (4), (D) - (1)
(c) (A) - (1), (B) - (3), (C) - (2), (D) - (4)
(d) (A) - (3), (B) - (4), (C) - (1), (D) - (2)

## DIAGRAM TYPE QUESTIONS

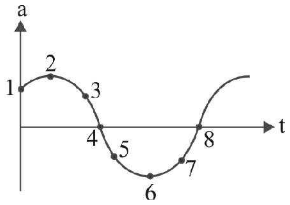
**85.** The displacement vs time of a particle executing SHM is shown in figure. The initial phase $\phi$ is



(a) $-\pi < \phi < -\frac{\pi}{2}$ (b) $\pi < \phi < \frac{3\pi}{2}$

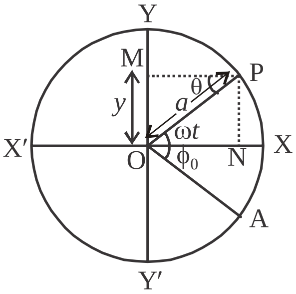
(c) $-\frac{3\pi}{2} < \phi < -\pi$ (d) $\frac{\pi}{2} < \phi < \pi$

**86.** The acceleration of a particle undergoing SHM is graphed in figure. At point 2 the velocity of the particle is



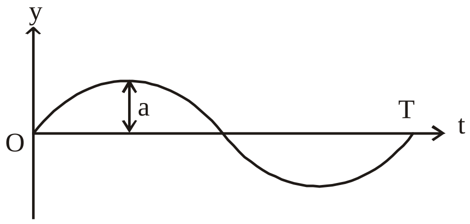
(a) zero (b) negative
(c) positive (d) None of these

**87.** For the given figure,



(a) $y = a \sin \omega t$
(b) $y = a \sin (\omega t - \phi_0)$
(c) $y = a \cos \omega t$
(d) $y = a \cos (\omega t - \phi_0)$

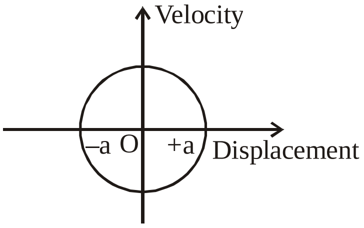
**88.** In the given displacement time curve for SHM at what value of $t$ is the amplitude negative?



(a) $\frac{T}{2}$ (b) $\frac{T}{4}$

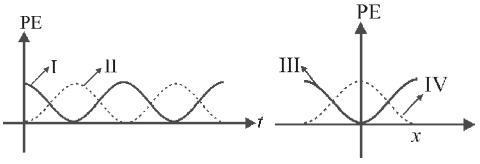
(c) $\frac{3T}{4}$ (d) $\frac{3T}{2}$

**89.** The graph shown in figure represents



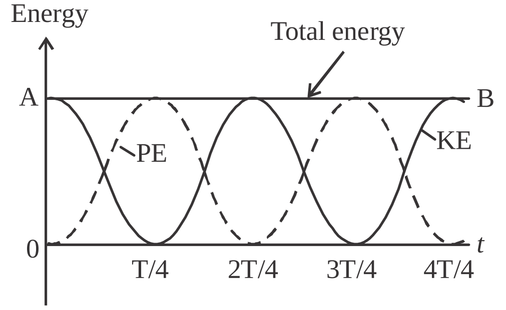
(a) S.H.M. (b) circular motion
(c) rectillinear motion (d) uniform circular motion

**90.** For a particle executing SHM the displacement $x$ is given by $x = A\cos\omega t.$ Identify the graph which represents the variation of potential energy (P.E.) as a function of time $t$ and displacement $x$.



(a) I, III (b) II, IV
(c) II, III (d) I, IV

**91.** What do you conclude from the graph about the frequency of KE, PE and SHM ?



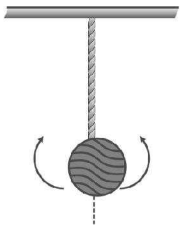
(a) Frequency of KE and PE is double the frequency of SHM

(b) Frequency of KE and PE is four times the frequency SHM.

(c) Frequency of PE is double the frequency of K.E.

(d) Frequency of KE and PE is equal to the frequency of SHM.

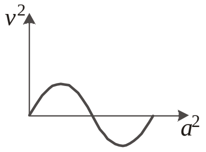
**92.** A simple pendulum is made of a body which is a hollow sphere containing mercury suspended by means of a wire. If a little mercury is drained off, the period of pendulum will



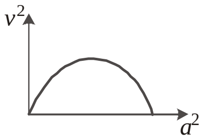
| | |
|---|---|
| (a) remain unchanged | (b) increase |
| (c) decrease | (d) become erratic |

**93.** A graph of the square of the velocity against the square of the acceleration of a given simple harmonic motion is

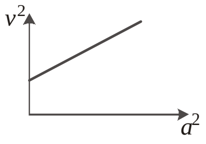
(a)



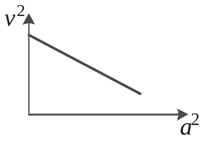
(b)



(c)

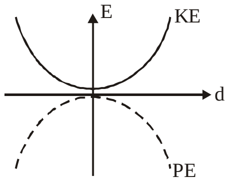


(d)

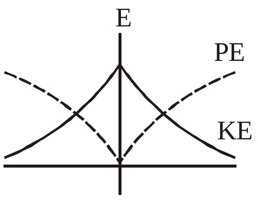


**94.** For a simple pendulum, a graph is plotted between its kinetic energy (KE) and potential energy (PE) against its displacement d. Which one of the following represents these correctly? (*graphs are schematic and not drawn to scale*)

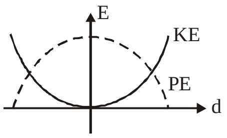
(a)



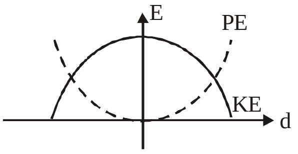
(b)



(c)



(d)



## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

**95.** **Assertion :** An oscillatory motion is necessarily periodic.
**Reason :** A simple harmonic motion is necessarily oscillatory.

**96.** **Assertion :** All oscillatory motions are necessarily periodic motion but all periodic motion are not oscillatory
**Reason :** Simple pendulum is an example of oscillatory motion.

**97.** **Assertion :** In oscillatory motion, displacement of a body from equilibrium can be represented by *sine* or *cosine* function.
**Reason :** The body oscillates to and fro about its mean position.

**98.** **Assertion :** *Sine* and *cosine* functions are periodic functions.
**Reason :** Sinusoidal functions repeats it values after a difinite interval of time

**99.** **Assertion :** A S.H.M. may be assumed as composition of many S.H.M.'s.
**Reason :** Superposition of many S.H.M.'s (along same line) of same frequency will be a S.H.M.

**100.** **Assertion :** In simple harmonic motion, the motion is to and fro and periodic
**Reason :** Velocity of the particle $(v) = \omega\sqrt{k^2 - x^2}$ (where x is the displacement).

**101.** **Assertion :** In SHM, the the velocity is maximum when acceleration is minimum.
**Reason :** Displacement and velocity of SHM differ in phase by $\frac{\pi}{2}$ rad.

**102.** **Assertion :** The force acting on a particle moving along *x*-axis is
$F = -k(x + v_0 t)$, where $k$ is a constant.
**Reason :** To an observer moving along x-axis with constant velocity $v_0$, it represents SHM.

**103.** **Assertion :** At extreme positions of a particle executing SHM, both velocity and acceleration are zero.
**Reason :** In SHM, acceleration always acts towards mean position.

**104.** **Assertion :** A particle executing simple harmonic motion comes to rest at the extreme positions .

**Reason :** The resultant force on the particle is zero at these positions.

**105.** **Assertion :** The graph of total energy of a particle in SHM w.r.t. position is a straight line with zero slope.

**Reason :** Total energy of particle in SHM remains constant throughout its motion.

**106.** **Assertion :** In a S.H.M. kinetic and potential energies become equal when the displacement is $1/\sqrt{2}$ times the amplitude.

**Reason :** In SHM, kinetic energy is zero when potential energy is maximum.

**107.** **Assertion :** If the amplitude of simple harmonic oscillator is doubled, its total energy becomes four times.

**Reason :** The total energy is directly proportional to the square of amplitude of oscillations.

**108.** **Assertion :** The graph between velocity and displacement for a harmonic oscillator is an ellipse.

**Reason :** Velocity does not change uniformly with displacement in harmonic motion.

**109.** **Assertion :** The periodic time of a hard spring is less as compared to that of a soft spring.

**Reason :** The periodic time depends upon the spring constant, and spring constant is large for hard spring.

**110.** **Assertion:** Time period of a loaded spring does not change when taken to moon.

**Reason:** Time period of a loaded spring depends upon the mass attached and the spring constant and not on acceleration due to gravity *g*.

**111.** **Assertion:** Pendulum clock will gain time on the mountain top.

**Reason:** On the mountain top the length of the pendulum will decrease and $T \propto \sqrt{l}$, so it will also decrease.

**112.** **Assertion:** If amplitude of simple pendulum increases then the motion of pendulum is oscillatory but not simple harmonic.

**Reason:** For larger amplitude θ is large and then $\sin\theta \neq \theta$, so the motion is no longer SHM.

**113.** **Assertion :** When a simple pendulum is made to oscillate on the surface of moon, its time period increases.

**Reason :** Moon is much smaller as compared to earth.

**114.** **Assertion :** The amplitude of an oscillating pendulum decreases gradually with time

**Reason :** The frequency of the pendulum decreases with time

**115.** **Assertion :** Damped oscillation indicates loss of energy.

**Reason :** The energy loss in damped oscillation may be due to friction, air resistance etc.

**116.** **Assertion:** Amplitude of a forced vibration can never reach infinity.

**Reason:** The driving frequency cannot be increased beyond a certain limit.

**117.** **Assertion :** Resonance is special case of forced vibration in which the natural frequency of vibration of the body is the same as the impressed frequency of external periodic force and the amplitude of forced vibration is maximum

**Reason :** The amplitude of forced vibrations of a body increases with an increase in the frequency of the externally impressed periodic force.

## CRITICAL THINKING TYPE QUESTIONS

**118.** A particle executing simple harmonic motion covers a distance equal to half of its amplitude in one second. Then the time period of the simple harmonic motion is

(a) 4 s (b) 6 s (c) 8 s (d) 12 s

**119.** Two particles are executing simple harmonic motion of the same amplitude A and frequency ω along the *x*-axis. Their mean position is separated by distance $X_0(X_0 > A)$. If the maximum separation between them is $(X_0 + A)$, the phase difference between their motion is

(a) $\frac{\pi}{3}$ (b) $\frac{\pi}{4}$ (c) $\frac{\pi}{6}$ (d) $\frac{\pi}{2}$

**120.** Two particles are oscillating along two close parallel straight lines side by side, with the same frequency and amplitudes. They pass each other, moving in opposite directions when their displacement is half of the amplitude. The mean positions of the two particles lie on a straight line perpendicular to the paths of the two particles. The phase difference is

(a) 0 (b) 2π/3 (c) π (d) π/6

**121.** The displacement of a particle in SHM is $x = 10\sin\left(2t - \frac{\pi}{6}\right)$ metre. When its displacement is 6 m, the velocity of the particle (in m s$^{-1}$) is

(a) 8 (b) 24 (c) 16 (d) 10

**122.** The maximum velocity of a particle, executing simple harmonic motion with an amplitude 7 mm, is 4.4 m/s. The period of oscillation is

(a) 0.01 s (b) 10 s (c) 0.1 s (d) 100 s

**123.** Two simple harmonic motions are represented by the equations $y_1 = 0.1 \sin\left(100\pi t + \frac{\pi}{3}\right)$ and $y_2 = 0.1 \cos \pi t$.

The phase difference of the velocity of particle 1 with respect to the velocity of particle 2 is

(a) $\frac{\pi}{3}$ (b) $\frac{-\pi}{6}$ (c) $\frac{\pi}{6}$ (d) $\frac{-\pi}{3}$

**124.** A body is executing S.H.M. When its displacement from the mean position are 4 cm and 5 cm, it has velocities 10 cm s$^{-1}$ and 8 cm s$^{-1}$ respectively. Its periodic time is

(a) π/2 s (b) π s (c) 3 π/2 s (d) 2 π s

**125.** A point mass oscillates along the x-axis according to the law $x = x_0 \cos(\omega t - \pi/4)$. If the acceleration of the particle is written as $a = A\cos(\omega t + \delta)$, then

(a) $A = x_0\omega^2, \delta = 3\pi/4$ (b) $A = x_0, \delta = -\pi/4$
(c) $A = x_0\omega^2, \delta = \pi/4$ (d) $A = x_0\omega^2, \delta = -\pi/4$

**126.** Starting from the origin a body oscillates simple harmonically with a period of 2 s. After what time will its kinetic energy be 75% of the total energy?

(a) $\frac{1}{6}s$ (b) $\frac{1}{4}s$ (c) $\frac{1}{3}s$ (d) $\frac{1}{12}s$

**127.** A particle of mass m executes simple harmonic motion with amplitude a and frequency ν. The average kinetic energy during its motion from the position of equilibrium to the end is

(a) $2\pi^2 ma^2\nu^2$ (b) $\pi^2 ma^2\nu^2$
(c) $\frac{1}{4}ma^2\nu^2$ (d) $4\pi^2 ma^2\nu^2$

**128.** A particle is executing simple harmonic motion with amplitude A. When the ratio of its kinetic energy to the potential energy is $\frac{1}{4}$, its displacement from its mean position is

(a) $\frac{2}{\sqrt{5}}A$ (b) $\frac{\sqrt{3}}{2}A$ (c) $\frac{3}{4}A$ (d) $\frac{1}{4}A$

**129.** A mass of 4 kg suspended from a spring of force constant 800 N $m^{-1}$ executes simple harmonic oscillations. If the total energy of the oscillator is 4 J, the maximum acceleration (in m $s^{-2}$) of the mass is

(a) 5 (b) 15 (c) 45 (d) 20

**130.** The period of oscillation of a mass M suspended from a spring of negligible mass is T. If along with it another mass M is also suspended, the period of oscillation will now be

(a) T (b) $T/\sqrt{2}$
(c) 2T (d) $\sqrt{2}\,T$

**131.** A particle at the end of a spring executes S.H.M with a period $t_1$, while the corresponding period for another spring is $t_2$. If the period of oscillation with the two springs in series is T then

(a) $T^{-1} = t_1^{-1} + t_2^{-1}$ (b) $T^2 = t_1^2 + t_2^2$
(c) $T = t_1 + t_2$ (d) $T^{-2} = t_1^{-2} + t_2^{-2}$

**132.** The displacement of an object attached to a spring and executing simple harmonic motion is given by $x = 2 \times 10^{-2} \cos \pi t$ metre.The time at which the maximum speed first occurs is

(a) 0.25 s (b) 0.5 s (c) 0.75 s (d) 0.125 s

**133.** When two displacements represented by $y_1 = a\sin(\omega t)$ and $y_2 = b\cos(\omega t)$ are superimposed the motion is:

(a) simple harmonic with amplitude $\frac{a}{b}$
(b) simple harmonic with amplitude $\sqrt{a^2 + b^2}$
(c) simple harmonic with amplitude $\frac{(a + b)}{2}$
(d) not a simple harmonic

**134.** For a particle moving according to the equation $x = a \cos \pi t$, the displacement in 3 s is

(a) 0 (b) 0.5a
(c) 1.5a (d) 2a

**135.** A particle is executing SHM along a straight line. Its velocities at distances $x_1$ and $x_2$ from the mean position are $V_1$ and $V_2$, respectively. Its time period is

(a) $2\pi\sqrt{\frac{x_2^2 - x_1^2}{V_1^2 - V_2^2}}$ (b) $2\pi\sqrt{\frac{V_1^2 + V_2^2}{x_1^2 + x_2^2}}$
(c) $2\pi\sqrt{\frac{V_1^2 - V_2^2}{x_1^2 - x_2^2}}$ (d) $2\pi\sqrt{\frac{x_1^2 - x_2^2}{V_1^2 - V_2^2}}$

**136.** If the differential equation for a simple harmonic motion is $\frac{d^2y^2}{dt^2} + 2y = 0$, the time-period of the motion is

(a) $\pi\sqrt{2}s$ (b) $\frac{\sqrt{2}s}{\pi}s$
(c) $\frac{\pi}{\sqrt{2}}s$ (d) $2\pi s$

**137.** The total energy of the particle executing simple harmonic motion of amplitude A is 100 J. At a distance of 0.707 A from the mean position, its kinetic energy is

(a) 25 J (b) 50 J
(c) 100 J (d) 12.5 J

**138.** A particle moves with simple harmonic motion in a straight line. In first $\tau$s, after starting from rest it travels a distance a, and in next $\tau$ s it travels 2a, in same direction, then:

(a) amplitude of motion is 3a
(b) time period of oscillations is $8\tau$
(c) amplitude of motion is 4a
(d) time period of oscillations is $6\tau$

**139.** A particle is executing a simple harmonic motion. Its maximum acceleration is α and maximum velocity is β. Then its time period of vibration will be :

(a) $\frac{\alpha}{\beta}$ (b) $\frac{\beta^2}{\alpha}$
(c) $\frac{2\pi\beta}{\alpha}$ (d) $\frac{\beta^2}{\alpha^2}$

**140.** When the displacement of a particle executing simple harmonic motion is half of its amplitude, the ratio of its kinetic energy to potential energy is `

(a) 1 : 3 (b) 2 : 1
(c) 3 : l (d) l : 2

**141.** A body oscillates with SHM according to the equation (in SI units), $x = 5\cos\left(2\pi t \frac{\pi}{4}\right)$.

Its instantaneous displacement at $t = 1$ second is

(a) $\frac{\sqrt{2}}{5}$ m (b) $\frac{1}{\sqrt{3}}$ m

(c) $\frac{5}{\sqrt{2}}$ m (d) $\frac{1}{2}$ m

**142.** The length of a simple pendulum executing simple harmonic motion is increased by 21%. The percentage increase in the time period of the pendulum of increased length is

(a) 11% (b) 21% (c) 42% (d) 10%

**143.** The bob of a simple pendulum executes simple harmonic motion in water with a period t, while the period of oscillation of the bob is $t_0$ in air. Neglecting frictional force of water and given that the density of the bob is (4/3) × 1000 kg / m$^3$. What relationship between t and $t_0$ is true

(a) $t = 2t_0$ (b) $t = t_0 / 2$

(c) $t = t_0$ (d) $t = 4t_0$

**144.** If a simple pendulum has significant amplitude (upto a factor of $1/e$ of original) only in the period between $t = 0s$ to $t = \tau s$, then $\tau$ may be called the average life of the pendulum. when the spherical bob of the pendulum suffers a retardation (due to viscous drag) proportional to its velocity with b as the constant of proportionality, the average life time of the pendulum is (assuming damping the small) in seconds

(a) $\frac{0.693}{b}$ (b) $b$ (c) $\frac{1}{b}$ (d) $\frac{2}{b}$

**145.** Two pendulums of lengths 1.44 m and 1 m start to swing together. The number of vibrations after which they will again start swinging together is

(a) 4 (b) 3 (c) 5 (d) 2

**146.** A simple pendulum has a metal bob, which is negatively charged. If it is allowed to oscillate above a positively charged metallic plate, then its time period will

(a) increase (b) decrease

(c) become zero (d) remain the same

**147.** A block connected to a spring oscillates vertically. A damping force $F_d$, acts on the block by the surrounding medium. Given as $F_d = -bV$ $b$ is a positive constant which depends on :

(a) viscosity of the medium

(b) size of the block

(c) shape of the block

(d) All of these

**148.** The amplitude of a damped oscillator decreases to 0.9 times its original magnitude in 5s. In another 10s it will decrease to $\alpha$ times its original magnitude, where $\alpha$ equals

(a) 0.7 (b) 0.81 (c) 0.729 (d) 0.6

**149.** The amplitude of a damped oscillator becomes $\left(\frac{1}{3}\right)^{rd}$ in 2 seconds. If its amplitude after 6 seconds is $\frac{1}{n}$ times the original amplitude, the value of $n$ is

(a) $3^2$ (b) $3^3$ (c) $\sqrt[3]{3}$ (d) $2^3$

**150.** When two springs A and B with force constants $k_A$ and $k_B$ are stretched by the same force, then the respective ratio of the work done on them is

(a) $k_B : k_A$ (b) $k_A : k_B$

(c) $k_A k_B : 1$ (d) $\sqrt{k_B} : \sqrt{k_A}$

**151.** Two oscillating simple pendulums with time periods T and $\frac{5T}{4}$ are in phase at a given time. They are again in phase after an elapse of time

(a) 4T (b) 3T (c) 6T (d) 5T

**152.** A pendulum made of a uniform wire of cross sectional area A has time period T. When an additional mass M is added to its bob, the time period changes to $T_M$. If the Young's modulus of the material of the wire is Y then $\frac{1}{Y}$ is equal to: ($g$ = *gravitational acceleration*)

(a) $\left[1-\left(\frac{T_M}{T}\right)^2\right]\frac{A}{Mg}$ (b) $\left[1-\left(\frac{T}{T_M}\right)^2\right]\frac{A}{Mg}$

(c) $\left[\left(\frac{T_M}{T}\right)^2-1\right]\frac{A}{Mg}$ (d) $\left[\left(\frac{T_M}{T}\right)^2-1\right]\frac{Mg}{A}$

**153.** A pendulum of time period 2 s on earth is taken to another planet whose mass and diameter are twice that of earth. Then its time period on the planet is (in second)

(a) $\frac{1}{2}$ (b) $2\sqrt{2}$ (c) $\frac{1}{\sqrt{2}}$ (d) 2

**154.** A simple harmonic oscillator of angular frequency 2 rad s$^{-1}$ is acted upon by an external force $F = \sin t$ N. If the oscillator is at rest in its equilibrium position at $t = 0$, its position at later times is proportional to

(a) $\sin t + \frac{1}{2}\cos 2t$ (b) $\cos t - \frac{1}{2}\sin 2t$

(c) $\sin t - \frac{1}{2}\sin 2t$ (d) $\sin t + \frac{1}{2}\sin 2t$

**155.** A pendulum with time period of 1s is losing energy due to damping. At certain time its energy is 45 J. If after completing 15 oscillations, its energy has become 15 J, its damping constant (in s$^{-1}$) is :

(a) $\frac{1}{2}$ (b) $\frac{1}{30}$In3

(c) 2 (d) $\frac{1}{15}$In3

**156.** A cylindrical block of wood (density = 650 kg m$^{-3}$), of base area 30cm$^2$ and height 54 cm, floats in a liquid of density 900 kg m$^{-3}$. The block is depressed slightly and then released. The time period of the resulting oscillations of the block would be equal to that of a simple pendulum of length (nearly)

(a) 52 cm (b) 65 cm

(c) 39 cm (d) 26 cm

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(c)**

**2.** **(a)** The motion of the particle is periodic, (not oscillatory), beacuse it returns to its starting point after a fixed time

**3.** **(a)** $F \propto x$ in SHM.

**4.** **(b)** Since $T$ is independent of mass, so a girl sitting accompanied by another girl will not affect $T$ but if the girl stands up then due to the shift in the location of centre of mass upwards, the effective length decreases and hence $T$ decrease $(T \propto \sqrt{L})$.

**5.** **(a)** $y = 10 \sin(20t + 0.5)$

$y(t) = a \sin(\omega t + \theta)$

$\therefore$ Frequency, $v = \frac{\omega}{2\pi} = \frac{20}{2\pi}$

**6.** **(c)** General equation of wave motion should be represented by

$y = f(ax \pm bt)$ or $f(at \pm bx)$

when $y$ is a *sine* or *cosine* function such as

$y = a \sin(\omega t - kx)$

or $y = a \cos(\omega t - kx)$

is called simple harmonic progressive wave.

**7.** **(b)** There is no basic difference between oscillation and vibration. For oscillation, frequency is small and for vibration, frequency is high. e.g., oscillation of a pendulum and vibration of a string of a guitar.

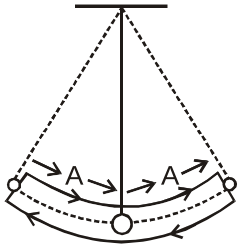
**8.** **(b)**

**9.** **(c)** The motion of particle is circular or elliptic, when two S.H.M. which are perpendicular to each other superimpose on the particle. The particle moves on a

(i) Ellipse if amplitudes of two S.H.M. are different

(ii) Circle, if amplitudes of two S.H.M. are same.

**10.** **(d)** As seen from figure after one time period the bob return to its equilibrium position, so diplacement of the particle is zero, but distance covered by the particle in one time period is 4A (where A is amplitude of bob, when it does S.H.M.)



**11.** **(d)** A periodic motion is a periodic function of time.

$f(t) = A \cos \omega t$ and $f(t) = A \sin \omega t$

A linear combination of the two is

$f(t) = A \sin \omega t + A \cos \omega t$

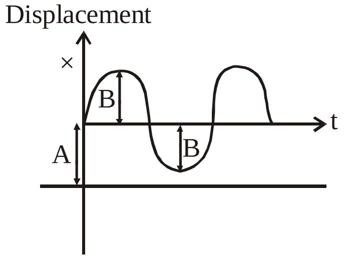
are all periodic motion equation.

**12.** **(c)** $e^{-2\omega t}$ is not periodic. It decreases with increasing $t$ and never repeats its value.

**13.** **(c)** Clearly $\sin^2 \omega t$ is a periodic function as $\sin \omega t$ is periodic with period $\frac{\pi}{\omega}$

**14.** **(b)**

**15.** **(b)** The motion is S.H.M. (as seen from fig.) with an amplitude B.



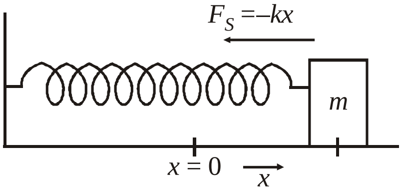
**16.** **(d)** In simple harmonic motion, frequency remains constant and else changes with time.

**17.** **(b)** The simplest type of oscillatory motion is SHM

In SHM

$F \propto x$

$F_s = -kx$



Simple harmonic motion arises when the force on the oscillating body is directly proportional to its displacement from the mean position, which is also the equilibrium position.

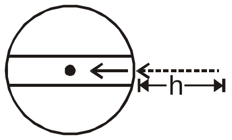
Further, at any point in its oscillation, this force is directed towards the mean position. Displacement and force are in opposite directions.

**18.** **(a)** If $\mathbf{F} \propto \mathbf{x}$, this motion is known as linear harmonic motion.

Here, constant proportionality is negative.

If $\mathbf{F}$ is proportional to higher powers of $x$, this motion is known as non-linear harmonic motion.

**19.** **(c)** When a particle is dropped from a height h above the centre of tunnel.



(i) It will oscillate, through the earth to a height h on both sides.

(ii) The motion of particle is periodic.

(iii) The motion of particle will not be S.H.M.

**20.** **(d)** Its motion is complex, but not periodic, oscillatory or S.H.M.

**21.** **(d)** The motion of particle is S.H.M. with

$x = A \sin \omega t + B \cos \omega t$

$= a \sin (\omega t + \theta)$

Where $a = \sqrt{A^2 + B^2}$, $A = a \cos\theta$, $B = a \sin\theta$, $\theta = \tan^{-1} B/A$.

**22.** **(b)** Elasticity brings the particle towards mean position and inertia needed to cross mean position.

**23.** **(d)** $x(t) = A \cos(\omega t + \phi)$

$$V(t) = \frac{dx}{dt} = -\omega A \sin(\omega t + \phi)$$

$$a(f) = \frac{dv}{dt} = -\omega^2 A \cos(\omega t + \phi)$$

**24.** **(c)** Displacement, $y = r \sin \omega t$

$$V = \frac{dy}{dt} = r\,\omega \cos \omega t$$

$$a = \frac{dV}{dt} = -\omega^2 r \sin \omega t$$

$a = -\omega^2 y$

$\therefore \quad a \propto y$

**25.** **(c)** Displacement in simple harmonic motion is given by

$y = a \sin \omega t$ .... (i)

Differentiating with respect to time $t$

$$\frac{dy}{dt} = \frac{d}{dt}(a \sin \omega t)$$

$v = a(\cos \omega t)\omega$

$= a\omega\sqrt{(1 - \sin^2 \omega t)}$

Substituting value of $\sin \omega t$ from Eq. (i), we get

$$\therefore \quad v = a\omega\sqrt{(1 - \frac{y^2}{a^2}}$$

$$v = a\omega\sqrt{\frac{a^2 - y^2}{a^2}}$$

$$v = \omega\sqrt{a^2 - y^2}$$

**26.** **(d)** **27.** **(b)** **28.** **(d)**

**29.** **(d)** Let $y = A \sin \omega t$

$$v_{\text{inst}} = \frac{dy}{dt} = A\omega \cos \omega t = A\omega \sin(\omega t + \pi/2)$$

Acceleration $= -A\omega^2 \sin \omega t$

$= A\omega^2 \sin(\pi + \omega t)$

$$\therefore \phi = \frac{\pi}{2} = 0.5\pi$$

**30.** **(a)** $a = -kX$, $X = x + a$.

In simple harmonic motion acceleration is directly proportional to the displacement from the mean position. Also the acceleration is in the opposite direction of displacement.

**31.** **(d)**

**32.** **(d)** Total mechanical energy is constant throughout the motion and equals $\frac{1}{2}m\omega^2 A^2$.

**33.** **(a)** If displacement of particle is $y$, then

$$KE = \frac{1}{2}m\omega^2(a^2 - y^2)$$

$$\& \quad P.E. = \frac{1}{2}m\omega^2 y^2$$

If KE = PE

$$\frac{1}{2}m\omega^2 y^2 = \frac{1}{2}m\omega^2 a^2 - \frac{1}{2}m\omega^2 y^2$$

$$2y^2 = a^2 \quad \therefore y = \frac{a}{\sqrt{2}}$$

**34.** **(a)** Energy of a particle in simple harmonic motion is given by

$$E = \frac{1}{2}m\omega^2 a^2 \qquad \therefore \quad E \propto a^2$$

Therefore, the energy in simple harmonic motion depends on $a^2$.

**35.** **(a)** At any instant the total energy is

$$\frac{1}{2}kx^2 + \frac{1}{2}mv^2 = \frac{1}{2}kA_0^2 = \text{constant}$$

$A_0$ = amplitude

hence U is independent of x.

**36.** **(a)** P.E. of body in S.H.M. at an instant,

$$U = \frac{1}{2}m\,\omega^2 y^2 = \frac{1}{2}ky^2$$

If the displacement, $y = (a - x)$ then

$$U = \frac{1}{2}k(a - x)^2 = \frac{1}{2}k(x - a)^2$$

**37.** **(b)** $$K = \frac{1}{2}m\omega^2(A^2 - x^2)$$

$$\therefore \quad K_{\max} = \frac{1}{2}m\omega^2 A^2, \text{ at } x = 0.$$

**38.** **(a)** $$E_{av} = U_{av} = \frac{1}{4}m\omega^2 A^2$$

**39.** **(d)** $E = \frac{1}{2}m\omega^2 a^2 \Rightarrow E \propto a^2$

**40.** **(d)** The acceleration of the particle at equilibrium position is zero.

**41.** **(c)**

**42.** **(c)** In S.H.M., kinetic energy of particle at any point P is

$$\text{Kinetic energy} = \frac{1}{2}m\omega^2(a^2 - x^2)$$

Potential energy $= \left(\frac{1}{2}m\omega^2x^2\right)$

Where a is amplitude of particle and x is the distance from mean position.
So, at mean position, x = 0

$$\text{K.E.} = \frac{1}{2}m\omega^2a^2 \quad \text{(maximum)}$$

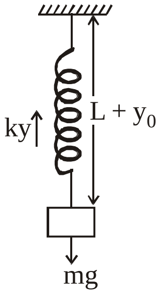
P.E. = 0

**43.** **(c)** For spring mass m system, the time period of the oscillation of mas m is defined as

$$T = 2\pi\sqrt{m/k} = 2\pi\sqrt{y/g}$$

where m = mass of particle
k = spring constant
y = extension in spring
L = natural length of spring

If g is changed, then y also changes so that y/g is constant, so the time period T of spring mass is independent from the variation in g. Hence ν (frequency) will also not change.



**44.** **(a)** $\frac{1}{k_{eq}} = \frac{1}{k_1} + \frac{1}{k_2} \Rightarrow \frac{1}{k_{eq}} = \frac{k_1+k_2}{k_1k_2}$

$$\Rightarrow k_{eq} = \frac{k_1k_2}{k_1+k_2}$$

**45.** **(b)** In parallel combination, the effective spring constant (K) of springs
$K = K_1 + K_2 + ...$
Hence, option (b) is wrong.

**46.** **(b)** Time period of a simple pendulum $T = 2\pi\sqrt{\frac{L}{g}}$

**47.** **(b)** $T = mg\cos\theta$
At the mean position, θ = 0° and cos 0° = 1
So, the value of tension is greatest.

**48.** **(c)** $\frac{E_1}{E_2} = \frac{\frac{1}{2}m\omega^2r_1^2}{\frac{1}{2}m\omega^2r_2^2} = \left(\frac{r_1}{r_2}\right)^2 = \left(\frac{5}{10}\right)^2 = 1:4$

**49.** **(b)** Time period of a simple pendulum of length $l$ is given by

$T = 2\pi\sqrt{\frac{l}{g}}$ where $g$ is acceleration due to gravity.

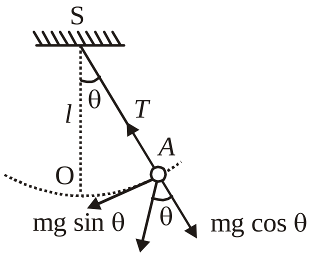
**50.** **(a)** Potential energy of a simple pendulum is given by

$$U = \frac{1}{2}m\omega^2y^2$$

Potential energy is maximum when the displacement of the pendulum is maximum, i.e., at the turning points of the oscillations.

**51.** **(c)**

**52.** **(c)** Let a simple pendulum be taken as shown. The restoring force on the bob is
$F = -mg\sin\theta$



where $m$ is mass of bob, $g$ the acceleration due to gravity. When angular displacement of bob is small sin θ and θ measured in radians, then

$$\sin\theta \cong \theta = \frac{OA}{SA} = \frac{x}{l}$$

$$\therefore \quad F = -\left(\frac{mg}{l}\right)x \qquad \left[\text{angle} = \frac{\text{arc}}{\text{radius}}\right]$$

Since, $m, g$ and $l$ are constant.

$$\therefore \quad F \propto -x$$

Therefore, the motion of bob is simple harmonic.

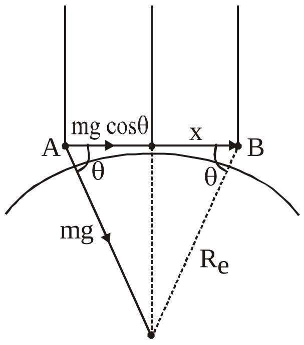
**53.** **(c)** The motion of a planet around the sun is periodic motion but not a simple harmonic motions.

**54.** **(d)** Tension is maximum at the mean position.

**55.** **(b)** $p_{max} = \sqrt{2mE_{max}}$

**56.** **(a)** Time period $T = 2\pi\sqrt{\frac{L}{g}}$

**57.** **(a)** The both of the pendulum will more along a straight line AB.



The direction of the Earth's gravitational field is radial

Now, $F = \frac{GM_e m}{R_e^2} = mg$

$$F_x = -F\cos\theta = -F\frac{x}{R_e} = -\frac{GM_e m}{R_e^3}x = -kx$$

where $k = \frac{GM_e m}{{R_e}^3}$

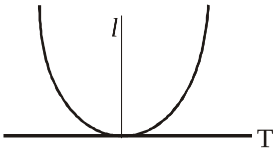
Time period of a simple harmonic oscillator,

$$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{m}{GM_e m / R_e^3}}$$

$$\text{or } T = 2\pi\sqrt{\frac{\frac{R_e}{GM_e}}{R_e^2}} = 2\pi\sqrt{\frac{R_e}{g}}$$

**58.** **(a)** **59.** **(c)**

**60.** **(d)** $T = 2\pi\sqrt{\frac{l}{g}}$



$l = \left(\frac{g}{4\pi^2}\right)T^2$

$\therefore\ l \propto T^2$

**61.** **(a)**

**62.** **(c)** Kinetic energy, $K = \frac{1}{2}mv^2 = \frac{1}{2}m\omega^2 A^2 \sin^2(\omega t + \phi)$

Potential energy, $U = \frac{1}{2}m\omega^2 A^2 \cos^2(\omega t + \phi)$

$\therefore$ Total mech. energy $= \frac{1}{2}m\omega^2 A^2$

**63.** **(a)** In case of sustained force oscillations the amplitude of oscillations decreases linearly.

**64.** **(c)** A particle oscillating under a force $\overline{F} = -k\overline{x} - b\overline{\upsilon}$ is a damped oscillator. the first term $-k\overline{x}$ represents the restoring force and second term $-b\overline{\upsilon}$ represents the damping force.

**65.** **(b)**

**66.** **(c)** In forced oscillations, the body oscillates at the angular frequency of the driving force.

**67.** **(b)** The resonance wave becomes very sharp when damping force is small.

**68.** **(d)** **69.** **(b)**

## STATEMENT TYPE QUESTIONS

**70.** **(b)** Every simple harmonic motion (S.H.M.) is necessarily periodic, but a periodic motion may or may not be simple harmonic motion.

**71.** **(b)**

**72.** **(c)** In SHM, acceleration of particle is always directed towards mean position but velocity is either towards or away from mean position. Similarly displacement is always away from the position. So they can not be in phase always.

**73.** **(c)** In one vibration the particle goes twice to extreme positions and twice crosses the mean position. So does the PE and KE.

**74.** **(b)**

**75.** **(a)** Displacement amplitude of an oscillator depends on the angular frequency of the driving force.

**76.** **(d)** Examples of oscillatory motion can be found around us very easily.

In most of the musical instruments either string or some memberane oscillates to produce pleasant sound. Due to the oscillation of air molecules sound propagates in a air.

**77.** **(d)**

**78.** **(b)** $(\omega t + \phi)$ represents the phase of the particle in SHM.

$\phi$ represents the phase constant and is the value of phase at $t = 0$

**79.** **(c)** Fs = –K x (spring force) ... (i)

F = – m$\omega^2 x$ (For SHM condition) ... (ii)

On comparing Eqs. (i) and (ii),

$$\omega = \sqrt{\frac{k}{m}} \Rightarrow T = 2\pi\sqrt{\frac{m}{k}} \qquad \left(\because T = \frac{2\pi}{\omega}\right)$$

$$\Rightarrow T \propto \sqrt{m} \Rightarrow T \propto \frac{1}{\sqrt{k}}$$

So, $T$ does not depends on the amplitude of the oscillation $T$ depend on m, k.

## MATCHING TYPE QUESTIONS

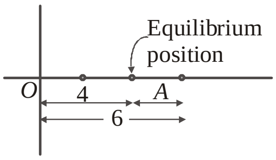
**80.** **(c)**

**81.** **(a)**

(A) For equilibrium, $F = 8 - 2x = 0$

or $x = 4m$

(B) From figure,



$A = 2m$

(C) Time taken from $x = 2$ to 4

or A to O is $\frac{T}{4}$, which differes in phase by $\frac{\pi}{2}$.

(D) Energy of SHM, $E = \int_4^6 F dx$

$= \int_4^6 (8 - 2x)dx = \left|8x - x^2\right|_4^6$

$= 4$ J.

**82.** **(b)** $\frac{1}{2}kx_0^2 = \frac{1}{2}mv_0^2$ or $x_0 = \sqrt{\frac{mv_0^2}{k}}$

Time period, $T' = \left[2\frac{T}{4} + 2t\right]$

$= \left[\frac{2\pi}{2}\sqrt{\frac{m}{k}} + 2\frac{\ell_0}{v_0}\right]$

Energy of oscillation $= \frac{1}{2}mv_0^2$.

**83.** **(c)** **84.** **(d)**

## DIAGRAM TYPE QUESTIONS

**85.** **(a)** For $x = (-A)$, we have

$-A = A\sin(\omega \times 0 + \phi_0)$

or $\phi_0 = -\frac{\pi}{2}$.

So for $x < (-A)$, $\phi_0 < (-\pi/2)$.

**86.** **(a)** At point 2, the acceleration of the particle is maximum, which is at the extreme position. At extreme position, the velocity of the particle will be zero.

**87.** **(b)** $\frac{y}{a} = \sin\theta$

$\therefore \quad y = a\sin\theta$

$\theta = \angle XOP = \omega t - \phi_0$

$\therefore \quad y = a\sin(\omega t - \phi_0)$

**88.** **(c)**

**89.** **(a)** t = 0, v maximum. The motion begins from mean position. So it represents S.H.M.

**90.** **(a)** In $x = A\cos\omega t$, the particle starts oscillating from extreme position. So at $t = 0$, its potential energy is maximum.

**91.** **(a)** KE and PE completes two vibration in a time during which SHM completes one vibration. Thus frequency of PE or KE is double than that of SHM.

**92.** **(b)** When some mercury is drained off, the centre of gravity of the bob moves down and so length of the pendulum increases, which result increase in time period.

**93.** **(d)** $v^2 = \omega^2(A^2 - x^2) \quad \ldots(i)$

and $a^2 = (\omega^2 x)^2 = \omega^4 x^2 \quad \ldots(ii)$

From above equations, we have

$$v^2 = -\frac{a^2}{\omega^2} + \omega^2 A^2 \Rightarrow y = mx + c$$

It represents straight line with negative slope.

**94.** **(d)** K.E $= \frac{1}{2}k(A^2 - d^2)$

and P.E. $= \frac{1}{2}kd^2$

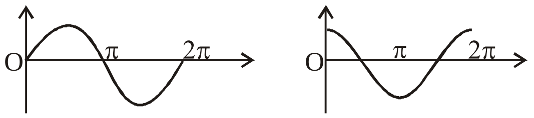
At mean position $d = 0$. At extrement positions $d = A$

## ASSERTION- REASON TYPE QUESTIONS

**95.** **(d)** Damped oscillations are non-periodic.

**96.** **(b)** **97.** **(b)**

**98.** **(a)** A periodic function is one whose value repeats after a definite interval of time sin θ and cos θ are periodic functions because they repeat itself after 2π interval of time



sin curve cos curve

**99.** **(b)** So rod remains stationary after the release.

**100.** **(c)** S.H.M. is to and fro motion of an object and it is periodic.

$v = \omega\sqrt{k^2 - x^2}$

If x = 0, v has maximum value. At x = k, v has minimum velocity. Similarly, when x = – k, v has zero value, all these indicate to and from movement.

**101.** **(b)** $x = A\sin\omega t$

and $v = \omega A\cos\omega t = \omega A\sin(\omega t + \pi/2)$

**102.** **(a)** With respect to an observer, the force on the particle

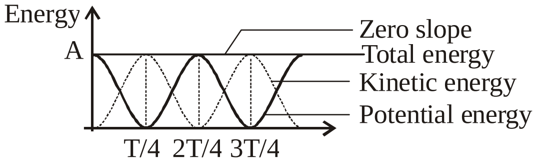
$F = -k[x + (v_0 - v_0)t] = -kx$, so it represents SHM.

**103.** **(d)** At extreme position, $a = \omega^2 A$ and $v = 0$.

**104.** **(c)** The force at the extreme position is, $F = m\omega^2 A$.

**105.** **(a)** The total energy of S.H.M = Kinetic energy of particle + potential energy of particle

The variation of total energy of the particle in SHM with time is shown in a graph



**106.** **(b)** In SHM. K.E.$= \frac{1}{2}m\omega^2(a^2 - y^2)$ and P.E. $= \frac{1}{2}m\omega^2 y^2$.

For K.E. = P.E. $\Rightarrow 2y^2 = a^2 \Rightarrow y = a/\sqrt{2}$. Since total energy remains constant through out the motion, which is E = K.E. + P.E. So, when P.E. is maximum then K.E. is zero and viceversa.

**107.** **(a)** As $E \propto A^2$, $E' = 4E$.

**108.** **(c)**

**109.** **(a)** The time period of a oscillating spring is given by

$T = 2\pi\sqrt{\frac{m}{k}} \Rightarrow T \propto \frac{1}{\sqrt{k}}$, Since the spring constant is large for hard spring, therefore hard spring has a less periodic time as compared to soft spring.

**110.** **(a)**

**111. (d)** Both assertion and reason are wrong. At the mountain top $g$ will decrease and $T \propto \frac{1}{\sqrt{g}}$.

It will increase. Thus the pendulum clock will become slow. So, pendulum clock loses time.

**112. (a)**

**113. (b)** At moon $T = 2\pi\sqrt{\frac{\ell}{(g/6)}}$, so time period increases.

**114. (c)** The amplitude of an oscillating pendulum decreases with time because of friction due to air. Frequency of pendulum is independent $\left(T = \frac{1}{2\pi}\sqrt{\frac{g}{l}}\right)$ of amplitude.

**115. (b)** Energy of damped oscillator at an any instant t is given by

$$E = E_0 e^{-bt/m} \text{ [where } E_0 = \frac{1}{2}kx^2 = \text{maximum energy]}$$

Due to damping forces the amplitude of oscillator will go on decreasing with time whose energy is expressed by above equation.

**116. (c)** Damping can never be zero in reality, so amplitude can never be infinity.

**117. (c)** Amplitude of oscillation for a forced damped oscillatory is $A = \frac{F_0/m}{\sqrt{(\omega^2 - \omega_0{}^2) + (b\omega/m)^2}}$, where b is constant related to the strength of the resistive force, $\omega_0 = \sqrt{k/m}$ is natural frequency of undamped oscillator (b = 0)

When the frequency of driving force $(\omega) \approx \omega_0$, then amplitude A is very larger.

For $\omega < \omega_0$ or $\omega > \omega_0$, the amplitude decreases.

## CRITICALTHINKING TYPE QUESTIONS

**118. (d)** According to equation of SHM

$x = A\sin\omega t$

Here, $x = \frac{A}{2}$ and $t = 1$

$\therefore \frac{A}{2} = A\sin\omega \times 1$

$= A\sin\omega$

or, $\sin\ \omega = \frac{1}{2}, \omega = \frac{\pi}{6}$

$\therefore \frac{2\pi}{T} = \frac{\pi}{6}$ or T = 12 s

**119. (a)** Let $x_1 = A\sin(\omega t + \phi_1)$ and $x_2 = A\sin(\omega t + \phi_2)$

$x_2 - x_1 = A[\sin(\omega t + \phi_2) - \sin(\omega t - \phi_1)]$

$$= 2A\cos\left(\frac{2\omega t + \phi_1 + \phi_2}{1}\right)\sin\left(\frac{\phi_2 - \phi_1}{2}\right)$$

The resultant motion can be treated as a simple harmonic motion with amplitude $2A\sin\left(\frac{\phi_2 - \phi_1}{2}\right)$.

Given, maximum distance between the particles

$\therefore$ Amplitude of resultant S.H.M.

$= X_0 + A - X_0 = A$

$\therefore \quad 2A\sin\left(\frac{\phi_2 - \phi_1}{2}\right) = A.$

$\Rightarrow \quad \phi_2 - \phi_1 = \pi/3.$

**120. (b)** Equation of S.H.M. is given by

$x = A\sin(\omega t + \delta)$

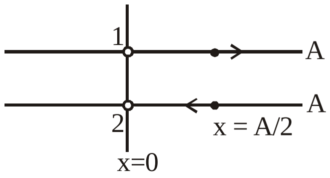
$(\omega t + \delta)$ is called phase.

When $x = \frac{A}{2}$, then

$\sin(\omega t + \delta) = \frac{1}{2}$

$\Rightarrow \omega t + \delta = \frac{\pi}{6}$

or $\phi_1 = \frac{\pi}{6}$



For second particle,

$\phi_2 = \pi - \frac{\pi}{6} = \frac{5\pi}{6}$

$\therefore \phi = \phi_2 - \phi_1 = \frac{4\pi}{6} = \frac{2\pi}{3}$

**121. (c)** Given, $x = 10\sin\left(2t - \frac{\pi}{6}\right)$

A = 10 and ω = 2 Hz

$\therefore \upsilon = \omega\sqrt{A^2 - d^2} = 2\sqrt{(10)^2 - (6)^2}$

$= 2\sqrt{100 - 36} = 2 \times 8 = 16 \text{m s}^{-1}$

**122. (a)** Maximum velocity,

$v_{max} = a\omega$

$v_{max} = a \times \frac{2\pi}{T}$

$\Rightarrow T = \frac{2\pi a}{v_{max}} = \frac{2 \times 3.14 \times 7 \times 10^{-3}}{4.4} \approx 0.01 \text{ s}$

**123. (b)** $v_1 = \frac{dy_1}{dt} = 0.1 \times 100\pi\cos\left(100\pi t + \frac{\pi}{3}\right)$

$v_2 = \frac{dy_2}{dt} = -0.1\pi\sin\pi t = 0.1\pi\cos\left(\pi t + \frac{\pi}{2}\right)$

$\therefore$ Phase diff. $= \phi_1 - \phi_2 = \frac{\pi}{3} - \frac{\pi}{2} = \frac{2\pi - 3\pi}{6} = -\frac{\pi}{6}$

**124. (b)** Using $v^2 = \omega^2(a^2 - y^2)$ we have

$10^2 = \omega^2(a^2 - 4^2)$ and $8^2 = \omega^2(a^2 - 5^2)$ ;

so $10^2 - 8^2 = \omega^2(5^2 - 4^2) = (3\omega^2)$ or $6 = 3\ \omega$ or $\omega = 2$

or $T = 2\ \pi/\omega = 2\ \pi/2 = \pi$ s.

**125. (a)** Here,

$x = x_0 \cos(\omega t - \pi/4)$

∴ Velocity,

$$v = \frac{dx}{dt} = -x_0\omega\sin\left(\omega t - \frac{\pi}{4}\right)$$

Acceleration,

$$a = \frac{dv}{dt} = -x_0\omega^2\cos\left(\omega t - \frac{\pi}{4}\right)$$

$$= x_0\omega^2\cos\left[\pi + \left(\omega t - \frac{\pi}{4}\right)\right]$$

$= x_0\,\omega^2$

$\cos\left(\omega t + \frac{3\pi}{4}\right)$ ...(1)

Acceleration, $a = A\cos(\omega t + \delta)$ ...(2)

Comparing the two equations, we get

$A = x_0\omega^2$ and $\delta = \frac{3\pi}{4}$

**126. (a)** K.E. of a body undergoing S.H.M. is given by

$$\text{K.E.} = \frac{1}{2}ma^2\omega^2\cos^2\omega t$$

$$\text{T.E.} = \frac{1}{2}ma^2\omega^2$$

Given K.E. = 0.75 T.E.

$$\Rightarrow 0.75 = \cos^2\omega t \Rightarrow \omega t = \frac{\pi}{6}$$

$$\Rightarrow t = \frac{\pi}{6\times\omega} \Rightarrow t = \frac{\pi\times 2}{6\times 2\pi} \Rightarrow t = \frac{1}{6}\text{ s}$$

**127. (b)** The kinetic energy of a particle executing S.H.M. is given by

$$K = \frac{1}{2}ma^2\omega^2\sin^2\omega t$$

where, m = mass of particle
a = amplitude
ω = angular frequency
t = time

Now, average K.E. = < K >

$$= <\frac{1}{2}m\omega^2a^2\sin^2\omega t>$$

$$= \frac{1}{2}m\omega^2a^2<\sin^2\omega t>$$

$$= \frac{1}{2}m\omega^2a^2\left(\frac{1}{2}\right) \quad \left(\because <\sin^2\theta> = \frac{1}{2}\right)$$

$$= \frac{1}{4}m\omega^2a^2$$

$$= \frac{1}{4}ma^2(2\pi\nu)^2 \quad (\because \omega = 2\pi\nu)$$

or, $<K> = \pi^2ma^2\nu^2$

**128. (a)** As we know,

$$\text{kinetic energy} = \frac{1}{2}m\omega^2(A^2 - x^2)$$

$$\text{Potential energy} = \frac{1}{2}m\omega^2x^2$$

$$\therefore \frac{\frac{1}{2}m\omega^2(A^2 - x^2)}{\frac{1}{2}m\omega^2x^2} = \frac{1}{4} \Rightarrow \frac{A^2 - x^2}{x^2} = \frac{1}{4}$$

$$4A^2 - 4x^2 = x^2 \qquad \Rightarrow x^2 = \frac{4}{5}A^2$$

$$x = \frac{2}{\sqrt{5}}A.$$

**129. (d)** Here, $m = 4$ kg; $k = 800$ Nm$^{-1}$; $E = 4$ J

In SHM, $E = \frac{1}{2}kA^2$

$$\therefore 4 = \frac{1}{2}\times 800\times A^2$$

$$A^2 = \frac{8}{800} = \frac{1}{100}, A = 0.1\text{ m}$$

Maximum acceleration, $a_{max} = \omega^2 A$

$$= \frac{k}{m}A \quad \left(\because \omega = \sqrt{\frac{k}{m}}\right)$$

$$= \frac{800\,\text{Nm}^{-1}}{4\,\text{kg}}\times 0.1\text{ m} = 20\,\text{ms}^{-2}$$

**130. (d)** $T = 2\pi\sqrt{\frac{m}{K}} \qquad \therefore \frac{T_1}{T_2} = \sqrt{\frac{M_1}{M_2}}$

$$\therefore \quad T_2 = T_1\sqrt{\frac{M_2}{M_1}} = T_1\sqrt{\frac{2M}{M}}$$

$T_2 = T_1\sqrt{2} = \sqrt{2}\,T$ (where $T_1 = T$)

**131. (b)** $t_1 = 2\pi\sqrt{\frac{m}{k_1}}, t_2 = 2\pi\sqrt{\frac{m}{k_2}}$

when springs are in series then, $k_{eff} = \frac{k_1k_2}{k_1 + k_2}$

$$\therefore T = 2\pi\sqrt{\frac{m(k_1 + k_2)}{k_1k_2}}$$

$$\therefore T = 2\pi\sqrt{\frac{m}{k_2} + \frac{m}{k_1}} = 2\pi\sqrt{\frac{t_2^2}{(2\pi)^2} + \frac{t_1^2}{(2\pi)^2}}$$

$$\Rightarrow T^2 = t_1^2 + t_2^2$$

**132. (b)** Here, $x = 2 \times 10^{-2} \cos \pi t$

Speed is given by

$$v = \frac{dx}{dt} = -2 \times 10^{-2}\ \pi \sin \pi t$$

For the first time, the speed to be maximum,

$\sin \pi t = 1$

or, $\sin \pi t = \sin \frac{\pi}{2}$

$$\Rightarrow \quad \pi t = \frac{\pi}{2} \quad \text{or} \quad t = \frac{1}{2} = 0.5 \text{ sec.}$$

**133. (b)** The two displacements equations are $y_1 = a \sin(\omega t)$

and $y_2 = b \cos(\omega t) = b \sin\left(\omega t + \frac{\pi}{2}\right)$

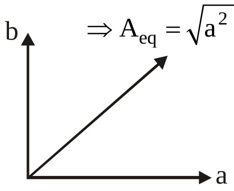
$$y_{eq} = y_1 + y_2$$

$$= a \sin\omega t + b \cos\omega t = a \sin\omega t + b \sin\left(\omega t + \frac{\pi}{2}\right)$$

Since the frequencies for both SHMs are same, resultant motion will be SHM.

$$\text{Now } A_{eq} = \sqrt{a^2 + b^2 + 2ab \cos \frac{\pi}{2}}$$

$$\Rightarrow A_{eq} = \sqrt{a^2 + b^2}$$



**134. (d)** Initially $t = 0$

$x = a \cos \pi t = -a \cos 0° = a$

Finally at $t = 3$

$x = a \cos 3\pi = -3a$

Total displacement = 2a

**135. (a)** As we know, for particle undergoing SHM,

$$V = \omega\sqrt{A^2 - X^2}$$

$$V_1^2 = \omega^2 (A^2 - x_1^2)$$

$$V_2^2 = \omega^2 (A^2 - x_2^2)$$

Substructing we get,

$$\frac{V_1^2}{\omega^2} + x_1^2 = \frac{V_2^2}{\omega^2} + x_2^2$$

$$\Rightarrow \frac{V_1^2 - V_2^2}{\omega^2} = x_2^2 - x_1^2$$

$$\Rightarrow w = \sqrt{\frac{V_1^2 - V_2^2}{x_2^2 - x_1^2}}$$

$$\Rightarrow T = 2\pi \sqrt{\frac{x_2^2 - x_1^2}{V_1^2 - V_2^2}}$$

**136. (a)** The differential equation of simple harmonic motion is

$$\frac{d^2y}{dt^2} + 2y = 0 \text{ or } \frac{d^2y}{dt^2} = -2y \qquad ...(i)$$

Standard equation of simple harmonic motion is

$$\frac{d^2y}{dt^2} = -\omega^2 y \qquad ...(ii)$$

Comparing eq. (i) and (ii),

$\omega^2 = 2$ or $\omega = \sqrt{2}$

As we know, $\omega = \frac{2\pi}{T}$

$$\therefore \text{ Time period, } T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{2}} = \pi\sqrt{2}s$$

**137. (b)** In SHM, Total energy, $E_{total} = \frac{1}{2} m\omega^2 A^2$

and, Kinetic energy, $E_K = \frac{1}{2} m\omega^2 (A^2 - x^2)$

where $x$ is the distance from the mean position.

At $x = 0.707A$

$$E_K = \frac{1}{2} m\omega^2 (A^2 - (0.707A^2) = \frac{1}{2} m\omega^2 (0.5A^2)$$

As per question, $E_{total}$ = 100 J

$$\therefore E_K = 0.5\left(\frac{1}{2} m\omega^2 A^2\right) = 0.5 \times 100J = 50J$$

**138. (d)** In simple harmonic motion, starting from rest,

At $t = 0$, $x = A$

$x = A\cos\omega t$ ..... (i)

When $t = \tau$, $x = A - a$

When $t = 2\tau$, $x = A - 3a$

From equation (i)

$A - a = A\cos\omega\tau$ ......(ii)

$A - 3a = A\cos 2\omega\tau$ ......(iii)

As $\cos 2\omega\tau = 2\cos^2 \omega\tau - 1$ ...(iv)

From equation (ii), (iii) and (iv)

$$\frac{A - 3a}{A} = 2\left(\frac{A - a}{A}\right)^2 - 1$$

$$\Rightarrow \frac{A - 3a}{A} = \frac{2A^2 + 2a^2 - 4Aa - A^2}{A^2}$$

$\Rightarrow A^2 - 3aA = A^2 + 2a^2 - 4Aa$

$\Rightarrow 2a^2 = aA$

$\Rightarrow A = 2a$

$$\Rightarrow \frac{a}{A} = \frac{1}{2}$$

Now, $A - a = A\cos\omega\tau$

$$\Rightarrow \cos\omega\tau = \frac{A - a}{A}$$

$$\Rightarrow \quad \cos\omega\tau = \frac{1}{2} \quad \text{or} \quad \frac{2\pi}{T}\tau = \frac{\pi}{3}$$

$$\Rightarrow \quad T = 6\tau$$

**139. (c)** As, we know, in SHM

Maximum acceleration of the particle, $\alpha = A\omega^2$

Maximum velocity, $\beta = A\omega$

$$\Rightarrow \omega = \frac{\alpha}{\beta}$$

$$\Rightarrow T = \frac{2\pi}{\omega} = \frac{2\pi\beta}{\alpha} \qquad \left[\because \omega = \frac{2\pi}{T}\right]$$

**140. (c)** Given, $x = \frac{A}{2}$

$\therefore$ from $x = A \sin \omega t$

$\Rightarrow \omega t = 30°$

$$\text{And, } \frac{KE}{PE} = \cot^2 \omega t = \left(\sqrt{3}\right)^2$$

$$= 3$$

**141. (c)** Given $t = 1$s

$$\therefore x = 5\cos\left(2\pi + \frac{\pi}{4}\right)$$

$$= 5\cos\frac{\pi}{4} = \frac{5}{\sqrt{2}} \text{ m}$$

i.e., displacement at $t = 1$s is $\frac{5}{\sqrt{2}}$ m

**142. (d)** $T = 2\pi\sqrt{\frac{\ell}{g}}$

$$\log T = \log(2\pi) + \frac{1}{2}\log\left(\frac{\ell}{g}\right)$$

$$\Rightarrow \quad \log T = \log(2\pi) + \frac{1}{2}\log(\ell) - \frac{1}{2}\log(g)$$

$$\text{Differentiating, } \frac{\Delta T}{T} = 0 + \frac{1}{2} \times \frac{\Delta\ell}{\ell} - 0$$

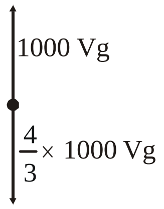
$$\Rightarrow \quad \frac{\Delta T}{T} \times 100 = \frac{1}{2} \times \frac{\Delta\ell}{\ell} \times 100$$

$$= \frac{1}{2} \times 21 = 10.5 \approx 10\%$$

***Note:*** In this method, the % error obtained is an approximate value on the higher side. Exact value is less than the obtained one.

**143. (a)** $t = 2\pi\sqrt{\frac{\ell}{g_{eff}}}$ ; $t_0 = 2\pi\sqrt{\frac{\ell}{g}}$

Bob in air



Bob in water

$$\text{Net force} = \left(\frac{4}{3} - 1\right) \times 1000 \text{ Vg} = \frac{1000}{3}\text{Vg}$$

$$g_{eff} = \frac{1000\text{Vg}}{3 \times \frac{4}{3} \times 1000\text{V}} = \frac{g}{4} \left[\text{Mass} = \frac{4}{3} \times 1000 \times \text{V}\right]$$

$$\therefore t = 2\pi\sqrt{\frac{\ell}{g/4}}$$

$$\therefore \quad t = 2t_0$$

**144. (d)** For damped harmonic motion,

$$ma = -kx - mbv$$

or $\quad ma + mbv + kx = 0$

Solution to above equation is

$$x = A_0 e^{-\frac{bt}{2}} \sin\omega t; \text{ with } \omega^2 = \frac{k}{m} - \frac{b^2}{4}$$

where amplitude drops exponentially with time

i.e., $\quad A_\tau = A_0 e^{-\frac{b\tau}{2}}$

Average time $\tau$ is that duration when amplitude drops by 63%, i.e., becomes $A_0/e$.

Thus, $\quad A_\tau = \frac{A_0}{e} = A_0 e^{-\frac{b\tau}{2}}$

or $\quad \frac{b\tau}{2} = 1$ or $\tau = \frac{2}{b}$

**145. (c)** $(n+1)T_S = nT_L$

$$(n+1)\sqrt{1} = n\sqrt{1.44}$$

$$\Rightarrow (n+1) = 1.2n \Rightarrow n = \frac{1}{0.2} = 5$$

**146. (b)**

**147. (d)** $F = -bV$, $b$ depends on all the three i.e, shape and size of he block and viscosity of the medium.

**148. (c)** $\because A = A_0 e^{-\frac{bt}{2m}}$ (where, $A_0$ = maximum amplitude)

According to the questions, after 5 seconds,

$$0.9A_0 = A_0 e^{-\frac{b(5)}{2m}} \qquad \ldots(i)$$

After 10 more seconds,

$$A = A_0 e^{-\frac{b(15)}{2m}} \quad \ldots\text{(ii)}$$

From equations (i) and (ii)

$A = 0.729 A_0$

$\therefore \ \alpha = 0.729$

**149. (b)** Amplitude of a damped oscillator at any instant $t$ is given by

$A = A_0 e^{-bt/2m}$

where $A_0$ is the original amplitude

From question,

When t = 2 s, $A = \dfrac{A_0}{3}$

$$\therefore \ \frac{A_0}{3} = A_0 e^{-2b/2m}$$

$$\text{or, } \frac{1}{3} = e^{-b/m} \quad \ldots\text{(i)}$$

When t = 6 s, $A = \dfrac{A_0}{n}$

$$\therefore \ \frac{A_0}{n} = A_0 e^{-6b/2m}$$

$$\text{or, } \frac{1}{n} = e^{-3b/m} = (e^{-b/m})^3$$

$$\text{or, } \frac{1}{n} = \left(\frac{1}{3}\right)^3 \quad \text{(Using eq. (i))}$$

$\therefore n = 3^3$

**150. (a)** Force on a spring $F = k.x$

$$W = \frac{1}{2}kx^2 = \frac{F.x}{2} = \frac{F}{2}.\frac{F}{k} = \frac{F^2}{2k}$$

$$\text{Now, } \quad \frac{W_1}{W_2} = \frac{k_2}{k_1} = \frac{k_B}{k_A}$$

**151. (d)**

$$(n+1)T = \frac{5T}{4} \times n$$

$$n = 4$$

$$\text{Time } t = (n+1)\,T = 5T$$

**152. (c)** As we know, time period, $T = 2\pi\sqrt{\dfrac{\ell}{g}}$

When additional mass M is added then

$$T_M = 2\pi\sqrt{\frac{\ell + \Delta\ell}{g}}$$

$$\frac{T_M}{T} = \sqrt{\frac{\ell + \Delta\ell}{\ell}} \quad \text{or} \quad \left(\frac{T_M}{T}\right)^2 = \frac{\ell + \Delta\ell}{\ell}$$

$$\text{or, } \left(\frac{T_M}{T}\right)^2 = 1 + \frac{Mg}{Ay} \qquad \left[\because \Delta\ell = \frac{Mg\ell}{Ay}\right]$$

$$\therefore \ \frac{1}{y} = \left[\left(\frac{T_M}{T}\right)^2 - 1\right]\frac{A}{Mg}$$

**153. (b)** The time period of pendulam is given by

$$T = 2\pi\frac{l}{g}$$

Acceleration due to gravity of earth is

$$g_e = \frac{GM}{R_e^2}$$

Value of 'g' on planet is

$$g_p = \frac{GM_p}{R_p^2} = \frac{G.2M}{4R^2} = \frac{g_e}{2}$$

$$\therefore T_p = 2\pi\sqrt{\frac{l.2}{g_e}} = \sqrt{2}T$$

i.e. $T_p = 2\sqrt{2}$

**154.** (c) As we know,

$F = ma \Rightarrow a \propto F$

or, $a \propto \sin t$

$$\Rightarrow \ \frac{dv}{dt} \propto \sin t$$

$$\Rightarrow \ \int_0^0 dV \propto \int_0^t \sin t \ dt$$

$V \propto -\cos t + 1$

$$\int_0^x dx = \int_0^t (-\cos t + 1)\ dt$$

$$x = \sin t - \frac{1}{2}\sin 2t$$

**155.** (d) As we know, $E = E_0 e^{-\frac{bt}{m}}$

$$15 = 45e^{-\frac{b15}{m}}$$

[As no. of oscillations = 15 so $t$ = 15sec]

$$\frac{1}{3} = e^{-\frac{b15}{m}}$$

Taking log on both sides

$$\frac{b}{m} = \frac{1}{15}\ell n\, 3$$

**156.** (c) $h$ = Length of block immerged in water

$mg = F_B$

$\rho A l\, g = \rho_B A h g$

$650 \times A \times 54 \times 10^{-2} g = 900 \times A \times hg$

$\Rightarrow h = 0.39\ m = 39$ cm.

# CHAPTER 15

# WAVES

## FACT/DEFINITION TYPE QUESTIONS

**1.** Water waves produced by a motor boat sailing in water are
(a) only longitudinal
(b) only transverse
(c) both longitudinal and transverse
(d) neither longitudinal nor transverse

**2.** For which of the following do the longitudinal waves exist?
(a) Vacuum (b) Air
(c) Water (d) Both (b) and (c)

**3.** Which of the following is a transverse wave ?
(a) Wave produced in a cylinder containing a liquid by moving its position back and forth.
(b) Ultrasonic wave in air produced by a vibrating quartz crystal.
(c) Both (a) and (b)
(d) None of these

**4.** There is no transmission of energy in
(a) electromagnetic waves
(b) transverse progressive waves
(c) longitudinal progressive waves
(d) stationary waves

**5.** What type of vibrations are produced in a sitar wire ?
(a) Progressive transverse
(b) Progressive longitudinal
(c) Stationary transverse
(d) Stationary longitudinal

**6.** The waves associated with the moving particles are called
(a) mechanical waves (b) ultrasonic waves
(c) matter waves (d) shock waves

**7.** The property of a medium necessary for wave propagation is
(a) inertia (b) elasticity
(c) low resistance (d) All of the above

**8.** Which of the following phenomenon cannot be observed for sound waves?
(a) Refraction (b) interference
(c) diffraction (d) polarisation

**9.** Which one of the following statements is true?
(a) Both light and sound waves in air are transverse
(b) The sound waves in air are longitudinal while the light waves are transverse
(c) Both light and sound waves in air are longitudinal
(d) Both light and sound waves can travel in vacuum

**10.** With the propagation of a longitudinal wave through a material medium, the quantities transmitted in the propagation direction are
(a) energy, momentum and mass
(b) energy
(c) energy and mass
(d) energy and linear momentum

**11.** When a sound wave goes from one medium to another, the quantity that remains unchanged is
(a) frequency (b) amplitude
(c) wavelength (d) speed

**12.** Speed of a progressive wave is given by
(a) $v = n\lambda$ (b) $v = n/\lambda$
(c) $v = \lambda/n$ (d) $T/\lambda$

**13.** Sound travels in rocks in the form of
(a) longitudinal elastic waves only
(b) transverse elastic waves only
(c) both longitudinal and transverse elastic waves
(d) non-elastic waves

**14.** Sound waves are not transmitted to long distances because,
(a) they are absorbed by the atmosphere
(b) they have constant frequency
(c) the height of antenna required, should be very high
(d) velocity of sound waves is very less

**15.** For a sinusoidal wave represented by $y(x, t) = a \sin(kx - \omega t + \phi)$, for a given a, the factor determines the displacement of the wave of any position and at any instant is
(a) constant $k$ (b) angular velocity $\omega$
(c) time interval $t$ (d) phase $(kx - \omega t + \phi)$

**16.** Speed of mechanical wave is determined by
(a) inertial properties of the medium
(b) elastic properties of the medium
(c) Both (a) and (b)
(d) None of these

**17.** Speed of sound is maximum in
(a) solids
(b) liquids
(c) gases
(d) depends on the temperature of the medium

**18.** Where will a person hear the maximum sound ?
(a) At nodes
(b) At antinodes
(c) At harmonics
(d) Same at nodes and antinodes

**19.** Which of the following is true about the velocity of sound $V$ in a gaseous medium ?
(a) $V \propto \sqrt{\text{density of gas}}$
(b) $V \propto \dfrac{1}{\text{density of gas}}$
(c) $V \propto$ density of gas
(d) $V \propto \dfrac{1}{\sqrt{\text{density of gas}}}$

**20.** For which of the following waves, the speed depends on temperature ?
(a) Light
(b) Sound
(c) Both (a) and (b)
(d) None of these

**21.** The velocity of sound in a gas
(a) increases by 0.61 m/s when the temperature rises by 1° C
(b) decreases by 0.61 m/s when the temperature rises by 1° C
(c) depends upon the pressure of the gas
(d) depends upon the coefficient of the shearing of the gas

**22.** Ultrasonic, infrasonic and audible waves travel through a medium with speeds $v_{u,}$ $v_{i,}$ $v_a$ respectively, then
(a) $v_{u,}$ $v_{i,}$ $v_a$ are nearly equal
(b) $v_u \geq v_a \geq v_i$
(c) $v_u \leq v_a \leq v_i$
(d) $v_{a,} \leq v_u$ and $v_u \approx v_i$

**23.** The differential equation of a wave is
(a) $d^2y/dt^2 = v^2d^2y/dx^2$
(b) $d^2y/dx^2 = v^2d^2y/dt^2$
(c) $d^2y/dx^2 = \frac{1}{v}d^2y/dt^2$
(d) $d^2y/dx^2 = -v\,d^2y/dt^2$

**24.** Sound waves are travelling in a medium whose adiabatic elasticity is E and isothermal elasticity E'. The velocity of sound waves is proportional to
(a) E
(b) $\sqrt{E}$
(c) $\sqrt{E'}$
(d) $\dfrac{E}{E'}$

**25.** The speed of sound in a perfectly rigid rod is
(a) infinite
(b) zero
(c) 332 m/s
(d) $3 \times 10^8$ m/s

**26.** The ratio of the speed of a body to the speed of sound is called
(a) Mach number
(b) Doppler ratio
(c) sonic index
(d) refractive index

**27.** In the experiment to determine the speed of sound using a resonance column,
(a) prongs of the tuning fork are kept in a vertical plane
(b) prongs of the tuning fork are kept in a horizontal plane
(c) in one of the two resonances observed, the length of the resonating air column is close to the wavelength of sound in air
(d) in one of the two resonances observed, the length of the resonating air column is close to half of the wavelength of sound in air

**28.** The relation between velocity of sound in a gas (v) and r.m.s. velocity of molecules of gas ($v_{r.m.s.}$) is
(a) $v = v_{r.m.s.}(\gamma/3)^{1/2}$
(b) $v_{r.m.s.} = v(2/3)^{1/2}$
(c) $v = v_{r.m.s.}$
(d) $v = v_{r.m.s.}(3/\gamma)^{1/2}$

**29.** What is the effect of humidity on sound waves when humidity increases?
(a) Speed of sound waves is more
(b) Speed of sound waves is less
(c) Speed of sound waves remains same
(d) Speed of sound waves becomes zero

**30.** The bulk modulus of a liquid of density 8000 kg $m^{-3}$ is $2 \times 10^9$ N $m^{-2}$. The speed of sound in that liquid is (in m $s^{-1}$)
(a) 200
(b) 250
(c) 100
(d) 500

**31.** A wave travelling on a string is described by
$y(x, t) = 0.005 \sin(80.0x - 3.0t)$
The period of the wave is
(a) 3.00 s
(b) 2.09 s
(c) 0.48 s
(d) 0.05 s

**32.** The frequency of fundamental note is given by
(a) $v = \dfrac{1}{L}\sqrt{\dfrac{T}{m}}$
(b) $v = \dfrac{1}{L}\sqrt{\dfrac{2T}{m}}$
(c) $v = \dfrac{1}{2L}\sqrt{\dfrac{T}{m}}$
(d) $v = 2L\sqrt{\dfrac{T}{m}}$

**33.** The SI unit of propagation constant $k$ is
(a) rad $m^{-1}$
(b) m $rad^{-1}$
(c) rad m
(d) unitless

**34.** The intensity of harmonic wave
(a) depends upon its frequency and not on its amplitude
(b) depends upon its amplitude and not on its frequency
(c) depends upon both, its frequency and not on amplitude
(d) depends neither on frequency nor on its amplitude

**35.** Standing waves in a string are due to
(a) beats
(b) reflection of waves
(c) interference of waves
(d) Doppler's effect

**36.** Of the following, the equation of plane progressive wave is
(a) $y = r \sin \omega t$
(b) $y = r \sin(\omega t - kx)$
(c) $y = \dfrac{a}{\sqrt{r}} \sin(\omega t - kx)$
(d) $y = \dfrac{a}{r} \sin(\omega t - kr)$

**37.** In ordinary talk, the amplitude of vibration is approximately

(a) $10^{-12}$ m (b) $10^{-11}$ m

(c) $10^{-8}$ m (d) $10^{-7}$ m

**38.** Phon is unit of

(a) wavelength (b) loudness

(c) frequency (d) intensity

**39.** The equation of plane progressive wave motion is

$y = a\sin\frac{2\pi}{\lambda}(vt - x)$. Velocity of the particle is

(a) $y\frac{dv}{dx}$ (b) $v\frac{dy}{dx}$ (c) $-y\frac{dv}{dx}$ (d) $-v\frac{dy}{dx}$

**40.** The rate of transfer of energy in a wave depends

(a) directly on the square of the wave amplitude and square of the wave frequency

(b) directly on the square of the wave amplitude and root of the wave frequency

(c) directly on the wave amplitude and square of the wave frequency

(d) None of these

**41.** Two waves are said to be coherent, if they have

(a) same phase but different amplitude

(b) same frequency but different amplitude

(c) same frequency, phase & amplitude

(d) different frequency, phase and amplitude

**42.** If the intensities of two interfering waves be $I_1$ and $I_2$, the contrast between maximum and minimum intensity is maximum, when

(a) $I_1 >> I_2$ (b) $I_1 << I_2$

(c) $I_1 = I_2$ (d) either $I_1$ or $I_2$ is zero

**43.** When a wave is reflected from a denser medium, the change in phase is

(a) 0 (b) $\pi$

(c) $2\pi$ (d) $3\pi$

**44.** On reflection of a wave from a rarer medium, change in phase is

(a) zero (b) $\pi/2$

(c) $\pi$ (d) $3\pi/4$

**45.** A progressive wave $y = A\sin(kx - \omega t)$ is reflected by a rigid wall at $x = 0$. Then the reflected wave can be represented by

(a) $y = A\sin(kx + \omega t)$ (b) $y = A\cos(kx + \omega t)$

(c) $y = -A\sin(kx - \omega t)$ (d) $y = -A\sin(kx + \omega t)$

**46.** When temperature increases, the frequency of a tuning fork

(a) increases

(b) decreases

(c) remains same

(d) increases or decreases depending on the material

**47.** The equation $y = a\sin\frac{2\pi}{\lambda}(vt - x)$ is expression for

(a) stationary wave of single frequency along x-axis

(b) a simple harmonic motion

(c) a progressive wave of single frequency along x-axis

(d) the resultant of two SHMs of slightly different frequencies

**48.** Consider the three waves $z_1$, $z_2$ and $z_3$ as

$z_1 = A\sin(kx - \omega t)$

$z_2 = A\sin(kx + \omega t)$

$z_3 = A\sin(ky - \omega t)$

Which of the following represents a standing wave?

(a) $z_1 + z_2$ (b) $z_2 + z_3$

(c) $z_3 + z_1$ (d) $z_1 + z_2 + z_3$

**49.** Shock waves are produced by objects

(a) carrying electric charge and vibrating

(b) vibrating with frequency greater than 20000 Hz

(c) vibrating with very large amplitude

(d) moving with a speed greater than that of sound in the medium

**50.** A travelling wave reflected at an open boundary undergoes a phase change of

(a) $\pi$ (b) 0

(c) $\frac{\pi}{2}$ (d) $\frac{\pi}{3}$

**51.** Which of the following changes at an antinode in a stationary wave?

(a) Density only

(b) Pressure only

(c) Both pressure and density

(d) Neither pressure nor density

**52.** The notes of frequencies which are integral multiple of the fundamental frequencies are called

(a) beats (b) harmonics

(c) antinodes (d) tones

**53.** Beats is a phenomenon which arises from ......... of waves

(a) reflection (b) diffraction

(c) superposition (d) interference

**54.** The essential condition for the formation of beats is

(a) difference in frequencies of two sources should be $\geq 10$

(b) difference in frequencies of two sources should be $< 10$

(c) difference in frequencies of two sources should be $> 10$

(d) difference in frequencies of two sources should be $\leq 10$

**55.** Possible wavelength of stationary waves are constrained by the relation

(A) $\lambda = \frac{L}{n}$ (B) $\lambda = \frac{2L}{n}$

(C) $\lambda = \frac{L}{2n}$ (D) $\lambda = \frac{L}{3n}$

**56.** The pipe open at both ends will produce

(a) all the harmonics
(b) all the odd harmonics
(c) all the even harmonics
(d) None of the harmonics

**57.** Reverberation time does not depend upon

(a) temperature (b) volume of room
(c) size of window (d) carpet and curtain

**58.** The reason for introducing Laplace correction in the expression for the velocity of sound in a gaseous medium is

(a) no change in the temperature of the medium during the propagation of the sound through it
(b) no change in the heat of the medium during the propagation of the sound through it
(c) change in the pressure of the gas due to the compression and rarefaction
(d) change in the volume of the gas

**59.** On account of damping, the frequency of a vibrating body

(a) remains unaffected (b) increases
(c) decreases (d) changes erratically

**60.** Frequencies of sound produced from an organ pipe open at both ends are

(a) only fundamental note
(b) only even harmonics
(c) only odd harmonics
(d) even and odd harmonics

**61.** The tenth harmonic is set up in a pipe. The pipe is

(a) open pipe (b) close pipe
(c) any of them (d) none

**62.** Beats are the result of

(a) diffraction
(b) destructive interference
(c) constructive and destructive interference
(d) superposition of two waves of nearly equal frequency

**63.** Maximum number of beats frequency heard by a human being is

(a) 10 (b) 4
(c) 20 (d) 6

**64.** A closed organ pipe (closed at one end) is excited to support the third overtone. It is found that air in the pipe has

(a) three nodes and three antinodes
(b) three nodes and four antinodes
(c) four nodes and three antinodes
(d) four nodes and four antinodes

**65.** When two sound waves are superimposed, beats are produced when they have different

(a) amplitudes and phases
(b) velocities
(c) phases
(d) frequencies

**66.** Two sound waves of slightly different frequencies propagating in the same direction produce beats due to

(a) Interference (b) Diffraction
(c) Polarization (d) Refraction

**67.** For which of the following cases, there will be no Doppler effect ?

(a) If source and listener, both move in the same direction with same speed.
(b) If one of the source/listener is at the centre of a circle, while the other is moving on it.
(c) When both the source and listener are at rest.
(d) All of these

**68.** Doppler's effect in sound takes place when source and observer are

(a) stationary
(b) moving with same velocity
(c) in relative motion
(d) None of these

**69.** Doppler’s effect is not applicable for

(a) audio waves (b) electromagnetic waves
(c) shock waves (d) None of these

**70.** A train moving at a speed $v_s$ towards a stationary observer on a platform emits sound of frequency f and velocity v. Then the apparent frequency heard by him is

(a) $f\left(1+\frac{v}{v_s}\right)$ (b) $f\left(1-\frac{v_s}{v}\right)$

(c) $f\left(1+\frac{v_s}{v}\right)$ (d) $f\left(1-\frac{v}{v_s}\right)$

**71.** Doppler shift in frequency does not depend upon

(a) frequency of the wave produced
(b) velocity of the source
(c) velocity of the observer
(d) distance from the source to the listener

**72.** Doppler effect is applicable for

(a) moving bodies
(b) one is moving and other is stationary
(c) for relative motion
(d) None of these

**73.** Doppler phenomena is related with

(a) Pitch (Frequency) (b) Loudness
(c) Quality (d) Reflection

## STATEMENT TYPE QUESTIONS

**74.** Which of the following statements is/are correct about waves ?

I. Waves are patterns of disturbance which move without the actual physical transfer of flow of matter as a whole.
II. Waves cannot transport energy.
III. The pattern of disturbance in the form of waves carry information that propagate from one point to another.
IV. All our communications essentially depend on transmission of signals through waves.

(a) I and III (b) Only IV
(c) I, II and III (d) I, III and IV

**75.** A pebble is dropped in a pond of a still in water disturb the water surface.

Which of the given statements are correct for the above situation ?

I. The disturbance produced does not remain confined to one place but propagates outward along a circle.
II. If a cork piece is put on the disturbed surface, it moves along with the disturbance in the same direction.
III. The water mass does not flow outward with the circles formed but rather a moving disturbance is created.

(a) I and III (b) II and III
(c) I and II (d) I, II and III

**76.** Consider the following statements and select the correct option.

I. Mechanical wave can travel without a medium
II. When a wave motion passes through a medium particle of medium only vibrate simple harmonically about their mean position
III. There is no phase difference amongst successive particles of the medium.

(a) I only (b) II only
(c) I and III (d) II and III

**77.** Consider the following statements and select the incorrect statement(s) from the following.

I. Mechanical waves transfer energy and matter both from one point to another.
II. Mechanical waves transfer only energy from one point to another.
III. Mechanical waves transfer only matter from one point to another.

(a) I only (b) II only
(c) I and III (d) I, II and III

**78.** Which of the following statements are correct ?

I. A steel bar possesses both bulk and shear elastic moduli.
II. A steel bar propagate both longitudinal as well as transverse waves having different speeds.
III. Air can propagate both longitudinal and transverse wave.

(a) I and III (b) II and III
(c) I, and II (d) I, II and III

**79.** Choose the false statement(s) about speed of transverse waves on a stretched string.

I. It depends on linear mass density of the string
II. It depends on the tension in the string
III. It depends on the frequency of the wave

(a) I only (b) II only
(c) III only (d) I, II and III

**80.** Which of the following statements is/are correct about the standing wave?

I. In a standing wave the disturbance produce is confined to the region where it is produced.
II. In a standing wave, all the particles cross their mean position together.
III. In a standing wave, energy is transmitted from one region of space to other.

(a) I and II (b) Only II
(c) Only III (d) I, II and III

**81.** Which of the following statements related to organ pipe is/are correct ?

I. In a closed organ pipe closed at one end longitudinal standing waves are present.
II. In a closed organ pipe only odd harmonics are present.
III. The harmonics which are present in a pipe, open at both ends are odd harmonics only.

(a) Only I (b) II and III
(c) I and II (d) I, II and III

**82.** Choose the false statement(s) from the following.

I. Change in frequency due to Doppler effect will be positive if the distance between source and listener increases.
II. Change in frequency due to Doppler effect will be negative if the distance between source and listener

(a) I only (b) II only
(c) I and II (d) None of these

## MATCHING TYPE QUESTIONS

**83.** Match the Columns I and II.

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | A region of low pressure and low density | (1) | Particles oscillate at right angle |
| (B) | A region of high pressure and high density | (2) | Particles oscillate in the same direction |
| (C) | Longitudinal wave | (3) | Compression |
| (D) | Transverse wave | (4) | Rarefaction |

(a) $(A)\rightarrow(3)$ ; $(B)\rightarrow(4)$ ; $(C)\rightarrow(1)$ ; $(D)\rightarrow(2)$
(b) $(A)\rightarrow(1)$ ; $(B)\rightarrow(2)$ ; $(C)\rightarrow(3)$ ; $(D)\rightarrow(4)$
(c) $(A)\rightarrow(4)$ ; $(B)\rightarrow(3)$ ; $(C)\rightarrow(2)$ ; $(D)\rightarrow(1)$
(d) $(A)\rightarrow(3)$ ; $(B)\rightarrow(4)$ ; $(C)\rightarrow(2)$ ; $(D)\rightarrow(2)$

**84.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Mechanical waves | (1) | Disturbance for short time |
| (B) | Pulse | (2) | Independent of amplitude of vibrations |
| (C) | Velocity of sound in air | (3) | SONAR |
| (D) | Tracking of fish in ocean | (4) | Require a material medium |

(a) (A) → (3) ; (B) → (4) ; (C) → (1) ; (D) → (2)
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(c) (A)→ (4) ; (B) → (1) ; (C) → (2) ; (D) → (3)
(d) (A) → (3) ; (B) → (4) ; (C) → (2) ; (D) → (2)

**85.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | $y = 4\sin(5x - 4t) + 3\cos(4t - 5x + \pi/6)$ | (1) | Particles at every position are performing SHM |
| (B) | $y = 10\cos\left(t - \frac{x}{330}\right)\sin(100)\left(t - \frac{x}{330}\right)$ | (2) | Equation of travelling wave |
| (C) | $y = 10\sin(2\pi x - 120t) + 10\cos(120t + 2\pi x)$ | (3) | Equation of standing wave |
| (D) | $y = 10\sin(2\pi x - 120t) + 8\cos(118t - 59/30\pi x)$ | (4) | Equation of Beats |

(a) (A) → (3) ; (B) → (4) ; (C) → (1) ; (D) → (2)
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(c) (A)→ (4) ; (B) → (3) ; (C) → (1) ; (D) → (2)
(d) (A) → (1,2) ; (B) → (4) ; (C) → (1,3) ; (D) → (4)

**86.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Sound | (1) | Frequency |
| (B) | SONAR | (2) | Mechanical wave |
| (C) | Reflection of sound | (3) | Finding depth of the sea |
| (D) | Pitch | (4) | Echo |

(a) (A) → (3) ; (B) → (4) ; (C) → (1) ; (D) → (2)
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(c) (A)→ (4) ; (B) → (3) ; (C) → (1) ; (D) → (2)
(d) (A) → (2) ; (B) → (3) ; (C) → (4) ; (D) → (1)

**87.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Pitch | (1) | Waveform |
| (B) | Quality | (2) | Frequency |
| (C) | Loudness | (3) | Intensity |
| (D) | Nodes | (4) | Position of zero amplitude |

(a) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(b) (A) → (2) ; (B) → (1) ; (C) → (3) ; (D) → (4)
(c) (A)→ (3) ; (B) → (1) ; (C) → (4) ; (D) → (2)
(d) (A) → (3) ; (B) → (4) ; (C) → (1) ; (D) → (2)

**88.**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Change in apparent frequency due to the relative motion between source and listner | (1) | Beats |
| (B) | Intensity of sound varies with | (2) | Transverse Wave |
| (C) | Sound waves in air | (3) | Doppler's effect |
| (D) | Light waves | (4) | Longitudinal wave |

(a) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(b) (A) → (2) ; (B) → (3) ; (C) → (4) ; (D) → (1)
(c) (A)→ (3) ; (B) → (1) ; (C) → (4) ; (D) → (2)
(d) (A) → (3) ; (B) → (4) ; (C) → (1) ; (D) → (2)

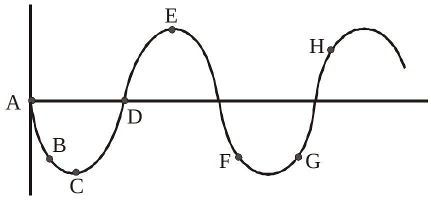
**89.** Source has frequency *f*. Source and observer both have same speed. For the apparent frequency observed by observer match the following.

| | Column-I | | Column-II |
|---|---|---|---|
| (A) | Observer is approaching the source but source is receding from the observer | (1) | More than *f* |
| (B) | Observer and source both approaching towards each other | (2) | Less than *f* |
| (C) | Observer and source both receding from each other | (3) | Equal to *f* |
| (D) | Source is approaching but observer is receding | (4) | Infinite |

(a) (A) → (3) ; (B) → (4) ; (C) → (1) ; (D) → (2)
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(c) (A)→ (4) ; (B) → (3) ; (C) → (1) ; (D) → (2)
(d) (A) → (3) ; (B) → (1) ; (C) → (2) ; (D) → (3)

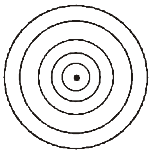
## DIAGRAM TYPE QUESTIONS

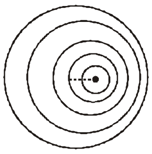
**90.** The diagram below shows the propagation of a wave. Which points are in same phase ?

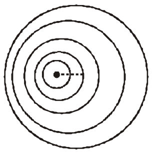


(a) *F* and *G*
(b) *C* and *E*
(c) *B* and *G*
(d) *B* and *F*

**91.** If the source is moving towards right, wave front of sound waves get modified to

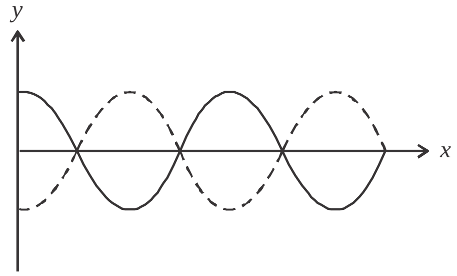
(a) 

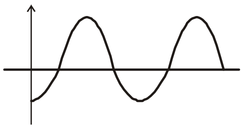
(b) 

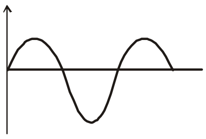
(c) 

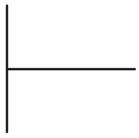
(d) None of these

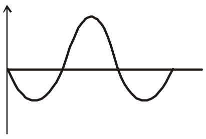
**92.** For the graph given, the resultant wave will be



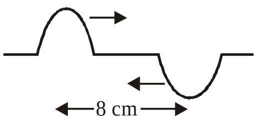
(a) 

(b) 

(c) 

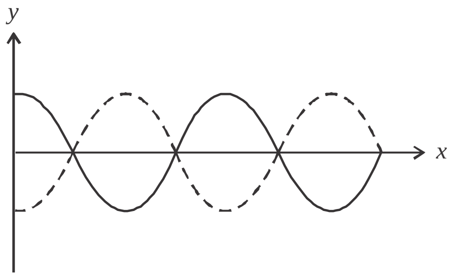
(d) 

**93.** Two pulses in a stretched string whose centres are initially 8 cm apart are moving towards each other as shown in the figure. The speed of each pulse is 2 cm/s. After 2 s, the total energy of the pulses will be



(a) Zero
(b) Purely kinetic
(c) Purely potential
(d) Partly kinetic and partly potential

**94.** For the graph given below for superposition of two waves, which of the following holds true ?



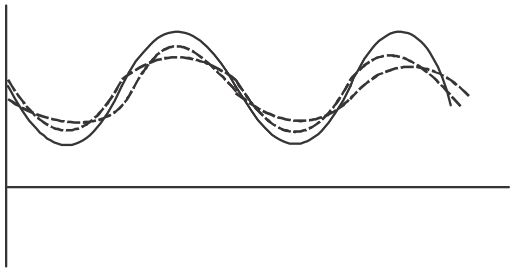
(a) Phase difference, $\phi = 0$

(b) Phase difference, $\phi = \frac{\pi}{2}$

(c) Phase difference, $\phi = \pi$

(d) Phase difference, $\phi = 2\pi$

**95.** The wave curves shown below represent:

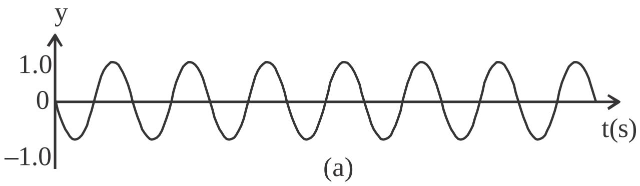


(a) Progressive wave formed from superposition of two harmonic waves travelling in same directions.
(b) Progressive waves formed from superposition of two harmonic waves travelling in opposite directions.
(c) Stationary wave formed from superposition of two harmonic waves travelling in same directions.
(d) Stationary wave formed from superposition of two harmonic waves travelling in opposite directions

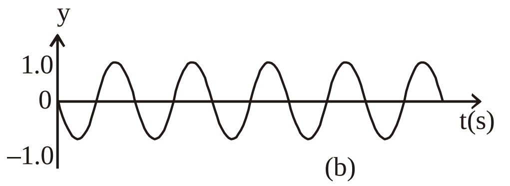
**96.** The fifth harmonic for vibrations of a stretched string is shown in figure. How many nodes are present here?

(a) 4 (b) 6
(c) 5 (d) 10

**97.** What will be the frequency of beats formed from the superposition of two harmonic waves shown below?



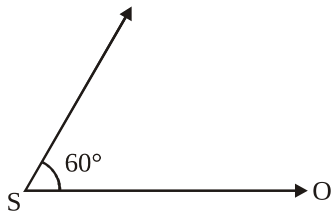
(a)



(b)

(a) 20 Hz (b) 11 Hz
(c) 9 Hz (d) 2 Hz

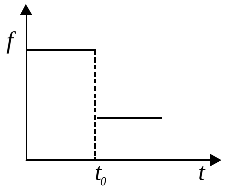
**98.** A source of sound S emitting waves of frequency 100 Hz and an observor O are located at some distance from each other. The source is moving with a speed of 19.4 ms$^{-1}$ at an angle of 60° with the source observer line as shown in the figure. The observor is at rest. The apparent frequency observed by the observer is (velocity of sound in air 330 ms$^{-1}$)



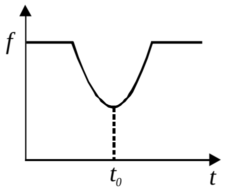
(a) 103 Hz (b) 106 Hz
(c) 97 Hz (d) 100 Hz

**99.** A man is standing on a railway platform listening to the whistle of an engine that passes the man at constant speed without stopping. If the engine passes the man at time $t_0$. How does the frequency $f$ of the whistle as heard by the man changes with time ?

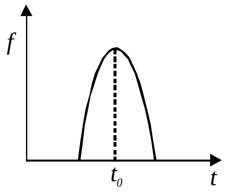
(a)



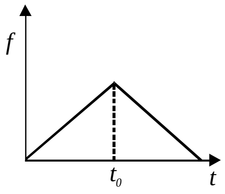
(b)



(c)



(d)



## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

**100.** **Assertion :** Compression and rarefaction involve changes in density and pressure.

**Reason :** When particles are compressed, density of medium increases and when they are rarefied, density of medium decreases.

**101.** **Assertion :** Solids can support both longitudinal and transverse waves but only longitudinal waves can propagate in gases.

**Reason :** For the propagation of transverse waves, medium must also necessarily have the property of rigidity.

**102.** **Assertion :** Sound wave is an example of longitudinal wave.

**Reason :** In longitudinal waves, the constituents of the medium oscillate perpendicular to the direction of wave propagation.

**103.** **Assertion :** Particle velocity and wave velocity both are independent of time.

**Reason :** For the propagation of wave motion, the medium must have the properties of elasticity and inertia.

**104.** **Assertion :** Waves on strings are always transverse.

**Reason :** It is because a string is non stretchable so compressions and rarefaction cannot be produced in string but strings have elasticity of shape, so waves on string are transverse.

**105.** **Assertion :** The change in air pressure affect the speed of sound.

**Reason :** The speed of sound in a gas is proportional to the square root of pressure.

**106.** **Assertion :** Two waves moving in a uniform string having uniform tension cannot have different velocities.

**Reason :** Elastic and inertial properties of string are same for all waves in same string. Moreover speed of wave in a string depends on its elastic and inertial properties only.

**107.** **Assertion :** A transverse waves are produced in a very long string fixed at one end. Only progressive wave is observed near the free end.

**Reason :** Energy of reflected wave does not reach the free end.

**108.** **Assertion:** Explosions on other planets are not heard on Earth.

**Reason:** Sound waves cannot travel to a far off distance

**109.** **Assertion:** Two astronauts can talk to each other on moon through microphone.

**Reason:** Microphone can convert their sound signals into transverse waves which can travel even in vacuum.

**110.** **Assertion :** The base of Laplace correction was that exchange of heat between the region of compression and rarefaction in air is negligible.

**Reason :** Air is bad conductor of heat and velocity of sound in air is quite large.

**111.** **Assertion :** Two longitudinal waves given by equations – $y_1(x, t) = 2a\sin(\omega t - kx)$ and $y_2(x, t) = a\sin(2\omega t - 2kx)$ will have equal intensity.

**Reason :** Intensity of waves of given frequency in same medium is proportional to square of amplitude only.

**112.** **Assertion :** Principle of superposition can be used for any physical quantity.

**Reason :** Principle of superposition can be used only when amplitude of quantity is small.

**113.** **Assertion :** It is not possible to have interference between the waves produced by two independent sources of same frequency.

**Reason :** For interference of two waves the phase difference between the waves remain constant.

**114.** **Assertion :** On reflection from a rigid boundary there takes place a complete reversal of phase.

**Reason:** On reflection from a denser medium, both the particle velocity and wave velocity are reversed in sign.

**115.** **Assertion :** Velocity of particles, while crossing mean position in case of stationary waves varies from maximum at antinodes to zero at nodes.

**Reason :** Amplitude of vibration at antinodes is maximum and at nodes, the amplitude is zero, and all particles between two successive nodes cross the mean position together.

**116.** **Assertion :** To hear distinct beats, difference in frequencies of two sources should not be greater than 10.

**Reason :** Persistance of human ear is 10 per second.

**117.** **Assertion :** In the case of a stationary wave, a person hear a loud sound at the nodes as compared to the antinodes.

**Reason :** In a stationary wave all the particles of the medium vibrate in phase.

**118.** **Assertion :** Sound produced by an open organ pipe is richer than the sound produced by a closed organ pipe.

**Reason :** Outside air can enter the pipe from both ends, in case of open organ pipe.

**119.** **Assertion :** The fundemental frequency of an open organ pipe increases as the temperature is increased.

**Reason :** As the temperature increses, the velocity of sound increases more rapidly than length of the pipe.

**120.** **Assertion:** Stringed instruments are provided with hollow boxes.

**Reason:** It increases the surface area of vibration which in turn increases the loudness of the sound.

**121.** **Assertion :** Speed of mechanical wave in the medium depends on the velocity of source, relative to an observer at rest.

**Reason :** Speed of mechanical wave is independent of the elastic and other properties such as mass density of the medium.

**122.** **Assertion :** Doppler formula for sound wave is symmetric with respect to the speed of source and speed of observer.

**Reason :** Motion of source with respect to stationary observer is not equivalent to the motion of an observer with respect to stationary source.

## CRITICAL THINKING TYPE QUESTIONS

**123.** Two waves are represented by the equations $y_1 = a\sin(\omega t + kx + 0.57)\,m$ and $y_2 = a\cos(\omega t + kx)\,m$, where $x$ is in meter and t in sec. The phase difference between them is

(a) 1.0 radian (b) 1.25 radian

(c) 1.57 radian (d) 0.57 radian

**124.** A transverse wave is represented by $y = A\sin(\omega t - kx)$. For what value of the wavelength is the wave velocity equal to the maximum particle velocity?

(a) $\frac{\pi A}{2}$ (b) $\pi A$

(c) $2\pi A$ (d) A

**125.** A balloon is filled with hydrogen. For sound waves, this balloon behaves like

(a) a converging lens (b) a diverging lens

(c) a concave mirror (d) Nothing can be said

**126.** A wave travelling in the +ve x-direction having displacement along y-direction as 1m, wavelength $2\pi$ m and frequency $\frac{1}{\pi}$ Hz is represented by

(a) $y = \sin(2\pi x - 2\pi t)$ (b) $y = \sin(10\pi x - 20\pi t)$

(c) $y = \sin(2\pi x + 2\pi t)$ (d) $y = \sin(x - 2t)$

**127.** The pressure variations in the propagation of sound waves in gaseous medium are

(a) adiabatic (b) isothermal

(c) isobaric (d) isochoric

**128.** The displacement y of a particle in a medium can be expressed as, $y = 10^{-6}\sin\left(100t + 20x + \frac{\pi}{4}\right)m$ where t is in second and x in meter. The speed of the wave is

(a) 20 m/s (b) 5 m/s

(c) 2000 m/s (d) $5\pi$ m/s

**129.** Velocity of sound waves in air is 330 m/s. For a particular sound wave in air, a path difference of 40 cm is equivalent to phase difference of $1.6\pi$. The frequency of this wave is

(a) 165 Hz (b) 150 Hz

(c) 660 Hz (d) 330 Hz

**130.** The equation of a wave on a string of linear mass density 0.04 kg $m^{-1}$ is given by

$$y = 0.02(m)\sin\left[2\pi\left(\frac{t}{0.04(s)} - \frac{x}{0.50(m)}\right)\right]$$

The tension in the string is

(a) 4.0 N (b) 12.5 N

(c) 0.5 N (d) 6.25 N

**131.** A sinusoidal travelling wave described by the equation $y(x, t) = a\sin(kx - \omega t + \phi)$. The value of displacement will

(a) vary 0 to $a$ (b) vary 0 to $-a$

(c) vary $-a$ to $a$ (d) None of these

**132.** The equation of a resultant wave obtained after superposition of two waves is given by $y(x, t) = 2a\sin kx\cos\omega t$. The position of nodes will be given by

(a) $\sin kx = -1$ (b) $\sin kx = 0$

(c) $\sin kx = 1$ (d) $\sin kx = \frac{n\pi}{2}$

**133.** A string is stretched between two fixed points separated by 75.0 cm. It is observed to have resonant frequencies of 420 Hz and 315 Hz. There are no other resonant frequencies between these two. The lowest resonant frequency for this string is :

(a) 205 Hz (b) 10.5 Hz

(c) 105 Hz (d) 155 Hz

**134.** Which of the following represents the equation of a spherical progressive wave ?

(a) $y = a\sin\omega t$ (b) $y = a\sin(\omega t - kr)$

(c) $y = \frac{a}{\sqrt{2}}\sin(\omega t - kr)$ (d) $y = \frac{a}{r}\sin(\omega t - kr)$

**135.** Two sound waves travel in the same direction in a medium. The amplitude of each wave is A and the phase difference between the two waves is 120°. The resultant amplitude will be

(a) $\sqrt{2}$A (b) 2A
(c) 3A (d) A

**136.** A sonometer wire supports a 4 kg load and vibrates in fundamental mode with a tuning fork of frequency 416 Hz. The length of the wire between the bridges is now doubled. In order to maintain fundamental mode, the load should be changed to

(a) 1 kg (b) 2 kg
(c) 4 kg (d) 16 kg

**137.** A sonometer wire of length 1.5 m is made of steel. The tension in it produces an elastic strain of 1%. What is the fundamental frequency of steel if density and elasticity of steel are $7.7 \times 10^3$ kg/m$^3$ and $2.2 \times 10^{11}$ N/m$^2$ respectively ?

(a) 188.5 Hz (b) 178.2 Hz
(c) 200.5 Hz (d) 770 Hz

**138.** If $n_1$, $n_2$ and $n_3$ are the fundamental frequencies of three segments into which a string is divided, then the original fundamental frequency n of the string is given by

(a) $\frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_3}$

(b) $\frac{1}{\sqrt{n}} = \frac{1}{\sqrt{n_1}} + \frac{1}{\sqrt{n_2}} + \frac{1}{\sqrt{n_3}}$

(c) $\sqrt{n} = \sqrt{n_1} + \sqrt{n_2} + \sqrt{n_3}$

(d) $n = n_1 + n_2 + n_3$

**139.** A cylindrical tube, open at both ends, has a fundamental frequency, *f*, in air. The tube is dipped vertically in water so that half of it is in water. The fundamental frequency of the air-column is now

(a) $f$ (b) $\frac{f}{2}$
(c) $\frac{3f}{4}$ (d) $2f$

**140.** Tube *A* has both ends open while tube *B* has one end closed, otherwise they are identical. The ratio of fundamental frequency of tube *A* and *B* is

(a) 1 : 2 (b) 1 : 4
(c) 2 : 1 (d) 4 : 1

**141.** An organ pipe $P_1$ closed at one end vibrating in its first overtone and another pipe $P_2$ open at both ends vibrating in third overtone are in resonance with a given tuning fork. The ratio of the length of $P_1$ to that of $P_2$ is

(a) 8/3 (b) 3/8
(c) 1/2 (d) 1/3

**142.** The number of possible natural oscillation of air column in a pipe closed at one end of length 85 cm whose frequencies lie below 1250 Hz are : (velocity of sound = 340 ms$^{-1}$)

(a) 4 (b) 5
(c) 7 (d) 6

**143.** The fundamental frequency of a closed organ pipe of length 20 cm is equal to the second overtone of an organ pipe open at both the ends. The length of organ pipe open at both the ends is

(a) 100 cm (b) 120 cm
(c) 140 cm (d) 80 cm

**144.** Two identical piano wires kept under the same tension T have a fundamental frequency of 600 Hz. The fractional increase in the tension of one of the wires which will lead to occurrence of 6 beats/s when both the wires oscillate together would be

(a) 0.02 (b) 0.03
(c) 0.04 (d) 0.01

**145.** Two vibrating tuning forks produce progressive waves given by $Y_1 = 4 \sin 500 \pi t$ and $Y_2 = 2 \sin 506 \pi t$. Number of beats produced per minute is

(a) 360 (b) 180
(c) 60 (d) 3

**146.** A tuning fork of frequency 512 Hz makes 4 beats per second with the vibrating string of a piano. The beat frequency decreases to 2 beats per sec when the tension in the piano string is slightly increased. The frequency of the piano string before increasing the tension was

(a) 510 *Hz* (b) 514 *Hz*
(c) 516 *Hz* (d) 508 *Hz*

**147.** The velocity of a moving galaxy is 300 km s$^{-1}$ and the apparent change in wavelength of a spectral line emitted from the galaxy is observed as 0.5 nm. Then, the actual wavelength of the spectral line is

(a) 3000 Å (b) 5000 Å
(c) 6000 Å (d) 4500 Å

**148.** Two sources of sound placed close to each other are emitting progressive waves given by $y_1 = 4 \sin 600 \pi t$ and $y_2 = 5 \sin 608 \pi t$. An observer located near these two sources of sound will hear

(a) 4 beats per second with intensity ratio 25 : 16 between waxing and waning.
(b) 8 beats per second with intensity ratio 25 : 16 between waxing and waning
(c) 8 beats per second with intensity ratio 81 : 1 between waxing and waning
(d) 4 beats per second with intensity ratio 81 : 1 between waxing and waning

**149.** Length of a sonometer wire between two fixed ends is 110 cm. If the fundamental frequencies are in the ratio of 1 : 2 : 3, then what is the ratio of lengths of these segments of the wire ?

(a) 3 : 2 : 1 (b) 6 : 3 : 2
(c) 6 : 2 : 3 (d) 2 : 3 : 6

**150.** A source of sound is moving with a uniform speed along a circle. The frequency of sound as heard by listener stationed at the centre of the path

(a) increases
(b) decreases
(c) remains the same
(d) may increase and decrease alternately

**151.** If we study the vibration of a pipe open at both ends, then which of the following statements is not true ?

(a) Odd harmonics of the fundamental frequency will be generated
(b) All harmonics of the fundamental frequency will be generated
(c) Pressure change will be maximum at both ends
(d) Antinode will be at open end

**152.** If wind blows from a stationary sounding object to a stationary listener, then the apparent frequency n' and actual frequency n are related as

(a) $n' \geq n$  (b) n' < n
(c) n' = n  (d) n' > n

**153.** A source of unknown frequency gives 4 beats/s, when sounded with a source of known frequency 250 Hz. The second harmonic of the source of unknown frequency gives five beats per second, when sounded with a source of frequency 513 Hz. The unknown frequency is

(a) 246 Hz  (b) 240 Hz
(c) 260 Hz  (d) 254 Hz

**154.** A car is moving towards a high cliff. The car driver sounds a horn of frequency *f*. The reflected sound heard by the driver has as frequency 2*f*. If v be the velocity of sound, then the velocity of the car, in the same velocity units, will be

(a) v /2  (b) $v/\sqrt{2}$
(c) v /3  (d) v /4

**155.** A speeding motorcyclist sees trafic jam ahead of him. He slows down to 36 km/hour. He finds that traffic has eased and a car moving ahead of him at 18 km/hour is honking at a frequency of 1392 Hz. If the speeds of sound is 343 m/s, the frequency of the honk as heard by him will be

(a) 1332 Hz  (b) 1372 Hz
(c) 1412 Hz  (d) 1464 Hz

**156.** A train moving at a speed of 220 $ms^{-1}$ towards a stationary object, emits a sound of frequency 1000 Hz. Some of the sound reaching the object gets reflected back to the train as echo. The frequency of the echo as detected by the driver of the train is (speed of sound in air is 330 $ms^{-1}$)

(a) 3500 Hz  (b) 4000 Hz
(c) 5000 Hz  (d) 3000 Hz

**157.** A whistle producing sound waves of frequencies 9500 HZ and above is approaching a stationary person with speed v$ms^{-1}$. The velocity of sound in air is 300 $ms^{-1}$. If the person can hear frequencies upto a maximum of 10,000 HZ, the maximum value of v upto which he can hear whistle is

(a) $15\sqrt{2}\ ms^{-1}$  (b) $\frac{15}{\sqrt{2}}\ ms^{-1}$
(c) $15\ ms^{-1}$  (d) $30\ ms^{-1}$

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(c)** Water waves are both longitudinal and transverse.

**2.** **(d)** Longitudinal waves like sound require material medium.

**3.** **(d)** Both are longitudinal waves not transverse waves.

**4.** **(d)** In a stationary wave, the wave only expand and shrink at their position without any forward or backward motion. Therefore, there is no transmission of energy in stationary waves.

**5.** **(c)** When vibrations are produced in a sitar wire the superposition takes place between incident and reflected wave from the rigid ends and a new wave is produced which appears stationary in the medium. This wave is called stationary wave and its nature is transverse.

**6.** **(c)** **7. (d)** **8. (d)**

**9.** **(b)** Sound waves in air are longitudinal while light waves are transverse. Sound waves require material medium to propagate but transverse waves do not require any material medium.

**10.** **(b)** With the propagation of a longitudinal wave, energy alone is propagated.

**11.** **(a)** Frequency of wave is a function of the source of waves. Therefore, it remains unchanged.

**12.** **(a)** speed, $v = n\lambda = \dfrac{\lambda}{T}$

**13.** **(c)** Sound can travel longitudinally as well as transversly in solids.

**14.** **(a)** Because they are absorbed by the atmosphere.

**15.** **(d)** **16. (c)**

**17.** **(a)** Speed of sound in decreasing order: Solids > liquid > gases

**18.** **(a)** Perception of sound is due to pressure variations which is maximum at nodes.

**19.** **(d)** Velocity of sound in gas $V_g = \sqrt{\dfrac{\gamma p}{\rho}}$

where $\rho$ is density of the gas.

**20.** **(b)** Sound waves are mechanical waves whose velocity $v = \sqrt{\gamma RT / M}$

Light are non-mechanical or electromagnetic for which speed $c = \dfrac{1}{\sqrt{\mu_0 \varepsilon_0}} = 3 \times 10^8$ m/s

**21.** **(a)** Velocity of sound at $t$°C is given by

$v_t = v_0 + 0.61t$

where $v_0$ is the velocity of sound at 0°C.

$\therefore \quad v_t - v_0 = 0.61t$

When temperature is increased by 1° C, then

$v_t - v_0 = 0.61$ m/s

Therefore, velocity of sound in a gas increases by 0.61 m/s when the temperature rises by 1°C.

**22.** **(b)** Speed of wave is given by

$$v = n\lambda$$

$\therefore$ Frequency of wave $n = \dfrac{v}{\lambda}$

Therefore, the frequency of wave varies directly with speed of wave.

Frequencies, $n_u \geq n_a \geq n_i$

Therefore speeds of waves

$v_u \geq v_a \geq v_i$

**23.** **(a)** The correct form of differential eqn. of a wave is

$$\frac{d^2y}{dt^2} = v^2 \frac{d^2y}{dx^2}$$

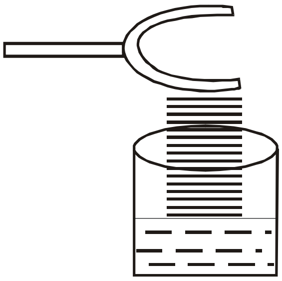
**24.** **(b)** $v = \sqrt{\dfrac{\gamma P}{\rho}} = \sqrt{\dfrac{E}{\rho}}$

**25.** **(a)** For a perfectly rigid rod, $\eta = \infty$

$\therefore \quad v = \sqrt{\eta / \rho} \rightarrow$ infinite

**26.** **(a)** $\dfrac{\text{speed of body}}{\text{speed of sound}} = \text{mach number}$

**27.** **(a)** As shown in the figure, the prongs of the tuning fork are kept in a vertical plane.



**28.** **(a)** Velocity of sound in a gas is

$v = \sqrt{\gamma P / \rho}$ and from $P = \dfrac{1}{3}\rho v_{\text{r.m.s.}}^2$

$v_{\text{r.m.s.}} = \sqrt{3P/\rho} \qquad \therefore \qquad \dfrac{v}{v_{\text{r.m.s.}}} = \sqrt{\dfrac{\gamma}{3}}$

**29.** **(a)** Velocity of sound $= \sqrt{\dfrac{\gamma RT}{M}}$

When water vapour are present in air, average molecular weight of air decreases and hence velocity increases.

**30.** **(d)** The speed of sound in liquid,

$$v = \sqrt{\frac{k}{\rho}} = \sqrt{\frac{2\times10^9}{8000}} = \sqrt{\frac{1}{4}\times10^6}$$

$$v = \frac{1}{2}\times10^3 = 500\text{m s}^{-1}.$$

**31.** **(b)** Time period, $T = \frac{2\pi}{\omega}$; from given eqn.

$\omega = 3.0\ s^{-1}$

or $T = \frac{2\pi}{3} = 2.09$ s

**32.** **(c)**

**33.** **(a)** $\lambda = \frac{2\pi}{k}$ or $k = \frac{2\pi\ (\text{rad})}{\lambda\ \ (m)}$

**34.** **(c)** The intensity of wave

$I = 2\pi^2a^2n^2\rho v$

$\therefore\ I \propto a^2 \propto n^2$

Therefore the intensity of a wave depends upon both, its frequency and amplitude.

**35.** **(c)** When two waves, one incident and other reflected wave, interfere with each other in the string than a new type of wave is produced, which appears stationary in the medium. This wave is called stationary or standing wave. Therefore, standing wave in a string are produced due to interference of waves.

**36.** **(b)** The position of such a wave changes in two dimensional plane with time.

**37.** **(c)** In ordinary talk, the amplitude of vibration is about $10^{-8}$ m

**38.** **(b)** Phon is the unit of loudness.

**39.** **(d)**

**40.** **(a)** The intensity of wave, $I = 2\pi^2 f^2 A^2 \rho v$, so $I \propto f^2$ and $I \propto A^2$.

**41.** **(c)** The waves, whose frequencies, phases and amplitudes are same at a given time or at a given place in space are known as coherent waves.

**42.** **(c)** The contrast will be maximum, when $I_1 = I_2$ i.e. a = b. In that event, $I_{min} = (a - b)^2 = 0$, where a and b are the amplitudes of interfering waves.

**43.** **(b)** On reflection at a denser medium, change of phase = π (radian)

**44.** **(a)** On reflection at a rarer medium, no change of phase occures

**45.** **(d)** $yz\,A\sin(kx - \omega t)$ for the wave progressing along the *x*-axis and for the reflected wave,

$y' = A\sin(kx + \omega t)$.

But the position of the rigid wall is at $x = 0$.

∴ For the given wave, its reflected wave

$y' = -A\sin(kx + \omega t)$.

**46.** **(b)**

**47.** **(c)** The equation of progressive wave propagating in the positive direction of X-axis is

$$y = a\sin\frac{2\pi}{\lambda}(vt - x)\text{ or}$$

$$y = a\sin(\omega t - kx)$$

**48.** **(a)** Standing waves are produced when two waves propagate in opposite direction

As $z_1$ & $z_2$ are propagating in +ve x-axis & –ve x-axis

so, $z_1 + z_2$ will represent a standing wave.

**49.** **(d)**

**50.** **(b)** In case of an open boundry :

Incident wave is $y_1 = a\sin(wt - kx)$

and reflected wave is $y_2 = a\sin(wt + kx)$

No phase change occurs,

**51.** **(d)** **52.** **(b)** **53.** **(d)** **54.** **(d)** **55.** **(b)**

**56.** **(a)** A pipe open at both ends produce all odd and even harmonics.

**57.** **(d)** The time for which sound continues to be heard after the source has stopped producing sound is called reverberation time. Sabine formula for reverberation time of a hall is

$$T = \frac{0.16V}{\Sigma as}$$

where *V* is volume of the hall in $m^3$ and $\Sigma as$ is total absorption. In particular, reverberation time of a hall is adjusted by providing a few open windows, covering the walls with absoring materials.

**58.** **(b)** According to Laplace when sound propagate in a gaseous medium the compressions and rarefactions are formed periodically at a very high speed. Some heat is produced at the places of compressions and some heat is lost at the places of rarefactions, but there is no transfer of heat between the compressions and rarefactions in the gaseous medium.

**59.** **(c)** Damping is caused by opposing force, which decreases the frequency.

**60.** **(d)**

**61.** **(a)** The even number of harmonics possible in open pipe.

**62.** **(d)**

**63.** **(a)** Persistence of hearing is $\frac{1}{10}$ s.

**64.** **(d)** Third overtone has a frequency 7 n, which means $L = \frac{7\lambda}{4}$ = three full loops + one half loop, which would make four nodes and four antinodes.

**65.** **(d)** For producing beats, their must be small difference in frequency.

**66.** **(a)** **67.** **(d)**

**68.** **(c)** These apparent change in frequency due to motion of source and observer relative to the medium along the line of sight is called Doppler's effect.

**69. (c)**

**70. (c)** The apparent frequency heard by the stationary observer

$$f' = f\left(\frac{v}{v - v_s}\right) = f\left(\frac{1}{1 - \frac{v_s}{v}}\right)$$

$$= f\left(1 - \frac{v_s}{v}\right)^{-1}$$

$$= f\left(1 + \frac{v_s}{v}\right) \text{ (By expanding binomially)}$$

**71. (d)** **72. (c)** **73. (a)**

## STATEMENT TYPE QUESTIONS

**74. (d)** Waves are kind of disturbances which moves from one place to another without the actual physical transfer of matter of the medium as a whole. The particles of the medium only oscillate but do not travel from one place to another.

Waves transport energy and the pattern of disturbance has information that propagate from one point to another. Here, wave pattern propagates.

All our communication essentially depend on transmission of signals through the waves.

**75. (a)** When a stone is dropped in a pond still water following observation/conclusion may deduced.

I. The disturbance produced propagates outwards from the point of disturbance along a circle-observation.

II. If a cork piece is put on the disturbed surface, it moves up and down, but do not move away from the centre of disturbance-observation.

III. Conclusion This shows that the water mass does not flow outward with the circle, but rather a moving disturbance is created.

**76. (b)**

**77. (b)** Mechanical waves only transfer energy from one point to another.

**78. (c)** A steel bar possessing both bulk and shear elastic moduli can propagate longitudinal as well as transverse waves. But air can propagate only longitudinal pressure waves (sound).

Moreover, when a medium such as a steel bar propagates both longitudinal and transverse waves, their speeds can be different, since they arise from different elastic moduli.

**79. (c)** Speed of a transverse wave in a stretched string,

$$v = \sqrt{\frac{T}{m}}$$

Speed of transverse wave on a stretched string does not depend upon the frequency of the wave.

**80. (a)** In a standing wave energy of one region is always confined in that region. All particles cross their mean position together.

**81. (c)** In a closed organ pipe, two waves travelling in opposite direction (one incident and other reflected wave from boundary) superimpose with each other to develop a wave pattern which is standing or stationary.

Harmonics in closed organ pipe :

$v_1 : v_2 : v_3 ....... = 1 : 3 : 5 : ......$

So, only odd harmonics are present. ⇒ II correct

Natural frequencies = $v = \frac{nv}{2L}$ ; $n = 1, 2, 3, .....$

Thus, even and odd i.e., all the harmonics are present.

**82. (c)** Change in frequency has nothing to do with distance between source and listener.

## MATCHING TYPE QUESTIONS

**83. (c)** $A \to (4);\ B \to (3);\ C \to (2);\ D \to (1)$

**84. (c)** $A \to (4);\ B \to (1);\ C \to (2);\ D \to (3)$

**85. (d)** $(A) \to (1, 2), (B) \to (4), (C) \to (1, 3), (D) \to (4)$

(A) $y = 4\sin(5x - 4t) + 3\cos\left(4t - 5x + \frac{\pi}{6}\right)$

is super position of two coherent waves, so their equivalent will be an another travelling wave

(B) $y = 10\cos\left(t - \frac{x}{330}\right)\sin(100)\left(t - \frac{x}{330}\right)$

Lets check at any point, say at x = 0, y = (10 cos t) sin (100t) at any point amplitude is changing sinusoidally. so this is equation of beats.

(C) $y = 10\sin(2\pi x - 120t) + 10\cos(120t + 2\pi x)$

= superposition of two coherent waves travelling in opposite direction.

⇒ equation of standing waves

(D) $y = 10\sin(2\pi x - 120t) + 8\cos(118t - 59/30\pi x)$

= superposition of two waves whose frequency are slightly different

$(\omega_1 = 120, \omega_2 = 118)$ ⇒ equation of beats

**86. (d)** $A \to (2);\ B \to (3);\ C \to (4);\ D \to (1)$

**87. (b)** $A \to (2);\ B \to (1);\ C \to (3); D \to (4)$

**88. (c)** Change in apparent frequency due to relative motion between source and listener is Doppler effect.

A - (3)

Intensity of sound varies with time in case of beats.

B - (1)

Sound waves in air are longitudinal in nature.

C - (4)

Light waves are transverse in nature.

D - (2)

**89. (d)** $A \to (3); B \to (1); C \to (2); D \to (3)$

## DIAGRAM TYPE QUESTIONS

**90. (d)** The displacement of the points *B* and *F* are equal in magnitude and sign. So these points are in same phase.

**91. (b)** For a moving source, $\lambda' < \lambda$ (normal wavelength).

**92. (c)** As two waves meet a point with opposite phase hence desctructive interference i.e., minimum sound at that point.

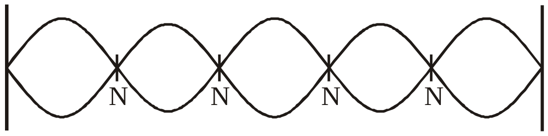
**93.** **(b)** After 2 s, the each wave travels a distance = 2 × 2 = 4 m.
The wave shape is shown in figure.
Thus energy is purely kinetic.

**94.** **(c)** When the waves meet a point with opposite phase, destructive interference is obtained at that point. In this case phase difference,

$$\phi = 180° \text{ or } (2n-1)\pi \quad n = 1, 2, 3, .......$$

**95.** **(d)** Two sinusoidal waves of same amplitude travel along the string in opposite directions forms stationary wave

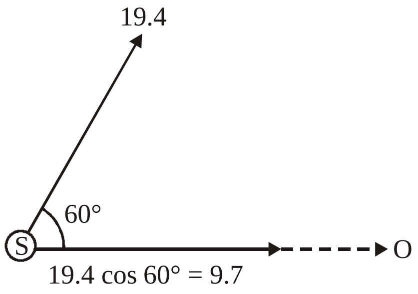
**96.** **(a)**



Total no. of nodes = 4

**97.** **(d)** Figure(a) represents a harmonic wave of frequency 7.0 Hz, figure (b) represents a harmonic wave of frequency 5.0 Hz. Therefore beat frequency $v_s = 7 - 5 = 2.0$ Hz.

**98.** **(a)** Here, original frequency of sound, $f_0 = 100$ Hz
Speed of source $V_s = 19.4 \cos 60° = 9.7$



From Doppler's formula

$$f^1 = f_0\left(\frac{V - V_0}{V - V_s}\right)$$

$$f^1 = 100\left(\frac{V - 0}{V - (+9.7)}\right)$$

$$f^1 = 100\frac{V}{V\left(1 - \frac{9.7}{V}\right)}$$

$$f^1 = 100\left(1 + \frac{9.7}{330}\right) = 103\text{Hz}$$

Apparent frequency $f^1 = 103$ Hz

**99.** **(a)** $f_1 = f\left(\frac{v}{v - v_s}\right)$ and $f_2 = f\left(\frac{v}{v + v_s}\right)$; so the frequency of
whistle suddenly changes from $f_1$ to $f_2$.

## ASSERTION- REASON TYPE QUESTIONS

**100.** **(a)**

**101.** **(a)** For the propagation of traverse

**102.** **(c)** In longitudinal waves, the constituents of the medium oscillate parallel to the direction of wave propagation. So sound wave is an example of longitudinal wave.

**103.** **(d)** Particle velocity, $v_P = \omega A \cos(\omega t - kx)$, which depends on time, $v = \sqrt{\gamma P / \rho}$.

**104.** **(a)**

**105.** **(d)** With change in pressure, density of medium also changes and so $P/\rho$ remains constant.

**106.** **(d)** Two waves moving in uniform string with uniform tension shall have same speed and may be moving in opposite directions. Hence both waves may have velocities in opposite direction. Hence statement-1 is false.

**107.** **(b)**

**108.** **(c)** There is no material medium over a long distance between earth and other planets. So explosions on other planets are not heard on Earth.

**109.** **(a)** Two astronauts cannot talk to each other on moon because moon has no atmosphere and hence there is no medium for propagation of sound.

**110.** **(c)** Laplace assumed adiabatic process during sound propagation.

**111.** **(b)** intensity, $I = \frac{1}{2}\rho\omega^2 A^2 v$

$\therefore$ Intensity depend upon amplitude, frequency as well as velocity of wave.
Also $I_1 = I_2$

**112.** **(d)** Principle of superposition can be used for vector quantity or tensor quantity.

**113.** **(a)** In case of independent sources, the phase difference between them does not remain constant.

**114.** **(a)** Reflection from a rigid boundary is a case of reflection from a denser medium. In that case the particle velocity and wave velocity are reversed in sign.

**115.** **(a)**

**116.** **(a)**

**117.** **(c)** At nodes pressure is maximum. Particles within a loop vibrate in phase.

**118.** **(b)** Open pipe can produce more number of harmonics in comparison to close pipe.

**119.** **(a)** As $f = \frac{v}{2l}$; and so with increase in temperature v increases more than $l$.

Also $v = \sqrt{\frac{\gamma RT}{M}}$

**120.** **(a)**

**121.** **(d)** Relative to an observer at rest in a medium the speed of a mechanical wave in that medium depends only on elastic and other properties of the medium. It does not depend on the velocity of the source.

**122.** **(d)** In doppler effect for sound wave effect due to observer and source motion are different.

## CRITICALTHINKING TYPE QUESTIONS

**123. (a)** Here, $y_1 = a\sin(\omega t + kx + 0.57)$

and $y_2 = a\cos(\omega t + kx)$

$$= a\sin\left[\frac{\pi}{2} + (\omega t + kx)\right]$$

Phase difference, $\Delta\phi = \phi_2 - \phi_1$

$$= \frac{\pi}{2} - 0.57$$

$$= \frac{3.14}{2} - 0.57 = 1.57 - 0.57 = 1 \text{ radian}$$

**124. (c)** $y = A\sin(\omega t - kx)$

Particle velocity,

$$v_p = \frac{dy}{dt} = A\,\omega\cos(\omega t - kx)$$

$$\therefore\ v_{p\,\max} = A\,\omega$$

wave velocity $= \frac{\omega}{k}$

$$\therefore\ A\omega = \frac{\omega}{k}$$

i. e., $A = \frac{1}{k}$ But $k = \frac{2\pi}{\lambda}$

$$\therefore\ \lambda = 2\pi A$$

**125. (b)** As density of hydrogen is less than density of air, velocity of sound in hydrogen is greater than vel. of sound in air. Therefore hydrogen acts as a rarer medium and the balloon behaves as a diverging lens.

**126. (d)** As $Y = A\sin(\omega t - kx + \phi)$

$$\omega = 2\pi f = \frac{2\pi}{\pi} = 2 \qquad \left[\because\ f = \frac{1}{\pi}\right]$$

$$k = \frac{2\pi}{\lambda} = \frac{2\pi}{2\pi} = 1 \qquad [\because\ \lambda = 2\pi]$$

$\therefore\ Y = 1\sin(2t - x + \phi)[\because\ A = 1\,m]$

**127. (a)** The pressure variations in the propagation of sound waves in gaseous medium are adiabatic.

**128. (b)** From equation, $\omega = 100$

$$\therefore \frac{2\pi}{T} = 100 \Rightarrow \nu = \frac{100}{2\pi}$$

$$\frac{2\pi}{\lambda} = 20 \Rightarrow \lambda = \frac{2\pi}{20}$$

$$v = \lambda\nu = \frac{2\pi}{20} \times \frac{100}{2\pi} = 5\,m/s$$

**129. (c)** From $\Delta x = \frac{\lambda}{2\pi}\Delta\phi$, $\lambda = 2\pi\frac{\Delta x}{\Delta\phi} = \frac{2\pi(0.4)}{1.6\pi} = 0.5\,m$

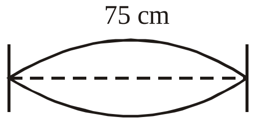
$$\nu = \frac{v}{\lambda} = \frac{330}{0.5} = 660\ \text{Hz}$$

**130. (d)** $T = \mu v^2 = \mu\frac{\omega^2}{k^2} = 0.04\frac{(2\pi/0.004)^2}{(2\pi/0.50)^2} = 6.25$ N

**131. (c)** Since the sine function varies between – 1 and 1 so, the displacement varies – *a* and *a.*

**132. (b)** From the equation $y(x, t) = 2a\sin kx\cos\omega t$ the position of nodes (where amplitude is zero) are given by $\sin kx = 0$ or $kx = n\pi$ where $n = 0, 1, 2, 3, ...$

**133. (c)** In a stretched string all multiples of frequencies can be obtained i.e., if fundamental frequency is *n* then higher frequencies will be 2n, 3n, 4n ...



So, the difference between any two successive frequencies will be 'n'

According to question, n = 420 – 315

= 105 Hz

So the lowest frequency of the string is 105 Hz.

**134. (d)** In the spherical source, the amplitude A of wave is inversely proportional to the distance r i.e., $A \propto \frac{1}{r}$

Where r is distance of source from the point of consideration.

**135. (d)** Here, $A_1 = A, A_2 = A, \phi = 120°$

The amplitude of the resultant wave is

$$A_R = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\phi}$$

$$= \sqrt{A^2 + A^2 + 2AA\cos 120°}$$

$$= \sqrt{A^2 + A^2 - A^2} \quad \left(\because\ \cos 120° = -\frac{1}{2}\right)$$

$= A_R = A$

**136. (d)** Load supported by sonometer wire = 4 kg

Tension in sonometer wire = 4 g

If $\mu$ = mass per unit length

then frequency $\upsilon = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

$$\Rightarrow\ 416 = \frac{1}{2l}\sqrt{\frac{4g}{\mu}}$$

When length is doubled, i.e., $l' = 2l$

Let new load = L

As, $\upsilon' = \upsilon$

$$\therefore \frac{1}{2l'}\sqrt{\frac{Lg}{\mu}} = \frac{1}{2l}\sqrt{\frac{4g}{\mu}}$$

$$\Rightarrow \frac{1}{4l}\sqrt{\frac{Lg}{\mu}} = \frac{1}{2l}\sqrt{\frac{4g}{\mu}}$$

$$\Rightarrow \sqrt{L} = 2\times 2 \Rightarrow L = 16\,\text{kg}$$

**137. (b)** Fundamental frequency,

$$f = \frac{v}{2\ell} = \frac{1}{2\ell}\sqrt{\frac{T}{\mu}} = \frac{1}{2\ell}\sqrt{\frac{T}{A\rho}} \left[\because v = \sqrt{\frac{T}{\mu}} \text{ and } \mu = \frac{m}{\ell}\right]$$

Also, $Y = \frac{T\ell}{A\Delta\ell} \Rightarrow \frac{T}{A} = \frac{Y\Delta\ell}{\ell} \Rightarrow f = \frac{1}{2\ell}\sqrt{\frac{\gamma\Delta\ell}{\ell\rho}}$ ....(i)

$\ell = 1.5$ m, $\frac{\Delta\ell}{\ell} = 0.01$, $\rho = 7.7 \times 10^3$ kg/m$^3$ (given)

$\gamma = 2.2 \times 10^{11}$ N/m$^2$ (given)

Putting the value of $\ell, \frac{\Delta\ell}{\ell}, \rho$ and $\gamma$ in eq$^n$. (i) we get,

$$f = \sqrt{\frac{2}{7}} \times \frac{10^3}{3}$$

or, $f \approx 178.2$ Hz

**138. (a)** Total length of string $\ell = \ell_1 + \ell_2 + \ell_3$

(As string is divided into three segments)

But frequency $\propto \frac{1}{\text{length}} \left(\because f = \frac{1}{2\ell}\sqrt{\frac{T}{m}}\right)$

so $\frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_3}$

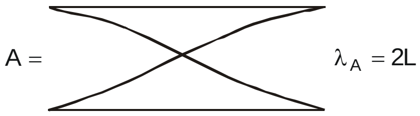
**139. (a)** Initially for open organ pipe, fundamental frequency,

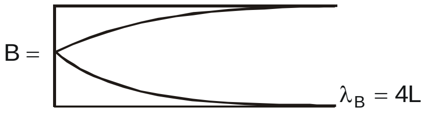
$v_0 = \frac{v}{2l} = f$ (given)

But when it is half dipped in water, then it becomes closed organ pipe of length $\frac{l}{2}$. In this case, fundamental frequency,

$$v_c = \frac{v}{4l'} = \frac{v}{4\frac{l}{2}} = \frac{v}{2l} = f$$

**140. (c)** $\frac{\lambda_A}{\lambda_B} = \frac{1}{2} \Rightarrow \frac{n_A}{n_B} = \frac{2}{1}$





**141. (b)** $3\times\frac{v}{4l_c} = 4\times\frac{v}{2l_0}$ or $\frac{l_c}{l_0} = \frac{3v}{4}\times\frac{2}{4v} = \frac{3}{8}$

**142. (d)** In case of closed organ pipe frequency,

$$f_n = (2n+1)\frac{v}{4l}$$

for $n = 0, f_0 = 100$ Hz
$n = 1, f_1 = 300$ Hz
$n = 2, f_2 = 500$ Hz
$n = 3, f_3 = 700$ Hz
$n = 4, f_4 = 900$ Hz
$n = 5, f_5 = 1100$ Hz
$n = 6, f_6 = 1300$ Hz

Hence possible natural oscillation whose frequencies < 1250 Hz = 6(n = 0, 1, 2, 3, 4, 5)

**143. (b)** Fundamental frequency of closed organ pipe

$$V_c = \frac{V}{4l_c}$$

Fundamental frequency of open organ pipe

$$V_0 = \frac{V}{2l_0}$$

Second overtone frequency of open organ pipe

$$= \frac{3V}{2l_0}$$

From question,

$$\frac{V}{4l_c} = \frac{3V}{2l_0}$$

$$\Rightarrow l_0 = 6l_c = 6 \times 20 = 120\,\text{cm}$$

**144. (a)** For fundamental mode,

$$f = \frac{1}{2\ell}\sqrt{\frac{T}{\mu}}$$

Taking logarithm on both sides, we get

$$\log f = \log\left(\frac{1}{2\ell}\right) + \log\left(\sqrt{\frac{T}{\mu}}\right)$$

$$= \log\left(\frac{1}{2\ell}\right) + \frac{1}{2}\log\left(\frac{T}{\mu}\right)$$

or $\log f = \log\left(\frac{1}{2\ell}\right) + \frac{1}{2}[\log T - \log\mu]$

Differentiating both sides, we get

$\frac{df}{f} = \frac{1}{2}\frac{dT}{T}$ (as $\ell$ and $\mu$ are constants)

$$\Rightarrow \frac{dT}{T} = 2\times\frac{df}{f}$$

Here df = 6
f = 600 Hz

$$\therefore \frac{dT}{T} = \frac{2\times 6}{600} = 0.02$$

**145. (b)** Equation of progressive wave is given by

$Y = A \sin 2\pi f t$

Given $Y_1 = 4\sin 500\,\pi t$ and $Y_2 = 2\sin 506\pi t$.

Comparing the given equations with equation of progressive wave, we get

$2f_1 = 500, \quad \Rightarrow f_1 = 250$

$2f_2 = 506 \quad \Rightarrow f_2 = 253$

Beats = $f_2 - f_1 = 253 - 250 = 3$ beats/sec

= 3 × 60 = 180 beats/minute.

**146. (d)** The frequency of the piano string $= 512 \pm 4 = 516$ or 508. When the tension is increased, beat frequency decreases to 2, it means that frequency of the string is 508 as frequency of string increases with tension.

**147. (b)** Here, $\Delta\lambda = 0.5\,\text{nm} = 0.5 \times 10^{-9}\,\text{m}$

$\upsilon = 300\,\text{km s}^{-1} = 300 \times 10^3\,\text{ms}^{-1}$

$$\text{As, } \frac{\Delta\lambda}{\lambda} = \frac{\upsilon}{c} \quad \therefore \quad \lambda = \frac{\Delta\lambda c}{\upsilon}$$

$$\lambda = \frac{(0.5\times10^{-9}\,\text{m})(3\times10^{8}\,\text{ms}^{-1})}{(300\times10^{3}\,\text{ms}^{-1})} = 5\times10^{-7}\,\text{m}$$

$= 5000 \times 10^{-10}\,\text{m} = 5000\,\text{Å}$

**148. (d)** $2\pi f_1 = 600\,\pi$

$f_1 = 300 \quad \text{... (1)}$

$2\pi f_2 = 608\,\pi$

$f_2 = 304 \quad \text{...(2)}$

$|f_1 - f_2| = 4$ beats

$$\frac{I_{\max}}{I_{\text{m.n}}} = \frac{(A_1 + A_2)^2}{(A_1 + A_2)^2} = \frac{(5+4)^2}{(5-4)^2} = \frac{81}{1}$$

where $A_1, A_2$ are amplitudes of given two sound wave.

**149. (b)** Frequency $\nu = \frac{1}{2L}\sqrt{\frac{T}{m}} \quad \because V \propto \frac{1}{l}$

$$\therefore \quad l_1 : l_2 : l_3 = \frac{1}{1} : \frac{1}{2} : \frac{1}{3} = 6 : 3 : 2$$

**150. (c)** Pressure change will be minimum at both ends. In fact, pressure variation is maximum at $\ell/2$ because the displacement node is pressure antinode.

**151. (c)** The apparent frequency remains the same because distance between the source and observer does not change.

**152. (c)** Frequency is not affected by blowing of wind so long as source and listener are stationary.

**153. (d)** When sounded with a source of known frequency fundamental frequency

$= 250 \pm 4\,\text{Hz} = 254\,\text{Hz}$ or $246\,\text{Hz}$

2nd harmonic if unknown frequency (suppose) 254 Hz

$= 2 \times 254 = 508\,\text{Hz}$

As it gives 5 beats

$\therefore 508 + 5 = 513\,\text{Hz}$

Hence, unknown frequency is 254 Hz

**154. (c)** Let $f'$ be the frequency of sound heard by cliff.

$$\therefore f' = \frac{vf}{v - v_c} \quad \text{......(1)}$$

Now for the reflected wave cliff. acts as a source

$$\therefore 2f' = \frac{f'(v + v_c)}{v} \quad \text{......(2)}$$

$$2f = \frac{(v + v_c)f}{v - v_c} \Rightarrow 2v - 2\,v_c = v + v_c \text{ or } \frac{v}{3} = v_c$$

**155. (c)** According to Doppler's effect

Apparent frequency

$$n' = n\left(\frac{v + v_0}{v + v_s}\right) = 1392\left(\frac{343 + 10}{343 + 5}\right).$$

$= 1412\,\text{Hz}$

**156. (c)** Frequency of the echo detected by the driver of the train is

(According to Doppler effect in sound)

$$f' = \left(\frac{v + u}{v - u}\right) f$$

where $f$ = original frequency of source of sound

$f'$ = Apparent frequency of source because of the relative motion between source and observer.

$$f' = \left(\frac{330 + 220}{330 - 220}\right)1000 = 5000\,\text{Hz}$$

**157. (c)**

$$v' = v\left[\frac{v}{v - v_s}\right]$$

$$\Rightarrow 10000 = 9500\left[\frac{300}{300 - v}\right]$$

$$\Rightarrow 300 - v = 300 \times 0.95$$

$$\Rightarrow v = 300 - 0.05 = 15\,\text{ms}^{-1}$$

CHAPTER

# 16

# ELECTRIC CHARGES AND FIELDS

## FACT/DEFINITION TYPE QUESTIONS

**1.** Charge is the property associated with matter due to which it produces and experiences
(a) electric effects only
(b) magnetic effects only
(c) both electric and magnetic effects
(d) None of these

**2.** Charge is
(a) transferable (b) associated with mass
(c) conserved (d) All of these

**3.** A body is positively charged, it implies that
(a) there is only positive charge in the body.
(b) there is positive as well as negative charge in the body but the positive charge is more than negative charge
(c) there is equal positive and negative charge in the body but the positive charge lies in the outer regions
(d) negative charge is displaced from its position

**4.** On rubbing, when one body gets positively charged and other negatively charged, the electrons transferred from positively charged body to negatively charged body are
(a) valence electrons only
(b) electrons of inner shells
(c) both valence electrons and electrons of inner shell
(d) yet to be established

**5.** Which of the following is the best insulator?
(a) Carbon (b) Paper
(c) Graphite (d) Ebonite

**6.** If a body is negatively charged, then it has
(a) excess of electrons (b) excess of protons
(c) deficiency of electrons (d) deficiency of neutrons

**7.** When a body is charged by induction, then the body
(a) becomes neutral
(b) does not lose any charge
(c) loses whole of the charge on it
(d) loses part of the charge on it

**8.** On charging by conduction, mass of a body may
(a) increase (b) decreases
(c) increase or decrease (d) None of these

**9.** Quantisation of charge implies
(a) charge cannot be destroyed
(b) charge exists on particles
(c) there is a minimum permissible charge on a particle
(d) charge, which is a fraction of a coulomb is not possible.

**10.** If an object possesses an electric charge, it is said to be electrified or ... *A* ... When it has no charge, it is said to be ... *B* ... Here, A and B refer to
(a) charged, neutral (b) neutral, charged
(c) discharged, charged (d) active, reactive

**11.** A positively charged rod is brought near an uncharged conductor. If the rod is then suddenly withdrawn, the charge left on the conductor will be
(a) positive (b) negative
(c) zero (d) cannot say

**12.** Two spheres A and B of exactly same mass are given equal positive and negative charges respectively. Their masses after charging
(a) remains unaffected (b) mass of A > mass of B
(c) mass of A < mass of B (d) Nothing can be said

**13.** When a comb rubbed with dry hair attracts pieces of paper. This is because the
(a) comb polarizes the piece of paper
(b) comb induces a net dipole moment opposite to the direction of field
(c) electric field due to the comb is uniform
(d) comb induces a net dipole moment perpendicular to the direction of field

**14.** When some charge is transferred to ...*A*... it readily gets distributed over the entire surface of ... *A*... If some charge is put on ... *B*..., it stays at the same place.
Here, A and B refer to
(a) insulator, conductor (b) conductor, insulator
(c) insulator, insulator (d) conductor, conductor

**15.** Quantisation of charge was experimentally demonstrated by
(a) Einstein's photoelectric effect
(b) Frank-Hertz experiment
(c) Davisson and Germer experiment
(d) Millikan's oil drop experiment

**16.** In annihilation process, in which an electron and a positron transform into two gamma rays, which property of electric charge is displayed?

(a) Additivity of charge
(b) Quantisation of charge
(c) Conservation of charge
(d) Attraction and repulsion

**17.** The law, governing the force between electric charges is known as

(a) Ampere's law (b) Ohm's law
(c) Faraday's law (d) Coulomb's law

**18.** The value of electric permittivity of free space is

(a) $9 \times 10^9\ NC^2/m^2$ (b) $8.85 \times 10^{-12} Nm^2/C^2$ sec
(c) $8.85 \times 10^{-12}\ C^2/Nm^2$ (d) $9 \times 10^9 C^2/Nm^2$

**19.** Coulomb's law is true for

(a) atomic distances ($= 10^{-11}$ m)
(b) nuclear distances ($= 10^{-15}$ m)
(c) charged as well as uncharged particles
(d) all the distances

**20.** What happens when some charge is placed on a soap bubble?

(a) Its radius decreases (b) Its radius increases
(c) The bubble collapses (d) None of these

**21.** Two point charges + Q and + q are separated by a certain distance. If + Q > + q then in between the charges the electric field is zero at a point

(a) closer to + Q
(b) closer to + q
(c) exactly at the mid-point of line segment joining + Q and + q.
(d) no where on the line segment joining + Q and + q.

**22.** An electric field can deflect

(a) neutrons (b) X-rays
(c) $\gamma$-rays (d) $\alpha$-particles

**23.** The unit of electric field is not equivalent to

(a) $N / C$ (b) $J / C$
(c) $V / m$ (d) $J / Cm$

**24.** If an electron has an initial velocity in a direction different from that of an electric field, the path of the electron is

(a) a straight line (b) a circle
(c) an ellipse (d) a parabola

**25.** A charged particle is free to move in an electric field. It will travel

(a) always along a line of force
(b) along a line of force, if its initial velocity is zero
(c) along a line of force, if it has some initial velocity in the direction of an acute angle with the line of force
(d) none of the above

**26.** If a linear isotropic dielectric is placed in an electric field of strength E, then the polarization P is

(a) independent of E
(b) inversely proportional to E
(c) directly proportional to $\sqrt{E}$
(d) directly proportional to E

**27.** A point charge is kept at the centre of metallic insulated spherical shell. Then

(a) electric field out side the sphere is zero
(b) electric field inside the sphere is zero
(c) net induced charge on the sphere is zero
(d) electric potential inside the sphere is zero

**28.** If one penetrates a uniformly charged spherical cloud, electric field strength

(a) decreases directly as the distance from the centre
(b) increases directly as the distance from the centre
(c) remains constant
(d) None of these

**29.** Electric lines of force about a negative point charge are

(a) circular anticlockwise
(b) circular clockwise
(c) radial, inwards
(d) radial, outwards

**30.** Electric lines of force

(a) exist everywhere
(b) exist only in the immediate vicinity of electric charges
(c) exist only when both positive and negative charges are near one another
(d) are imaginary

**31.** Positive electric flux indicates that electric lines of force are directed

(a) outwards (b) inwards
(c) either (a) or (b) (d) None of these

**32.** The S.I. unit of electric flux is

(a) weber (b) newton per coulomb
(c) volt × metre (d) joule per coulomb

**33.** If the flux of the electric field through a closed surface is zero, then

(a) the electric field must be zero everywhere on the surface
(b) the electric field may not be zero everywhere on the surface
(c) the charge inside the surface must be zero
(d) the charge in the vicinity of the surface must be zero

**34.** Electric flux over a surface in an electric field may be

(a) positive (b) negative
(c) zero (d) All of the above

**35.** If the electric flux entering and leaving an enclosed surface respectively is $\phi_1$ and $\phi_2$, the electric charge inside the surface will be

(a) $(\phi_2 + \phi_2) \times \varepsilon_o$ (b) $(\phi_2 - \phi_2) \times \varepsilon_o$
(c) $(\phi_1 + \phi_2) \times \varepsilon_o$ (d) $(\phi_2 - \phi_1) \times \varepsilon_o$

**36.** For distance far away from centre of dipole the change in magnitude of electric field with change in distance from the centre of dipole is

(a) zero.
(b) same in equatorial plane as well as axis of dipole.
(c) more in case of equatorial plane of dipole as compared to axis of dipole.
(d) more in case of axis of dipole as compared to equatorial plane of dipole.

**37.** A region surrounding a stationary electric dipoles has
(a) magnetic field only
(b) electric field only
(c) both electric and magnetic fields
(d) no electric and magnetic fields

**38.** The electric field at a point on equatorial line of a dipole and direction of the dipole moment
(a) will be parallel
(b) will be in opposite direction
(c) will be perpendicular
(d) are not related

**39.** Debye is the unit of
(a) electric flux (b) electric dipole moment
(c) electric potential (d) electric field intensity

**40.** An electric dipole will experience a net force when it is placed in
(a) a uniform electric field
(b) a non-uniform electric field
(c) both (a) and (b)
(d) None of these

**41.** An electric dipole is kept in a non-uniform electric field. It experiences
(a) a force and a torque
(b) a force but not a torque
(c) a torque but no force
(d) neither a force nor a torque

**42.** The formation of a dipole is due to two equal and dissimilar point charges placed at a
(a) short distance (b) long distance
(c) above each other (d) none of these

**43.** If a dipole of dipole moment $\vec{p}$ is placed in a uniform electric field $\vec{E}$, then torque acting on it is given by
(a) $\vec{\tau}=\vec{p}.\vec{E}$ (b) $\vec{\tau}=\vec{p}\times\vec{E}$
(c) $\vec{\tau}=\vec{p}+\vec{E}$ (d) $\vec{\tau}=\vec{p}-\vec{E}$

**44.** If $E_a$ be the electric field strength of a short dipole at a point on its axial line and $E_e$ that on the equatorial line at the same distance, then
(a) $E_e = 2E_a$ (b) $E_a = 2E_e$
(c) $E_a = E_e$ (d) None of the above

**45.** When an electric dipole $\vec{P}$ is placed in a uniform electric field $\vec{E}$ then at what angle between $\vec{P}$ and $\vec{E}$ the value of torque will be maximum?
(a) 90° (b) 0°
(c) 180° (d) 45°

**46.** An electric dipole is placed at an angle of 30° to a non-uniform electric field. The dipole will experience
(a) a translational force only in the direction of the field
(b) a translational force only in the direction normal to the direction of the field
(c) a torque as well as a translational force
(d) a torque only

**47.** An electric dipole is placed at the centre of a sphere then
(a) the flux of the electric field through the sphere is not zero.
(b) the electric field is zero at every point of the sphere.
(c) the electric field is not zero anywhere on the sphere.
(d) the electric field is zero on a circle on the sphere.

**48.** If a dipole of dipole moment $\vec{p}$ is placed in a uniform electric field $\vec{E}$, then torque acting on it is given by
(a) $\vec{\tau}=\vec{p}.\vec{E}$ (b) $\vec{\tau}=\vec{p}\times\vec{E}$
(c) $\vec{\tau}=\vec{p}+\vec{E}$ (d) $\vec{\tau}=\vec{p}-\vec{E}$

**49.** An electric dipole has a pair of equal and opposite point charges *q* and –*q* separated by a distance 2*x*. The axis of the dipole is
(a) from positive charge to negative charge
(b) from negative charge to positive charge
(c) Perpendicular to the line joining the two charges drawn at the centre and pointing upward direction
(d) Perpendicular to the line joining the two charges drawn at the centre and pointing downward direction

**50.** Gauss's law states that
(a) the total electric flux through a closed surface is $\frac{1}{\varepsilon_0}$ times the total charge placed near the closed surface.
(b) the total electric flux through a closed surface is $\frac{1}{\varepsilon_0}$ times the total charge enclosed by the closed surface.
(c) the total electric flux through an open surface is $\frac{1}{\varepsilon_0}$ times the total charge placed near the open surface.
(d) the line integral of electric field around the boundary of an open surface is $\frac{1}{\varepsilon_0}$ times the total charge placed near the open surface.

**51.** The Gaussian surface
(a) can pass through a continuous charge distribution.
(b) cannot pass through a continuous charge distribution.
(c) can pass through any system of discrete charges.
(d) can pass through a continuous charge distribution as well as any system of discrete charges.

**52.** Gauss's law is valid for
(a) any closed surface
(b) only regular close surfaces
(c) any open surface
(d) only irregular open surfaces

**53.** The total electric flux emanating from a closed surface enclosing an $\alpha$-particle is (e-electronic charge)
(a) $\frac{2e}{\varepsilon_0}$ (b) $\frac{e}{\varepsilon_0}$
(c) $e\varepsilon_0$ (d) $\frac{\varepsilon_0 e}{4}$

**54.** The electric field due to an infinitely long straight uniformly charged wire at a distance r is directly proportional to

(a) r (b) $r^2$

(c) $\frac{1}{r}$ (d) $\frac{1}{r^2}$

**55.** For a given surface the Gauss's law is stated as $\oint \vec{E}.\,d\vec{A} = 0$. From this we can conclude that

(a) E is necessarily zero on the surface
(b) E is perpendicular to the surface at every point
(c) the total flux through the surface is zero
(d) the flux is only going out of the surface

**56.** The electric field inside a spherical shell of uniform surface charge density is

(a) zero
(b) constant different from zero
(c) proportional to the distance from the curve
(d) None of the above

**57.** The electric field near a conducting surface having a uniform surface charge density is given by

(a) $\frac{\sigma}{\varepsilon_0}$ and is parallel to the surface

(b) $\frac{2\sigma}{\varepsilon_0}$ and is parallel to the surface

(c) $\frac{\sigma}{\varepsilon_0}$ and is normal to the surface

(d) $\frac{2\sigma}{\varepsilon_0}$ and is normal to the surface

**58.** A hollow sphere of charge does not have electric field at

(a) outer point (b) interior point
(c) beyond 2 m (d) beyond 100 m

**59.** Charge motion within the Gaussian surface gives changing physical quantity

(a) electric field (b) electric flux
(c) charge (d) gaussian surface area

**60.** Gauss's law is true only if force due to a charge varies as

(a) $r^{-1}$ (b) $r^{-2}$
(c) $r^{-3}$ (d) $r^{-4}$

**61.** What about Gauss's theorem is not incorrect?

(a) It can be derived by using Coulomb's Law
(b) It is valid for conservative field obeys inverse square root law
(c) Gauss's theorem is not applicable in gravitation
(d) Both (a) & (b)

## STATEMENT TYPE QUESTIONS

**62.** Study of charges, by scientists, concludes that

I. there are two kinds of electric charges.
II. bodies like plastic, fur acquire elecrtic charge on rubbing.
III. like charges attract, unlike charges repel each other.
IV. the property which differentiates two kinds of charges is called the polarity of the charge.

Which of the above statements is incorrect?

(a) Only I (b) Only II
(c) Only III (d) Only IV

**63.** Which of the following statements is incorrect?

I. The charge *q* on a body is always given by *q* = ne, where *n* is any integer, positive or negative.
II. By convention, the charge on an electron is taken to be negative.
III. The fact that electric charge is always an integral multiple of e is termed as quantisation of charge.
IV. The quatisation of charge was experimentally demonstrated by Newton in 1912.

(a) Only I (b) Only II
(c) Only IV (d) Only III

**64.** Select the correct statements Coulomb's law correctly describes the electric force that

I. binds the electrons of an atom to its nucleus
II. binds the protons and neutrons in the nucleus of an atom
III. binds atoms together to form molecules

(a) I and II (b) I and III
(c) II and III (d) I, II and III

**65.** Select the correct statements from the following

I. Inside a charged or neutral conductor, electrostatic field is zero
II. The electrostatic field at the surface of the charged conductor must be tangential to the surface at any point
III. There is no net charge at any point inside the conductor

(a) I and II (b) I and III
(c) II and III (d) I, II and III

**66.** In a uniform electric field $\vec{E}$ a charge +q having negligible mass is released at a point. Which of the following statements are correct?

I. Velocity increases with time.
II. A force acts on it in the direction of electric field.
III. Its momentum changes with time.

(a) I and II (b) II and III
(c) I and III (d) I, II and III

**67.** Field due to multiple charges at a point is found by using

I. superposition principle.
II. Coulomb's law.
III. law of conservation of charges.

(a) I and II (b) II and III
(c) I and III (d) I, II and III

**68.** Select the incorrect statements about electric field lines.

I. Two electric field lines can never cross each other.
II. They start from positive charge and end at negative charge.
III. Electric field lines form closed loops.

(a) I and II (b) I and III
(c) II and III (c) I, II and III

**69.** An electric dipole of moment $\vec{p}$ is placed in a uniform electric field $\vec{E}$. Then

I. the torque on the dipole is $\vec{p} \times \vec{E}$.

II. the potential energy of the system is $\vec{p} \cdot \vec{E}$.

III. the resultant force on the dipole is zero.

Which of the above statements is/are correct

(a) I, II and III
(b) I and III
(c) Only I
(d) I and II

**70.** Select the incorrect statements from the following.

I. Polar molecules have permanent electric dipole moment.

II. $CO_2$ molecule is a polar molecule.

III. $H_2O$ is a non-polar molecule.

(a) II and III
(b) I and II
(c) I and III
(d) I, II and III

**71.** Select the correct statements from the following.

I. The electric field due to a charge outside the Gaussian surface contributes zero net flux through the surface.

II. Total flux linked with a closed body, not enclosing any charge will be zero.

III. Total electric flux, if a dipole is enclosed by a surface is zero.

(a) I and II
(b) II and III
(c) I and III
(d) I, II and III

## MATCHING TYPE QUESTIONS

**72.** Match Column I and Column II.

| **Column I** | **Column II** |
|---|---|
| (A) Additivity of charge | (1) $^1_0n + ^{235}_{92}U \rightarrow ^{144}_{56}Ba + ^{89}_{36}Kr + 3^1_0n$ |
| (B) Conservation of charge | (2) $-5\mu C + 15\mu C = 10\mu C$ |
| (C) Quantisation of charge | (3) Gold nucleus repels alpha particle. |
| (D) Attraction and repulsion | (4) q = ne |

(a) (A)→(3), (B)→(2), (C)→(4), (D)→(1)
(b) (A)→(2), (B)→(4), (C)→(1), (D)→(3)
(c) (A)→(2), (B)→(1), (C)→(4), (D)→(3)
(d) (A)→(1), (B)→(2), (C)→(3), (D)→(4)

**73.** Match the physical quantities in column I and the information related to them in Column II.

| **Column I** | **Column II** |
|---|---|
| (A) Electric dipole moment | (1) Vector product |
| (B) Electric field | (2) Scalar product |
| (C) Electric flux | (3) Points towards positive charge |
| (D) Torque | (4) Points away from positive charge |

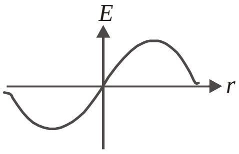
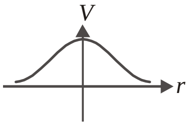
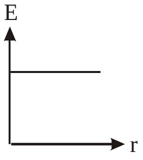
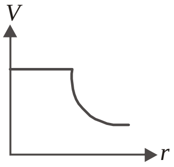
(a) (A)→(3), (B)→(2), (C)→(4), (D)→(1)
(b) (A)→(1), (B)→(3), (C)→(4), (D)→(2)
(c) (A)→(3), (B)→(4), (C)→(2), (D)→(1)
(d) (A)→(1), (B)→(2), (C)→(3), (D)→(4)

**74.**

| **Column I** | **Column II** |
|---|---|
| (A) Linear charge density | (1) $\frac{\text{Charge}}{\text{Volume}}$ |
| (B) Surface charge density | (2) $\frac{\text{Charge}}{\text{Length}}$ |
| (C) Volume charge density | (3) $\frac{\text{Charge}}{\text{Area}}$ |
| (D) Discrete charge distribution | (4) System consisting of ultimate individual charges |

(a) A → (2), B → (3), C → (1), D → (4)
(b) A → (1), B → (3), C → (1), D → (4)
(c) A → (3), B → (1), C → (2), D → (4)
(d) A → (3), B → (2), C → (1), D → (4)

**75.** Column II describe graph for charge distribution given in column-I. Match the description.

| **Column I** | **Column II** |
|---|---|
| (A) Uniformly charged ring | (1)  |
| (B) Infinitely large charge conducting sheet | (2)  |
| (C) Infinite non conducting | (3)  |
| (D) Hollow non conducting sphere | (4)  |

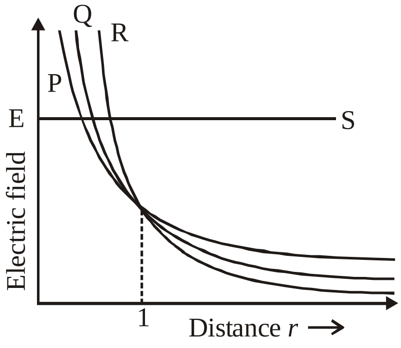
(a) A→(1, 2), B→(3), C→(3), D→(4)
(b) A → (3, 4), B → (2), C → (3, 1), D → (4)
(c) A → (1), B → (2), C → (3), D → (4)
(d) A → (2), B → (3), C → (4), D → (1)

**76.** Match the entries of column I with that of Column II.

| **Column I** | **Column II** |
|---|---|
| (A) Coulomb's law | (1) Total electric flux through a closed surface. |
| (B) Gauss's law | (2) Vector sum of forces. |
| (C) Principle of superposition | (3) Force is inversely proportional to square of distance |
| (D) Quantisation of charge | (4) Discrete nature of charge |

(a) (A) $\rightarrow$ (2), (B) $\rightarrow$ (3), (C) $\rightarrow$ (1), (D) $\rightarrow$ (4)
(b) (A) $\rightarrow$ (3), (B) $\rightarrow$ (1), (C) $\rightarrow$ (2), (D) $\rightarrow$ (4)
(c) (A) $\rightarrow$ (1), (B) $\rightarrow$ (4), (C) $\rightarrow$ (3), (D) $\rightarrow$ (2)
(d) (A) $\rightarrow$ (1), (B) $\rightarrow$ (2), (C) $\rightarrow$ (3), (D) $\rightarrow$ (4)

**77.** The curves in the graph show the variation of electric field E with distance r for various kinds of charge distributions given in Column I. Match them with their correct curves in Column II.



| **Column I** | **Column II** |
|---|---|
| (A) Electric field of a point sized dipole. | (1) P |
| (B) Electric field due to an infinitely long straight uniformly charged wire. | (2) Q |
| (C) Electric field due to a uniformly charged plane sheet. | (3) R |
| (D) Electric field due to a point charge. | (4) S |

(a) (A) $\rightarrow$ (2), (B) $\rightarrow$ (4), (C) - (3), (D) $\rightarrow$ (1)
(b) (A) $\rightarrow$ (4), (B) $\rightarrow$ (3), (C) $\rightarrow$ (2), (D) $\rightarrow$ (1)
(c) (A) $\rightarrow$ (1), (B) $\rightarrow$ (2), (C) $\rightarrow$ (3), (D) $\rightarrow$ (4)
(d) (A) $\rightarrow$ (3), (B) $\rightarrow$ (1), (C) $\rightarrow$ (4), (D) $\rightarrow$ (2)

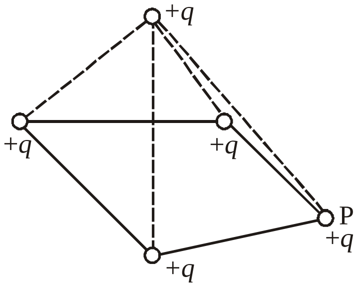
**78.** Match the source of charge given in Column I with expressions of electric field produced by them in Column II.

| **Column I** | **Column II** |
|---|---|
| (A) Point charge | (1) $\dfrac{\lambda}{2\pi\varepsilon_0 r}$ |
| (B) Infinitely long straight uniformly charged wire | (2) $\dfrac{\sigma}{2\varepsilon_0}$ |
| (C) Uniformly charged infinite plane sheet | (3) 0 |
| (D) At a point inside a uniformly charged thin spherical shell. | (4) $\dfrac{q}{4\pi\varepsilon_0 r^2}$ |

(a) (A) $\rightarrow$ (1), (B) $\rightarrow$ (3), (C) $\rightarrow$ (4), (D) $\rightarrow$ (2)
(b) (A) $\rightarrow$ (4), (B) $\rightarrow$ (3), (C) $\rightarrow$ (2), (D) $\rightarrow$ (1)
(c) (A) $\rightarrow$ (4), (B) $\rightarrow$ (1), (C) $\rightarrow$ (2), (D) $\rightarrow$ (3)
(d) (A) $\rightarrow$ (2), (B) $\rightarrow$ (4), (C) $\rightarrow$ (1), (D) $\rightarrow$ (3)

## DIAGRAM TYPE QUESTIONS

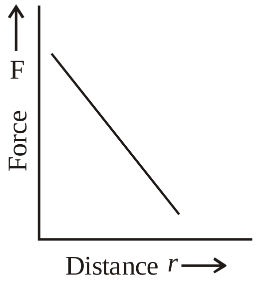
**79.** The figure shows a charge $+q$ at point P held in equilibrium in air with the help of four $+q$ charges situated at the vertices of a square. The net electrostatic force on q is given by



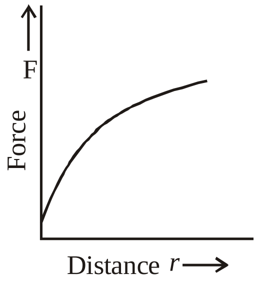
(a) Gauss's law
(b) Coulomb's law
(c) Principle of superposition
(d) net electric flux out the position of $+q$.

**80.** Which of the following graphs shows the correct variation of force when the distance r between two charges varies ?

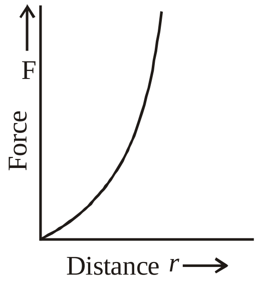
(a)



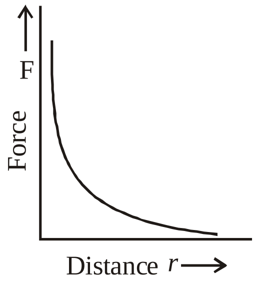
(b)



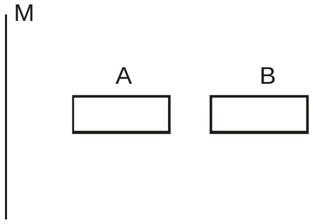
(c)



(d)



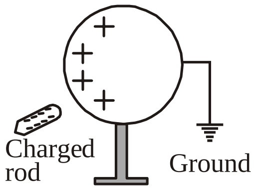
**81.** A large nonconducting sheet M is given a uniform charge density. Two uncharged small metal rods A and B are placed near the sheet as shown in figure. Then



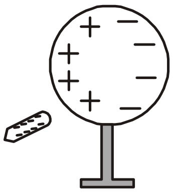
(a) M attracts A (b) M attracts B
(c) A attracts B (d) All of the above

**82.** A metal sphere is being charged by induction using a charged rod, but the sequence of diagrams showing the process misplaced.

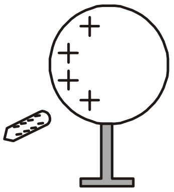
I.



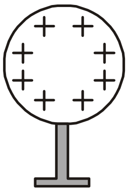
II.



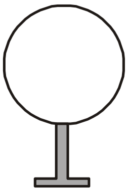
III.



IV.



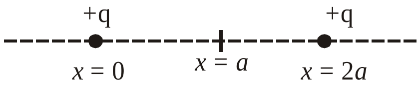
V.



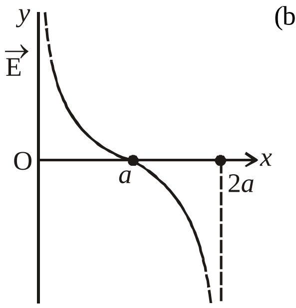
Correct order of charging is

(a) I → II → III → IV → V
(b) V → II → III → I → IV
(c) V → II → I → III → IV
(d) IV → II → III → I → V

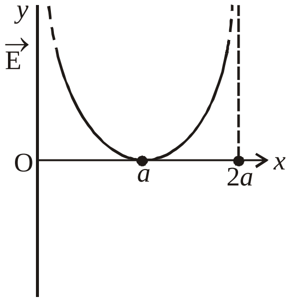
**83.** Figure shows two charges of equal magnitude separated by a distance 2a. As we move away from the charge situated at x = 0 to the charge situated at x = 2a, which of the following graphs shows the correct behaviour of electric field ?



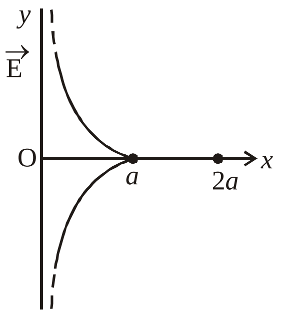
(a)



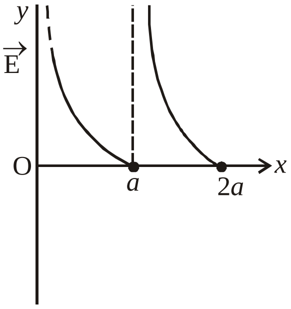
(b)



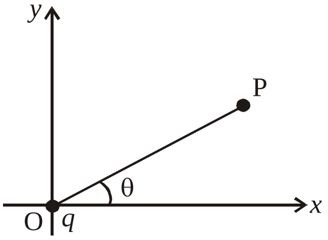
(c)



(d)



**84.** In the figure, charge q is placed at origin O. When the charge q is displaced from its position the electric field at point P changes



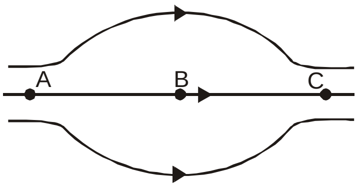
(a) at the same time when q is displaced.

(b) at a time after $\frac{OP}{c}$ where $c$ is the speed of light.

(c) at a time after $\frac{OP\cos\theta}{c}$.

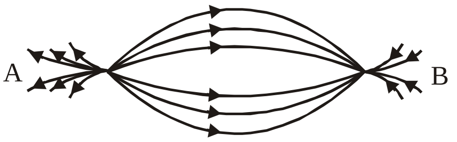
(d) at a time after $\frac{OP\sin\theta}{c}$

**85.** Figure shows some of the electric field lines corresponding to an electric field. The figure suggests that



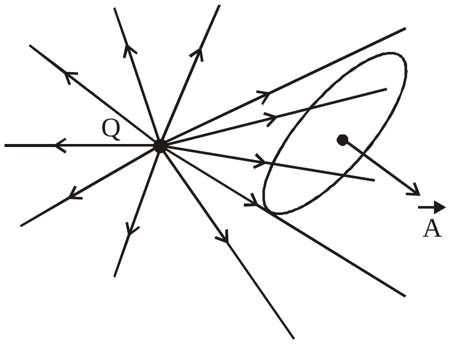
(a) $E_A > E_B > E_C$ (b) $E_A = E_B = E_C$
(c) $E_A = E_C > E_B$ (d) $E_A = E_C < E_B$

**86.** The spatial distribution of electric field due to charges (A, B) is shown in figure. Which one of the following statements is correct ?



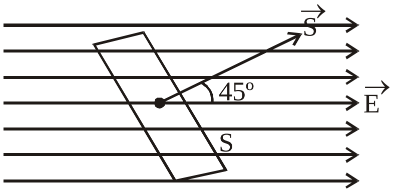
(a) A is +ve and B –ve, |A| > |B|
(b) A is –ve and B +ve, |A| = |B|
(c) Both are +ve but A > B
(d) Both are –ve but A > B

**87.** In the figure the net electric flux through the area $A$ is $\phi = \vec{E} \cdot \vec{A}$ when the system is in air. On immersing the system in water the net electric flux through the area

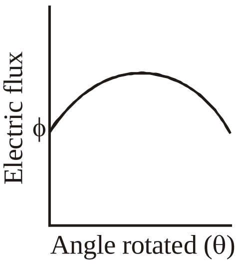


(a) becomes zero
(b) remains same
(c) increases
(d) decreases

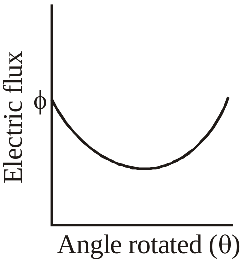
**88.** Which of the following graphs shows the correct behaviour of electric flux through the surface S when it is rotated by an angle 90° clockwise in a uniform electric field?



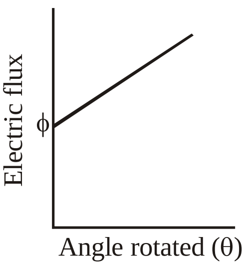
(a)



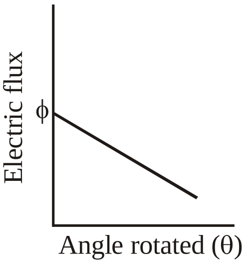
(b)



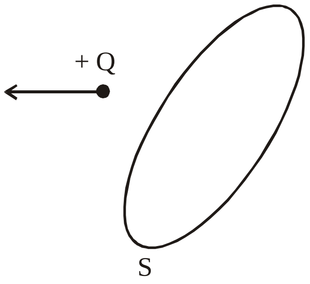
(c)



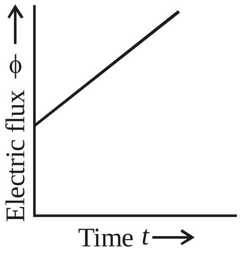
(d)



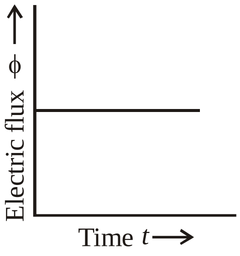
**89.** Which of the following graphs correctly show the change of electric flux $\phi$ with time t through the surface S when the charge +Q is moved away from the surface?



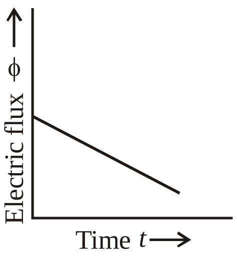
(a)



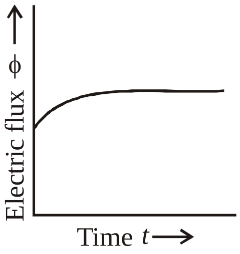
(b)



(c)

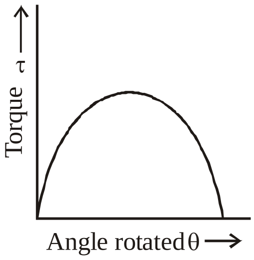


(d)

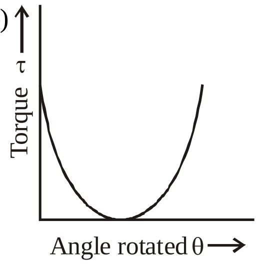


**90.** Which of the following graphs shows the correct variation in magnitude of torque on an electric dipole rotated in a uniform electric field from stable equillibrium to unstable equillibrium?

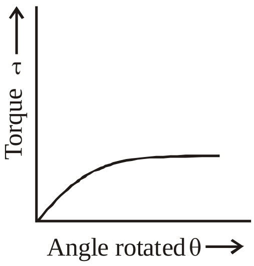
(a)



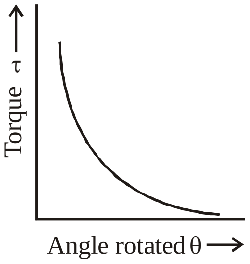
(b)



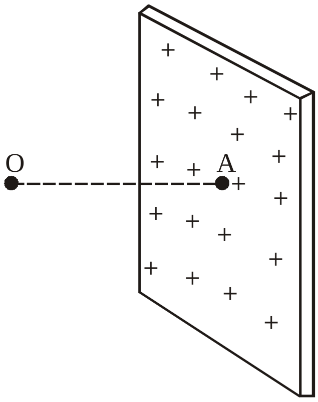
(c)



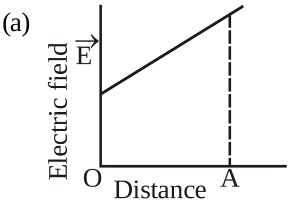
(d)

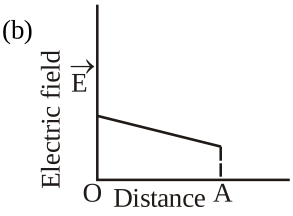


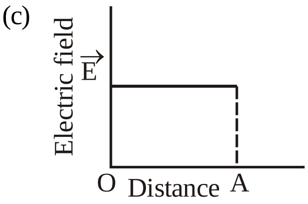
**91.** Figure shows the part of an infinite plane sheet of charge.

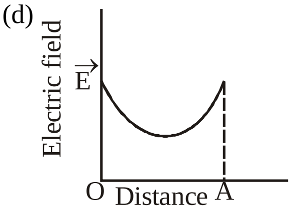


Which of the following graphs correctly shows the behaviour of electric field intensity as we move from point O to A.

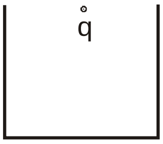








**92.** A charge q is placed at the centre of the open end of a cylindrical vessel. The flux of the electric field through the surface of the vessel is



(a) zero (b) $q/\varepsilon_o$
(c) $q/2\varepsilon_o$ (d) $2q/\varepsilon_o$

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

**93.** **Assertion :** When bodies are charged through friction, there is a transfer of electric charge from one body to another, but no creation or destruction of charge.

**Reason :** This follows from conservation of electric charges.

**94.** **Assertion :** The tyres of aircraft are slightly conducting.

**Reason :** If a conductor is connected to ground, the extra charge induced on conductor will flow to ground.

**95.** **Assertion :** Some charge is put at the centre of a conducting sphere. It will move to the surface of the sphere.

**Reason :** Conducting sphere has no free electrons at the centre.

**96.** **Assertion :** Coulomb force and gravitational force follow the same inverse-square law.

**Reason :** Both laws are same in all aspects.

**97.** **Assertion :** The coulomb force is the dominating force in the universe.

**Reason :** The coulomb force is weaker than the gravitational force.

**98.** **Assertion :** If there exists coulomb attraction between two bodies, both of them may not be charged.

**Reason :** In coulomb attraction two bodies are oppositely charged.

**99.** **Assertion :** A deuteron and an $\alpha$-particle are placed in an electric field. If $F_1$ and $F_2$ be the forces acting on them and $a_1$ and $a_2$ be their accelerations respectively then, $a_1 = a_2$.

**Reason :** Forces will be same in electric field.

**100.** **Assertion :** The property that the force with which two charges attract or repel each other are not affected by the presence of a third charge.

**Reason :** Force on any charge due to a number of other charge is the vector sum of all the forces on that charge due to other charges, taken one at a time.

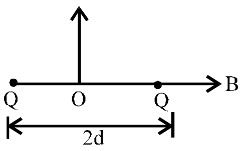
**101.** **Assertion :** A metallic shield in form of a hollow shell may be built to block an electric field.

**Reason :** In a hollow spherical shield, the electric field inside it is zero at every point.

**102.** **Assertion :** A point charge is brought in an electric field, the field at a nearby point will increase or decrease, depending on the nature of charge.

**Reason :** The electric field is independent of the nature of charge.

**103.** **Assertion :** Consider two identical charges placed distance 2d apart, along x-axis.



The equilibrium of a positive test charge placed at the point O midway between them is stable for displacements along the x-axis.

**Reason:** Force on test charge is zero.

**104.** **Assertion :** When a conductor is placed in an external electrostatic field, the net electric field inside the conductor becomes zero after a small instant of time.

**Reason :** It is not possible to set up an electric field inside a conductor.

**105.** **Assertion :** A uniformly charged disc has a pin hole at its centre. The electric field at the centre of the disc is zero.

**Reason :** Disc can be supposed to be made up of many rings. Also electric field at the centre of uniformly charged ring is zero.

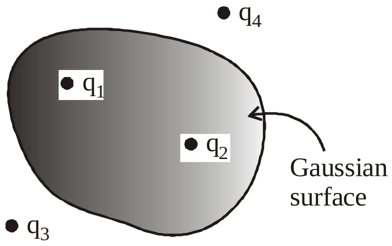
**106.** **Assertion :** Electric lines of field cross each other.

**Reason :** Electric field at a point superimpose to give one resultant electric field.

**107.** **Assertion :** On bringing a positively charged rod near the uncharged conductor, the conductor gets attracted towards the rod.

**Reason :** The electric field lines of the charged rod are perpendicular to the surface of conductor.

**108.** **Assertion :** Four point charges $q_1$, $q_2$, $q_3$ and $q_4$ are as shown in figure. The flux over the shown Gaussian surface depends only on charges $q_1$ and $q_2$.



**Reason :** Electric field at all points on Gaussian surface depends only on charges $q_1$ and $q_2$.

**109.** **Assertion :** On disturbing an electric dipole in stable equillibrium in an electric field, it returns back to its stable equillibrium orientation.

**Reason :** A restoring torque acts on the dipole on being disturbed from its stable equillibrium.

**110.** **Assertion :** On going away from a point charge or a small electric dipole, electric field decreases at the same rate in both the cases.

**Reason :** Electric field is inversely proportional to square of distance from the charge or an electric dipole.

**111.** **Assertion :** The electric flux of the electric field $\oint \vec{E} \bullet d\vec{A}$ is zero. The electric field is zero everywhere on the surface.

**Reason :** The charge inside the surface is zero.

**112.** **Assertion :** On moving a distance two times the initial distance away from an infinitely long straight uniformly charged wire the electric field reduces to one third of the initial value.

**Reason :** The electric field is inversely proportional to the distance from an infinitely long straight uniformly charged wire.

## CRITICAL THINKING TYPE QUESTIONS

**113.** The metal knob of a gold leaf electroscope is touched with a positively charged rod. When it is taken away the leaves stay separated. Now the metal knob is touched by negatively charged rod. The separation between the leaves

(a) increases

(b) decreases

(c) remains same

(d) first increases then decreases.

**114.** Two identical metal spheres A and B are supported on insulating stands and placed in contact. What kind of charges will A and B develop when a negatively charged ebonite rod is brought near A?

(a) A will have a positive charge and B will have a negative charge

(b) A will have a negative charge and B will have a positive charge

(c) Both A and B will have positive charges

(d) Both A and B will have negative charges

**115.** The force of repulsion between two electrons at a certain distance is F. The force between two protons separated by the same distance is ($m_p = 1836\, m_e$)

(a) 2 F  (b) F

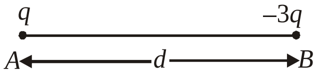
(c) 1836 F  (d) $\frac{F}{1836}$

**116.** The force between two small charged spheres having charges of $1 \times 10^{-7}$ C and $2 \times 10^{-7}$ C placed 20 cm apart in air is

(a) $4.5 \times 10^{-2}$ N  (b) $4.5 \times 10^{-3}$ N

(c) $5.4 \times 10^{-2}$ N  (d) $5.4 \times 10^{-3}$ N

**117.** Two charge $q$ and $-3q$ are placed fixed on $x$–axis separated by distance $d$. Where should a third charge $2q$ be placed such that it will not experience any force ?



(a) $\frac{d-\sqrt{3}d}{2}$  (b) $\frac{d+\sqrt{3}d}{2}$

(c) $\frac{d+3d}{2}$  (d) $\frac{d-3d}{2}$

**118.** Two insulated charged metalic sphere $P$ and $Q$ have their centres separated by a distance of 60 cm. The radii of $P$ and $Q$ are negligible compared to the distance of separation. The mutual force of electrostatic repulsion if the charge on each is $3.2 \times 10^{-7}$ C is

(a) $5.2 \times 10^{-4}\, N$  (b) $2.5 \times 10^{-3}\, N$

(c) $1.5 \times 10^{-3} N$  (d) $3.5 \times 10^{-4}\, N$

**119.** If a charge q is placed at the centre of the line joining two equal charges Q such that the system is in equilibrium then the value of q is

(a) Q/2  (b) –Q/2

(c) Q/4  (d) –Q/4

**120.** Two positive ions, each carrying a charge $q$, are separated by a distance $d$. If $F$ is the force of repulsion between the ions, the number of electrons missing from each ion will be ($e$ being the charge of an electron)

(a) $\frac{4\pi\varepsilon_0 Fd^2}{e^2}$ (b) $\sqrt{\frac{4\pi\varepsilon_0 Fe^2}{d^2}}$

(c) $\sqrt{\frac{4\pi\varepsilon_0 Fd^2}{e^2}}$ (d) $\frac{4\pi\varepsilon_0 Fd^2}{q^2}$

**121.** Three charge q, Q and 4q are placed in a straight line of length $l$ at points distant 0, $\frac{1}{2}$ and $l$ respectively from one end. In order to make the net froce on q zero, the charge Q must be equal to

(a) –q (b) – 2q

(c) $\frac{-q}{2}$ (d) q

**122.** Force between two identical charges placed at a distance of r in vacuum is F. Now a slab of dielectric of dielectric contrant 4 is inserted between these two charges. If the thickness of the slab is r/2, then the force between the charges will become

(a) F (b) $\frac{3}{5}F$

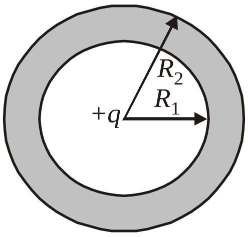
(c) $\frac{4}{9}F$ (d) $\frac{F}{2}$

**123.** Two particle of equal mass m and charge q are placed at a distance of 16 cm. They do not experience any force. The value of $\frac{q}{m}$ is

(a) 1 (b) $\sqrt{\frac{\pi\varepsilon_0}{G}}$

(c) $\sqrt{\frac{G}{4\pi\varepsilon_0}}$ (d) $\sqrt{4\pi\varepsilon_0 G}$

**124.** A metallic spherical shell has an inner radius $R_1$ and outer radius $R_2$. A charge is placed at the centre of the shperical cavity. The surface charge density on the inner surface is



(a) $\frac{q}{4\pi R_1^2}$ (b) $\frac{-q}{4\pi R_1^2}$

(c) $\frac{q^2}{4\pi R_2^2}$ (d) $\frac{q}{4\pi R_2^2}$

**125.** A uniformly charged conducting sphere of 4.4 m diameter has a surface charge density of 60 μ$C$ m$^{-2}$. The charge on the sphere is

(a) 7.3 × 10$^{-3}$$C$ (b) 3.7 × 10$^{-6}$ C

(c) 7.3 × 10$^{-6}$ $C$ (d) 3.7 × 10$^{-3}$ $C$

**126.** A rod of length 2.4 $m$ and radius 4.6 $mm$ carries a negative charge of 4.2 × 10$^{-7}$ C spread uniformly over it surface. The electric field near the mid–point of the rod, at a point on its surface is

(a) –8.6 × 10$^{5}$ N C$^{-1}$ (b) 8.6 × 10$^{4}$ N C$^{-1}$

(c) –6.7 × 10$^{5}$ N C$^{-1}$ (d) 6.7 × 10$^{4}$ N C$^{-1}$

**127.** If electric field in a region is radially outward with magnitude E = Ar, the charge contained in a sphere of radius r centred at the origin is

(a) $\frac{1}{4\pi\varepsilon_o}Ar^3$ (b) $4\pi\varepsilon_o Ar^3$

(c) $\frac{1}{4\pi\varepsilon_o}\frac{A}{r^3}$ (d) $\frac{4\pi\varepsilon_o A}{r^3}$

**128.** The electric field intensity just sufficient to balance the earth's gravitational attraction on an electron will be: (given mass and charge of an electron respectively are $9.1\times10^{-31}$kg and $1.6\times10^{-19}$C.)

(a) –5.6 × 10$^{-11}$ N/C (b) –4.8 × 10$^{-15}$ N / C

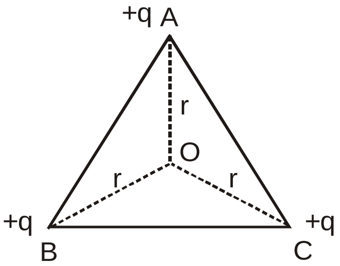
(c) –1.6 × 10$^{-19}$ N/C (d) –3.2 × 10$^{-19}$ N / C

**129.** The insulation property of air breaks down when the electric field is 3 × 10$^{6}$ Vm$^{-1}$. The maximum charge that can be given to a sphere of diameter 5 m is approximately

(a) 2 × 10$^{-2}$ C (b) 2 × 10$^{-3}$ C

(c) 2 × 10$^{-4}$ C (d) 2 × 10$^{-5}$ C

**130.** ABC is an equilateral triangle. Charges +q are placed at each corner as shown in fig. The electric intensity at centre O will be



(a) $\frac{1}{4\pi\in_o}\frac{q}{r}$ (b) $\frac{1}{4\pi\in_o}\frac{q}{r^2}$

(c) $\frac{1}{4\pi\in_o}\frac{3q}{r^2}$ (d) zero

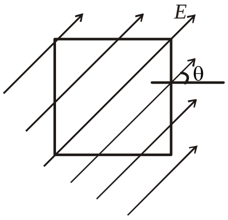
**131.** A hollow insulated conduction sphere is given a positive charge of 10 μC. What will be the electric field at the centre of the sphere if its radius is 2 m?

(a) Zero (b) 5 μCm$^{-2}$

(c) 20 μCm$^{-2}$ (d) 8 μCm$^{-2}$

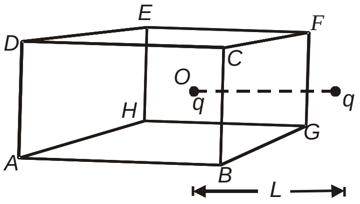
**132.** The number of electric lines of force that radiate outwards from one coulomb of charge in vacuum is
(a) $1.13 \times 10^{11}$ (b) $1.13 \times 10^{10}$
(c) $0.61 \times 10^{11}$ (d) $0.61 \times 10^{9}$

**133.** A square surface of side $L$ meter in the plane of the paper is placed in a uniform electric field $E$ (volt/m) acting along the same plane at an angle $\theta$ with the horizontal side of the square as shown in Figure. The electric flux linked to the surface is



(a) $EL^2$ (b) $EL^2 \cos\theta$
(c) $EL^2 \sin\theta$ (d) zero

**134.** A charged particle $q$ is placed at the centre $O$ of cube of length $L$ ($A\,B\,C\,D\,E\,F\,G\,H$). Another same charge $q$ is placed at a distance $L$ from $O$. Then the electric flux through $ABCD$ is



(a) $q/4\pi\in_0 L$ (b) zero
(c) $q/2\,\pi\in_0 L$ (d) $q/3\pi\in_0 L$

**135.** If the electric flux entering and leaving an enclosed surface respectively is $\phi_1$ and $\phi_2$, the electric charge inside the surface will be
(a) $(\phi_2 + \phi_2) \times \varepsilon_o$ (b) $(\phi_2 - \phi_2) \times \varepsilon_o$
(c) $(\phi_1 + \phi_2) \times \varepsilon_o$ (d) $(\phi_2 - \phi_1) \times \varepsilon_o$

**136.** In a region of space having a uniform electric field E, a hemispherical bowl of radius r is placed. The electric flux $\phi$ through the bowl is
(a) $2\pi RE$ (b) $4\pi R^2 E$
(c) $2\pi R^2 E$ (d) $\pi R^2 E$

**137.** A cylinder of radius R and length $\ell$ is placed in a uniform electric field E parallel to the axis of the cylinder. The total flux over the curved surface of the cylinder is
(a) zero (b) $\pi R^2 E$
(c) $2\pi R^2 E$ (d) $E / \pi R^2$

**138.** At the centre of a cubical box + Q charge is placed. The value of total flux that is coming out a wall is
(a) $Q / \varepsilon_o$ (b) $Q / 3\varepsilon_o$
(c) $Q / 4\varepsilon_o$ (d) $Q / 6\varepsilon_o$

**139.** The electric intensity due to a dipole of length 10 cm and having a charge of 500 μC, at a point on the axis at a distance 20 cm from one of the charges in air, is
(a) $6.25 \times 10^7$ N/C (b) $9.28 \times 10^7$ N/C
(c) $13.1 \times 10^{11}$ N/C (d) $20.5 \times 10^7$ N/C

**140.** Intensity of an electric field ($E$) depends on distance $r$, due to a dipole, is related as
(a) $E \propto \frac{1}{r}$ (b) $E \propto \frac{1}{r^2}$
(c) $E \propto \frac{1}{r^3}$ (d) $E \propto \frac{1}{r^4}$

**141.** An electric dipole has the magnitude of its charge as q and its dipole moment is p. It is placed in uniform electric field E. If its dipole moment is along the direction of the field, the force on it and its potential energy are respectively.
(a) q.E and max. (b) 2 q.E and min.
(c) q.E and min (d) zero and min.

**142.** An electric dipole of moment ´$p$´ is placed in an electric field of intensity ´$E$´. The dipole acquires a position such that the axis of the dipole makes an angle θ with the direction of the field. Assuming that the potential energy of the dipole to be zero when = 90°, the torque and the potential energy of the dipole will respectively be
(a) $pE\sin\theta, -pE\cos\theta$ (b) $pE\sin\theta, -2pE\cos\theta$
(c) $pE\sin\theta, 2pE\cos\theta$ (d) $pE\cos\theta, -pE\cos\theta$

**143.** If the dipole of moment $2.57 \times 10^{-17}$ cm is placed into an electric field of magnitude $3.0 \times 10^4$ N/C such that the fields lines are aligned at 30° with the line joining P to the dipole, what torque acts on the dipole?
(a) $7.7 \times 10^{-13}$ Nm (b) $3.855 \times 10^{-13}$ Nm
(c) $3.855 \times 10^{-15}$ Nm (d) $7.7 \times 10^{-15}$ Nm

**144.** An electric dipole is placed at an angle of 30° with an electric field of intensity $2 \times 10^5$ NC$^{-1}$, It experiences a torque of 4 Nm. Calculate the charge on the dipole if the dipole length is 2 cm.
(a) 8mC (b) 4mC
(c) 8 μC (d) 2mC

**145.** On decreasing the distance between the two charges of a dipole which is perpendicular to electric field and decreasing the angle between the dipole and electric field, the torque on the dipole
(a) increases (b) decreases
(c) remains same (d) cannot be predicted.

**146.** An electric dipole is put in north-south direction in a sphere filled with water. Which statement is correct?
(a) Electric flux is coming towards sphere
(b) Electric flux is coming out of sphere
(c) Electric flux entering into sphere and leaving the sphere are same
(d) Water does not permit electric flux to enter into sphere

**147.** The surface density on the copper sphere is σ. The electric field strength on the surface of the sphere is
(a) σ (b) σ/2
(c) $Q / 2\varepsilon_o$ (d) $Q / \varepsilon_o$

**148.** A charge Q is enclosed by a Gaussian spherical surface of radius R. If the radius is doubled, then the outward electric flux will
(a) increase four times (b) be reduced to half
(c) remain the same (d) be doubled

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(c)** **2.** **(d)**

**3.** **(b)** When we say that a body is charged, we always mean that the body is having excess of electrons (negatively charged) or is of deficient of electrons (positively charged).

**4.** **(a)** Valence electrons are outermost electrons these can get transferred on rubbing.

**5.** **(d)** **6.** **(a)** **7.** **(b)** **8.** **(c)** **9.** **(d)**

**10.** (a) A body with charge is called charged body. A body without charge is called neutral body.When we say that a body is charged, either it has excess electrons or it has lesser elctrons as compared to number of protons inside body.

**11.** **(c)** **12.** **(c)**

**13.** **(a)** Comb induces charge on paper due to which paper is attracted towards the comb.

**14.** **(b)** When some charge is given to conductor it spreads on its surface. When some charge is given to insulator, it remains there, it do not spread, Free charges in conductor interact with added charge, so added charge spreads on surface to be in equilibrium.

**15.** **(d)**

**16.** **(c)** Electron having a charge of $-1.6 \times 10^{-19}$C undergoes annihilation with it's antiparticle positron having a charge of $+1.6 \times 10^{-19}$C as

$$e^- + e^+ \to \gamma + \gamma$$

Net charge before annihilation

$$= -1.6\times10^{-19}C + 1.6\times10^{-19}C = 0$$

Net charge after annihilation = 0 + 0 = 0

i.e., net charge remains same.

**17.** **(d)** **18.** **(c)** **19.** **(d)** **20.** **(b)**

**21.** **(b)** Electric field is directly proportional to the magnitude of charge and inversely proportional to the square of the distance from the charge. Therefore charge +Q produce a comparatively stronger electric field than +q which get at cancelled with each other at a point closer to +q.

**22.** **(d)** **23.** **(b)** **24.** **(d)**

**25.** **(b)** If charge particle is put at rest in electric field, then it will move along line of force.

**26.** **(d)** For linear isotropic dielectric,

polarization $P = \chi_e E$,

$P \propto E$,

**27.** **(c)** By Gauss Law

**28.** **(a)** **29.** **(c)** **30.** **(d)** **31.** **(a)**

**32.** **(c)** S.I. unit of electric flux is $\dfrac{N\times m^2}{C} = \dfrac{J\times m}{C}$

= Volt × m.

**33.** **(c)** **34.** **(d)** **35.** **(d)**

**36.** **(d)** For distances far away from centre of dipole

$$E_{axis} = E_a = \frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}$$

$$E_{equa} = E_e = \frac{1}{4\pi\varepsilon_0} - \frac{p}{r^3}$$

$$\frac{d}{dr}(E_a) = \frac{1}{4\pi\varepsilon_0}2p\frac{d}{dr}(r^{-3})$$

$$= -6\cdot\frac{1}{4\pi\varepsilon_0}\frac{p}{r^4} \quad \text{...(i)}$$

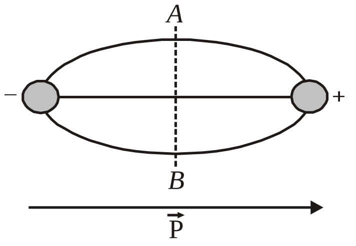
$$\frac{d}{dr}(E_e) = \frac{1}{4\pi\varepsilon_0}p\frac{d}{dr}(r^{-3})$$

$$= -3\frac{1}{4\pi\varepsilon_0}\frac{p}{r^4} \quad \text{...(ii)}$$

From equation (i) and (ii) the magnitude of change in electric field w.r.t. distance is more in case of axis of dipole as compared to equatorial plane.

**37.** **(b)**

**38.** **(b)** The direction of electric field at equatorial point *A* or *B* will be in opposite direction, as that of direction of dipole moment.



**39.** **(b)** **40.** **(b)** **41.** **(a)**

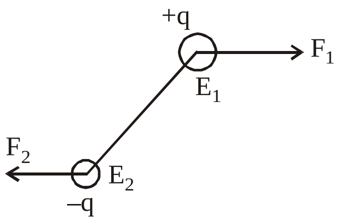
**42.** **(a)** Dipole is formed when two equal and unlike charges are placed at a short distance.

**43.** **(b)** **Given :** Dipole moment of the dipole = $\vec{p}$ and uniform electric field = $\vec{E}$. We know that dipole moment (p) = q.a (where q is the charge and a is dipole length). And when a dipole of dipole moment $\vec{p}$ is placed in uniform electric field $\vec{E}$, then Torque (τ) = Either force × perpendicular distance between the two forces = qaEsinθ or $\tau = pE\sin\theta$ or $\vec{\tau} = \vec{p}\times\vec{E}$ (vector form)

**44.** **(b)** We have $E_a = \dfrac{2kp}{r^3}$ and $E_e = \dfrac{kp}{r^3}$; $\therefore E_a = 2E_e$

**45.** **(a)**

**46.** **(c)**



The electric field will be different at the location of force on the two charges. Therefore the two charges will be unequal. This will result in a force as well as torque.

**47.** **(c)**

**48.** **(b)** **Given :** Dipole moment of the dipole = $\vec{p}$ and uniform electric field = $\vec{E}$. We know that dipole moment (p) = q.a (where q is the charge and a is dipole length). And when a dipole of dipole moment $\vec{p}$ is placed in uniform electric field $\vec{E}$, then Torque (τ) = Either force × perpendicular distance between the two forces = qaEsinθ or $\tau = pE\sin\theta$ or $\vec{\tau} = \vec{p} \times \vec{E}$ (vector form)

**49.** **(b)**

**50.** **(b)** Gauss's law is applicable only for closed surface and for the charge placed inside it not near it.

Total electric flux, $\phi_\in = \frac{1}{\varepsilon_0} Q$

**51.** **(a)** Gaussian surface cannot pass through any discrete charge because electric field due to a system of discrete charges is not well defined at the location of the charges. But the Gaussian surface can pass through a continuous charge distribution.

**52.** **(a)** Gauss's law is valid for any closed surface, no matter what its shape or size.

**53.** **(a)** According to Gauss's law total electric flux through a closed surface is $\frac{1}{\varepsilon_0}$ times the total charge inside that surface.

Electric flux, $\phi_E = \frac{q}{\varepsilon_0}$

Charge on α-particle = 2e

$\phi_E = \frac{2e}{\varepsilon_0}$

**54.** **(c)** The electric field due to an infinitely straight uniformly charged wire at any distance r

$$E = \frac{\lambda}{2\pi\varepsilon_0 r} \quad \therefore \; E \propto \frac{1}{r}$$

**55.** **(c)** $\oint \vec{E}.d\vec{A} = 0$, represents charge inside close surface is zero. Electric field as any point on the surface may be zero.

**56.** **(a)** Electric charge resides only on the surface of a spherical shell. According to Gauss's theorem the total electric flux over a closed surface is equal to the $\frac{1}{\varepsilon_0}$ times the total charge enclosed by the closed surface.

**57.** **(c)** Electric field near the conductor surface is given by $\frac{\sigma}{\varepsilon_0}$ and it is perpendicular to surface.

**58.** **(b)** **59.** **(a)** **60.** **(b)** **61.** **(d)**

## STATEMENT TYPE QUESTIONS

**62.** **(c)** Like charges repel ⟵ ⊕ ⊕ ⟶

Unlike charges attract ⊕ ⟶ ⟵ ⊖

To specify particular charge on body, term used is polarity.

On rubbing, plastic rod acquires negative charge, cat's fur acquires positive charge. There are only two kinds of charges: +, –.

**63.** **(c)** Milikan demonstrated the quantisation of charge experimentally. Charge on electron = – e = $-1.6 \times 100^{-19}$C. Addition of charge can occur in integral multiples of *e*.

**64.** **(b)** Nuclear force binds the protons and neutrons in the nucleus of an atom.

**65.** **(b)** (i) Electrostatic field is zero inside a charged conductor or neutral conductor.

(ii) Electrostatic field at the surface of a charged conductor must be normal to the surface at every point.

(iii) There is no net charge at any point inside the conductor and any excess charge must reside at the surface.

**66.** **(d)**

**67.** **(a)** Consider a system of charges $q_1, q_2, ..., q_n$ with position vectors $r_1, r_2 ..., r_n$ relative to some origin O. Like the field due to a single charage, electric field at a point in space due to the system of charges is defined to be the force experienced by a unit test charge placed at that point,, without disturbing the original position of charges $q_1, q_2, ..., q_n$. We can use Coulomb's law and the superposition principale to determine this field.

**68.** **(a)** Electric field lines start from positive charge and end at negative charge so they do not form closed loops.

**69.** **(b)** In a uniform electric field $\vec{E}$, dipole experiences a torque $\vec{\tau}$ given by

$$\vec{\tau} = \vec{p} \times \vec{E}$$

And potential energy of the dipole is

$$U = -\vec{p}.\vec{E}$$

**70.** **(a)** Polar molecules have permanent electric dipole moment.

**71.** **(d)**

## MATCHING TYPE QUESTIONS

**72.** **(c)** (A) → (2); (B) → (1) because total charge on L.H.S. is equal to total charge on R.H.S. (C) → (4) charge q is integer times the charge on an electron (D) → (3) because both are positively charged.

**73.** **(a)** Electric dipole moment points from negative charge to positive charge. Electric field points away from positive charge. Electric flux is the scalar product of electric field and area vector and torque is vector product of electric dipole moment and electric field.

**74. (a)** Linear charge density, $\lambda = \frac{\text{charge}}{\text{Length}}$

Surface charge density, $\sigma = \frac{\text{charge}}{\text{Area}}$

Volume charge density, $\rho = \frac{\text{charge}}{\text{volume}}$

**75. (a)** **76. (b)**

**77. (d)** For a point sized dipole $E \propto \frac{1}{r^3}$, for an infinitely long straight uniformly charged wire $E \propto \frac{1}{r}$ and for a point charge $E \propto \frac{1}{r^2}$.

Therefore as distance decreases the increase in electric field is maximum for dipole [curve(c)], then for point charge [curve (b)] and then for charged wire (curve (a)). The electric field is constant for a uniformly charged plane sheet.

**78. (c)**

## DIAGRAM TYPE QUESTIONS

**79. (c)** The weight mg of the charge hold in air is in equillibrium with net electrostatic force exerted by the four charges situated at the corners. The net electrostatic force is given by the vector sum of the individual forces exerted by the charges at the corners. This is principle of superposition.

**80. (d)** From Coulomb's law $F = \frac{Kq_1q_2}{r^2}$ i.e., $F \propto \frac{1}{r^2}$ which is correctly shown by graph (d).

**81. (d)**

**82. (c)** When charged rod is brought near uncharged conductor near end of conductor has opposite charge.When for end of this conductor is connected is ground (i.e., earthed), charge of far end flows down to ground when for end connection and rod are removed charge on conductor spreads uniformly on surface.

**83. (a)** For the distances close to the charge at x = 0 the field is very high and is in positive direction of x-axis. As we move towards the other charge the net electric field becomes zero at x = a thereafter the influence of charge at x = 2a dominates and net field increases in negative direction of x-axis and grows unboundedly as we come closer and closer to the charge at x = 2a.

**84. (b)** The electric field around a charge propagates with the speed of light away from the charge. Therefore the required time $= \frac{\text{distance}}{\text{speed}} = \frac{OP}{c}$.

**85. (c)**

**86. (a)** Since lines of force starts from A and ends at B, so A is +ve and B is –ve. Lines of forces are more crowded near A, so A > B.

**87. (d)** Since electric field $\vec{E}$ decreases inside water, therefore flux $\phi = \vec{E}.\vec{A}$ also decreases.

**88. (a)** The flux through the surface S is given by $\phi = ES\cos\theta$. When surface is rotated θ takes values $45° \to 0° \to -45°$ cos θ has maximum value at 0° therefore. The flux first increases, attain a maximum value and then decreases.

**89. (c)** Since electric field due to a point charge is inversely proportional to the square of distance therefore the field decreases at the place of surface S as the charge + Q moves away. Therefore the flux given by $\phi = \vec{E}\cdot\vec{S}$ also decreases.

**90. (a)** Torque is given by t = pE sin q. When the dipole is rotated from stable equillibrium to unstable equillibrium, θ takes values as $0° \to 90° \to 180°$ and sin θ takes corresponding values as $0 \to 1 \to 0$. Therefore torque increases from 0, attains maximum value and then again decreases to zero.

**91. (c)** The electric field due to a uniformly charged infinite plane sheet is given by $\vec{E} = \frac{\sigma}{2\varepsilon_0}\hat{n}$ which is independent of distance from the sheet. Therefore field remains constant.

**92. (a)** The flux is zero according to Gauss' Law because it is a open surface which enclosed a charge q.

## ASSERTION- REASON TYPE QUESTIONS

**93. (a)** Conservation of electric charge states that the total charge of an isolated system remains unchanged with time

**94. (b)** Both the statements are independently correct.

**95. (a)** Because of repulsion, the free electrons will mole to the outer surface.

**96. (c)** Coulomb force and gravitational force follow the same inverse-square law. But gravitational force has only one sign which is always attractive, while coulomb force can be of both signs which are attractive and repulasive.

**97. (d)** Gravitational force is the dominating force in nature and not coulomb's force. Gravitational force is the weakest force. Also, Coulomb's force > > gravitational force.

**98. (b)** Coulomb attraction exists even when one body is charged, and the other is uncharged.

**99. (c)** $q_d = e,\ m_d = 2m_p = 2m$

$q_\alpha = 2e,\ m_\alpha = 4m_p = 4m$

$F_1 = F_\alpha = eE,\ F_2 = F_\alpha = 2eE \neq F_1$

Further, $a_1 = \frac{F_1}{2m} = \frac{eE}{2m}$

and $a_2 = \frac{F_2}{2m} = \frac{2eE}{4m} = \frac{eE}{2m} = a_1$ s

**100. (b)** Force on any charge due to a number of other charges is the vector sum of all the forces on that charge due to the other charges, taken one at a time. The individual force are unaffected due to the presence of other charges. This is the principle of superposition of charges.

**101. (a)** The electrostatic shielding is possible by metallic conductor.

**102. (c)** The electric field will increase if positive charge is brought in an electric field.

**103. (b)** If +ve charge is displaced along x-axis, then net force will always act in a direction opposite to that of displacement and the test charge will always come back to its original position.

**104. (c)** Statement-1 is correct. The induced field cancels the external field. Statement-2 is false. When a current is set up in a conductor, there exists an electric field inside it.

**105. (a)** The electric field due to disc is superposition of electric field due to its constituent ring as given in Reason.

**106. (d)** Two field lines never intersect.

**107. (b)** Though the net charge on the conductor is still zero but due to induction negatively charged region is nearer to the rod as compared to the positively charged region. That is why the conductor gets attracted towards the rod.

**108. (d)** Electric field at any point depends on presence of all charges.

**109. (a)** The restoring torque brings it back to its stable equillibrium.

**110. (d)** The rate of decrease of electric field is different in the two cases. In case of a point charge, it decreases as $1/r^2$ but in the case of electric dipole it decreases more rapidly, as $E \propto 1/r^3$.

**111. (d)** $\oint \vec{E}.\vec{A} = EA\cos\theta$, this value can be zero, if either E is zero or $\theta = 90°$. But it must show that net charge inside close surface is zero.

**112. (a)** Since for an infinitely long straight uniformly charged wire, $\mathrm{E} = \frac{\lambda}{2\pi\varepsilon_0 \mathrm{r}}$ on moving a distance two times the initial distance away from wire, the distance from wire becomes 3r. Therefore final value of electric field

$$\mathrm{E}' = \frac{\lambda}{2\pi\varepsilon_0(3\mathrm{r})} = \frac{\mathrm{E}}{3}.$$

## CRITICALTHINKING TYPE QUESTIONS

**113. (b)** On touching the metal knob with a positively charged rod some electrons from the gold leaves get transferred to the rod making gold leaves positively charged and they get separated. When a negatively charged rod is touched with metal knob some negative charge flows to the gold leaves lessening the positive charge there and the separation between the leaves decreases.

**114. (a)**

**115. (b)** Electrostatic force is given by

$$\mathrm{F} = \frac{1}{4\pi\varepsilon_0}\frac{\mathrm{q_1 q_2}}{\mathrm{r}^2}$$

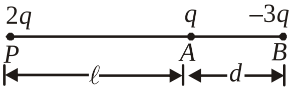
Here, charge and distance are same. So, force between two protons will be same

**116. (b)** Here, $q_1 = 1 \times 10^{-7}$C, $q_2$ and $2 \times 10^{-7}$ C, $r = 20$ cm $= 20 \times 10^{-2}\ m$

$$\text{As } F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}$$

$$= \frac{9\times10^9 \times 1\times10^{-7} \times 2\times10^{-7}}{(20\times10^{-2})^2} = 4.5 \times 10^{-3}\ N$$

**117. (b)**



Let a charge $2q$ be placed at $P$, at a distance $I$ from A where charge $q$ is placed, as shown in figure. The charge $2q$ will not experience any force, when force, when force of repulsion on it due to $q$ is balanced by force of attraction on it due to $-3q$ at $B$ where AB = $d$

$$\text{or} \quad \frac{(2q)(q)}{4\pi\varepsilon_0 \ell^2} = \frac{(2q)(-3q)}{4\pi\varepsilon_0(\ell+d)^2}$$

$$(\ell + d)^2 = 3\ell^2$$

$$\text{or} \quad 2\ell^2 - 2\ell d - d^2 = 0$$

$$\therefore \quad \ell = \frac{2d \pm \sqrt{4d^2 + 2d^2}}{4} = \frac{d}{2} \pm \frac{\sqrt{3}d}{2}$$

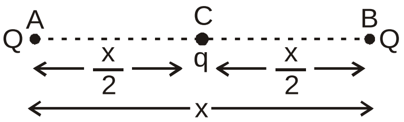
$$\ell = \frac{d + \sqrt{3}d}{2}$$

**118. (b)** Here $q_1 = q_2 = 3.2 \times 10^{-7}$ C, $r = 60$ cm $= 0.6\ m$

$$\text{Electrostatic force, } F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

$$= \frac{9\times10^9(3.2\times10^{-7})^2}{(0.6)^2} = 2.56 \times 10^{-3}\ N$$

**119. (d)** Let q charge is situated at the mid position of the line AB. The distance between AB is x. A and B be the positions of charges Q and Q respectively.



$$\text{Let } \mathrm{AC} = \frac{\mathrm{x}}{2},\ \mathrm{BC} = \frac{\mathrm{x}}{2}$$

The force on A due to charge q at C,

$$\vec{\mathrm{F}}_{\mathrm{CA}} = \frac{1}{4\pi\varepsilon_0}\cdot\frac{\mathrm{Q.q}}{(\mathrm{x}/2)^2} \text{ along } \overrightarrow{\mathrm{AC}}$$

The force on A due to charge Q at B

$$\vec{\mathrm{F}}_{\mathrm{AB}} = \frac{1}{4\pi\varepsilon_0}\cdot\frac{\mathrm{Q}^2}{\mathrm{x}^2} \text{ along } \overrightarrow{\mathrm{BA}}$$

The system is in equilibrium, then two oppositely directed force must be equal, i.e., total force on A is equal to zero.

$$\vec{F}_{CA}+\vec{F}_{AB}=0 \Rightarrow \vec{F}_{CA}=-\vec{F}_{AB}$$

$$\frac{1}{4\pi\varepsilon_0}.\frac{4Q.q}{x^2}=\frac{-1}{4\pi\varepsilon_0}.\frac{Q^2}{x^2}$$

$$\Rightarrow q=-\frac{Q}{4}$$

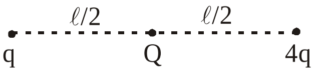
**120. (c)** Let $n$ be the number of electrons missing.

$$F=\frac{1}{4\pi\varepsilon_0}\cdot\frac{q^2}{d^2} \Rightarrow q=\sqrt{4\pi\varepsilon_0 d^2F}=ne$$

$$\therefore\quad n=\sqrt{\frac{4\pi\varepsilon_0 Fd^2}{e^2}}$$

**121. (a)** $(F_{net})_q=0$

$$\Rightarrow k\frac{Qq}{\left(\frac{\ell}{2}\right)^2}+k\frac{4q^2}{\ell^2}=0$$



where $k=\frac{1}{4\pi\varepsilon_0}$

$\Rightarrow 4Qq+4q^2=0$

$\Rightarrow Q=-q$

**122. (c)** In vacuum, $F=\frac{1}{4\pi\varepsilon_0}\frac{q^2}{r^2}$ …(i)

Suppose, force between the chrages is same when charges are r′ distance apart in dielectric.

$\therefore\quad F'=\frac{1}{4\pi\varepsilon_0}\frac{q^2}{kr'^2}$ …(ii)

From (i) and (ii), $kr'^2=r^2$ or, $r=\sqrt{kr'}$

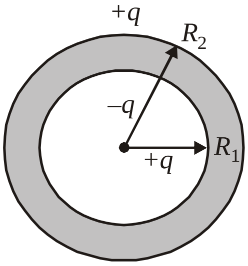
In the given situation, force between the charges would be

$$F'=\frac{1}{4\pi\varepsilon_0}\frac{q^2}{\left(\frac{r}{2}+\sqrt{4}\frac{r}{2}\right)^2}=\frac{4}{9}\frac{q^2}{4\pi\varepsilon_0 r^2}=\frac{4F}{9}$$

**123. (d)** They will not experience any force if $|\vec{F}_G|=|\vec{F}_e|$

$$\Rightarrow G\frac{m^2}{(16\times10^{-2})^2}=\frac{1}{4\pi\varepsilon_0}.\frac{q^2}{(16\times10^{-2})^2}\Rightarrow\frac{q}{m}=\sqrt{4\pi\varepsilon_0 G}$$

**124. (b)** When a charge + $q$ is placed at the centre of spherical as shown in figure.



Charge induced on the inner surface of shell $=-q$ ... (i)

Charge induced on the outer surface of shell $=+q$ ... (ii)

$\therefore$ Surface charge density on the inner surface $=\frac{-q}{4\pi R_1^2}$

**125. (d)** Here, $D=2r=4.4$ m, or $=r=2.2$ m

$\sigma=60\ \mu C\ m^{-2}$

Charge on the sphere, $q=\sigma\times4\pi r^2$

$=60\times10^{-6}\times4\times\frac{22}{7}\times(2.2)^2=3.7\times10^{-3}$ C

**126. (c)** Here, $\ell=2.4$ m, $r=4.6$ mm $=4.6\times10^{-3}$ m

$q=-4.2\times10^{-7}$ C

Linear charge density, $\lambda=\frac{q}{\ell}$

$$=\frac{-4.2\times10^{-7}}{2.4}=-1.75\times10^{-7}\ C\ m^{-1}$$

Electric field, $E=\frac{\lambda}{2\pi\varepsilon_0 r}$

$$=\frac{-1.75\times10^{-7}}{2\times3.14\times8.854\times10^{-12}\times4.6\times10^{-3}}$$

$=-6.7\times10^5$ N C$^{-1}$

**127. (b)** $E=\frac{q}{4\pi\varepsilon_o r^2}\Rightarrow Ar=\frac{q}{4\pi\epsilon_0 r^2}\Rightarrow q=4\pi\varepsilon_o Ar^3$

**128. (a)** $-eE=mg$

$$\vec{E}=-\frac{9.1\times10^{-31}\times10}{1.6\times10^{-19}}=-5.6\times10^{-11}\,N/C$$

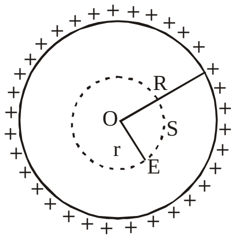
**129. (b)** $E=\frac{kQ}{r^2}\Rightarrow Q=\frac{E\times r^2}{k}=\frac{3\times10^6\times(2.5)^2}{9\times10^9}$

$$=2\times10^{-3}\,C$$

**130. (d)** Unit positive charge at O will be repelled equally by three charges at the three corners of triangle. By symmetry, resultant $\vec{E}$ at O would be zero.

**131. (a)** Charge resides on the outer surface of a conducting hollow sphere of radius R. We consider a spherical surface of radius r < R.

By Gauss theorem



$\int_s \vec{E}.\vec{ds} = \frac{1}{\varepsilon_0} \times$ charge enclosed or $E \times 4\pi r^2 = \frac{1}{\varepsilon_0} \times 0$

$\Rightarrow E = 0$

i.e electric field inside a hollow sphere is zero.

**132. (a)** Here, $q = 1$ C, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2N^{-1}m^{-2}$
Number of lines of force = Electric force

$$= \frac{q}{\varepsilon_0} = \frac{1}{8.85 \times 10^{-12}} = 1.13 \times 10^{11}$$

**133. (d)** Electric flux, $\phi = EA\cos\theta$, where $\theta$ = angle between $E$ and normal to the surface.

Here $\theta = \frac{\pi}{2}$

$\Rightarrow \phi = 0$

**134. (b)** The flux for both the charges exactly cancels the effect of each other.

**135. (d)**

**136. (c)** $\phi = E(ds)\cos\theta = E(2\pi r^2)\cos 0° = 2\pi r^2 E$.

**137. (a)** For the curved surface, θ = 90°

$\therefore \phi = E\ ds \cos 90° = 0$.

**138. (d)** According to Gauss' Law

$$\oint E.ds = \frac{Q_{\text{enclosed by closed surface}}}{\varepsilon_o} = \text{flux}$$

so total flux = $Q/\varepsilon_o$
Since cube has six face, so flux coming out through one wall or one face is $Q/6\varepsilon_o$.

**139. (a)** **Given :** Length of the dipole ($2l$) = 10cm = 0.1m or $l$ = 0.05m
Charge on the dipole (q) = 500 μC = 500 × $10^{-6}$ C and distance of the point on the axis from the mid-point of the dipole (r) = 20 + 5 = 25 cm = 0.25 m.
We know that the electric field intensity due to dipole on the given point (E)

$$= \frac{1}{4\pi\varepsilon_0} \times \frac{2(q.2l)r}{(r^2 - l^2)^2}$$

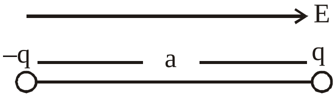
$$= 9 \times 10^9 \times \frac{2(500 \times 10^{-6} \times 0.1) \times 0.25}{[(0.25)^2 - (0.05)^2]^2}$$

$$= \frac{225 \times 10^3}{3.6 \times 10^{-3}} = 6.25 \times 10^7 \text{ N/C} \text{ (k = 1 for air)}$$

**140. (c)** Intensity of electric field due to a Dipole

$$E = \frac{p}{4\pi\varepsilon_0 r^3}\sqrt{3\cos^2\theta + 1} \Rightarrow E \propto \frac{1}{r^3}$$

**141. (d)** When the dipole is in the direction of field then net force is qE + (–qE) = 0



and its potential energy is minimum = – p.E.
= – qaE

**142. (a)** The torque on the dipole is given as
$\tau = PE\sin\theta$
The potential energy of the dipole in the electric field is given as
$U = -PE\cos\theta$

**143. (b)** $\tau = \left(2.57 \times 10^{-17}\text{Cm}\right)\left(3.0 \times 10^4 \frac{\text{N}}{\text{C}}\right)\left(\frac{1}{2}\right)$

$= 3.855 \times 10^{-13}$ Nm.

**144. (d)** Torque, $\vec{\tau} = \vec{p} \times \vec{E} = pE\sin\theta$
$4 = p \times 2 \times 10^5 \times \sin 30°$

or, $p = \frac{4}{2 \times 10^5 \times \sin 30°} = 4 \times 10^{-5}$Cm

Dipole moment, p = q × $l$

$$q = \frac{p}{l} = \frac{4 \times 10^{-5}}{0.02} = 2 \times 10^{-3}\text{C} = 2\text{mC}$$

**145. (b)** Since $\tau = pE\sin\theta$ on decreasing the distance between the two charges, and on decreasing angle θ between the dipole and electric field, sin θ decreases therefore torque decreases.

**146. (c)** If electric dipole, the flux coming out from positive charge is equal to the flux coming in at negative charge *i.e.* total charge on sphere = 0. From Gauss law, total flux passing through the sphere = 0.

**147. (d)** According to Gauss's theorem,

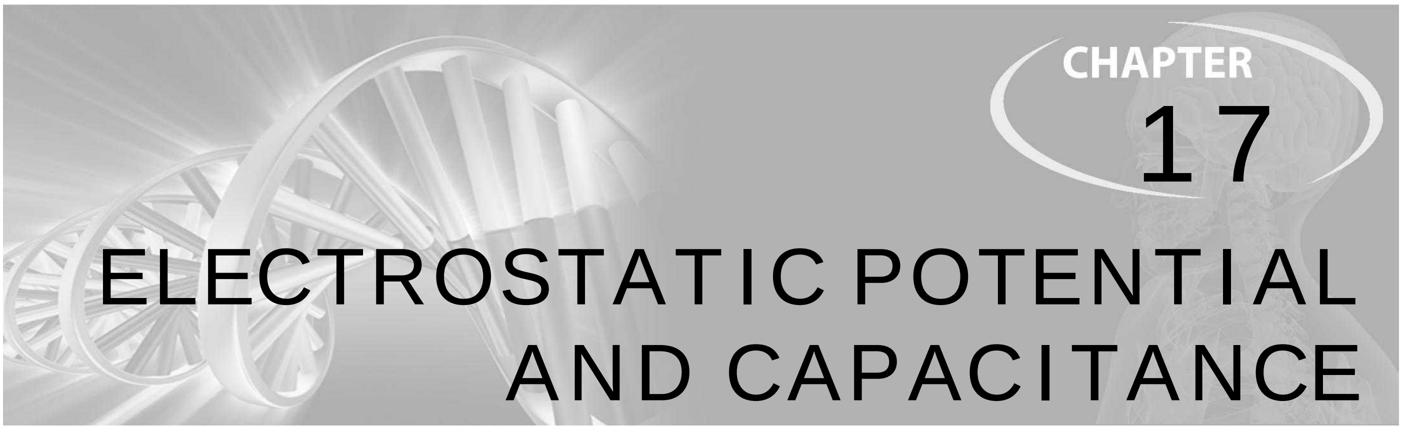
$$E\oint ds = \frac{q}{\epsilon_0}\left[\text{Here} \oint ds = 4\pi R^2\right]$$

$$\therefore E = \frac{q/4\pi R^2}{\epsilon_0} \quad [\because q/4\pi R^2 = \sigma]$$

or $E = \sigma/\varepsilon_o$

**148. (c)** By Gauss's theorem, $\phi = \frac{Q_{in}}{\epsilon_0}$

Thus, the net flux depends only on the charge enclosed by the surface. Hence, there will be no effect on the net flux if the radius of the surface is doubled.



# CHAPTER 17

# ELECTROSTATIC POTENTIAL AND CAPACITANCE

## FACT/DEFINITION TYPE QUESTIONS

**1.** In a region of constant potential
(a) the electric field is uniform
(b) the electric field is zero
(c) the electric field shall necessarily change if a charge is placed outside the region
(d) None of these

**2.** The electric potential inside a conducting sphere
(a) increases from centre to surface
(b) decreases from centre to surface
(c) remains constant from centre to surface
(d) is zero at every point inside

**3.** It becomes possible to define potential at a point in an electric field because electric field
(a) is a conservative field
(b) is a non-conservative field
(c) is a vector field
(d) obeys principle of superposition

**4.** Which of the following about potential at a point due to a given point charge is true ?
The potential at a point P due to a given point charge
(a) is a function of distance from the point charge.
(b) varies inversely as the square of distance from the point charge.
(c) is a vector quantity
(d) is directly proportional to the square of distance from the point charge.

**5.** Which of the following quantities do not depend on the choice of zero potential or zero potential energy?
(a) Potential at a point
(b) Potential difference between two points
(c) Potential energy of a two-charge system
(d) None of these

**6.** A cube of a metal is given a positive charge Q. For this system, which of the following statements is true?
(a) Electric potential at the surface of the cube is zero
(b) Electric potential within the cube is zero
(c) Electric field is normal to the surface of the cube
(d) Electric field varies within the cube

**7.** A unit charge moves on an equipotential surface from a point A to point B, then
(a) $V_A - V_B = +\text{ve}$ (b) $V_A - V_B = 0$
(c) $V_A - V_B = -\text{ve}$ (d) it is stationary

**8.** An equipotential surface is that surface
(a) on which each and every point has the same potential
(b) which has negative potential
(c) which has positive potential
(d) which has zero potential

**9.** To obtain 3 μF capacity from three capacitors of 2 μF each, they will be arranged.
(a) all the three in series
(b) all the three in parallel
(c) two capacitors in series and the third in parallel with the combinatioin of first two
(d) two capacitors in parallel and the third in series with the combinatioin of first two

**10.** There are two metallic spheres of same radii but one is solid and the other is hollow, then
(a) solid sphere can be given more charge
(b) hollow sphere can be given more charge
(c) they can be charged equally (maximum)
(d) None of the above

**11.** If a unit positive charge is taken from one point to another over an equipotential surface, then
(a) work is done on the charge
(b) work is done by the charge
(c) work done is constant
(d) no work is done

**12.** On moving a charge of Q coulomb by X cm, W J of work is done, then the potential difference between the points is
(a) $\frac{W}{Q}$ V (b) QWV (c) $\frac{Q}{W}$ V (d) $\frac{Q^2}{W}$ V

**13.** The positive terminal of 12 V battery is connected to the ground. Then the negative terminal will be at
(a) $-6$ V (b) $+12$ V (c) zero (d) $-12$ V

**14.** The maximum electric field that a dielectric medium can withstand without break-down is called its
(a) permittivity (b) dielectric constant
(c) electric susceptibility (d) dielectric strength

**15.** The potential energy of a system of two charges is negative when
- (a) both the charges are positive
- (b) both the charges are negative
- (c) one charge is positive and other is negative
- (d) both the charges are separated by infinite distance

**16.** The electric potential at a point on the equatorial line of an electric dipole is
- (a) directly proportional to distance
- (b) inversely proportional to distance
- (c) inversely proportional to square of the distance
- (d) None of these

**17.** An electric dipole is kept in non-uniform elecric field. it experiences
- (a) a force and a torque
- (b) a force but not a torque
- (c) a torque but not a force
- (d) Neither a force nor a torque

**18.** The value of electric potential at any point due to any electric dipole is
- (a) $k.\frac{\vec{p}\times\vec{r}}{r^2}$ (b) $k.\frac{\vec{p}\times\vec{r}}{r^3}$
- (c) $k.\frac{\vec{p}.\vec{r}}{r^2}$ (d) $k.\frac{\vec{p}.\vec{r}}{r^3}$

**19.** An electric dipole of moment $\vec{p}$ is placed normal to the lines of force of electric intensity $\vec{E}$, then the work done in deflecting it through an angle of 180° is
- (a) $pE$ (b) $+2pE$
- (c) $-2pE$ (d) zero

**20.** The energy required to charge a parallel plate condenser of plate separation $d$ and plate area of cross-section $A$ such that the uniform electric field between the plates is $E$, is
- (a) $\in_0 E^2\text{Ad}$ (b) $\frac{1}{2}\in_0 E^2\text{Ad}$
- (c) $\frac{1}{2}\in_0 E^2/\text{Ad}$ (d) $\in_0 E^2/\text{Ad}$

**21.** A hollow metal sphere of radius 5 cm is charged such that the potential on its surface is 10 V. The potential at a distance of 2 cm from the centre of the sphere is
- (a) zero (b) 10 V (c) 4 V (d) 10/3 V

**22.** A charge is brought from a point on the equatorial plane of a dipole to its mid-point. Which of the following quantities remains constant ?
- (a) Electric field
- (b) Force on the charge brought.
- (c) Torque exerted by the charge on dipole.
- (d) Electric potential

**23.** On decreasing the distance between the plates of a parallel plate capacitor, its capacitance
- (a) remains unaffected
- (b) decreases
- (c) first increases then decreases.
- (d) increases

**24.** Energy is stored in a capacitor in the form of
- (a) electrostatic energy (b) magnetic energy
- (c) light energy (d) heat energy

**25.** If in a parallel plate capacitor, which is connected to a battery, we fill dielectrics in whole space of its plates, then which of the following increases?
- (a) Q and V (b) V and E
- (c) E and C (d) Q and C

**26.** A capacitor works in
- (a) A. C. circuits (b) D. C. circuits
- (c) both (a) and (b) (d) neither (a) nor (b)

**27.** In a charged capacitor, the energy is stored in
- (a) the negative charges
- (b) the positive charges
- (c) the field between the plates
- (d) both (a) and (b)

**28.** A sheet of aluminium foil of negligible thickness is introduced between the plates of a capacitor. The capacitance of the capacitor
- (a) decreases (b) remains unchanged
- (c) becomes infinite (d) increases

**29.** The potential gradient at which the dielectric of a condenser just gets punctured is called
- (a) dielectric constant (b) dielectric strength
- (c) dielectric resistance (d) dielectric number

**30.** When air in a capacitor is replaced by a medium of dielectric constant $K$, the capacity
- (a) decreases $K$ times (b) increases $K$ times
- (c) increases $K^2$ times (d) remains constant

**31.** A parallel plate condenser is immersed in an oil of dielectric constant 2. The field between the plates is
- (a) increased, proportional to 2
- (b) decreased, proportional to $\frac{1}{2}$
- (c) increased, proportional to – 2
- (d) decreased, proportional to $-\frac{1}{2}$

**32.** A conductor carries a certain charge. When it is connected to another uncharged conductor of finite capacity, then the energy of the combined system is
- (a) more than that of the first conductor
- (b) less than that of the first conductor
- (c) equal to that of the first conductor
- (d) uncertain

**33.** The energy stored in a condenser of capacity $C$ which has been raised to a potential $V$ is given by
- (a) $u = \frac{1}{2}CV$ (b) $u = \frac{1}{2}CV^2$
- (c) $u = CV$ (d) $u = \frac{1}{2VC}$

**34.** Capacitiors are used in electrical circuits where applicances need more

(a) voltage (b) current

(c) resistance (d) power

**35.** The work done in placing a charge of $8 \times 10^{-18}$ coulomb on a condenser of capacity 100 micro-farad is

(a) $3.1 \times 10^{-26}$ joule (b) $4 \times 10^{-10}$ joule

(c) $32 \times 10^{-32}$ joule (d) $16 \times 10^{-232}$ joule

**36.** An arrangement which consists of two conductors separated by a dielectric medium is called

(a) resistor (b) inductor

(c) rectifier (d) capacitor

**37.** Capacity of a parallel plate condenser can be increased by

(a) increasing the distance between the plates

(b) increasing the thickness of the plates

(c) decreasing the thickness of the plates

(d) decreasing the distance between the plates

**38.** In a charged capacitor, the energy resides

(a) in the positive charges.

(b) in both the positive and negative charges.

(c) in the field between the plates.

(d) around the edges of the capacitor plates.

**39.** The resultant capacitance of n condenser of capacitances $C_1, C_2 .... C_n$ connected in series is given by

(a) $C_s = \frac{1}{C_1} + \frac{1}{C_2} + ........ + \frac{1}{C_n}$

(b) $\frac{1}{C_s} = \frac{1}{C_1} + ........ + \frac{1}{C_n}$

(c) $C_s = C_1 + C_2 + ..... + C_n$

(d) $C_s = C_1 - C_2 + ..... - C_n$

**40.** The resultant capacity of n condensers of capacitances $C_1$, $C_2 .... C_n$ connected in parallel is

(a) $C_p = C_1 + C_2 + ....... + C_n$

(b) $C_p = C_1 - C_2 - C_3 ....... - C_n$

(c) $\frac{1}{C_p} = \frac{1}{C_1} + \frac{1}{C_2} + ...... + \frac{1}{C_n}$

(d) $C_p = \frac{1}{C_1} + \frac{1}{C_2} + ...... + \frac{1}{C_n}$

**41.** ...*X*... is a machine that can build up high voltages of the order of a few million volts. Here, A refers to

(a) Dynamo (b) Van De Graaff generator

(c) DC generator (d) AC generator

**42.** In case of a Van de Graaff generator, the breakdown field of air is

(a) $2 \times 10^8 \ V m^{-1}$ (b) $3 \times 10^6 \ V m^{-1}$

(c) $2 \times 10^8 \ V m^{-1}$ (d) $3 \times 10^4 \ V m^{-1}$

**43.** Van de Graaff generator is used to

(a) store electrical energy

(b) build up high voltage of few million volts

(c) decelerate charged particle like electrons

(d) both (a) and (b)

**44.** Which of the following is / are true about the principle of Van de Graaff generator?

(a) The action of sharp points.

(b) The charge given to a hollow conductor is tranferred to outer surface and is distributed uniformly over it.

(c) It is used for accelerating uncharged particle.

(d) Both (a) and (b)

## STATEMENT TYPE QUESTIONS

**45.** Which of the following about potential difference between any two points is true?

I. It depends only on the initial and final position.

II. It is the work done per unit positive charge in moving from one point to other.

III. It is more for a positive charge of two units as compared to a positive charge of one unit.

(a) I only (b) II only

(c) I and II (d) I, II and III

**46.** An electric dipole of moment $\vec{P}$ is placed in a uniform electric field $\vec{E}$. Then which of the following is/are correct?

I. The torque on the dipole is $\vec{p} \times \vec{E}$.

II. The potential energy of the system is $\vec{p}.\vec{E}$.

III. The resultant force on the dipole is zero.

(a) I, II and II (b) I and III

(c) II and III (d) I, II and III

**47.** Consider the following statements and select the correct option

I. In an external electric field, the positive and negative charges of a non–polar molecule are displaced in opposite directions.

II. In non –polar molecules displacement stops when the external force on the constituent charges of the molecule is balanced by the restoring force.

III. The non–polar molecule develops an induced dipole moment.

(a) I and II (b) II and III

(c) I and III (d) I, II and III

**48.** Consider the following statements and select the correct statement(s).

I. Electric field lines are always perpendicular to equipotential surface.

II. No two equipotential surfaces can intersect each other.

III. Electric field lines are in the direction of tangent to an equipotential surface.

(a) I only (b) II only

(c) I and II (d) I, II and III

**49.** The energy stored in a parallel plate capacitor is given by $V_E = \frac{Q^2}{2C}$. Now which of the following statements is not true ?

I. The work done in charging a capacitor is stored in the form of electrostatic potential energy given by expression $V_E = \frac{Q^2}{2C}$

II. The net charge on the capacitor is Q.

III. The magnitude of the net charge on one plate of a capacitor is Q.

(a) I only (b) II only
(c) I and II (d) I, II and III

**50.** Which of the following statements is/are correct for equipotential surface ?

I. The potential at all the points on an equipotential surface is same.

II. Equipotential surfaces never intersect each other.

III. Work done in moving a charge from one point to other on an equipotential surface is zero.

(a) I only (b) II only
(c) I and II (d) I, II and III

**51.** When a metal plate is introduced between the two plates of a charged capacitor and insulated from them, then which of following statement(s) is/are correct ?

I. The metal plate divides the capacitor into two capacitors connected in parallel to each other

II. The metal plate divides the capacitors into two capacitors connected in series with each other

III. The metal plate is equivalent to a dielectric of zero dielectric constant

(a) I only (b) II only
(c) I and II (d) I, II and III

**52.** Consider the followoing statements regarding series grouping of capacitors and select the correct statements.

I. Charge on each capacitor remains same and equals to the main charge supplied by the battery.

II. Potential difference and energy distributes in the reverse ratio of capacitance.

III. Effective capacitance is even les than the least of teh individual capacitances.

(a) I and II (b) I and III
(c) II and III (d) I, II and III

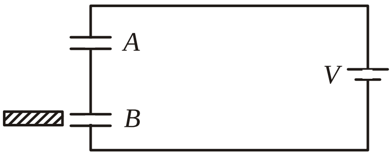
## MATCHING TYPE QUESTIONS

**53.** Match the Column I and Column II.

| | Column-I | | Column -II |
|---|---|---|---|
| (A) | Electric potential near an isolated positive charge | (1) | Negative |
| (B) | Electric potential near an isolated negative charge | (2) | Positive |
| (C) | Electric potential due to a charge at its own location is not defined | (3) | Varies inversly of radius |
| (D) | Electric potential due to uniformly charged solid non-conducting sphere | (4) | Infinite |

(a) (A) $\rightarrow$ (2); (B) $\rightarrow$ (1); (C) $\rightarrow$ (4); (D) $\rightarrow$ (3)
(b) (A) $\rightarrow$ (1); (B) $\rightarrow$ (3); (C) $\rightarrow$ (4); (D) $\rightarrow$ (2)
(c) (A) $\rightarrow$ (4); (B) $\rightarrow$ (1); (C) $\rightarrow$ (3); (D) $\rightarrow$ (4)
(d) (A) $\rightarrow$ (3); (B) $\rightarrow$ (2); (C) $\rightarrow$ (1); (D) $\rightarrow$ (4)

**54.** When a dielectric slab is inserted between the plates of one of the two identical capacitors shown in the figure then match the following:



| | Column-I | | Column -II |
|---|---|---|---|
| (A) | Charge on A | (1) | Increases |
| (B) | Potential difference across A | (2) | Decreases |
| (C) | Potential difference across B | (3) | Remains constant |
| (D) | Charge on B | (4) | Cannot say |

(a) (A) $\rightarrow$ (1); (B) $\rightarrow$ (2); (C) $\rightarrow$ (2); (D) $\rightarrow$ (1)
(b) (A) $\rightarrow$ (1); (B) $\rightarrow$ (1); (C) $\rightarrow$ (2); (D) $\rightarrow$ (2)
(c) (A) $\rightarrow$ (2); (B) $\rightarrow$ (2); (C) $\rightarrow$ (2); (D) $\rightarrow$ (4)
(d) (A) $\rightarrow$ (1); (B) $\rightarrow$ (2); (C) $\rightarrow$ (2); (D) $\rightarrow$ (3)

**55.** Match the entries of Column I and Column II

| | Column I | | Column II |
|---|---|---|---|
| (A) | Inside a conductor placed in an external electric field. | (1) | Potential energy = 0 |
| (B) | At the centre of a dipole | (2) | Electric field = 0 |
| (C) | Dipole in stable equilibrium | (3) | Electric potential = 0 |
| (D) | Electric dipole perpendicular to uniform electric field. | (4) | Torque = 0 |

(a) (A) $\rightarrow$ (2); (B) $\rightarrow$ (4); (C) $\rightarrow$ (3); (D) $\rightarrow$ (1)
(b) (A) $\rightarrow$ (2); (B) $\rightarrow$ (3); (C) $\rightarrow$ (4); (D) $\rightarrow$ (1)
(c) (A) $\rightarrow$ (2); (B) $\rightarrow$ (3); (C) $\rightarrow$ (1); (D) $\rightarrow$ (4)
(d) (A) $\rightarrow$ (1); (B) $\rightarrow$ (3); (C) $\rightarrow$ (4); (D) $\rightarrow$ (2)

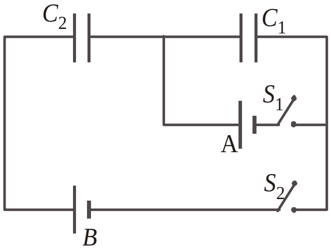
**56.** Match the types of capacitors in Column I and expressions of capacitances in Column II.

| | Column I | | Column II |
|---|---|---|---|
| (A) | Spherical capacitor | (1) | $\frac{\varepsilon_0 KA}{d}$ |
| (B) | Cylindrical capacitor | (2) | $\frac{\varepsilon_0 A}{d}$ |

| | | | |
|---|---|---|---|
| (C) | Parallel plate capacitor air filled | (3) | $\dfrac{2\pi\varepsilon_0\ell}{\ln\left(\dfrac{r_2}{r_1}\right)}$ |
| (D) | Parallel plate capacitor with dielectric slab between the plates. | (4) | $\dfrac{4\pi\varepsilon_0 r_1 r_2}{r_1 - r_2}$ |

(a) (A) → (4); (B) → (2); (C) → (3); (D) → (1)
(b) (A) → (4); (B) → (3); (C) → (1); (D) → (2)
(c) (A) → (3); (B) → (4); (C) → (2); (D) → (1)
(d) (A) → (4); (B) → (3); (C) → (2); (D) → (1)

**57.** In the given circuit diagram, both capacitors are initially uncharged. The capacitance $C_1$ = 2F and $C_2$ = 4F emf of battery *A* and *B* are 2V and 4V respectively.

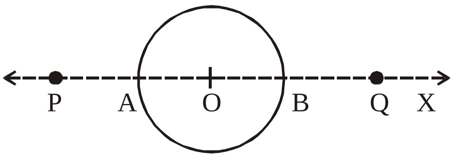


| **Column - I** | | **Column - II (Magnitude only)** | |
|---|---|---|---|
| (A) | On closing switch $S_1$ with $S_2$ open work done by battery *A* is | (1) | $\dfrac{64}{3}$ |
| (B) | Switch $S_1$ is open and $S_2$ is closed, work done by battery *B* is | (2) | 4 |
| (C) | Charge on capacitor $C_2$ is (after $S_1$ open and $S_2$ closed) | (3) | 8 |
| (D) | Charge on $C_1$ when both are closed | (4) | $\dfrac{16}{3}$ |
| | | (5) | zero |

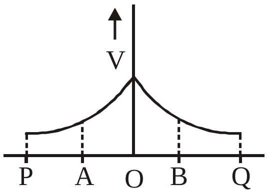
(a) (A) → (1); (B) → (2); (C) → (2); (D) → (4)
(b) (A) → (4); (B) → (3); (C) → (3); (D) → (1)
(c) (A) → (2); (B) → (3); (C) → (2); (D) → (1)
(d) (A) → (3); (B) → (1); (C) → (4); (D) → (2)

## DIAGRAM TYPE QUESTIONS

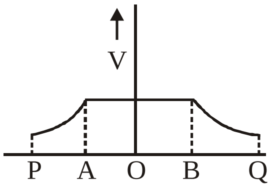
**58.** Which of the following graphs correctly shows the variation of electric potential due to uniformly charged thin spherical shell with its centre at origin, as we move from point P to Q along x-axis?



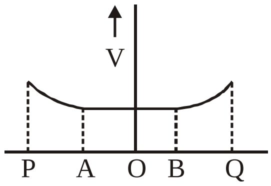
(a)



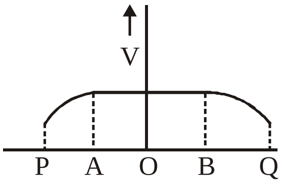
(b)



(c)

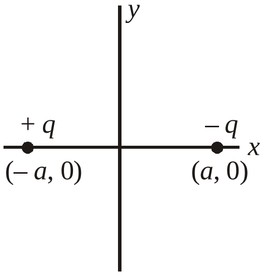


(d)

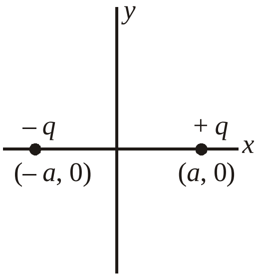


**59.** In which of the following cases is the electric field zero but potential is not zero at a point on x-axis ?

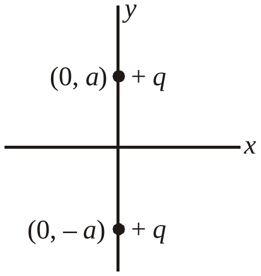
(a)



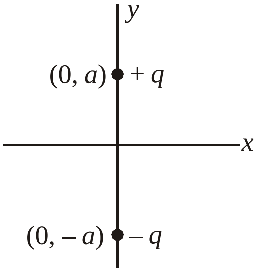
(b)



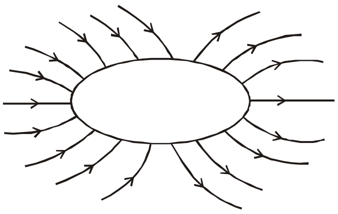
(c)



(d)

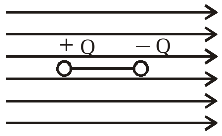


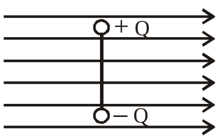
**60.** Figure below shows a hollow conducting body placed in an electric field. Which of the quantities are zero inside the body?

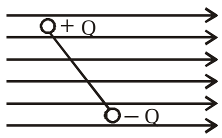


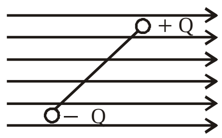
(a) Electric field and potential
(b) Electric field and charge density
(c) Electric potential and charge density.
(d) Electric field, potential and charge density.

**61.** The following figures show an electric dipole in four orientations in uniform electric field. Arrange them in increasing order of potential energy.

(i)


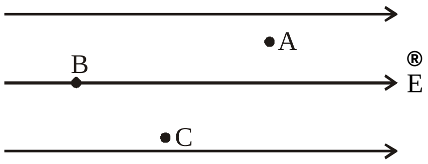
(ii)


(iii)


(iv)


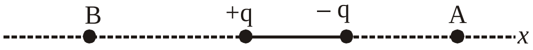
(a) (i), (ii), (iii), (iv)
(b) (iv), (iii), (ii), (i)
(c) (iv), (ii), (i), (iii)
(d) (iv), (ii), (iii), (i)

**62.** A, B and C are three points in a uniform electric field. The electric potential is



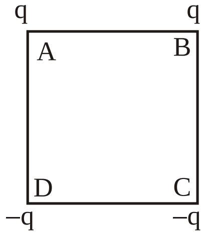
(a) maximum at B
(b) maximum at C
(c) same at all the three points A, B and C
(d) maximum at A

**63.** The figure shows the electric dipole placed along x-axis. As we move from point A to point B potential changes from



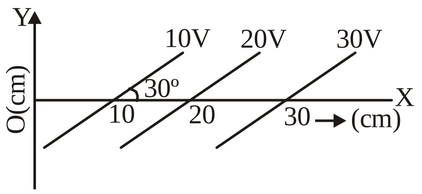
(a) positive to negative
(b) negative to positive
(c) positive to zero
(d) does not change

**64.** Charges are placed on the vertices of a square as shown. Let $\vec{E}$ be the electric field and V the potential at the centre. If the charges on A and B are interchanged with those on D and C respectively, then



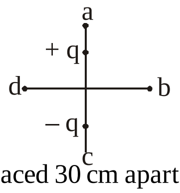
(a) $\vec{E}$ changes, V remains unchanged
(b) $\vec{E}$ remains unchanged, V changes
(c) both $\vec{E}$ and V change
(d) $\vec{E}$ and V remain unchanged

**65.** Equipotential surfaces are shown in figure. Then the electric field strength will be



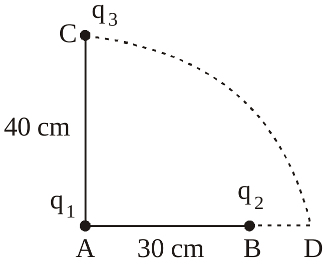
(a) 100 $Vm^{-1}$ along X-axis
(b) 100 $Vm^{-1}$ along Y-axis
(c) 200 $Vm^{-1}$ at an angle 120° with X-axis
(d) 50 $Vm^{-1}$ at an angle 120° with X-axis

**66.** Four points a, b, c and d are set at equal distance from the centre of a dipole as shown in figure. The electrostatic potential $V_a$, $V_b$, $V_c$, and $V_d$ would satisfy the following relation:



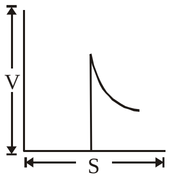
(a) $V_a > V_b > V_c > V_d$
(b) $V_a > V_b = V_d > V_c$
(c) $V_a > V_c = V_b = V_d$
(d) $V_b = V_d > V_a > V_c$

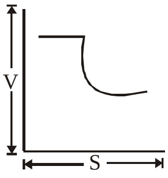
**67.** Two charges $q_1$ and $q_2$ are placed 30 cm apart, as shown in the figure. A third charge $q_3$ is moved along the arc of a circle of radius 40 cm from C to D. The change in the potential energy of the system is $\frac{q_3}{4\pi\epsilon_0}k$,, where k is

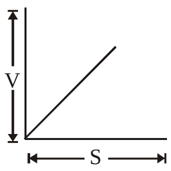


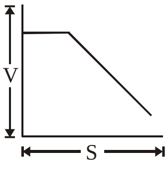
(a) $8q_1$ (b) $6q_1$ (c) $8q_2$ (d) $6q_2$

**68.** In a hollow spherical shell, potential (V) changes with respect to distance (s) from centre as

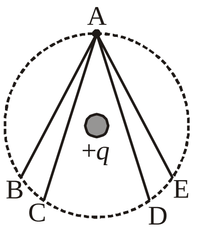
(a)


(b)


(c)


(d)


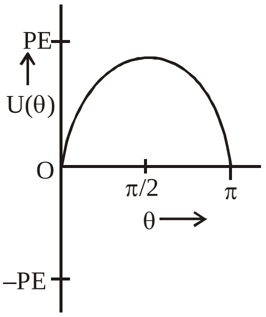
**69.** In the electric field of a point charge *q*, a certain charge is carried from point *A* to *B*, *C*, *D* and *E*. Then the work done is



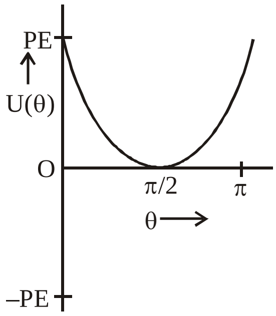
(a) least along the path *AB*
(b) least along the path *AD*
(c) zero along all the paths *AB*, *AC*, *AD* and *AE*
(d) least along *AE*

**70.** Which of the following graphs show the correct variation of magnitude of potential energy of a dipole when rotated from stable equillibrium to unstable equillibrium?

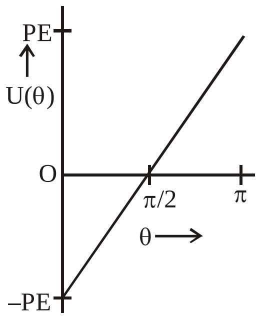
(a)



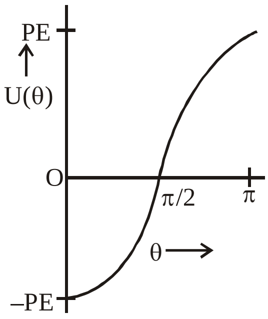
(b)



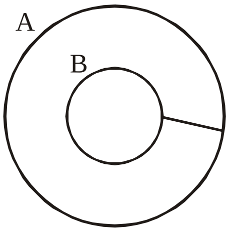
(c)



(d)

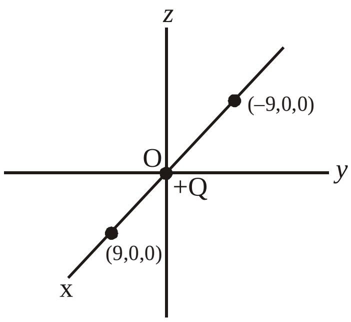


**71.** Figure shows two hollow charged conductors A and B having same positive surface charge densities. B is placed inside A and does not touches it. On connecting them with a conductor



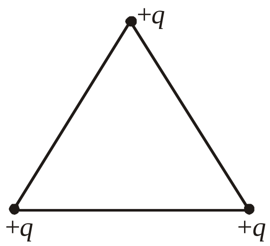
(a) charge will flow from A to B
(b) charge will flow from B to A
(c) charge oscillates between A and B
(d) No charge will flow.

**72.** Figure shows a charge + Q placed at origin. Another charge + q is brought from infinity to (9, 0, 0) from positive direction of x-axis in case I and from infinity to (–9, 0, 0) from negative direction of x-axis in case II. Which one of the following is true?



(a) The potential energy is positive in case I and negative in case II.
(b) The potential energy is negative in case I and positive in case II.
(c) The potential energy is same in both the cases and is negative.
(d) The potential energy is same in both the cases and is positive.

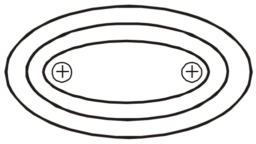
**73.** Figure shows a system of three positive charges placed at the vertices of an equilateral triangle. To decrease the potential energy of the system,



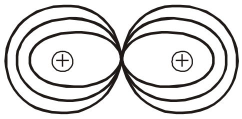
(a) a positive charge should be placed at centroid
(b) a negative charge should be placed at centroid.
(c) distance between the charges should be decreased.
(d) it should be rotated by an angle of $\frac{\pi}{2}$ radian.

**74.** Which of the following figure shows the correct equipotential surfaces of a system of two positive charges?

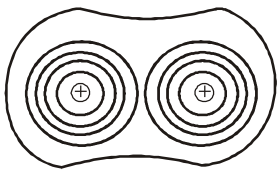
(a)



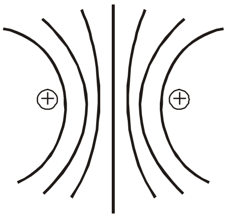
(b)



(c)

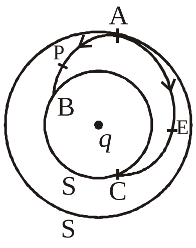


(d)

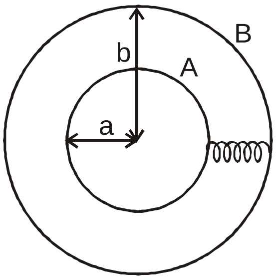


**75.** Two equipotential surfaces $S_1$ and $S_2$ are around a charge q. A test charge is moved from $S_1$ to $S_2$ along the paths APB and AEC as shown in figure. The work done is

(a) more in case of APB
(b) more in case of AEC
(c) same in both the cases
(d) cannot say



**76.** Two spherical conductors A and B of radii a and b (b>a) are placed concentrically in air. The two are connected by a copper wire as shown in figure. Then the equivalent capacitance of the system is



(a) $4\pi\varepsilon_0 \dfrac{ab}{b-a}$

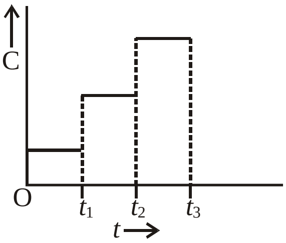
(b) $4\pi\varepsilon_0(a+b)$

(c) $4\pi\varepsilon_0 b$

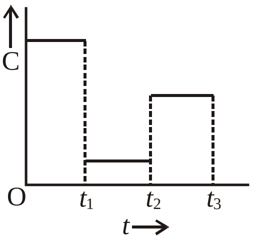
(d) $4\pi\varepsilon_0 a$

**77.** A parallel plate capacitor is charged in air (dielectric constant = 1.0006). For time 0 to $t_1$ only air is in between the plates of capacitor. For time $t_1$ to $t_2$ only water (dielectric constant = 81) and for time $t_2$ to $t_3$ only glycerine (dielectric constant = 56) is there in between the plates of capacitor. Which of the following graphs shows the correct variation of capacitance C with time t qualitatively?

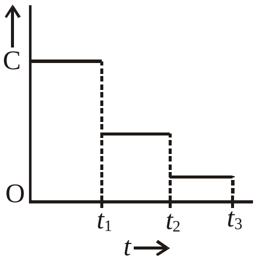
(a)



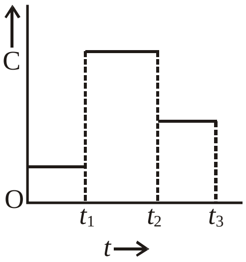
(b)



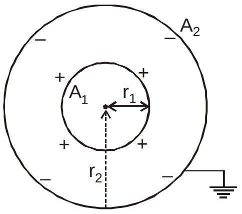
(c)



(d)



**78.** Two spherical conductors $A_1$ and $A_2$ of radii $r_1$ and $r_2$ ($r_2 > r_1$) are placed concentrically in air. $A_1$ is given a charge +Q while $A_2$ is earthed. Then the equivalent capacitance of the system is



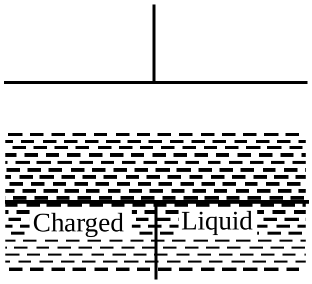
(a) $\dfrac{4\pi \in_0 r_1 r_2}{r_2 - r_1}$

(b) $4\pi \in_0 (r_1 + r_2)$

(c) $4\pi \in_0 r_2$

(d) $4\pi \in_0 r_1$

**79.** A parallel plate capacitor is located horizontally such that one of the plates is submerged in a liquid while the other is above the liquid surface. When plates are charged the level of liquid



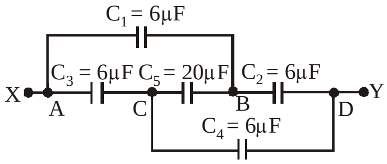
(a) rises

(b) falls

(c) remains unchanged

(d) may rise or fall depending on the of charge amount

**80.** What is the effective capacitance between points X and Y?



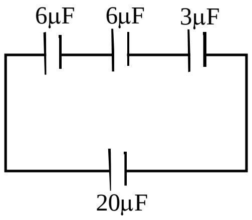
(a) 24 µF

(b) 18 µF

(c) 12 µF

(d) 6 µF

**81.** The capacitor, whose capacitance is 6, 6 and 3µF respectively are connected in series with 20 volt line. Find the charge on 3µF.



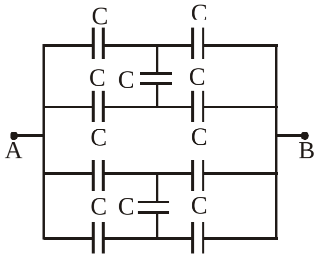
(a) 30 µc

(b) 60 µF

(c) 15 µF

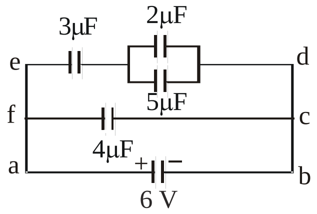
(d) 90 µF

**82.** The effective capacitance of combination of equal capacitors between points A and B shown in figure is



(a) C (b) 2C (c) 3C (d) $\dfrac{C}{2}$

**83.** In the circuit given below, the charge in µC, on the capacitor having capacitance 5 µF is



(a) 4.5 (b) 9 (c) 7 (d) 15

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

**84.** **Assertion:** The potential difference between any two points in an electric field depends only on initial and final position.
**Reason:** Electric field is a conservative field so the work done per unit positive charge does not depend on path followed.

**85.** **Assertion :** Electric field inside a conductor is zero.
**Reason:** The potential at all the points inside a conductor is same.

**86.** **Assertion :** Electric field is discontinuous across the surface of a spherical charged shell.
**Reason :** Electric potential is continuous across the surface of a spherical charged shell.

**87.** **Assertion :** Work done in moving a charge between any two points in an electric field is independent of the path followed by the charge, between these points.
**Reason:** Electrostatic force is a non conservative force.

**88.** **Assertion :** Two adjacent conductors of unequal dimensions, carrying the same positive charge have a potential difference between them.
**Reason :** The potential of a conductor depends upon the charge given to it.

**89.** **Assertion :** Electric potential and electric potential energy are different quantities.
**Reason :** For a system of positive test charge and point charge electric potential energy = electric potential.

**90.** **Assertion :** For a non-uniformly charged thin circular ring with net charge is zero, the electric field at any point on axis of the ring is zero.
**Reason :** For a non-uniformly charged thin circular ring with net charge zero, the electric potential at each point on axis of the ring is zero.

**91.** **Assertion :** For a charged particle moving from point $P$ to point $Q$, the net work done by an electrostatic field on the particle is independent of the path connecting point $P$ to point $Q$.
**Reason :** The net work done by a conservative force on an object moving along a closed loop is zero.

**92.** **Assertion :** Polar molecules have permanent dipole moment.
**Reason :** In polar molecules, the centres of positive and negative charges coincide even when there is no external field.

**93.** **Assertion :** Dielectric polarisation means formation of positive and negative charges inside the dielectric.
**Reason:** Free electrons are formed in this process.

**94.** **Assertion :** In the absence of an external electric field, the dipole moment per unit volume of a polar dielectric is zero.
**Reason :** The dipoles of a polar dielectric are randomly oriented.

**95.** **Assertion :** For a point charge, concentric spheres centered at a location of the charge are equipotential surfaces.
**Reason :** An equipotential surface is a surface over which potential has zero value.

**96.** **Assertion :** Electric energy resides out of the spherical isolated conductor.
**Reason :** The electric field at any point inside the conductor is zero.

**97.** **Assertion :** Two equipotential surfaces cannot cut each other.
**Reason :** Two equipotential surfaces are parallel to each other.

**98.** **Assertion.** Two equipotential surfaces can be orthogonal.
**Reason:** Electric field lines are normal to the equipotential surface.

**99.** **Assertion.** The equatorial plane of a dipole is an equipotential surface.
**Reason:** The electric potential at any point on equatorial plane is zero.

**100.** **Assertion:** The electric potential at any point on the equatorial plane of a dipole is zero.
**Reason:** The work done in bringing a unit positive charge from infinity to a point in equatorial plane is equal for the two charges of the dipole.

**101.** **Assertion :** A parallel plate capacitor is connected across battery through a key. A dielectric slab of dielectric constant k is introduced between the plates. The energy stored becomes k times.
**Reason :** The surface density of charge on the plate remains constant.

**102.** **Assertion :** Two metal plates having charges $Q$, $-Q$ face each other at some separation and are dipped into an oil tank. If the oil is pumped out, the electric field between the plates increases.
**Reason :** Electric field between the plates, $E_{\text{med}} = \dfrac{E_{\text{air}}}{\kappa}$.

**103.** **Assertion :** When a dielectric slab is gradually inserted between the plates of an isolated parallel-plate capacitor, the energy of the system decreases.
**Reason :** The force between the plates decreases.

**104.** **Assertion :** A dielectric is inserted between the plates of a battery connected capacitor. The energy of the capacitor increases.
**Reason :** Energy of the capacitor, $U = \dfrac{1}{2}CV^2$.

## CRITICAL THINKING TYPE QUESTIONS

**105.** A long, hollow conducting cylinder is kept coaxially inside another long, hollow conducting cylinder of larger radius. Both the cylinders are initially electrically neutral. Then

(a) a potential difference appears between the two cylinders when a charge density is given to the inner cylinder.
(b) a potential difference appears between the two cylinders when a charge density is given to the outer cylinder.
(c) no potential difference appears between the two cylinders when a uniform line charge is kept along the axis of the cylinders
(d) no potential difference appears between the two cylinders when same charge density is given to both the cylinders.

**106.** Two equally charged spheres of radii a and b are connected together. What will be the ratio of electric field intensity on their surfaces?

(a) $\frac{a}{b}$ (b) $\frac{a^2}{b^2}$ (c) $\frac{b}{a}$ (d) $\frac{b^2}{a^2}$

**107.** A given charge is situated at a certain distance from an electric dipole in the end-on position experiences a force $F$. If the distance of the charge is doubled, the force acting on the change will be

(a) $2F$ (b) $F / 2$
(c) $F / 4$ (d) $F / 8$

**108.** An electric charge $10^{-3}$ m C is placed at the origin (0, 0) of X – Y co-ordinate system. Two points A and B are situated at $\left(\sqrt{2},\sqrt{2}\right)$ and (2, 0) respectively. The potential difference between the points A and B will be

(a) 4.5 volt (b) 9 volt
(c) zero (d) 2 volt

**109.** The potential at a point x (measured in $\mu$ m) due to some charges situated on the x-axis is given by $V(x) = 20/(x^2 - 4)$ volt

The electric field E at x = 4 $\mu$ m is given by

(a) (10/9) volt/$\mu$ m and in the +ve x direction
(b) (5/3) volt/$\mu$ m and in the –ve x direction
(c) (5/3) volt/$\mu$ m and in the +ve x direction
(d) (10/9) volt/$\mu$ m and in the –ve x direction

**110.** The expression $E = -\frac{dv}{dr}$ implies, that electric field is in that direction in which

(a) increase in potential is steepest.
(b) decrease in potential is steepest.
(c) change in potential is minimum.
(d) None of these

**111.** Two parallel metal plates having charges + Q and – Q face each other ata certain distance between them. If the plates are now dipped in kerosene oil tank, the electric field between the plates will

(a) remain same (b) become zero
(c) increases (d) decrease

**112.** Four point charges $-Q$, $-q$, $2q$ and $2Q$ are placed, one at each corner of the square. The relation between $Q$ and $q$ for which the potential at the centre of the square is zero is

(a) $Q = -q$ (b) $Q = -\frac{1}{q}$
(c) $Q = q$ (d) $Q = \frac{1}{q}$

**113.** A conducting sphere of radius R is given a charge Q. The electric potential and the electric field at the centre of the sphere respectively are:

(a) Zero and $\frac{Q}{4\pi\varepsilon_0 R^2}$
(b) $\frac{Q}{4\pi\varepsilon_0 R}$ and Zero
(c) $\frac{Q}{4\pi\varepsilon_0 R}$ and $\frac{Q}{4\pi\varepsilon_0 R^2}$
(d) Both are zero

**114.** In a region, the potential is represented by $V(x, y, z) = 6x - 8xy - 8y + 6yz$, where V is in volts and x, y, z are in metres. The electric force experienced by a charge of 2 coulomb situated at point (1, 1, 1) is

(a) $6\sqrt{5}$ N (b) 30 N
(c) 24 N (d) $4\sqrt{35}$ N

**115.** Two conducting spheres of radii $R_1$ and $R_2$ having charges $Q_1$ and $Q_2$ respectively are connected to each other. There is

(a) no change in the energy of the system
(b) an increase in the energy of the system
(c) always a decrease in the energy of the system
(d) a decrease in the energy of the system unless $Q_1R_2 = Q_2R_1$

**116.** A parallel plate capacitor is charged by connecting it to a battery. Now the distance between the plates of the capacitor is increased. Which of the following remains constant ?

(a) Capacitance
(b) Charge on each plate of the capacitor.
(c) Potential difference between the plates of capacitor
(d) Energy stored in the capacitor.

**117.** Two vertical metallic plates carrying equal and opposite charges are kept parallel to each other like a parallel plate capacitor. A small spherical metallic ball is suspended by a long insulated thread such that it hangs freely in the centre of the two metallic plates. The ball, which is uncharged, is taken slowly towards the positively charged plate and is made to touch that plate. Then the ball will

(a) stick to the positively charged plate
(b) come back to its original position and will remain there
(c) oscillate between the two plates touching each plate in turn
(d) oscillate between the two plates without touch them

**118.** When air is replaced by a dielectric medium of force constant K, the maximum force of attraction between two charges, separated by a distance

(a) decreases K-times (b) increases K-times

(c) remains unchanged (d) becomes $\frac{1}{K^2}$ times

**119.** A parallel plate capacitor is charged and then isolated. What is the effect of increasing the plate separation on charge, potential, capacitance, respectively?

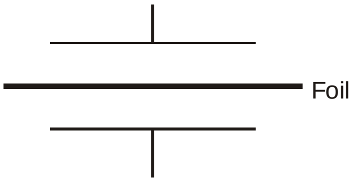
(a) Constant, decreases, decreases

(b) Increases, decreases, decreases

(c) Constant, decreases, increases

(d) Constant, increases, decreases

**120.** A foil of aluminium of negligible thickness is inserted in between the space of a parallel plate condenser. If the foil is electrically insulated, the capacity of the condenser will



(a) increase (b) decrease

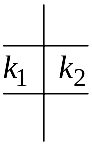
(c) remain unchanged (d) become zero

**121.** Eight drops of mercury of equal radii possessing equal charges combine to form a big drop. Then the capacitance of bigger drop compared to each individual small drop is

(a) 8 times (b) 4 times

(c) 2 times (d) 32 times

**122.** A parallel plate condenser is filled with two dielectrics as shown. Area of each plate is A $m^2$ and the separation is $t$ $m$. The dielectric constants are $k_1$ and $k_2$ respectively. Its capacitance in farad will be



(a) $\frac{\varepsilon_o A}{t}(k_1 + k_2)$ (b) $\frac{\varepsilon_o A}{t}.\frac{k_1+k_2}{2}$

(c) $\frac{2\varepsilon_o A}{t}(k_1 + k_2)$ (d) $\frac{\varepsilon_o A}{t}.\frac{k_1-k_2}{2}$

**123.** A capacitor of capacity $C_1$ is charged upto $V$ volt and then connected to an uncharged capacitor of capacity $C_2$. Then final potential difference across each will be

(a) $\frac{C_2V}{C_1+C_2}$ (b) $\left(1+\frac{C_2}{C_1}\right)V$

(c) $\frac{C_1V}{C_1+C_2}$ (d) $\left(1-\frac{C_2}{C_1}\right)V$

**124.** A parallel plate capacitor with air between the plates is charged to a potential difference of 500V and then insulated. A plastic plate is inserted between the plates filling the whole gap. The potential difference between the plates now becomes 75V. The dielectric constant of plastic is

(a) 10/3 (b) 5 (c) 20/3 (d) 10

**125.** From a supply of identical capacitors rated 8 mF, 250V, the minimum number of capacitors required to form a composite 16 mF, 1000V is

(a) 2 (b) 4 (c) 16 (d) 32

**126.** A parallel plate air capacitor of capacitance C is connected to a cell of emf V and then disconnected from it. A dielectric slab of dielectric constant K, which can just fill the air gap of the capacitor, is now inserted in it. Which of the following is incorrect ?

(a) The energy stored in the capacitor decreases K times.

(b) The chance in energy stored is $\frac{1}{2}CV^2\left(\frac{1}{K}-1\right)$

(c) The charge on the capacitor is not conserved.

(d) The potential difference between the plates decreases K times.

**127.** In a Van de Graaff generator, a spherical metal shell is to be $15 \times 10^6$ V electrode. The dielectric strength of the gas surrounding the electrode is $5 \times 10^7$V $m^{-1}$. The minimum radius of the spherical shell required is

(a) 1 $m$ (b) 2 $m$

(c) 1.5 $m$ (d) 3 $m$

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(b)**

**2.** **(c)** Electric potential inside a conductor is constant and it is equal to that on the surface of the conductor.

**3.** **(a)** Potential energy is defined only in case of conservative forces like electrostatic force (and due to which electrostatic field is a conservative field). It is not defined for non-conservative forces like friction.

**4.** **(a)** Since $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$, for a given point charge, q is constant, therefore V depends only on r. Hence V is a function of distance.

**5.** **(b)**

**6.** **(d)** Surface of metallic cube is an equipotential surface. Therefore, electric field is normal to the surface of the cube.

**7.** **(b)** **8.** **(a)**

**9.** **(c)** $C = \frac{2 \times 2}{2+2} + 2 = 3\,\mu F$

**10.** **(c)** Because in case of metallic spheres either solid or hollow, the charge will reside on the surface of the sphere. Since both spheres have same surface area, so they can hold equal maximum charge.

**11.** **(d)** On the equipotential surface, electric field is normal to the charged surface (where potential exists) so that no work will be done.

**12.** **(a)** Potential difference between two points in a electric field is,

$$V_A - V_B = \frac{W}{q_0}$$

**13.** **(d)** When negative terminal is grounded, positive terminal of battery is at +12 V. When positive terminal is grounded, the negative terminal will be at –12 V.

**14.** **(d)**

**15.** **(c)** The potential energy is negative whenever there is attraction. Since a positive and negative charge attract each other therefore their energy is negative. When both the charges are separated by infinite distance, they do not attract each other and their energy is zero.

**16.** **(d)**

**17.** **(a)** As the dipole will feel two forces, which are although opposite but not equal.

$\therefore$ A net force will be there and as these forces act at different points of a body, a torque is also present.

**18.** **(d)** $V = k\frac{\vec{p}.\vec{r}}{r^3} = \frac{k\,pr\cos\theta}{r^3}$

$$= k\frac{p\cos\theta}{r^2}.$$

**19.** **(d)** $W = \text{PE}(\cos 90° - \cos 270°) = 0.$

**20.** **(a)** Energy required to charge the capacitor is $W = U = QV$

$$\Rightarrow \quad U = CV^2 = \frac{\varepsilon_0 A}{d}.V^2 = \frac{\varepsilon_0 Ad}{d^2}.V^2 = \varepsilon_0 E^2\text{Ad}$$

$$\left[\because E = \frac{V}{d}\right].$$

**21.** **(b)** Potential at any point inside the sphere = potential at the surface of the sphere = 10V.

**22.** **(d)** The equatorial plane of a dipole is an equipotential surface, therefore potential remains constant.

**23.** **(d)** Since capacitance $C = \frac{\varepsilon_0 A}{d}$, as d decreases capacitance increases.

**24.** **(a)** **25.** **(d)** **26.** **(a)** **27.** **(c)** **28.** **(b)** **29.** **(b)**

**30.** **(b)** $C_{\text{medium}} = K \times C_{\text{air}}$

**31.** **(b)** In oil, C becomes twice, V becomes half. Therefore, E = V/d becomes half.

**32.** **(b)** Energy will be lost during transfer of charge (heating effect).

**33.** **(b)** $U = \int_0^v CV\ dV = \frac{1}{2}CV^2$

**34.** **(b)**

**35.** **(c)** Work done $= \frac{1}{2}\frac{q^2}{C} = \frac{(8 \times 10^{-18})^2}{2 \times 100 \times 10^{-6}} = 32 \times 10^{-32}$ J

**36.** **(d)** **37.** **(d)** **38.** **(c)** **39.** **(b)** **40.** **(a)**

**41.** (b) Van De graff generator is a machine that can built up high voltages of the order of a few million volts. The resulting large electric fields are used to accelerate charged particles (electrons, protons, ions) to high energies needed for experiments to probe the small scale structure of matter.

**42.** **(b)** **43.** **(b)** **44.** **(d)**

## STATEMENT TYPE QUESTIONS

**45.** **(c)** Since $V = \frac{W}{Q}$, more work will be done for a positive charge of two units as compared to positive charge of one unit, but the ratio $\frac{W}{Q}$ is same. Therefore potential difference is same.

**46.** **(b)** In a uniform electric field $\vec{E}$, dipole experiences a torque $\vec{\tau}$ given by $\vec{\tau} = \vec{p}\times\vec{E}$ but experiences no force. The potential energy of the dipole in a uniform electric field $\vec{E}$ is $U = -\ \vec{p}.\vec{E}$

**47.** (d) In an external electric field, the positive and negative charges of a non-polar molecule are displaced in opposite directions. The displacement stops when the external force on the constituent charges of the molecule is balanced by the restoring force (due to internal fields in the molecule). The non-polar molecule thus develops an induced dipole moment. The dielectric is said to be polarised by the external field.

**48.** **(c)** Electric field lines are always perpendicular to equipotential surface so, they cannot be in a direction of tangent to an equipotential surface.

**49.** **(b)** There is equal and opposite charge on the plates of a parallel plate capacitor. Therefore there is no net charge on capacitor.

**50.** **(d)** Since potential at every point on an equipotential surface is same therefore, for any two points on equipotential surface the potential difference is zero.

**51.** **(b)** **52.** **(d)**

## MATCHING TYPE QUESTIONS

**53** **(a)** A - 2; B - 1; C - 4; D - 3

**54.** **(b)** If V is the potential applied across the capacitor then p.d. across each capacitor will be $\frac{V}{2}$. When

A- 1 : dielectric is inserted in capacitor B, then

B- 1 : $V_1 + V_2 = V$

C- 2 : and $CV_1 = kCV_2$

D-2 : On solving above equations, we get

$$V_1 = \left(\frac{kV}{k+1}\right) \text{ and } V_2 = \left(\frac{V}{k+1}\right).$$

Clearly potential of A increases and that of B decreases. Initial charges on the capacitors are :

$$q_1 = \frac{CV}{2},\quad q_2 = \frac{CV}{2}$$

charges :

$$q_1' = CV_1 = \frac{kCV}{k+1} \quad\text{and}\quad q_2' = \frac{CV}{k+1}.$$

Charge on capacitor A will increase, and on B will decrease.

**55.** **(b)** A → (2); B → (3); C → (4); D → (1)

**56.** **(d)** A → (4); B → (3); C → (2); D → (1)

**57.** **(d)** A → (3); B → (1); C → (4); D → (2)

W.d. by battery A, $= 2\left(\frac{1}{2}C_1V_1^2\right) = 2\times 2^2 = 8J$

W.d. by battery B, $= 2\left[\frac{1}{2}CV_2^2\right]$

$$= 2\left[\frac{1}{2}\times\frac{4\times 2}{4+2}\times 4^2\right] = \frac{64}{3}J$$

$$q_2 = CV = \left(\frac{4\times 2}{4+2}\right)\times 4 = \frac{16}{3}$$

$$q_1 = C_1V_1 = 2\times 2 = 4$$

## DIAGRAM TYPE QUESTIONS

**58.** **(b)** For regions outside the spherical shell potential is given by $V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$, i.e. $V \propto \frac{1}{r}$ and it increases as we come closer to the spherical shell. Therefore potential increases as we move from P to A according to $V \propto \frac{1}{r}$.

For the regions inside the shell potential has a constant value at that on the surface, hence it remains constant for A to B. After B as we move away from the spherical shell it decreases as $V \propto \frac{1}{r}$.

**59.** **(c)** In this case electric fields due to the two charges at origin are just equal and opposite and thus cancel each other whereas potential due to the two charges add up and is not zero.

**60.** **(b)** Electric field is always zero inside a conductor. If there is any excess of charge on a hollow conductor it always resides on the outer surface of conductor. Therefore inside a hollow conductor there is no charge and hence charge density is zero.

**61.** **(d)** The potential energy of a dipole in uniform electric field is given by

$$U = -\vec{p}\cdot\vec{E} = -pE\cos\theta.$$

(i) For $\theta = 180°$,

$U = -pE\cos 180° = pE$. This is maximum value.

(ii) For $\theta = 90°$, $U = -\ pE\cos 90° = 0$

(iii) For $90° < \theta < 180°$,

∴ $\cos\theta$ is negative and hence U is positive.

(iv) For $0° < \theta < 90°$,

∴ $\cos\theta$ is positive and hence U is negative.

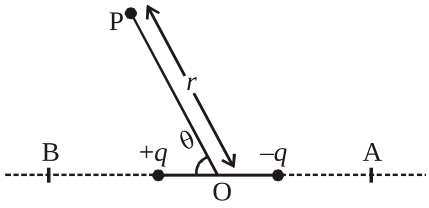
Therefore the correct increasing order is (iv), (ii), (iii), (i)

**62.** **(a)** Potential at B, $V_B$ is maximum

$$V_B > V_C > V_A$$

As in the direction of electric field potential decreases.

**63.** **(b)** The potential due to dipole at any arbitrary point P is given by



$$V = \frac{1}{4\pi\varepsilon_0}\frac{P\cos\theta}{r^2}$$

For A, $\theta = 180°$

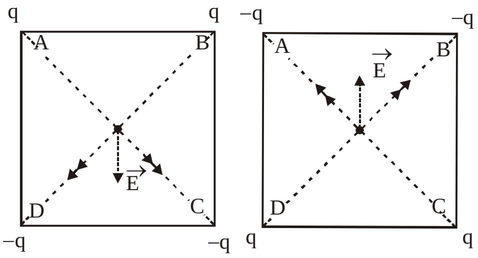
$\therefore \quad V_A = \frac{1}{4\pi\varepsilon_0}\frac{P\cos 180°}{r^2} = -\frac{1}{4\pi\varepsilon_0}\frac{P}{r^2}$ = a negative quantity.

For B, $\theta = 0°$.

$\therefore \quad V_B = \frac{1}{4\pi\varepsilon_0}\frac{P\cos 0°}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{P}{r^2}$ = a positive quantity.

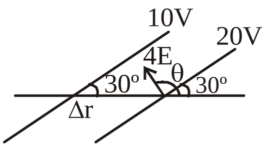
Therefore as we move from A to B potential change from negative to positive.

**64.** **(a)** As shown in the figure, the resultant electric fields before and after interchanging the charges will have the same magnitude, but opposite directions.
Also, the potential will be same in both cases as it is a scalar quantity.



**65.** **(c)** Using $dV = -\vec{E}.d\vec{r}$

$\Rightarrow \Delta V = -E\,\Delta r\cos\theta$



$$\Rightarrow E = \frac{-\Delta V}{\Delta r\cos\theta}$$

$$\Rightarrow E = \frac{-(20-10)}{10\times10^{-2}\cos 120°}$$

$$= \frac{-10}{10\times10^{-2}(-\sin 30°)}$$

$$= \frac{-10^2}{-1/2} = 200\ V/m$$

Direction of $E$ be perpendicular to the equipotential surface *i.e.* at 120° with X-axis.

**66.** **(b)**

**67.** **(c)** We know that potential energy of discrete system of charges is given by

$$U = \frac{1}{4\pi\epsilon_0}\left(\frac{q_1q_2}{r_{12}} + \frac{q_2q_3}{r_{23}} + \frac{q_3q_1}{r_{31}}\right)$$

According to question,

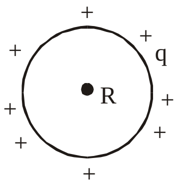
$$U_{\text{initial}} = \frac{1}{4\pi\epsilon_0}\left(\frac{q_1q_2}{0.3} + \frac{q_2q_3}{0.5} + \frac{q_3q_1}{0.4}\right)$$

$$U_{\text{final}} = \frac{1}{4\pi\epsilon_0}\left(\frac{q_1q_2}{0.3} + \frac{q_2q_3}{0.1} + \frac{q_3q_1}{0.4}\right)$$

$$U_{\text{final}} - U_{\text{initial}} = \frac{1}{4\pi\epsilon_0}\left(\frac{q_2q_3}{0.1} - \frac{q_2q_3}{0.5}\right)$$

$$= \frac{1}{4\pi\epsilon_0}\left[10q_2q_3 - 2q_2q_3\right] = \frac{q_3}{4\pi\epsilon_0}(8q_2)$$

**68.** **(b)** In shell, q charge is uniformly distributed over its surface, it behaves as a conductor.



V= potential at surface $= \frac{q}{4\pi\varepsilon_0 R}$ and inside

$$V = \frac{q}{4\pi\varepsilon_0 R}$$

Because of this it behaves as an equipotential surface.

**69.** **(c)** ABCDE is an equipotential surface, on equipotential surface no work is done in shifting a charge from one place to another.

**70.** **(d)** The potential energy of a dipole placed in uniform electric field is given by

$$U(\theta) = -\vec{p}\cdot\vec{E} = -pE\cos\theta$$

$$= pE(-\cos\theta).$$

For stable equillibrium θ = 0° and for unstable equillibrium θ = 180°. Therefore the correct variation is shown by graph of – cos θ from 0 to π with maximum and minimum values pE and – pE respectively.

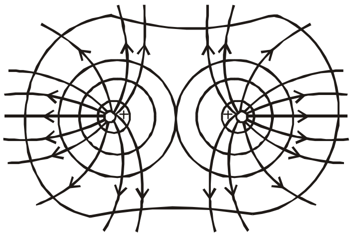
**71.** **(b)** Irrespective of the charges on the inner and outer conductors, the inner conductor is always at a higher potential as long as the charge on inner conductor is not zero. Therefore charge flows from B to A. When the whole charge of B flows to A and charge on B becomes zero then A and B are at same potential.

**72. (d)** The potential energy of a system of two charges $q_1$ and $q_2$ is given by

$$U = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}}$$ where $r_{12}$ is the distance between the charges. Here $q_1 = +Q$ and $q_2 = +q$. Distance between both the charges is same in both the cases which is $|a| = |-a| = a$. Therefore potential energy is same in both the cases and is positive.

**73. (c)** Potential energy decreases whenever there is attraction. A negative charge placed at centroid causes attraction.

**74. (c)** Equipotential surfaces are normal to the electric field lines. The following figure shows the equipotential surfaces along with electric field lines for a system of two positive charges.



**75. (c)** B and C are at the same potential, therefore potential difference between A and B and that between A and C is same in both the cases. Hence work done is same in both the cases.

**76. (c)** All the charge given to inner sphere will pass on to the outer one. So capacitance that of outer one is $4\pi \in_0 b$.

**77. (d)** The capacitance of a parallel plate capacitor is given by

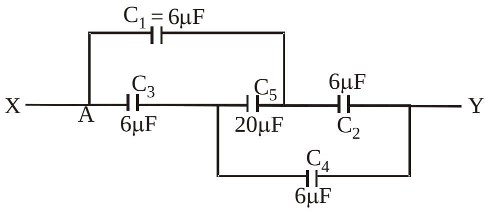
$$C = \frac{\varepsilon_0 K A}{d}$$ where K is dielectric constant of the dielectric.

Therefore more the dielectric constant, more will be the capacitance.

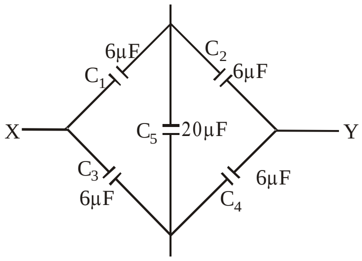
**78. (a)**

**79. (a)** The molecules of liquid will convert into induced dipole, get oriented along the electric field produced between the plates and rise due to force of attraction.

**80. (d)**

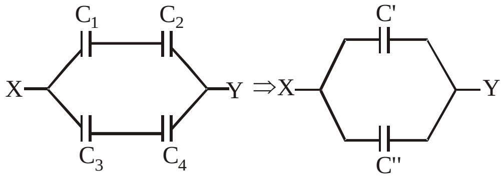


Equivalent circuit



As $\frac{C_1}{C_3} = \frac{C_2}{C_4}$

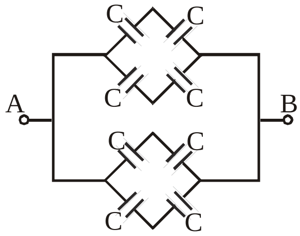
Hence no charge will flow through 20μF



$C_1$ and $C_2$ are in series, also $C_3$ and $C_4$ are in series.
Hence C' = 3 μF, C'' = 3 μF
C' and C'' are in parallel hence net capacitance
= C' + C'' = 3 + 3 = 6 μF

**81. (a)** In series $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ and charge on each capacitor is same.

**82. (b)**



The figure shows two independent balanced wheatstone Brides connected in parallel each having a capacitance C. So,

$$C_{net} = C_{AB} = 2C$$

**83. (b)** Potential difference across the branch de is 6 V. Net capacitance of de branch is 2.1 μF

So, q = CV
$\Rightarrow q = 2.1 \times 6\ \mu C$
$\Rightarrow q = 12.6\ \mu C$

Potential across 3 μF capacitance is

$$V = \frac{12.6}{3} = 4.2 \text{ volt}$$

Potential across 2 and 5 combination in parallel is $6 - 4.2 = 1.8$ V

So, q' = (1.8) (5) = 9 μC

## ASSERTION- REASON TYPE QUESTIONS

**84. (a) 85. (b) 86. (b) 87. (c) 88. (b)**

**89. (c)** Potential and potential energy are different quantities and cannot be equated.

**90. (d)** For a non-uniformly charged thin circular ring with net zero charge, electric potential at each point on its axis is zero. Hence electric field at each point on its axis must be perpendicular to the axis. Therefore Assertion is false and Reason is true.

**91. (a) 92. (c) 93. (c) 94. (a) 95. (c)**

**96. (a)** As these is no electric field inside the conductor, and so no energy inside it.

**97. (c)** Reason is false because the work done in bringing a unit positive charge from infinity to a point in equatorial plane is equal and opposite for the two charges of the dipole.

**98. (d)** Two equipotential surfaces never intersect each other so they cannot be orthogonal.

**99. (b)**

**100. (d)** Two equipotential surfaces are not necessarily parallel to each other.

**101. (c)** $C' = kC$, and so, $U' = \frac{1}{2}(kC)V^2 = kU$. Also $q' = C'V = kCV = kq$, and so charge density increases.

**102. (c)** Reason is the correct explanation of statement-1.

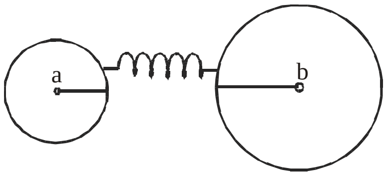
**103. (c)** $C' = kC$, and $U' = \frac{q^2}{2C'} = \frac{q^2}{2kC}$. With the introduction of dielectric, energy of the system decreases. As charge on the capacitor remains same, and so force between them remains same.

**104. (a)** $U = \frac{1}{2}CV^2$. In the battery connected capacitor $V$ remains constant while $C$ increases with the introduction of dielectric and so $U$ will increase.

## CRITICALTHINKING TYPE QUESTIONS

**105. (a)** When a charge density is given to the inner cylinder, the potential developed at its surface is different from that on the outer cylinder. This is because the potential decreases with distance for a charged conducting cylinder when the point of consideration is outside the cylinder. But when a charge density is given to the outer cylinder, it will charge its potential by the same amount as that of the inner cylinder. Therefore no potential difference will be produced between the cylinders in this case.

**106. (c)**



Let charge on each sphere $= q$
when they are connected together their potential will be equal .

Now let charge on $a = q_1$ and on $b = 2q - q_1$

$$\Rightarrow V_a = V_b \text{ or } \frac{1}{4\pi\varepsilon_o}\frac{q_1}{a} = \frac{1}{4\pi\varepsilon_o}\frac{2q-q_1}{b}$$

$$\Rightarrow \frac{q_1}{2q-q_1} = \frac{a}{b}$$

$$\frac{E_a}{E_b} = \frac{\frac{1.}{4\pi\varepsilon_o}\frac{q_1}{a^2}}{\frac{1}{4\pi\varepsilon_o}\frac{q_2}{b^2}} = \left(\frac{q_1}{2q-q_1}\right)\frac{b^2}{a^2} = \frac{a}{b}.\frac{b^2}{a^2} = \frac{b}{a}$$

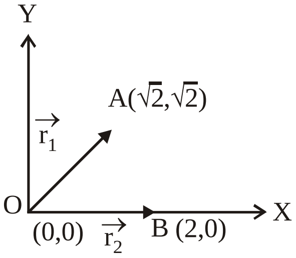
$$= b : a$$

**107. (d)** Force on charge $F = q\,(E_a) = q \times \frac{k.2p}{r^3}$

$$\Rightarrow \quad F \propto \frac{1}{r^3}$$

When $r \to$ doubled; $F \to \frac{1}{8}$ times

**108. (c)**



The distance of point $A(\sqrt{2}, \sqrt{2})$ from the origin,

$$OA = |\vec{r}_1| = \sqrt{(\sqrt{2})^2 + (\sqrt{2})^2}$$

$= \sqrt{4} = 2$ units.

The distance of point B(2, 0) from the origin,

$OB = |\vec{r}_2| = \sqrt{(2)^2 + (0)^2} = 2$ units.

Now, potential at A, $V_A = \frac{1}{4\pi \in_0}.\frac{Q}{(OA)}$

Potential at B, $V_B = \frac{1}{4\pi \in_0}.\frac{Q}{(OB)}$

$\therefore$ Potential difference between the points A and B is given by

$$V_A - V_B = \frac{1}{4\pi \in_0}.\frac{Q}{OA} - \frac{1}{4\pi \in_0}.\frac{Q}{OB}$$

$$= \frac{Q}{4\pi \in_0}\left(\frac{1}{OA} - \frac{1}{OB}\right) = \frac{Q}{4\pi \in_0}\left(\frac{1}{2} - \frac{1}{2}\right)$$

$$= \frac{10^{-3} \times 10^{-6}}{4\pi \in_0} \times 0 = 0.$$

**109. (a)** Here, $V(x)=\frac{20}{x^2-4}$ volt

We know that $E=-\frac{dV}{dx}=-\frac{d}{dx}\left(\frac{20}{x^2-4}\right)$

or, $E=+\frac{40x}{(x^2-4)^2}$

At $x=4\,\mu m$,

$$E=+\frac{40\times4}{(4^2-4)^2}=+\frac{160}{144}=+\frac{10}{9}\text{ volt}/\mu m.$$

Positive sign indicates that $\vec{E}$ is in +ve x-direction.

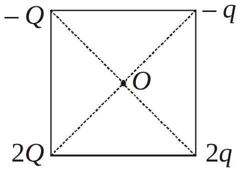
**110. (b)** As we move towards a positive charge distribution V increases i.e., $\frac{dV}{dr}$ is positive. The increase in potential is steepest when we move exactly towards charge distribution. But E is in a direction exactly away from charge distribution, therefore E is in exactly opposite direction in which increase in potential is steepest. Hence $E=-\frac{dV}{dr}$.

**111. (d)** Electric field $E=\frac{\sigma}{\varepsilon}=\frac{Q}{A\varepsilon}$

$\varepsilon$ of kerosine oil is more than that of air.

As $\varepsilon$ increases, E decreases.

**112. (a)** Let the side length of square be '$a$' then potential at centre $O$ is



$$V=\frac{k(-Q)}{\left(\frac{a}{\sqrt{2}}\right)}+\frac{k(-q)}{\frac{a}{\sqrt{2}}}+\frac{k(2q)}{\frac{a}{\sqrt{2}}}+\frac{k(2Q)}{\frac{a}{\sqrt{2}}}=0 \quad \text{(Given)}$$

$=-Q-q+2q+2Q=0=Q+q=0$

$=Q=-q$

**113. (b)** Due to conducting sphere

At centre, electric field E = 0

And electric potential $V=\frac{Q}{4\pi\in_0 R}$

**114. (d)** $\vec{E}=-\frac{\partial V}{\partial x}\hat{i}-\frac{\partial V}{\partial y}\hat{j}-\frac{\partial V}{\partial z}\hat{k}$

$=-[(6-8y)\hat{i}+(-8x-8+6z)\hat{j}+(6y)\hat{k}]$

At (1, 1, 1), $\vec{E}=2\hat{i}+10\hat{j}-6\hat{k}$

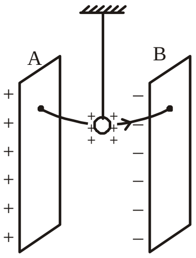
$\Rightarrow (\vec{E})=\sqrt{2^2+10^2+6^2}=\sqrt{140}=2\sqrt{35}$

$\therefore F=q\vec{E}=2\times2\sqrt{35}=4\sqrt{35}$

**115. (d)** When $\frac{Q_1}{R_1}-\frac{Q_2}{R_2}$; current will flow in connecting wire so that energy decreases in the form of heat through the connecting wire.

**116. (c)** As the capacitor remains connected to the battery, the potential difference provided by the battery remains constant.

**117. (c)** The ball on touching plate A will get positively charged. It will be repelled by A and get attracted towards B. After touching B it will get negatively charged. It will now be repelled by B and get attracted towards A. Thus it will remain oscillating and at the extreme position touch the plates.



**118. (a)** In air $F_{air}=\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}$

In medium $F_m=\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{Kr^2}$

$\therefore \frac{F_m}{F_{air}}=\frac{1}{K}\Rightarrow F_m=\frac{F_{air}}{K}$ (decreases K-times)

**119. (d)**

**120. (c)**

**121. (c)** Volume of 8 small drops = Volume of big drop

$8\times\frac{4}{3}\pi R^3=\frac{4}{3}\pi R^3 \Rightarrow \quad R=2r$

As capacity is proportional to $r$, hence capacity becomes 2 times.

**122. (b)** The two capacitors are in parallel so

$C=\frac{\varepsilon_0 A}{t\times2}(k_1+k_2)$

**123. (c)** Common potential $V'=\frac{C_1V+C_2\times0}{C_1+C_2}=\frac{C_1}{C_1+C_2}.V$

**124. (c)** $V_0=\frac{q}{C_0}$

$V=\frac{q}{C}\Rightarrow\frac{V}{V_0}=\frac{C_0}{C}$

$\Rightarrow\frac{C_0}{C}=\frac{500}{75}=\frac{20}{3}$

By definition, $C=kC_0\Rightarrow k=\frac{20}{3}$

**125. (d)** Let ‘n’ such capacitors are in series and such ‘m’ such branch are in parallel.

$\therefore\ 250 \times n = 1000 \quad \therefore\ n = 4 \qquad \ldots(i)$

Also $\frac{8}{n} \times m = 16$

$$m = \frac{16 \times n}{8} = 8 \qquad \ldots(ii)$$

$\therefore$ No. of capacitor $= 8 \times 4 = 32$

**126. (c)** Capacitance of the capacitor, $C = \frac{Q}{V}$

After inserting the dielectric, new capacitance

$C^1 = K.C$

New potential difference

$$V^1 = \frac{V}{K}$$

$$u_i = \frac{1}{2}cv^2 = \frac{Q^2}{2C} \qquad (\because Q = cv)$$

$$u_f = \frac{Q^2}{2f} = \frac{Q^2}{2kc} = \frac{C^2V^2}{2KC} = \left(\frac{u_i}{k}\right)$$

$$\Delta u = u_f - u_i = \frac{1}{2}cv^2\left\{\frac{1}{k} - 1\right\}$$

As the capacitor is isolated, so change will remain conserved p.d. between two plates of the capacitor

$$L = \frac{Q}{KC} = \frac{V}{K}$$

**127. (d)** : Here, $V = 15 \times 10^6\ V$ dielectric strength

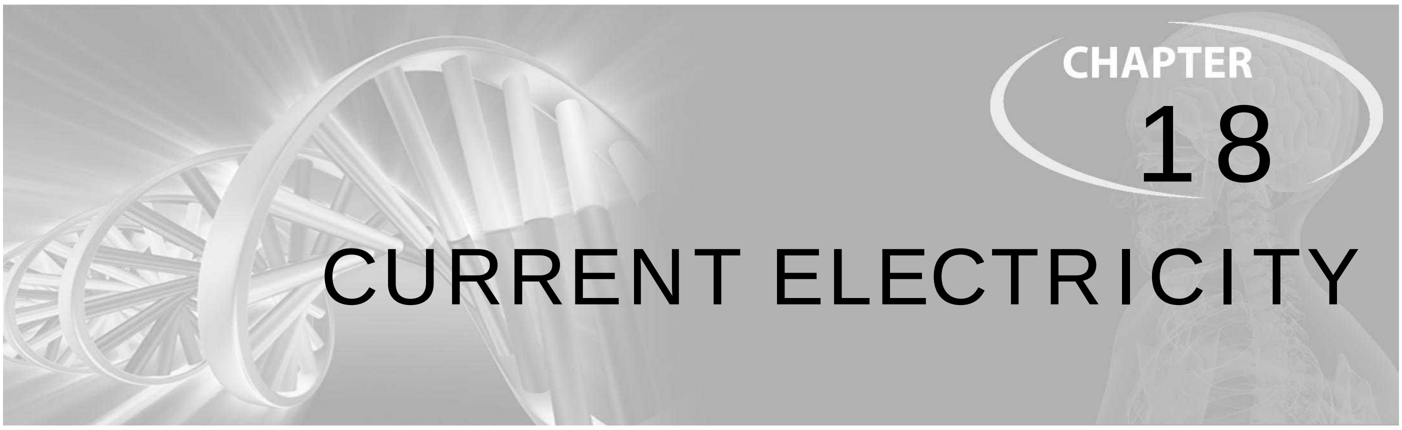
$= 5 \times 10^7\ V\ m^{-1}$

Maximum electric field, $E$ = 10% of dielectirc stength

$$\therefore \quad E = \frac{10}{100} \times 5 \times 10^7 = 5 \times 10^6\ V\ m^{-1}$$

As $E = \frac{V}{r}$

$$\therefore \quad r = \frac{V}{E} = \frac{15 \times 10^6}{5 \times 10^6} = 3\ m$$



## CHAPTER 18

# CURRENT ELECTRICITY

### FACT/DEFINITION TYPE QUESTIONS

**1.** In a current carrying conductor the net charge is
(a) $1.6 \times 10^{-19}$ coulomb (b) $6.25 \times 10^{-18}$ coulomb
(c) zero (d) infinite

**2.** The current which is assumed to be flowing in a circuit from positive terminal to negative, is called
(a) direct current (b) pulsating current
(c) conventional current (d) alternating current

**3.** When no current is passed through a conductor,
(a) the free electrons do not move
(b) the average speed of a free electron over a large period of time is not zero
(c) the average velocity of a free electron over a large period of time is zero
(d) the average of the velocities of all the free electrons at an instant is non zero

**4.** A current passes through a wire of nonuniform cross-section. Which of the following quantities are independent of the cross-section?
(a) The charge crossing (b) Drift velocity
(c) Current density (d) Free-electron density

**5.** In the equation AB = C, A is the current density, C is the electric field, Then B is
(a) resistivity (b) conductivity
(c) potential difference (d) resistance

**6.** Drift velocity of electrons is due to
(a) motion of conduction electrons due to random collisions.
(b) motion of conduction electrons due to electric field $\vec{E}$.
(c) repulsion to the conduction electrons due to inner electrons of ions.
(d) collision of conduction electrons with each other.

**7.** The speed at which the current travels, in conductor, is nearly equal to
(a) $3 \times 10^4$ m/s (b) $3 \times 10^5$ m/s
(c) $4 \times 10^6$ m/s (d) $3 \times 10^8$ m/s

**8.** In the absence of an electric field, the mean velocity of free electrons in a conductor at absolute temperature (T) is
(a) zero (b) independent of T
(c) proportional to T (d) proportional to $T^2$

**9.** When a potential difference V is applied across a conductor at a temperature T, the drift velocity of electrons is proportional to
(a) $\sqrt{V}$ (b) V
(c) $\sqrt{T}$ (d) T

**10.** For which of the following dependence of drift velocity $v_d$ on electric field E, is Ohm's law obeyed?
(a) $v_d \propto E^2$ (b) $v_d = E^{1/2}$
(c) $v_d$ = constant (d) $v_d = E$

**11.** The current density (number of free electrons per $m^3$) in metallic conductor is of the order of
(a) $10^{22}$ (b) $10^{24}$
(c) $10^{26}$ (d) $10^{28}$

**12.** A current passes through a resistor. If $K_1$ and $K_2$ represent the average kinetic energy of the conduction electrons and the metal ions respectively then
(a) $K_1 < K_2$
(b) $K_1 = K_2$
(c) $K_1 > K_2$
(d) any of these three may occur

**13.** A metal wire is subjected to a constant potential difference. When the temperature of the metal wire increases, the drift velocity of the electron in it
(a) increases, thermal velocity of the electron increases
(b) decreases, thermal velocity of the electron increases
(c) increases, thermal velocity of the electron decreases
(d) decreases, thermal velocity of the electron decreases

**14.** The electric field intensity E, current density J and specific resistance k are related to each other through the relation
(a) $E = J/k$ (b) $E = J k$
(c) $E = k/J$ (d) $k = J E$

**15.** The relaxation time in conductors
(a) increases with the increases of temperature
(b) decreases with the increases of temperature
(c) it does not depends on temperature
(d) all of sudden changes at 400 *K*

**16.** We are able to obtain fairly large currents in a conductor because
(a) the electron drift speed is usually very large
(b) the number density of free electrons is very high and this can compensate for the low values of the electron drift speed and the very small magnitude of the electron charge
(c) the number density of free electrons as well as the electron drift speeds are very large and these compensate for the very small magnitude of the electron charge
(d) the very small magnitude of the electron charge has to be divided by the still smaller product of the number density and drift speed to get the electric current

**17.** In conductor when electrons move between two collisons, their paths are ... *A*... when external fields are absent and ... *B*...when external filed is present. Here, *A* and *B* refer to
(a) straight lines, straight lines
(b) straight lines, curved lines
(c) curved lines, straight lines
(d) curved lines, curved lines

**18.** If N, e, $\tau$ and m are representing electron density, charge, relaxation time and mass of an electron respectively, then the resistance of wire of length $\ell$ and cross-sectional area A is given by
(a) $\frac{m\ell}{Ne^2A^2\tau}$ (b) $\frac{2m\tau A}{Ne^2\ell}$
(c) $\frac{Ne^2\tau A}{2m\ell}$ (d) $\frac{Ne^2A}{2m\tau\ell}$

**19.** The unit of specific resistance is
(a) $\Omega m^{-1}$ (b) $\Omega^{-1}m^{-1}$
(c) $\Omega^{-1}$ (d) $2.5\Omega m^2$

**20.** The example of non-ohmic resistance is
(a) diode (b) copper wire
(c) filament lamp (d) carbon resistor

**21.** Constantan wire is used for making standard resistance, because it has
(a) high melting point
(b) low specific resistance
(c) high specific resistance
(d) negligible temperature coefficient of resistance

**22.** At temperature 0K, the germanium behaves as a / an
(a) conductor (b) insulator
(c) super-conductor (d) ferromagnetic

**23.** Which of the following is used for the formation of thermistor?
(a) Copper oxide (b) Nickel oxide
(c) Iron oxide (d) All of the above

**24.** What is the suitable material for electric fuse?
(a) Cu (b) Constantan
(c) Tin-lead alloy (d) Nichrome

**25.** A strip of copper and another of germanium are cooled from room temperature to 80 K. The resistance of
(a) each of these increases
(b) each of these decreases
(c) copper strip increases and that of germanium decreases
(d) copper strip decreases and that of germanium increases

**26.** The electric resistance of a certain wire of iron is R. If its length and radius are both doubled, then
(a) the resistance and the specific resistance, will both remain unchanged
(b) the resistance will be doubled and the specific resistance will be halved
(c) the resistance will be halved and the specific resistance will remain unchanged
(d) the resistance will be halved and the specific resistance will be doubled

**27.** Nichrome or Manganin is widely used in wire bound standard resistors because of their
(a) temperature independent resistivity
(b) very weak temperature dependent resistivity.
(c) strong dependence of resistivity with temperature.
(d) mechanical strength.

**28.** With increase in temperature the conductivity of
(a) metals increases and of semiconductor decreases.
(b) semeconductors increases and metals decreases.
(c) in both metals and semiconductors increases.
(d) in both metal and semiconductor decreases.

**29.** The resistance of a metal increases with increasing temperature because
(a) the collisions of the conducting electrons with the electrons increase
(b) the collisions of the conducting electrons with the lattice consisting of the ions of the metal increase
(c) the number of conduction electrons decreases
(d) the number of conduction electrons increases

**30.** To minimise the power loss in the transmission cables connecting the power stations to homes and factories, the transmission cables carry current
(a) at a very low voltage.
(b) at a very high voltage
(c) at 220 volt
(d) neither at a very high voltage nor at a very low voltage.

**31.** Appliances based on heating effect of current work on
(a) only a.c. (b) only d.c.
(c) both a.c. and d.c. (d) None of these

**32.** In the series combination of two or more than two resistances
(a) the current through each resistance is same
(b) the voltage through each resistance is same
(c) neither current nor voltage through each resistance is same
(d) both current and voltage through each resistance are same.

**33.** Two or more resistors are said to be in ...*A*... if one end of all resistors is joined together and similarly the other ends joined together, Here, *A* refers to

(a) series (b) parallel
(c) either (a) or (b) (d) None of these

**34.** Emf of a cell is

(a) the maximum potential difference between the terminals of a cell when no current is drawn from the cell.
(b) the force required to push the electrons in the circuit.
(c) the potential difference between the positive and negative terminal of a cell in a closed circuit.
(d) less than terminal potential difference of the cell.

**35.** When potential difference is applied across an electrolyte, then Ohm's law is obeyed at

(a) zero potential (b) very low potential
(c) negative potential (d) high potential

**36.** To draw a maximum current from a combination of cells, how should the cells be grouped?

(a) Parallel
(b) Series
(c) Mixed grouping
(d) Depends upon the relative values of internal and external resistances.

**37.** Under what condition will the strength of current in a wire of resistance R be the same for connection is series and in parallel of n identical cells each of the internal resistance r? When

(a) $R = n\,r$ (b) $R = r/n$
(c) $R = r$ (d) $R \to \infty, r \to 0$

**38.** A cell of internal resistance r is connected to an external resistance R. The current will be maximum in R, if

(a) $R = r$ (b) $R < r$
(c) $R > r$ (d) $R = r/2$

**39.** An energy source will supply a constant current into the load if its internal resistance is

(a) very large as compared to the load resistance
(b) equal to the resistance of the load
(c) non-zero but less than the resistance of the load
(d) zero

**40.** The resistance of the coil of an ammeter is R. The shunt required to increase its range n-fold should have a resistance

(a) $\frac{R}{n}$ (b) $\frac{R}{n-1}$
(c) $\frac{R}{n+1}$ (d) nR

**41.** A cell of internal resistance r is connected across an external resistance nr. Then the ratio of the terminal voltage to the emf of the cell is

(a) $\frac{1}{n}$ (b) $\frac{1}{n+1}$
(c) $\frac{n}{n+1}$ (d) $\frac{n-1}{n}$

**42.** If n cells each of emf ε and internal resistance *r* are connected in parallel, then the total emf and internal resistances will be

(a) $\varepsilon, \frac{r}{n}$ (b) $\varepsilon, nr$
(c) $n\varepsilon, \frac{r}{n}$ (d) $n\varepsilon, nr$

**43.** The internal resistance of dry cell is ...*A*..., than the internal resistance of common electrolytic cell. Here, A refers to

(a) much lower (b) much higher
(c) slightly lower (d) slightly higher

**44.** Kirchoff's first law, i.e., **S** i = 0 at a junction, deals with the conservation of

(a) charge (b) energy
(c) momentum (d) angular momentum

**45.** The Kirchhoff's second law ($\Sigma iR = \Sigma E$), where the symbols have their usual meanings, is based on

(a) conservation of momentum
(b) conservation of charge
(c) conservation of potential
(d) conservation of energy

**46.** Why is the Wheatstone bridge better than the other methods of measuring resistances?

(a) It does not involve Ohm's law
(b) It is based on Kirchoff's law
(c) It has four resistor arms
(d) It is a null method

**47.** If in the experiment of Wheatstone's bridge, the positions of cells and galvanometer are interchanged, then balance point will

(a) change
(b) remain unchanged
(c) depend on the internal resistance of cell and resistance of galvanometer
(d) None of these

**48.** In a wheatstone bridge in the battery and galvanometer are interchanged then the deflection in galvanometer will

(a) change in previous direction
(b) not change
(c) change in opposite direction
(d) none of these.

**49.** In meter bridge or Wheatstone bridge for measurement of resistance, the known and the unknown resistance are interchanged. The error so removed is

(a) end correction
(b) index error
(c) due to temperature effect
(d) random error

**50.** Potentiometer is based on

(a) deflection method
(b) zero deflection method
(c) both (a) and (b)
(d) None of these

**51.** In potentiometer a balance point is obtained, when

(a) the e.m.f. of the battery becomes equal to the e.m.f of the experimental cell

(b) the p.d. of the wire between the +ve end of battery to jockey becomes equal to the e.m.f. of the experimental cell

(c) the p.d. of the wire between +ve point of cell and jockey becomes equal to the e.m.f. of the battery

(d) the p.d. across the potentiometer wire becomes equal to the e.m.f. of the battery

**52.** In the experiment of potentiometer, at balance point, there is no current in the

(a) main circuit

(b) galvanometer circuit

(c) potentiometer circuit

(d) both main and galvanometer circuits

**53.** Sensitivity of potentiometer can be increased by

(a) increasing the e.m.f of the cell

(b) increasing the length of the potentiometer

(c) decreasing the length of the potentiometer wire

(d) None of these

**54.** Potentiometer measures potential more accurately because

(a) it measures potential in open circuit

(b) it uses sensitive galvanometer for null deflection

(c) it uses high resistance potentiometer wire

(d) it measures potential in closed circuit

**55.** For measuring voltage of any circuit, potentiometer is preferred to voltmeter because

(a) the potentiometer is cheap and easy to handle.

(b) calibration in the voltmeter is sometimes wrong .

(c) the potentiometer almost draws no current during measurement.

(d) range of the voltmeter is not as wide as that of the potentiometer.

## STATEMENT TYPE QUESTIONS

**56.** Consider the following statements and select the correct statement(s).

I. Current is the time rate of flow of charge through any cross-section

II. For a given conductor current does not change with change in cross-sectional area

III. The net charge in a current carrying conductor is infinite

(a) I and II (b) II and III

(c) I and III (d) I, II and III

**57.** Which of the following statements are incorrect ?

I. The order of magnitude of current flowing in household appliances is one ampere.

II The order of magnitude of current in lightening is about one ampere.

III. The order of magnitude of current in nerves in human body is one ampere.

(a) II and III (b) I and II

(c) I and III (d) I, II and III

**58.** Ohm's law fails in which of the following cases

I. Potential *V* depends on I non-linearly.

II. The relation between *V* and *I* depends on the sign of *V* for the same absolute value of *V*.

III. *V* depends on I linearly.

(a) I only (b) II only

(c) I and III (d) I and II

**59.** When no electric field is present.

I. The electrons will be moving due to thermal motion during which they collide with the fixed ions.

II. An electron colliding with an ion emerges with the same speed as before the collision. However the direction of its velocity after the collision is completely random.

III. At a given time, there is no preferential direction for the velocities of the electrons. Thus, on an average, the number of electrons travelling in any direction will be equal to the number of electrons travelling in the opposite direction. So, there will be no net electric current.

Which of the above statements are correct?

(a) I and II (b) II and III

(c) I and III (d) I, II and III

**60.** What should be the characteristic of fuse wire?

I. High melting point, high specific resistance

II. Low melting point, low specific resistance

III. Low melting point, high specific resistance

(a) I only (b) I and II

(c) I and III (d) III only

**61.** In household electric circuit

I. all electric appliances drawing power are joined in parallel

II. a switch may be either in series or in parallel with the appliance which it controls

III. if a switch is in parallel with an appliance, it will draw power when the switch is in the 'off' position (open)

IV. if a switch is in parallel with an appliance, the fuse will blow (burn out) when the switch is put 'on' closed.

Which of the above statements are correct?

(a) I and IV (b) I, III and IV

(c) II, III and IV (d) I, II and IV

**62.** Consider the following statements and select the correct option.

I. When resistances are connected in parallel the equivalent resistance is less than the smallest resistance.

II. When resistances are connected in parallel, current distributes in the inverse ratio of resistances.

III. When resistances are connected in series maximum current flows through the resistance having least value.

(a) I only (b) II only

(c) I and II (d) I, II and III

## MATCHING TYPE QUESTIONS

**63.** Match the Column I and Column II.

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Ohm's law is applicable to | (1) | Metals |
| (B) | Ohm's law is not applicable to | (2) | Greater resistivity |
| (C) | Alloys have | (3) | Diodes, electrolytes semiconductors |
| (D) | A heat sensitive resistor | (4) | Thermistors |

(a) (A) → (2); (B) → (1); (C) → (3); (D) → (4)
(b) (A) → (1); (B) → (3); (C) → (2); (D) → (4)
(c) (A) → (4); (B) → (3); (C) → (2); (D) → (1)
(d) (A) → (2); (B) → (1); (C) → (4); (D) → (3)

**64.**

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Silver | (1) | Wire bound resistor |
| (B) | Semiconductor | (2) | Resistor of higher range |
| (C) | Carbon resistor | (3) | Negative temperature coefficient of resistivity |
| (D) | Manganin | (4) | Least resistivity |

(a) (A) → (2); (B) → (1); (C) → (3); (D) → (4)
(b) (A) → (2); (B) → (2); (C) → (4); (D) → (3)
(c) (A) → (4); (B) → (3); (C) → (2); (D) → (1)
(d) (A) → (4); (B) → (3); (C) → (2); (D) → (1)

**65.** Match the physical quantities in Column I and their mathematical expressions in Column II.

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Current | (1) | $\frac{ne^2\tau}{m}$ |
| (B) | Conductivity | (2) | $\frac{1}{p}\left(\frac{dp}{dT}\right)$ |
| (C) | Current density | (3) | $\vec{j}\cdot\overrightarrow{\Delta S}$ |
| (D) | Temperature coefficient of resistivity | (4) | $nq\,\vec{v}_d$ |

(a) (A) → (2); (B) → (1); (C) → (3); (D) → (4)
(b) (A) → (2); (B) → (2); (C) → (4); (D) → (3)
(c) (A) → (3); (B) → (1); (C) → (4); (D) → (2)
(d) (A) → (2); (B) → (1); (C) → (4); (D) → (3)

**66.** Match the Column I and Column II.

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Smaller the resistance greater the current | (1) | If the same voltager is applied and resistance are in series |
| (B) | Greater or smaller the resistance the current is same | (2) | If the same current is passed |
| (C) | Greater the resistance smaller the power | (3) | When resistances are connected in series |
| (D) | Greater the resistance greater the power | (4) | When resistances are connected in parallel |

(a) (A) → (3); (B) → (1); (C) → (2); (D) → (4)
(b) (A) → (1); (B) → (3); (C) → (2); (D) → (4)
(c) (A) → (2); (B) → (1); (C) → (4); (D) → (2)
(d) (A) → (4); (B) → (3); (C) → (1); (D) → (2)

**67.**

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Junction rule | (1) | Another statement of Ohm's law. |
| (B) | Loop rule | (2) | Magnitude of drift velocity per unit electric field. |
| (C) | $\vec{j}=\sigma\vec{E}$ | (3) | Based on law of conservation of charge |
| (D) | Mobility | (4) | Based on law of conservation of energy. |

(a) (A) → (1); (B) → (2); C → (3); (D) → (4)
(b) (A) → (1); (B) → (3); C → (2); (D) → (4)
(c) (A) → (4); (B) → (2); C → (1); (D) → (3)
(d) (A) → (3); (B) → (4); C → (1); (D) → (2)

**68.** Column I gives certain situations in which a straight metallic wire of resistance *R* is used and Column II gives some resulting effects.

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | A charged capacitor is connected to the ends of the wire | (1) | A constant current flows through the wire |
| (B) | The wire is moved perpendicular to its length with a constant velocity in a uniform magnetic field perpendicular to the plane of motion | (2) | Thermal energy is generated in the wire |
| (C) | The wire is placed in a constant electric field that has a direction along the length of the wire | (3) | A constant potential difference develops between the ends of the wire |
| (D) | A battery of constant emf is connected to the ends of the wire. | (4) | charges of constant magnitude appear at ends of the wire |

(a) (A) → (2); (B) → (3); (C) → (4); (D) → (1, 2, 3)
(b) (A) → (1); (B) → (2, 3); (C) → (4); (D) → (3)
(c) (A) → (1); (B) → (2); (C) → (1, 3); (D) → (4)
(d) (A) → (1); (B) → (2); (C) → (3); (D) → (4)

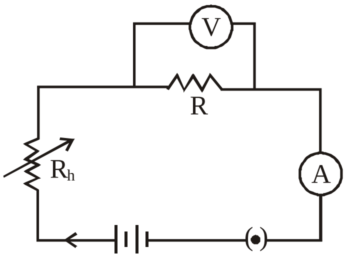
**69.** Match the entries of Column I with their correct mathematical expressions in Column II

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Balanced condition of wheatstone bridge | (1) | $\frac{R_1}{R_2}=\frac{R_3}{R_4}$ |
| (B) | Comparison of emf of two cells field. | (2) | $\frac{R}{S}=\frac{l_1}{100-l_1}$ |
| (C) | Determination of internal resistance of a cell | (3) | $\frac{E_1}{E_2}=\frac{l_1}{l_2}$ |
| (D) | Determination of unknown resistance by meter bridge | (4) | $r=R\left(\frac{l_1}{l_2}-1\right)$ |

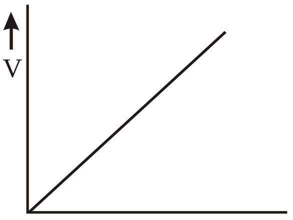
(a) (A) $\rightarrow$ (4); (B) $\rightarrow$ (2); C $\rightarrow$ (3); (D) $\rightarrow$ (1)
(b) (A) $\rightarrow$ (1); (B) $\rightarrow$ (3); C $\rightarrow$ (4); (D) $\rightarrow$ (2)
(c) (A) $\rightarrow$ (3); (B) $\rightarrow$ (4); C $\rightarrow$ (2); (D) $\rightarrow$ (1)
(d) (A) $\rightarrow$ (4); (B) $\rightarrow$ (3); C $\rightarrow$ (2); (D) $\rightarrow$ (1)

## DIAGRAM TYPE QUESTIONS

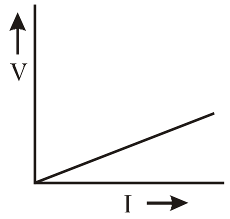
**70.** The figure (1) shows the experimental set up for verification of Ohm's law. Graph obtained for this set up is shown in figure (2). If the resistance *R* is changed with a new reistance of value 2R and the experiment is repeated again then which of the following will be the correct V-I graph?

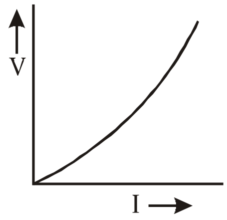


(1)



(2)

(a)


(b)


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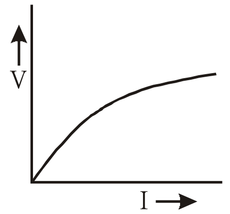
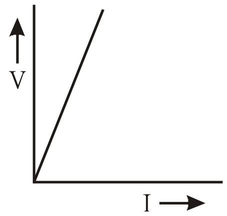
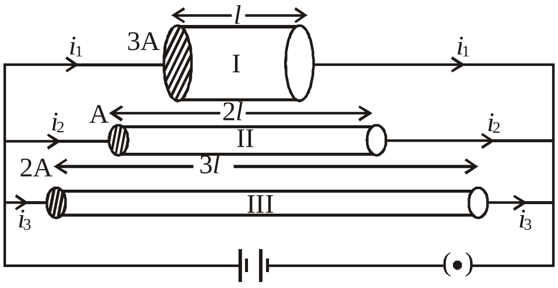


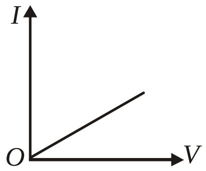
(d)


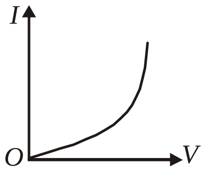
**71.** The figure shows three conductors I, II and III of same material, different lengths *l*, 2*l* and 3*l* and of different areas of cross-section 3A, A and 2A respectively. Arrange them in the increasing order of current drawn from battery.

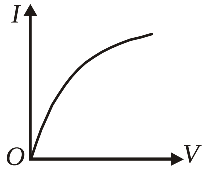


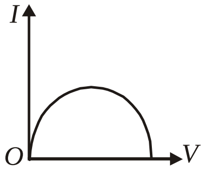
(a) $i_1 < i_2 < i_3$
(b) $i_3 < i_2 < i_1$
(c) $i_2 < i_1 < i_3$
(d) $i_2 ` < i_3 < i_1$

**72.** Which of the following *I-V* graph represents ohmic conductors ?

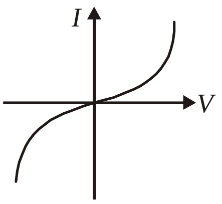
(a)


(b)


(c)


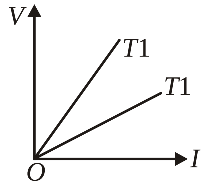
(d)


**73.** The *I-V* characteristics shown in figure represents



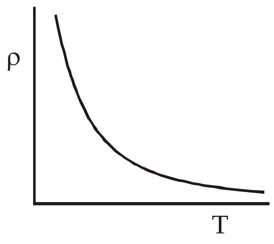
(a) ohmic conductors
(b) non-ohmic conductors
(c) insulators
(d) superconductors

**74.** The voltage *V* and current *I* graphs for a conductor at two different temperatures $T_1$ and $T_2$ are shown in the figure. The relation between $T_1$ and $T_2$ is



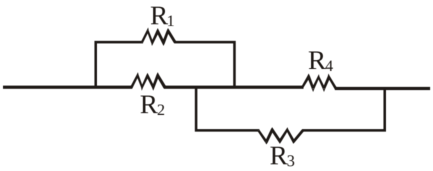
(a) $T_1 > T_2$
(b) $T_1 < T_2$
(c) $T_1 = T_2$
(d) $T_1 = \frac{1}{T_2}$

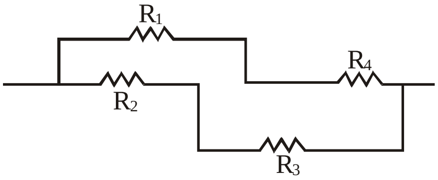
**75.** The graph shows the variation of resistivity with temperature T. The graph can be of

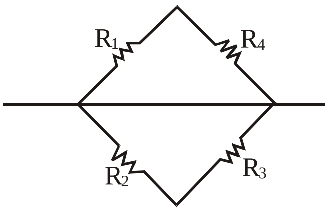


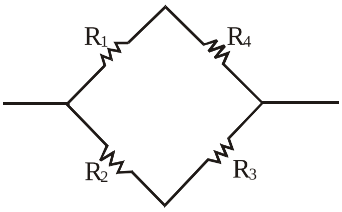
(a) copper
(b) nichrome
(c) germanium
(d) silver

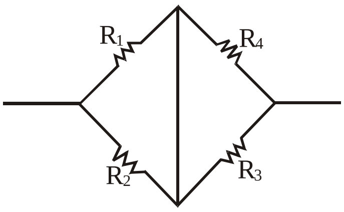
**76.** Choose the correct circuit diagram which is equivalent to the circuit diagram given in the figure.



(a)


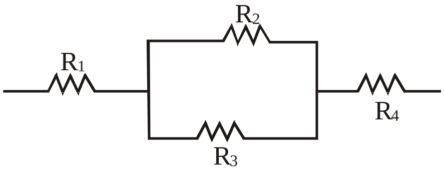
(b)


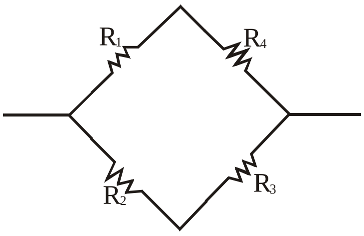
(c)


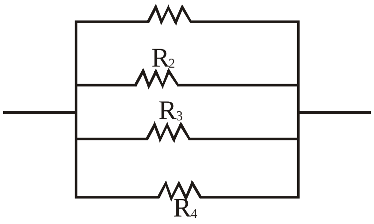
(d)


**77.** Four resistors $R_1$, $R_2$, $R_3$ and $R_4$ are connected in different ways. Which of the following combinations will draw the maximum current when connected to a battery ?

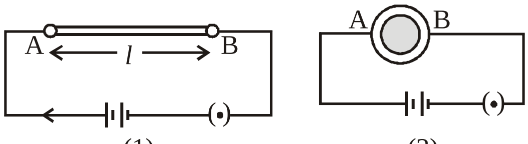
(a)


(b)


(c)


(d)


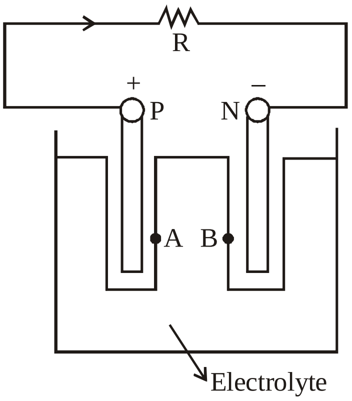
**78.** A wire of length *l* is connected to a battery between point *A* and *B* as shown in fig (1). The same wire is bent in the form of a circle and then connected to the battery between the points *A* and *B* as shown in fig. (2). The current drawn from the battery



(1) (2)

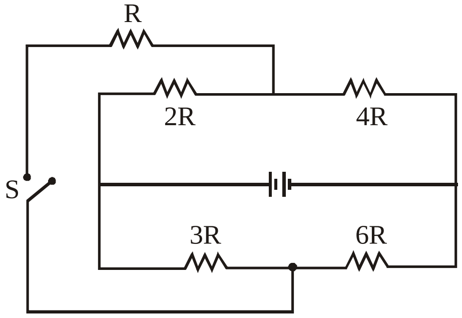
(a) increases
(b) decreases
(c) remains same
(d) increases if upper part of wire between *A* and *B* is a major arc and decreases if it is minor arc.

**79.** Figure shows a cell in which electrodes *P* and *N* are dipped in electrolyte. Points *A* and *B* are just adjacent to the electrodes. *P* is positive electrode and *N* is negative electrode. Which of the following is true?



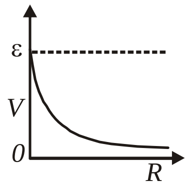
(a) Inside the cell current flows from *A* to B.
(b) Inside the cell current flows from *B* to A.
(c) Current does not flow inside the cell.
(d) Inside the cell current flows in both the directions *A* to *B* and B to A.

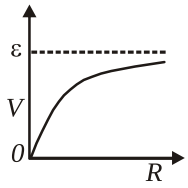
**80.** The figure shows the circuit diagram of five resistors, a battery and a switch. If the switch S is closed then current drawn from the battery

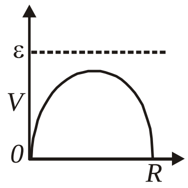


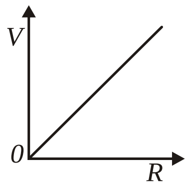
(a) increases
(b) decreases
(c) remains same
(d) initially increases and when the resistance *R* gets heated then decreases.

**81.** A cell having an emf ε and internal resistance *r* is connected across a variable external resistance *R*. As the resistance *R* is increased, the plot of potential difference *V* across *R* is given by

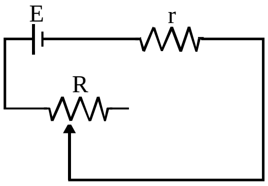
(a)


(b)


(c)


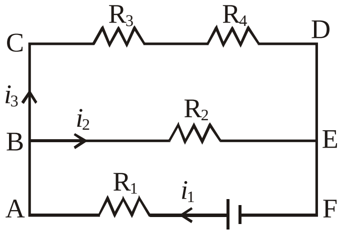
(D)


**82.** A battery of e.m.f E and internal resistance r is connected to a variable resistor R as shown. Which one of the following is true ?



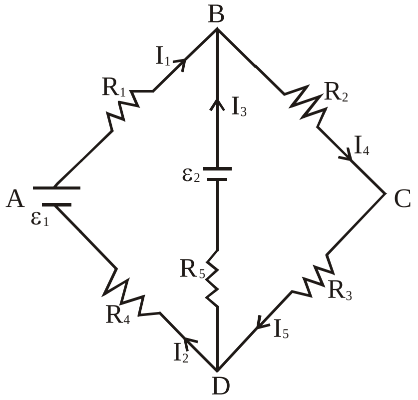
(a) Potential difference across the terminals of the battery is maximum when R = r
(b) Power delivered to resistor is maximum when R = 2r
(c) Current in the circuit is maximum when R = r
(d) Current in the circuit is maximum when R >> r

**83.** Which of the following is the correct equation when kirchhoff's loop rule is applied to the loop BCDEB in clockwise direction?



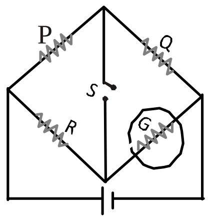
(a) $-i_3 R_3 - i_3 R_4 - i_2 R_2 = 0$
(b) $-i_3 R_3 - i_3 R_4 + i_2 R_2 = 0$
(c) $-i_3 R_3 + i_3 R_4 + i_2 R_2 = 0$
(d) $-i_3 R_3 + i_3 R_4 + i_2 R_2 = 0$

**84.** For the circuit diagram shown in the figure the value of $I_1$ comes out to be negative. It implies that



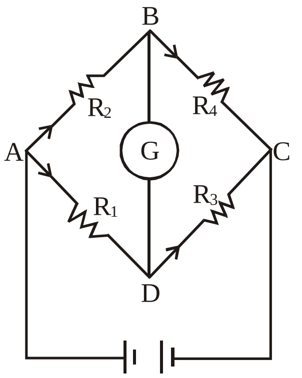
(a) the actual current flows in opposite direction of arrow
(b) the actual current flows in the direction of arrow.
(c) Kirchhoff's junction rule is wrongly applied to find current.
(d) Kirchhoff's loop rule is wrongly applied to find the current.

**85.** The figure shows a circuit diagram of a Wheatstone Bridge' to measure the resistance *G* of the galvanometer. The relation $\frac{P}{Q} = \frac{R}{G}$ will be satisfied only when

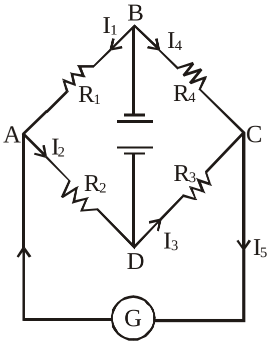


(a) the galvanometer shows a deflection when switch *S* is closed
(b) the galvanometer show a deflection when switch *S* is open
(c) the galvanometer shows no change in deflection whether *S* is open or closed
(d) the galvanometer shows no deflection

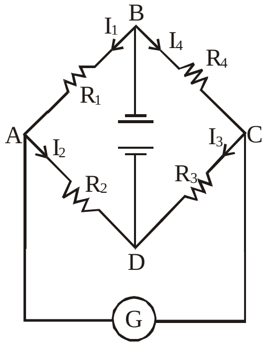
**86.** The bridge is at balanced condition in figure. Now the battery and galvanometer are interchanged. Which of the following figures show the correct direction of flow of current?



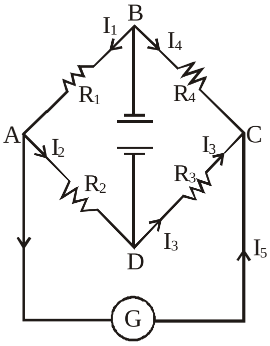
(a)



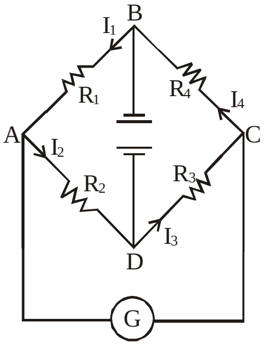
(b)



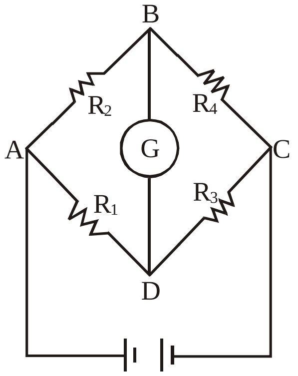
(c)



(d)

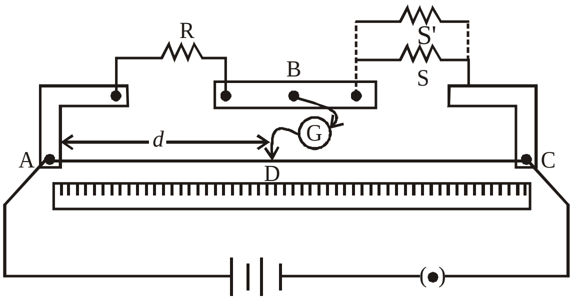


**87.** In the figure in balanced condition of wheatstone bridge



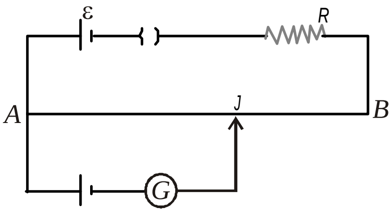
(a) *B* is at higher potential
(b) *D* is at higher potential
(c) Any of the two *B* or *D* can be at higher potential than other arbitrarily.
(d) *B* and *D* are at same potential.

**88.** The figure shows a meter bridge in which null point is obtained at a length AD = *l*. When a resistance S' is connected in parallel with resistance S the new position of null point is obtained



(a) to the left of D
(b) to the right of D
(c) at the same point D
(d) to the left of D if S' has lesser value than S and to the right of D if S' has more value than S.

**89.** *AB* is a wire of potentiometer with the increase in value of resistance *R*, the shift in the balance point *J* will be



(a) towards *B*
(b) towards *A*
(c) remains constant
(d) first towards *B* then back towards *A*

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

**90.** **Assertion:** Current is a vector quantity.
**Reason:** Current has magnitude as well as direction.

**91.** **Assertion :** A stream of positively charged particle produces an electric field E at a centrain distance from it.
**Reason :** A current currying conductor produces an electric field 2E at the same distance.

**92.** **Assertion :** Electric field outside the conducting wire which carries a constant current is zero.
**Reason :** Net charge on conducting wire is zero.

**93.** **Assertion:** The statement of Ohm's law is *V* = IR.
**Reason:** *V* = IR is the equation which defines resistance.

**94.** **Assertion :** A current flows in a conductor only when there is an electric field within the conductor.
**Reason :** The drift velocity of electron in presence of electric field decreases.

**95.** **Assertion :** Drift speed $v_d$ is the average speed between two successive collisions.
**Reason :** If $\Delta\ell$ is the average distance moved between two collision and $\Delta t$ is the corresponding time, then

$$v_d = \lim_{\Delta t \to 0} \frac{\Delta \ell}{\Delta t}.$$

**96.** **Assertion :** When a current is established in a wire, the free electrons drift in the direction opposite to the current and so the number of free electrons in the wire continuously decrease.

**Reason :** Charge is a conserved quantity.

**97.** **Assertion :** The electric bulb glows immediately when switch is on.

**Reason :** The drift velocity of electrons in a metallic wire is very high.

**98.** **Assertion:** $\vec{E} = \rho \vec{j}$ is the statement of Ohm's law.

**Reason:** If the resistivity of the conducting material is independent of the direction and magnitude of applied field then the material obeys Ohm's law.

**99.** **Assertion:** For a conductor resistivity increases with increase in temperature.

**Reason:** Since $\rho = \frac{m}{ne^2 \tau}$, when temperature increases the random motion of free electrons increases and vibration of ions increases which decreases $\tau$.

**100.** **Assertion :** The drift velocity of electrons in a metallic wire will decrease, if the temperature of the wire is increased.

**Reason :** On increasing temperature, conductivity of metallic wire decreases.

**101.** **Assertion :** Bending a wire does not effect electrical resistance.

**Reason:** Resistance of wire is proportional ot resistivity of material.

**102.** **Assertion :** Two non ideal batteries are connected in parallel. The equivalent emf is smaller than either of the two emfs.

**Reason :** The equivalent internal resistance is smaller than either of the two internal resistances.

**103.** **Assertion :** Kirchoff's juction rule can be applied to a junction of several lines or a point in a line.

**Reason :** When steady current is flowing, there is no accumulation of charges at any junction or at any point in a line.

**104.** **Assertion :** Kirchoff′s junction rule follows from conservation of charge.

**Reason :** Kirchoff′s loop rule follows from conservation of momentum.

**105.** **Assertion :** In meter bridge experiment, a high resistance is always connected in series with a galvanometer.

**Reason :** As resistance increases current through the circuit increases.

**106.** **Assertion :** In a meter bridge experiment, null point for an unknown resistance is measured. Now, the unknown resistance is put inside an enclosure maintained at a higher temperature. The null point can be obtained at the same point as before by decreasing the value of the standard resistance.

**Reason :** Resistance of a metal increases with increase in temperature.

**107.** **Assertion :** In meter bridge experiment, a high resistance is always connected in series with a galvanometer.

**Reason :** As resistance increase current more accurately then ammeter.

**108.** **Assertion :** The e.m.f of the driver cell in the potentiometer experiment should be greater that the e.m.f of the cell to be determined.

**Reason :** The fall of potential across the potentiometer wire should not be less than the e.m.f of the cell to be determined.

**109.** **Assertion :** A potentiometer of longer length is used for accurate measurement.

**Reason :** The potential gradient for a potentiometer of longer length with a given source of e.m.f becomes small.

## CRITICALTHINKING TYPE QUESTIONS

**110.** The amount of charge Q passed in time t through a cross-section of a wire is $Q = 5t^2 + 3t + 1$. The value of current at time t = 5 s is

(a) 9 A (b) 49 A

(c) 53 A (d) None of these

**111.** A conductor carries a current of 50 μ A. If the area of cross-section of the conductor is 50 mm$^2$, then value of the current density in Am$^{-2}$ is

(a) 0.5 (b) 1

(c) $10^{-3}$ (d) $10^{-6}$

**112.** Two wires A and B of the same material, having radii in the ratio 1 : 2 and carry currents in the ratio 4 : 1. The ratio of drift speed of electrons in A and B is

(a) 16 : 1 (b) 1 : 16

(c) 1 : 4 (d) 4 : 1

**113.** When a current I is set up in a wire of radius r, the drift velocity is $v_d$. If the same current is set up through a wire of radius 2 r, the drift velocity will be

(a) 4 $v_d$ (b) 2 $v_d$

(c) $v_d/2$ (d) $v_d/4$

**114.** A straight conductor of uniform cross-section carries a current I. If s is the specific charge of an electron, the momentum of all the free electrons per unit length of the conductor, due to their drift velocity only is

(a) I s (b) $\sqrt{I/s}$

(c) I/s (d) $(I/s)^2$

**115.** When the current *i* is flowing through a condutor, the drift velocity is *v*. If 2*i* current flows through the same metal but having double the are of cross-section, then the drift velocity will be

(a) $v \setminus 4$ (b) $v / 2$

(c) $v$ (d) $4v$

**116.** If the resistance of a conductor is 5Ω at 50º C & 7Ω at 100º C, then mean temperature coefficient of resistance (of material) is

(a) 0.013/ºC (b) 0.004/ºC

(c) 0.006/ºC (d) 0.008/ºC

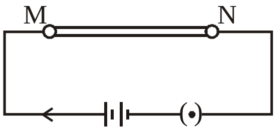
**117.** If negligibly small current is passed though a wire of length 15 m and resistance of 5Ω, having uniform cross section of $6 \times 10^{-7}$ m$^2$, then coefficient of resistivity of material is

(a) $1\times10^{-7}\Omega$–m (b) $2\times10^{-7}\Omega$–m
(c) $3\times10^{-7}\Omega$–m (d) $4\times10^{-7}\Omega$–m

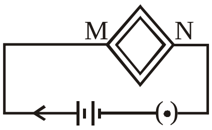
**118.** The resistance of a wire at room temperature 30°C is found to be 10 Ω. Now to increase the resistance by 10%, the temperature of the wire must be [ The temperature coefficient of resistance of the material of the wire is 0.002 per °C]

(a) 36°C (b) 83°C
(c) 63°C (d) 33°C

**119.** A wire is connected to a battery between the point *M* and *N* as shown in the figure (1). The same wire is bent in the form of a square and then connected to the battery between the points *M* and *N* as shown in the figure (2). Which of the following quantities increases ?



(1)



(2)

(a) Heat produced in the wire and resistance offered by the wire.
(b) Resistance offered by the wire and current through the wire.
(c) Heat produced in the wire, resistance offered by the wire and current through the wire.
(d) Heat produced in the wire and current through the wire.

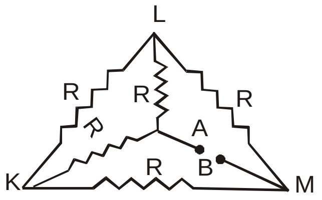
**120.** When a piece of aluminium wire of finite length is drawn through a series of dies to reduce its diameter to half its original value, its resistance will become

(a) two times (b) four times
(c) eight times (d) sixteen times

**121.** A wire X is half the diameter and half the length of a wire Y of similar material. The ratio of resistance of X to that of Y is

(a) 8 : 1 (b) 4 : 1
(c) 2 : 1 (d) 1 : 1

**122.** Each of the resistance in the network shown in fig. is equal to R. The resistance between the terminals A and B is



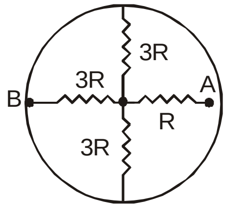
(a) R (b) 5R
(c) 3R (d) 6R

**123.** A wire has a resistance 12 Ω. It is bent in the form of a circle. The effective resistance between two points on any diameter is

(a) 6 Ω (b) 3 Ω
(c) 12 Ω (d) 24 Ω

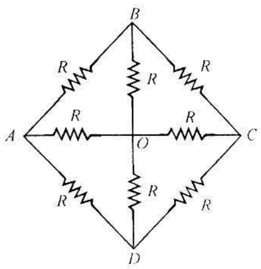
**124.** In the network shown below, the ring has zero resistance. The equivalent resistance between the point A and B is

(a) 2R
(b) 4R
(c) 7R
(d) 10R

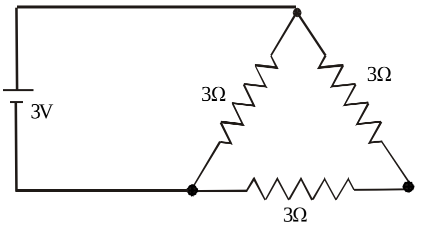


**125.** In the network shown, each resistance is equal to R. The equivalent resistance between adjacent corners A and D is

(a) R
(b) $\frac{2}{3}$R
(c) $\frac{3}{7}$R
(d) $\frac{8}{15}$R



**126.** A 3 volt battery with negligible internal resistance is connected in a circuit as shown in the figure. The current I, in the circuit will be



(a) 1 A (b) 1.5 A
(c) 2 A (d) 1/3 A

**127.** Two sources of equal emf are connected to an external resistance R. The internal resistance of the two sources are $R_1$ and $R_2$ ($R_2 > R_1$). If the potential difference across the source having internal resistance $R_2$ is zero, then

(a) $R = R_2 - R_1$
(b) $R = R_2 \times (R_1 + R_2)/(R_2 - R_1)$
(c) $R = R_1R_2/(R_2 - R_1)$
(d) $R = R_1R_2/(R_1 - R_2)$

**128.** In the series combination of *n* cells each cell having emf ε and internal resistance *r*. If three cells are wrongly connected, then total emf and internal resistance of this combination will be

(a) $n\varepsilon$, $(nr - 3r)$ (b) $(n\varepsilon - 2\varepsilon)$ $nr$
(c) $(n\varepsilon - 4\varepsilon)$, $nr$ (d) $(n\varepsilon - 6\varepsilon)$, $nr$

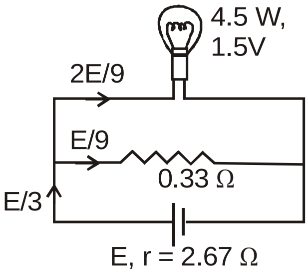
**129.** The internal resistance of a 2.1 V cell which gives a current of 0.2 A through a resistance of 10 Ω is

(a) 0.5 Ω (b) 0.8 Ω
(c) 1.0 Ω (d) 0.2 Ω

**130.** A primary cell has an e.m.f. of 1.5 volt. When short-circuited it gives a current of 3 ampere. The internal resistance of the cell is

(a) 4.5 ohm (b) 2 ohm
(c) 0.5 ohm (d) (1/4.5) ohm

**131.** A torch bulb rated as 4.5 W, 1.5 V is connected as shown in fig. The e.m.f. of the cell, needed to make the bulb glow at full intensity is

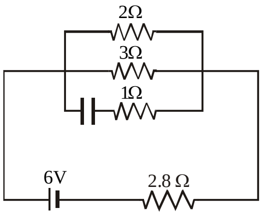


(a) 4.5 V (b) 1.5 V
(c) 2.67 V (d) 13.5 V

**132.** A battery of e.m.f. 10 V and internal resistance 0.5 Ω is connected across a variable resistance R. The value of R for which the power delivered in it is maximum is given by

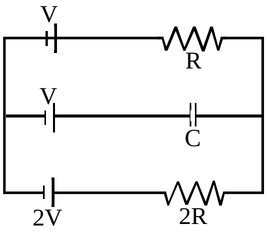
(a) 0.5 Ω (b) 1.0 Ω
(c) 2.0 Ω (d) 0.25 Ω

**133.** Determine the current in 2Ω resistor.



(a) 1 A (b) 1.5 A
(c) 0.9 A (d) 0.6 A

**134.** In the circuit shown in figure, with steady current, the potential drop across the capacitor must be



(a) V (b) $\frac{V}{2}$

(c) $\frac{V}{3}$ (d) $\frac{2V}{3}$

**135.** The resistance of the four arms P, Q, R and S in a Wheatstone's bridge are 10 ohm, 30 ohm, 30 ohm and 90 ohm, respectively. The e.m.f. and internal resistance of the cell are 7 volt and 5 ohm respectively. If the galvanometer resistance is 50 ohm, the current drawn from the cell will be

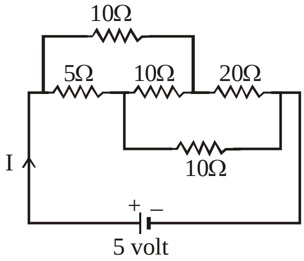
(a) 0.2 A (b) 0.1 A
(c) 2.0 A (d) 1.0 A

**136.** In a Wheatstone's bridge, three resistances P, Q and R connected in the three arms and the fourth arm is formed by two resistances $S_1$ and $S_2$ connected in parallel. The condition for the bridge to be balanced will be

(a) $\frac{P}{Q}=\frac{2R}{S_1+S_2}$ (b) $\frac{P}{Q}=\frac{R(S_1+S_2)}{S_1S_2}$

(c) $\frac{P}{Q}=\frac{R(S_1+S_2)}{2S_1S_2}$ (d) $\frac{P}{Q}=\frac{R}{S_1+S_2}$

**137.** The current I drawn from the 5 volt source will be

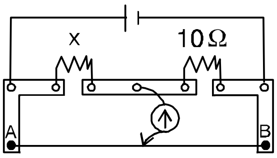


(a) 0.33 A (b) 0.5 A
(c) 0.67 A (d) 0.17 A

**138.** In a Wheatstone bridge all the four arms have equal resistance R. If the resistance of galvanometer arm is also R, the equivalent resistance of combination is

(a) 2R (b) R/4
(c) R/2 (d) R

**139.** A meter bridge is set up as shown, to determine an unknown resistance 'X' using a standard 10 ohm resistor. The galvanometer shows null point when tapping-key is at 52 cm mark. The end-corrections are 1 cm and 2 cm respectively for the ends A and B. The determined value of 'X' is



(a) 10.2 ohm (b) 10.6 ohm
(c) 10.8 ohm (d) 11.1 ohm

**140.** In a metre bridge, the balancing length from the left end (standard resistance of one ohm is in the right gap) is found to be 20 cm. The value of the unknown resistance is

(a) 0.8 Ω (b) 0.5 Ω

(c) 0.4 Ω (d) 0.25 Ω

**141.** If specific resistance of a potentiometer wire is $10^{-7}\Omega$m current flowing through it, is 0.1 amp and cross sectional area of wire is $10^{-6}$ m$^2$, then potential gradient will be

(a) $10^{-2}$ volt/m (b) $10^{-4}$ volt/m

(c) $10^{-6}$ volt/m (d) $10^{-8}$ volt/m

**142.** The current in the primary circuit of a potentiometer wire is 0.5 A, ρ for the wire is $4 \times 10^{-7}$ Ω–m and area of cross-section of wire is $8 \times 10^{-6}$ m$^2$. The potential gradient in the wire would be

(a) 25 mV/meter (b) 2.5 mV/meter

(c) 25 V/meter (d) 10 V/meter

**143.** A cell when balanced with potentiometer gave a balance length of 50 cm. 4.5 Ω external resistance is introduced in the circuit, now it is balanced on 45 cm. The internal resistance of cell is

(a) 0.25 Ω (b) 0.5 Ω

(c) 1.0 Ω (d) 1.5 Ω

**144.** A potentiometer consists of a wire of length 4m and resistance 10Ω. It is connected to a cell of e.m.f. 3V. The potential gradient of wire is

(a) 5V/m (b) 2V/m

(c) 5V/m (d) 10V/m

**145.** Potentiometer wire of length 1 m is connected in series with 490Ω resistance and 2 V battery. If 0.2 mV/cm is the potential gradient, then resistance of the potentiometer wire is

(a) 4.9 Ω (b) 7.9 Ω

(c) 5.9 Ω (d) 6.9 Ω

**146.** A potentiometer wire, 10 m long, has a resistance of 40Ω. It is connected in series with a resistance box and a 2 V storage cell. If the potential gradient along the wire is 0.1 m V/cm, the resistance unplugged in the box is

(a) 260 Ω (b) 760 Ω

(c) 960 Ω (d) 1060 Ω

**147.** In an experiment to measure the internal resistance of a cell, by a potentiometer, it is found that the balance point is at a length of 2 m, when the cell is shunted by a 5 Ω resistance and is at a length of 3 m when the cell is shunted by a 10 Ω resistance. The internal resistance of the cell is

(a) 1.5 Ω (b) 10 Ω

(c) 15 Ω (d) 1 Ω

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(c)** In a current carrying conductor, the net charge is zero.

**2.** **(c)** **3.** **(d)** **4.** **(d)**

**5.** **(a)** $J = \sigma E \Rightarrow J\rho = E$

J is current density, E is electric field
so B = ρ = resistivity.

**6.** **(b)** Motion of conduction electrons due to random collisions has no preffered direction and average to zero. Drift velocity is caused due to motion of conduction electrons due to applied electric field $\vec{E}$.

**7.** **(d)** **8.** **(a)** **9.** **(b)**

**10.** **(d)** **11.** **(d)** **12.** **(c)**

**13.** **(b)** When the temperature increases, resistance increases. As the e.m.f. applied is the same, the current density decreases the drift velocity decreases. But the rms velocity of the electron due to thermal motion is proportional to $\sqrt{T}$. The Thermal velocity increases.

**14.** **(b)**

**15.** **(b)** Because as temperature increases, the resistivity increases and hence the relaxation time decreases for conductors $\left(\tau \propto \frac{1}{\rho}\right)$

**16.** **(b)**

**17.** **(a)** In conductor when electrons move between two collisions, their paths are **straight lines** when external fields are absent and paths are **curved in general** when external field is present.

**18.** **(a)** **19.** **(c)** **20.** **(a)** **21.** **(d)** **22.** **(b)**

**23.** **(d)** **24.** **(c)** **25.** **(d)**

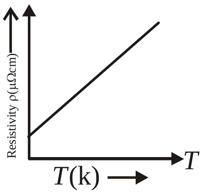
**26.** **(c)** $R = \frac{\rho \ell_1}{A_1}$, now $\ell_2 = 2\ell_1$

$A_2 = \pi(r_2)^2 = \pi(2r_1)^2 = 4\pi r_1{}^2 = 4A_1$

$\therefore \quad R_2 = \frac{\rho(2\ell_1)}{4A_1} = \frac{\rho \ell}{2A} = \frac{R}{2}$

∴ Resistance is halved, but specific resistance remains the same.

**27.** **(b)** These materials exhibit a very weak dependence of resistivity on temperature. Their resistance values would be changed very little with temperature as shown in figure. Hence these materials are widely used as heating element.



**28.** **(b)** Semiconductors having negative temperature coefficient of resistivity whereas metals are having positive temperature coefficient of resistivity with increase in temperature the resistivity of metal increases where a resistivity of semiconductor decreases.

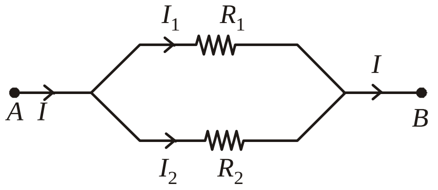
**29.** **(a)** The conduction electrons collides with each other more. the specific resistance of a conductor increases with temperature according to the reaction $\rho_T = \rho_0{}^{eEg/kgT}$ where $\rho_0$ is the specific resistance at 0° C, $E_g$ = energy of the gap between the valence and the conduction band, $k_B$ is the Boltzmann constant and $T$, the temperature of the resistor.

**30.** **(b)** The power dissipated in the transmission cables is inversely proportional to the square of voltage at which current is transmitted through the cables. Therefore to minimize the power loss the transmission cables carry current at a very high voltage.

**31.** **(c)**

**32.** **(a)** In series combination, current across its circuit components is always constant and in parallel combination the voltage across the circuit components in constant.

**33.** **(b)** Two or more resistors are said to be in parallel, if one end of all resistors is joined together and similarly the other ends joined together.



Two resistors $R_1$ and $R_2$ connected in parallel.

**34.** **(a)** **35.** **(d)** **36.** **(d)** **37.** **(c)** **38.** **(a)**

**39.** **(d)** $I = \frac{E}{R + r}$, Internal resistance (r) is zero,

$I = \frac{E}{R}$ = constant.

**40.** **(b)** $S = \frac{I_g R}{nI_g - I_g} \Rightarrow S = \frac{I_g}{(n-1)I_g} R$

**41.** **(c)** Internal resistance = r, External resistance = nr.
Let terminal voltage = V

then $V = E - Ir \Rightarrow V = E - \frac{Er}{(n+1)r}$

$V = \frac{nE}{n+1} \Rightarrow \frac{V}{E} = \frac{n}{n+1}$

**42.** **(a)** **:** In the parallel combination,

$$\frac{\varepsilon_{eq}}{r_{eq}} = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2} + .... + \frac{\varepsilon_n}{r_n}$$

$$\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2} + .... + \frac{1}{r_n}$$

($\because$ $\varepsilon_1 = \varepsilon_2 = \varepsilon_3 = ..... = \varepsilon_n = \varepsilon$ and $r_1 = r_2 = r_3 = ... r$)

$$\therefore \quad \frac{\varepsilon_{eq}}{r_{eq}} = \frac{\varepsilon}{r} + \frac{\varepsilon}{r} + .... + \frac{\varepsilon}{r} = n\frac{\varepsilon}{r} \qquad .... (i)$$

$$\frac{\varepsilon}{r_{eq}} = \frac{1}{r} + \frac{1}{r} + .... + \frac{1}{r} = \frac{n}{r} \quad r_{eq} = r/n \qquad ...(ii)$$

From (i) and (ii)

$$\varepsilon_{eq} = n\frac{\varepsilon}{r_{eq}} \times r_{eq} = n \times \frac{\varepsilon}{r} \times \frac{\varepsilon}{r} = \varepsilon$$

**43.** **(b)** The internal resistance of dry cells, is much higher than the common electrolytic cells.

**44.** **(a)**

**45.** **(d)** Kirchhoff's first law is based on conservation of charge and Kirchhoff's second law is based on conservation of energy.

**46.** **(d)** **47.** **(b)**

**48.** **(b)** The deflection in galvanometer will not be changed due to interchange of battery and the galvanometer.

**49.** **(a)** In meter bridge experiment, it is assumed that the resistance of the *L* shaped plate is negligible, but actually it is not so. The error created due to this is called end error. To remove this the resistance box and the unknown resistance must be interchanged and then the mean reading must be taken.

**50.** **(b)** Potentiometer is based on zero deflection method.

**51.** **(b)** **52.** **(b)** **53.** **(b)** **54.** **(a)** **55.** **(c)**

## STATEMENT TYPE QUESTIONS

**56.** **(a)**

**57.** **(a)** The order of magnitude of current in lightening is very high approx 10,000 of amperes. The order of magnitude of current in human body and galvanometer is also not one ampere.

**58.** **(d)** According to Ohm's law, the plot of I versus *V* is linear so how can it fail if *V* depends on I linearly.

**59.** **(d)** Consider the case when no electric field is present. The electrons will be moving due to thermal motion during which they collide with the fixed ions. An electron colliding with an ion emerges with the same speed as before the collision. However, the direction of its velocity after the collision is completely random. At a given time, there is no preferential direction for the velocities of the electrons. Thus, on the average, the number of electrons travelling in any direction will be equal to the number of electrons travelling in the opposite direction. So, there will be no net electric current.

**60.** **(d)** **61.** **(b)**

**62.** **(c)** When resistances are connected in series the same current flows through each resistance.

## MATCHING TYPE QUESTIONS

**63.** **(b)** (A) → (1) if the temperature is not very high.
(B) → (3)
(C) → (2)
(D) → (4)

**64.** **(d)** A - (4) as silver has least resistivity. B - (3) because the resistivity of semiconductor decreases with temperature so they have negative temperature coefficient of resistivity. C-(2) as carbon resistors have high range. D-(1) because wires of alloys like managanin, constantan, nichrome etc are used to make wire bound resistors.

**65.** **(c)** **66.** **(c)**

**67.** **(d)** A-(3) Kirchhoff's junction rule is based on law of conservation of charge. B-(4) Kirchhoff's loop rule is based on law of conservation of energy. C-(1) $\vec{j} = \sigma\vec{E}$ is also an equivalent form of Ohm's law. D-(2) as mobility is defined as the magnitude of drift velocity per unit electric field.

**68.** **(a)** A-2 : Energy stored in capacitor will convert into thermal energy.
B-3 : Induced emf, $e = Bv\ell$.
C-4 : Because of electric force ends of wire will have opposite charges.
D-1, 2, 3 : When battery is connected to wire a constant current flows in the wire which produces heating effect.

**69.** **(b)**

## DIAGRAM TYPE QUESTIONS

**70.** **(d)** Even if resistance *R* is changed with 2*R*, according to Ohm's law *V* is still proportional to *I* i.e., the graph between *V* and *I* is a straight line. Then why option (a) is not correct? Because the slope of *V.I.* graph gives the value of resistance. As the value of resistance is increased from *R* to 2*R*, the slope of given graph must also increase which is shown in fig. (d).

**71.** **(d)** As we know, resistance R = $\rho\frac{l}{A}$. The resistance of conductor *l* is given by

$$R_l = \rho\frac{l}{3A} = \frac{R}{3} \qquad \left(\text{where} \quad R = \rho\frac{l}{A}\right)$$

Similarly, $R_{II} = \rho\frac{2l}{A} = 2R$

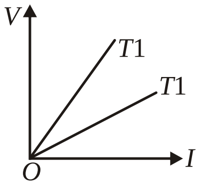
and $R_{III} = \rho\frac{3l}{2A} = \frac{3}{2}R$

From this we conclude that $R_{II} > R_{III} > R_I$. Since in parallel combination of resistances current distributes in inverse ratio of resistances, therefore $i_2 < i_3 < i_1$

**72.** **(a)** Ohm's law $V = IR$ is an equation of straight line Hence $I$ - $V$ characteristics for ohmic conductors is also a straight line and its slope gives resistance of the conductor.

**73.** **(b)** The figure is showing $I – V$ characteristics of non ohmic or non linear conductors.

**74.** **(a)**



The slope of $V – I$ graph gives the resistance of a conductor at a given temperature.

From the graph, it follows that resistance of a conductor at temperature $T_1$ is greater than at temperature $T_1$ As the resistance of a conductor is more at higher temperature and less at lower temperature, hence $T_1 > T_2$

**75.** **(c)** The resistivity of semiconductor decreases with increase in temperature.

**76.** **(d)** This is a balanced Wheatstone bridge condition.

**77.** **(d)** When all the resistances are connected in parallel the equivalent resistance is minimum so, current drawn will be maximum.

**78.** **(a)** In figure (2) the upper and lower part of the wire between $A$ and $B$ are in parallel. Therefore the equivalent resistance of these two parts is less than the resistance of each of the upper and lower part. Since the resistance between $A$ and $B$ decreases in fig. (2) therefore the current drawn from the battery increases.

**79.** **(b)** Current does flow through the electrolyte inside the cell and it flows from negative electrode to positive electrode.

**80.** **(c)** No current flows through the resistor $R$ as $A$ and $C$ are at same potential. Hence current drawn from battery will remain same on closing the switch.

**81.** **(b)** Current in the circuit,

$$I = \frac{\varepsilon}{R+r}$$

Potential difference across $R$,

$$V = IR = \left(\frac{\varepsilon}{R+r}\right)R = \frac{\varepsilon}{1+\frac{r}{R}}$$

When $R = 0$, $V = 0$

$R = \infty$, $V = \varepsilon$

**82.** **(c)** $I = \frac{E}{R+r} = \frac{E}{(\sqrt{R}-\sqrt{r})^2 + 2\sqrt{R}\sqrt{r}}$

I is maximum when R = r

$P = I^2R$, when I is max, P is also max.

$P_{max} = I^2_{max}R$.

**83.** **(b)** If we apply Kirchhoff's loop rule to the loop BCDEB in clockwise direction the changes in potential across $R_3$ and $R_4$ are negative. Therefore $i_3\,R_3$ and $i_3\,R_4$ should have negative sign. But for this clockwise direction we are moving in a direction opposite to $i_2$ across $R_2$. Current flows from higher potential to lower potential but we are moving from lower potential to higher potential i.e., potential is increasing. So the change in potential is positive. Therefore $i_2\,R_2$ has positive sign.

**84.** **(a)** If the value of current comes out positive then actual current is in the direction of arrow and if it comes out negative then actual current is in opposite direction of the arrow.

**85.** **(c)** In balances condition, no current will flow through the branch containing $S$.

**86.** **(b)** In the balance condition if the battery and galvanometer are interchanged even then no current flows through the galvanometer as $A$ and C are at same potential.

**87.** **(d)** In balance condition, since no current flows through the galvanometer therefore $B$ and D are at the same potential.

**88.** **(b)** The working principle of meter bridge is

$$\frac{R}{S} = \frac{l}{100-l} \quad \ldots(i)$$

When S' is connected in parallel with S we obtain equivalent resistance $S_{eq}$ of S and S' which is less than S. Thus if the value of denominator of L.H.S. of eq. (i) decreases then value of denominator of R.H.S. of eq. (i) also decreases. For this to happen the null point shifts to the right of D.

**89.** **(a)** Due to increases in resistance $R$ the current through the wire will decrease and hence the potential gradient also decreases, which results in increase in balancing length. So. $J$ will shift towards $B$.

## ASSERTION- REASON TYPE QUESTIONS

**90.** **(d)** We call those quantities as vector quantities which have magnitude and direction and obey laws of vector addition. Though current has magnitude as well as direction but it does not obey laws of vector addition. Hence it is not a vector quantity.

**91.** **(c)** The net charge on current carrying conductor is zero, and so its electric field is also zero.

**92.** **(a)**

**93.** **(d)** A diode does not obey Ohm's law while a resistor obeys. But the equation $V = IR$ can be applied to both. In fact the equation $V = IR$ can be applied to all the conducting devices whether they obey Ohm's law or not. So $V = IR$

is not a statement of Ohm's law. Ohm's law states that $V$ is directly proportional to $I$ i.e.. $V \propto I$. The proportionality sign is changed to equality sign in the equation $V = IR$ with $R$ as constant of proportionality know as resistance of conductor. Thus the equation $V = IR$ defines resistance.

**94. (c)** Before the presence of electric field, the free electrons move randomly in the conductor, so their drift velocity is zero and therefore there is no current in the conductor. In the presence of electric field, each electron in the conductor experience a force in a direction opposite to the electric field. Now the free electrons are accelerated from negative and to the positive end of the conductor and hence a current starts to flow from the conductor.

**95. (c)** Drift speed is the average speed between two successive collision.

**96. (d)** The free electron density in any part of the conductor remains constant.

**97. (c)** The drift velocity of electrons in metals is order of $10^{-4}$ m/s.

**98. (a)** We know that $V = IR$

Since $R = \rho\frac{l}{A}$

Therefore $V = I\rho\frac{l}{A}$ ...(i)

Now $\frac{I}{A} = j$ is the current density.

Therefore eq. (i) becomes

$V = j\rho l$ or $\frac{V}{l} = j\rho$

Now $\frac{V}{l} = E,$ where $E$ is magnitude of electric field.

Therefore $E = j\rho$ ...(ii)

Current density $\vec{j}$ is also a vector which is directed along $\vec{E}$. Therefore the relation (ii) can also be written in vector form $\vec{E} = \rho\,\vec{j}$.

**99. (a)** When temperature increases the random motion of electrons and vibration of ions increases which results in more frequent collisions of electrons with the ions. Due to this the average time between the successive collisions, denoted by $\tau$, decreases which increases $\rho$.

**100. (b)** On increasing temperature of wire the kinetic energy of free electrons increase and so they collide more rapidly with each other and hence their drift velocity decreases. Also when temperature increases, resistivity increases and resistivity is inversely proportional to conductivity of material.

**101. (a)** Resistance wire $R = \rho\frac{I}{A}$, where $\rho$ is resistivity of material which does not depend on the geometry of wire. Since when wire is bent resistivity, length and area of cross-section do not change, therefore resistance of wire also remain same.

**102. (d)** The equivalent *emf* of the two batteries in parallel,

$e = \left(\frac{e_1r_2 + r_2r_1}{r_1 + r_2}\right)$. $e$ may be; $e_1 \le e \le e_2$.

Internal resistance, $r = \left(\frac{r_1r_2}{r_1 + r_2}\right)$. This value is smaller than either of $r_1$ and $r_2$.

**103. (a)**

**104. (c)** Kirchoff's loop rule follows from conservation of energy.

**105. (c)** The resistance of the galvanometer is fixed. In meter bride experiments, to protect the galvanometer from a high current, high resistance is connected to the galvanometer.

**106. (d)** With increase in temperature, resistance of metal wire increases, but balance conduction will not change.

**107. (c)** The resistance of the galvanometer is flexed. In meter bridge experiments, to protect the galvanometer from a high current, high resistance is conneted to the galvanometer in order to protect it from damage.

**108. (a)** If either e.m.f. of the driver cell or potential difference across the whole potentiometer wire is lesser than the e.m.f. of then experimental cell, then balance point will not obtained.

**109. (a)** Sensitivity $\propto \frac{1}{\text{Potential gradient}} \propto$ (Length of wire)

## CRITICALTHINKING TYPE QUESTIONS

**110. (c)** $\mathrm{I = \frac{dQ}{dt} = 10t + 3}$

At t = 5s, I = 10 × 5 + 3 = 53 A

**111. (b)** Current density J = I/A

$= 50\times16^{-6}/50\times10^{-6} = 1\ \mathrm{Am}^{-2}$

**112. (a)** Current flowing through the conductor,
I = n e v A. Hence

$$\frac{4}{1} = \frac{\mathrm{nev}_{d_1}\pi(1)^2}{\mathrm{nev}_{d_2}\pi(2)^2} \text{ or } \frac{v_{d_1}}{v_{d_2}} = \frac{4\times1}{1} = \frac{16}{1}.$$

**113. (d)** $\mathrm{I = n\,A\,e\,v_d}$ or $v_d \propto 1/\pi r^2$

**114. (c)**

**115. (c)** $v_d = \frac{J}{\mathrm{ne}} \Rightarrow v_d \propto J$ [current density]

$J_1 = \frac{i}{A}$ and $J_2 = \frac{2i}{2A} = \frac{1}{A}J_1$;

$\therefore\ (v_d)_1 = (v_d)_2 = v$

**116. (a)** [Hint $\Rightarrow \mathrm{R_t = R_0(1 + \alpha\,t)}$]

$5\Omega = \mathrm{R_0}(1 + \alpha\times50)$ and $7\Omega = \mathrm{R_0}(1 + \alpha\times100)$

or $\frac{5}{7} = \frac{1+50\alpha}{1+100\alpha}$ or $\alpha = \frac{2}{150} = 0.0133/°\mathrm{C}$

**117. (b)** (Hint $\Rightarrow \rho = \frac{R.A}{\ell}$ = Coefficient of resistivity)

**118. (b)** $R_t = R_0(1 + \alpha t)$

Initially, $R_0(1 + 30\alpha) = 10\,\Omega$

Finally, $R_0(1 + \alpha t) = 11\,\Omega$

$$\therefore \frac{11}{10} = \frac{1+\alpha t}{1+30\alpha}$$

or, $10 + (10 \times 0.002 \times t) = 11 + 330 \times 0.002$

or, $0.02t = 1 + 0.66 = 1.066$ or $t = \frac{1.66}{0.02} = 83°C.$

**119. (d)** When the wire is bent in the form of a square and connected between *M* and *N* as shown in fig. (2), the effective resistance between *M* and *N* decreases to one fourth of the value in fig. (1). The current increases four times the initial value according to the relation $V = IR$. Since $H = I^2 Rt$, the decrease in the value of resistance is more than compensated by the increases in the value of current. Hence heat produced increases.

**120. (d)**

**121. (c)** $R = \frac{\rho\ell}{(\pi D^2/4)}$ or $R \propto \frac{\ell}{D^2}.$

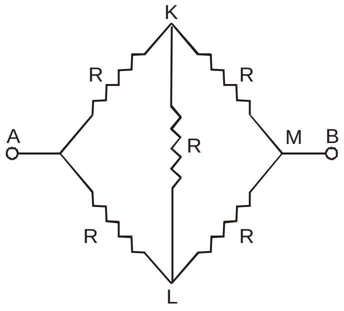
$$\frac{R_x}{R_y} = \frac{\ell_x}{D_x{}^2} \times \frac{D_y{}^2}{\ell_y} = \frac{\ell_y/2}{(D_y/2)^2} \times \frac{D_y{}^2}{\ell_y} = \frac{2}{1}$$

**122. (a)** The equivalent circuit is shown in fig. Since the Wheatstone's bridge is balanced, therefore no current will flow through the arm KL. Equivalent resistance between

AKM = R + R = 2 R

Equivalent resistance between ALM = R + R = 2 R

The two resistances are in parallel. Hence equivalent resistance between A and B is given by



$$\frac{1}{R'} = \frac{1}{2R} + \frac{1}{2R} = \frac{2}{2R} = \frac{1}{R}$$

i.e., $R' = R$

**123. (b)** Resistance of the wire of a semicircle = 12/2 = 6Ω

For equivalent resistance between two points on any diameter, 6Ω and 6Ω are in parallel.

**or**

If a wire of resistance R is bent in the form of a circle, the effective resistance between the ends of a diameter = R/4.

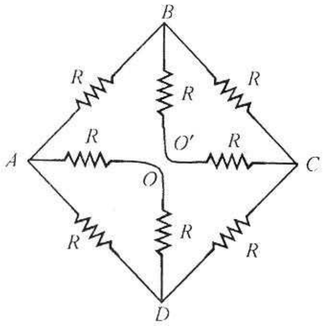
**124. (a)** As the ring has no resistance, the three resistances of 3R each are in parallel.

$$\Rightarrow \frac{1}{R'} = \frac{1}{3R} + \frac{1}{3R} + \frac{1}{3R} = \frac{1}{R} \Rightarrow R' = R$$

$\therefore$ between point A and B equivalent resistance = R + R = 2R

**125. (d)** The equivalent circuit is as shown in figure.

The resistance of arm AOD (= R + R) is in parallel to the resistance R of arm AD.



Their effective resistance $R_1 = \frac{2R \times R}{2R \times R} = \frac{2}{3}R$

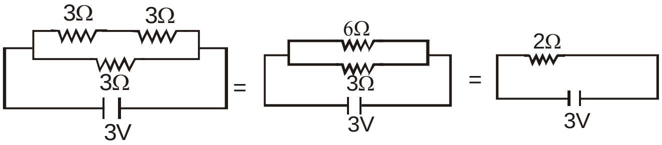
The resistance of arms AB, BC and CD is

$$R_2 = R + \frac{2}{3}R + R = \frac{8}{3}R$$

The resistance $R_1$ and $R_2$ are in parallel. The effective resistance between A and D is

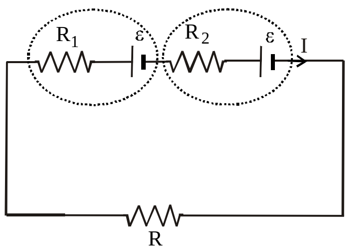
$$R_3 = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{\frac{2}{3}R \times \frac{8}{3}R}{\frac{2}{3}R + \frac{8}{3}R} = \frac{8}{15}R.$$

**126. (b)**



$$\Rightarrow \; I = \frac{3}{2} = 1.5\,A$$

**127. (c)** $I = \frac{2\varepsilon}{R + R_1 + R_2}$



Pot. difference across second cell $= V = \varepsilon - IR_2 = 0$

$$\varepsilon = \frac{2\varepsilon}{R+R_1+R_2}.R_2 = 0$$

$$R+R_1+R_2-2R_2=0$$

$$R+R_1-R_2=0 \qquad \therefore\ R = R_2-R_1$$

**128. (d)** Since due to wrong connection of each cell the total emf reduced to 2ε then for wrong connection of three cells the total emf will reduced to (*n*ε – 6ε) whereas the total or equivalent resistance of cell combination will be *nr*.

**129. (a)** Given : emf $\varepsilon = 2.1$ V

$I = 0.2$ A, $R = 10\Omega$

Internal resistance r = ?

From formula.

$\varepsilon - Ir = V = IR$

$2.1 - 0.2r = 0.2 \times 10$

$2.1 - 0.2r = 2$ or $0.2r = 0.1$

$$\Rightarrow\ r = \frac{0.1}{0.2} = 0.5\,\Omega$$

**130. (c)** $r = E/I = 1.5/3 = 0.5$ ohm.

**131. (d)** Resistance of bulb $R_b = \frac{(1.5)^2}{4.5} = 0.5\Omega$

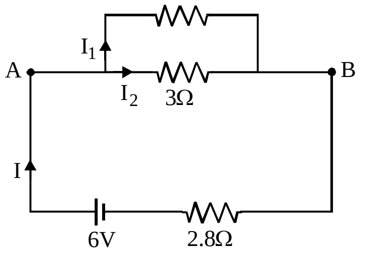
Current drawn from battery $= \frac{E}{2.67+0.33} = \frac{E}{3}$

Share of bulb $= \frac{2}{3}\times\frac{E}{3} = \frac{2E}{9}$

$$\therefore\ \left(\frac{2E}{9}\right)^2 \times 0.5 = 4.5 \text{ or } E = 13.5\text{ V.}$$

**132. (a)** According to maximum power theorem, the power in the circuit is maximum if the value of external resistance is equal to the internal resistance of battery.

**133. (c)** At steady state the capacitor will be fully charged and thus there will be no current in the $1\Omega$ resistance. So the effective circuit becomes



Net current from the 6V battery,

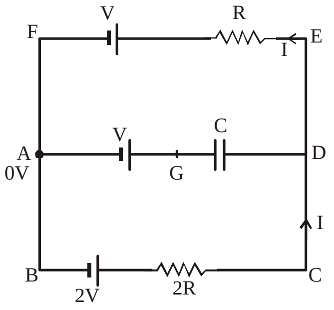
$$I = \frac{6}{\left(\frac{2\times3}{2+3}\right)+\frac{2.8}{1}} = \frac{6}{1.2+2.8} = \frac{3}{2} = 1.5\text{A}$$

Between A and B, voltage is same in both resistances,

$2I_1 = 3I_2$ where $I_1 + I_2 = I = 1.5$

$$\Rightarrow \quad 2I_1 = 3(1.5 - I_1) \Rightarrow I_1 = 0.9\text{A}$$

**134. (c)**



Applying Kirchhoff's law in BCDEFAB we get, $I = \frac{V}{3R}$

Let A be at 0 V. Then potential at G is V.

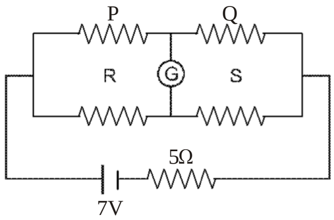
Applying Krichhoff's law for AFED, we get

$$0+V+IR=V_D \Rightarrow 0+V+\frac{V}{3R}\times R = V_D \Rightarrow V_D = \frac{4V}{3}$$

$\therefore$ potential different across capacitor $= \frac{4V}{3} - V = \frac{V}{3}$

**135. (a)** Given : V = 7 V

r = 5Ω



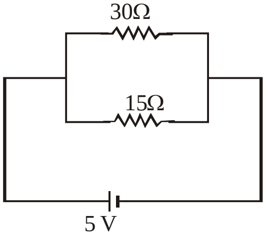
$$R_{eq} = \frac{40\times120}{40+120}\,\Omega$$

$$I = \frac{V}{R} = \frac{7}{5+\frac{40\times120}{40+120}}$$

$$= \frac{7}{5+30} = \frac{1}{5} = 0.2\text{ A.}$$

**136. (b)** $\frac{P}{Q} = \frac{R}{S}$ where $S = \frac{S_1S_2}{S_1+S_2}$

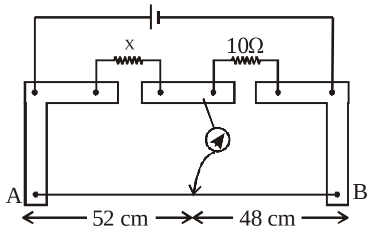
**137. (b)** The network of resistors is a balanced wheatstone bridge. The equivalent current is



$$R_{eq} = \frac{15\times30}{15+30} = 10\ \Omega \Rightarrow I = \frac{V}{R} = \frac{5}{10} = 0.5\ A$$

**138. (d)**

**139. (b)** At Null point



$$\frac{X}{\ell_1} = \frac{10}{\ell_2}$$

Here $\ell_1 = 52$ + End correction = 52 + 1 = 53 cm

$\ell_2 = 48$ + End correction = 48 + 2 = 50 cm

$$\therefore \frac{X}{53} = \frac{10}{50} \qquad \therefore X = \frac{53}{5} = 10.6\Omega$$

**140. (d)** $\frac{P}{Q} = \frac{l}{(100-l)}$ or $P = \frac{l}{100-l}\times Q = \frac{20}{80}\times 1 = 0.25\Omega.$

**141. (a)** Potential gradient $= \frac{V_A - V_B}{\ell} = \frac{i\times\rho}{A} = \frac{0.1\times10^{-7}}{10^{-6}}$

$$= 10^{-2}\,V/m$$

**142. (a)** Potential gradient of wire $= \frac{V}{\ell} = \left(\frac{\rho}{A}\right)\times I$

where $\ell$ & A are the length and cross-section of wire

so $\frac{V}{\ell} = \frac{4\times10^{-7}}{8\times10^{-6}}\times 0.5 = 25\text{mV/meter}$

**143. (a)**

**144. (a)** **Hint :** Potential gradient $= \frac{\text{Pot. Difference}}{\text{length of wire}} = \frac{V_A - V_B}{\ell}$

**145. (a)** Pot. gradient = 0.2mV/cm

$$= \frac{0.2\times10^{-3}}{10^{-2}} = 2\times10^{-2}\,V/m$$

Emf of cell = $2\times10^{-2}\times1\text{m} = 2\times10^{-2}\,V = 0.02\,V$

As per the condition of potentiometer

$0.02\,(R + 490) = 2\,(R)$ or $1.98\,R = 9.8$

$$\Rightarrow \quad R = \frac{9.8}{1.98} = 4.9\ \Omega$$

**146. (b)** Potential gradient along wire

$$= \frac{\text{potential difference along wire}}{\text{length of wire}}$$

or, $0.1\times10^{-3} = \frac{I\times40}{1000}\,V/cm$

or, Current in wire, $I = \frac{1}{400}\,A$

or, $\frac{2}{40+R} = \frac{1}{400}$ or $R = 800 - 40 = 760\,\Omega$

**147. (b)** In case of internal resistance measurement by potentiometer,

$$\frac{V_1}{V_2} = \frac{\ell_1}{\ell_2} = \frac{\{E R_1/(R_1+r)\}}{\{E R_2/(R_2+r)\}} = \frac{R_1(R_2+r)}{R_2(R_1+r)}$$

Here $\ell_1 = 2\,m$, $\ell_2 = 3\,m$, $R_1 = 5\Omega$ and $R_2 = 10\Omega$

$$\therefore \frac{2}{3} = \frac{5(10+r)}{10(5+r)} \text{ or } 20 + 4r = 30 + 3r \text{ or } r = 10\,\Omega$$

CHAPTER

19

# MOVING CHARGES AND MAGNETISM

## FACT/DEFINITION TYPE QUESTIONS

**1.** According to oersted, around a current carrying conductor, magnetic field exists
- (a) as long as there is current in the wire
- (b) even after removing the current in the wire
- (c) only few seconds after removing the current
- (d) None of these

**2.** The magnetic field $d\vec{B}$ due to a small current element $d\vec{\ell}$ at a distance $\vec{r}$ and element carrying current $i$ is,

(a) $d\vec{B} = \frac{\mu_0}{4\pi} i\left(\frac{d\vec{\ell} \times \vec{r}}{r}\right)$ (b) $d\vec{B} = \frac{\mu_0}{4\pi} i^2\left(\frac{d\vec{\ell} \times \vec{r}}{r}\right)$

(c) $d\vec{B} = \frac{\mu_0}{4\pi} i^2\left(\frac{d\vec{\ell} \times \vec{r}}{r^2}\right)$ (d) $d\vec{B} = \frac{\mu_0}{4\pi} i\left(\frac{d\vec{\ell} \times \vec{r}}{r^3}\right)$

**3.** Ampere's circuital law states that
- (a) the surface integral of magnetic field over the open surface is equal to $\mu_0$ times the total current passing through the surface.
- (b) the surface integral of magnetic field over the open surface is equal to $\mu_0$ times the total current passing near the surface.
- (c) the line integral of magnetic field along the boundary of the open surface is equal to $\mu_0$ times the total current passing near the surface.
- (d) the line integral of magnetic field along the boundary of the open surface is equal to $\mu_0$ times the total current passing through the surface.

**4.** Biot-Savart law indicates that the moving electrons velocity (V) produce a magnetic field B such that
- (a) $B \parallel V$
- (b) $B \perp V$
- (c) it obeys inverse cube law
- (d) it is along the line joining electron and point of observation

**5.** Ampere's circuital law is equivalent to
- (a) Biot-Savart law (b) Coulomb's law
- (c) Faraday's law (d) Kirchhoff's law

**6.** Ampere's circuital law is given by
- (a) $\oint \vec{H}.\vec{dI} = \mu_0 I_{enc}$ (b) $\oint \vec{B}.\vec{dI} = \mu_0 I_{enc}$
- (c) $\oint \vec{B}.\vec{dI} = \mu_0 I$ (d) $\oint \vec{H}.\vec{dI} = \mu_0 I$

**7.** The magnetic field around a long straight current carrying wire is
- (a) spherical symmetry (b) cylindrical symmetry
- (c) cubical symmetry (d) unsymmetrical

**8.** A current is passed through a straight wire. The magnetic field established around it has its lines of force
- (a) circular and endless
- (b) oval in shape and endless
- (c) straight
- (d) All of the above

**9.** If a copper rod carries a direct current, the magnetic field associated with the current will be
- (a) only inside the rod
- (b) only outside the rod
- (c) both inside and outside the rod
- (d) neither inside nor outside the rod

**10.** Magnetic field at the centre of a circular coil of radius $r$, through which a current $I$ flows is
- (a) directly proportional to $r$
- (b) inverseley proportional to $I$
- (c) directly proportional to $I$
- (d) directly proprotional to $I^2$

**11.** The magnetic field $B$ at a point on one end of a solenoid having $n$ turns per metre length and carrying a current of $i$ ampere is given by
- (a) $\frac{\mu_0 ni}{e}$ (b) $\frac{1}{2}\mu_0 ni$
- (c) $4\pi\mu_0 ni$ (d) $ni$

**12.** Magnetic field inside a solenoid is
- (a) directly proportional to its length
- (b) directly proportional to current
- (c) inversely proportional to total number of turns
- (d) inversely porportional to current

**13.** A long solenoid has a radius $a$ and number of turns per unit length $n$. If it carries a current $i$, then the magnetic field on its axis is directly proportional to

(a) $ani$ (b) $ni$

(c) $\frac{ni}{a}$ (d) $n^2 i$

**14.** If a current is passed through a spring then the spring will

(a) expand (b) compress

(c) remains same (d) None of these

**15.** Lorentz force is

(a) electrostatic force acting on a charged particle.

(b) magnetic force acting on a moving charged particle.

(c) the vector sum of electrostatic and magnetic force acting on a moving charged particle.

(d) the vector sum of gravitational and magnetic force acting on a moving charged particle.

**16.** Which one of the following is the correct expression for magnetic field on the axis of a circular current loop with x-axis as its axis ?

(a) $\vec{B} = \frac{\mu_0 IR^2 \cdot \hat{i}}{2(x^2 + R^2)^2}$ (b) $\vec{B} = \frac{\mu_0 IR^2}{2(x^2 + R^2)^{3/2}}\hat{i}$

(c) $\vec{B} = \frac{\mu_0 IR}{2(x^2 + R^2)^{3/2}}\hat{i}$ (d) $\vec{B} = \frac{\mu_0 IR^{3/2}}{2(x^2 + R^2)^2}\hat{i}$

**17.** Which of the following is true ?

(a) Parallel currents repel, and antiparallel currents attract.

(b) Parallel currents attract, and antiparallel currents repel.

(c) Both parallel and antiparallel currents attract.

(d) Both parallel and antiparallel currents repel.

**18.** Which of the following is the correct definition of ampere?

(a) The ampere is the value of that steady current which when maintained in each of the two very long, straight, parallel conductors of negligible cross-section, and placed one metre apart in vacuum, would produce on each of these conductors a force equal to $2 \times 10^7$ N/m of length.

(b) The ampere is the value of that steady current which when maintained in each of the two very long, straight, parallel conductors of negligible cross-section, and placed one centimetre apart in vacuum, would produce on each of these conductors a force equal to $2 \times 10^{-7}$ N/m of length.

(c) The ampere is the value of that steady current which, when maintained in each of the two very long, straight, parallel conductors of negligible cross-section, and placed one metre apart in vacuum, would produce on each of these conductors a force equal to $2 \times 10^{-7}$ N/m of length.

(d) The ampere is the value of that steady current which, when maintained in each of the two very long, straight, parallel conductors of negligible cross-section, and placed ten metre apart in vacuum, would produce on each of these conductors a force equal to $2 \times 10^{-7}$ N/m of length.

**19.** The work done by a magnetic field, on a moving charge is

(a) zero because $\vec{F}$ acts parallel to $\vec{v}$

(b) positive because $\vec{F}$ acts perpendicular to $\vec{v}$

(c) zero because $\vec{F}$ acts perpendicular to $\vec{v}$

(d) negative because $\vec{F}$ acts parallel to $\vec{v}$

**20.** An electron having a charge e moves with a velocity v in X-direction. An electric field acts on it in Y-direction? The force on the electron acts in

(a) positive direction of Y-axis

(b) negative direction of Y-axis

(c) positive direction of Z-axis

(d) negative direction of Z-axis

**21.** An electric charge in uniform motion produces

(a) an electric field only

(b) a magnetic field only

(c) both electric and magnetic fields

(d) no such field at all

**22.** If a long hollow copper pipe carries a direct current, the magnetic field associated with the current will be

(a) only inside the pipe

(b) only outside the pipe

(c) neither inside nor outside the pipe

(d) both inside and outside the pipe

**23.** Energy in a current carrying coil is stored in the form of

(a) electric field (b) magnetic field

(c) dielectric strength (d) heat

**24.** Lorentz force can be calculated by using the formula

(a) $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$ (b) $\vec{F} = q(\vec{E} - \vec{v} \times \vec{B})$

(c) $\vec{F} = q(\vec{E} + \vec{v} . \vec{B})$ (d) $\vec{F} = q(\vec{E} \times \vec{B} + \vec{v})$

**25.** Two free parallel wires carrying currents in the opposite directions

(a) attract each other

(b) repel each other

(c) do not attract each other

(d) get rotated to be perpendicular to each other

**26.** Two parallel wires carrying currents in the same direction attract each other because of

(a) potential difference between them

(b) mutual inductance between them

(c) electric forces between them

(d) magnetic forces between them

**27.** A wire is placed parallel to the lines of force in a magnetic field and a current flows in the wire. Then

(a) the wire will experience a force in the direction of the magnetic field

(b) the wire will not experience any force at all

(c) the wire will experience a force in a direction opposite to the field

(d) it experiences a force in a direction perpendicular to lines of force

**28.** A current carrying loop is placed in a uniform magnetic field. The torque acting on it does not depend upon

(a) shape of the loop (b) area ot the loop

(c) value of the current (d) magnetic field

**29.** The magnetic force $\vec{F}$ on a current carrying conductor of length $I$ in an exteranal magnetic field $\vec{B}$ is given by

(a) $\frac{I \times \vec{B}}{\vec{I}}$ (b) $\frac{\vec{I} \times \vec{B}}{I}$

(c) $I(\vec{I} \times \vec{B})$ (d) $I^2 \vec{I} \times \vec{B}$

**30.** A charged particle moves through a magnetic field in a direction perpendicular to it. Then the

(a) velocity remains unchanged

(b) speed of the particle remains unchanged

(c) direction of the particle remains unchanged

(d) acceleration remains unchanged

**31.** An electron moves in a circular orbit with a uniform speed v. It produces a magnetic field B at the centre of the circle. The radius of the circle is proportional to

(a) $\sqrt{\frac{B}{v}}$ (b) $\frac{B}{v}$

(c) $\sqrt{\frac{v}{B}}$ (d) $\frac{v}{B}$

**32.** A charged particle of mass m and charge q travels on a circular path of radius r that is perpendicular to a magnetic field B. The time taken by the particle to complete one revolution is

(a) $\frac{2\pi q^2 B}{m}$ (b) $\frac{2\pi mq}{B}$

(c) $\frac{2\pi m}{qB}$ (d) $\frac{2\pi qB}{m}$

**33.** In cyclotron the gyro radius is

(a) proportional to momentum

(b) proportional to energy

(c) inversely proportional to momentum

(d) inversely proportional to energy

**34.** In cyclotron the resonance condition is

(a) the frequency of revolution of charged particle is equal to the frequency of A.C. voltage sources

(b) the frequency of revolution of charged particle is equal to the frequency of applied magnetic field

(c) the frequency of revolution of charged particle is equal to the frequency of rotation of earth

(d) the frequency of revolution of charged particle, frequency of A.C. source and frequency of magnetic field are equal

**35.** A long solenoid has $n$ turns per meter and current I A is flowing through it. The magnetic field within the solenoid is

(a) $\frac{\mu_0 nI}{2}$ (b) $\mu_0 nI$

(c) zero (d) $2\mu_0 nI$

**36.** Two thin, long, parallel wires, separated by a distance 'd' carry a current of 'i' A in the same direction. They will

(a) repel each other with a force of $\mu_0 i^2/(2\pi d)$

(b) attract each other with a force of $\mu_0 i^2/(2\pi d)$

(c) repel each other with a force of $\mu_0 i^2/(2\pi d^2)$

(d) attract each other with a force of $\mu_0 i^2/(2\pi d^2)$

**37.** A charge q is moving with a velocity v parallel to a magnetic field B. Force on the charge due to magnetic field is

(a) q v B (b) q B/v

(c) zero (d) B v/q

**38.** A particle of mass $m$ and charge $q$ enters a magnetic field $B$ perpendicularly with a velocity $v$. The radius of the circular path described by it will be

(a) $Bq / mv$ (b) $mq / Bv$

(c) $mB / qv$ (d) $mv / Bq$

**39.** Cyclotron is used to accelerate

(a) electrons (b) neutrons

(c) positive ions (d) negative ions

**40.** The magnetic dipole moment of a current loop is independent of

(a) magnetic field in which it is lying

(b) number of turns

(c) area of the loop

(d) current in the loop

**41.** Magnetic dipole moment of a rectangular loop is

(a) inversely proportional to current in loop

(b) inversely proportional to area of loop

(c) parallel to plane of loop and porportional to area of loop

(d) perpendicular to plane of loop and porportional to area of loop

**42.** If $m$ is magnetic moment and $B$ is the magnetic field, then the torque is given by

(a) $\vec{m}.\vec{B}$ (b) $\frac{|\vec{m}|}{|\vec{B}|}$

(c) $\vec{m} \times \vec{B}$ (d) $|\vec{m}|.|\vec{B}|$

**43.** The magnetic moment of a circular coil carrying current is

(a) directly proportional to the length of the wire in the coil

(b) inversely proportional to the length of the wire in the coil

(c) directly proportional to the square of the length of the wire in the coil

(d) inversely proportional to the square of the length of the wire in the coil

**44.** To make the field radial in a moving coil galvanometer

(a) the number of turns in the coil is increased

(b) magnet is taken in the form of horse-shoe

(c) poles are cylindrically cut

(d) coil is wounded on aluminium frame

**45.** The deflection in a moving coil galvanometer is
(a) directly proportional to the torsional constant
(b) directly proportional to the number of turns in the coil
(c) inversely proportional to the area of the coil
(d) inversely proportional to the current flowing

**46.** In a moving coil galvanometer, the deflection of the coil $\theta$ is related to the elecrical current $i$ by the relation
(a) $i \propto \tan\theta$ (b) $i \propto \theta$
(c) $i \propto \theta^2$ (d) $i \propto \sqrt{\theta}$

**47.** A moving coil galvanometer has $N$ number of turns in a coil of effective area $A$, it carries a current $I$. The magnetic field $B$ is radial. The torque acting on the coil is
(a) $NA^2B^2I$ (b) $NABI^2$
(c) $N^2ABI$ (d) $NABI$

**48.** Two parallel circular coils of equal radii having equal number of turns placed coaxially and separated by a distance equal to the radii of the coils carrying equal currents in same direction are known as
(a) Biot-savart's coils (b) Ampere's coils
(c) Helmholtz coils (d) Oersted's coils.

**49.** The current sensitivity of a galvanometer is defined as
(a) the current flowing through the galvanometer when a unit voltage is applied across its terminals.
(b) current per unit deflection.
(c) deflection per unit current.
(d) dflection per unit current when a unit voltage is applied across its terminals

## STATEMENT TYPE QUESTIONS

**50.** Similarities of Biot–Savart's law and Coulomb's law for the electrostatics are
I. both are long range and inversely proportional to the square of distance from the source to the point of interest.
II. both are linear in source.
III. both are produced by scalar sources.
IV. both follow principle of superposition.
(a) I, II and III (b) II, III and IV
(c) I, II and IV (d) I, III and IV

**51.** Direction of force due to magnetic field on a moving charged particle is
I. perpendicular to direction of velocity of charged particle.
II. perpendicular to direction of magnetic field.
III. parallel to direction of velocity of charged particle.
IV. parallel to the direction of magnetic field.
Correct statements are
(a) I and IV (b) I and II
(c) I and III (d) III and IV

**52.** Consider a moving charged particle in a region of magnetic field. Which of the following statements are correct ?
I. If **v** is parallel to **B**, then path of particle is spiral.
II. If **v** is perpendicular to **B**, then path of particle is a circle.
III. If **v** has a component along **B**, then path of particle is helical.
IV. If **v** is along **B**, then path of particle is a circle.
(a) I and II (b) II and III
(c) III and IV (d) IV and I

**53.** Consider the following statements and select the incorrect statement(s).
I. The presence of a large magnetic flux through a coil maintains a current in the coil if the circuit is continuous
II. A coil of a metal wire kept stationary in a non–uniform magnetic field has an e.m.f induced in it
III. A charged particle enters a region of uniform magnetic field at an angle of 85° to the magnetic lines of force, the path of the particle is a circle
IV. There is no change in the energy of a charged particle moving in a magnetic field although a magnetic force is acting on it
(a) I and II (b) II and III
(c) II only (d) IV only

**54.** When a positively charged particle enters a region of uniform magnetic field, its trajectory can be
I. a straight line. II. a circle.
III. a helix. IV. a spiral
(a) Only I (b) II or III
(c) I or II (d) Anyone of I, II or III

**55.** A velocity selector; (a region of perpendicular electric and magnetic field)
I. allows charged particles to pass straight when $v = E/B$.
II. deflects particles in the direction of electric field when $v < E/B$.
III. deflects particles in a direction perpendicular to both v and B, when $v < E/B$.
IV. deflects all particles in a direction perpendicular to both $E$ and $B$.
Which of the above statements are correct?
(a) I, III and IV (b) II, III and IV
(c) I, II and III (d) I, II and IV

**56.** Select the correct statements about Lorentz Force.
I. In presence of electric field $\vec{E}(r)$ and magnetic field $\vec{B}(r)$ the force on a moving electric charge is
$$\vec{F} = q[\vec{E}(r) + v \times \vec{B}(r)]$$
II. The force, due to magnetic field on a negative charge is opposite to that on a positive charge.
III. The force due to magnetic field are become zero if velocity and magnetic field are parallel or antiparallel.
IV. For a static charge the magnetic force is maximum.
(a) I and II only (b) II and III only
(c) I, II and III (d) I, II, III and IV

**57.** Which of the following statements is/are correct ?
I. The magnetic field in the open space inside the toroid is constant.
II. The magnetic field in the open space exterior to the toroid is constant.
III. The magnetic field inside the core of toroid is constant.

(a) I and II (b) II and III
(c) III only (d) I only

**58.** A proton and a deuterium nucleus having certain kinetic energy enter in a uniform magnetic field perpendicular to it. Which of the following statements are incorrect ?

I. Proton has more frequency of revolution.
II. Deuterium nucleus has more frequency of revolution.
III. The particle which has greater speed has more frequency of revolution.

(a) I and II (b) II and III
(c) I and III (d) I, II and III

**59.** The galvanometer cannot as such be used as an ammeter to measure the value of current in a given circuit. The following reasons are

I. galvanometer gives full scale deflection for a small current.
II. galvanometer has a large resistance.
III. a galvanometer can give inaccurate values.

The correct reasons are:

(a) I and II (b) II and III
(c) I and III (d) I, II and III

## MATCHING TYPE QUESTIONS

**60.** Match Column I and Column II.

| | Column I | | Column II |
|---|---|---|---|
| (A) | Biot-Savart's law | (1) | $\oint \vec{B}.\vec{dl} = \mu_0 \Sigma i$ |
| (B) | Ampere's circuital law | (2) | $q[\vec{E} + (\vec{V} \times \vec{B})]$ |
| (C) | Force between two parallel current carrying conductors | (3) | $\oint \vec{B}.\vec{dl} = \mu_0 \Sigma i$ |
| (D) | Lorentz force | (4) | $\vec{B} = \frac{\mu_0 i}{4\pi} \int \frac{dl \sin\theta}{r^2} \hat{n}$ |

(a) (A) → (4); (B) → (3); (C) → (1); (D) → (2)
(b) (A) → (2); (B) → (2); (C) → (4); (D) → (3)
(c) (A) → (4); (B) → (3); (C) → (2); (D) → (1)
(d) (A) → (2); (B) → (1); (C) → (4); (D) → (3)

**61.** Match the entries given in Column I to their analogue entries of electrostatics given in Column II.

| | Column I | | Column II |
|---|---|---|---|
| (A) | Ampere's circuital law | (1) | Electric dipole |
| (B) | Biot-Savart's law | (2) | Gauss's law in electrostatics |
| (C) | Planar current loop | (3) | Permitivity of free space |
| (D) | Permeability of free space | (4) | Coulomb's law |

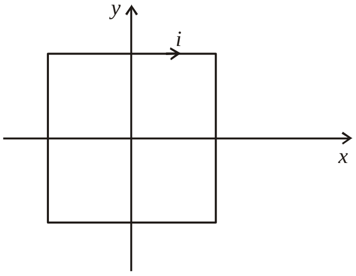
(a) (A) → (2); (B) → (4); (C) → (1); (D) → (3)
(b) (A) → (2); (B) → (2); (C) → (4); (D) → (3)
(c) (A) → (4); (B) → (3); (C) → (2); (D) → (1)
(d) (A) → (2); (B) → (1); (C) → (4); (D) → (3)

**62.** A charged particle having charge $q$ and mass $m$ is to be subjected to a combination of constant uniform magnetic field $(\vec{B})$ and a constant uniform gravitational field $(\vec{G})$. Apart from these field forces there exists no other force. Now match the column.

| | Column-I | | Column -II |
|---|---|---|---|
| (A) | The charged particle moves without change in its direction. | (1) | It is possible that both $\vec{B}$ and $\vec{G}$ are zero. |
| (B) | The charged particle moves without change in its velocity. | (2) | It is possible that both $\vec{B}$ and $\vec{G}$ are non zero. |
| (C) | The charged particle takes a circular path | (3) | It is possible that $\vec{B}$ is zero and $\vec{G}$ is not zero. |
| (D) | The charged particle takes a parabolic path | (4) | It is possible that $\vec{B}$ is non zero and $\vec{G}$ is zero. |

(a) (A) → (2); (B) → (1); (C) → (3); (D) → (4)
(b) (A) → (2); (B) → (2); (C) → (4); (D) → (3)
(c) (A) → (1,2,3,4); (B) → (1,2,4); (C) → (4); (D) → (3)
(d) (A) → (2); (B) → (1); (C) → (4); (D) → (3)

**63.** A square loop of side a and carrying current $i$ as shown in the figure is placed in gravity free space having magnetic field $B = B_0 \hat{k}$. Now match following :



| | Column-I | | Column -II |
|---|---|---|---|
| (A) | Torque on loop | (1) | is zero |
| (B) | Net force on loop | (2) | is in direction $(-\hat{k})$ |
| (C) | Potential energy of loop | (3) | has minimum magnitudes |
| (D) | Magnetic moment of loop | (4) | has maximum magnitudes |

(a) (A) → (2); (B) → (1); (C) → (3); (D) → (4)
(b) (A) → (1,2); (B) → (1); (C) → (4); (D) → (2)
(c) (A) → (4); (B) → (3); (C) → (2); (D) → (1)
(d) (A) → (2); (B) → (1); (C) → (4); (D) → (3)

**64.** Match the physical quantities of Column I with their mathematical expressions in Column II.

| | Column I | | Column II |
|---|---|---|---|
| (A) | Torque on a circular current loop placed in uniform magnetic field | (1) | $\frac{\mu_0 i}{2R}$ |
| (B) | Force per unit length between parallel current carrying wires | (2) | $iAB \sin\theta$ |
| (C) | Magnetic field at the centre of a circular current carrying loop. | (3) | $\frac{mV}{qB}$ |
| (D) | Radius of circular path of a charge particle moving in uniform magnetic field. | (4) | $\frac{\mu_0 i_1 i_2}{2\pi d}$ |

(a) (A) → (2); (B) → (1); (C) → (3); (D) → (4)
(b) (A) → (2); (B) → (2); (C) → (4); (D) → (3)
(c) (A) → (4); (B) → (3); (C) → (2); (D) → (1)
(d) (A) → (2); (B) → (4); (C) → (1); (D) → (3)

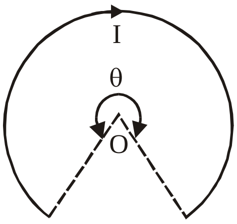
**65.** A circular current carrying loop with magnetic moment parallel to the magnetic field is rotated by an angle of 90° slowly about one of its diameter in a uniform magnetic field. Match the quantities of Column I with Column II.

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Torque on the loop | (1) | Decreases from maximum to zero. |
| (B) | Potential energy of the loop | (2) | Remains constant |
| (C) | Magnetic moment of the loop | (3) | Increases from zero to maximum |
| (D) | Magnetic flux through the loop | (4) | Increases from minimum to zero. |

(a) (A) → (2); (B) → (1); (C) → (3); (D) → (4)
(b) (A) → (3); (B) → (4); (C) → (3); (D) → (1)
(c) (A) → (4); (B) → (3); (C) → (2); (D) → (1)
(d) (A) → (2); (B) → (1); (C) → (4); (D) → (3)

## DIAGRAM TYPE QUESTIONS

**66.** A current of I ampere flows in a wire forming a circular arc of radius r metres subtending an angle θ at the centre as shown. The magnetic field at the centre O in tesla is

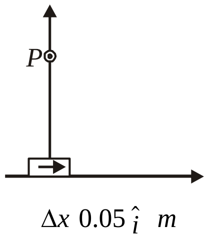


(a) $\frac{\mu_0 I\theta}{4\pi r}$ (b) $\frac{\mu_0 I\theta}{2\pi r}$

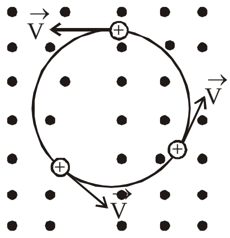
(c) $\frac{\mu_0 I\theta}{2r}$ (d) $\frac{\mu_0 I\theta}{4r}$

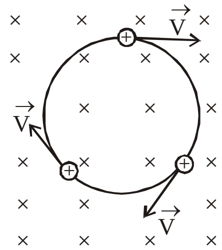
**67.** An element of $0.05\,\hat{i}$ $m$ is placed at the origin as shown in figure which carries a large current of 10 A. distance of 1 m in perpendicular direction. The value of magnetic field is

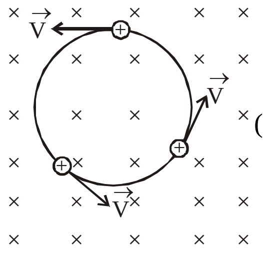
(a) $4.5 \times 10^{-8}$ T
(b) $5.5 \times 10^{-8}$ T
(c) $5.0 \times 10^{-8}$ T
(d) $7.5 \times 10^{-8}$ T

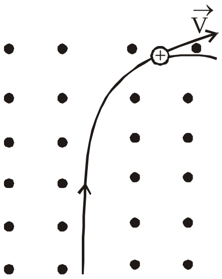


**68.** A positively charged particle enters in a uniform magnetic field with velocity perpendicular to the magnetic field. Which of the following figures shows the correct motion of charged particle?

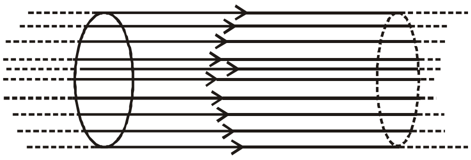
(a)


(b)


(c)


(d)


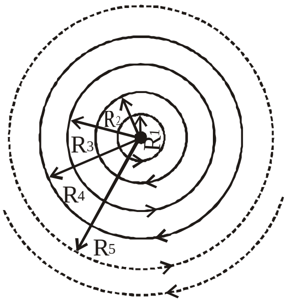
**69.** The figure shows $n$ ($n$ being an even number) wires placed along the surface of a cylinder of radius $r$. Each wire carries current $i$ in the same direction. The net magnetic field on the axis of the cylinder is



(a) $\mu_0\, ni$ (b) $\frac{\mu_0 ni}{2\pi r}$

(c) zero (d) $\frac{\mu_0 ni}{4\pi r}$

**70.** The figure shows a system of infinite concentric circular current loops having radii $R_1, R_2, R_3 \rightarrow R_n$. The loops carry net current $i$ alternately in clockwise and anticlockwise direction. The magnitude of net magnetic field of the centre of the loops is



(a) $\frac{\mu_0 i}{2}\left[\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_4}...\right]$

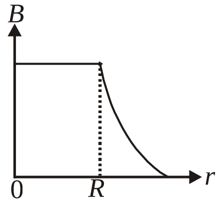
(b) $\frac{\mu_0 i}{2}\left[\frac{1}{R_1}-\frac{1}{R_2}+\frac{1}{R_3}-\frac{1}{R_4}+...\right]$

(c) $\frac{\mu_0 i}{4\pi}\left[\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_4}+...\right]$

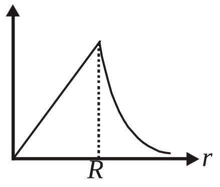
(d) $\frac{\mu_0 i}{4\pi}\left[\frac{1}{R_1}-\frac{1}{R_2}+\frac{1}{R_3}-\frac{1}{R_4}+...\right]$

**71.** The correct plot of the magnitude of magnetic field $\vec{B}$ vs distance $r$ from centre of the wire is, if the radius of wire is $R$

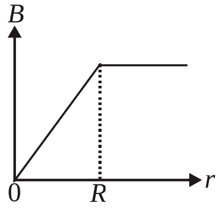
(a)



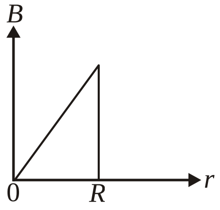
(b)



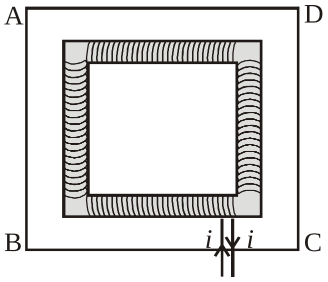
(c)



(d)



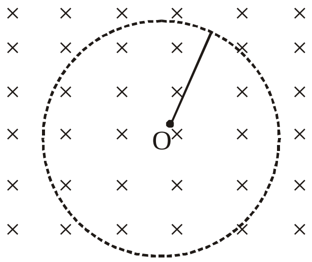
**72.** The figure shows a closely wound coil on a square core of inside edge length $l$. The no. of turns per unit length of the coil is $n$. Each turn carries current $i$ into the plane of paper and out of the plane of papers. ABCD is an Amperian loop enclosing an open surface in the plane of the paper. The current enclosed by the loop is



(a) 4 $ni$ (b) 4 $nli$

(c) 8 $nli$ (d) zero

**73.** The figure shows a thin metalic rod whose one end is pivoted at point O. The rod rotates about the end O in a plane perpendicular to the uniform magnetic field with angular frequency $w$ in clockwise direction. Which of the following is correct ?



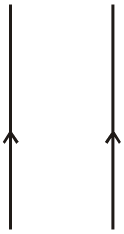
(a) The free electrons of the rod move towards the outer end

(b) The free electrons of the rod move towards the pivoted end.

(c) The free electrons of the rod move towards the mid-point of the rod.

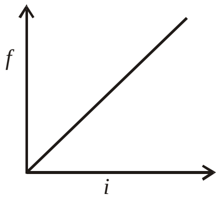
(d) The free electrons of the rod do not move towards any end of the rod as rotation of rod has no effect on motion of free electrons.

**74.** The figure shows two long straight current carrying wire separated by a fixed distance $d$. The magnitude of current, flowing in each wire varies with time but the magnitude of current in each wire is equal at all times.

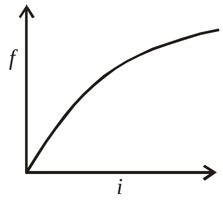


Which of the following graphs shows the correct variation of force per unit length $f$ between the two wires with current $i$?

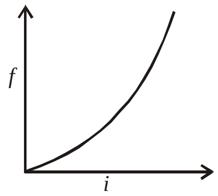
(a)



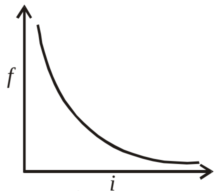
(b)



(c)

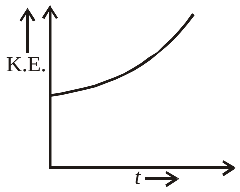


(d)

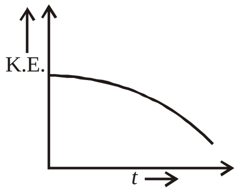


**75.** A charged particle enters in a magnetic field in a direction perpendicular to the magnetic field. Which of the following graphs show the correct variation of kinetic energy of the particle with time $t$ ?

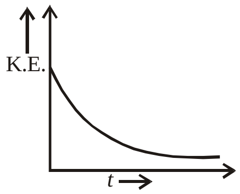
(a)



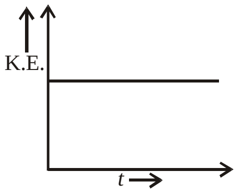
(b)



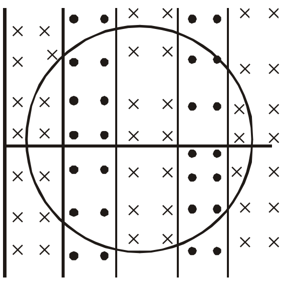
(c)

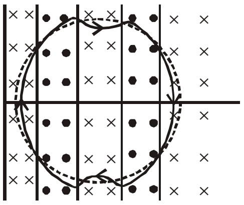


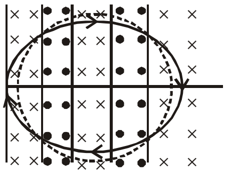
(d)

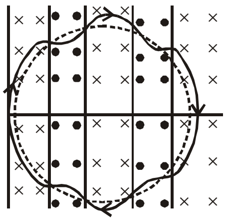


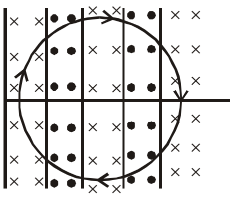
**76.** The figure shows a circular current loop placed in magnetic fields. When current flows through the loop in clockwise direction, which of the following figures shows the correct shape of current loop ?



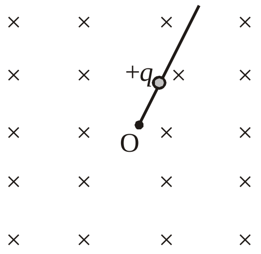
(a)


(b)


(c)


(d)


**77.** The figure shows a thin rod pivoted at point O and rotating clockwise in the plane of paper with constant angular velocity *w*. A bead having charge + *q* can slide freely on the rod as the rod rotates.



Which of the following statements is incorrect ?

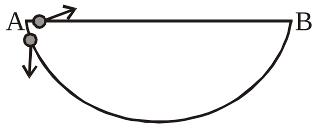
(a) Magnetic moment of current loop generated by the bead increases.

(b) Angular momentum of the bead increases.

(c) Torque on current loop generated is zero.

(d) Potentential energy of current loop generated decreases.

**78.** The figure shows a closed loop bent in the form of a semi-circle. One bead having charge +*q* slides from *A* to *B* along the diameter in uniform motion and other bead having the same charge slides along the arc from *A* to *B* in uniform circular motion. Both take some time to travel from *A* to *B*. When both the beads are at the mid-point of their journey, then the forces exerted by lower bead and upper bead are respectively



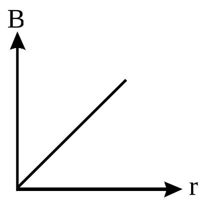
(a) gravitational and magnetic

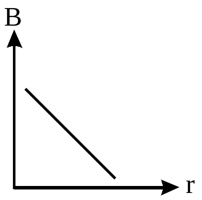
(b) magnetic and electric

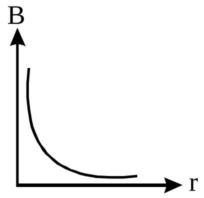
(c) electric and gravitational

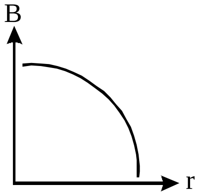
(d) gravitational and electric.

**79.** The magnetic flux density B at a distance r from a long straight wire carrying a steady current varies with r as

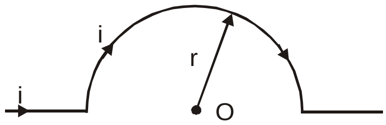
(a)


(b)


(c)


(d)


**80.** A portion of a conductive wire is bent in the form of a semicircle of radius r as shown below in fig. At the centre of semicircle, the magnetic induction will be



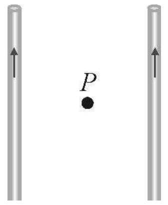
(a) zero

(b) infinite

(c) $\frac{\mu_0}{4\pi}.\frac{\pi i}{r}$ gauss

(d) $\frac{\mu_0}{4\pi}.\frac{\pi i}{r}$ tesla

**81.** Two long straight wires are set parallel to each other. Each carries a current *i* in the same direction and the separation between them is 2*r*. The intensity of the magnetic field midway between them is



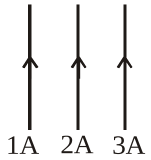
(a) $\mu_0 i/r$

(b) $4\mu_0 i/r$

(c) zero

(d) $\mu_0 i/4r$

**82.** Three wires are situated at the same distance. A current of 1A, 2A, 3A flows through these wires in the same direction. What is ratio of $F_1/F_2$, where $F_1$ is force on 1 and $F_2$ on 2?



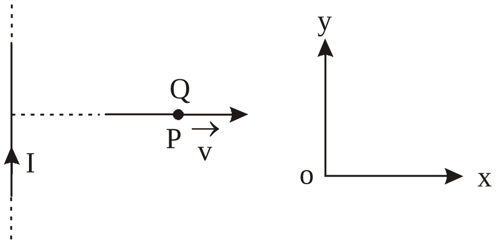
(a) 7/8

(b) 1

(c) 9/8

(d) None of these

**83.** A very long straight wire carries a current I. At the instant when a charge + Q at point P has velocity $\vec{v}$, as shown, the force on the charge is



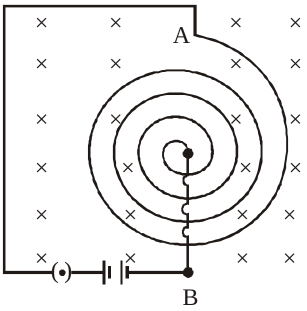
(a) along oy

(b) opposite to oy

(c) along ox

(d) opposite to ox

**84.** Figure shows a spiral coil of negligible mass lying in a plane perpendicular to uniform magnetic field. When the key is closed the spiral coil will



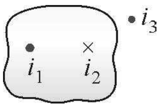
(a) contract
(b) expand
(c) neither contract nor expand
(d) tend to rotate about an axis passing through *A* and *B*.

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

**85.** **Assertion :** Ampere′s law used for the closed loop shown in figure is written as $\oint \vec{B}\cdot d\vec{\ell} = \mu_0(i_1 - i_2)$. Right side of it does not include $i_3$, because it produces no magnetic field at the loop.



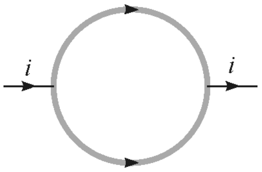
**Reason :** The line integral of magnetic field produced by $i_3$ over the close loop is zero.

**86.** **Assertion:** Ampere's circuital law is independent of Biot-Savart's law.
**Reason:** Ampere's circuital law can be derived from the Biot-savart's law.

**87.** **Assertion :** The magnetic field due to a very large current carrying loop is zero at its centre.

**Reason :** Magnetic field at the centre of loop is, $B = \frac{\mu_0 i}{2R}$.

**88.** **Assertion :** Figure shows a current carrying circular loop. The magnetic field at the centre of loop is zero.

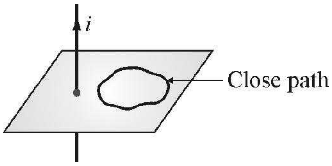


**Reason :** Magnetic field at the centre of loop is given by $B = \frac{\mu_0 ni}{2R}$.

**89.** **Assertion :** If the current in a solenoid is reversed in direction while keeping the same magnitude, the magnetic field energy stored in the solenoid decreases.
**Reason :** Magnetic field energy density is proportional to square of current.

**90.** **Assertion :** If a charged particle is released from rest in a region of uniform electric and magnetic fields parallel to each other, it will move in a straight line.
**Reason :** The electric field exerts no force on the particle but the magnetic field does.

**91.** **Assertion :** Figure shows a current carrying conductor and a close path. For the close path $\oint \vec{B}\cdot d\vec{\ell} = 0$.



**Reason :** For the close path, the magnetic field at each point on the path is zero.

**92.** **Assertion :** A charged particle moves in a uniform magnetic field. The velocity of the particle at same instant makes an acute angle with the magnetic field. The path of the particle is a helix with constant pitch.

**Reason :** The force on the particle is given by $\vec{F} = q(\vec{v} \times \vec{B})$.

**93.** **Assertion:** The work done by magnetic force on a charged particle is zero.
**Reason:** The work done by magnetic force on a charged particle is zero when the force is perpendicular to velocity of particle, in other cases it is not zero.

**94.** **Assertion :** Alternating current shows no magnetic effect.
**Reason :** The magnetic field produced by alternating current in complete cycle is zero.

**95.** **Assertion :** A direct current flows through a thin conductor produces magnetic field only outside the conductor.
**Reason :** There is no flow of charge carriers inside the conductor.

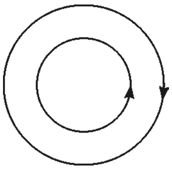
**96.** **Assertion :** The force between two parallel current carrying conductors carrying currents in same direction is attractive because there is no electrical interaction between them.
**Reason :** The force between two electrons streams moving in the same direction repulsive because there is no magnetic interaction between them.

**97.** **Assertion :** The net charge in a current carrying wire is zero and so magnetic force on the wire in magnetic field is zero.
**Reason :**
The force on a current carrying wire is given by $F = Bi\ell \sin\theta$.

**98.** **Assertion :** A current carrying loop placed in a magnetic field must experience a torque.
**Reason :** Torque on the loop is given by $\tau$=MBsin$\theta$.

**99.** **Assertion:** The frequency of circular motion of a charged particle in cyclotron is independent of the mass of the particle.
**Reason:** Greater the mass of the particle less will be the frequency of the particle.

**100.** **Assertion :** The figure shows the circular paths of two particles : electron and proton that travel at the same speed in a uniform magnetic field $\vec{B}$, which is directed into the page. The electron follows the path of smaller radius.



**Reason :** The radius of path in the perpendicular magnetic field is given by $r = \frac{mv}{qB}$.

**101.** **Assertion :** A cyclotron cannot accelerate neutrons.
**Reason :** Neutrons are neutral.

**102.** **Assertion:** To convert a galvanometer into an ammeter a small resistance is connected in parallel with it.
**Reason:** The small resistance increases the combined resistance of the combination.

## CRITICAL THINKING TYPE QUESTIONS

**103.** A current I flows along the length of an infinitely long, straight, thin walled pipe. Then
(a) the magnetic field at all points inside the pipe is the same, but not zero
(b) the magnetic field is zero only on the axis of the pipe
(c) the magnetic field is different at different points inside the pipe
(d) the magnetic field at any point inside the pipe is zero

**104.** The magnetic field due to a current carrying circular loop of radius 3 cm at a point on the axis at a distance of 4 cm from the centre is 54 $\mu$T. What will be its value at the centre of loop ?
(a) 125 $\mu$T (b) 150 $\mu$T
(c) 250 $\mu$T (d) 75 $\mu$T

**105.** A current i ampere flows along an infinitely long straight thin walled tube, then the magnetic induction at any point inside the tube is
(a) $\frac{\mu_0}{4\pi}.\frac{2i}{r}$ tesla (b) zero
(c) infinite (d) $\frac{2i}{r}$ tesla

**106.** A long straight wire in the horizontal plane carries a current of 75 *A* in north of south direction, magnitude and direction of field *B* at a point 3 m east of the wire is
(a) $4 \times 10^{-6}$ T, vertical up
(b) $5 \times 10^{-6}$ T, vertical down
(c) $5 \times 10^{-6}$ T, vertical up
(d) $4 \times 10^{-6}$ T, vertical down

**107.** Two concentric coils each of radius equal to 2 $\pi$ cm are placed at right angles to each other. 3 ampere and 4 ampere are the currents flowing in each coil respectively. The magnetic induction in weber/m$^2$ at the centre of the coils will be $(\mu_0 = 4\pi \times 10^{-7} \text{Wb/A.m})$
(a) $10^{-5}$ (b) $12\times10^{-5}$
(c) $7 \times 10^{-5}$ (d) $5 \times 10^{-5}$

**108.** A coil of one turn is made of a wire of certain length and then from the same length a coil of two turns is made. If the same current is passed in both the cases, then the ratio of the magnetic inductions at their centres will be
(a) 2 : 1 (b) 1.4
(c) 4 : 1 (d) 1 : 2

**109.** A circular coil of wire consisting of 100 turns each of radius 9 cm carries a current of 0.4 A. The magnitude of manetic field at the centre of the coil is
(a) $2.4 \times 10^{-4}$ T (b) $3.5 \times 10^{-4}$ T
(c) $2.79 \times 10^{-4}$ T (d) $3 \times 10^{-4}$ T

**110.** A long solenoid has 200 turns per cm and carries a current i. The magnetic field at its centre is $6.28 \times 10^{-2}$ Weber/m$^2$. Another long solenoid has 100 turns per cm and it carries a current $\frac{i}{3}$. The value of the magnetic field at its centre is
(a) $1.05 \times 10^{-2}$ weber/m$^2$ (b) $1.05 \times 10^{-5}$ weber/m$^2$
(c) $1.05 \times 10^{-3}$ weber/m$^2$ (d) $1.05 \times 10^{-4}$ weber/m$^2$

**111.** A solenoid of length 1.5 m and 4 cm diameter possesses 10 turns per cm. A current of 5A is flowing through it, the magnetic induction at axis inside the solenoid is

$(\mu_0 = 4\pi \times 10^{-7} \text{ weber amp}^{-1} \text{ m}^{-1})$

(a) $4\pi \times 10^{-5}$ gauss (b) $2\pi \times 10^{-5}$ gauss
(c) $4\pi \times 10^{-5}$ tesla (d) $2\pi \times 10^{-5}$ tesla

**112.** A long solenoid is formed by winding 20 turns/cm. The current necessary to produce a magnetic field of 20 millitesla inside the solenoid will be approximately

$(\frac{\mu_0}{4\pi} = 10^{-7}$ *tesla – metre / ampere*)

(a) 8.0 A (b) 4.0 A
(c) 2.0 A (d) 1.0 A

**113.** A solenoid of length 0.6 *m* has a radius of 2 cm and is made up of 600 turns If it carries a current of 4 A, then the magnitude of the magnetic field inside the solenoid is
(a) $6.024 \times 10^{-3}$ T (b) $8.024 \times 10^{-3}$ T
(c) $5.024 \times 10^{-3}$ T (d) $7.024 \times 10^{-3}$ T

**114.** A square current carrying loop is suspended in a uniform magnetic field acting in the plane of the loop. If the force on one arm of the loop is $\vec{F}$, the net force on the remaining three arms of the loop is
(a) 3 $\vec{F}$ (b) $-\vec{F}$
(c) $-3\vec{F}$ (d) $\vec{F}$

**115.** A long solenoid carrying a current produces a magnetic field B along its axis. If the current is double and the number of turns per cm is halved, the new value of the magnetic field is
(a) 4 B (b) B/2
(c) B (d) 2 B

**116.** A current of I ampere flows along an infinitely long straight thin walled hollow metallic cylinder of radius r. The magnetic field at any point inside the cylinder at a distance x from the axis of the cylinder is

(a) infinite
(b) $\frac{\mu_0 I}{2\pi r}$
(c) $\frac{\mu_0 I}{2\pi x}$
(d) zero

**117.** If we double the radius of a coil keeping the current through it unchanged, then the magnetic field at any point at a large distance from the centre becomes approximately

(a) double
(b) three times
(c) four times
(d) one-fourth

**118.** Charge q is uniformly spread on a thin ring of radius R. The ring rotates about its axis with a uniform frequency f Hz. The magnitude of magnetic induction at the centre of the ring is

(a) $\frac{\mu_0 qf}{2R}$
(b) $\frac{\mu_0 q}{2f\,R}$
(c) $\frac{\mu_0 q}{2\pi f\,R}$
(d) $\frac{\mu_0 qf}{2\pi R}$

**119.** A current i ampere flows in a circular arc of wire which subtends an angle (3 π/2) radians at its centre, whose radius is R. The magnetic induction B at the centre is

(a) $\mu_0$ i/R
(b) $\mu_0$ i/2R
(c) 2 $\mu_0$ i/R
(d) 3 $\mu_0$ i/8R

**120.** A steady current I flows down a hollow cylindrical tube of radius a and is uniformly distributed around the tube. Let r be the distance from the axis of symmetry of the tube to a given point. What is the magnitiude of the magnetic field B at a point inside the tube?

(a) 0
(b) 2 I/r c
(c) $2\,I\,r/a^2c$
(d) $4\,\pi\,(r-a)\,I/r^2$

**121.** A current i ampere flows along an infinitely long straight thin walled tube, then the magnetic induction at any point inside the tube is

(a) infinite
(b) zero
(c) $\frac{\mu_0}{4\pi}.\frac{2i}{r}$ tesla
(d) $\frac{2i}{r}$ tesla

**122.** A conducting circular loop of radius r carries a constant current i. It is placed in a uniform magnetic field **B** such that B is perpendicular to the plane of the loop. The magnetic force acting on the loop is

(a) i r B
(b) 2 π r i B
(c) zero
(d) π r i B

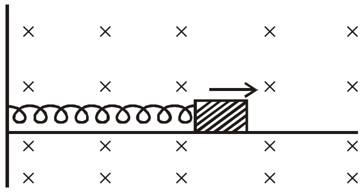
**123.** If a charged particle has a velocity component in a direction parallel to magnetic field in addition to the component perpendicular to magnetic field then charged particle moves in magnetic field in a

(a) circular path
(b) parabolic path
(c) helical path
(d) straight line

**124.** A charged particle enters in a uniform magnetic field with a certain velocity. The power delivered to the particle by the magnetic field depends on

(a) force exerted by magnetic field and velocity of the particle.
(b) angular speed *w* and radius *r* of the circular path.
(c) angular speed *w* and acceleration of the particle.
(d) None of these

**125.** The figure shows a spring-block system executing SHM in a uniform magnetic field. The block slides on the frictionless surface of a weighing machine. The block is having charge +*q* on it. Assume that the block is so heavy that any force exerted by magnetic field cannot lift it. Select the correct option from the following.



(a) When the block moves to right the machine shows more reading and when to left, less reading.
(b) When the block moves to right the machine shows less reading and when to left, more reading.
(c) The machine shows same reading which is less than the actual weight of the block in both cases.
(d) The machine shows same reading which is more than the actual weight of the block in both cases.

**126.** A proton and a deuterium nucleus having certain kinetic energies enter in a uniform magnetic field with same component of velocity in the direction of magnetic field. Which of the following is correct ?

(a) Proton has greater pitch of helical motion.
(b) Deuterium nucleus has greater pitch of helical motion.
(c) Both particles have same pitch of helical motion.
(d) Which particle has greater pitch depends on the fact that which particle has greater component of velocity perpendicular to magnetic field.

**127.** A charged particle goes undeflected in a region containing electric and magnetic fields. It is possible that

(a) $\vec{E} \parallel \vec{B}, \vec{v} \parallel \vec{E}$
(b) $\vec{E}$ is not parallel to $\vec{B}$
(c) $\vec{v} \parallel \vec{B}$ but $\vec{E}$ is not parallel to $\vec{B}$
(d) $\vec{E} \parallel \vec{B}$ but $\vec{v}$ is not parallel to $\vec{E}$

**128.** A positively charged particle moving due east enters a region of uniform magnetic field directed vertically upwards. This particle will

(a) get deflected in vertically upward direction
(b) move in circular path with an increased speed
(c) move in a circular path with decreased speed
(d) move in a circular path with uniform speed

**129.** A proton moving with a constant velocity passes through a region of space without any change in its velocity. If E and B represent the electric and magnetic fields respectively, this region of space may not have

(a) $E = 0, B = 0$
(b) $E = 0, B \neq 0$
(c) $E \neq 0, B = 0$
(d) $E \neq 0, B \neq 0$

**130.** A charged particle enters into a magnetic field with a velocity vector making an angle of 30º with respect to the direction of magnetic field. The path of the particle is

(a) circular
(b) helical
(c) elliptical
(d) straight line

**131.** If a charged particle goes unaccelerated in a region containing electric and magnetic fields, then

(a) $\vec{E}$ must be perpendicular to $\vec{B}$
(b) $\vec{v}$ must be perpendicular to $\vec{E}$
(c) $\vec{E}$ must be perpendicular to $v\vec{B}$
(d) None of these

**132.** Two long wires are hanging freely. They are joined first in parallel and then in series and then are connected with a battery. In both cases which type of force acts between the two wires?

(a) Attraction force when in parallel and repulsion force when in series
(b) Repulsion force when in parallel and attraction force when in series
(c) Repulsion force in both cases
(d) Attraction force in both cases

**133.** A charged particle with charge q enters a region of constant, uniform and mutually orthogonal fields $\vec{E}$ and $\vec{B}$ with a velocity $\vec{v}$ perpendicular to both $\vec{E}$ and $\vec{B}$, and comes out without any change in magnitude or direction of $\vec{v}$. Then

(a) $\vec{v} = \vec{B} \times \vec{E}/E^2$
(b) $\vec{v} = \vec{E} \times \vec{B}/B^2$
(c) $\vec{v} = \vec{B} \times \vec{E}/B^2$
(d) $\vec{v} = \vec{E} \times \vec{B}/E^2$

**134.** A uniform electric field and uniform magnetic field are acting along the same direction in a certain region. If an electron is projected in the region such that its velocity is pointed along the direction of fields, then the electron

(a) will turn towards right of direction of motion
(b) speed will decrease
(c) speed will increase
(d) will turn towards left direction of motion

**135.** If an electron and a proton having same momenta enter perpendicular to a magnetic field, then

(a) curved path of electron and proton will be same (ignoring the sense of revolution)
(b) they will move undeflected
(c) curved path of electron is more curved than that of the proton
(d) path of proton is more curved

**136.** In a region, steady and uniform electric and magnetic fields are present. These two fields are parallel to each other. A charged particle is released from rest in this region. The path of the particle will be a

(a) helix
(b) straight line
(c) ellipse
(d) circle

**137.** A uniform electric field and a uniform magnetic field are acting along the same direction in a certain region. If an electron is projected along the direction of the fields with a certain velocity then

(a) its velocity will increase
(b) its velocity will decrease
(c) it will turn towards left of direction of motion
(d) it will turn towards right of direction of motion

**138.** Under the influence of a uniform magnetic field a charged particle is moving in a circle of radius R with constant speed v. The time period of the motion

(a) depends on both R and v
(b) is independent of both R and v
(c) depends on R and not v
(d) depends on v and not on R

**139.** If an electron describes half a revolution in a circle of radius r in a magnetic field B, the energy acquired by it is

(a) zero
(b) $\frac{1}{2}mv^2$
(c) $\frac{1}{4}mv^2$
(d) $\pi r \times Bev$

**140.** A cell is connected between two points of a uniformly thick circular conductor and $i_1$ and $i_2$ are the currents flowing in two parts of the circular conductor of radius a. The magnetic field at the centre of the loop will be

(a) zero
(b) $\frac{\mu_0}{4\pi}(I_1 - I_2)$
(c) $\frac{\mu_0}{2a}(I_1 + I_2)$
(d) $\frac{\mu_0}{a}(I_1 + I_2)$

**141.** Two straight long conductors AOB and COD are perpendicular to each other and carry currents $I_1$ and $I_2$. The magnitude of the magnetic induction at a point P at a distance a from the point O in a direction perpendicular to the plane ABCD is

(a) $\frac{\mu_0}{2\pi a}(I_1 + I_2)$
(b) $\frac{\mu_0}{2\pi a}(I_1 - I_2)$
(c) $\frac{\mu_0}{2\pi a}(I_1^2 + I_2^2)^{\frac{1}{2}}$
(d) $\frac{\mu_0}{2\pi a}\frac{I_1 I_2}{I_1 + I_2}$

**142.** A current carrying conductor placed in a magnetic field experiences maximum force when angle between current and magnetic field is

(a) 3 π/4
(b) π/2
(c) π/4
(d) zero

**143.** A current of 3 A is flowing in a linear conductor having a length of 40 cm. The conductor is placed in a magnetic field of strength 500 gauss and makes an angle of 30º with the direction of the field. It experiences a force of magnitude

(a) $3 \times 10^{-4}$ N
(b) $3 \times 10^{-2}$ N
(c) $3 \times 10^{2}$ N
(d) $3 \times 10^{4}$ N

**144.** A current of 10 A is flowing in a wire of length 1.5 m. A force of 15 N acts on it when it is placed in a uniform magnetic field of 2 T. The angle between the magnetic field and the direction of the current is

(a) 30° (b) 45°
(c) 60° (d) 90°

**145.** An 8 cm long wire carrying a current of 10 A is placed inside a solenoid perpendicular to its axis. If the magnetic field inside the solenoid is 0.3 T, then magnetic force on the wire is

(a) 0.14 N (b) 0.24 N
(c) 0.34 N (d) 0.44 N

**146.** A 10eV electron is circulating in a plane at right angles to a uniform field at a magnetic induction $10^{-4}$ Wb/m$^2$ (= 1.0 gauss). The orbital radius of the electron is

(a) 12cm (b) 16cm
(c) 11 cm (d) 18 cm

**147.** An electron (mass = $9 \times 10^{-31}$ kg, charge = $1.6 \times 10^{-19}$ C) moving with a velocity of $10^6$ m/s enters a magnetic field. If it describes a circle of radius 0.1m, then strength of magnetic field must be

(a) $4.5 \times 10^{-5}$ T (b) $1.4 \times 10^{-5}$ T
(c) $5.5 \times 10^{-5}$ T (d) $2.6 \times 10^{-5}$ T

**148.** A charged particle with velocity $2 \times 10^3$ m/s passes undeflected through electric and magnetic field. Magnetic field is 1.5 tesla. The electric field intensity would be

(a) $2 \times 10^3$ N/C (b) $1.5 \times 10^3$ N/C
(c) $3 \times 10^3$ N/C (d) $4/3 \times 10^{-3}$ N/C

**149.** What is cyclotron frequency of an electron with an energy of 100 e V in the earth's magnetic field of $1 \times 10^{-4}$ weber / m$^2$ if its velocity is perpendicular to magnetic field?

(a) 0.7 MHz (b) 2.8 MHz
(c) 1.4 MHz (d) 2.1 MHz

**150.** The orbital speed of electron orbiting around a nucleus in a circular orbit of radius 50 pm is $2.2 \times 10^6$ ms$^{-1}$. Then the magnetic dipole moment of an electron is

(a) $1.6 \times 10^{-19}$ Am$^2$ (b) $5.3 \times 10^{-21}$ Am$^2$
(c) $8.8 \times 10^{-24}$ Am$^2$ (d) $8.8 \times 10^{-26}$ Am$^2$

**151.** A helium nucleus makes a full rotation in a circle of radius 0.8 meter in 2 sec. The value of the magnetic field induction B in tesla at the centre of circle will be

(a) $2 \times 10^{-19} \mu_0$ (b) $10^{-19} / \mu_0$
(c) $10^{-19} \mu_0$ (d) $2 \times 10^{-20} / \mu_0$

**152.** Two long parallel wires P and Q are held perpendicular to the plane of paper with distance of 5 m between them. If P and Q carry current of 2.5 amp. and 5 amp. respectively in the same direction, then the magnetic field at a point half-way between the wires is

(a) $\mu_0 / 17$ (b) $\sqrt{3}\mu_0 / 2\pi$
(c) $\mu_0 / 2\pi$ (d) $3\mu_0 / 2\pi$

**153.** Through two parallel wires A and B, 10A and 2A of currents are passed respectively in opposite directions. If the wire A is infinitely long and the length of the wire B is 2m, then force on the conductor B, which is situated at 10 cm distance from A, will be

(a) $8 \times 10^{-7}$ N (b) $8 \times 10^{-5}$ N
(c) $4 \times 10^{-7}$ N (d) $4 \times 10^{-5}$ N

**154.** A circular loop of area 0.02 m$^2$ carrying a current of 10A, is held with its plane perpendicular to a magnetic field induction 0.2 T. The torque acting on the loop is

(a) 0.01 Nm (b) 0.001 Nm
(c) zero (d) 0.8 Nm

**155.** A coil carrying a heavy current and having large number of turns is mounted in a N-S vertical plane. A current flows in the clockwise direction. A small magnetic needle at its centre will have its north pole in

(a) east-north direction (b) west-north direction
(c) east-south direction (d) west-south direction

**156.** A galvanometer having a resistance of 80 ohms is shunted by a wire of resistance 2 ohms. If the total current is 1amp., the part of it passing through the shunt will be

(a) 0.25 amp (b) 0.8 amp
(c) 0.02 amp (d) 0.5 amp

**157.** A moving coil galvanometer has a resistance of 900 Ω. In order to send only 10% of the main current through this galvanometer, the resistance of the required shunt is

(a) 0.9 Ω (b) 100 Ω
(c) 405 Ω (d) 90 Ω

**158.** A galvanometer of resistance 5 ohms gives a full scale deflection for a potential difference of 10 mV. To convert the galvanometer into a voltmeter giving a full scale deflection for a potential difference of 1V, the size of the resistance that must be attached to the voltmeter is

(a) 0.495 ohm (b) 49.5 ohm
(c) 495 ohm (d) 4950 ohm

**159.** A galvanometer of resistance 100 Ω gives a full scale deflection for a current of $10^{-5}$ A. To convert it into a ammeter capable of measuring upto 1 A, we should connect a resistance of

(a) 1 Ω in parallel (b) $10^{-3}$ Ω in parallel
(c) $10^5$ Ω in series (d) 100 Ω in series

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1. (a)**

**2. (d)** $dB = \frac{\mu_0}{4\pi}.\frac{id\ell\sin\theta}{r^2} \Rightarrow \quad d\vec{B} = \frac{\mu_0}{4\pi}.\frac{i(d\vec{\ell}\times\vec{r})}{r^3}$

**3. (d)** According to Ampere's circuital law $\int \vec{B}.\vec{dl} = \mu_o I$

**4. (b)** **5. (a)** **6. (b)**

**7. (b)** Magnetic field is given by $B = \frac{\mu_0 i}{2\pi r}$ i.e., $B \propto \frac{1}{r}$ which implies that field has cylindrical symmetry.

**8. (a)** **9. (c)**

**10. (c)** Field at the center of a circular coil of radius $r$ is

$$B = \frac{\mu_0 I}{2r}$$

**11. (b)** Magnetic field at a point on one end of a solenoid

$$B = \frac{1}{2}\mu_0 ni$$

**12. (b)** $B = \mu_0 ni$

**13. (b)** Because $B = \mu_0 ni \Rightarrow B \propto ni$

**14. (b)** It will compress due to the force of attraction between two adjacent coils carrying current in the same direction.

**15. (c)** As Lorentz force is given by

$$\vec{F} = q\left(\vec{E} + \vec{V}\times\vec{B}\right) = q\vec{E} + q\left(\vec{V}\times\vec{B}\right)$$

$$\vec{F} = \vec{F}_E + \vec{F}_B$$

**16. (b)**

**17. (b)** Parallel currents attract and anti-parallel currents repel can be verified by the application of right hand thumb rule.

**18. (c)** **19. (c)** **20. (b)** **21. (c)** **22. (b)**

**23. (b)**

**24. (a)** Lorentz force is given by

$$\vec{F} = \overrightarrow{F_e} + \overrightarrow{F_m}$$

$$= q\vec{E} + q(\vec{v}\times\vec{B}) = q[(\vec{E} + (\vec{v}\times\vec{B})]$$

**25. (b)** **26. (d)** **27. (b)**

**28. (a)** Because $\tau = NiAB\cos\theta$

**29. (c)**

**30. (b)** Magnetic force acts perpendicular to the velocity. Hence speed remains constant.

**31. (d)** $r = \frac{mv}{qB} \Rightarrow r \propto \frac{v}{B}$

**32. (c)** Equating magnetic force to centripetal force,

$$\frac{mv^2}{r} = qvB\sin 90^o$$

Time to complete one revolution,

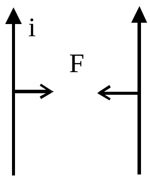
$$T = \frac{2\pi r}{v} = \frac{2\pi m}{qB}$$

**33. (a)** $Bqv = \frac{mv^2}{r} \Rightarrow r = \frac{mv}{Bq}$

**34. (a)**

**35. (b)**

**36. (b)**



$$\frac{F}{\ell} = \frac{\mu_0 i_1 i_2}{2\pi d} = \frac{\mu_0 i^2}{2\pi d}$$

(attractive as current is in the same direction)

**37. (c)**

**38. (d)** $\because F = qVB = \frac{mv^2}{R} \quad \therefore R = \frac{mv}{Bq}$

**39. (c)**

**40. (a)** Current loop acts as a magnetic dipole. Its magnetic moment is given by

$M = NIA$

where $N$ = number of turns, $I$ = current in a loop,

A = area of the loop

From the above relation, we can conclude that magnetic dipole moment of a current loop is independent of magnetic field in which it is lying.

**41. (d)** Mgnetic dipole moment, $M = NiA$

**42. (c)**

**43. (c)** $M = NiA \Rightarrow M \propto A \Rightarrow M \propto r^2$

[As $\ell = 2\pi r \Rightarrow \ell \propto r$]

$\Rightarrow M \propto \ell^2$

**44. (c)**

**45.** **(b)** $\theta = \frac{NiAB}{C} \Rightarrow \theta \propto N$ [Number of turns]

**46.** **(b)** $i = \frac{C\theta}{NAB} \Rightarrow i \propto \theta$

**47.** **(d)** $\tau = MB \sin\theta \Rightarrow \tau_{max} = NiAB,\ [\ \theta = 90°]$

**48.** **(c)**

**49.** **(c)** Current sensitivity of a galvanometer is the amount of deflection produced in the galvanometer when unit current flows through it.

## STATEMENT TYPE QUESTIONS

**50.** **(c)** The Biot–Savart's law for the magnetic field has certain similarities as well as differences with the Coulomb's law for the electrostatic field. Some of these are :

(i) Both are long range, since both depend inversly on the square of distance from the source to the point of interest. The principle of superposition applies to both fields. In this connection, note that the magnetic field is linear in the source *Idl* just as the electrostatic field is linear in its source the electric charge.

(ii) The electrostatic field is produced by a scalar source, namely, the electric charge. The magnetic field is produced by a vector source *Idl*.

**51.** **(b)**

(i) Lorentz force depends on *q*, **v** and **B** (charge of the particle, the velocity and the magnetic field). Force on a negative charge is opposite to that on a positive charge.

(ii) The magnetic force *q* [**v** × **B**] includes a vector product of velocity and magnetic field. The vector product makes the force due to magnetic field vanish (become zero) if velocity and magnetic field are parallel or anti-parallel. The force acts in a (sideways) direction perpendicular to both the velocity and the magnetic field. Its direction is given by the screw rule.

**52.** **(b)** If $v \perp B$, then path is circular and if v has a component along B, then path will be helical.

**53.** **(d)** When charged particle enters perpendicularly in a magnetic field, it moves in a circular path with a constant speed. Hence its kinetic energy also remains constant.

**54.** **(d)** When v || B, F = 0, then path is a straight line.
If $v \perp B$ , F = Bqv, so path is a circle. while v makes some angle θ with *B*, then $F = Bqv\sin\theta$ so path is helical.

**55.** **(c)** In a velocity selector, where $F_e$ and $F_B$ are electric and magetic field, we get

Case I $F_e = F_B \Rightarrow v = \frac{E}{B}$

Case II $F_e > F_B \Rightarrow v < \frac{E}{B}$

Case III $F_e < F_B \Rightarrow v > E / B$

**56.** **(c)** If charge is not moving then the magnetic force is zero.

Since $\vec{F}_m = q(\vec{v} \times \vec{B})$

As $\vec{v} = 0$, for stationary charge

$\therefore\ \vec{F}_m = 0$

**57.** **(c)**

**58.** **(b)** The frequency of revolution is given by

$$\nu = \frac{qB}{2\pi m}.$$

If charge is constant, then $\nu \propto \frac{1}{m}$

**59.** **(a)** The galvanometer cannot as such be used as an ammeter to measure the value of the current in a given circuit. This is for two reasons (i) Galvanometer is a very sensitive device, it gives a full-scale deflection for a current of the order of μA. (ii) For measuring currents, the galvanometer has to be connected in series and as it has a large resistance, this will change the value of the current in the circuit.

## MATCHING TYPE QUESTIONS

**60.** **(a)** $(A) \to (4);\ (B) \to (3);\ (C) \to (1);\ (D) \to (2)$

**61.** **(a)** $(A) \to (2);\ (B) \to (4);\ (C) \to (1);\ (D) \to (3)$

**62.** **(c)** $(A) \to (1, 2, 3, 4);\ (B) \to (1, 2, 4);\ (C) \to (4);\ (D) \to (3)$

**63.** **(b)** $(A) \to (1,2);\ (B) \to (1);\ (C) \to (4);\ (D) \to (2)$

**64.** **(d)** $(A) \to (2);\ (B) \to (4);\ (C) \to (1);\ (D) \to (3)$

**65.** **(b)** A - (3) $I = mB\sin\theta$, as $\sin\theta$ from $0 \to 1$.
B - (4) $U(\theta) = -mB\cos\theta$, as $\cos\theta$ from $1 \to 0$, then $U(\theta)$ from $U(\theta)_{\min} = -mB \to 0$.

C - (3) as $\vec{m} = i\,\vec{A}.$

D -(1) as $\phi_B = BA\cos\theta$. As $\cos\theta$ from $1 \to 0$, then $\phi_B$ from $BA = (\phi_B)_{\max} \to 0$.

## DIAGRAM TYPE QUESTIONS

**66.** **(a)** $B = \frac{\mu_0 I}{2r} \times \frac{\theta}{2\pi} = \frac{\mu_0 I\theta}{4\pi r}$

**67.** **(c)** $dB = \frac{\mu_0}{4\pi}\frac{Idl\sin\theta}{r^2}$

Here, $dl = \Delta x = 0.05\ m$, $I = 10\ A$, $r = 1\ m$

$\sin\theta = \sin 90° = 1$,

$\therefore dB = 10^{-7} \times \frac{10 \times 0.05 \times 1}{(1)^2}$

$= 0.50 \times 10^{-7} = 5.0 \times 10^{-8}$ T

**68.** **(c)** Force, $\vec{F}_B = q(\vec{V} \times \vec{B})$

which gives direction of force towards centre.

**69.** **(c)** Since $n$ is an even number, we can assume the wires in pairs such that the two wires forming a pair is placed diametrically opposite to each other on the surface of cylinder. The fields produced on the axis by them are equal and opposite and can get cancelled with each other.

**70.** **(b)** Field at the centre of a circular current loop is given by $B = \frac{\mu i}{2R}$. Since the currents are alternately in opposite directions therefore the correct net field at centre is given by vector sum of field produced by each loop which are alternately in opposite directions.

**71.** **(b)** The magnetic field from the centre of wire of radius $R$ is given by

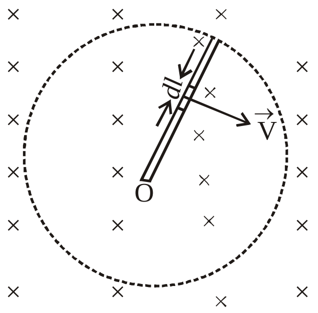
$B = \left(\frac{\mu_0 I}{2R^2}\right)r \quad (r < R) \Rightarrow B \propto r$

and $B = \frac{\mu_0 I}{2\pi r} \quad (r > R) \Rightarrow B \propto \frac{1}{r}$

From the above descriptions, we can say that the graph (b) is a correct representation.

**72.** **(d)** Since the total current going into the surface is equal to total current coming out of the surface, therefore current enclosed is zero.

**73.** **(b)** The application of equation $\vec{F}_B = q(\vec{V} \times \vec{B})$ on the element $dl$ of the rod gives force on positive charge towards the outer end. Therefore electrons will move towards pivoted end.



**74.** **(c)** The force per unit length is given by $f = \frac{\mu_0 i^2}{2\pi d}$

i.e., $f \propto i^2$

**75.** **(d)** The change in K.E. is equal to work done by net force which is zero because the magnetic force is perpendicular to velocity. K.E. remains constant.

**76.** **(c)** The equation $d\vec{F}_B = i\,d\vec{l} \times \vec{B}$ gives the direction of force radially outward in those regions where the field is directed into the plane of paper and radially inward on the section of loop where the field is pointing towards the reader.

**77.** **(d)** Since P.E. $= -\vec{m}\cdot\vec{B} = -mB\cos 0°$

$\therefore$ P.E. $= -mB$

Since $\vec{m}$ increases in magnitude, therefore P.E. decreases.

**78.** **(d)** Obviously gravitational and electric force is there as both the particle have mass and charge. Since both charges are in motion so they constitute currents which generate magnetic fields around them and thus exert magnetic force on each other.

**79.** **(c)**

**80.** **(d)** The straight part will not contribute magnetic field at the centre of the semicircle because every element of the straight part will be 0º or 180º with the line joining the centre and the element

Due to circular portion, the field is $\frac{1}{2}\frac{\mu_0 i}{2r} = \frac{\mu_0 i}{4r}$

Hence total field at O $= \frac{\mu_0 i}{4r}$ tesla

**81.** **(c)** $B = \frac{\mu_0}{2\pi}.\frac{i}{r} - \frac{\mu_0}{2\pi}.\frac{i}{r} = 0$

**82.** **(a)** Due to flow of current in same direction at adjacent side, an attractive magnetic force will be produced.

**83.** **(a)** The direction of B is along $(-\hat{k})$

$\therefore$ The magnetic force

$\vec{F} = Q(\vec{v} \times \vec{B}) = Q(v\hat{i}) \times B(-\hat{k}) = QvB\hat{j}$

$\Rightarrow$ along OY.

**84.** **(b)** As the current flows in the spiral in clockwise direction, the application of equation $d\vec{F}_B = i\,d\vec{l} \times \vec{B}$ given the force on current element $dl$ in radially outward direction hence expand.

## ASSERTION- REASON TYPE QUESTIONS

**85.** **(d)** The magnetic field at any point on the closed loop is due to all the three currents, but line integral of $i_3$ over the closed loop will be zero.

**86.** **(d)** Ampere's circuital law can be derived from Biot-Savart law and is not independent of Biot-Savart law.

**87.** **(a)** Magnetic field at the centre of circular loop is given by

$B = \frac{\mu_0 i}{2R}$, as $R \to \infty$, and so $B \to 0$.

**88.** **(a)** The magnetic field of two equal halfs of the loop is equal and opposite and so $\vec{B} = 0$.

**89.** **(a)** Reversing the direction of the current reverses the direction of the magnetic field. However, it has no effect on the magnetic-field energy density, which is proportional to the square of the magnitude of the magnetic field.

**90.** **(c)** Due to electric field, the force is $\vec{F} = q\vec{E}$ in the direction of $\vec{E}$. Since $\vec{E}$ is parallel to $\vec{B}$, the particle velocity $\vec{v}$ (acquired due to force $\vec{F}$) is parallel to $\vec{B}$. Hence $\vec{B}$ will not exert any force since $\vec{v} \times \vec{B} = 0$ and the motion of the particle is not affected by $\vec{B}$.

**91.** **(c)** We know that, $\oint \vec{B}.d\vec{\ell} = \mu_0 i_{in}$. Since $i_{in} = 0$ and so $\oint \vec{B}.d\vec{\ell} = 0$. The magnetic field on any point on the close loop is zero.

**92.** **(b)**

**93.** **(c)** Since the magnetic force is always perpendicular to the velocity of the charged particle so, work done is always zero.

**94.** **(d)** Current shows magnetic effect, but in one cmplete cycle the net magnetic field beocmes zero.

**95.** **(c)** The magnetic field inside conductor is given by

$B = \frac{\mu_0}{2\pi}.\frac{ir}{a^2}$

For thin conductor, the point is on the axis of the conductor and so $r = 0$, $B = 0$.

**96.** **(c)** In case of two electron streams the electric repulsion is greater than magnetic attraction.

**97.** **(d)** The magnetic force acts only on moving electrons, and so net force on the conductor is non-zero.

**98.** **(d)** The value of torque depends on θ. For $\theta = 0$, $\tau = MBx \sin 0° = 0$.

**99.** **(d)** The frequency of revolution is given by

$\nu = \frac{qB}{2\pi m}$, hence Statement I is false and II is true.

**100.** **(a)** The radius of path, $r = \frac{mv}{qB}$. As mass of electron is smaller than mass of proton, so radius of electron is smaller.

**101.** **(b)** Neutrons are neutral.

**102.** **(c)** An ammeter should have a low resistance which we get when we connect low resistance in parallel with galvanometer.

## CRITICALTHINKING TYPE QUESTIONS

**103.** **(d)** There is no current inside the pipe. Therefore

$$\oint \vec{B}.\vec{dt} = \mu_o I$$

$$I = 0 \qquad \therefore \; B = 0$$

**104.** **(c)**

$$B = \frac{\mu_0 i\, a^2}{2(x^2 + a^2)^{3/2}}$$

$$B' = \frac{\mu_0 i}{2a} = \frac{\mu_0 i\, a^2}{2a(x^2 + a^2)^{3/2}}\left(\frac{(x^2 + a^2)^{3/2}}{a^2}\right)$$

$$B' = \frac{B.(x^2 + a^2)^{3/2}}{a^3}$$

Put $x = 4$ & $a = 3 \Rightarrow B' = \frac{54(5^3)}{3 \times 3 \times 3} = 250\mu T$

**105.** **(b)** Using Ampere's law at a distance r from axis, B is same from symmetry.

$$\int B.dl = \mu i$$

$$B \times 2\pi r = \mu_0 i$$

Here i is zero, for r < R, whereas R is radius

$\therefore B = 0$

**106.** **(c)** From Ampere circuital law

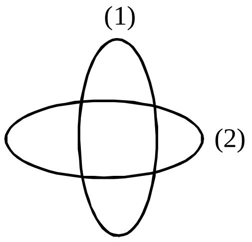
$$\oint \vec{B}.\vec{dI} = \mu_0 I_{enc}$$

$$B \times 2\pi R = \mu_0 I_{enc}$$

$$B = \frac{\mu_0 I_{enc}}{2\pi R} = 2 \times 10^{-7} \times \frac{75}{3} = 5 \times 10^{-6}\ T$$

The direction of field at the given point will be vertical up determined by the screw rule or right hand rule.

**107. (d)**



The magnetic field due to circular coil,

$$B_1 = \frac{\mu_0 i_1}{2r} = \frac{\mu_0 i_1}{2(2\pi \times 10^{-2})} = \frac{\mu_0 \times 3 \times 10^2}{4\pi}$$

$$B_2 = \frac{\mu_0 i_2}{2(2\pi \times 10^{-2})} = \frac{\mu_0 \times 4 \times 10^2}{4\pi}$$

$$B = \sqrt{B_1^2 + B_2^2} = \frac{\mu_0}{4\pi} . 5 \times 10^2$$

$$\Rightarrow B = 10^{-7} \times 5 \times 10^2 \Rightarrow B = 5 \times 10^{-5} \text{ Wb/m}^2$$

**108. (b)** Let $\ell$ be length of wire

Ist case : $\ell = 2\pi r \Rightarrow r = \frac{\ell}{2\pi}$

$$B = \frac{\mu_0 I}{2\pi r} = \frac{\mu_0 I}{\ell}$$

2nd Case : $\ell = 2(2\pi r') \Rightarrow r' = \frac{\ell}{4\pi}$

$$B' = \frac{\mu_0 In}{2\pi \frac{\ell}{4\pi}} = \frac{2\mu_0 I}{\frac{\ell}{2}} \quad \text{(where n = 2)}$$

on putting the value of B $\Rightarrow B' = 4\left(\frac{\mu_0 I}{l}\right) = 4B$

**109. (c)** Here, $N = 100$

$R = 9$ cm $= 9 \times 10^{-2}$ $m$, and $I = 0.4$ $A$

Now, $B = \frac{\mu_0 NI}{2R} = \frac{2\pi \times 10^{-7} \times 100 \times 0.4}{9 \times 10^{-2}}$

$$= \frac{2 \times 3.14 \times 0.4}{9} \times 10^{-3}$$

$= 0.279 \times 10^{-3}$ T $= 0.279 \times 10^{-4}$ T

**110. (a)** $\frac{B_2}{B_1} = \frac{\mu_0 n_2 i_2}{\mu_0 n_1 i_1} \Rightarrow \frac{B_2}{6.28 \times 10^{-2}} = \frac{100 \times \frac{i}{3}}{200 \times i}$

$$\Rightarrow B_2 = \frac{6.28 \times 10^{-2}}{6} = 1.05 \times 10^{-2} \text{ Wb/m}^2$$

**111. (d)** $B = \mu_0 nI = 4\pi \times 10^{-7} \times 10 \times 5 = 2\pi \times 10^{-5}$ T.

**112. (a)** $B = \mu_0 ni \Rightarrow i = \frac{B}{\mu_0 n}$

$$= \frac{20 \times 10^{-3}}{4\pi \times 10^{-7} \times 20 \times 100} = 7.9 \text{ A} = 8 \text{ A}$$

**113. (c)** Here, $n = \frac{600}{0.6} = 1000$ turns / $m$ $I = \mu A$

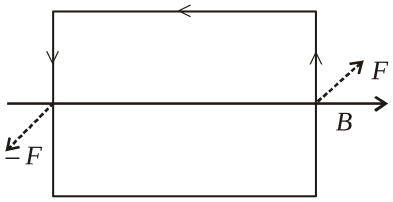
$I = 0.6$ $m$, $r = 0.02$ $m$ $\because \frac{1}{r} = 30$ *i.e.* $I >> r$

Hence, we can use long solenoid formula, them

$\therefore$ $B = \mu_0 nI = 4 \times 10^{-7} \times 10^3 \times 4$

$= 50.24 \times 10^{-4} = 5.024 \times 10^{-3}$ T

**114. (b)** The force on the two arms parallel to the field is zero.



$\therefore$ Force on remaining arms $= -F$

**115. (c)** $B = \mu_0 N_0 i$ ; $B_1 = (\mu_0)\left(\frac{N_0}{2}\right)(2\ i) = \mu_0 N_0 i = B$

$\Rightarrow B_1 = B$

**116. (d)** Since no current is enclosed inside the hollow conductor. Hence $B_{\text{inside}} = 0$.

**117. (c)** $B_{\text{axis}} = \left(\frac{\mu_0 NI}{2x^3}\right) R^2$

$B \propto R^2$

So, when radius is doubled, magnetic field becomes four times.

**118. (a)** Magnetic field at the centre of the ring is

$$\frac{\mu_0 qf}{2R}$$

**119. (d)** **120. (a)** **121. (b)** **122. (c)**

**123. (c)** With parallel component it will move in the direction of magnetic field and with perpendicular component it will trace circular path and the combination of both these yield helical path.

**124. (d)** Power $= \dfrac{\text{work done}}{\text{time}}$

As no work is done by magnetic force on the charged particle because magnetic force is perpendicular to velocity, hence power delivered is zero.

**125. (b)** When the block moves to the right application of equation $\vec{F}_B = q(\vec{V}\times\vec{B})$ gives magnetic force in upward direction similarly when block moves left, $\vec{F}_B$ is in downward direction.

**126. (b)** Due to perpendicular component both will execute circular motion for which $T = \dfrac{2\pi m}{qB}$. Since $q$ is same, therefore $T \propto m$. Hence deuterium nucleus will travel more distance.

**127. (a)** **128. (d)** **129. (c)**

**130. (b)** **131. (a)** **132. (a)**

**133. (b)** Here, $\vec{E}$ and $\vec{B}$ are perpendicular to each other and the velocity $\vec{v}$ does not change; therefore

$$qE = qvB \Rightarrow v = \frac{E}{B}$$

If velocity $\vec{v}$ is $\perp^r$ to both $\vec{E}$ and $\vec{B}$,

$$\text{Also,}\left|\frac{\vec{E}\times\vec{B}}{B^2}\right| = \frac{E\,B\sin\theta}{B^2} = \frac{E\ B\ \sin 90°}{B^2} = \frac{E}{B} = |\vec{v}| = v$$

**134. (b)** $\vec{v}$ and $\vec{B}$ are in same direction so that magnetic force on electron becomes zero, only electric force acts. But force on electron due to electric field is opposite to the direction of velocity.

**135. (a)** r = mv/Bq is same for both.

**136. (b)** The charged particle will move along the lines of electric field (and magnetic field). Magnetic field will exert no force. The force by electric field will be along the lines of uniform electric field. Hence the particle will move in a straight line.

**137. (b)** Due to electric field, it experiences force and accelerates i.e. its velocity decreases.

**138. (b)** In a uniform magnetic field, a charged particle is moving in a circle of radius R with constant speed v.

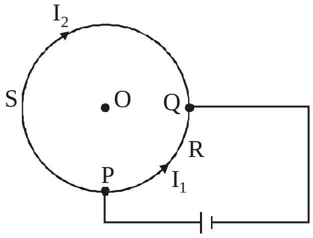
$$\therefore \frac{mv^2}{R} = Bqv \quad \text{or, } R = \frac{mv}{Bq} \qquad .....(1)$$

$$\text{Time period, } T = \frac{2\pi R}{v} = \frac{2\pi mv}{Bqv} = \frac{2\pi m}{Bq} \qquad .....(2)$$

Time period T does not depend on both R and v because when v is changed, R is also changed proportionately and for period, it is R/v that is taken.

**139. (a)** Since magnetic force is always perpendicular to the velocity of electron, so it can only change the direction of velocity of electron, but it (the magnetic force) cannot accelerate or deaccelerate the electron.

**140. (a)** Let $\ell_1$, $\ell_2$ be the lengths of the two parts PRQ and PSQ of the conductor and ρ be the resistance per unit length of the conductor. The resistance of the portion PRQ will be $R_1 = \ell_1\,\rho$



The resistance of the portion PSQ will be $R_2 = \ell_2\,\rho$

Pot. diff. across P and Q $= I_1 R_1 = I_2 R_2$

or $I_1\,\ell_1\,\rho = I_2\,\ell_2\,\rho$ or $I_1\,\ell_1 = I_2\,\ell_2$ ...(1)

Magnetic field induction at the centre O due to currents through circular conductors PRQ and PSQ will be

$$= B_1 - B_2 = \frac{\mu_0}{4\pi}\frac{I_1\ell_1\sin 90°}{r^2} - \frac{\mu_0}{4\pi}\frac{I_2\ell_2\sin 90°}{r^2} = 0.$$

**141. (c)** The point P is lying symmetrically w.r.t. the two long straight current carrying conductors. The magnetic fields at P due to these current carrying conductors are mutually perpendicular.

**142. (b)** F = iB l sin θ. This is maximum when sin θ = 1 or θ = π/2.

**143. (b)** $F = I\ell\,B\sin\theta = 3\times0.40\times(500\times10^{-4})\times\sin 30°$
$= 3\times10^{-2}$ N.

**144. (a)** $F = IIB\sin\theta$ or $\sin\theta = \dfrac{F}{IIB}$

$$\sin\theta = \frac{15}{10\times1.5\times2} = \frac{1}{2} \quad \text{or } \theta = 30°$$

**145. (b)** $F = IIB$

Here, $\theta = 90°$, $I = 10\ A$

$I = 8$ cm $= 8\times10^{-2}\ m$, $B = 0.3\ T$

$\therefore$ $F = 10\times8\times10^{-2}\times0.3\times\sin 90° = 0.24\ N$

**146. (b)** [Hint $\Rightarrow \dfrac{mv^2}{r} = qvB$ ].

**147. (c)** $$Bqv = \frac{m\,v^2}{r} \text{ or } B = \frac{m\,v}{rq} = \frac{(9\times10^{-31})\times10^6}{0.1\times(1.6\times10^{-19})}$$

$$= 5.5\times10^{-5}\ \text{T}$$

**148. (c)** $E = vB = 2\times10^3\times1.5 = 3\times10^3\ \text{V/m}.$

**149. (b)**

**150. (c)** Magnetic dipole moment

$$m = iA = \frac{e}{T}\times\pi r^2 = \frac{e}{(2\pi r/v)}\times\pi r^2 = \frac{erv}{2}.$$

$$= \frac{1.6\times10^{-19}\times50\times10^{-12}\times2.2\times10^6}{2}$$

$$= 8.8\times10^{-24}\,\text{Am}^2.$$

**151. (c)** $B = \frac{\mu_0}{4\pi}\frac{2\pi i}{r}$ where

$$i = \frac{2e}{t} = \frac{2\times1.6\times10^{-19}}{2} = 1.6\times10^{-19}\ \text{A}$$

$$\therefore\ B = \frac{\mu_0 i}{2r} = \frac{\mu_0\times1.6\times10^{-19}}{2\times0.8} = \mu_0\times10^{-19}\ \text{T}$$

**152. (c)** $B = \frac{\mu_0}{4\pi}\frac{2i_2}{(r/2)} - \frac{\mu_0}{4\mu}\frac{2i_1}{(r/2)} = \frac{\mu_0}{4\pi}\frac{4}{r}(i_2 - i_1)$

$$= \frac{\mu_0}{4\pi}\frac{4}{5}(5-2.5) = \frac{\mu_0}{2\pi}.$$

**153. (b)** $F = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{r}\times\ell = \frac{10^{-7}\times2\times10\times2}{0.1}\times2 = 8\times10^{-5}\ \text{N}$

**154. (c)**

**155. (b)**

**156. (c)** [Hint $\Rightarrow S\times(I-I_g) = R_g\times I_g$]

**157. (b)** $I_g = 0.1I,\ I_s = 0.9I;\ S = I_g\ R_g/I_s$

$$= 0.1\times900/0.9 = 100\,\Omega.$$

**158. (c)** $I_g = 10\times10^{-3}/5 = 2\times10^{-3}\ \text{A};$

$$R = \frac{V}{I_g} - R_g = \frac{1}{2\times10^{-3}} - 5 = 495\,\Omega.$$

**159. (b)** Here, $R_g = 100\,\Omega;\ I_g = 10^{-5}\ \text{A};\ I = 1\text{A};\ S = ?$

$$S = \frac{I_gR_g}{I - I_g} = \frac{10^{-5}\times100}{1-10^{-5}} = 10^{-3}\,\Omega \text{ in parallel}$$

## CHAPTER

## 20

# MAGNETISM AND MATTER

### FACT/DEFINITION TYPE QUESTIONS

**1.** The magnetism of magnet is due to
- (a) pressure of big magnet inside the earth
- (b) earth
- (c) cosmic rays
- (d) the spin motion of electron

**2.** The primary origin (s) of magnetism lies in
- (a) atomic currents
- (b) polar nature of molecules
- (c) extrinsic spin of electron
- (d) None of these

**3.** For bar magnet effective length (Le) related with geometrical length ($L_g$) as

(a) $Le = \frac{6}{5} L_g$ (b) $Le = \frac{5}{6} L_g$

(c) $Le = L_g$ (d) $Le = 2 L_g$

**4.** A bar magnet of magnetic moment M, is placed in magnetic field of induction B. The torque exerted on it is

(a) $\vec{M}.\vec{B}$ (b) $-\vec{M}.\vec{B}$

(c) $\vec{M}\times\vec{B}$ (d) $-\vec{B}\times\vec{M}$

**5.** A bar magnet is cut into two equal halves by a plane parallel to the magnetic axis. Of the following physical quantities the one which remains unchanged is
- (a) pole strength
- (b) magnetic moment
- (c) intensity of magnetisation
- (d) None of these

**6.** Current I is flowing in a coil of area A and number of turns is N, then magnetic moment of the coil in M equal to

(a) NIA (b) NI/A

(c) $NI/\sqrt{A}$ (d) $N^2 AI$

**7.** Magnetic dipole moment is a vector quantity directed from
- (a) south pole to north pole
- (b) north pole to south pole
- (c) east to west
- (d) west to east

**8.** When a current in a circular loop is equivalently replaced by a magnetic dipole
- (a) the pole strength m of each pole is fixed
- (b) the distance d between the poles is fixed
- (c) the product md is fixed
- (d) None of these

**9.** Magnetic lines of force due to a bar magnet do not intersect because
- (a) a point always has a single net magnetic field
- (b) the lines have similar charges and so repel each other
- (c) the lines always diverge from a single force
- (d) the lines need magnetic lenses to be made to interest

**10.** The magnetic lines of force inside a bar magnet
- (a) are from N-pole to S-pole of magnet
- (b) do not exist
- (c) depend upon the area of cross section of bar magnet
- (d) are from S-pole of magnet

**11.** A circular loop carrying a current is replaced by an equivalent magnetic dipole. A point on the axis of the loop is in

(a) end-on position (b) broadside-on position

(c) both (d) None of these

**12.** The ratio of magnetic fields due to a smaller bar magnet in the end on position to broad side on position is

(a) 1/4 (b) 1/2

(c) 1 (d) 2

**13.** Let r be the distance of a point on the axis of a bar magnet from its centre. The magentic field at such a point is proportional to

(a) $\frac{1}{r}$ (b) $\frac{1}{r^2}$

(c) $\frac{1}{r^3}$ (d) None of these

**14.** Magnetic field intensity is defined as
- (a) Magnetic moment per unit volume
- (b) Magnetic induction force acting on a unit magnetic pole
- (c) Number of lines of force crossing per unit area
- (d) Number of lines of force crossing per unit volume

**15.** On cutting a solenoid in half, the field lines remain ...A..., emerging from one face of the solenoid and entering into the other face.
Here, A refers to
(a) irregular (b) discontinuous
(c) continuous (d) alternate

**16.** The magnetic moment of a bar magnet is thus ...*A*... to the magnetic moment of an equivalent solenoid that produces the same magnetic field.
Here, *A* refers to
(a) unequal (b) different
(c) equal (d) same

**17.** The lines of force due to earth's horizontal magnetic field are
(a) parallel and straight (b) concentric circles
(c) elliptical (d) curved lines

**18.** The earth's magnetic field always has a vertical component except at the
(a) magnetic equator (b) magnetic poles
(c) geographic north pole (d) latitude 45º

**19.** At magnetic poles, the angle of dip is
(a) 45º (b) 30º
(c) zero (d) 90º

**20.** The strength of the earth's magnetic field is
(a) constant everywhere
(b) zero everywhere
(c) having very high value
(d) vary from place to place on the earths surface

**21.** At the magnetic north pole of the earth, the value of the horizontal component of earth's magnetic field and angle of dip are respectively
(a) zero, maximum (b) maximum, minimum
(c) maximum, maximum (d) minimum, minimum

**22.** The magnetic compass is not useful for navigation near the magnetic poles, since
(a) $R = 0$ (b) $V = 0$
(c) $H = 0$ (d) $\theta = 0^{\circ}$

**23.** A compass needle which is allowed to move in a horizontal plane is taken to a geomagnetic pole. It will
(a) stay in north-south direction only
(b) stay in east-west direction only
(c) become rigid showing no movement
(d) stay in any position

**24.** A dip circle is taken to geomagnetic equator. The needle is allowed to move in a vertical plane perpendicular to the mangetic meridian. the needle will stay in
(a) horizontal direction only
(b) vertical direction only
(c) any direction except vertical and horizontal
(d) any direction it is released

**25.** Which of the following is responsible for the earth's magnetic field?
(a) Convective currents in earth's core.
(b) Diversive current in earth's core.
(c) Rotational motion of earth.
(d) Translational motion of earth.

**26.** One can define ...*A*... of a place as the vertical plane which passes through the imaginary line joining the magnetic North and the South–poles.
Here, A refers to
(a) geographic meridian (b) magnetic meridian
(c) magnetic declination (d) magnetic inclination

**27.** The ratio of intensity of magnetisation and magnetising field is called
(a) permeability (b) magnetic intensity
(c) magnetic intensity (d) magnetic susceptibility

**28.** Susceptibility is positive and large for a
(a) paramagnetic substance
(b) ferromagnetic substance
(c) diamagnetic substance
(d) non magnetic substance

**29.** The relation between B, H and I in S.I. units is
(a) $B = \mu_0(H + I)$ (b) $B = H + 4\pi I$
(c) $H = \mu_0(B + I)$ (d) None of these

**30.** If $\mu_0$ is absolute permeability of vacuum and $\mu_r$ is relative magnetic permeability of another medium, then permeability $\mu$ of the medium is
(a) $\mu_0 \mu_r$ (b) $\mu_0/\mu_r$
(c) $\mu_r/\mu_0$ (d) $1/\mu_0 \mu_r$

**31.** Which of the following is not correct about relative magnetic permeability $(\mu,)$?
(a) It is a dimensionsless pure ratio.
(b) For vacuum medium its value is one.
(c) For ferromagnetic materials $\mu, >> 1$
(d) For paramagnetic materials $\mu, > 1$.

**32.** Hysterisis is the phenomenon of lagging of
(a) I behind B (b) B behind I
(c) I and B behind H (d) H behind I

**33.** Metals getting magnetised by orientation of atomic magnetic moments in external magnetic field are called
(a) diamagnetic (b) paramagnetic
(c) ferromagnetic (d) antimagnetic

**34.** The magnetic susceptibility for diamagnetic materials is
(a) small and negative (b) small and positive
(c) large and positive (d) large and negative

**35.** Which magnetic materials have negative susceptibility?
(a) diamagnetic materials
(b) paramagnetic materials
(c) ferromagnetic materials
(d) All the above

**36.** If a diamagnetic substance is brought near north or south pole of a bar magnet, it is
(a) attracted by poles
(b) repelled by poles
(c) replaced by north pole and attracted by south pole
(d) attracted by north pole and repelled by south pole

**37.** Among which of the following the magnetic susceptibility does not depend on the temperature?
(a) Dia-magnetism (b) Para-magnetism
(c) Ferro-magnetism (d) Ferrite

**38.** The narrowest hysterisis loop is for
(a) cobalt steel (b) alnico
(c) perm alloy (d) stainless steel

**39.** The hysterisis curve is studied generally for
(a) ferromagnetic materials (b) paramagnetic materials
(c) diamagnetic materials (d) all of the above

**40.** Of dia, para and ferromagnetism, the universal property of all substances is
(a) diamagnetism (b) paramagnetism
(c) ferromagnetism (d) all of the above

**41.** Curie temperature is the temperature above which
(a) a ferromagnetic material becomes paramagenetic
(b) a paramagnetic material becomes diamagnetic
(c) a ferromagnetic material becomes diamagnetic
(d) a paramagnetic meterial becomes ferromagnetic

**42.** A material is placed in a magnetic field and it is thrown out of it. Then the material is
(a) paramagnetic (b) diamagnetic
(c) ferromagnetic (d) non-magnetic

**43.** A diamagnetic material in a magnetic field moves
(a) perpendicular to field
(b) from stronger to weaker parts of field
(c) from weaker to stronger parts of the field
(d) None of these

**44.** A temporary magnet is made of
(a) cast iron (b) steel
(c) soft iron (d) stainless steel

**45.** The hysteresis cycle for the material of permanent magnet is
(a) short and wide (b) tall and narrow
(c) tall and wide (d) short and narrow

**46.** Materials suitable for permanent magnet, must have which of the following properties?
(a) High retentivity, low coercivity and high permeability.
(b) Low retentivity, low coercivity and low permeability.
(c) Low retentivity, high coercivity and low permeability.
(d) High retentivity, high coercivity and high permeability.

**47.** Which of the following is the most suitable material for making permanent magnet ?
(a) Steel (b) Soft iron
(c) Copper (d) Nickel

**48.** The materials suitable for making electromagnets should have
(a) high retentivity and low coercivity
(b) low retentivity and low coercivity
(c) high retentivity and high coercivity
(d) low retentivity and high coercivity

**49.** Core of elctromagnets are made of ferromagnetic materials which have
(a) low permeability and low retentivity
(b) high permeability and high retentivity
(c) high permeability and high retentivity.
(d) low permeability and high retentivity.

**50.** Permanent magnets are the substances having the property of
(a) ferromagnetism at room temperature for a long period of time.
(b) paramagnetism at room temperature for a long period of time.
(c) anti ferromagnetism at room temperature for a long period of time.
(d) diamagnetism at room temperature for a long period of time.

**51.** Identify the mismatched pair
(a) Hard magnet - Alnico
(b) Soft magnet - Soft iron
(c) Bar magnet - Equivalent solenoid
(d) Permanent magnet - Loud speaker

**52.** When the temperature of a magnetic material decreases, the magnetization
(a) decreases in a diamagnetic material
(b) decreases in a paramagnetic material
(c) decreases in a ferromagnetic material
(d) remains the same in a diamagnetic material

**53.** Identify the correctly matched pair
(a) Diamagnetic - Gadolinium
(b) Soft ferromagnetic - Alnico
(c) Hard ferromagnetic - Copper
(d) Paramagnetic - Sodium

**54.** A magnetic needle is kept in a non-uniform magnetic field. It experiences
(a) neither a force nor a torque
(b) a torque but not a force
(c) a force but not a torque
(d) a force and a torque

**55.** If $\mu_0$ is absolute permeability of vacuum and $\mu_r$ is relative magnetic permeability of another medium, then permeability $\mu$ of the medium is
(a) $\mu_0 \mu_r$ (b) $\mu_0/\mu_r$
(c) $\mu_r/\mu_0$ (d) $1/\mu_0 \mu_r$

**56.** Susceptibility is positive and large for a
(a) paramagnetic substance
(b) ferromagnetic substance
(c) diamagnetic substance
(d) non magnetic substance

**57.** Relative permittivity and permeability of a material are $\varepsilon_r$ and $\mu_r$, respectively. Which of the following values of these quantities are allowed for a diamagnetic material ?
(a) $\varepsilon_r = 1.5, \mu_r = 0.5$ (b) $\varepsilon_r = 0.5, \mu_r = 0.5$
(c) $\varepsilon_r = 1.5, \mu_r = 1.5$ (d) $\varepsilon_r = 0.5, \mu_r = 1.5$

**58.** Magnetic permeability is maximum for
(a) diamagnetic substance
(b) paramagnetic substance
(c) ferromagnetic substance
(d) All of the above

**59.** When a piece of a ferromagnetic substance is put in a uniform magnetic field, the flux density inside it is four times the flux density away from the piece. The magnetic permeability of the material is
(a) 1 (b) 2
(c) 3 (d) 4

**60.** Demagnetisation of magnets can be done by
(a) rough handling
(b) heating
(c) magnetising in the opposite direction
(d) All of the above

**61.** A diamagnetic material in a magnetic field moves
(a) perpendicular to the field
(b) from stronger to the weaker parts of the field
(c) from weaker to the stronger parts of the field
(d) None of these

**62.** A ferromagnetic material is heated above its curie temperature. Which one is a correct statement?
(a) Ferromagnetic domains are perfectly arranged
(b) Ferromagnetic domains become random
(c) Ferromagnetic domains are not influenced
(d) Ferromagnetic material changes into diamagnetic material

**63.** A substance which retains magnetic moment for a long time is
(a) Diamagnetic (b) Paramagnetic
(c) Ferromagnetic (d) Non magnetic

**64.** Ferromagnetism arises due to
(a) vacant inner shells of an atom
(b) filled inner sub shells of an atom
(c) partially filled inner sub shells
(d) large number of electrons in valence orbit

**65.** Domain is a region where in all atoms have their magnetic momentum
(a) parallel
(b) antiparallel
(c) randomly oriented
(d) perpendicular to one another

**66.** Domains are formed in
(a) non magnetic substance
(b) paramagnetic substance
(c) ferromagnetic substance
(d) para and ferromagnet substance

**67.** The magnetic susceptibility is given by
(a) $\chi = \frac{1}{H}$ (b) $\chi = \frac{B}{H}$
(c) $\chi = \frac{M_{net}}{V}$ (d) $\chi = \frac{M_z}{H}$

**68.** Iron is ferromagnetic
(a) above 770°C (b) below 770°C
(c) at all temperature (d) above 1100°C

**69.** According to Curie's law,
(a) $\chi \propto (T - T_c)$ (b) $\chi \propto \frac{1}{T - T_c}$
(c) $\chi \propto \frac{1}{T}$ (d) $\chi \propto T$

**70.** Susceptibility of ferromagnetic substance is
(a) $> 1$ (b) $< 1$
(c) 0 (d) 1

**71.** Magnetic field intensity due to a dipole varies as $x^n$, where n is
(a) 2 (b) – 2
(c) 3 (d) – 3

**72.** A susceptibility of a certain magnetic material is 400. What is the class of the magnetic material?
(a) Diamagnetic (b) Paramagnetic
(c) Ferromagnetic (d) Ferroelectric

**73.** Which of the following is paramagnetic?
(a) Gold (b) Water
(c) Nickel (d) Aluminium

**74.** On applying an external magnetic field, to a ferromagnetic substance domains
(a) align in the direction of magnetic field
(b) align in the opposite direction of magnetic field
(c) remain undeflected
(d) None of these

**75.** The magnetic moment of atoms of diamagnetic substances is
(a) equal to zero (b) less than zero
(c) greater than 1 (d) none of these

**76.** If the susceptibility of dia, para and ferromagnetic materials are $\chi_d$, $\chi_p$, $\chi_f$ respectively, then
(a) $\chi_d < \chi_p < \chi_f$ (b) $\chi_d < \chi_f < \chi_p$
(c) $\chi_f < \chi_d < \chi_p$ (d) $\chi_f < \chi_p < \chi_d$

**77.** The magnetic susceptibility of a paramagnetic substances at –73°C is 0.0060, then its value at –173°C will be
(a) 0.0030 (b) 0.0120
(c) 0.0180 (d) 0.0045

**78.** Needles $N_1$, $N_2$ and $N_3$ are made of a ferromagnetic, a paramagnetic and a diamagnetic substance respectively. A magnet when brought close to them will
(a) attract $N_1$ and $N_2$ strongly but repel $N_3$
(b) attract $N_1$ strongly, $N_2$ weakly and repel $N_3$ weakly
(c) attract $N_1$ strongly, but repel $N_2$ and $N_3$ weakly
(d) attract all three of them

**79.** If a paramagnetic liquid is placed in a watch glass, resting on the pole pieces, the liquid accumulates where the field is
(a) zero (b) weak
(c) strong (d) None of these

## STATEMENT TYPE QUESTIONS

**80.** Which of the following statements is / are correct about magnetism ?
I. The Earth behaves as a magnet with the magnetic field pointing approximately from the geographic South to the North.
II. When a bar magnet is freely suspended, it points in the North–South direction. The tip which points to the geographic North is called the North –pole and the tip which points to georaphic South is called the South–pole of magnet.
III. There is a repulsive force when North–poles (or South–poles) of two magnets are brought close together. Conversely, there is an attractive force

between the North–pole of one magnet and the South–pole of other.

IV. We can isolate the North or South–pole of a magnet.

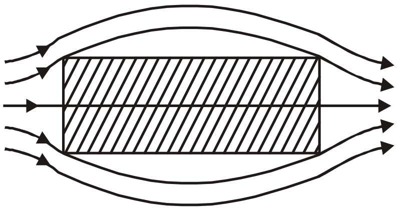
(a) I and II
(b) I, II and IV
(c) III and IV
(d) I, II and III

**81.** Consider the given statements with respect to the figure showing a bar of diamagnetic material placed in an external magnetic field.

I. The field lines are repelled or expelled and the field inside the material is reduced.

II. When placed in a non–uniform magnetic field, the bar will tend to move from high to low field.

III. Reduction in the field inside the material slight, being one part in $10^5$



Which of the above statements are correct?

(a) I and II
(b) I and III
(c) II and III
(d) I, II and III

**82.** A ferromagnetic material is heated above its curie temperature. Which of the following are incorrect ?

I. Ferromagnetic domains are perfectly arranged

II. Ferromagnetic domains are not influenced

III. Ferromagnetic material changes into diamagnetic material

(a) I and II (b) I, II and III
(c) II and III (d) I and III

**83.** Consider the following statements and identify incorrect statement(s).

I Diamagnetism is temperature independent.

II Paramagnetism is explained by domain theory.

III Above curie temperature a ferromagnetic material becomes paramagnetic.

IV Magnetic susceptibility is small and negative for diamagnetic substance.

(a) I only (b) II only
(c) I, II and III (d) II and IV

**84.** Consider the following statements and select the correct statement(s).

I Diamagnetic materials do not have permanent magnetic moment

II Diamagnetism is explained in terms of electromagnetic induction

III Diamagnetic materials have a small positive susceptibility

(a) I only (b) II only
(c) I and II (d) I, II and III

**85.** Consider the following statements and choose the incorrect statement(s)

I A paramagnetic material tends to move from a strong magnetic field to weak magnetic field

II A magnetic material is in the paramagnetic phase below its Curie temperature.

III The resultant magnetic moment in an atom of a diamagnetic substance is zero

(a) I only (b) II only
(c) I and II (d) I, II and III

## MATCHING TYPE QUESTIONS

**86.** Match the columns I and II.

| **Column I** | **Column II** |
|---|---|
| (A) Axial field for a short dipole | (1) – M.B |
| (B) Equatorial field for a short dipole | (2) M × B |
| (C) External field torque | (3) $\mu_0 2M/4\pi r^3$ |
| (D) External field energy | (4) $-\mu_0 M/4\pi r^3$ |

(a) (A) → (3) ; (B) → (4) ; (C) → (2) ; (D) → (1)
(b) (A) → (3) ; (B) → (4) ; (C) → (3) ; (D) → (1)
(c) (A) → (4) ; (B) → (3) ; (C) → (2) ; (D) → (1)
(d) (A) → (2) ; (B) → (1) ; (C) → (4) ; (D) → (3)

**87.**

| **Column I** | **Column II** |
|---|---|
| (A) Horizontal component | (1) $B_E \sin\theta$ |
| (B) Vertical component | (2) $\frac{B_V}{B_H}$ |
| (C) tan θ | (3) $B_E \cos\theta$ |
| (D) Tangent law | (4) $B = B_H \tan\theta$ |

(a) A → (3); B → (2); C → (1); D → (4)
(b) A → (3); B → (1); C → (2); D → (4)
(c) A → (2); B → (3); C → (1); D → (4)
(d) A → (1); B → (3); C → (2); D → (4)

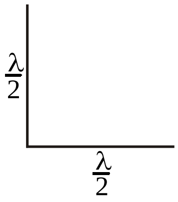
**88.**

| **Column I** | **Column II** |
|---|---|
| (A) Negative susceptibility | (1) Ferromagnetic |
| (B) Positive and small susceptibility | (2) Diamagnetic |
| (C) Positive and large susceptibility | (3) Paramagnetic |
| (D) Loadstone | (4) Magnetite |

(a) A → (3); B → (2); C → (4); D → (1)
(b) A → (1); B → (2); C → (3); D → (4)
(c) A → (2); B → (3); C → (1); D → (4)
(d) A → (2); B → (1); C → (4); D → (3)

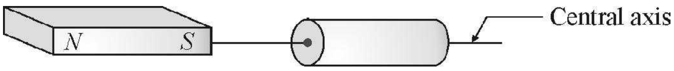
## DIAGRAM TYPE QUESTIONS

**89.** A steel wire of length $\ell$ has a magnetic moment M. It is bent in L-shape (Figure). The new magnetic moment is



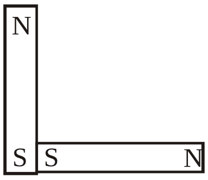
(a) M
(b) $\frac{M}{\sqrt{2}}$
(c) $\frac{M}{2}$
(d) 2M

**90.** Imagine rolling a sheet of paper into a cylinder and placing a bar magnet near its end as shown in figure. What can you say about the sign of $\vec{B}.d\vec{A}$ for every area $d\vec{A}$ on the surface?

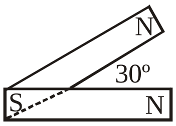


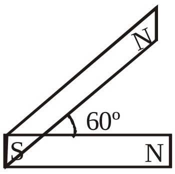
(a) Positive
(b) Negative
(c) No sign
(d) Can be positive or negative

**91.** Following figures show the arrangement of bar magnets in different configurations. Each magnet has magnetic dipole moment $\vec{m}$. Which configuration has highest net magnetic dipole moment ?

A.


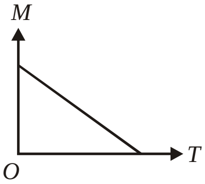
B.

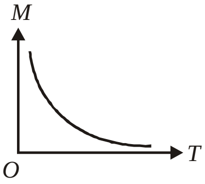

C.


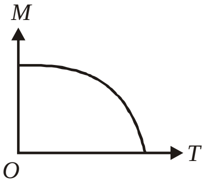
D.


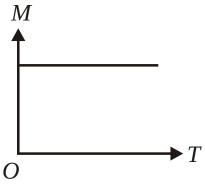
(a) A
(b) B
(c) C
(d) D

**92.** A curve between magnetic moment and temperature of magnet is

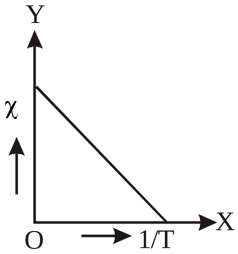
(a)


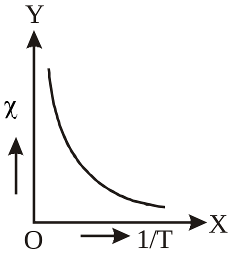
(b)


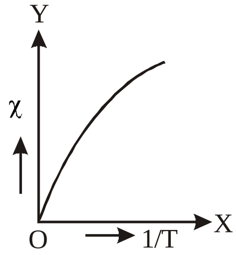
(c)


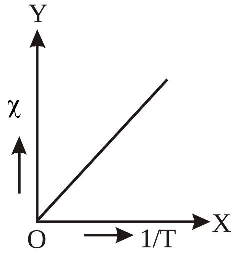
(d)


**93.** The graph between χ and 1/T for paramagnetic material will be represented by

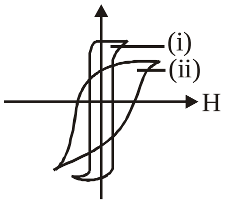
(a)


(b)


(c)


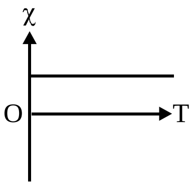
(d)


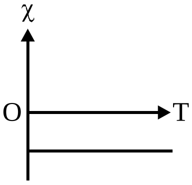
**94.** The B – H curve (i) and (ii) shown in fig associated with

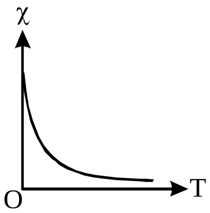


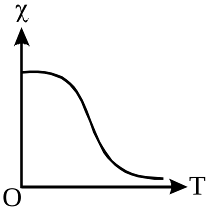
(a) (i) diamagnetic and (ii) paramagnetic substance
(b) (i) paramagnetic and (ii) ferromagnetic substance
(c) (i) soft iron and (ii) steel
(d) (i) steel and (ii) soft iron

**95.** The variation of magnetic susceptibility ($x$) with temperature for a diamagnetic substance is best represented by

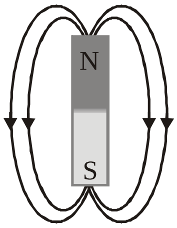
(a)


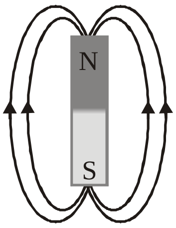
(b)


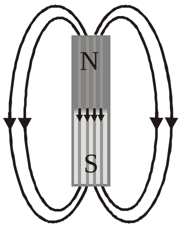
(c)


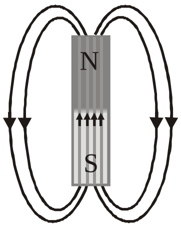
(d)


**96.** The magnetic field lines due to a bar magnet are correctly shown in

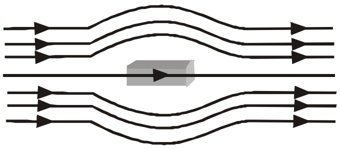
(a)


(b)


(c)


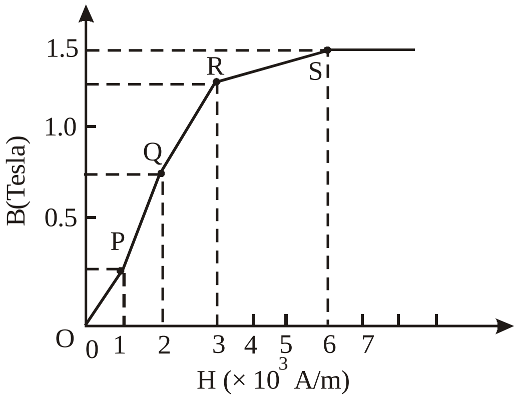
(d)


**97.** The given figure represents a material which is



(a) paramagnetic (b) diamagnetic
(c) ferromagnetic (d) none of these

**98.** The basic magnetization curve for a ferromagnetic material is shown in figure. Then, the value of relative permeability is highest for the point



(a) P (b) Q
(c) R (d) S

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

**99.** **Assertion :** The poles of magnet can not be separated by breaking into two pieces.

**Reason :** The magnetic moment will be reduced to half when a magnet is broken into two equal pieces.

**100.** **Assertion :** We cannot think of magnetic field configuration with three poles.

**Reason :** A bar magnet does not exert a torque on itself due to its own field.

**101.** **Assertion :** The earth′s magnetic field is due to iron present in its core.

**Reason :** At a high temperature magnet losses its magnetism.

**102.** **Assertion :** To protect any instrument from external magnetic field, it is put inside an iron body.

**Reason :** Iron has high permeability.

**103.** **Assertion :** The sensitivity of a moving coil galvanometer is increased by placing a suitable magnetic material as a core inside the coil.

**Reason :** Soft iron has high magnetic permeability and cannot be easily magnetized or demagnetized.

**104.** **Assertion :** Magnetism is relativistic.

**Reason :** When we move along with the charge so that there is no motion relative to us, we find no magnetic field associated with the charge.

**105.** **Assertion :** The ferromagnetic substance do not obey Curie’s law.

**Reason :** At Curie point a ferromagnetic substance start behaving as a paramagnetic substance.

**106.** **Assertion :** A paramagnetic sample display greater magnetisation (for the same magnetic field) when cooled.

**Reason :** The magnetisation does not depend on temperature.

**107.** **Assertion :** Electromagnets are made of soft iron.

**Reason :** Coercivity of soft iron is small.

## CRITICAL THINKING TYPE QUESTIONS

**108.** A bar magnet has a length 8 cm. The magnetic field at a point at a distance 3 cm from the centre in the broad side-on position is found to be $4\times10^{-6}\,T$. The pole strength of the magnet is.

(a) $6\times10^{-5}$ Am (b) $5\times10^{-5}$ Am
(c) $2\times10^{-4}$ Am (d) $3\times10^{-4}$ Am

**109.** Two bar magnets of the same mass, same length and breadth but having magnetic moments M and 2M are joined together pole for pole and suspended by a string. The time period of assembly in a magnetic field of strength H is 3 seconds. If now the polarity of one of the magnets is reversed and combination is again made to oscillate in the same field, the time of oscillation is

(a) $\sqrt{3}$ sec (b) $3\sqrt{3}$ sec
(c) 3 sec (d) 6 sec

**110.** A compass needle made of pure iron (with density 7900 kg/m$^3$) has a length $L$ of 3.0 cm, a width of 1.00 mm, and a thickness of 0.50 mm. The magnitude of the magnetic dipole moment of an iron atom is $M_{Fe}=2.1\times10^{-23}\,J/T$. If the magnetisation of the needle is equivalent to the alignment of 10% of the atoms in the needle, what is the magnitude of the needle′s magnetic dipole moment $\vec{M}$ ?

(a) $2.7\times10^{-1}$ J/T (b) $2.7\times10^{-2}$ J/T
(c) $2.7\times10^{-3}$ J/T (d) $2.7\times10^{-4}$ J/T

**111.** The work done in turning a magnet of magnetic moment M by an angle of 90° from the meridian, is n times the corresponding work done to turn it through an angle of 60°. The value of n is given by

(a) 2 (b) 1
(c) 0.5 (d) 0.25

**112.** A short bar magnet of magnetic moment $0.4 \text{J T}^{-1}$ is placed in a uniform magnetic field of 0.16 T. The magnet is in stable equilibrium when the potential energy is

(a) – 0.64 J (b) zero
(c) – 0.082 J (d) 0.064 J

**113.** The magnetic moment of a magnet is 0.1 amp × $m^2$. It is suspended in a magnetic field of intensity $3 \times 10^{-4}$ weber/$m^2$. The couple acting upon it when deflected by 30º from the magnetic field is

(a) $1 \times 10^{-5}$ N m (b) $1.5 \times 10^{-5}$ N m
(c) $2 \times 10^{-5}$ N m (d) $2.5 \times 10^{-5}$ N m

**114.** Time periods of vibation of two bar magnets in sum and difference positions are 4 sec and 6 sec respectively. The ratio of their magnetic moments $M_1 / M_2$ is

(a) 6 : 4 (b) 30 : 16
(c) 2 . 6 : 1 (d) 1 . 5 : 1

**115.** A magnet of magnetic moment 20 C.G.S. units is freely suspended in a uniform magnetic field of intensity 0.3 C.G.S. units. The amount of work done in deflecting it by an angle of 30° in C.G.S. units is

(a) 6 (b) $3\sqrt{3}$
(c) $3(2-\sqrt{3})$ (d) 3

**116.** A magnet of length 0.1 m and pole strength $10^{-4}$ *A.m.* is kept in a magnetic field of 30 $Wb / m^2$ at an angle 30°. The couple acting on it is ........ × $10^{-4}$ *Nm.*

(a) 7.5 (b) 3.0
(c) 1.5 (d) 6.0

**117.** A short bar magnet is placed in the magnetic meridian of the earth with north pole pointing north. Neutral points are found at a distance of 30 cm from the magnet on the East – West line, drawn through the middle point of the magnet. The magnetic moment of the magnet in $Am^2$ is close to: (Given $\frac{\mu_0}{4\pi}$ = $10^{-7}$ in SI units and $B_H$ =Horizontal component of earth's magnetic field = 3.6 × $10^{-5}$ tesla)

(a) 14.6 (b) 19.4
(c) 9.7 (d) 4.9

**118.** A bar magnet of moment of inertia $9 \times 10^{-5}$ kg $m^2$ placed in a vibration magnetometer and oscillating in a uniform magnetic field $16\pi^2 \times 10^{-5}$T makes 20 oscillations in 15 s. The magnetic moment of the bar magnet is

(a) 3 $Am^2$ (b) 2 $Am^2$
(c) 5 $Am^2$ (d) 4 $Am^2$

**119.** If a magnetic dipole of moment *M* situated in the direction of a magnetic field *B* is rotated by 180°, then the amount of work done is

(a) MB (b) 2MB
(c) $\frac{MB}{\sqrt{2}}$ (d) $\sqrt{MB}$

**120.** Two short magnets with their axes horizontal and perpendicular to the magnetic maridian are placed with their centres 40 cm east and 50 cm west of magnetic needle. If the needle remains undeflected, the ratio of their magnetic moments $M_1 : M_2$ is

(a) 4 : 5 (b) 16 : 25
(c) 64 : 125 (d) 2 : $\sqrt{5}$

**121.** A bar magnet 8 cms long is placed in the magnetic merdian with the N-pole pointing towards geographical north. Two netural points separated by a distance of 6 cms are obtained on the equatorial axis of the magnet. If horizontal component of earth's field = $3.2 \times 10^{-5}$ T, then pole strength of magnet is

(a) 5 ab-amp × c (b) 10 ab-amp × cm
(c) 2.5 ab-amp × cm (d) 20 ab-amp × cm

**122.** At a certain place, the angle of dip is 30º and the horizontal component of earth's magnetic field is 0.50 oerested. The earth's total magnetic field (in oerested) is

(a) $\sqrt{3}$ (b) 1
(c) $\frac{1}{\sqrt{3}}$ (d) $\frac{1}{2}$

**123.** Two magnets are held together in a vibration magnetometer and are allowed to oscillate in the earth's magnetic field with like poles together. 12 oscillations per minute are made but for unlike poles together only 4 oscillations per minute are executed. The ratio of their magnetic moments is

(a) 3 : 1 (b) 1 : 3
(c) 3 : 5 (d) 5 : 4

**124.** The horizontal component of the earth's magnetic field is $3.6 \times 10^{-5}$ tesla where the dip angle is 60°. The magnitude of the earth's magnetic field is

(a) $2.8 \times 10^{-4}$ tesla (b) $2.1 \times 10^{-4}$ tesla
(c) $7.2 \times 10^{-5}$ tesla (d) $3.6 \times 10^{-5}$ tesla

**125.** A torque of $10^{-5}$ Nm is required to hold a magnet at 90° with the horizontal component H of the earth's magnetic field. The torque to hold it at 30° will be

(a) $5 \times 10^{-6}$ Nm (b) data is insufficient
(c) $\frac{1}{3} \times 10^{-5}$ Nm (d) $5\sqrt{3} \times 10^{-6}$ Nm

**126.** A short magnet oscillates in an oscillation magnetometer with a time period of 0.10s where the earth′s horizontal magnetic field is 24 $\mu T$. A downward current of 18 A is established in a vertical wire placed 20 cm east of the magnet. Find the new time period.

(a) 0.076 s (b) 0.5 s
(c) 0.1 s (d) 0.2 s

**127.** The susceptibility of annealed iron at saturation is 5500. Find the permeability of annealed iron at saturation.
(a) $6.9 \times 10^{-3}$ (b) $5.1 \times 10^{-2}$
(c) $5 \times 10^{2}$ (d) $3.2 \times 10^{-5}$

**128.** The moment of a magnet (15 cm × 2 cm × 1 cm) is 1.2 A-m$^2$. What is its intensity of magnetisation?
(a) $4 \times 10^4$ A m$^{-1}$ (b) $2 \times 10^4$ A m$^{-1}$
(c) $10^4$ A m$^{-1}$ (d) None of these

**129.** A magnetising field of $2 \times 10^3$ A m$^{-1}$ produces a magnetic flux density of 8π T in an iron rod. The relative permeability of the rod will be
(a) $10^2$ (b) 1
(c) $10^4$ (d) $10^3$

**130.** A permanent magnet in the shape of a thin cylinder of length 10 cm has magnetisation ($M$) = $10^6$ A m$^{-1}$. Its magnetization current $I_M$ is
(a) $10^5$ A (b) $10^6$ A
(c) $10^7$ A (d) $10^8$ A

**131.** If relative permeability of iron is 2000. Its absolute permeability in S.I. units is
(a) $8\pi \times 10^{-4}$ (b) $8\pi \times 10^{-3}$
(c) $800/\pi$ (d) $8\pi \times 10^9/\pi$

**132.** The relative permeability of a medium is 0.075. What is its magnetic susceptibility?
(a) 0.925 (b) –0.925
(c) 1.075 (d) –1.075

**133.** At a temperatur of 30°C, the susceptibility of a ferromagnetic material is found to be $\chi$. Its susceptibility at 333°C is
(a) $\chi$ (b) $0.5\chi$
(c) $2\chi$ (d) $11.1\chi$

**134.** Assume that each iron atom has a permanent magnetic moment equal to 2 Bohr magnetons (1 Bohr magneton = $9.27\times10^{-24}$ A-m$^2$). The density of atoms in iron is $8.52 \times 10^{28}$ $atoms/m^3$. Find the maximum magnetisation $I$ in a long cylinder of iron.
(a) $1.5 \times 10^2$ A|m (b) $1.58 \times 10^6$ A|m
(c) $1.2 \times 10^5$ A|m (d) $1.3 \times 10^6$ A|m

**135.** The coercivity of a small magnet where the ferromagnet gets demagnetized is $3\times10^3$ Am$^{-1}$. The current required to be passed in a solenoid of length 10 cm and number of turns 100, so that the magnet gets demagnetized when inside the solenoid, is:
(a) 30 mA (b) 60 mA
(c) 3 A (d) 6 A

**136.** A bar magnet has coercivity $4 \times 10^3$ Am$^{-1}$. It is desired to demagnetise it by inserting it inside a solenoid 12 cm long and having 60 turns. The current that should be sent through the solenoid is
(a) 2 A (b) 4 A
(c) 6 A (d) 8 A

**137.** A magnetising field of $2 \times 10^3$ amp/m produces a magnetic flux density of 8π tesla in an iron rod. The relative permeability of the rod will be
(a) $10^2$ (b) $10^0$
(c) $10^3$ (d) $10^4$

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

1. (d) 2. (a) 3. (b) 4. (c) 5. (c)
6. (a) 7. (a) 8. (c) 9. (a) 10. (d)
11. (a) 12. (d) 13. (d)

**14. (b)** Number of lines of force passing through per unit area normally is intensity of magnetic field, hence option (c) is incorrect. The correct option is (b).

**15. (c)** The field lines remain continuous, emerging from one face of the solenoid and entering into the other face.

**16. (c)** The magnetic moment of a bar magnet is thus equal to the magnetic moment of an equivalent solenoid that produces the same magnetic field.

17. (b) 18. (a) 19. (d)

**20. (d)** The streangth of the earths magnetic field is not constant. It varies from one place to other place on the surface of earth. Its value being of the order of $10^{-5}$ T.

21. (a) 22. (c) 23. (d) 24. (d)

**25. (a)** The earth,s core is hot and molten. Hence, convective current in earth’s core is responsibli for it’s magnetic field.

**26. (b)** Magnetic meridian of a place is defined as the vertical plane which passes through the imaginary line joining the magnetic North and South-poles. This pane would intersect the surface of the Earth in a longitude like circle.

27. (d) 28. (b) 29. (a)

30. (a)

**31. (d)** Relative magnetic permeability

$$\mu_r = \frac{\text{magnetic permeability of material}(\mu)}{\text{permeability of free space}(\mu_0)}$$

It is a dimensionless pure ratio and for paramagnetic materials $\mu_r > 1$.

32. (c) 33. (b) 34. (a) 35. (a) 36. (b)
37. (a) 38. (c) 39. (a) 41. (a) 41. (a)
42. (b) 43. (b) 44. (a) 45. (c)

**46. (d)** Materials suitable for permanent magnets should have high retentivity, high coercivity and high permeability.

47. (a)

**48. (b)** Electro magnet should be amenable to magnetisation and demagnetization

∴ retentivity should be low and coercivity should be low.

**49. (c)** Core of electromagnets are made of soft iron that is a ferromagnetic material with high permeability and low retentivity.

**50. (a)** Permanent magnets are those substances that retain their ferromagnetic property for a long period of time at room temperature.

**51. (d)** Permanent magnet – Loud speaker

**52. (d)** When the temperature of a magnetic material decreases, the magnetization remains the same in a diamagnetic material.

53. (d)

**54. (d)** A magnetic needle kept in non uniform magnetic field experience a force and torque due to unequal forces acting on poles.

**55. (a)** $\mu = \mu_r \mu_0$, as $\mu_r = \mu / \mu_0$.

**56. (b)** For ferromagnetic substances, $\chi_m$ is large and positive.

**57. (a)** $\mu_r < 1$ and $\varepsilon_r > 1$.

58. (c)

**59. (d)** The magnetic permeability of the material

$$\mu = \frac{B}{H} = \frac{4H}{H} = 4$$

60. (d)

**61. (b)** A diamagnetic material in a magnetic field moves from stronger to the weaker parts of the field.

**62. (b)** Beyond curie temperature, ferormagnetic material turns into paramagnetic material, as if ferromagnetic domains become random.

63. (c) 64. (c) 65. (a) 66. (c) 67. (d)
68. (b) 69. (c) 70. (a)

**71. (d)** Magnetic field intensity $= \frac{\mu_0}{4\pi}\frac{M}{x^3}$

$\propto Mx^{-3}$

∴ $n = -3$

72. (c) 73. (d)

**74. (a)** By the property of ferromagnetic substance.

75. (a)

**76. (a)** $\chi_d < \chi_p < \chi_f$

For diamagnetic substance $\chi_d$ is small negative $(10^{-5})$

For paramagnetic substances $\chi_p$ is small and positive $(10^{-3}$ to $10^{-5})$

For ferromagnetic substanes $\chi_f$ is very large $(10^3$ to $10^5)$

**77.** **(b)** As magnetic susceptibility $\chi_m \propto \frac{1}{T}$, therefore

$$\frac{\chi_2}{\chi_1}=\frac{T_1}{T_2} \Rightarrow \frac{\chi_2}{0.0060}=\frac{273-73}{273-173}=\frac{200}{100}=2$$

$\chi_2 = 2\times 0.0060 = 0.0120$

**78.** **(b)** Ferromagnetic substance has magnetic domains whereas paramagnetic substances have magnetic dipoles which get attracted to a magnetic field.

Diamagnetic substances do not have magnetic dipole but in the presence of external magnetic field due to their orbital motion of electrons these substances are repelled.

**79.** **(c)**

## STATEMENT TYPE QUESTIONS

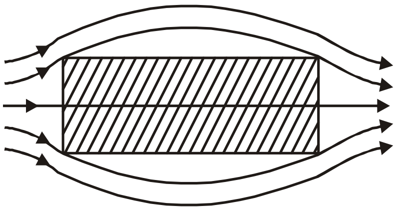
**80.** **(d)** (i) The Earth behaves as a magnet with the magnetic field pointing appoximately from the geographic South to the North.

(ii) When a bar magnet is freely suspended, it points in the North-South direction. The tip which points to the geographic North is called the North pole and the tip which points to the geographic South is called the South-pole of the magnet.

(iii) There is a repulsive force when North poles (or South-poles) of two magnets are brought close together. Conversely there is an attractive force between the North-pole of one magnet and the South-pole of the other.

(iv) We cannot isolate the North or South-pole of a magnet. If a bar magnet is broken into two halves, we get two similar bar magnets with somewhat weaker properties. Unlike electric charges, isolated magnetic North and South poles known as magnetic monopoles do not exist.

**81.** **(d)** Figure shows a bar of diamagnetic material placed in an external magnetic field.



The field lines are repelled or expelled and the field inside the material is reduced, this reduction is slight, being one part in $10^5$. When placed in a non-uniform magnetic field, the bar will tend to move from high to low field.

**82.** **(b)**

**83.** **(b)** Domain theory is for ferromagnetic substance.

**84.** **(c)** Susceptibility of diamagnetic substance is negative and it does not change with temperature.

**85.** **(c)** Diamagnetic substances are those substances in which resultant magnetic moment in an atom is zero.

A paramagnetic material tends to move from a weak magnetic field to strong magnetic field.

A magnetic material is in the paramagnetic phase above its Curie temperature.

Typical domain size of a ferromagnetic material in 1 mm.

## MATCHING TYPE QUESTIONS

**86.** **(a)** **(A) → 3; (B) → 4; (C) → 2; (D) → 1**

**87.** **(b)** **88.** **(c)**

## DIAGRAM TYPE QUESTIONS

**89.** **(b)** Magnetic moment, M = m$\ell$

$\frac{M}{\ell} = m$, where m is the polestrength.

Therefore distance between poles

$$=\sqrt{(\ell/2)^2+(\ell/2)^2}=\frac{\ell}{\sqrt{2}}$$

So, $M' = \frac{m\ell}{\sqrt{2}} = \frac{M}{\sqrt{2}}$

**90.** **(b)** The field is entering into the surface so flux is negative.

**91.** **(c)** Net magnetic dipole moment = 2 Mcos $\frac{\theta}{2}$

As value of cos $\frac{\theta}{2}$ is maximum in case (c) hence net magnetic dipole moment is maximum for option (c).

**92.** **(c)** Magnetism of a magnet falls with rise of temperatue and becomes practically zero above curie temperature.

**93.** **(d)** **94.** **(c)** **95.** **(b)** **96.** **(d)** **97.** **(b)**

**98.** **(b)** $B = \mu_0\mu_r H \Rightarrow \mu_r \propto \frac{B}{H}$ = slope of B-H curve

According to the given graph, slope of the graph is highest at point Q.

## ASSERTION- REASON TYPE QUESTIONS

**99.** **(b)** When a magnet is cut into pieces, each piece becomes new magnet. $M' = \frac{m\ell}{2} = \frac{M}{2}$.

**100.** **(b)**

**101.** **(d)** Magnetic field of earth is due to moving charged particles in the atmosphere. With increase in temperature, the magnetic moment of magnet decreases.

**102. (a)** Because of high permeability of the iron, the entire magnetic field will pass through iron, and so rest space becomes free from magnetic field.

**103. (c)** Sensitivity of galvanometer,

$$s = \frac{\theta}{i} \simeq \frac{\tan\theta}{i}$$

$$= \frac{\mu_0 N}{2RB_H}.$$

If a magnetic material is placed inside coil of galvanometer, then

$$s' = \frac{\mu_r \mu_0 N}{2RB_H}.$$

**104. (b)** A magnetic field is produced by the motion of electric charge. Since motion is relative, the magnetic field is also relative.

**105. (c)** The susceptibility of ferromagnetic substance decreases with the rise of temperature in a complicated manner. After Curies point in the susceptibility of ferromagnetic substance varies inversely with its absolute tempearture. Ferromagnetic substance obey's Curie's law only above its Curie point.

**106. (d)** A paramagnetic sample display greater magnetisation when cooled, this is because at lower temperature, the tendency to disrupt the alignment of dipoles (due to magnetising field) decreases on account of reduced random thermal motion.

**107. (b)** Electromagnets are magnets, which can be turnd on and off by switching the current on and off.

As the material in electromagnets is subjected to cyclic changes (magnification and demangetisation), the hysteresis loss of the material must be small. The material should attain high value of I and B with low value of magnetising field intensity H. As soft iron has small coercivity, so it is a best choice for this purpose.

## CRITICAL THINKING TYPE QUESTIONS

**108. (a)** Magnetic field due to a bar magnet in the broad-side on position is given by

$$B = \frac{\mu_0}{4\pi}\frac{M}{\left[r^2 + \frac{\ell^2}{4}\right]^{3/2}} \quad ; M = m\ell .$$

After substituting the values and simplifying we get

$$B = 6\times10^{-5} \text{ A-m}$$

**109. (b)** $\frac{T_2^2}{T_1^2} = \frac{2M+M}{2M-M} = 3 \qquad \therefore \; T_2 = T_1\sqrt{3} = 3\sqrt{3}\,\text{s.}$

**110. (c)** The volume of the needle,

$$V = (3\times10^{-2})\times(1\times10^{-3})\times(0.5\times10^{-3})$$

$$= 1.5\times10^{-8}\,\text{m}^3$$

The mass of the needle = $\rho V$

$$= 7900\times1.5\times10^{-8}$$

$$= 1.183\times10^{-4}\,\text{kg}$$

The number of atoms in the needle

$$= \left[\frac{1.185\times10^{-4}}{56\times10^{-3}}\right]\times6.02\times10^{23}$$

$$= 1.27\times10^{21}$$

The needle's dipole moment

$$M = \frac{1}{10}(1.27\times10^{21})\times(2.1\times10^{-23})$$

$$= 2.7\times10^{-3}\,\text{J/T}$$

**111. (a)** Magnetic moment = M; Initial angle through which magnet is turned $(\theta_1)$ = 90° and final angle which magnet is turned $(\theta_2)$= 60°. Work done in turning the magnet through

90°$(W_1)$ = MB (cos 0° – cos 90°)= MB (1–0) = MB.

Similarly, $W_2$ = MB (cos 0° – cos 60°)

$$= MB\left(1 - \frac{1}{2}\right) = \frac{MB}{2}.$$

$\therefore\; W_1 = 2W_2$ or n = 2.

**112. (a)** For stable equilibrium

$U = -MB = -(0.4)(0.16) = -0.064$ J

**113. (b)** $\tau = MB\sin\theta = 0.1\times3\times10^{-4}\sin30°$

or $\tau = 1.5\times10^{-5}$ N–m.

**114. (c)** $\frac{M_1}{M_2} = \frac{T_2^2 + T_1^2}{T_2^2 - T_1^2} = \frac{6^2+4^2}{6^2-4^2} = \frac{52}{20} = (2.6):1$

**115. (c)** Work done $W = MB_H(1-\cos\theta)$

$$= 20\times0.3(1-\cos30°) = 6\left(1-\frac{\sqrt{3}}{2}\right) = 3(2-\sqrt{3})$$

**116. (c)** $\tau = MB\sin\theta = m\times(2\ell)\times B\sin\theta$

$= 10^{-4}\times0.1\times30\sin30° = 1.5\times10^{-4}\,Nm$

**117. (c)** Here, r = 30cm = 0.3cm

we know $\frac{\mu_0 M}{4\pi r^3} = B_H = 3.6\times10^{-5}$

$$\Rightarrow M = \frac{3.6\times10^{-5}}{10^{-7}}(0.3)^3$$

Hence, M = 9.7 Am$^2$

**118. (d)** Given, $I = 9\times10^{-5}$ kg m$^2$, $B = 16\pi^2\times10^{-5}$ T

$$T = \frac{15}{20} = \frac{3}{4}\text{s}$$

In a vibration magnetometer

Time period, $T = 2\pi\sqrt{\dfrac{I}{MB}}$ or $M = \dfrac{4\pi^2 I}{BT^2}$

$$M = \frac{4\pi^2 \times 9 \times 10^{-5}}{16\pi^2 \times 10^{-5} \times \left(\frac{3}{4}\right)^2} = 4 \text{ A m}^2$$

**119. (b)** Work done in rotating the magnetic dipole from position $\theta_1 = 0°$ to $\theta_2 = 180°$

$\because\ W = MB(\cos\theta_1 - \cos\theta_2)$

$\therefore\ W = MB(\cos\theta° - \cos 180°) = 2MB$

**120. (c)** For null deflection $\dfrac{M_1}{M_2} = \left(\dfrac{d_1}{d_2}\right)^3 = \left(\dfrac{40}{50}\right)^3 = \dfrac{64}{125}$

**121. (a)** Here, $2\ell = 8\,\text{cm},\ \ell = 4\,\text{cm},\ \text{d} = \dfrac{6}{2} = 3\,\text{cm}.$

At neutral point,

$$\text{H} = \text{B} = \frac{\mu_0}{4\pi}\frac{\text{M}}{(\text{d}^2 + \ell^2)^{3/2}}$$

$$= 10^{-7}\frac{\text{M}}{(5 \times 10^{-2})^3} = \frac{\text{M}}{1250}$$

$$\therefore\ \text{M} = 1250\,\text{H} = 1250 \times 3.2 \times 10^{-5}\ \text{Am}^2$$

$$\text{m} = \frac{\text{M}}{2\ell} = \frac{1250 \times 3.2 \times 10^{-5}}{8 \times 10^{-2}}\text{A m.}$$

$$= 0.5\ \text{Am} = 0.5 \times \frac{1}{10}\text{ab amp} \times 100\ \text{cm}$$

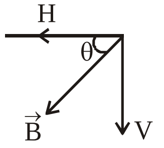
$$= 5\ \text{ab-amp cm.}$$

**122. (c)** $\text{B} = \dfrac{\text{H}}{\cos\theta} = \dfrac{0.50}{\cos 30°} = \dfrac{0.50 \times 2}{\sqrt{3}} = 1/\sqrt{3}$

**123. (d)** Here, $\text{T}_1 = \dfrac{60}{12} = 5\text{s},\ \text{T}_2 = \dfrac{60}{4} = 15\text{s}$

$$\frac{\text{M}_1}{\text{M}_2} = \frac{\text{T}_2^2 + \text{T}_1^2}{\text{T}_2^2 - \text{T}_1^2} = \frac{15^2 + 5^2}{15^2 - 5^2} = \frac{250}{200} = \frac{5}{4}$$

**124. (c)**



Horizontal component of earth's field, $\text{H} = \text{B}\cos\theta$, since, $\theta = 60°$

$$3.6 \times 10^{-5} = \text{B} \times \frac{1}{2} \Rightarrow \text{B} = 7.2 \times 10^{-5}\ \text{Tesla}$$

**125. (a)** The torque acting on the magnet of magnetic moment M, when held at angle $\theta$ to magnetic field B,

$\tau = \text{MB}\sin\theta$

$\tau = \text{MB} = 10^{-5}\,\text{Nm.}$

$\tau = \text{MB}\sin 30° = 0.5 \times 10^{-5}\,\text{Nm.}$

$= 5 \times 10^{-6}$ Nm

**126. (a)** We know that $T_1 = 2\pi\sqrt{\dfrac{T}{MB_{H_1}}}$ ...(i)

Where $B_{H_1} = 24 \times 10^{-6}\,\text{T}$

The magnetic field produced by, wire

$$B = \frac{\mu_0}{2\pi}.\frac{i}{r}$$

$$= (2 \times 10^{-7}) \times \frac{(18)}{0.20}$$

$$= 1.8 \times 10^{-6}\ \text{T}$$

Now $B_{H_2} = B_{H_1} + B = 42 \times 10^{-6}\,\text{T}$

$T_2 = 2\pi\sqrt{\dfrac{I}{MBH_2}}$ ...(ii)

Using equations (i) and (ii) , and substituting the values, we get

$T_2 = 0.076\,\text{s}$

**127. (a)** We know that $\mu_r = 1 + x$

$= 1 + 5500 = 5501$

$\therefore\ \mu = \mu_r\mu_0 = (5501) \times (4\pi \times 10^{-7})$

$= 6.9 \times 10^{-3}$

**128. (a)** Intensity of magnetisation

$$\text{I}_\text{m} = \frac{\text{M}}{\text{V}} = \frac{1.2}{(15 \times 2 \times 1)10^{-6}} = 4 \times 10^4\,\text{A m}^{-1}$$

**129. (c)** Here, $H = 2 \times 10^3$ A $m^{-1}$, $B = 8\pi$ T, $\mu_0 = 4\pi \times 10^7$

Since $\mu_r = \dfrac{\mu}{\mu_0} = \dfrac{\mu H}{\mu_0 H} = \dfrac{B}{\mu_0 H}$

$$= \frac{8\pi}{4\pi \times 10^{-7} \times 2 \times 10^3} = 10^4$$

**130. (a)** As $BI = \mu_0 MI_M = \mu_0(I + I_M)$

Here, $I = 0$

Then $\mu_0 MI = \mu_0(I_M)$

$\Rightarrow\ I_M = MI = 10^6 \times 0.1^3\ 10^{-5}$ A

**131.** **(a)** $\mu = \mu_0 \mu_r = (4\pi\times10^{-7})\times 2000 = 8\pi\times10^{-4}$ S.I. units

**132.** **(b)** From $\mu_r = 1+\chi_m$;

Magnetic suscaptibility, $\chi_m = \mu_r - 1$

$\chi_m = 0.075-1 = -0.925.$

**133.** **(b)** According to Curie's law, $\chi_m = \frac{\mu_0 C}{T}$
where C is Curie constant, T = temperature

$$\therefore \chi_m \alpha \frac{1}{T}$$

$$\frac{\chi_{m_1}}{\chi_{m_2}} = \frac{T_2}{T_1} = \frac{273+333}{273+30} = \frac{606}{303} = 2$$

$$\therefore \chi_{m_2} = \chi_{m_1}/2 = 0.5\chi_{m_1} = 0.5\chi.\left(\because \chi_{m_1} = \chi\right)$$

**134.** **(b)** The total magnetic moment per unit volume. i.e., magnetisation

$$I = \frac{(8.52\times10^{28})\times(2\times9.27\times10^{-24})}{1}$$

$$= 1.58\times10^{6} \text{ A/m}$$

**135.** **(c)** Magnetic field in solenoid $B = \mu_0 n$ i

$$\Rightarrow \frac{B}{\mu_0} = ni$$

(Where $n$ = number of turns per unit length)

$$\Rightarrow \frac{B}{\mu_0} = \frac{Ni}{L}$$

$$\Rightarrow 3\times10^3 = \frac{100i}{10\times10^{-2}}$$

$$\Rightarrow i = 3\text{A}$$

**136.** **(d)** The bar magnet has coercivity $4 \times 10^3$ Am$^{-1}$ i.e., it requires a magnetic intensity H = $4 \times 10^3$ Am$^{-1}$ to get demagnetised. Let *i* be the current carried by solenoid having n number of turns per metre length, then by definition H = ni. Here, H = $4 \times 10^3$ Am$^{-1}$

$$n = \frac{N}{l} = \frac{60}{0.12} = 500 \text{ turn metre}^{-1}$$

$$\Rightarrow \quad i = \frac{H}{n} = \frac{4\times10^3}{500} = 8\text{A}$$

**137.** **(d)** $\mu_r = \frac{\mu}{\mu_0} = \frac{B}{\mu_0 H}$

$$= \frac{8\pi}{\left(4\pi\times10^{-7}\right)\left(2\times10^{3}\right)}$$

$$\mu_r = 10^4$$

## CHAPTER 21

# ELECTROMAGNETIC INDUCTION

## FACT/DEFINITION TYPE QUESTIONS

**1.** Whenever the magnetic flux linked with an electric circuit changes, an emf is induced in the circuit. This is called
(a) electromagnetic induction
(b) lenz's law
(c) hysteresis loss
(d) kirchhoff's laws

**2.** An induced e.m.f. is produced when a magnet is plunged into a coil. The strength of the induced e.m.f. is independent of
(a) the strength of the magnet
(b) number of turns of coil
(c) the resistivity of the wire of the coil
(d) speed with which the magnet is moved

**3.** According to Faraday's law of electromagnetic induction
(a) electric field is produced by time varying magnetic flux.
(b) magnetic field is produced by time varying electric flux.
(c) magnetic field is associated with a moving charge.
(d) None of these

**4.** A moving conductor coil produces an induced e.m.f. This is in accordance with
(a) Lenz's law (b) Faraday's law
(c) Coulomb's law (d) Ampere's law

**5.** A coil of insulated wire is connected to a battery. If it is taken to galvanometer, its pointer is deflected, because
(a) the induced current is produced
(b) the coil acts like a magnet
(c) the number of turns in the coil of the galvanometer are changed
(d) None of these

**6.** Lenz's law is a consequence of the law of conservation of
(a) charge (b) mass
(c) energy (d) momentum

**7.** A magnet is moved towards a coil (i) quickly (ii) slowly, then the induced e.m.f. is
(a) larger in case (i)
(b) smaller in case (i)
(c) equal to both the cases
(d) larger or smaller depending upon the radius of the coil

**8.** The laws of electromagnetic induction have been used in the construction of a
(a) galvanometer (b) voltmeter
(c) electric motor (d) generator

**9.** Two identical coaxial circular loops carry a current i each circulating in the same direction. If the loops approach each other, you will observe that the current in
(a) each increases
(b) each decreases
(c) each remains the same
(d) one increases whereas that in the other decreases

**10.** Which of the following represents correct formula for magnetic flux?
(a) $d\phi = \vec{ds}.\vec{B}$ (b) $d\phi = \vec{v}.\vec{B}$
(c) $d\phi = \vec{B}.\vec{ds}$ (d) $d\phi = \vec{B}.\vec{dl}$

**11.** Magnetic flux is
(a) total charge per unit area.
(b) total current through a surface.
(c) total number of magnetic field lines passing normally through given area.
(d) total e.m.f. in closed circuit.

**12.** In electromagnetic induction, the induced charge is independent of
(a) change of flux
(b) time.
(c) resistance of the coil
(d) None of these

**13.** The induced e.m.f. in a rod of length $l$ translating at a speed v making an angle θ with length $l$ and perpendicular to magnetic field B is
(a) $Blv$ (b) $Blv \cos\theta$
(c) $Blv \sin\theta$ (d) $Blv \tan\theta$

**14.** Len'z law provides a relation between
(a) current and magnetic field.
(b) induced e.m.f. and the magnetic flux.
(c) force on a conductor in magnetic field.
(d) current and induced e.m.f.

**15.** A conducting loop is placed in a uniform magnetic field with its plane perpendicular to the field. An e.m.f. is induced in the loop, if

(a) it is translated.
(b) it is rotated about its axis.
(c) both (a) and (b).
(d) it is rotated about its diameter.

**16.** The expression for the induced e.m.f. contains a negative sign $\left[e = -\frac{d\phi}{dt}\right]$. What is the significance of the negative sign?
(a) The induced e.m.f. is produced only when the magnetic flux decreases.
(b) The induced e.m.f. opposes the change in the magnetic flux.
(c) The induced e.m.f. is opposite to the direction of the flux.
(d) None of the above.

**17.** A coil of insulated wire is connected to a battery. If it is connected to galvanometer, its pointer is deflected, because
(a) induced current is set up
(b) no induced current is set up
(c) the coil behaves as a magnet
(d) the number of turns is changed

**18.** A cylindrical bar magnet is kept along the axis of a circular coil. On rotating the magnet about its axis, the coil will have induced in it
(a) a current (b) no current
(c) only an e.m.f. (d) both an e.m.f. and a current

**19.** Direction of current induced in a wire moving in a magnetic field is found using
(a) Fleming's left found rule
(b) Fleming's right hand rule
(c) Ampere's rule
(d) Right hand clasp rule

**20.** A circular coil expands radially in a region of magnetic field and no electromotive force is produced in the coil This is because
(a) the magnetic field is constant
(b) the magnetic field is in the same plane as the circular coil and it may or may not vary.
(c) the magnetic field has a perpendicular (to the plane of the coil) component whose magnitude is decreasing suitably.
(d) both (b) and (c).

**21.** Whenever, current is changed in a coil, an induced e.m.f. is produced in the same coil. This property of the coil is due to
(a) mutual induction (b) self induction
(c) eddy currents (d) hysteresis

**22.** When current i passes through an inductor of self inductance L, energy stored in it is 1/2. L $i^2$. This is stored in the
(a) current (b) voltage
(c) magnetic field (d) electric field

**23.** An inductor may store energy in
(a) its electric field
(b) its coils
(c) its magnetic field
(d) both in electric and magnetic fields

**24.** If N is the number of turns in a coil, the value of self inductance varies as
(a) $N^0$ (b) N
(c) $N^2$ (d) $N^{-2}$

**25.** Two coils of inductances $L_1$ and $L_2$ are linked such that their mutual inducatance is M. Then
(a) $M = L_1 + L_2$
(b) $M = \frac{1}{2}(L_1 + L_2)$
(c) the maximum value of M is $(L_1 + L_2)$
(d) the minimum value of M is $\sqrt{L_1 L_2}$

**26.** The SI unit of inductance, the henry can be written as
(a) weber/ampere (b) volt second/ampere
(c) joule/ampere$^2$ (d) all of the above

**27.** The mutual inductance between two coils depends on
(a) medium between the coils
(b) separation between the two coils
(c) orientation of the two coils
(d) All of the above

**28.** Which of the following units denotes the dimension $\frac{ML^2}{Q^2}$, where Q denotes the electric charge?
(a) Wb/m$^2$ (b) henry (H)
(c) H/m$^2$ (d) weber (Wb)

**29.** The emf is induced in a single, isolated coil due to ...A... of flux through the coil by means of varying the current through the same coil. This phenomenon is called ...B... Here, A and B refer to
(a) constancy, mutual induction
(b) change, self induction
(c) constancy, self induction
(d) changes, mutual induction

**30.** Two coils, A and B, are lined such that emf ε is induced in B when the current in A is changing at the rate I. If current i is now made to flow in B, the flux linked with A will be
(a) $(\varepsilon/I)i$ (b) $\varepsilon\, i\, I$
(c) $(\varepsilon I)i$ (d) $iI/\varepsilon$

**31.** The polarity of induced emf is given by
(a) Ampere's circuital law (b) Biot-Savart law
(c) Lenz's law (d) Fleming's right hand rule

**32.** The self inductance of a coil is a measure of
(a) electrical inertia (b) electrical friction
(c) induced e.m.f. (d) induced current

**33.** The coils in resistance boxes are made from doubled insulated wire to nullify the effect of
(a) heating (b) magnetism
(c) pressure (d) self induced e.m.f.

**34.** Two pure inductors each of self inductance L are connected in series, the net inductance is
(a) L (b) 2 L
(c) L/2 (d) L/4

**35.** The self inductance associated with a coil is independent of

(a) current (b) induced voltage

(c) time (d) resistance of a coil

**36.** Induction coil is an instrument based on the principle of

(a) electromagnetic induction

(b) mutual induction

(c) self induction

(d) induction furnace.

**37.** If the magnetic flux linked with a coil through which a current of x A is set up is y Wb, then the coefficient of self inductance of the coil is

(a) (x – y) henry (b) $\frac{x}{y}$ henry

(c) $\frac{y}{x}$ henry (d) x y henry

**38.** Production of induced e.m.f. in a coil due to the changes of current in the same coil is

(a) self induction (b) mutual induction

(c) dynamo (d) none of these

**39.** Henry is the S.I. unit of

(a) resistance (b) capacity

(c) inductance (d) current

**40.** Mutual induction is the production of induced e.m.f. in a coil due to the changes of current in the

(a) same coil (b) neighbouring coil

(c) both (a) and (b) (d) neither (a) nor (b)

**41.** The self inductance associated with a coil is independent of

(a) current (b) time

(c) induced voltage (d) resistance of coil

**42.** Eddy currents are produced when

(a) A metal is kept in varying magnetic field

(b) A metal is kept in the steady magnetic field

(c) A circular coil is placed in a magnetic field

(d) Through a circular coil, current is passed

**43.** Which of the following does not use the application of eddy current ?

(a) Electric power meters (b) Induction furnace

(c) LED lights (d) Magnetic brakes in trains

**44.** Induction furnace make use of

(a) self induction (b) mutual induction

(c) eddy current (d) None of these

**45.** When strength of eddy currents is reduced, as dissipation of electrical energy into heat depends on the ...A... of the strength of electrical energy into heat depends on the ...*A*... of the strength of electric current heat loss is substantially ...*B* ... .

Here, *A* and *B* refer to

(a) cube, increase (b) inverse, increased

(c) inverse, decreased (d) square, reduced

**46.** The plane in which eddy currents are produced in a conductor is inclined to the plane of the magnetic field at an angle equal to

(a) 45° (b) 0°

(c) 180° (d) 90°

**47.** Which of the following is not the application of eddy currents?

(a) Induction furnace (b) Dead beat galvanometer

(c) speedometer (d) X-ray crystallography

**48.** Eddy currents do not cause

(a) damping (b) heating

(c) sparking (d) loss of energy

**49.** For magnetic breaking in trains, strong electromagnets are situated above the rails in some electrically powered trains. When the electromagnets are activated, the ...*A*... induced in the rails oppose the motion of the train. As there are no ... *B*... linkages, the ...*C*... effects is smooth. Here, *A*, *B* and *C* refer to

(a) eddy currents, mechanical, breaking

(b) induced currents, thermal, accelerating

(c) induced emf, mechanical, accelerating

(d) eddy currents, thermal, flying

**50.** The pointer of a dead-beat galvanometer gives a steady deflection because

(a) eddy currents are produced in the conducting frame over which the coil is wound.

(b) its magnet is very strong.

(c) its pointer is very light.

(d) its frame is made of ebonite.

**51.** Eddy currents do not produce

(a) heat (b) a loss of energy

(c) spark (d) damping of motion

**52.** If in a galvanometer the coil is wound on a bad conductor, the eddy current will be

(a) zero (b) maximum

(c) minimum (d) 50% of the actual value

**53.** Certain galvanometers have a fixed core made of non-magnetic metallic material, when the coil oscillates, ...*A*... generated in the core ...*B*... the motion and bring the coil to rest ...*C*...

Here, *A*, *B* and *C* refer to

(a) induced emf, support, long time

(b) induced current, support, long time

(c) mechanical energy, oppose, long time

(d) eddy currents, oppose, quickly

**54.** When the plane of the armature of an a.c. generator is parallel to the field. in which it is rotating

(a) both the flux linked and induced emf in the coil are zero.

(b) the flux linked with it is zero, while induced emf is maximum.

(c) flux linked is maximum while induced emf is zero.

(d) both the flux and emf have their respective maximum values.

**55.** A dynamo converts

(a) mechanical energy into thermal energy

(b) electrical energy into thermal energy

(c) thermal energy into electrical energy

(d) mechanical energy into electrical energy

(e) electrical energy into mechanical energy

**56.** Choke coil works on the principle of
(a) transient current (b) self induction
(c) mutual induction (d) wattless current

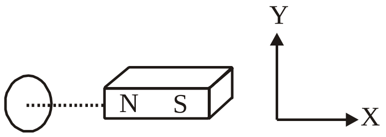
**57.** If a coil made of conducting wires is rotated between poles pieces of the permanent magnet. The motion will generate a current and this device is called
(a) An electric motor (b) An electric generator
(c) An electromagnet (d) All of the above

## STATEMENT TYPE QUESTIONS

**58.** A current carrying infinitely long wire is kept along the diameter of a circular wire loop, without touching it, the correct statement(s) is(are)
I. The emf induced in the loop is zero if the current is constant.
II. The emf induced in the loop is finite if the current is constant.
III. The emf induced in the loop is zero if the current decreases at a steady rate.
(a) I only (b) II only
(c) I and II (d) I, II and III

**59.** Whenever the magnetic flux linked with a coil changes, an induced e.m.f.is produced in the circuit. The e.m.f. lasts
I. for a short time
II. for a long time
III. so long as the change in flux takes place
The correct statement(s) is/are
(a) I and II (b) II and III
(c) I and III (d) III only

**60.** Consider coil and magnet



Current is induced in coil when
I. coil and magnet both are at rest.
II. coil is at rest and magnet moves along x.
III. magnet is at rest and coil moves along x.
IV. both coil and magnet move along y with same speed.
The correct statements are
(a) I and IV (b) I and II
(c) III and IV (d) II and III

**61.** Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon
I. relative position and orientation of the two coils
II. the materials of the wires of the coils
III. the rates at which currents are changing in the two coils
Which of the above statements is/are correct?
(a) I only (b) II only
(c) I and III (d) II and III

**62.** A coil of self-inductance L is connected in series with a bulb B and an AC source. Brightness of the bulb decreases when
I. number of turns in the coil is reduced
II. a capacitance of reactance $X_C = X_L$ is included in the same circuit
III. an iron rod is inserted in the coil
Which of the above statements is/are correct?
(a) I only (b) II and III
(c) III only (d) I and II

## MATCHING TYPE QUESTIONS

**63.** Match the column-I and column-II

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | AC generator | (1) | Eddy current |
| (B) | DC motor | (2) | Slip rings |
| (C) | Dead beat galvanometer | (3) | Split ring |
| (D) | Solenoid | (4) | Insulated copper wire wound in the form of a cylindrical coil |

(a) $A \to 2 ; B \to 3 ; C \to 2 ; D \to 1$
(b) $A \to 4 ; B \to 2 ; C \to 1 ; D \to 3$
(c) $A \to 2 ; B \to 3 ; C \to 1 ; D \to 4$
(d) $A \to 2 ; B \to 1 ; C \to 3 ; D \to 4$

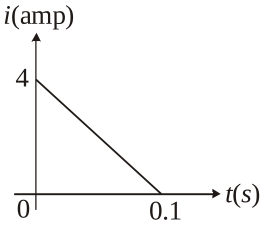
**64.** Match the column-I and column-II

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Ring uniformly charged | (1) | Constant electrostatic field out of system |
| (B) | Rotating ring uniformly charged | (2) | Magnetic field strength rotating with angular velocity ω |
| (C) | Constant current in ring *i* | (3) | Electric field (induced) |
| (D) | $i = i_0 \cos\omega t$ | (4) | Magnetic dipole moment |

(a) $A \to 2 ; B \to 2, 3 ; C \to 1, 4, 3 ; D \to 3$
(b) $A \to 3, 4 ; B \to 1 ; C \to 2, 3 ; D \to 2$
(c) $A \to 1 ; B \to 1, 2, 4 ; C \to 2, 4 ; D \to 3$
(d) $A \to 2 ; B \to 4, 2, 1 ; C \to 2, 1 ; D \to 4, 2$

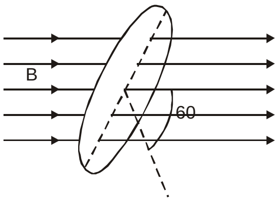
## DIAGRAM TYPE QUESTIONS

**65.** In a coil of resistance 10 Ω, the induced current developed by changing magnetic flux through it, is shown in figure as a function of time. The magnitude of change in flux through the coil in weber is



(a) 8 (b) 2
(c) 6 (d) 4

**66.** Fig shown below represents an area $A = 0.5 \text{ m}^2$ situated in a uniform magnetic field $B = 2.0 \text{ weber/m}^2$ and making an angle of 60° with respect to magnetic field.

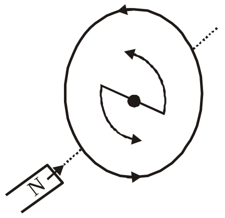


The value of the magnetic flux through the area would be equal to

(a) 2.0 weber (b) $\sqrt{3}$ weber

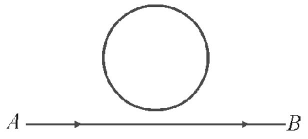
(c) $\sqrt{3}/2$ weber (d) 0.5 weber

**67.** In the given situation, the bar magnet experinces a ...A... force due to the ... B ... in coil.



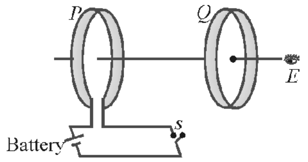
Here, A and B refer to
(a) an attractive, air
(b) an attractive, induced current
(c) repulsive, induced current
(d) attractive, vacuum

**68.** An electron moves along the line *AB*, which lies in the same plane as a circular loop of conducting wires as shown in the diagram. What will be the direction of current induced if any, in the loop



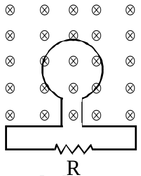
(a) no current will be induced
(b) the current will be clockwise
(c) the current will be anticlockwise
(d) the current will change direction as the electron passes by

**69.** As shown in the figure, *P* and *Q* are two coaxial conducting loops separated by some distance. When the switch *S* is closed, a clockwise current $I_P$ flows in *P* (as seen by *E*) and an induced current $I_{Q_1}$ flows in *Q*. The switch remains closed for a long time. When *S* is opened, a current $I_{Q_2}$ flows in *Q*. Then the directions of $I_{Q_1}$ and $I_{Q_2}$ (as seen by *E*) are



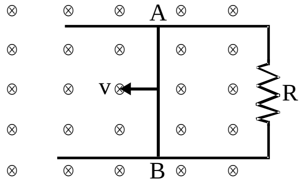
(a) respectively clockwise and anticlockwise
(b) both clockwise
(c) both anticlockwise
(d) respectively anticlockwise and clockwise

**70.** In the figure the flux through the loop perpendicular to the plane of the coil and directed into the paper is varying according to the relation $\phi = 6t^2 + 7t + 1$ where $\phi$ is in milliweber and t is in second. The magnitude of the emf induced in the loop at t = 2 s and the direction of induce current through R are



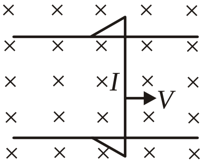
(a) 39 mV; right to left
(b) 39 mV; left to right
(c) 31 mV; right to left
(d) 31 mV; left to right

**71.** Consider the situation shown. The wire AB is sliding on fixed rails with a constant velocity. If the wire AB is replaced by semi-circular wire, the magnitude of induced e.m.f. will



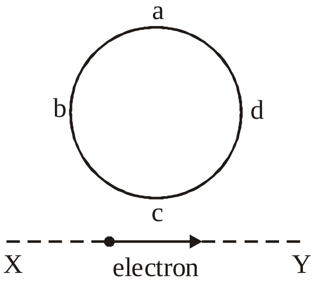
(a) increase
(b) decrease
(c) remain the same
(d) increase or decrease depending on whether the semi-circle buldges towards the resistance or away from it.

**72.** The figure shows a wire sliding on two parallel conducting rails placed at a separation *I*. A magnetic field *B* exists in a direction perpendicular to the plane of the rails. The force required to keep the wire moving at a constant velocity *v* will be



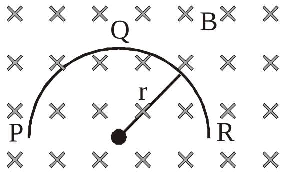
(a) $evB$
(b) $\frac{\mu_0 Bv}{4\pi I}$
(c) $BIv$
(d) zero

**73.** An electron moves on a straight line path XY as shown. The abcd is a coil adjacent to the path of electron. What will be the direction of current if any, induced in the coil?



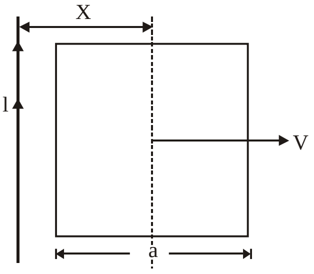
(a) adcb
(b) The current will reverse its direction as the electron goes past the coil
(c) No current induced
(d) abcd

**74.** A thin semicircular conducting ring (PQR) of radius 'r' is falling with its plane vertical in a horizontal magnetic field B, as shown in figure. The potential difference developed across the ring when its speed is v, is :



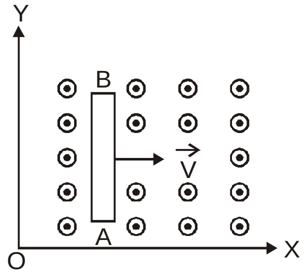
(a) Zero
(b) $Bv\pi r^2/2$ and P is at higher potnetial
(c) $\pi rBv$ and R is at higher potnetial
(d) 2rBv and R is at higher potential

**75.** A conducting square frame of side ‘a’ and a long staight wire carrying current I are located in the same plane as shown in the figure. The frame moves to the right with a constant velocity ‘V’. The emf induced in the frame will be proportional to



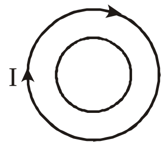
(a) $\dfrac{1}{(2x-a)^2}$
(b) $\dfrac{1}{(2x+a)^2}$
(c) $\dfrac{1}{(2x-a)(2x+a)}$
(d) $\dfrac{1}{x^2}$

**76.** A conducting rod AB moves parallel to X-axis in a uniform magnetic field, pointing in the positive X-direction. The end A of the rod gets



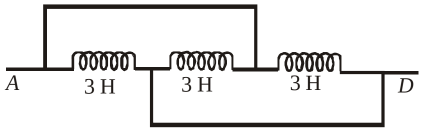
(a) positively charged
(b) negatively charged
(c) neutral
(d) first positively charged and then negatively charged

**77.** Two different wire loops are concentric and lie in the same plane. The current in the outer loop (I) is clockwise and increases with time. The induced current in the inner loop



(a) is clockwise
(b) is zero
(c) is counter clockwise
(d) has a direction that depends on the ratio of the loop radii.

**78.** The inductance between A and D is



(a) 3.66 H
(b) 9 H
(c) 0.66 H
(d) 1 H

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

**79.** **Assertion :** Induced emf will always occur whenever there is change in magnetic flux.
**Reason :** Current always induces whenever there is change in magnetic flux.

**80.** **Assertion :** Faraday's laws are consequence of conservation of energy.
**Reason :** In a purely resistive ac circuit, the current legs behind the emf in phase.

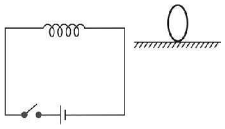
**81.** **Assertion :** Only a change in magnetic flux will maintain an induced current in the coil.
**Reason :** The presence of large magnetic flux through a coil maintain a current in the coil of the circuit is continuous.

**82.** **Assertion :** Lenz's law violates the principle of conservation of energy.
**Reason :** Induced emf always opposes the change in magnetic flux responsible for its production.

**83.** **Assertion :** An induced current has a direction such that the magnetic field due to the current opposes the change in the magnetic flux that induces the current.
**Reason :** Above statement is in accordance with conservation of energy.

**84.** **Assertion :** Acceleration of a magnet falling through a long solenoid decreases.
**Reason :** The induced current produced in a circuit always flow in such direction that it opposes the change to the cause that produced it.

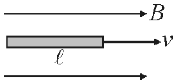
**85.** **Assertion :** Figure shows a horizontal solenoid connected to a battery and a switch. A copper ring is placed on a smooth surface, the axis of the ring being horizontal. As the switch is closed, the ring will move away from the solenoid.



**Reason :** Induced emf in the ring, $e = -\dfrac{d\phi}{dt}$.

**86.** **Assertion :** An emf can be induced by moving a conductor in a magnetic field.
**Reason :** An emf can be induced by changing the magnetic field.

**87.** **Assertion :** Figure shows a metallic conductor moving in magnetic field. The induced emf across its ends is zero.



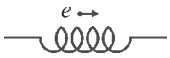
**Reason :** The induced emf across the ends of a conductor is given by $e = Bv\ell\sin\theta$.

**88.** **Assertion :** Eddy currents are produced in any metallic conductor when magnetic flux is changed around it.
**Reason :** Electric potential determines the flow of charge.

**89.** **Assertion :** An induced emf appears in any coil in which the current is changing.
**Reason :** Self induction phenomenon obeys Faraday's law of induction.

**90.** **Assertion :** When number of turns in a coil is doubled, coefficient of self-inductance of the coil becomes 4 times.
**Reason :** This is because $L \propto N^2$.

**91.** **Assertion :** Figure shows an emf $e$ induced in a coil. It happens due to rightward decreasing current.



**Reason :** In the coil self induced emf $e = -L\frac{di}{dt}$.

**92.** **Assertion :** In the phenomenon of mutual induction, self induction of each of the coil persists.

**Reason :** Self induction arises due to change in current in the coil itself. In mutual induction current changes in both the individual coil.

## CRITICALTHINKING TYPE QUESTIONS

**93.** A coil having an area $A_0$ is placed in a magnetic field which changes from $B_0$ to $4\ B_0$ in time interval t. The e.m.f. induced in the coil will be

(a) $3A_0\ B_0 / t$ (b) $4A_0\ B_0 / t$

(c) $3B_0 / A_0 t$ (d) $4A_0 / B_0 t$

**94.** An infinitely long cylinder is kept parallel to an uniform magnetic field B directed along positive z axis. The direction of induced current as seen from the z axis will be

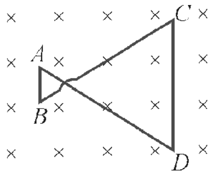
(a) zero

(b) anticlockwise of the +ve z axis

(c) clockwise of the +ve z axis

(d) along the magnetic field

**95.** A conducting wire frame is placed in a magnetic field which is directed into the paper. The magnetic field is increasing at a constant rate. The directions of induced current in wires *AB* and *CD* are



(a) *B* to *A* and *D* to *C* (b) *A* to *B* and *C* to *D*

(c) *A* to *B* and *D* to *C* (d) *B* to *A* and *C* to *D*

**96.** The magnetic flux through a circuit of resistance R changes by an amount Δϕ in a time Δt. Then the total quantity of electric charge Q that passes any point in the circuit during the time Δt is represented by

(a) $Q = R.\frac{\Delta\phi}{\Delta t}$ (b) $Q = \frac{1}{R}.\frac{\Delta\phi}{\Delta t}$

(c) $Q = \frac{\Delta\phi}{R}$ (d) $Q = \frac{\Delta\phi}{\Delta t}$

**97.** The north pole of a bar magnet is moved towards a coil along the axis passing through the centre of the coil and perpendicular to the plane of the coil. The direction of the induced current in the coil when viewed in the direction of the motion of the magnet is

(a) clockwise

(b) anti-clockwise

(c) no current in the coil

(d) either clockwise or anti-clockwise

**98.** If a current increases from zero to one ampere in 0.1 second in a coil of 5 mH, then the magnitude of the induced e.m.f. will be

(a) 0.005 volt (b) 0.5 volt

(c) 0.05 volt (d) 5 volt

**99.** A coil has 200 turns and area of 70 $cm^2$. The magnetic field perpendicular to the plane of the coil is 0.3 $Wb/m^2$ and take 0.1 sec to rotate through 180º.The value of the induced e.m.f. will be

(a) 8.4 V (b) 84 V

(c) 42 V (d) 4.2 V

**100.** A coil of resistance 400Ω is placed in a magnetic field. If the magnetic flux ϕ (wb) linked with the coil varies with time $t$ (sec) as $\phi = 50t^2 + 4$. The current in the coil at $t = 2$ sec is

(a) 0.5 A (b) 0.1 A

(c) 2 A (d) 1 A

**101.** A coil having n turns and resistance R Ω is connected with a galvanometer of resistance 4R Ω. This combination is moved in time t seconds from a magnetic field $W_1$ weber to $W_2$ weber. The induced current in the circuit is

(a) $-\frac{(W_1 - W_2)}{Rnt}$ (b) $-\frac{n(W_2 - W_1)}{5\ Rt}$

(c) $-\frac{(W_2 - W_1)}{5\ Rnt}$ (d) $-\frac{n(W_2 - W_1)}{Rt}$

**102.** Magnetic flux ϕ in weber in a closed circuit of resistance 10Ω varies with time ϕ(sec) as $f = 6t^2 - 5t + 1$. The magnitude of induced current at t = 0.25s is

(a) 0.2 A (b) 0.6 A

(c) 1.2 A (d) 0.8 A

**103.** The flux linked with a coil at any instant 't' is given by $\phi = 10t^2 - 50t + 250$. The induced emf at t = 3s is

(a) –190 V (b) –10 V

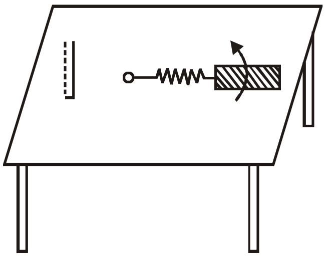
(c) 10 V (d) 190 V

**104.** A copper rod of length $I$ rotates about its end with angular velocity ω in uniform magnetic field $B$. The emf developed between the ends of the rod if the field is normal to the plane of rotation is

(a) $B\omega I^2$ (b) $\frac{1}{2}\ B\omega I^2$

(c) $2\ B\omega I^2$ (d) $\frac{1}{4}\ B\omega I^2$

**105.** A metallic rod of length '$\ell$' is tied to a string of length $2\ell$ and made to rotate with angular speed ω on a horizontal table with one end of the string fixed. If there is a vertical magnetic field 'B' in the region, the e.m.f. induced across the ends of the rod is



(a) $\frac{2B\omega\ell^2}{2}$

(b) $\frac{3B\omega\ell^2}{2}$

(c) $\frac{4B\omega\ell^2}{2}$

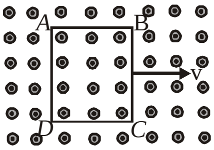
(d) $\frac{5B\omega\ell^2}{2}$

**106.** In a uniform magnetic field of induction B, a wire in the form of a semicircle of radius r rotates about the diameter of the circle with an angular frequency ω. The axis of rotation is perpendicular to the field. If the total resistance of the circuit is R, the mean power generated per period of rotation is

(a) $\frac{(B\pi r\omega)^2}{2R}$ (b) $\frac{(B\pi r^2\omega)^2}{2R}$

(c) $\frac{B\pi r^2\omega}{2R}$ (d) $\frac{(B\pi r\omega^2)^2}{8R}$

**107.** A metallic square loop *ABCD* is moving in its own plane with velocity *v* in a unifrom magnetic field perpendicular to its plane as shown in figure. An electric field is induced



(a) in *AD*, but not in *BC*
(b) in *BC*, but not in *AD*
(c) neither in *AD* nor in *BC*
(d) in both *AD* and *BC*

**108.** A conductor of length 0.4 m is moving with a speed of 7 m/s perpendicular to a magnetic field of intensity 0.9 $Wb/m^2$. The induced e.m.f. across the conductor is

(a) 1.26 V (b) 2.52 V
(c) 5.04 V (d) 25.2 V

**109.** A circular coil and a bar magnet placed nearby are made to move in the same direction. If the coil covers a distance of 1 m in 0.5. sec and the magnet a distance of 2 m in 1 sec, the induced e.m.f. produced in the coil is

(a) zero (b) 0.5 V
(c) 1 V (d) 2 V.

**110.** A circular coil of radius 6 cm and 20 turns rotates about its vertical diameter with an angular speed of 40 rad $s^{-1}$ in a uniform horizontal magnetic field of magnitude $2 \times 10^{-2}$ T. If the coil form a closed loop of resistance 8Ω, then the average power loss due to joule heating is

(a) $2.07 \times 10^{-3}$ W (b) $1.23 \times 10^{-3}$ W
(c) $3.14 \times 10^{-3}$ W (d) $1.80 \times 10^{-3}$ W

**111.** A boy peddles a stationary bicycle the pedals of bicycle. are attached to a 200 turn coil of area 0.10 $m^2$, The coil ratotes at half a revolution per second and it is placed in a uniform magnetic field of 0.02 T perpendicular to the axis of rotation of the coil. The maximum voltage generated in the coil is

(a) 1.26 V (b) 2.16 V
(c) 3.24 V (d) 4.12 V

**112.** A conducting circular loop is placed in a uniform magnetic field, $B = 0.025\,T$ with its plane perpendicular to the loop. The radius of the loop is made to shrink at a constant rate of 1 mm $s^{-1}$. The induced e.m.f. when the radius is 2 cm, iss

(a) $2\pi\mu V$ (b) $\pi\mu V$

(c) $\frac{\pi}{2}\mu V$ (d) $2\mu V$

**113.** Two pure inductors, each of self inductance L are connected in parallel but are well separated from each other, then the total inductance is

(a) L (b) 2 L
(c) L/2 (d) L/4

**114.** Two coils of self inductances $L_1$ and $L_2$ are placed so close together that effective flux in one coil is completely linked with the other. If M is the mutual inductance between them, then

(a) $M = L_1L_2$ (b) $M = L_1/L_2$
(c) $M = (L_1L_2)^2$ (d) $M = \sqrt{(L_1 L_2)}$

**115.** The mutual inductance of a pair of coils, each of N turns, is M henry. If a current of I ampere in one of the coils is brought to zero in t second, the emf induced per turn in the other coil, in volt, will be

(a) $\frac{MI}{t}$ (b) $\frac{NMI}{t}$

(c) $\frac{MN}{It}$ (d) $\frac{MI}{Nt}$

**116.** In an inductor of self-inductance L = 2 mH, current changes with time according to relation $i = t^2e^{-t}$. At what time emf is zero?

(a) 4s (b) 3s
(c) 2s (d) 1s

**117.** When the current in a coil changes from 2 amp. to 4 amp. in 0.05 sec., an e.m.f. of 8 volt is induced in the coil. The coefficient of self inductance of the coil is

(a) 0.1 henry (b) 0.2 henry
(c) 0.4 henry (d) 0.8 henry

**118.** The north pole of a long horizontal bar magnet is being brought closer to a vertical conducting plane along the perpendicular direction. The direction of the induced current in the conducting plane will be

(a) horizontal (b) vertical
(c) clockwise (d) anticlockwise

**119.** Two coils of self inductances 2 mH and 8 mH are placed so close together that the effective flux in one coil is completely linked with the other. The mutual inductance between these coils is

(a) 6 mH (b) 4 mH
(c) 16 mH (d) 10 mH

**120.** The mutual inductance of a pair of coils is 0.75 H. If current in the primary coil changes from 0.5 A to zero in 0.01 s, find average induced e.m.f. in secondary coil.

(a) 25.5 V (b) 12.5 V
(c) 22.5 V (d) 37.5 V

**121.** A coil of 50 turns is pulled in 0.02 s between the poles of a magnet, where its area includes $31 \times 10^{-6}$ Wb to $1 \times 10^{-6}$Wb. The average e.m.f. is

(a) $7.5 \times 10^{-2}$ V (b) $7.5 \times 10^{-3}$ V
(c) zero (d) $7.5 \times 10^{-4}$V

**122.** A wire of length 50 cm moves with a velocity of 300 m/min, perpendicular to a magnetic field. If the e.m.f. induced in the wire is 2 V, the magnitude of the field in tesla is

(a) 2 (b) 5
(c) 0.8 (d) 2.5

**123.** A circular wire of radius r rotates about its own axis with angular speed ω in a magnetic field B perpendicular to its plane, then the induced e.m.f. is

(a) $\frac{1}{2}B r \omega^2$ (b) $B r \omega^2$
(c) $2B r \omega^2$ (d) zero

**124.** The coefficient of self inductance of a solenoid is 0.18 mH. If a core of soft iron of relative permeability 900 is inserted, then the coefficient of self inductance will become nearly.

(a) 5.4 mH (b) 162 mH
(c) 0.006 mH (d) 0.0002 mH

**125.** The inductance of a closed-packed coil of 400 turns is 8 mH. A current of 5 mA is passed through it. The magnetic flux through each turn of the coil is

(a) $\frac{1}{4\pi}\mu_0$Wb (b) $\frac{1}{2\pi}\mu_0$Wb
(c) $\frac{1}{3\pi}\mu_0$Wb (d) 0.4 $\mu_0$Wb

**126.** A 100 millihenry coil carries a current of 1 ampere. Energy stored in its magnetic field is

(a) 0.5 J (b) 1 J
(c) 0.05 J (d) 0.1 J

**127.** Two solenoids of same cross-sectional area have their lengths and number of turns in ratio of 1 : 2. The ratio of self-inductance of two solenoids is

(a) 1 : 1 (b) 1 : 2
(c) 2 : 1 (d) 1 : 4

**128.** The self inductance of the motor of an electric fan is 10 H. In order to impart maximum power at 50 Hz, it should be connected to a capacitance of

(a) 8 μF (b) 4 μF
(c) 2 μF (d) 1 μF

**129.** A long solenoid having 200 turns per cm carries a current of 1.5 amp. At the centre of it is placed a coil of 100 turns of cross-sectional area $3.14 \times 10^{-4}$ m$^2$ having its axis parallel to the field produced by the solenoid. When the direction of current in the solenoid is reversed within 0.05 sec, the induced e.m.f. in the coil is

(a) 0.48 V (b) 0.048 V
(c) 0.0048 V (d) 48 V

**130.** Two coils have a mutual inductance 0.005H. The current changes in first coil according to equation $I = I_0 \sin \omega t$ where $I_0$ = 10A and ω = 100π radian/sec. The max. value of e.m.f. in second coil is

(a) 2π (b) 5π
(c) π (d) 4π

**131.** A coil is wound on a frame of rectangular cross-section. If all the linear dimensions of the frame are increased by a factor 2 and the number of turns per unit length of the coil remains the same, self-inductance of the coil increases by a factor of

(a) 4 (b) 8
(c) 12 (d) 16

**132.** A small square loop of wire of side $\ell$ is placed inside a large square loop of side L (L >> $\ell$). The loop are coplanar and their centres coincide. The mutual inductance of the system is proportional is

(a) $\frac{\ell}{L}$ (b) $\frac{\ell^2}{L}$
(c) $\frac{L}{\ell}$ (d) $\frac{L^2}{\ell}$

**133.** A solenoid has 2000 turns wound over a length of 0.3 m. Its cross-sectional area is $1.2 \times 10^{-3}$ m$^2$. Around its central section a coil of 300 turns is wound. If an initial current of 2 A flowing in the solenoid is reversed in 0.25 s, the emf induced in the coil will be

(a) $2.4 \times 10^{-4}$ V (b) $2.4 \times 10^{-2}$ V
(c) $4.8 \times 10^{-4}$ V (d) $4.8 \times 10^{-2}$ V

**134.** Two coaxial solenoids are made by winding thin insulated wire over a pipe of cross-sectional area A = 10 cm$^2$ and length = 20 cm. If one of the solenoid has 300 turns and the other 400 turns, their mutual inductance is
($\mu_0 = 4\pi \times 10^{-7}$ Tm A$^{-1}$)

(a) $2.4\pi \times 10^{-5}$ H (b) $4.8\pi \times 10^{-4}$ H
(c) $4.8\pi \times 10^{-5}$ H (d) $2.4\pi \times 10^{-4}$ H

**135.** In an AC generator, a coil with N turns, all of the same area A and total resistance R, rotates with frequency ω in a magnetic field B. The maximum value of emf generated in the coil is

(a) N.A.B.R.ω (b) N.A.B.
(c) N.A.B.R. (d) N.A.B.ω

**136.** A copper disc of radius 0.1 m rotated about its centre with 10 revolutions per second in a uniform magnetic field of 0.1 tesla with its plane perpendicular to the field. The e.m.f. induced across the radius of disc is

(a) $\frac{\pi}{10}$ volt (b) $\frac{2\pi}{10}$ volt
(c) $\pi \times 10^{-2}$ volt (d) $2\pi \times 10^{-2}$ volt

**137.** A generator has an e.m.f. of 440 Volt and internal resistance of 4000 hm. Its terminals are connected to a load of 4000 ohm. The voltage across the load is

(a) 220 volt (b) 440 volt
(c) 200 volt (d) 400 volt

**138.** An AC generator of 220 V having internal resistance r = 10Ω and external resistance R = 100Ω. What is the power developed in the external circuit?

(a) 484 W (b) 400 W
(c) 441 W (d) 369 W

**139.** A conducting ring of radius 1 *m* kept in a uniform magnetic field *B* of 0.01 *T*, rotates uniformly with an angular velocity 100 rad s$^{-1}$ with its axis of rotation perpendicular to *B*. The maximum induced emf in it is

(a) 1.5πV (b) πV
(c) 2πV (d) 0.5πV

**140.** A six pole generator with fixed field excitation develops an e.m.f. of 100 V when operating at 1500 r.p.m. At what speed must it rotate to develop 120V?

(a) 1200 r.p.m (b) 1800 r.p.m
(c) 1500 r.p.m (d) 400 r.p.m

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(a)** **2.** **(c)**

**3.** **(a)** Farady's law states that time varying magnetic flux can induce an e.m.f.

**4.** **(b)** **5.** **(a)** **6.** **(c)** **7.** **(a)**

**8.** **(d)** **9.** **(b)** **10.** **(c)** **11.** **(c)** **12.** **(b)** **13.** **(c)**

**14.** **(b)** **15.** **(d)** **16.** **(b)** **17.** **(a)** **18.** **(b)**

**19.** **(b)** **:** Direction of current induced in a wire moving in a magnetic field is found by using Fleming's right hand rule.

**20.** **(d)** When a circular coil expands radially in a region of magnetic field, induced emf developed is

$\varepsilon = BIv = B \times$ rate of change of area

Here, magnetic field $B$ is in a plane perpendicular to the plane of the circular coil.

As $\varepsilon = 0$, magnetic field must be in the plane of circular coil so that its component perpendicular to the plane of the coil, whose magnitude is decreasing suitably so that magnitic flux linked with the coil stays constant then $\varepsilon = \frac{d\phi}{dt} = 0$

So both option (b) and (c) are correct.

**21.** **(b)** **22.** **(c)** **23.** **(c)** **24.** **(c)** **25.** **(d)** **26.** **(d)**

**27.** **(d)** Mutual inductance between two coils depends on all the three factors given here.

**28.** **(b)** Mutual inductance $= \frac{\phi}{I} = \frac{BA}{I}$

$$[\text{Henry}] = \frac{[MT^{-1}Q^{-1}L^2]}{[QT^{-1}]} = ML^2Q^{-2}$$

**29.** **(b)** Inductance it is also possible the emf is induced in a single isolated coil due to change of flux through the coil by means of varying the current through the same coil. This phenomenon is called self-induction. In this case, flux linkage through a coil of N turns is proportional to the currente through the coil and is expressed as $N\phi_B \propto I \Rightarrow N\phi_B \propto LI$ ...(i)

where, constant of proportionality L is called self-inductance of the coil. It is also called the coefficient of self-induction of the coil. When the current is varied, the flux linked with the coil also changes and an emf is induced in the coil. Using Eq. (i) the induced emf is given by

$$\varepsilon = -\frac{d(N\phi_B)}{dt} \Rightarrow \varepsilon = -L\frac{dI}{dt}$$

Thus, the self-induced emf always opposes any change (increase or decrease) of current in the coil.

**30.** **(a)**

**31.** **(c)** Lenz's law gives the polarity of induced emf.

**32.** **(a)** **33.** **(d)** **34.** **(b)** **35.** **(d)** **36.** **(b)**

**37.** **(c)** $\phi = LI \Rightarrow L = \frac{\phi}{I} = \frac{y}{x}$ henry

**38.** **(a)** **39.** **(c)** **40.** **(b)** **41.** **(d)**

**42.** **(a)** **43.** **(c)** **44.** **(c)**

**45.** **(d)** $P = I^2R$ when I becomes half, then P becomes one-fourth, heat per unit time depends on square of $I$. When $I$ is reduced $P$ is substancially reduced.

**46.** **(d)** **47.** **(d)** **48.** **(c)**

**49.** **(a)** Magnetic braking in trans, Strong electromagnets are situated above the rails in some electrically powered trains. When the electromagnets are activated, the eddy currents induced in the rails oppose the motion of the train. As there are no mechanical linkages, the braking effect is smooth.

**50.** **(a)** **51.** **(c)** **52.** **(a)**

**53.** **(d)** Electromagnetic damping certain galvanometers have a fixed core made of non-magnetic metallic material. When the coil oscillates, the eddy currents generated in the core oppose the motion and bring the coil to rest quickly.

**54.** **(b)** As $\phi = NAB \cos 90° = 0$

$\varepsilon = \varepsilon_0 \sin 90° = \varepsilon_0 =$ maximum

$\theta$ is the angle between the field and normal to the plane of the coil.

**55.** **(d)** A dynamo is a device which converts mechanical energy into electrical energy

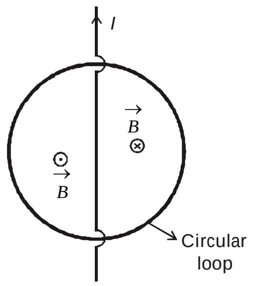
**56.** **(b)** **57.** **(b)**

## STATEMENT TYPE QUESTIONS

**58.** **(a)** Emf will be induced in the circular wire loop when flux through it changes with time.

$$e = -\frac{\Delta\phi}{\Delta t}$$

when the current is constant, the flux changing through it will be zero.



When the current is decreasing at a steady rate then the change in the flux (decreasing inwards) on the right half of the wire is equal to the change in flux (decreasing outwards) on the left half of the wire such that $\Delta\phi$ through the circular loop is zero.

**59.** **(d)**

**60.** **(d)** Relative motion between the magnet and the coil that is responsible for induction in the coil.

**61.** **(a)**

**62.** **(c)** By inserting iron rod in the coil,
$L \uparrow z \uparrow I \downarrow$ so brightness $\downarrow$

## MATCHING TYPE QUESTIONS

**63.** **(c)** $(A) \rightarrow (2); (B) \rightarrow (3); (C) \rightarrow (1); (D) \rightarrow (4)$

**64.** **(c)** A - 1 ; A charged ring can produced electric field out of the centre.
B - 1, 2, 4 ; A charged rotating ring can produce electric field out of centre, magnetic and dipole moment.
C- 2, 4 ; Current carrying produces magnetic field at the centre.
D- 3 ; Alternating current can produce induced electric field .

## DIAGRAM TYPE QUESTIONS

**65.** **(b)** The charge through the coil = area of current-time ($i - t$) graph

$$q = \frac{1}{2} \times 0.1 \times 4 = 0.2\,\text{C}$$

$$q = \frac{\Delta\phi}{R} \quad \because \text{Change in flux } (\Delta\phi) = q \times R$$

$$q = 0.2 = \frac{\Delta\phi}{10}$$

$\Delta\phi = 2$ weber

**66.** **(d)** $\phi = BA\cos\theta = 2.0 \times 0.5 \times \cos 60^\circ$

$$= \frac{2.0 \times 0.5}{2} = 0.5 \text{ weber.}$$

**67.** **(c)** In this situation, the bar magent experiences a repulsive force due to the induced current. Therefore, a person has to do work in moving the magnet.

**68.** **(d)** When electron approaches nearby the loop flux inside loop will increase and when electron recedes from the loop the flux inside loop decreases and so current change in direction.

**69.** **(d)**

**70.** **(d)** $\phi = 6t^2 + 7t + 1 \Rightarrow \dfrac{d\phi}{dt} = 12t + 7$

At time, t = 2 sec.

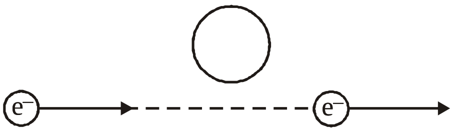
$$\frac{d\phi}{dt} = 24 + 7 = 31 \text{ volt}$$

Direction of current is from left to right according to Flemmings right hand rule.

**71.** **(c)** E.m.f. will remain same because change in area per unit time will be same in both cases.

**72.** **(d)** No change in flux, hence no force required

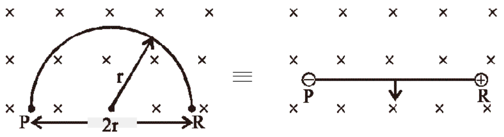
**73.** **(b)** Current will be induced,
when $e^-$ comes closer the induced current will be anticlockwise
when $e^-$ comes farther induced current will be clockwise



**74.** **(d)** Rate of decreasing of area of semicircular ring = $\dfrac{dA}{dt} = (2r)V$

From Faraday's law of electromagnetic induction

$$e = -\frac{d\theta}{dt} = -B\frac{dA}{dt} = -B(2rV)$$



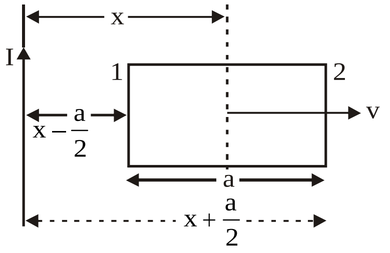
As induced current in ring produces magnetic field in upward direction hence R is at higher potential.

**75.** **(c)** Emf induced in side 1 of frame $e_1 = B_1 V\ell$

$$B_1 = \frac{\mu_0 I}{2\pi\,(x - a/2)}$$

Emf induced in side 2 of frame $e_2 = B_2 V\ell$

$$B_2 = \frac{\mu_0 I}{2\pi\,(x + a/2)}$$



Emf induced in square frame
$e = B_1 V\ell - B_2 V\ell$

$$= \frac{\mu_0 I}{2\pi\,(x - a/2)}\ell v - \frac{\mu_0 I}{2\pi\,(x + a/2)}\ell v$$

$$\text{or, } e \propto \frac{1}{(2x - a)(2x + a)}$$

**76.** **(a)** According to right hand palm rule, the Lorentz force on free electrons in the conductor will be directed towards end B. Hence, the end A gets positively charged.

**77.** **(c)** As I increases, $\phi$ increases
$\therefore$ $I_i$ is such that it opposes the increases in $\phi$.
Hence, $\phi$ decreases (By Right Hand Rule). The induced current will be counterclockwise.

**78.** **(d)** The given circuit clearly shows that the inductors are in parallel we have, $\dfrac{1}{L} = \dfrac{1}{3} + \dfrac{1}{3} + \dfrac{1}{3}$ or L= 1H

## ASSERTION- REASON TYPE QUESTIONS

**79.** **(c)** Emf will always induces whenever, there is change in magnetic flux. The current will induced only in closed loop.

**80.** **(c)** In purely resistive circuit, the current and emf are in the same phase.

**81.** **(c)**

**82.** **(a)** Lenz's law (that the direction of induced emf is always such as to oppose the change that cause it) is direct consequence of the law of conservation of energy.

**83.** **(b)** **84. (a)**

**85.** **(a)** When switch is closed , the magnetic flux through the ring will increase and so ring will move away form the solenoil so as to compensate this flux. This is according to Lenz's law.

**86.** **(b)** In both the cases, the magnetic flux will change, and so there is an induced current.

**87.** **(a)** In the given case, there is no component of velocity, perpendicular to the magnetic field and so $e = Bv\ell \sin 0°$.

**88.** **(b)** Both the statements are independently correct.

**89.** **(b)** **90. (b)** **91. (a)** **92. (a)**

## CRITICALTHINKING TYPE QUESTIONS

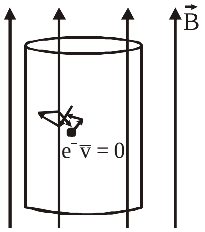
**93.** **(a)** Induced e.m.f. $\varepsilon = \frac{d\phi}{dt} = \frac{dBA}{dt} = A_0 \frac{dB}{dt}$

$$= A_0\left(\frac{4B_0 - B_0}{t}\right) = 3A_0 B_0 / t$$

**94.** **(a)** For a current to induce in the cylindrical conducting rod.

(a) The cylindrical rod should cut magnetic lines of force which will happen only when the cylindrical conducting rod is moving.

Since conducting rod is at rest, no current will be induced.



(b) The magnitude / direction of the magnetic field changes. A changing magnetic field will create an electric field which can apply force on the free electrons of the conducting rod and a current will get induced.

But since the magnetic field is constant, no current will be induced.

**95.** **(a)** As the magnetic field increases, its flux also increases into the page and so induced current in bigger loop will be anticlockwise. i.e., from D to C in bigger loop and then from B to A in smaller loop.

**96.** **(c)** $\frac{\Delta\phi}{\Delta t} = \varepsilon = iR \Rightarrow \Delta\phi = (i\Delta t)R = QR \Rightarrow Q = \frac{\Delta\phi}{R}$

**97.** **(b)**

**98.** **(c)** $\varepsilon = (5\times10^{-3})(1/0.1) = 0.05\,V$ .

**99.** **(a)** Change in flux = 2 B A N

$$\therefore \text{ Induced e.m.f. } = \frac{2\times0.3\times200\times70\times10^{-4}}{0.1}$$

**100.** **(a)** According, to Faraday's law of induction

Induced e.m.f. $\varepsilon = -\frac{d\phi}{dt} = -(100t)$

Induced current $i$ at $t = 2$ sec.

$$= \left|\frac{\varepsilon}{R}\right| = +\frac{100\times2}{400} = +0.5\,\text{Amp}$$

**101.** **(b)** $\frac{d\phi}{dt} = \frac{(W_2 - W_1)}{t}$ $R_{tot} = (R + 4R)\Omega = 5R\ \Omega$

$$i = \frac{nd\varphi}{R_{tot}dt} = \frac{-n(W_2 - W_1)}{5Rt}.$$

($\because$ $W_2$ & $W_1$ are magnetic flux)

**102.** **(a)** $e = \frac{-d\phi}{dt} = \frac{-d}{dt}\left(6t^2 - 5t + 1\right) = -12t + 5$

$e = -12\,(0.25) + 5 = 2$ volt

$$i = \frac{e}{R} = \frac{2}{10} = 0.2A.$$

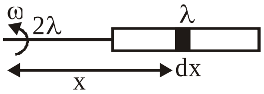
**103.** **(b)** $\phi = 10t^2 - 50t + 250$

$$e = -\frac{d\phi}{dt} = -(20t - 50)$$

$$e_{t=3} = -10\ V$$

**104.** **(b)**

**105.** **(d)** Here, induced e.m.f.



$$e = \int_{2\ell}^{3\ell} (\omega x)B dx$$

$$= B\omega\frac{[(3\ell)^2 - (2\ell)^2]}{2} = \frac{5B\ell^2\omega}{2}$$

**106.** **(b)** $\varphi = \vec{B}.\vec{A}$ $\phi = BA\cos\omega t$

$$\varepsilon = -\frac{d\phi}{dt} = \omega BA\sin\omega t\ ;\ i = \frac{\omega BA}{R}\sin\omega t$$

$$P_{inst} = i^2R = \left(\frac{\omega BA}{R}\right)^2 \times R\sin^2\omega t$$

$$P_{avg} = \frac{\int_0^T P_{inst}\times dt}{\int_0^T dt} = \frac{(\omega BA)^2}{R}\frac{\int_0^T \sin^2\omega t dt}{\int_0^T dt}$$

$$= \frac{(\omega BA)^2}{R}\left(\frac{T}{2.T}\right).$$

$$\therefore P_{avg} = \frac{(\omega B\pi r^2)^2}{2R}$$

**107.** **(c)** The electric field/emf is induced neither in sides *AD* and nor in *BC*. Unless the metallic square loop is entering or leaving the magnetic field and the flux linked with it is changing.

**108.** **(b)** Length of conductor ($l$) = 0.4 m; Speed (v) = 7 m/s and magnetic field (B) = 0.9 Wb/ m$^2$. Induced e.m.f. ($\varepsilon$) = B$l$v cos q = 0.9 × 0.4 × 7 × cos 0° = 2.52 V.

**109. (a)** Vel. of coil $= \frac{1}{0.5} = 2\text{m/s}$

velocity of magnet $= \frac{2}{1} = 2\text{m/s}.$

As they are made to move in the same direction, their relative velocity is zero. Therefore, induced e.m.f. = 0.

**110. (a)** Here, $r = 6$ cm $= 6 \times 10^{-2}$ $m$, $N = 20$, $\omega = 40$ rads$^{-1}$

$B = 2 \times 10^{-2}$ $T$, $R = 8\Omega$

Maximum emf induced, $\varepsilon = NAB\omega$

$= N(\pi r^2)B\omega$

$= 20 \times \pi \times (6 \times 10^{-2})\ 2 \times 10^{-2} \times 40 = 0.18$ V

Average value of emf induced over a full cycle

$\varepsilon_{av} = 0$

Maximum value of current in the coil.

$$I = \frac{\varepsilon I}{R} = \frac{0.18}{8} = 0.023 \text{ A}$$

Average power dissipated,

$$P = \frac{\varepsilon I}{2} = \frac{0.18 \times 0.023}{2} = 2.07 \times 10^{-3} \text{ W}$$

**111. (a)** Here $\upsilon = 0.5$ Hz, $N = 200$, $A = 0.1$ $m^2$

and $B = 0.02$ $T$

Maximum voltage generated is

$\varepsilon_0 = \text{NBA}\ (2\pi\upsilon)$

$= 200 \times 0.02 \times 0.1 \times (2\pi \times 0.5) = 1.26$ $V$

**112. (b)** Magnetic flux linked with the loop is $\phi = B\pi r^2$

$$|e| = \frac{d\phi}{dt} = B\pi \cdot 2r\frac{dr}{dt}$$

When $r = 2$ cm, $\frac{dr}{dt} = 1$ mm $s^{-1}$

$e = 0.025 \times \pi \times 2 \times 2 \times 10^{-2} \times 10^{-3}$

$= 0.100 \times \pi \times 10^{-5} = \pi \times 10^{-6}$ V $= \pi\mu$V

**113. (c)** When the coils are connected in parallel, let the currents in the two coils be $i_1$ and $i_2$ respectively. Total induced current

$$i = i_1 + i_2 \text{ or } \frac{di}{dt} = \frac{di_1}{dt} + \frac{di_2}{dt} \qquad \ldots\ldots(1)$$

Now $e = -L_1\left(\frac{di_1}{dt}\right) = -L_2\left(\frac{di_2}{dt}\right)$

(Q In parallel, induced e.m.f. across each coil will be same)

$$\text{Hence } \frac{di_1}{dt} = -\frac{e}{L_1} \text{ and } \frac{di_2}{dt} = -\frac{e}{L_2} \qquad \ldots\ldots(2)$$

Let L' be the equivalent inductance.

$$\text{Then } e = -L'\frac{di}{dt} \text{ or } \frac{di}{dt} = -\frac{e}{L'} \qquad \ldots\ldots(3)$$

From eqs. (1), (2) and (3), we get

$$-\frac{e}{L'} = -\frac{e}{L_1} - \frac{e}{L_2} \text{ or } \frac{1}{L'} = \frac{1}{L_1} + \frac{1}{L_2}$$

$$\therefore L' = \frac{L_1 L_2}{L_1 + L_2}$$

Here $L_1 = L_2 = L$

$$\therefore \ L' = \frac{L \times L}{L + L} = \frac{L}{2}$$

**114. (d)**

**115. (a)** $E = \frac{d}{dt}(NMI) \Rightarrow E = NM\frac{dI}{dt} \Rightarrow E = \frac{NMI}{t}$

emf induced per unit turn $= \frac{E}{N} = \frac{MI}{t}$

**116. (c)** $L = 2mH, i = t^2e^{-t}$

$E = -L\frac{di}{dt} = -L[-t^2e^{-t} + 2te^{-t}]$

when E = 0

$-e^{-t}\,t^2 + 2te^{-t} = 0$

$2t\ e^{-t} = e^{-t}\,t^2$

t = 2 sec.

**117. (b)** $\varepsilon = M\frac{di}{dt}$ or $8 = M\left[\frac{(4-2)}{0.05}\right]$

$\therefore \ M = \frac{8 \times 0.05}{2} = 0.2$ henry

**118. (d)** According to Lenz's law

**119. (b)** Mutual Inductance of two coils

$M = \sqrt{M_1 M_2} = \sqrt{2mH \times 8mH} = 4mH$

**120. (d)** Given : $M = 0.75$ H and $\frac{dI}{dt} = \frac{0.5 - 0}{0.01} = 50$ A/s

$\therefore$ Average induced e.m.f. in secondary coil

$e = M\frac{dI}{dt} = 0.75 \times 50 = 37.5$ V

**121. (a)** $e = \frac{-n(\phi_2 - \phi_1)}{t}$

$= \frac{-50(1 \times 10^{-6} - 31 \times 10^{-6})}{0.02}$

$= 7.5 \times 10^{-2}$ V

**122. (c)** The magnitude of induced e.m.f. is given by

$|e| = Blv$

$v = 300$ m/min $= 5$m/s

$\therefore \quad B = \frac{|e|}{lv} = \frac{2}{0.5 \times 5} = 0.8$ tesla

**123 (d)** The e.m.f. is induced when there is change of flux. As in this case there is no change of flux, hence no e.m.f. will be induced in the wire.

**124. (b)** $L = \mu_0 nI$

$\therefore \quad \frac{L_2}{L_1} = \frac{\mu}{\mu_0}$ ----($\because$ n and I are same)

$\therefore \quad L_2 = \mu_r L_1 = 900 \times 0.18 = 162$ mH

**125. (a)** $N\phi = LI$

$\therefore \quad \phi = \frac{LI}{N} = \frac{8 \times 10^{-3} \times 5 \times 10^{-3}}{400}$

$= 10^{-7} = \frac{\mu_0}{4\pi}$ Wb

**126. (c)** Energy stored U is given by

$U = \frac{1}{2} L i^2 = \frac{1}{2} \times (100 \times 10^{-3})\ (1)^2 = 0.05$ J.

**127. (b)** From $L = \frac{\mu_0 N^2 A}{l} \alpha \frac{N^2}{l}$

we get, $\frac{L_1}{L_2} = \frac{(1/2)^2}{1/2} = \frac{1}{2}$

**128. (d)** For maximum power, $X_L = X_C$, which yields

$C = \frac{1}{(2\pi n)^2 L} = \frac{1}{4\pi^2 \times 50 \times 50 \times 10}$

$\therefore \quad C = 0.1 \times 10^{-5}$ F $= 1\mu$F

**129. (b)** $B = \mu_0 n i = (4\pi \times 10^{-7})\ (200 \times 10^{-2}) \times 1.5$

$= 3.8 \times 10^{-2}$ Wb / m$^2$

Magnetic flux through each turn of the coil

$\phi = BA = (3.8 \times 10^{-2})(3.14 \times 10^{-4}) = 1.2 \times 10^{-5}$ weber

When the current in the solenoid is reversed, the change in magnetic flux

$= 2 \times (1.2 \times 10^{-5}) = 2.4 \times 10^{-5}$ weber

Induced e.m.f. $= N\frac{d\phi}{dt} = 100 \times \frac{2.4 \times 10^{-5}}{0.05} = 0.048$ V.

**130. (b)** $\varepsilon = \frac{M}{dt} dI = 0.005 \times I_0 \cos\omega t \times \omega$

and $\varepsilon_{\max} = 0.005 \times I_0 \times \omega = 5\pi$

**131. (b)** Self inductance $= \mu_0 n^2 AL = \mu_0 n^2 (\ell \times b) \times L$

n = Total number of turns/length

L = Length of inductor

l = Length of rectangular cross section

b = breadth of rectangular cross-section

So, when all linear dimensions are increased by a factor of 2. The new self inductance becomes L' = 8L.

**132. (b)**

**133. (b)** $n = \frac{N}{\ell} = \frac{2000}{0.3} = \frac{20000}{3}$

$\xi = \frac{d}{dt}(NBA) = NA\frac{dB}{dt}$

Since $B = \mu_0 nI$

$\Rightarrow \quad \xi = (\mu NAn)\frac{dt}{dt} \Rightarrow \quad \xi = 0.024$ V

**134. (d)** $M = \frac{\mu_0 N_1 N_2 A}{\ell} = \frac{4\pi \times 10^{-7} \times 300 \times 400 \times 100 \times 10^{-4}}{0.2}$

$= 2.4\pi \times 10^{-4}$ H

**135. (d)** $e = -\frac{d\phi}{dt} = -\frac{d(N\vec{B}.\vec{A})}{dt}$

$= -N\frac{d}{dt}(BA\cos\omega t) = NBA\omega\sin\omega t$

$\Rightarrow e_{\max} = NBA\omega$

**136. (c)** e.m.f. induced $= \frac{1}{2}BR^2\omega = \frac{1}{2}BR^2(2\pi n)$

$= \frac{1}{2} \times (0.1) \times (0.1)^2 \times 2\pi \times 10 = (0.1)^2\ \pi$ volts

**137. (d)** Total resistance of the circuit = 4000 + 400 = 4400 W

Current flowing $i = \frac{V}{R} = \frac{440}{4400} = 0.1$ amp.

Voltage across load = R i = 4000 × 0.1 = 400 volt.

**138. (b)** $V = 200$V; $r = 10\Omega$

$R' = 10 + 100\Omega = 110\Omega$

$I = \frac{V}{R'} = \frac{220}{100} = 2A$

$P = I^2 R = 4 \times 100 = 400\ W$

**139. (b)** Given, $B = 0.01\ T, A = \pi R^2 = \pi \times (1\text{ m})^2 = \pi\text{m}^2$

$\omega = 100$ rads$^{-1}$

$\therefore$ The maximum induced emf $\varepsilon_{\max} = BA\omega$

$= 0.01 \times \pi \times 100$ V $= \pi$V

**140. (b)** The e.m.f. induced is directly proportional to rate at which flux is intercepted which in turn varies directly as the speed of rotation of the generator.

## CHAPTER 22

# ALTERNATING CURRENT

## FACT/DEFINITION TYPE QUESTIONS

**1.** In general in an alternating current circuit
(a) the average value of current is zero
(b) the average value of square of the current is zero
(c) average power dissipation is zero
(d) the phase difference between voltage and current is zero

**2.** The frequency of A.C. mains in India is
(a) 30 c/s (b) 50 c/s
(c) 60 c/s (d) 120 c/s

**3.** A.C. power is transmitted from a power house at a high voltage as
(a) the rate of transmission is faster at high voltages
(b) it is more economical due to less power loss
(c) power cannot be transmitted at low voltages
(d) a precaution against theft of transmission lines

**4.** The electric mains supply in our homes and offices is a voltage that varies like a *sine* function with time such a voltage is called ... *A*... and the current driven by it in a circuit is called the ... *B*... Here, *A* and *B* refer to
(a) DC voltage, AC current
(b) AC voltage, DC current
(c) AC voltage, DC voltage
(d) AC voltage, AC current

**5.** Alternating currents can be produced by a
(a) dynamo (b) choke coil
(c) transformer (d) electric motor

**6.** The alternating current of equivalent value of $\frac{I_0}{\sqrt{2}}$ is
(a) peak current (b) r.m.s. current
(c) D.C. current (d) all of these

**7.** The alternating e.m.f. of $e = e_0 \sin \omega t$ is applied across capacitor C. The current through the circuit is given by
(a) $I = I_0 \sin \omega t$ (b) $I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$
(c) $I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$ (d) $I = I_0 \sin(\omega t - \pi)$

**8.** The peak value of the a.c. current flowing throw a resistor is given by
(a) $I_0 = e_0/R$ (b) $I = e/R$
(c) $I_0 = e_0$ (d) $I_0 = R/e_0$

**9.** The alternating current can be measured with the help of
(a) hot wire ammeter
(b) hot wire voltmeter
(c) moving magnet galvanometer
(d) suspended coil type galvanometer

**10.** Alternating current can not be measured by D.C. ammeter, because
(a) A. C. is virtual
(b) A. C. changes its direction
(c) A. C. can not pass through D.C. ammeter
(d) average value of A. C for complete cycle is zero

**11.** The heat produced in a given resistance in a given time by the sinusoidal current $I_0 \sin \omega t$ will be the same as that of a steady current of magnitude nearly
(a) $0.71\, I_0$ (b) $1.412\, I_0$
(c) $I_0$ (d) $\sqrt{I_0}$

**12.** In an a.c. circuit, the r.m.s. value of current, $I_{rms}$ is related to the peak current, $I_0$ by the relation
(a) $I_{rms} = \sqrt{2}\, I_0$ (b) $I_{rms} = \pi I_0$
(c) $I_{rms} = \frac{1}{\pi} I_0$ (d) $I_{rms} = \frac{1}{\sqrt{2}} I_0$

**13.** The ratio of mean value over half cycle to r.m.s. value of A.C. is
(a) $2 : \pi$ (b) $2\sqrt{2} : \pi$
(c) $\sqrt{2} : \pi$ (d) $\sqrt{2} : 1$

**14.** An A.C. source is connected to a resistive circuit. Which of the following is true?
(a) Current leads ahead of voltage in phase
(b) Current lags behind voltage in phase
(c) Current and voltage are in same phase
(d) Any of the above may be true depending upon the value of resistance.

**15.** In which of the following circuits the maximum power dissipation is observed?
(a) Pure capacitive circuit (b) Pure inductive circuit
(c) Pure resistive circuit (d) None of these

**16.** With increase in frequency of an A.C. supply, the inductive reactance
(a) decreases
(b) increases directly with frequency
(c) increases as square of frequency
(d) decreases inversely with frequency

**17.** The average power dissipated in a pure inductance is
(a) $\frac{1}{2}L\mathbf{I}^2$ (b) $L\mathbf{I}^2$
(c) $L\mathbf{I}^2/4$ (d) zero

**18.** If a current I given by $I = I_0 \sin(\omega t - \pi/2)$ flows in inductance in an A.C. circuit across which an A.C. potential $E = E_0 \sin \omega t$ has been applied, then power consumption P in the circuit will be
(a) $P = E_0 \mathbf{I}_0/\sqrt{2}$ (b) $P = E\mathbf{I}/\sqrt{2}$
(c) $P = E_0 \mathbf{I}_0/2$ (d) zero

**19.** In the case of an inductor
(a) voltage lags the current by $\frac{\pi}{2}$
(b) voltage leads the current by $\frac{\pi}{2}$
(c) voltage leads the current by $\frac{\pi}{3}$
(d) voltage leads the current by $\frac{\pi}{4}$

**20.** If the frequency of an A.C. is made 4 times of its initial value, the inductive reactance will
(a) be 4 times (b) be 2 times
(c) be half (d) remain the same

**21.** An inductance L having a resistance R is connected to an alternating source of angular frequency ω. The Quality factor Q of inductance is
(a) $R/\omega L$ (b) $(\omega L/R)^2$
(c) $(R/\omega L)^{½}$ (d) $\omega L/R$

**22.** A capacitor acts as an infinite resistance for
(a) DC (b) AC
(c) DC as well as AC (d) neither AC nor DC

**23.** The capacitive reactance in an A.C. circuit is
(a) effective resistance due to capacity
(b) effective wattage
(c) effective voltage
(d) None of these

**24.** Of the following about capacitive reactance which is correct?
(a) The reactance of the capacitor is directly proportional to its ability to store charge
(b) Capacitive reactance is inversely proportional to the frequency of the current
(c) Capacitive reactance is measured in farad
(d) The reactance of a capacitor in an A.C. circuit is similar to the resistance of a capacitor in a D.C. circuit

**25.** Phase difference between voltage and current in a capacitor in an ac circuit is
(a) π (b) π/2
(c) 0 (d) π/3

**26.** A capacitor has capacitance C and reactance X, if capacitance and frequency become double, then reactance will be
(a) 4X (b) X/2
(c) X/4 (d) 2X

**27.** When an ac voltage of 220 V is applied to the capacitor *C*, then
(a) the maximum voltage between plates is 220 V.
(b) the current is in phase with the applied voltage.
(c) the charge on the plate is not in phase with the applied votage.
(d) power delivered to the capacitor per cycle is zero.

**28.** In LCR circuit if resistance increases quality factor
(a) increases finitely (b) decreases finitely
(c) remains constant (d) None of these

**29.** An inductor, a resistor and a capacitor are joined in series with an AC source. As the frequency of the source is slightly increased from a very low value, the reactance of the
(a) inductor increases (b) resistor increases
(c) capacitor increases (d) circuit increases

**30.** With increase in frequency of an A.C. supply, the impedance of an L-C-R series circuit
(a) remains constant
(b) increases
(c) decreases
(d) decreases at first, becomes minimum and then increases.

**31.** If an LCR series circuit is connected to an ac source, then at resonance the voltage across
(a) R is zero
(b) R equals the applied voltage
(c) C is zero
(d) L equals the applied voltage

**32.** The current leads the voltage by an angle ϕ which is given by
(a) $\tan^{-1}\left(\frac{1}{\omega CR}\right)$ (b) $\tan^{-1}(\omega CR)$
(c) $\tan^{-1}\left(\frac{\omega C}{R}\right)$ (d) $\tan^{-1}\left(\frac{R}{\omega C}\right)$

**33.** In an L.C.R. series a.c. circuit, the current
(a) is always in phase with the voltage
(b) always lags the generator voltage
(c) always leads the generator voltage
(d) None of these

**34.** An LCR series circuit, connected to a source E, is at resonance. Then the voltage across
(a) R is zero (b) R equals applied voltage
(c) C is zero (d) L equals applied voltage

**35.** In a series resonant circuit, having L,C and R as its elements, the resonant current is i. The power dissipated in circuit at resonance is

(a) $\frac{i^2R}{(\omega L - 1/\omega C)}$
(b) zero
(c) $i^2 \omega L$
(d) $i^2 R$.

Whereas ω is angular resonant frequency

**36.** At resonance frequency the impedance in series *LCR* circuit is

(a) maximum
(b) minimum
(c) zero
(d) infinity

**37.** At resonant frequency the current amplitude in series *LCR* circuit is

(a) maximum
(b) minimum
(c) zero
(d) infinity

**38.** In tuning, we vary the capacitance of a capacitor in the tunning circuit such that the resonant frequency of the circuit becomes nearly equal to the frequency of the radio signal received. When this happens, the ...*A*... with the frequency of the signal of the particular radio station in the circuit is maximum. Here *A* refers to

(a) resonant frequency
(b) impedance
(c) amplitude of the current
(d) reactance

**39.** The power factor in a circuit connected to an A.C. The value of power factor is

(a) unity when the circuit contains an ideal inductance only
(b) unity when the circuit contains an ideal resistance only
(c) zero when the circuit contains an ideal resistance only
(d) unity when the circuit contains an ideal capacitance only

**40.** Current in a circuit is wattless if

(a) inductance in the circuit is zero
(b) resistance in the circuit is zero
(c) current is alternating
(d) resistance and inductance both are zero

**41.** Power factor is one for

(a) pure inductor
(b) pure capacitor
(c) pure resistor
(d) either an inductor or a capacitor.

**42.** The impedance of a LCR series circuit is

(a) $\sqrt{R^2 + (X_L - X_C)^2}$
(b) $\sqrt{R^2 + (X_L + X_C)^2}$
(c) $\sqrt{R + (X_L + X_C)^2}$
(d) $\sqrt{X_L - X_C + R}$

**43.** An A. C. of frequency f is flowing in a circuit containing a resistance R and capacitance C in series. The impedance of the circuit is equal to

(a) $R + f$
(b) $R + 2\pi fC$
(c) $R + \frac{1}{2\pi fC}$
(d) $\sqrt{R^2 + X_C^2}$

**44.** Power factor of the A. C. circuit varies between

(a) 0 to 0.5
(b) 0.5 to 1
(c) 0 to 1
(d) 1 to 2

**45.** The graph between inductive reactance and frequency is

(a) parabola
(b) straight line
(c) hyperbola
(d) an arc of a circle

**46.** For minimum dissipation of energy in the circuit the power factor should be

(a) large
(b) small
(c) moderate
(d) can not say

**47.** The inductive reactance of an inductor of inductance L is

(a) $\frac{1}{2\pi fC}$
(b) $\frac{1}{2\pi fL}$
(c) $2\pi fC$
(d) $2\pi fL$

**48.** The opposition offered by ohmic and non ohmic components is

(a) inductive reactance
(b) capacitive reactance
(c) impedance
(d) all of these

**49.** The average power dissipated in an A.C. circuit containing a resistance alone is

(a) $e_{rms} I_{rms}$
(b) $e_{rms} I_{rms} \cos \phi$
(d) 0
(d) none of these

**50.** The product $e_{rms} I_{rms}$ is called as

(a) true power
(b) apparent power
(c) power factor
(d) Q factor

**51.** Power in an A.C. circuit is rated per second at which

(a) charge flows
(b) work is done
(c) energy is spent
(d) current alternates

**52.** In an a.c. circuit with phase voltage V and current I, the power dissipated is

(a) $\frac{VI}{2}$
(b) $\frac{VI}{\sqrt{2}}$
(c) $VI$
(d) $VI \cos \theta$

**53.** The sinusoidal A.C. current flows through a resistor of resistance R. If the peak current is $I_p$, then power dissipated is

(a) $I_p^2 R \cos\theta$
(b) $\frac{1}{2} I_p^2 R$
(c) $\frac{4}{\pi} I_p^2 R$
(d) $\frac{1}{\pi^2} I_p^2 R$

**54.** The power factor of an AC circuit having resistance (R) and inductance (L) connected in series and an angular velocity ω is

(a) $R/\omega L$
(b) $R/(R^2\omega^2L^2)$
(c) $\omega L/R$
(d) $R/(R^2\omega^2L^2)^{1/2}$

**55.** The transformer voltage induced in the secondary coil of a transformer is mainly due to

(a) a varying electric field
(b) a varying magnetic field
(c) the vibrations of the primary coil
(d) the iron core of the transformer

**56.** A transformer is employed to
(a) convert A.C. into D.C.
(b) convert D.C. into A.C.
(c) obtain a suitable A.C. voltage
(d) obtain a suitable D.C. voltage

**57.** Transformers are used
(a) in DC circuit only
(b) in AC circuits only
(c) in both DC and AC circuits
(d) neither in DC nor in AC circuits

**58.** The loss of energy in the form of heat in the iron core of a transformer is
(a) iron loss (b) copper loss
(c) mechanical loss (d) None of these

**59.** Quantity that remains unchanged in a transformer is
(a) voltage (b) current
(c) frequency (d) None of these

**60.** Eddy currents in the core of transformer can't be developed by
(a) increasing the number of turns in secondary coil
(b) taking laminated transformer
(c) making step down transformer
(d) using a weak a.c. at high potential

**61.** The core of transformer is laminated to reduce
(a) flux leakage (b) hysteresis
(c) copper loss (d) eddy current

**62.** A transformer is based on the principle of
(a) mutual induction (b) self induction
(c) Ampere's law (d) X-ray crystallography

**63.** The transformation ratio in the step-up transformer is
(a) one
(b) greater than one
(c) less than one
(d) the ratio greater or less than one depends on the other factor

**64.** The parallel combination of inductor and capacitor is called as
(a) rectifier circuit (b) tank circuit
(c) acceptor circuit (d) filter circuit

## STATEMENT TYPE QUESTIONS

**65.** Consider the following statements and then select the correct statements.
I. Most of the electrical device we use require AC voltage.
II. Most of the electrical energy sold by power companies is transmitted and distributed as alternating current.
III. AC voltage can be easily and efficiently converted from one to the other by means of transformers.
(a) I is correct, II and III are incorrect
(b) I III are correct, II is incorrect
(c) I II are correct, III is incorrect
(d) I, II and III are correct

**66.** Which of the following statements is/are correct ?
I. In LCR series ac circuit, as the frequency of the source increases, the impedence of the circuit first decreases and then increases.
II. If the net reactance of an LCR series ac circuit is same as its resistance, then the current lags behind the voltage by 45°.
III. Below resonance, voltage leads the current while above it, current leads the voltage.
(a) I only (b) II only
(c) I and III (d) I and II

**67.** An alternating voltage of frequency ω is induced in electric circuit consisting of an inductance L and capacitance C, connected in parallel. Then across the inductance coil the
I. current is maximum when $\omega^2 = 1/(LC)$
II. current is minimum when $\omega^2 = 1/(LC)$
III. voltage is minimum when $\omega^2 = 1/(LC)$
IV. voltage is maximum when $\omega^2 = 1/(LC)$
Which of the above statements are correct?
(a) I and III (b) I and IV
(c) II and III (d) II and IV

**68.** Which of the following statements are correct ?
I. If the resonance is less sharp, not only is the maximum current less, the circuit is close to resonance for a larger range Δω of frequencies and the tuning of the circuit will not be good.
II. Less sharp the resonance less is the selectivity of the circuit or *vice–versa.*
III. If quality factor is large, i.e., R is low or L is large, the circuit is more selective.
(a) I and II only (b) II and III only
(c) I and III only (d) I, II and III

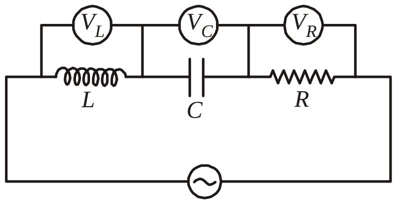
## MATCHING TYPE QUESTIONS

**69.** Match Columns I and II.

| **Column I** | **Column II** |
|---|---|
| (A) RL circuit | (1) Leading quantity - current |
| (B) RC circuit | (2) Leading quantity - voltage |
| (C) Inductive circuit | (3) Phase difference between voltage and current 0° |
| (D) Resistive circuit | (4) Phase difference between voltage and current 90° |

(a) (A) → (2) ; (B) → (1) ; (C) → (3) ; (D) → (4)
(b) (A) → (2) ; (B) → (2) ; (C) → (4) ; (D) → (3)
(c) (A) → (4) ; (B) → (3) ; (C) → (2) ; (D) → (1)
(d) (A) → (2) ; (B) → (1) ; (C) → (4) ; (D) → (3)

**70.** In an LCR series circuit connected to an ac source, the supply voltage is $V = V_0 \sin\left(100\pi t + \frac{\pi}{6}\right)$. $V_L$ = 40 $V$, $V_R$ = 40$V$, $Z$ = 5Ω and $R$ = 4Ω. Then match the column I and II.



| | Column I | | Column II |
|---|---|---|---|
| (A) | Peak current (in A) | (1) | $10\sqrt{2}$ |
| (B) | $V_0$ (in volts) | (2) | $50\sqrt{2}$ |
| (C) | Effective value of applied voltage (in volts) | (3) | 50 |
| (D) | $X_C$ (in Ω) | (4) | 1 |

(a) (A) → (1); (B) → (2); (C) → (1); (D) → (4)
(b) (A) → (2); (B) → (3); (C) → (1); (D) → (4)
(c) (A) → (4); (B) → (3); (C) → (2); (D) → (1)
(d) (A) → (4); (B) → (1); (C) → (3); (D) → (2)

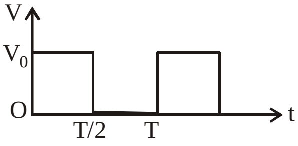
**71.** In a series LCR circuit, the e.m.f. leads current. Now the driving frequency is decreased slightly. Match columns I and II.

| | Column I | | Column II |
|---|---|---|---|
| (A) | Current amplitude | (1) | Increases |
| (B) | Phase constant | (2) | Decreases |
| (C) | Power developed in resistor | (3) | Remains same |
| (D) | Impedance | (4) | May increase or decrease |

(a) (A) → (1, 2); (B) → (2); (C) → (3, 4); (D) → (1)
(b) (A) → (1); (B) → (2); (C) → (1); (D) → (2)
(c) (A) → (1); (B) → (3); (C) → (1); (D) → (1, 2)
(d) (A) → (2); (B) → (3); (C) → (4); (D) → (1)

## DIAGRAM TYPE QUESTIONS

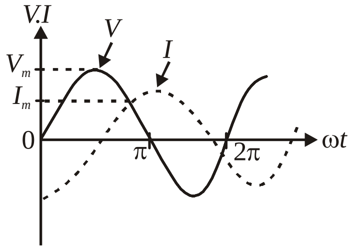
**72.** The r.m.s. value of potential difference V shown in the figure is



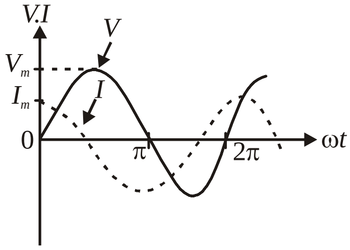
(a) $V_0$
(b) $V_0/\sqrt{2}$
(c) $V_0/2$
(d) $V_0/\sqrt{3}$

**73.** The phase relationship between current and voltage in a pure resistive circuit is best represented by

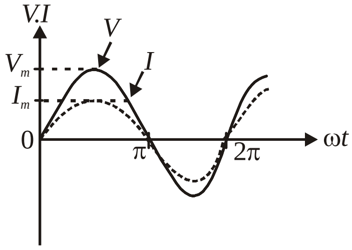
(a)



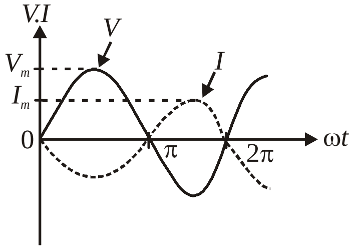
(b)



(c)

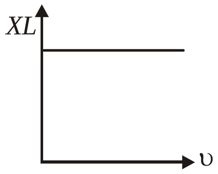


(d)

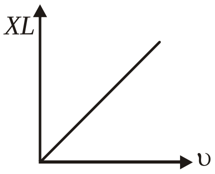


**74.** Which of the following graphs represents the correct variation of inductive reactance $X_L$ with frequency υ?

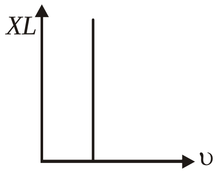
(a)



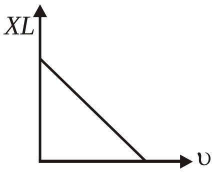
(b)



(c)

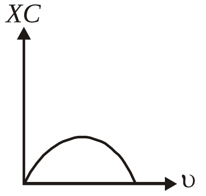


(d)

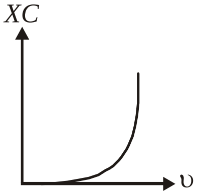


**75.** Which of the following graphs represents the correct variation of capacitive reactance $X_C$ with frequency υ?

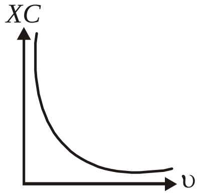
(a)



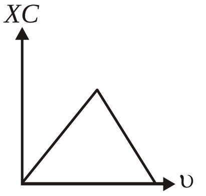
(b)



**(c)**



(d)



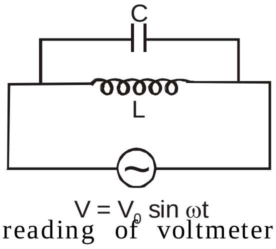
**76.** For the circuit shown in the fig., the current through the inductor is 0.9 A while the current through the condenser is 0.4 A. Then

(a) current drawn from source I = 1.13 A

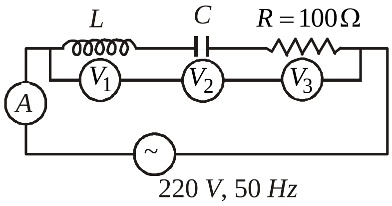
(b) $\omega = 1/(1.5\,LC)$

(c) I = 0.5 A

(d) I = 0.6 A



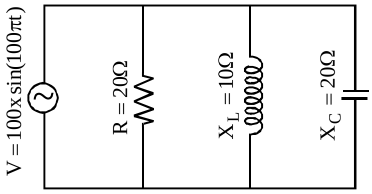
**77.** In the given circuit the reading of voltmeter $V_1$ and $V_2$ are 300 volt each. The reading of the voltmeter $V_3$ and ammeter *A* are respectively



(a) 150 *V* and 2.2 *A* (b) 220 *V* and 2.0 *A*

(c) 220 V and 2.0 *A* (d) 100 V and 2.0 *A*

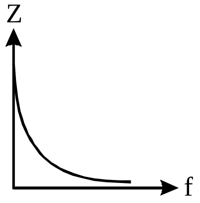
**78.** In the given circuit, the current drawn from the source is

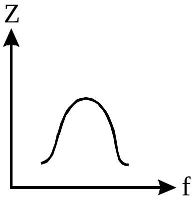


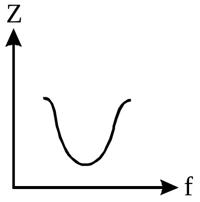
(a) 20 A (b) 10 A

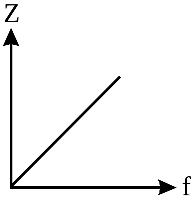
(c) 5 A (d) $5\sqrt{2}$ A

**79.** Which one of the following curves represents the variation of impedance (Z) with frequency f in series LCR circuit?

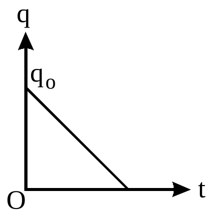
(a)


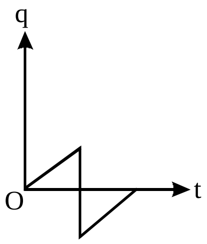
(b)


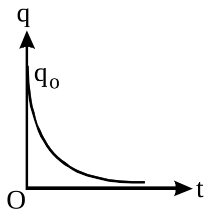
(c)


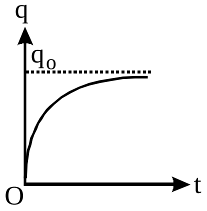
(d)


**80.** In LCR series circuit fed by a DC source, how does the amplitude of charge oscillations vary with time during discharge ?

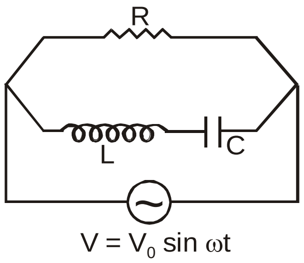
(a)


(b)


(c)


(d)


**81.** The current in resistance R at resonance is



(a) zero (b) minimum but finite

(c) maximum but finite (d) infinite

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

**82.** **Assertion :** Average value of ac over a complete cycle is always zero.

**Reason:** Average value of ac is always defined over half cycle.

**83.** **Assertion :** The voltage and current in a series AC circuit are given by $V = V_0 \sin\omega t$ and $i = i_0\cos\omega t$. The power dissipated in the circuit is zero.

**Reason :** Power in AC circuit is given by $P = \frac{V_0 i_0}{2}\cos\phi$.

**84.** **Assertion :** The alternating current lags behind the emf by a phase angle of $\frac{\pi}{2}$, when AC flows through an inductor.

**Reason :** The inductive reactance increases as the frequency of AC source increases.

**85.** **Assertion :** The inductive reactance limits amplitude of the current in a purely inductive circuit.
**Reason:** The inductive reactance is independent of the frequency of the current.

**85.** **Assertion :** A capacitor blocks direct current in the steady state.
**Reason :** The capacitive reactance of the capacitor is inversely proportional to frequency f of the source of emf.

**87.** **Assertion :** A capacitor is connected to a direct current source. Its reactance is infinite.
**Reason :** Reactance of a capacitor is given by $X_c = \frac{1}{\omega C}$.

**88.** **Assertion :** In a purely inductive or capacitive circuit, the current is referred to as wattless current.
**Reason:** No power is dissipated in a purely inductive or capacitive circuit even though a current is flowing in the circuit.

**89.** **Assertion :** The power in an ac circuit is minimum if the circuit has only a resistor.
**Reason:** Power of a circuit is independent of the phase angle.

**90.** **Assertion :** In the purely resistive element of a series LCR, AC circuit the maximum value of rms current increases with increase in the angular frequency of the applied emf.
**Reason :** $I_{max} = \frac{\varepsilon_{max}}{z}$, $z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$,
where $I_{max}$ is the peak current in a cycle.

**91.** **Assertion :** When the frequency of the AC source in an LCR circuit equals the resonant frequency, the reactance of the circuit is zero, and so there is no current through the inductor or the capacitor.
**Reason :** The net current in the inductor and capacitor is zero.

**92.** **Assertion :** In series LCR resonance circuit, the impedance is equal to the ohmic resistance.
**Reason:** At resonance, the inductive reactance exceeds the capacitive reactance.

**93.** **Assertion :** Choke coil is preferred over a resistor to control the current in an AC circuit.
**Reason :** Power factor of an ideal inductor is zero.

**94.** **Assertion :** The power is produced when a transformer steps up the voltage.
**Reason :** In an ideal transformer $VI$ = constant.

**95.** **Assertion :** A laminated core is used in transformers to increase eddy currents.
**Reason:** The efficiency of a transformer increases with increase in eddy currents.

## CRITICALTHINKING TYPE QUESTIONS

**96.** Determine the rms value of the emf given by
E (in volt) = 8 sin ( $\omega$ t) + 6sin (2 $\omega$ t)
(a) $5\sqrt{2}$V
(b) $7\sqrt{2}$V
(c) 10V
(d) $10\sqrt{2}$V

**97.** The r.m.s value of an a.c. of 50 Hz is 10 amp. The time taken by the alternating current in reaching from zero to maximum value and the peak value of current will be
(a) $2 \times 10^{-2}$ sec and 14.14 amp
(b) $1 \times 10^{-2}$ sec and 7.07 amp
(c) $5 \times 10^{-3}$ sec and 7.07 amp
(d) $5 \times 10^{-3}$ sec and 14.14 amp

**98.** The instantaneous voltage through a device of impedance 20 Ω is e = 80 sin 100 πt. The effective value of the current is
(a) 3 A
(b) 2.828 A
(c) 1.732 A
(d) 4 A

**99.** The impedance in a circuit containing a resistance of 1 Ω and an inductance of 0.1 H in series, for AC of 50 Hz, is
(a) $100\sqrt{10}\Omega$
(b) $10\sqrt{10}\Omega$
(c) $100\Omega$
(d) $\sqrt{10}\Omega$

**100.** An ac voltage is applied to a resistance R and an inductor L in series. If R and the inductive reactance are both equal to 3Ω, the phase difference between the applied voltage and the current in the circuit is
(a) π/6
(b) π/4
(c) π/2
(d) zero

**101.** A coil has resistance 30 ohm and inductive reactance 20 ohm at 50 Hz frequency. If an ac source, of 200 volt, 100 Hz, is connected across the coil, the current in the coil will be
(a) 4.0 A
(b) 8.0 A
(c) $\frac{20}{\sqrt{13}}$A
(d) 2.0 A

**102.** A coil of inductance 300 mH and resistance 2 Ω is connected to a source of voltage 2 V. The current reaches half of its steady state value in
(a) 0.1 s
(b) 0.05 s
(c) 0.3 s
(d) 0.15 s

**103.** An inductance of negligible resistance whose reactance is 22 Ω at 200 Hz is connected to 200 volts, 50 Hz power line. The value of inductance is
(a) 0.0175 henry
(b) 0.175 henry
(c) 1.75 henry
(d) 17.5 henry

**104.** An inductive circuit contains resistance of 10 ohms and an inductance of 2 henry. If an A.C. voltage of 120 Volts and frequency 60 Hz is applied to this circuit, the current would be nearly
(a) 0.32 A
(b) 0.16 A
(c) 0.48 A
(d) 0.80 A

**105.** An inductive coil has a resistance of 100 Ω. When an a.c. signal of requency 1000 Hz is fed to the coil, the applied voltage leads the current by 45°. What is the inductance of the coil ?
(a) 10mH
(b) 12mH
(c) 16mH
(d) 20mH.

**106.** In an LR circuit f = 50 Hz, L = 2H, E = 5 volts, R = 1 Ω then energy stored in inductor is
(a) 50 J
(b) 25 J
(c) 100 J
(d) None of these

**107.** In an ac circuit an alternating voltage e = 200 $\sqrt{2}$ sin 100 t volts is connected to a capacitor of capacity 1 μF. The r.m.s. value of the current in the circuit is

(a) 10 mA (b) 100 mA
(c) 200 mA (d) 20 mA

**108.** An alternating voltage E (in volts) = 200 $\sqrt{2}$ sin 100 t is connected to one micro farad capacitor through an a.c. ammeter. The reading of the ammeter shall be

(a) 100 mA (b) 20 mA
(c) 40 mA (d) 80 mA

**109.** An alternating voltage of 220 V, 50 Hz frequency is applied across a capacitor of capacitance 2 μF. The impedence of the circuit is

(a) $\frac{\pi}{5000}$ (b) $\frac{1000}{\pi}$
(c) 500 π (d) $\frac{5000}{\pi}$

**110.** In an experiment, 200 V A.C. is applied at the ends of an LCR circuit. The circuit consists of an inductive reactance ($X_L$) = 50 Ω, capacitive reactance ($X_C$) = 50 Ω and ohmic resistance (R) = 10 Ω. The impedance of the circuit is

(a) 10Ω (b) 20Ω
(c) 30Ω (d) 40Ω

**111.** In an electrical circuit *R*, *L*, *C* and an a.c. voltage source are all connected in series. When *L* is removed from the circuit, the phase difference between the voltage the current in the circuit is π/3. If instead, *C* is removed from the circuit, the phase difference is again π/3. The power factor of the circuit is

(a) 1/2 (b) $1/\sqrt{2}$
(c) 1 (d) $\sqrt{3}/2$

**112.** In an LCR series a.c. circuit, the voltage across each of the components, L, C and R is 50V. The voltage across the LC combination will be

(a) 100 V (b) $50\sqrt{2}$ V
(c) 50 V (d) 0 V

**113.** If resistance of 100Ω, and inductance of 0.5 henry and capacitance of 10 × $10^6$ farad are connected in series through 50 Hz A.C. supply, then impedance is

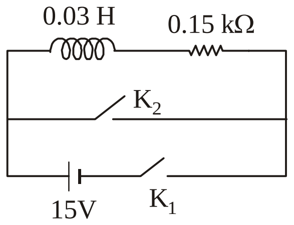
(a) 1.8765 Ω (b) 18.76 Ω
(c) 187.6 Ω (d) 101.3 Ω

**114.** In an LCR series resonant circuit, the capacitance is changed from C to 4C. For the same resonant frequency, the inductance should be changed from L to

(a) 2 L (b) $\frac{L}{2}$
(c) 4 L (d) $\frac{L}{4}$

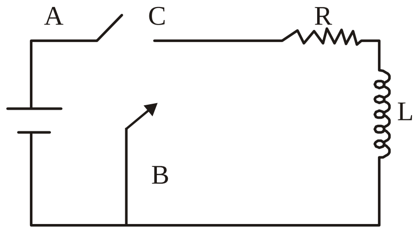
**115.** An inductor (L = 0.03 H) and a resistor (R = 0.15 kΩ) are connected in series to a battery of 15V EMF in a circuit shown below. The key $K_1$ has been kept closed for a long time. Then at t = 0, $K_1$ is opened and key $K_2$ is closed simultaneously.

At t = l ms, the current in the circuit will be : $(e^5 \cong 150)$



(a) 6.7 mA (b) 0.67 mA
(c) 100 mA (d) 67 mA

**116.** In the circuit shown here, the point 'C' is kept connected to point 'A' till the current flowing through the circuit becomes constant. Afterward, suddenly, point 'C' is disconnected from point 'A' and connected to point 'B' at time t = 0. Ratio of the voltage across resistance and the inductor at t = L/R will be equal to



(a) $\frac{e}{1-e}$ (b) 1
(c) –1 (d) $\frac{1-e}{e}$

**117.** A series R-C circuit is connected to an alternating voltage source. Consider two situations:

(a) When capacitor is air filled.
(b) When capacitor is mica filled.

Current through resistor is i and voltage across capacitor is V then :

(a) $V_a > V_b$ (b) $i_a > i_b$
(c) $V_a = V_b$ (d) $V_a < V_b$

**118.** A resistance 'R' draws power 'P' when connected to an AC source. If an inductance is now placed in series with the resistance, such that the impedance of the circuit becomes 'Z', the power drawn will be

(a) $P\sqrt{\frac{R}{Z}}$ (b) $P\left(\frac{R}{Z}\right)$
(c) P (d) $P\left(\frac{R}{Z}\right)^2$

**119.** In series L-C-R circuit, the voltages across R, L and C are $V_R$, $V_L$ and $V_C$ respectively. Then the voltage of applied a.c. source must be

(a) $V_R + V_L + V_C$
(b) $\sqrt{[(V_R)^2 + (V_L - V_C)^2]}$
(c) $V_R + V_C - V_L$
(d) $[(V_R + V_L)^2 + (V_C)^2]^{1/2}$

**120.** In a series resonant LCR circuit, the voltage across R is 100 volts and R = 1 k$\Omega$ with C = 2$\mu$F. The resonant frequency $\omega$ is 200 rad/s. At resonance the voltage across L is

(a) $2.5 \times 10^{-2}$ V (b) 40 V
(c) 250 V (d) $4 \times 10^{-3}$ V

**121.** In series combination of R, L and C with an A.C. source at resonance, if R = 20 ohm, then impedence Z of the combination is

(a) 20 ohm (b) zero
(c) 10 ohm (d) 400 ohm

**122.** The tuning circuit of a radio receiver has a resistance of 50 $\Omega$, an inductor of 10 mH and a variable capacitor. A 1 MHz radio wave produces a potential difference of 0.1 mV. The values of the capacitor to produce resonance is (Take $\pi^2 = 10$)

(a) 2.5 pF (b) 5.0 pF
(c) 25 pF (d) 50 pF

**123.** Resonance frequency of LCR series a.c. circuit is $f_0$. Now the capacitance is made 4 times, then the new resonance frequency will become

(a) $f_0/4$ (b) $2f_0$
(c) $f_0$ (d) $f_0/2$.

**124.** In a RLC circuit capacitance is changed from C to 2 C. For the resonant frequency to remain unchanged, the inductance should be changed from L to

(a) 4 L (b) 2 L
(c) L/2 (d) L/4

**125.** Resonance frequency of LCR series a.c. circuit is $f_0$. Now the capacitance is made 4 times, then the new resonance frequency will become

(a) $f_0/4$ (b) $2f_0$
(c) $f_0$ (d) $f_0/2$.

**126.** In an a.c. circuit the voltage applied is E = $E_0 \sin \omega t$. The resulting current in the circuit is $I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$.

The power consumption in the circuit is given by

(a) $P = \sqrt{2} E_0 I_0$ (b) $P = \frac{E_0 I_0}{\sqrt{2}}$

(c) P = zero (d) $P = \frac{E_0 I_0}{2}$

**127.** The instantaneous values of alternating current and voltages in a circuit are given as

$$i = \frac{1}{\sqrt{2}} \sin(100\pi t)\, A$$

$$e = \frac{1}{\sqrt{2}} \sin(100\pi t + \pi/3) \text{ Volt}$$

The average power in Watt consumed in the circuit is

(a) $\frac{1}{4}$ (b) $\frac{\sqrt{3}}{4}$

(c) $\frac{1}{2}$ (d) $\frac{1}{8}$

**128.** In a series LCR circuit $R = 200\Omega$ and the voltage and the frequency of the main supply is 220V and 50 Hz respectively. On taking out the capacitance from the circuit the current lags behind the voltage by 30°. On taking out the inductor from the circuit the current leads the voltage by 30°. The power dissipated in the LCR circuit is

(a) 305 W (b) 210 W
(c) Zero W (d) 242 W

**129.** In an A.C. circuit, the current flowing in inductance is I = 5 sin (100 t – $\pi$/2) amperes and the potential difference is V = 200 sin (100 t) volts. The power consumption is equal to

(a) 1000 watt (b) 40 watt
(c) 20 watt (d) Zero

**130.** In an a.c. circuit V and **I** are given by

V = 100 sin (100 t) volts
**I** = 100 sin (100 t + $\pi$/3) mA

the power dissipated in the circuit is

(a) $10^4$ watt (b) 10 watt
(c) 2.5 watt (d) 5.0 watt

**131.** An alternating voltage V = $V_0$ sin $\omega$t is applied across a circuit. As a result, a current I = $I_0$ sin ($\omega$t – $\pi$/2) flows in it. The power consumed per cycle is

(a) zero (b) 0.5 $V_0 I_0$
(c) 0.707 $V_0 I_0$ (d) 1.414 $V_0 I_0$

**132.** Two coils A and B are connected in series across a 240 V, 50 Hz supply. The resistance of A is 5 $\Omega$ and the inductance of B is 0.02 H. The power consumed is 3 kW and the power factor is 0.75. The impedance of the circuit is

(a) 0.144 $\Omega$ (b) 1.44 $\Omega$
(c) 14.4 $\Omega$ (d) 144 $\Omega$

**133.** A fully charged capacitor $C$ with initial charge $Q_0$ is connected to a coil of self inductance $L$ at $t = 0$. The time at which the energy is stored equally between the electric and the magnetic field is

(a) $\frac{\pi}{4}\sqrt{LC}$ (b) $2\pi\sqrt{LC}$

(c) $\sqrt{LC}$ (d) $\pi\sqrt{LC}$

**134.** A charged 30 $\mu$F capacitor is connected to a 27 mH inductor. The angular frequency of free oscillations of the circuit is

(a) $1.1 \times 10^3$ rad s$^{-1}$ (b) $2.1 \times 10^3$ rad s$^{-1}$
(c) $3.1 \times 10^3$ rad s$^{-1}$ (d) $4.1 \times 10^3$ rad s$^{-1}$

**135.** The primary winding of transformers has 500 turns whereas its secondary has 5000 turns. The primary is connected to an A.C. supply of 20 V, 50 Hz. The secondary will have an output of

(a) 2V, 5Hz (b) 200 V, 500 Hz
(c) 2V, 50 Hz (d) 200 V, 50Hz

**136.** A step up transformer operates on a 230 V line and supplies a current of 2 ampere. The ratio of primary and secondary winding is 1:25 . The current in primary is

(a) 25 A (b) 50 A
(c) 15 A (d) 12.5 A

**137.** A 220 volts input is supplied to a transformer. The output circuit draws a current of 2.0 ampere at 440 volts. If the efficiency of the transformer is 80%, the current drawn by the primary windings of the transformer is

(a) 3.6 ampere (b) 2.8 ampere
(c) 2.5 ampere (d) 5.0 ampere

**138.** In a transformers, number of turns in primary coil are 140 and that in secondary coil are 280. If current in primary coil is 4A, then that in secondary coil is

(a) 4 A (b) 2 A
(c) 6 A (d) 10 A

**139.** The primary winding of a transformer has 100 turns and its secondary winding has 200 turns. The primary is connected to an A.C. supply of 120 V and the current flowing in it is 10 A. The voltage and the current in the secondary are

(a) 240 V, 5 A (b) 240 V, 10 A
(c) 60 V, 20 A (d) 120 V, 20 A

**140.** A step down transformer is connected to 2400 volts line and 80 amperes of current is found to flow in output load. The ratio of the turns in primary and secondary coil is 20 : 1. If transformer efficiency is 100%, then the current flowing in the primary coil will be

(a) 1600 amp (b) 20 amp
(c) 4 amp (d) 1.5 amp

**141.** A step down transformer reduces 220 V to 110 V. The primary draws 5 ampere of current and secondary supplies 9 ampere. The efficiency of transformer is

(a) 20% (b) 44%
(c) 90% (d) 100%

**142.** A transformer is used to light a 140 W, 24 V bulb from a 240 V a.c. mains. The current in the main cable is 0.7 A. The efficiency of the transformer is

(a) 63.8 % (b) 83.3 %
(c) 16.7 % (d) 36.2 %

**143.** A transformer has an efficiency of 80%. It works at 4 kW and 100 V. If secondary voltage is 240 V, the current in primary coil is

(a) 0.4 A (b) 4 A
(c) 10 A (d) 40 A

**144.** The primary of a transformer has 400 turns while the secondary has 2000 turns. If the power output from the secondary at 1000 V is 12 kW, what is the primary voltage?

(a) 200 V (b) 300 V
(c) 400 V (d) 500 V

**145.** A transformer connected to 220 V mains is used to light a lamp of rating 100 W and 110 V. If the primary current is 0.5 A, the efficiency of the transformer is (approximately)

(a) 60% (b) 35%
(c) 50% (d) 90%

**146.** A transformer having efficiency of 90% is working on 200V and 3kW power supply. If the current in the secondary coil is 6A, the voltage across the secondary coil and the current in the primary coil respectively are :

(a) 300 V, 15A (b) 450 V, 15A
(c) 450V, 13.5A (d) 600V, 15A

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(a)**

**2.** **(b)** In India the frequency of A.C. current is 50 Hz.

**3.** **(b)**

**4.** **(d)** The electric mains supply in our homes and offices is a voltage that varies like a *sine* function with time. Such a voltage is called alternating voltage and the current driven by it in a circuit is called the alternating current.

**5.** **(a)** **6.** **(b)** **7.** **(b)** **8.** **(a)**

**9.** **(a)** **10.** **(d)** **11.** **(a)** **12.** **(d)**

**13.** **(b)** We know that $\mathbf{I}_{rms} = \mathbf{I}_0/\sqrt{2}$ and $\mathbf{I}_m = 2\mathbf{I}_0/\pi$

$$\therefore \frac{\mathbf{I}_m}{\mathbf{I}_{rms}} = \frac{2\sqrt{2}}{\pi}$$

**14.** **(c)** When resistance is connected to A.C source, then current & voltage are in same phase.

**15.** **(c)**

**16.** **(b)** $X_L = \omega L \Rightarrow X_L \propto \omega$

**17.** **(d)** In case of pure inductance cos $\phi$ = 0, so no power dissipates.

**18.** **(d)** $P = V_{r.m.s.} \times \mathbf{I}_{r.m.s.} \times \cos\phi \ = \frac{1}{2} E_0 \times \mathbf{I}_0 \cos \pi/2 = 0$

**19.** **(b)** In an inductor voltage leads the current by $\frac{\pi}{2}$ or current lags the voltage by $\frac{\pi}{2}$.

**20.** **(a)**

**21.** **(d)** $Q = \frac{\text{Potential drop across capacitor or inductor}}{\text{Potential drop across R.}}$

$$= \frac{\omega L}{R}$$

**22.** **(a)** $X_C$(reactance of capacitor) $= \frac{1}{\omega C}$ for D.C.,

$\omega = 0 \Rightarrow X_C = \infty$

**23.** **(a)** Capacitive reactance in an A.C circuit is

$X_C = \frac{1}{\omega C}$ ohm, where C is the capacitance of capacitor & $\omega = 2\pi n$ (n is the frequency of A.C source).

**24.** **(b)** $X_C = \frac{1}{\omega C} \Rightarrow X_C \propto \frac{1}{\omega}$ for given C.

**25.** **(b)** In a capacitive ac circuits, the voltage lags behind the current in phase by $\pi/2$ radian.

**26.** **(c)** The reactance of capacitor $X = \frac{1}{\omega C}$ where ω is frequency and C is the capacitance of capacitor.

**27.** **(d)** When an ac voltage of 220 V is applied to a capacitor *C*, the charge on the plates is in phase with the applied voltage.
As the circuit is pure capacitive so, the current developed leads the applied voltage by a phase angle of 90° Hence, power delivered to the capacitor per cycle is
$P = V_{rms} I_{rms} \cos 90° = 0$.

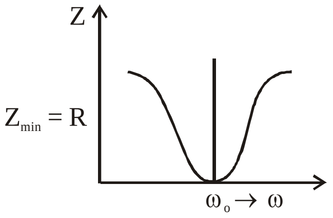
**28.** **(b)**

**29.** **(a)** The reactance of inductor, $X_L = \omega L$

The reactance of capacitor, $X_C = \frac{1}{\omega C}$

where $\omega = 2\pi n$ & n is the frequency of A.C source.

**30.** **(d)**



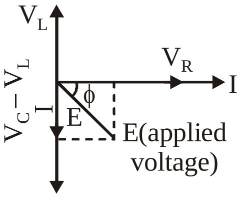
**31.** **(b)** In series RLC circuit,

Voltage, $V = \sqrt{V_R^2 + (V_L - V_C)^2}$

And, at resonance, $V_L = V_C$
Hence, $V = V_R$

**32.** **(a)**

**33.** **(d)**



$$\tan\phi = \frac{V_C - V_L}{V_R} \text{ (if } V_C > V_L)$$

$$= \frac{V_L - V_C}{R} \text{ (if } V_L > V_C)$$

where $\phi$ is angle between current & applied voltage.

**34.** **(b)** Power factor $= \cos\varphi = \frac{R}{Z} = \frac{12}{15} = \frac{4}{5} = 0.8$

**35.** **(d)** At resonance wL= 1/wC
and i = E/R , So power dissipated in circuit is $P = i^2R$.

**36.** **(b)** At resonance frequency, the inductive and capacitive reactance are equal.
*i.e.* $X_L = X_C$
$\therefore$ Impedance, $Z = \sqrt{R^2 + (X_L - X_C)^2}$
$= \sqrt{R^2 + 0^2} = R$

**37.** **(a)**

**38.** **(c)** When this happens the amplitude of the current with the frequency of the signal of the particular radio station in the circuit is maximum.

**39.** **(b)** $\cos\phi = \frac{R}{Z}$, where Z is the impedance &
$Z = \sqrt{R^2 + (X_L - X_C)^2}$ , if there is only resistance then $Z = R \Rightarrow \cos\phi = 1$

**40.** **(b)** If $R = 0 \Rightarrow \cos\phi = 0 \Rightarrow \phi = 90°$ so P =0, in this case power loss is zero & current flowing in the circuit is called wattless current.

**41.** **(c)** **42.** **(a)** **43.** **(d)** **44.** **(c)**
**45.** **(b)** **46.** **(a)** **47.** **(d)** **48.** **(c)**
**49.** **(a)** **50.** **(b)** **51.** **(b)**

**52.** **(d)** $P = V I \cos\theta$. So, power dissipation depends upon V and I.

**53.** **(b)** The value of r.m.s current is $I_{rms} = \frac{I_P}{\sqrt{2}}$
so power dissipated is $P = I_{rms}^2 R = \frac{1}{2} I_P^2 R$

**54.** **(b)** **55.** **(b)** **56.** **(c)** **57.** **(b)**

**58.** **(a)** **:** Iron loss is the energy loss in the form of heat due to the formation of eddy currents in the iron core of the transformer.

**59.** **(c)** A transformer does not change the frequency of ac.

**60.** **(b)**

**61.** **(d)** The core of a transformer is laminated to reduce eddy current.

**62.** **(a)** **63.** **(b)** **64.** **(b)**

## STATEMENT TYPE QUESTIONS

**65.** **(d)** Most of the electrical devices we use require AC voltage. This is mainly because most of the electrical energy sold by power companies is transmitted and distributed as alternating current. The main reason for preferring use of AC voltage over DC voltage is that Ac voltage can be easily and efficiently converted from one voltage to the other by means of transformers.

**66.** **(d)** Option (d) is false because the reason why the voltage leads the current is because $\frac{1}{C\omega} > L\omega$ and if the voltage lags, the inductive reactance is greater than the capacitive reactance.

**67.** **(d)**

**68.** **(d)** If the resonance is less sharp, not only is the maximum current less, the circuit is close to resonance for larger range $\Delta\omega$ of frequencies and the tuning of the circuit will not be good. So, less sharp the resonance, less is the selectivity of the circuit or vice-versa. If quality factor is large, i.e., *R* is low or L is large, the circuit is more selective.

## MATCHING TYPE QUESTIONS

**69.** **(d)** $(A) \to (2)$; $(B) \to (1)$; $(C) \to (4)$; $(D) \to (3)$

**70.** **(a)** A-1 : $i_{rms} = \frac{V_R}{R} = \frac{40}{4} = 10A$; $i_0 = \sqrt{2} i_{rms} = 2\sqrt{2}\ A$

B-2; $\therefore V_{rms} = iZ = 10 \times 5 = 50V$ ; $V_0 = \sqrt{2} V_{rms} = 50\sqrt{2} V$

C-1 :

D-4 : Now $V^2 = V_R^2 + (V_L - V_C)^2$

or $50^2 = 40^2 + (40 - V_C)^2$

$\therefore V_C = 10V$ ,

and $X_C = \frac{V_C}{i} = \frac{10}{10} = 1\Omega$

**71.** **(b)**

## DIAGRAM TYPE QUESTIONS

**72.** **(b)** $V_{rms} = \sqrt{\frac{(T/2)V_0{}^2 + 0}{T}} = \frac{V_0}{\sqrt{2}}$.

**73.** **(c)** In the pure resistive circuit current and voltage both are in phase. Hence graph (c) is correct.

**74.** **(b)** Inductive reactance,
$X_L = \omega L = 2\pi\upsilon L$
$\Rightarrow X_L \propto \upsilon$
Hence, inductive reactance increases linearly with frequency.

**75.** **(c)** Capacitive reactance, $X_C = \frac{1}{\omega C} = \frac{1}{2\pi \upsilon C}$

$\Rightarrow \; X_L \propto \frac{1}{\upsilon}$

With increases in frequency, $X_C$ decreases.
Hence, option (c) represents the corrent graph.

**76.** **(c)** The current drawn by inductor and capacitor will be in opposite phase. Hence net current drawn from generator
$= I_L - I_C = 0.9 - 0.4 = 0.5$ amp.

**77.** **(b)** As $V_L = V_C = 300\,V$, resonance will take place
$\therefore \; V_R = 220\,V$

Current, $I = \frac{220}{100} = 2.2A$

$\therefore$ reading of $V_3 = 220\,V$
and reading of $A = 2.2\,A$

**78.** **(d)**

**79.** **(c)** Impedance at resonant frequency is minimum in series LCR circuit.

So, $Z = \sqrt{R^2 + \left(2\pi fL - \frac{1}{2\pi fC}\right)^2}$

When frequency is increased or decreased, Z increases.

**80.** **(c)**

**81.** **(c)** At resonance $X_L = X_C \Rightarrow Z = R$ & current is maximum but finite, which is $I_{max} = \frac{E}{R}$, where E is applied voltage.

## ASSERTION- REASON TYPE QUESTIONS

**82.** **(b)** The means or average value of alternating current or e.m.f during a half cycle is given by
$I_m = 0.636 I_0$ or $E_m = 0.636 E_0$
During the next half cycle, the mean value of ac will be equal in magnitude but opposite in direction. For this reason the average value of ac over a complete cycle is always zero. So the average value is always defined over a half cycle of ac.

**83.** **(a)** $V = V_0 \sin \omega t \; i = i_0 \cos \omega t = i_0 \sin(\omega t + \pi/2)$

$\therefore \; \phi = \frac{\pi}{2}$, and $\cos\phi = 0$.

**84.** **(b)** In case of inductive circuit emf leads current by π/2 rad

**85.** **(c)** The inductive reactance limits the amplitude of current in a purely inductive circuit in the same way as the resistance limits the current in a purely resistive circuit.
i.e. $I_0 = \frac{\varepsilon_0}{X_L}$

**86.** **(b)**

**87.** **(a)** As $X_C = \frac{1}{\omega C}$, so for $\omega = 0, \; X_C \to \infty$.

**88.** **(a)** In a purely inductive or capacitive circuit, power factor, cos ϕ = 0 and no power is dissipated even though a current is flowing in the circuit. In such cases, current is referred to as wattless current.

**89.** **(d)** Power in a series ac circuit consisting of *L*, *C* and *R* is given by

$P = I_{rms} V_{rms} \cos\phi$ where $\phi = \tan^{-1}\left(\frac{|X_L - X_C|}{R}\right)$

For a purely resistive circuit $X_L = 0$ and $X_C = 0$
Therefore, $\tan\phi = 0$ or $\phi = 0$ and thereby $\cos\phi = 1$ and $P = IV$.
The power is maximum as cos ϕ is maximum. Power depends on the phase angle through the power factor cos ϕ.

**90.** **(c)**

**91.** **(d)** The currents in capacitor and in inductor are opposite and so net current is zero.

**92.** **(c)** In series resonance circuit,
inductive reactance is equal to capacitive reactance.
i.e. $\omega L = \frac{1}{\omega C}$

$\therefore \; Z = \sqrt{R^2 + \left(\omega L = \frac{1}{\omega C}\right)^2} = R$

**93.** **(a)**

**94.** **(a)** Transformer cannot produce power, but it transfer from primary to secondary.

**95.** **(d)** Large eddy currents are produced in non-laminated iron core of the transformer by the induced emf, as the resistance of bulk iron core is very small. By using thin iron sheets as core the resistance is increased. Laminating the core substantially reduces the eddy currents. Eddy current heats up the core of the transformer. More the eddy currents greater is the loss of energy and the efficiency goes down.

## CRITICALTHINKING TYPE QUESTIONS

**96.** **(a)** $E = 8\sin\omega t + 6\sin 2\omega t$

$\Rightarrow E_{peak} = \sqrt{8^2 + 6^2} = 10\text{ V}$

$E_{rms} = \frac{10}{\sqrt{2}} = 5\sqrt{2}\text{ V}$

**97.** **(d)**

**98. (b)** Given equation, $e = 80 \sin 100\pi t$ ...(i)

Standard equation of instantaneous voltage is given by $e = e_m \sin\omega t$ ...(ii)

Compare (i) and (ii), we get $e_m = 80$ V

where $e_m$ is the voltage amplitude.

Current amplitude $I_m = \frac{e_m}{Z}$ where Z = impendence

$$= 80/20 = 4 \text{ A}.$$

$$I_{r.m.s} = \frac{4}{\sqrt{2}} = \frac{4\sqrt{2}}{2} = 2\sqrt{2} = 2.828 \text{ A}.$$

**99. (b)**

**100. (b)** The phase difference $\phi$ is given by

$$\tan\phi = \frac{X_L}{R} = \frac{3}{3} = 1$$

$$\Rightarrow \phi = \frac{\pi}{4}.$$

**101. (a)** If $\omega = 50 \times 2\pi$ then $\omega L = 20\Omega$

If $\omega' = 100 \times 2\pi$ then $\omega' L = 40\Omega$

Current flowing in the coil is

$$I = \frac{200}{Z} = \frac{200}{\sqrt{R^2 + (\omega' L)^2}} = \frac{200}{\sqrt{(30)^2 + (40)^2}}$$

I = 4A.

**102. (a)** The charging of inductance given by,

$$i = i_0\left(1 - e^{-\frac{Rt}{L}}\right)$$

$$\frac{i_0}{2} = i_0\left(1 - e^{-\frac{Rt}{L}}\right) \Rightarrow e^{-\frac{Rt}{L}} = \frac{1}{2}$$

Taking log on both the sides,

$$-\frac{Rt}{L} = \log 1 - \log 2$$

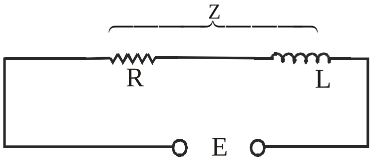
$$\Rightarrow t = \frac{L}{R}\log 2 = \frac{300 \times 10^{-3}}{2} \times 0.69 \Rightarrow t = 0.1 \text{ sec.}$$

**103. (a)** $X_L = \omega L = 2\pi n L$

$$\therefore L = \frac{X_L}{2\pi n} = \frac{22 \times 7}{2 \times 22 \times 200} \text{H} = 0.0175 \text{H}$$

**104. (b) 105. (c)**

**106. (d)** $L = 2H, E = 5$ volts, $R = 1\Omega$



Energy in inductor $= \frac{1}{2}LI^2 \quad I = \frac{E}{Z}$

$$I = \frac{5}{\sqrt{R^2 + (\omega L)^2}} = \frac{5}{\sqrt{1 + 4\pi^2 \times 50^2 \times 4}}$$

$$= \frac{5}{\sqrt{1 + (200\pi)^2}} = \frac{5}{200\pi}$$

$$\text{Energy} = \frac{1}{2} \times 2 \times \frac{5 \times 5}{200 \times 200\pi^2} = 6.33 \times 10^{-5} \text{ joules}$$

**107. (d)** $V_{rms} = \frac{200\sqrt{2}}{\sqrt{2}} = 200\text{V}$

$$I_{rms} = \frac{V_{rms}}{X_C} = \frac{200}{\frac{1}{100 \times 10^{-6}}}$$

$$= 2 \times 10^{-2} = 20\text{mA}$$

**108. (b)** $\mathbf{I} = \frac{E}{X_C} = E\omega C = \left(\frac{E_0}{\sqrt{2}} \times \omega C\right)$

$$\therefore I = 120 \times \left(\frac{200}{100}\right) = 240\text{V} \quad = 20 \times 10^{-3} \text{ amp.}$$

**109. (d)** Impedence of a capacitor is $X_C = 1/\omega C$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 50 \times 2 \times 10^{-6}} = \frac{5000}{\pi}.$$

**110. (a)** Given : Supply voltage $(V_{ac}) = 200$ V

Inductive reactance $(X_L) = 50$ W

Capacitive reactance $(X_C) = 50$ W

Ohmic resistance (R) = 10 W.

We know that impedance of the LCR circuit

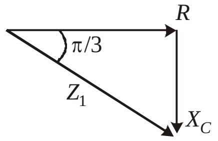
( Z )

$$= \sqrt{\{(X_L - X_C)^2 + R^2\}} = \sqrt{\{(50 - 50)^2 + (10)^2\}} = 10\Omega$$

**111. (c)** 

when *L* is removed from the circuit

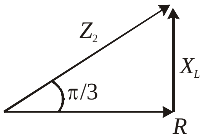
$$\frac{X_C}{R} = \tan\frac{\pi}{3}$$



$X_C = R\tan\frac{\pi}{3}$ ....(1)

when $C$ is remove from the circuit

$\frac{X_L}{R} = \tan\frac{\pi}{3}$



$X_C = R\tan\frac{\pi}{3}$ ...(2)

net impedence $Z = \sqrt{R^2 + (X_L - X_C)^2} = R$

power factor $\cos\phi = \frac{R}{Z} = 1$

**112. (d)** Since the phase difference between L & C is $\pi$

$\therefore$ net voltage difference across LC $= 50 - 50 = 0$

**113. (c)** $Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$

Here R = 100 W, L = 0.5 henry, C = 10 × $10^6$ farad

$\omega = 2\,p\;\pi = 100\;\pi.$

**114. (d)** For resonant frequency to remain same

$\sqrt{LC}$ = constant

LC = constant

As, $C \to 4C$

$\therefore\; L \to \frac{L}{4}$

**115. (b)** $I(0) = \frac{15\times100}{0.15\times10^3} = 0.1A$

$I(\infty) = 0$

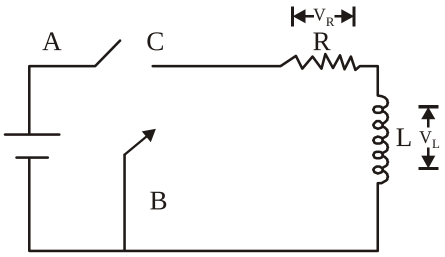
$I(t) = [I(0) - I(\infty)]\;e^{\frac{-t}{L/R}} + i(\infty)$

$I(t) = 0.1\;e^{\frac{-t}{L/R}} = 0.1\,e^{\frac{R}{L}}$

$I(t) = 0.1\;e^{\frac{0.15\times1000}{0.03}} = 0.67mA$

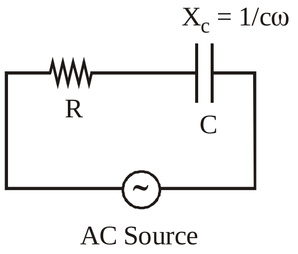
**116. (c)** Applying Kirchhoff's law of voltage in closed loop

$-V_R - V_C = 0 \;\Rightarrow\; \frac{V_R}{V_C} = -1$



**117. (a)** For series R – C circuit, capacitive reactance,

$Z_c = \sqrt{R^2 + \left(\frac{1}{C\omega}\right)^2}$



Current $i = \frac{V}{Z_c} = \frac{V}{\sqrt{R^2 + \left(\frac{1}{C\omega}\right)^2}}$

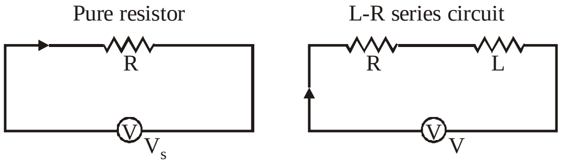
$V_c = iX_c = \frac{V}{\sqrt{R^2 + \left(\frac{1}{C\omega}\right)^2}} \times \frac{1}{C\omega}$

$V_c = \frac{V}{\sqrt{(RC\omega)^2 + 1}}$

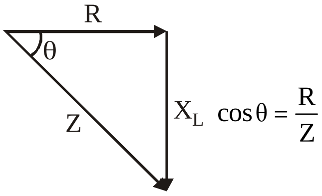
If we fill a di-electric material like mica instead of air then capacitance $C\uparrow \Rightarrow V_c\downarrow$

So, $V_a > V_b$

**118. (d)**



Phasor diagram



Z = impedance

For pure resistor circuit, power

$P = \frac{V^2}{R} \Rightarrow V^2 = PR$

For L-R series circuit, power

$P^1 = \frac{V^2}{Z}\cos\theta = \frac{V^2}{Z}\cdot\frac{R}{Z} = \frac{PR}{Z^2}\cdot R = P\left(\frac{R}{Z}\right)^2$

**119. (b)**

**120. (c)** Across resistor, $I = \frac{V}{R} = \frac{100}{1000} = 0.1$ A

At resonance,

$$X_L = X_C = \frac{1}{\omega C} = \frac{1}{200 \times 2 \times 10^{-6}} = 2500$$

Voltage across L is

$$I X_L = 0.1 \times 2500 = 250\,V$$

**121. (a)**

**122. (a)** $L = 10\,mHz = 10^{-2}\,Hz$

$f = 1MHz = 10^6\,Hz$

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$f^2 = \frac{1}{4\pi^2 LC}$$

$$\Rightarrow C = \frac{1}{4\pi^2 f^2 L} = \frac{1}{4 \times 10 \times 10^{-2} \times 10^{12}} = \frac{10^{-12}}{4} = 2.5\ pF$$

**123. (d)** In LCR series circuit, resonance frequency $f_0$ is given by

$$L\omega = \frac{1}{C\omega} \Rightarrow \omega^2 = \frac{1}{LC} \quad \therefore \quad \omega = \sqrt{\frac{1}{LC}} = 2\pi f_0$$

$$\therefore \quad f_0 = \frac{1}{2\pi\sqrt{LC}} \quad \text{or} \quad f_0 \alpha \frac{1}{\sqrt{C}}$$

When the capacitance of the circuit is made 4 times, its resonant frequency become $f_0^{'}$

$$\therefore \quad \frac{f_0^{'}}{f_0} = \frac{\sqrt{C}}{\sqrt{4C}} \quad \text{or} \quad f_0^{'} = \frac{f_0}{2}$$

**124. (c)** We know that $f = \frac{1}{2\pi\sqrt{(LC)}}$,

when C is doubled, L should be halved so that resonant frequency remains unchanged.

**125. (d)** In LCR series circuit, resonance frequency $f_0$ is given by

$$L\omega = \frac{1}{C\omega} \Rightarrow \omega^2 = \frac{1}{LC} \quad \therefore \quad \omega = \sqrt{\frac{1}{LC}} = 2\pi f_0$$

$$\therefore \quad f_0 = \frac{1}{2\pi\sqrt{LC}} \quad \text{or} \quad f_0 \alpha \frac{1}{\sqrt{C}}$$

When the capacitance of the circuit is made 4 times, its resonant frequency become $f_0^{'}$

$$\therefore \quad \frac{f_0^{'}}{f_0} = \frac{\sqrt{C}}{\sqrt{4C}} \quad \text{or} \quad f_0^{'} = \frac{f_0}{2}$$

**126. (c)** We know that power consumed in a.c. circuit is given by, $P = E_{rms} \cdot I_{rms} \cos\phi$

Here, $E = E_0 \sin\omega t$

$$I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$$

which implies that the phase difference,

$$\phi = \frac{\pi}{2}$$

$$\therefore \quad P = E_{rms} . I_{rms} . \cos\frac{\pi}{2} = 0 \quad \left(\because \quad \cos\frac{\pi}{2} = 0\right)$$

**127. (d)** The average power in the circuit where $\cos\phi$ = power factory

$$< P > = V_{rms} \times I_{rms} \cos\phi$$

$$\phi = \pi/3 = \text{phase difference} = \frac{180}{3} = 60$$

$$V_{rms} = \frac{\frac{1}{\sqrt{2}}}{\sqrt{2}} = \frac{1}{2}\text{volt}$$

$$I_{rms} = \frac{\frac{1}{\sqrt{2}}}{\sqrt{2}} = \left(\frac{1}{2}\right) A$$

$$\cos\phi = \cos\frac{\pi}{3} = \frac{1}{2}$$

$$< P > = \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{8} W$$

**128. (d)** When capacitance is taken out, the circuit is LR.

$$\therefore \tan\phi = \frac{\omega L}{R}$$

$$\Rightarrow \omega L = R\tan\phi = 200\times\frac{1}{\sqrt{3}} = \frac{200}{\sqrt{3}}$$

Again , when inductor is taken out, the circuit is CR.

$$\therefore \quad \tan\phi = \frac{1}{\omega CR}$$

$$\Rightarrow \frac{1}{\omega c} = R\tan\phi = 200\times\frac{1}{\sqrt{3}} = \frac{200}{\sqrt{3}}$$

Now, $Z = \sqrt{R^2 + \left(\frac{1}{\omega C} - \omega L\right)^2}$

**129. (d)** Power, $P = \mathbf{I}_{r.m.s} \times V_{r.m.s} \times \cos\phi$

In the given problem, the phase difference between voltage and current is p/2. Hence

$P = \mathbf{I}_{r.m.s} \times V_{r.m.s} \times \cos(\pi/2) = 0.$

**130. (c)** $P = V_{r.m.s} \times I_{r.m.s} \times \cos\phi = \frac{1}{2} V_0\, I_0 \cos\phi$

$$= \frac{1}{2} \times 100 \times (100 \times 10^{-3}) \cos\pi/3 = 2.5\,W$$

**131. (a)** The phase angle between voltage V and current I is π/2. Therefore, power factor cos ϕ = cos (π/2) = 0. Hence the power consumed is zero.

**132. (c)** $P = \frac{E_v^2 \cos\phi}{Z}$

$$P = 3000 = \frac{(240)^2(0.75)}{Z} d \quad \Rightarrow Z = 14.4\Omega$$

**133. (a)** As = $\omega^2 \frac{1}{LC}$ = or $\omega = \frac{1}{\sqrt{LC}}$

Maximum energy stored in capacitor = $\frac{1}{2}\frac{Q_0^2}{C}$

Let at any instant *t*, the energy be stored equally between electric and magnetic field. Then energy stored in electric field at instant *t* is

$$\frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}\left[\frac{1}{2}\frac{Q_0^2}{C}\right]$$

or $Q^2 = \frac{Q_0^2}{2}$ or $Q = \frac{Q_0}{\sqrt{2}}$

$$\Rightarrow Q_0 \cos\omega t = \frac{Q_0}{\sqrt{2}}$$

or $\omega t = \frac{\pi}{4}$ or $t = \frac{\pi}{4\omega} = \frac{\pi}{4\times(1/\sqrt{LC})}$

$$= \frac{\pi\sqrt{LC}}{4}$$

**134. (a)** : Here, $C$ 30 μF = 30 × $10^{-6}$ F,
$L$ = 27 mH = 27 × $10^{-3}$ H

$$\therefore \quad \omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{27\times10^{-3}\times30\times10^{-6}}} = \frac{1}{\sqrt{81\times10^{-8}}}$$

$$= \frac{10^4}{9} = 1.1 \times 10^3 \text{ rad s}^{-1}$$

**135. (d)**

**136. (b)** $\frac{n_p}{n_s} = \frac{E_p}{E_s} = \frac{1}{25}$

$\therefore E_s = 25E_p$

But $E_S I_S = E_P I_P \Rightarrow I_p = \frac{E_S \times I_S}{E_p} \Rightarrow I_p = 50A$

**137. (d)** $\frac{V_2}{V_1} = 0.8\frac{I_1}{I_2} \Rightarrow \frac{V_2 I_2}{V_1 I_1} = 0.8$

$V_1 = 220\,V, I_2 = 2.0\,A, V_2 = 440\,V$

$$I_1 = \frac{V_2\, I_2}{V_1} \times \frac{10}{8} = \frac{440\times2\times10}{220\times8} = 5\,A$$

**138. (b)**

**139. (a)** $\frac{E_s}{E_p} = \frac{n_s}{n_p}$ or $E_s = E_p \times \left(\frac{n_s}{n_p}\right)$

$$\therefore \quad E_s = 120\times\left(\frac{200}{100}\right) = 240\,V$$

$\frac{\mathbf{I}_p}{\mathbf{I}_s} = \frac{n_s}{n_p}$ or $\mathbf{I}_s = \mathbf{I}_p\left(\frac{n_p}{n_s}\right)$ $\therefore$ $\mathbf{I}_s = 10\left(\frac{100}{200}\right) = 5\,\text{amp}$

**140. (c)** $\frac{\mathbf{I}_s}{\mathbf{I}_p} = \frac{n_p}{n_s}$ ; $\frac{80}{\mathbf{I}_p} = \frac{20}{1}$ or $\mathbf{I}_p = 4\,\text{amp.}$

**141. (c)** $\eta = \frac{E_S I_S}{E_P I_P}$ $\therefore \eta = \frac{110 \times 9}{220 \times 5} = 0.9 \times 100\% = 90\%$

**142. (b)** Power of source = EI = 240 × 0.7 = 166

$\Rightarrow$ Efficiency $= \frac{140}{166} \Rightarrow \eta = 83.3\%$

**143. (d)** As $E_p \mathbf{I}_p = P_i$ $\therefore$ $\mathbf{I}_p = \frac{P_i}{E_p} = \frac{4000}{100} = 40\,\text{A}.$

**144. (a)** $N_P = 400, N_S = 2000$ and $V_S = 1000\,\text{V}.$

$\frac{V_P}{V_S} = \frac{N_P}{N_S}$ of, $V_P = \frac{V_S \times N_P}{N_S} = \frac{1000 \times 400}{2000} = 200\text{V}.$

**145. (d)** Power in primary of transformer is

$P_P = V_p.I_P = 220 \times 0.5$
$= 110$ W

But power in secondary of transformer is

$Ps = 100$ W

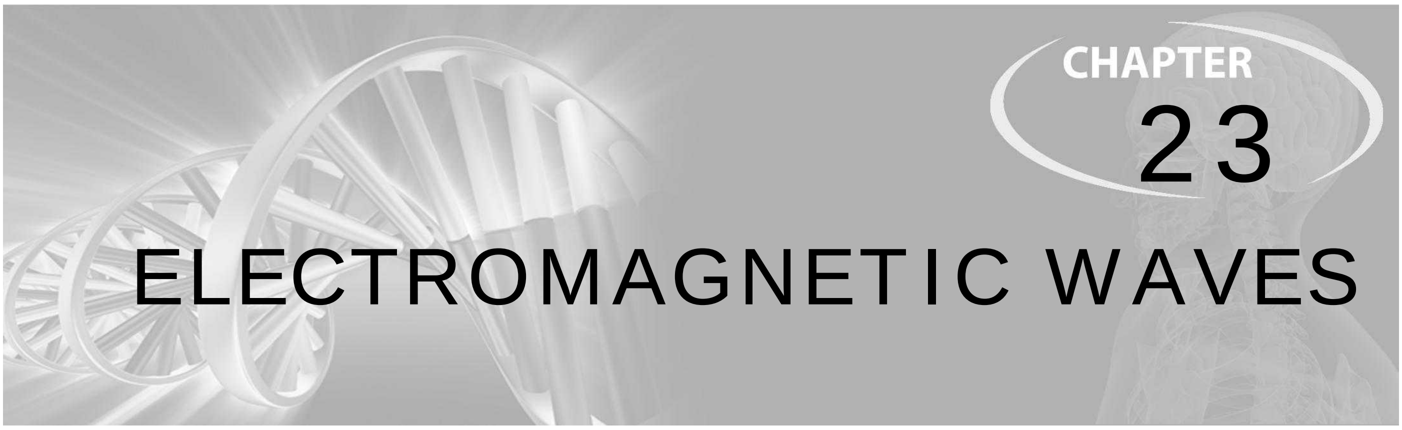
$\therefore \ \eta = \frac{100}{110} = 0.9 = 90\%$

**146. (b)** Efficiency $\eta = \frac{V_s I_s}{V_p I_p}$ $\Rightarrow$ $0.9 = \frac{V_s(6)}{3 \times 10^3}$

$\Rightarrow$ $V_s = 450\,\text{V}$

As $V_p I_p = 3000$ so

$I_p = \frac{3000}{V_p} = \frac{3000}{200}\text{A} = 15\text{A}$



CHAPTER

# 23

# ELECTROMAGNETIC WAVES

## FACT/DEFINITION TYPE QUESTIONS

**1.** The current in the electric circuit which arises due to flow of electrons in the connecting wires of the circuit in a defined closed path is called
(a) alternating current
(b) direct current
(c) conduction current
(d) displacement current

**2.** The conduction current is same as displacement current when source is
(a) ac only (b) dc only
(c) either ac or dc (d) neither dc nor ac

**3.** If a variable frequency ac source connected to a capacitor then with decrease in frequency, the displacement current will
(a) increase
(b) decrease
(c) remain constant
(d) first decrease then increase

**4.** Displacement current goes through the gap between the plates of a capacitor when the charge on the capacitor
(a) is changing with time (b) decreases
(c) does not change (d) decreases to zero

**5** The displacement current was first postulated by
(a) Maxwell (b) Marconi
(c) Ampere (d) Hertz

**6.** Ampere's circuital law holds good for
(a) conduction current (b) displacement current
(c) both (a) and (b) (d) None of these

**7.** When radio waves passes through ionosphere, phase difference between space current and capacitive displacement current is
(a) 0 rad (b) $(3\pi/2)$ rad
(c) $(\pi/2)$ rad (d) $\pi$ rad

**8.** Displacement current is
(a) continuous when electric field is changing in the circuit
(b) continuous when magnetic field is changing in the circuit
(c) continuous in both types of fields
(d) continuous through wires and resistance only

**9.** The displacement current is
(a) $\varepsilon_o\, d\phi_E/dt$ (b) $\frac{\varepsilon_o}{R}\, d\phi_E/dt$
(c) $\varepsilon_o\, E/R$ (d) $\varepsilon_o\, q\, C/R$

**10.** Maxwell's equation describe the fundamental law of
(a) electricity (b) magnetism
(c) mechanics (d) both (a) and (b)

**11.** If $\vec{E}$ and $\vec{B}$ represent the electric and magnetic field vectors of an electromagnetic wave, then the direction of propagation of the electromagnetic wave, is along
(a) $\vec{E}$ (b) $\vec{B}$
(c) $\vec{B}\times\vec{E}$ (d) $\vec{E}\times\vec{B}$

**12.** According to Maxwell's hypothesis, a changing electric field gives rise to
(a) an e.m.f
(b) electric displacement current
(c) magnetic field
(d) pressure gradient

**13.** Electromagnetic wave consists of periodically oscillating electric and magnetic vectors
(a) in mutually perpendicular planes but vibrating with a phase difference of $\pi$
(b) in mutually perpendicular planes but vibrating with a phase difference of $\frac{\pi}{2}$
(c) in randomly oriented planes but vibrating in phase
(d) in mutually perpendicular planes but vibrating in phase

**14.** An electromagnetic wave propagating along north has its electric field vector upwards. Its magnetic field vector point towards
(a) north (b) east
(c) west (d) downwards

**15.** The electromagnetic waves
(a) travel with the speed of sound
(b) travel with the same speed in all media
(c) travel in free space with the speed of light
(d) do not travel through a medium

**16.** Which of the following type of radiations are radiated by an oscillating electric charge?
(a) Electric (b) Magnetic
(c) Thermoelectric (d) Electromagnetic

**17.** If $\vec{E}$ and $\vec{B}$ are the electirc and magnetic field vectors of e.m. waves then the direction of propagation of e.m. wave is along the direction of
(a) $\vec{E}$ (b) $\vec{B}$
(c) $\vec{E} \times \vec{B}$ (d) None of these

**18.** According to Maxwell's equation the velocity of light in any medium is expressed as
(a) $\frac{1}{\sqrt{\mu_0 \varepsilon_o}}$ (b) $\frac{1}{\sqrt{\mu \varepsilon}}$ (c) $\sqrt{\mu / \varepsilon}$ (d) $\sqrt{\frac{\mu_0}{\varepsilon}}$

**19.** The electromagnetic waves do not transport
(a) energy (b) charge
(c) momentum (d) information

**20.** The amplitudes of electric and magnetic fields related to each other are
(a) $E_0 = B_0$ (b) $E_0 = c B_0$
(c) $E_0 = \frac{B_0}{c}$ (d) $E_0 = \frac{c}{B_0}$

**21.** In an electromagnetic wave, the direction of the magnetic induction $\vec{B}$ is
(a) parallel to the electric field $\vec{E}$
(b) perpendicular to the electric field $\vec{E}$
(c) antiparallel to the Poynting vector $\vec{S}$
(d) random

**22.** The speed of electromagnetic wave is same for
(a) odd frequencies (b) even frequencies
(c) all frequencies (d) all intensities

**23.** A plane electromagnetic wave is incident on a material surface. If the wave delivers momentum p and energy E, then
(a) $p = 0, E = 0$ (b) $p \neq 0, E \neq 0$
(c) $p \neq 0, E = 0$ (d) $p = 0, E \neq 0$

**24.** We consider the radiation emitted by the human body. Which one of the following statements is true?
(a) The radiation emitted is in the infrared region.
(b) The radiation is emitted only during the day.
(c) The radiation is emitted during the summers and absorbed during winters.
(d) The radiation is emitted lies in the ultraviolet region and hence is not visible.

**25.** The decreasing order of wavelength of infrared, microwave, ultraviolet and gamma rays is
(a) microwave, infrared, ultraviolet, gamma rays
(b) infrared, microwave, ultraviolet, gamma rays
(c) gama rays, ultraviolet, infrared, microwaves
(d) microwaves, gamma rays, infrared, ultraviolet

**26.** X-rays, gamma rays and microwaves travelling in vaccum have
(a) same wavelength but different velocities
(b) same frequency but different velocities
(c) same velocity but different wavelength
(d) same velocity and same frequency

**27.** Radio waves diffract around building, although light waves do not. The reason is that radio waves
(a) travel with speed larger than *c*
(b) have much larger wavelength than light
(c) are not electromagnetic waves
(d) None of these

**28.** Microwaves are detected by
(a) bolometer (b) point contact diodes
(c) thermopiles (d) the eye

**29.** Which of the following electromagnetic waves has the longest wavelength?
(a) uv-rays
(b) Visible light
(b) Radio waves
(d) Microwaves

**30.** Which of the following is of shortest wavelength?
(a) X-rays (b) $\gamma$-rays
(c) Microwaves (d) Radio waves

**31.** The range of wavelength of visible light is
(a) 10 Å to 100 Å (b) 4000 Å to 8000 Å
(c) 8000 Å to 10,000 Å (d) 10,000 Å to 15,000 Å

**32.** Which of the following is not electromagnetic waves?
(a) Cosmic rays (b) Gamma rays
(c) $\beta$-rays (d) X-rays

**33.** Which of the following electromagnetic radiations have the smallest wavelength?
(a) Ultraviolet waves (b) X-rays
(c) $\gamma$-rays (d) Microwaves

**34.** Which of the following rays has minimum frequency?
(a) U.V. ways (b) X-rays
(c) $\gamma$-rays (d) Infra-red rays

**35.** An accelerated electron would produce
(a) $\gamma$-rays (b) $\beta$-rays
(c) $\alpha$-rays (d) e.m. waves

**36.** Which of the following is the infrared wavelength?
(a) $10^{-4}$ cm (b) $10^{-5}$ cm
(c) $10^{-6}$ cm (d) $10^{-7}$ cm

**37.** The wavelength of X-ray is of the order of
(a) 1 metre (b) 1 cm
(c) 1 micron (d) 1 angstrom

**38.** Radio waves of constant amplitude can be generated with
(a) rectifier (b) filter
(c) F.E.T. (d) oscillator

**39.** Radio waves do not penetrate in the band of
(a) ionosphere (b) mesosphere
(c) troposphere (d) stratosphere

**40.** What is the cause of "Green house effect"?
(a) Infrared rays (b) Ultraviolet rays
(c) X-rays (d) Radio waves

**41.** If $v_s$, $v_x$ and $v_m$ are the speed of soft gamma rays, X-rays and microwaves respectively in vacuum, then

(a) $v_s > v_x > v_m$ (b) $v_s < v_x < v_m$

(c) $v_s > v_x < v_m$ (d) $v_s = v_x = v_m$

**42.** The waves which are electromagnetic in nature are

(a) sound waves and light waves

(b) water waves and radio waves

(c) light waves and X-rays

(d) sound waves and water waves

**43.** In electromagnetic spectrum, the frequencies $\gamma$-rays, X-rays and ultraviolet rays are denoted by $n_1$, $n_2$ and $n_3$ respectively then

(a) $n_1 > n_2 > n_3$ (b) $n_1 < n_2 < n_3$

(c) $n_1 > n_2 < n_3$ (d) $n_1 < n_2 > n_3$

**44.** Ultraviolet spectrum can be studied by using a

(a) flint glass prism (b) direct vision prism

(c) nicol prism (d) quartz prism

**45.** The ozone layer in the atmosphere absorbs

(a) only the radiowaves

(b) only the visible light

(c) only the $\gamma$-rays

(d) X-rays and ultraviolet rays

**46.** Which one of the following has the maximum energy?

(a) Radio waves (b) Infrared rays

(c) Ultraviolet rays (d) Micro waves

**47.** Which one of the following has the shortest wavelength?

(a) Infrared rays (b) Ultraviolet rays

(c) Microwaves (d) Gamma rays

**48.** When electromagnetic waves enter the ionised layer of ionosphere, then the relative permittivity i.e. dielectric constant of the ionised layer

(a) does not change

(b) appears to increase

(c) appears to decrease

(d) sometimes appears to increase and sometimes to decrease

**49.** Ultraviolet rays coming from sun are absorbed by

(a) troposphere (b) ionosphere

(c) stratosphere (d) mesosphere

**50.** The EM waves when travel into different media gets

(a) refracted (b) transmitted

(c) reflected (d) emitted

**51.** The absorption of radio waves by the atmosphere depends upon

(a) their velocities

(b) their frequencies

(c) their distance from the transmitter

(d) None of these

**52.** The velocity of all radio waves in free space is $3 \times 10^8$ m/s. The frequency of a radio wave of wavelength 150m is

(a) 20 kHz (b) 2 kHz (c) 2 MHz (d) 1 MHz

**53.** The polarisation of electromagnetic wave is in

(a) the directions of electric and magnetic field

(b) the directions of electric field

(c) the direction of magnetic field

(d) can not be polarized

**54.** If the frequency of EM radiations is halved then the energy of EM radiation will become

(a) double (b) remains unchanged

(c) becomes half (d) becomes one fourth

**55.** Microwaves are electromagnetic waves with frequency in the range of

(a) Micro hertz (b) Giga hertz

(c) Mega hertz (d) Hertz

**56.** For television broadcasting the frequency employed is normally

(a) 30-300 MHz (b) 30-300 GHz

(c) 30-300 kHz (d) 30-300 Hz

**57.** Electromagnetic waves of frequency .... are reflected from ionosphere.

(a) 100 MHz (b) 2 MHz to 80 MHz

(c) upto 1.5 MHz (d) less than 1.5 MHz

**58.** When an electromagnetic wave enters an ionised layer of earth's atmosphere present in ionosphere

(a) the electron cloud will not oscillate in the electric field of the wave

(b) the electron cloud will oscillate in the electric field of wave in the phase of sinusoidal electromagnetic wave

(c) the electron cloud will oscillate in the electric field of wave in the opposite phase of sinusoidal electromagnetic wave

(d) the electron cloud will oscillate in the electric field of wave with a phase retardation of 90° for a sinusoidal electromagnetic wave.

**59.** An electron oscillating with a frequency of $3 \times 10^6$ Hz, would generate

(a) X-rays (b) ultraviolet rays

(c) radio waves (d) microwaves

**60.** The cellular mobile radio frequency band is

(a) 88 – 108 MHz (b) 54 – 72 MHz

(c) 540 – 1600 KHz (d) 840 – 935 MHz

**61.** Select the wrong statement. EM waves

(a) are transverse in nature.

(b) travel in free space at a speed of light.

(c) are produced by accelerating charges.

(d) travel in all media with same speed.

**62.** Ozone layer above earth's atmosphere will not

(a) prevent infrared radiations from sun reaching earth.

(b) prevent infra red radiations originated from earth from escaping earth's atmosphere.

(c) prevent ultraviolet rays from sun.

(d) reflect back radio waves.

**63.** Intensity of electromagnetic wave will be

(a) $I = c\mu_0 B_0^2 / 2$
(b) $I = c\varepsilon_0 B_0^2 / 2$
(c) $I = B_0^2 / c\mu_0$
(d) $I = E_0^2 / 2c\varepsilon_0$

**64.** The frequency of electromagnetic wave, which best suited to observe a particle of radii $3 \times 10^{-4}$ cm is of the order of

(a) $10^{15}$
(b) $10^{14}$
(c) $10^{13}$
(d) $10^{12}$

**65.** If $\lambda = 10\,\text{Å}$ then it corresponds to

(a) infrared
(b) microwaves
(c) ultraviolet
(d) X-rays

**66.** 10 cm is a wavelength corresponding to the spectrum of

(a) infrared rays
(b) ultra-violet rays
(c) microwaves
(d) $\gamma$ -rays

**67.** In an electromagnetic wave

(a) power is transmitted along the magnetic field
(b) power is transmitted along the electric field
(c) power is equally transferred along the electric and magnetic fields
(d) power is transmitted in a direction perpendicular to both the fields

**68.** The electric and the magnetic field associated with an E.M. wave, propagating along the +z-axis, can be represented by

(a) $\left[\vec{E} = E_0\hat{i}, \vec{B} = B_0\hat{j}\right]$
(b) $\left[\vec{E} = E_0\vec{k}, \vec{B} = B_0\hat{i}\right]$
(c) $\left[\vec{E} = E_0\hat{j}, \vec{B} = B_0\hat{i}\right]$
(d) $\left[\vec{E} = E_0\hat{j}, \vec{B} = B_0\hat{k}\right]$

**69.** The condition under which a microwave oven heats up a food item containing water molecules most efficiently is

(a) the frequency of the microwaves has no relation with natural frequency of water molecules.
(b) microwaves are heat waves, so always produce heating.
(c) infra-red waves produce heating in a microwave oven.
(d) the frequency of the microwaves must match the resonant frequency of the water molecules.

**70.** Which of the following radiations has the least wavelength ?

(a) $\gamma$ -rays
(b) $\beta$ -rays
(c) $\alpha$ -rays
(d) X -rays

**71.** Which of the following has/have zero average value in a plane electromagnetic wave ?

(a) Both magnetic and electric field
(b) Electric field only
(c) Magnetic energy
(d) Electric energy

**72.** The ratio of electric field vector E and magnetic field vector H i.e., $\left(\frac{E}{H}\right)$ has the dimensions of

(a) resistance
(b) inductance
(c) capacitance
(d) product of inductance and capacitance

**73.** The ozone layer absorbs radiation of wavelengths

(a) less than $3 \times 10^{-7}$ m
(b) more than $3 \times 10^{-7}$ m
(c) less than $3 \times 10^{-5}$ m
(d) more than $3 \times 10^{-5}$ m

**74.** The speed of electromagnetic wave in vacuum depends upon the source of radiation. It

(a) increases as we move from $\gamma$-rays to radio waves
(b) decreases as we move from $\gamma$-rays to radio waves
(c) is same for all of them
(d) None of these

**75.** In which one of the following regions of the electromagnetic spectrum will the vibrational motion of molecules give rise to absorption ?

(a) Ultraviolet
(b) Microwaves
(c) Infrared
(d) Radio waves

**76.** The oscillating electric and magnetic vectors of an electromagnetic wave are oriented along

(a) the same direction but differ in phase by 90°
(b) the same direction and are in phase
(c) mutually perpendicular directions and are in phase
(d) mutually perpendicular directions and differ in phase by 90°

**77.** Biological importance of ozone layer is

(a) it stops ultraviolet rays
(b) ozone layer reduce green house effect
(c) ozone layer reflects radio waves
(d) ozone layer controls $O_2 / H_2$ radio in atmosphere

**78.** It is possible to take pictures of those objects which are not fully visible to the eye using camera films sensitive to

(a) ultraviolet rays
(b) infrared rays
(c) microwaves
(d) radiowaves

**79.** The waves used in telecommunication are

(a) IR
(b) UV
(c) Microwave
(d) Cosmic rays

**80.** The electromagnetic radiation used in food processing sterilizing agent is

(a) microwaves
(b) UV rays
(c) gamma rays
(d) radio waves

## STATEMENT TYPE QUESTIONS

**81.** Select the correct statement(s) from the following.

I. Displacement current comes into play in a region where electric field is changing with time.

II. Displacement current $I_D = \varepsilon_0 \frac{\partial\phi E}{\phi t}$

III. In case of a steady electric flux linked with a region the displacement current is minimum.

(a) I only
(b) II only
(c) I and II only
(d) I, II and III

**82.** An electromagnetic wave of intensity $I$ falls on a surface kept in vacuum and exerts radiation pressure $P$ on it. Which of the following statements are true?

I. Radiation pressure is $I/c$ if the wave is totally absorbed.
II. Radiation pressure is $I/c$ if the wave is totally reflected.
III. Radiation pressure is 2 $I/c$ if the wave is totally reflected.

(a) I and II (b) I and III
(c) III only (d) I, II and III

**83.** Which of the following is/are true for electromagnetic waves?

I. They transport energy.
II. They have momentum.
III. They travel at different speeds in air depending on their frequency.

(a) I and III (b) II only
(c) I, II and III (d) I and II

**84.** The amplitude of an electromagnetic wave in vacuum is doubled with no other changes made to the wave. As a result of this doubling of the amplitude, which of the following statements are incorrect?

I. The speed of wave propagation chages only
II. The frequency of the wave changes only
III. The wavelength of the wave changes only

(a) I and II (b) II and III
(c) I and III (d) I, II and III

**85.** Select the correct statement(s) from the following.

I. Wavelength of microwaves is greater than that of ultraviolet rays.
II. The wavelength of infrared rays is lesser than that of ultraviolet rays.
III. The wavelength of microwaves is lesser than that of infrared rays
IV. Gamma ray has shortest wavelength in the electromagnetic spectrum

(a) I and II (b) II and III
(c) III and IV (d) I and IV

## MATCHING TYPE QUESTIONS

**86.** Match the columns I and II.

| **Column I** | **Column II** |
|---|---|
| (A) Energy associated with an electromagnetic wave | 1. $\frac{1}{\sqrt{\mu\varepsilon}}$ |
| (B) Radiation pressure | 2. $\frac{u}{c}$ |
| (C) Speed of EM wave in a medium | 3. $\frac{1}{2}\varepsilon_0 E^2 + \frac{1}{2}\frac{B^2}{\mu_0}$ |
| (D) Displacement current | 4. $I_D = \varepsilon_0 \frac{d\phi E}{dt}$ |

(a) (A) → (3); (B) → (2); (C) → (1); (D) → (4)
(b) (A) → (2); (B) → (2); (C) → (4); (D) → (3)
(c) (A) → (4); (B) → (3); (C) → (2); (D) → (1)
(d) (A) → (2); (B) → (1); (C) → (4); (D) → (3)

**87.** Various electromagnetic waves are given in column I and various frequency ranges in column II. Match the two columns.

| **Column I** | **Column II** |
|---|---|
| (A) Radio waves | (1) $1 \times 10^{16}$ to $3 \times 10^{21}$ Hz |
| (B) γ–rays | (2) $1 \times 10^{9}$ to $3 \times 10^{11}$ HZ |
| (C) Microwaves | (3) $3 \times 10^{18}$ to $5 \times 10^{22}$ Hz |
| (D) X-rays | (4) $5 \times 10^{5}$ to $10^{9}$ Hz. |

(a) (A) → (2); (B) → (5); (C) → (3); (D) → (4)
(b) (A) → (2); (B) → (2); (C) → (4); (D) → (3)
(c) (A) → (4); (B) → (3); (C) → (2); (D) → (1)
(d) (A) → (2); (B) → (1); (C) → (4); (D) → (3)

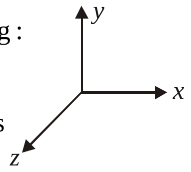
**88.** Match the Column I and Column II.

| **Column I**<br>Electromagnetic wave | **Column II**<br>Use |
|---|---|
| (A) ultraviolet rays | (1) In satellite for army purpose |
| (B) Infrared rays | (2) Aircraft navigation in' RADAR |
| (C) Microwave | (3) Television and cellular phones |
| (D) Radio wave | (4) Checking mineral sample |

(a) (A) → (4); (B) → (1); (C) → (2); (D) → (3)
(b) (A) → (2); (B) → (2); (C) → (4); (D) → (3)
(c) (A) → (4); (B) → (3); (C) → (2); (D) → (1)
(d) (A) → (2); (B) → (1); (C) → (4); (D) → (3)

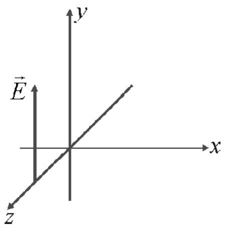
## DIAGRAM TYPE QUESTIONS

**89.** Light wave is travelling along $y$-direction. If the corresponding $\vec{E}$ vector at any time is along the $x$-axis, the direction of $\vec{B}$ vector at that time is along :



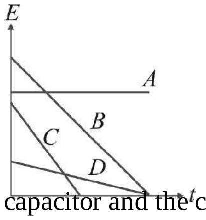
(a) $y$-axis (b) $x$-axis
(c) $+z$-axis (d) $-z$-axis

**90.** The figure here gives the electric field of an electromagnetic wave at a certain point and a certain instant. The wave is transporting energy in the negative $z$-direction. The direction of the magnetic field of the wave at that point and instant is



(a) + ve $x$-direction (b) –ve $x$-direction
(c) +ve $z$-direction (d) –ve $y$-direction

**91.** The figure shows graphs of the electric field magnitude $E$ versus time $t$ for four uniform electric fields, all contained within identical circular regions. Which of them is according to the magnitudes of the magnetic field?



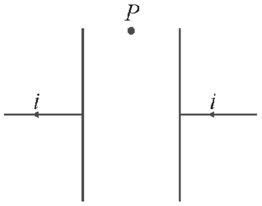
(a) $A$

(b) $B$

(c) $C$

(d) $D$

**92.** Figure shows a parallel plate capacitor and the current in the connecting wires that is discharging the capacitor.



(a) The displacement current is leftward.

(b) The displacement current is rightward

(c) The electric field $\vec{E}$ is rightward

(d) The magnetic field at point $P$ is out the page.

## ASSERTION- REASON TYPE QUESTIO

**Directions** : Each of these questions contains two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

**93.** **Assertion :** Displacement current goes through the gap between the plates of a capacitor when the charge of the capacitor does not change.

**Reason :** The displacement current arises in the region in which the electric field is constant with time.

**94.** **Assertion :** When variable frequency a.c. source is connected to a capacitor, displacement current increases with increase in frequency.

**Reason :** As frequency increases conduction current also increases.

**95.** **Assertion :** The displacement current in a parallel-plate capacitor of capacitance $C$ can be written as $i_d = C\left(\frac{dV}{dt}\right)$, where $V$ is the potential difference between the plates.

**Reason :** The displacement current in free space is given by $i_d = \epsilon_0 \frac{d\phi_e}{dt}$.

**96.** **Assertion :** Electromagnetic wave are transverse in nature.

**Reason :** The electric and magnetic fields in electromagnetic waves are perpendicular to each other and the direction of propagation.

**97.** **Assertion :** Electromagnetic waves interact with matter and set up oscillations.

**Reason :** Interaction is independent of the wavelength of the electromagnetic wave.

**98.** **Assertion :** Electromagnetic waves carry energy and momentum.

**Reason :** Electromagnetic waves can be polarised.

**99.** **Assertion :** Electromagnetic waves exert radiation pressure.

**Reason :** Electromagnetic waves carry energy.

**100.** **Assertion :** The electromagnetic wave is transverse in nature.

**Reason :** Electromanetic wave propagates parallel to the direction of electric and magnetic fields.

**101.** **Assertion :** The velocity of electromagnetic waves depends on electric and magnetic properties of the medium.

**Reason :** Velocity of electromagnetic waves in free space is constant.

**102.** **Assertion :** The basic difference between various types of electromagnetic waves lies in their wavelength or frequencies.

**Reason :** Electromagnetic waves travel through vacuum with the same speed.

**103.** **Assertion :** Microwaves are better carrier of signals than optical waves.

**Reason :** Microwaves move faster than optical waves.

**104.** **Assertion :** Infrared radiation plays an important role in maintaining the average temperature of earth.

**Reason :** Infrared radiations are sometimes referred to as heat waves.

## CRITICAL THINKING TYPE QUESTIONS

**105.** The charge on a parallel plate capacitor varies as $q = q_0 \cos 2\pi\upsilon t$. The plates are very large and close together (area = $A$, separation = $d$). The displacement current through the capacitor is

(a) $q_0\ 2\pi\upsilon \sin\pi\upsilon t$  (b) $-q_0\ 2\pi\upsilon \sin 2\pi\upsilon t$

(c) $q_0\ 2\pi \sin\pi\upsilon t$  (d) $q_0\ \pi\upsilon \sin 2\pi\upsilon t$

**106.** When an electromagnetic waves enter the ionised layer of ionosphere, the motion of electron cloud produces a space current and the electric field has its own capacitative displacement current, then

(a) the space current is in phase of displacement current

(b) the space current lags behind the displacement current by a phase 180°.

(c) the space current lags behind the displacement current by a phase 90°.

(d) the space current leads the displacement current by a phase 90°.

**107.** In order to establish an instantaneous displacemet current of 1 mA in the space between the plates of 2μF parallel plate capacitor, the potential difference need to apply is

(a) 100 $Vs^{-1}$ (b) 200 $Vs^{-1}$
(c) 300 $Vs^{-1}$ (d) 500 $Vs^{-1}$

**108.** The electric field of an electromagnetic wave travelling through vaccum is given by the equation $E = E_0 \sin(kx - \omega t)$. The quantity that is independent of wavelength is

(a) $k\omega$ (b) $\frac{k}{\omega}$
(c) $k^2\omega$ (d) $\omega$

**109.** An electromagnetic wave of frequency $\upsilon = 3$ MHz passes from vacuum into a dielectric medium with permittivity $\varepsilon = 4$. Then

(a) wavelength and frequency both become half.
(b) wavelength is doubled and frequency remains unchanged.
(c) wavelength and frequncy both remain unchanged.
(d) wavelength is halved and frequency remains unchanged.

**110.** The electric field associated with an e.m. wave in vacuum is given by $\vec{E} = \hat{i}\ 40 \cos(kz - 6 \times 10^8 t)$, where $E$, $z$ and $t$ are in volt/m, meter and seconds respectively. The value of wave vector $k$ is

(a) 2 $m^{-1}$ (b) 0.5 $m^{-1}$
(c) 6 $m^{-1}$ (d) 3 $m^{-1}$

**111.** The magnetic field in a travelling electromagnetic wave has a peak value of 20 nT. The peak value of electric field strength is

(a) 3 V/m (b) 6 V/m (c) 9 V/m (d) 12 V/m

**112.** If a source is transmitting electromagnetic wave of frequency $8.2 \times 10^6$ Hz, then wavelength of the electromagnetic waves transmitted from the source will be

(a) 36.6 m (b) 40.5 m
(c) 42.3 m (d) 50.9 m

**113.** In a plane electromagnetic wave propagating in space has an electric field of amplitude $9 \times 10^3$ V/m, then the amplitude of the magnetic field is

(a) $2.7 \times 10^{12}$ T (b) $9.0 \times 10^{-3}$ T
(c) $3.0 \times 10^{-4}$ T (d) $3.0 \times 10^{-5}$ T

**114.** In an electromagnetic wave, the electric and magnetic fields are 100 V $m^{-1}$ and 0.265 A $m^{-1}$. The maximum energy flow is

(a) 26.5 $W/m^2$ (b) 36.5 $W/m^2$
(c) 46.7 $W/m^2$ (d) 765 $W/m^2$

**115.** The transmitting antenna of a radiostation is mounted vertically. At a point 10 km due north of the transmitter the peak electric field is $10^{-3}$ $Vm^{-1}$. The magnitude of the radiated magnetic field is .

(a) $3.33 \times 10^{-10}$ T (b) $3.33 \times 10^{-12}$ T
(c) $10^{-3}$ T (d) $3 \times 10^5$ T

**116.** A plane electromagnetic wave travels in free space along x-axis. At a particular point in space, the electric field along y-axis is 9.3V $m^{-1}$. The magnetic induction (B) along z-axis is

(a) $3.1 \times 10^{-8}$ T (b) $3 \times 10^{-5}$ T
(c) $3 \times 10^{-6}$ T (d) $9.3 \times 10^{-6}$ T

**117.** A new system of unit is evolved in which the values of $\mu_0$ and $\epsilon_0$ are 2 and 8 respectively. Then the speed of light in this system will be

(a) 0.25 (b) 0.5
(c) 0.75 (d) 1

**118.** The rms value of the electric field of the light coming from the Sun is 720 N/C. The average total energy density of the electromagnetic wave is

(a) $4.58 \times 10^{-6}$ $J/m^3$ (b) $6.37 \times 10^{-9}$ $J/m^3$
(c) $81.35 \times 10^{-12}$ $J/m^3$ (d) $3.3 \times 10^{-3}$ $J/m^3$

**119.** The transmitting antenna of a radiostation is mounted vertically. At a point 10 km due north of the transmitter the peak electric field is $10^{-3}$ $Vm^{-1}$. The magnitude of the radiated magnetic field is

(a) $3.33 \times 10^{-10}$ T (b) $3.33 \times 10^{-12}$ T
(c) $10^{-3}$ T (d) $3 \times 10^5$ T

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(c)** **2.** **(c)**

**3.** **(b)** Current through capacitor,

$$I = \frac{E}{X_C} = \frac{E}{\frac{1}{\omega C}} = \omega CE = 2\pi \upsilon\, CE \text{ or } I \propto \upsilon.$$

$\therefore$ decrease in frequency $\upsilon$ of ac source decreases the conduction current. As displacement current is equal to conduction current, decrease in $\upsilon$ decreases displacement current in circuit.

**4.** **(a)** Displacement current arises when electric field in a region is changing with time. It will be so if the charge on a capacitor is changing with time.

**5.** **(a)**

**6.** **(c)** In the steady state $\oint B.dl = \mu_o(I)$, where I is conduction current.

[In non steady state $\oint B.d\ell = (I + I_d)$, where $I_d$ is displacement current.]

**7.** **(a)**

**8.** **(a)** Displacement current is set up in a region where the electric field is changing with time.

**9.** **(a)** $I_D = \varepsilon_o\, d\phi_E / dt$.

**10.** **(d)** Maxwell's equations describe the fundamental laws of electricity and magnetism.

**11.** **(d)**

**12.** **(c)** According to Maxwell, a changing electric field is a source of magnetic field.

**13.** **(d)** Electromagnetic wave consists of periodically oscillating electric and magnetic vectors in mutually perpendicular planes but vibrating in phase.

**14.** **(b)**

**15.** **(c)** The electromagnetic waves of all wavelengths travel with the same speed in space which is equal to velocity of light.

**16.** **(d)**

**17.** **(c)** The direction of propagation of electromagnetic wave is perpendicular to the variation of electric field $\vec{E}$ as well as to the magnetic field $\vec{B}$

**18.** **(b)** Velocity of light in a medium,

$$c = \frac{1}{\sqrt{\mu_0\, \varepsilon_o\, \mu_r\, \varepsilon_r}} = \frac{1}{\sqrt{\mu\, \varepsilon}}$$

**19.** **(b)** **20.** **(b)** **21.** **(b)**

**22.** **(d)** The speed of electromagnetic wave in a region is same for all intensities but different for different frequencies.

**23.** **(b)** An electromagnetic wave has both energy and momentum.

**24.** **(a)** Every body at all time, at all temperature emit radiation (except at $T = 0$), which fall in the infrared region.

**25.** **(a)**

**26.** **(c)** In vacuum X-rays, gamma rays and microwaves travel with same velocity, i.e., with the velocity of light $c$ (=3 × $10^8$ m $s^{-1}$) but have different wavelengths.

**27.** **(b)** The wavelength of radiowaves being much larger than light, has a size comparable to those of buildings, hense diffract from them.

**28.** **(b)** **29.** **(b)** **30.** **(b)**

**31.** **(b)** The range of visible radiations is 4000Å to 8000 Å

**32.** **(a)** Cosmic rays are coming from outer space, having high energy charged particles, like a-particle, proton etc. b-rays are stream of high energy electrons, coming from the nucleus of radioactive atoms.

**33.** **(c)** **34.** **(c)** **35.** **(d)**

**36.** **(a)** The wavelength of infrared region is 8 × $10^{-5}$ cm to 3 × $10^{-3}$ cm. So maximum wavelength of infrared region

$= 8 \times 10^{-5}$ cm $\approx 10^{-4}$ cm.

**37.** **(d)** **38.** **(d)**

**39.** **(a)** Radiowaves are reflected by ionosphere.

**40.** **(a)** **41.** **(d)**

**42.** **(c)** Light waves and X-rays are electromagnetic waves.

**43.** **(a)** From electromagnetic spectrum, frequencies of $\gamma$-rays is greater than frequency of X-rays. Frequency of X-rays is greater than frequency of ultraviolet rays.

**44.** **(d)** **45.** **(d)** **46.** **(c)** **47.** **(d)**

**48.** **(c)** **49.** **(b)** **50.** **(c)** **51.** **(a)**

**52.** **(c)** Here : Velocity of electromagnetic waves in free space and wavelength

$v = 3 \times 10^8$ m/s and $\lambda = 150\, m$

The frequency of radio waves is given by

$$= \frac{v}{\lambda} = \frac{3 \times 10^8}{150} = 2 \times 10^6\, Hz = 2 \text{ MHz}.$$

**53.** **(b)** **54.** **(c)** **55.** **(b)** **56.** **(a)** **57.** **(b)**

**58.** **(d)** **59.** **(c)** **60.** **(d)** **61.** **(d)**

**62.** **(d)** Ozone layer will absorb ultraviolet rays; reflect the infrared radiation and does not reflect back radiowaves.

**63.** **(b)** **64.** **(a)** **65.** **(d)** **66.** **(c)** **67.** **(d)**

**68.** **(a)** E.M. wave always propagates in a direction perpendicular to both electric and magnetic fields. So, electric and magnetic fields should be along + X and + Y- directions respectively. Therefore, option (a) is the correct option.

**69.** **(d)** Required condition : Frequency of microwaves = Resonant frequency of water molecules.

**71.** **(a)** $\xrightarrow[\text{RMIVUXGC}]{\lambda \text{ decrea}\sin g}$

R → Radio waves M → Micro waves

I → Infra red rays V → Visible rays

U → Ultraviolet rays X → x rays

G → γ rays C → Cosmic rays

⇒ γ rays has least wavelength

**71.** **(a)** Both magnetic and electric fields have zero average value in a plane e.m. wave.

**72.** **(a)** **73.** **(a)**

**74.** **(c)** Speed of EM waves in vacuum $= \dfrac{1}{\sqrt{\mu_0 \in_0}}$ = constant

**75.** **(b)** Molecular spectra due to vibrational motion lie in the microwave region of EM-spectrum. Due to Kirchhoff's law in spectroscopy the same will be absorbed.

**76.** **(c)** $\vec{\text{E}}$ and $\vec{\text{B}}$ are mutually perpendicular to each other and are in phase i.e., they become a zero and minimum at the same place and at the same time.

**77.** **(a)** **78.** **(b)** **79.** **(c)** **80.** **(b)**

## STATEMENT TYPE QUESTIONS

**81.** **(c)**

**82.** **(b)** Momentum per unit time per unit area

$$= \frac{\text{intensity}}{\text{speed of wave}} = \frac{I}{c}$$

Change in momentum per unit time per unit area $= \Delta I/c$ = radiation pressure ($P$), *i.e.* $P = \Delta I/c$.

Momentum of incident wave per unit time per unit area $= I/c$

When wave is fully absorbed by the surface, the momentum of the reflected wave per unit time per unit area = 0

Radiation pressure ($P$) = change in momentum per unit time per unit area $= \dfrac{\Delta I}{c} = \dfrac{I}{c} - 0 = \dfrac{I}{c}$

When wave is totally reflected, then mommentum of the reflected wave per unit time per unit area $= -I/c$.

Radiation pressure $(P) = \dfrac{I}{c} - \left(-\dfrac{I}{c}\right) = \dfrac{2I}{c}$

Here, $P$ lies between $\dfrac{I}{c}$ and $\dfrac{2I}{c}$.

**83.** **(c)**

**84.** **(d)** **:** Velocity of electromagnetic wave

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = 3 \times 10^8\ m\ \text{s}^{-1}$$

It is independent of amplitude, frequency and wavelength of electromagnetic wave.

**85.** **(d)** **:** $\lambda_{\text{micro}} > \lambda_{\text{infrared}} > \lambda_{\text{ultraviolet}} > \lambda_{\text{gamma}}$

## MATCHING TYPE QUESTIONS

**86.** **(a)** (A) → (3); (B) → (2); (C) → (1); (D) → (4)

**87.** **(c)** (A) → (4); (B) → (3); (C) → (2); (D) → (1)

The frequency ranges of various waves are as under : Radiowaves ; $5 \times 10^5$ to $10^9$ Hz; γ-rays ; $3 \times 10^{18}$ to $5 \times 10^{22}$ Hz Microwaves; $1 \times 10^9$ to $3 \times 10^{11}$ Hz; X-rays ; $1 \times 10^{16}$ to $3 \times 10^{21}$ Hz.

**88.** **(a)** (A) → (4); (B) → (1); (C) → (2); (D) → (3)

## DIAGRAM TYPE QUESTIONS

**89.** **(c)** Light wave is an electromagnetic wave in which $\vec{E}$ and $\vec{B}$ are at right angles to each other as well as at right angles to the direction of wave propagation.

**90.** **(a)** Direction of energy progration of EM-waves is given by

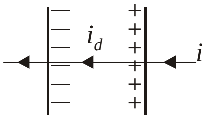
$$\vec{D} = K(\vec{E} \times \vec{B}) \qquad \text{or} \qquad -\hat{k} = K(E\,\hat{j} \times \vec{B})$$

Clearly direction of magnetic field is along positive $x$-axis.

**91.** **(c)** $\oint \vec{B}.d\vec{\ell}\sqrt{b^2 - 4ac} = \mu_0 \in_0 \dfrac{d\phi}{dt}$

or $B \times 2\pi r = \mu_0 \in_0 A\left(\dfrac{dE}{dt}\right) \quad \therefore\ B \propto \left(\dfrac{dE}{dt}\right)$

**92.** **(a)** According to conservation of charge, the displacement current must be leftward.



## ASSERTION- REASON TYPE QUESTIO

**93.** **(d)** Displacement current arises when electric field in a region is changing with time, which is given by

$$I_D = \varepsilon_0 \frac{d\phi_E}{dt}$$

It will be so if the charge on a capacitor is not constant but changing with time.

**94.** **(a)** **95.** **(a)**

**96.** **(a)** Transverse waves are those waves in which the particles of the medium oscillate perpendicular to the direction of wave propagation.

**97.** **(c)** Electrormagnetic waves interact with matter via their electric and magnetic field which in oscillation of charges present in all matter. The detailed interaction and so the mechanism of absorption, scattering, etc. depend of the wavelength of the electromagnetic wave, and the nature of the atoms and molecules in the medium.

**98.** **(b)** Consider a plane perpendicular to the direction of propagation of the electromagnetic wave. If electric charges are present in this plane, they will be set and sustained in motion by the electric and magnetic fields of the electromagnetic wave. The charge thus acquired energy and momentum from the wave. This illustrate the fact that an electromanetic wave like other waves carries energy and momentum.

**99.** **(a)** Electromagnetic waves have linear momentum as well as energy. This concludes that they can exert radiation pressure by falling beam of electromagnetic radiation on an object.

**100. (c)** This electromagnetic wave contains sinusoidally time varying electric and magnetic field which act perperndicular to each other as well as at right angle to the direction of propagation of waves, so electromagnetic waves are transverse in nature. Electromagnetic wave propagate in the perpendicular direction to both fields.

**101. (b)** $v = \dfrac{1}{\sqrt{\mu\varepsilon}} = \dfrac{c}{\sqrt{\mu_r \varepsilon_r}}$

**102. (a)** The basic difference between various types of electromagnetic waves lies in their wavelengths or frequencies since all of them travel through vacuum with the same speed. Consequently, the waves differ considerably in their mode of interaction with matter.

**103. (d)** The optical waves used in optical fibre communication are better carrier of signals than microwaves. The speed of microwave and optical wave is the same in vacuum.

**104. (b)** Infrared radiation help to maintain the earth warmth through the greenhouse effect. Incoming visible light which passes relatively easily through the atmosphere is absorbed by the earth's surface and re-radiated as infrared radiation. The radiation is trapped by greenhouse gases such as carbon dioxide and water vapour and they heat up and heat their surrondings.

## CRITICAL THINKING TYPE QUESTIONS

**105. (b)** Displacement current, $I_D$ = conduction current, $I_C$

$$\therefore \quad \frac{dq}{dt} = \frac{d}{dt}[q_0 \cos 2\pi\upsilon t] = -q_0\, 2\pi\upsilon \sin 2\pi\upsilon t$$

**106. (b)**

**107. (d)** $I_d = 1\ mA = 10^{-3}$ A

$C = 2\mu F = 2 \times 10^{-6}$ F

$$I_D = I_C = \frac{d}{dt}(CV) = C\frac{dV}{dt}$$

Therefore, $\dfrac{dV}{dt} = \dfrac{I_D}{C} = \dfrac{10^{-3}}{2\times10^{-6}} = 500\ \text{Vs}^{-1}$

Therefore, applying a varying potential difference of 500 V $s^{-1}$ would produce a displacement current of desired value.

**108. (b)** Here, $k = \dfrac{2\pi}{\lambda}$, $\omega = 2\pi\upsilon$

$$\therefore \quad \frac{k}{\omega} = \frac{2\pi/\lambda}{2\pi\upsilon} = \frac{1}{\pi\upsilon} = \frac{1}{c} \qquad (\because c = \upsilon\,\lambda)$$

where $c$ is the speed of electromagnetic wave in vacuum. It is a constant whose value is $3 \times 10^6\ m\ s^{-1}$

**109. (d)** The frequency of electromagnetic wave remains unchanged but the wavelength of electromagnetic wave changes when it passes from one medium to another.

$$c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$$

$$\therefore \quad c \propto \frac{1}{\sqrt{\varepsilon_0}} \qquad \text{and} \quad v \propto \frac{1}{\sqrt{\varepsilon}}$$

$$\therefore \quad \frac{c}{v} = \sqrt{\frac{\varepsilon}{\varepsilon_0}} = \sqrt{\frac{4}{1}} = 2$$

$$\frac{c}{v} = \frac{\upsilon\lambda}{\upsilon\lambda'} = \frac{\lambda}{\lambda'} = 2 \text{ or } \lambda' = \frac{\lambda}{2}$$

**110. (a)** On comparing the given equation to

$\vec{E} = a_0\hat{i}\cos(\omega t - kz)$

$\omega = 6 \times 10^{8z}$,

$$k = \frac{2\pi}{r} = \frac{\omega}{c}$$

$$k = \frac{\omega}{c} = \frac{6\times10^8}{3\times10^8} = 2\,\text{m}^{-1}$$

**111. (b)** From question,

$B_0 = 20$ nT $= 20 \times 10^{-9}$T

$\vec{E}_0 = \vec{B}_0 \times \vec{C}$

$|\vec{E}_0| = |\vec{B}_0|.|\vec{C}| = 20\times10^{-9}\times3\times10^8 = 6\,\text{V/m}.$

($\because$ velocity of light in vacuum C = $3 \times 10^8$ ms$^{-1}$)

**112. (a)** Here, $\lambda = \dfrac{c}{\nu} = \dfrac{3\times10^8}{8.2\times10^6} = 36.6\,\text{m}.$

**113. (d)** $B_0 = \dfrac{E_0}{c} = \dfrac{9\times10^3}{3\times10^8} = 3\times10^{-5}\text{T}.$

**114. (a)** Here, amplitude of electric field, $E_0$ = 100 V/m; amplitude of magnetic field, $H_0$ = 0.265 A/m. We know that the maximum rate of energy flow,

$S = E_0 \times H_0 = 100 \times 0.265 = 26.5$ W/m$^2$.

**115. (b)** $B_0 = \dfrac{E_0}{c}$

$E_0$ - Electric field, c - speed of light, $B_0$ - Magnetic Field.

$$B_0 = \frac{10^{-3}}{3\times10^8} = 3.33\times10^{-12}\ \text{T}$$

**116. (a)** Velocity of light

$$C = \frac{E}{B} \Rightarrow B = \frac{E}{C} = \frac{9.3}{3\times10^8} = 3.1\times10^{-8}\text{T}$$

**117. (a)** The speed of light $C = \dfrac{1}{\sqrt{\mu_0\varepsilon_0}} = \dfrac{1}{\sqrt{2\times8}} = \dfrac{1}{4} = 0.25$

**118. (a)** $E_{rms} = 720$

The average total energy density

$$= \frac{1}{2}\epsilon_0 E_0^2 = \frac{1}{2}\epsilon_0[\sqrt{2}E_{rms}]^2 = \epsilon_0 E_{rms}^2$$

$$= 8.85\times10^{-12}\times(720)^2$$

$$= 4.58\times10^{-6}\ \text{J/m}^3$$

**119. (b)** $B_0 = \dfrac{E_0}{c}$

$E_0$ - Electric field, c - speed of light, $B_0$ - Magnetic Field.

$$B_0 = \frac{10^{-3}}{3\times10^8} = 3.33\times10^{-12}\ \text{T}$$

# CHAPTER
# 24

# RAY OPTICS AND OPTICAL INSTRUMENTS

## FACT/DEFINITION TYPE QUESTIONS

**1.** Electromagnetic radiation belonging to _________ region of spectrum is called light.
(a) 100 nm to 400 nm (b) 400 nm to 750 nm
(c) 750 nm to 10 nm (d) 1000 nm to 1400 nm

**2.** The turning back of light into the same medium after incident on a boundary separating two media is called
(a) reflection of light (b) refraction of light
(c) dispersion of light (d) interference of light

**3.** A point source of light is placed in front of a plane mirror. Then
(a) all the reflected rays meet at a point when produced backward
(b) only the reflected rays close to the normal meet at a point when produced backward.
(c) only the reflected rays making a small angle with the mirror, meet at a point when produced backward.
(d) light of different colours make different images.

**4.** The field of view is maximum for
(a) plane mirror (b) concave mirror
(c) convex mirror (d) cylindrical mirror

**5.** A virtual image larger than the object can be obtained by
(a) concave mirror (b) convex mirror
(c) plane mirror (d) concave lens

**6.** An object is placed 40 cm from a concave mirror of focal length 20 cm. The image formed is
(a) real, inverted and same in size
(b) real, inverted and smaller
(c) virtual, erect and larger
(d) virtual, erect and smaller

**7.** All of the following statements are correct except
(a) the magnification produced by a convex mirror is always less than one
(b) a virtual, erect, same-sized image can be obtained using a plane mirror
(c) a virtual, erect, magnifield image can be formed using a concave mirror
(d) a real, inverted, same-sized image can be formed using a convex mirror.

**8.** A person is six feet tall. How tall must a plane mirror be if he is able to see his entire length?
(a) 3 ft (b) 4.5 ft (c) 7.5 ft (d) 6 ft

**9.** The image formed by a concave mirror is
(a) always real
(b) always virtual
(c) certainly real if the object is virtual
(d) certainly virtual if the object is real

**10.** In image formation from spherical mirrors, only paraxial rays are considered because they
(a) are easy to handle geometrically
(b) contain most of the intensity of the incident light
(c) form nearly a point image of a point source
(d) show minimum dispersion effect

**11.** For reflection through spherical surfaces, the normal at the point of incidence is
(a) perpendicular to the principle axis and passes through the centre of curvature
(b) perpendicular to the focal plane and passes through the pole.
(c) perpendicular to the tangent plane at pole and passes through the focus.
(d) perpendicular to the tangent plane at the point of incidence and passes through the centre of curvature.

**12.** The equation $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$ holds true for
(a) only concave mirror
(b) only convex mirror
(c) both concave and convex mirror
(d) any type of reflecting surface

**13.** Which of the following (referred to a spherical mirror) depends on whether the rays are paraxial or not?
(a) Pole (b) Focus
(c) Radius of curvature (d) Principal axis

**14.** Which of the following is correct for the beam which enters the medium?
(a) Travel as a cylindrical beam
(b) Diverge
(c) Converge
(d) Diverge near the axis and converge near the periphery

**15.** When light is refracted into a medium,
(a) its wavelength and frequency both increase
(b) its wavelength increases but frequency remains unchanged
(c) its wavelength decreases but frequency remains unchanged
(d) its wavelength and frequency both decrease

**16.** When light is refracted, which of the following does not change ?
(a) Wavelength (b) Frequency
(c) Velocity (d) Amplitude

**17.** If the light moving in a straight line bends by a small but fixed angle, it may be a case of
(a) reflection (b) refraction
(c) diffraction (d) both (a) & (b)

**18.** Total internal reflection can take place only if
(a) light goes from optically rarer medium (smaller refractive index) to optically denser medium
(b) light goes from optically denser medium to rarer medium
(c) the refractive indices of the two media are close to different
(d) the refractive indices of the two media are widely different

**19.** The difference between reflection and total internal reflection is that
(a) the laws of reflection hold true for reflection but not for total internal reflection.
(b) total internal reflection can take place only when light travels from a rarer medium to a denser medium while reflection can take place vice-versa also.
(c) reflection can take place when light travels from a rarer medium to denser medium and vice-versa but total internal reflection can take place only when it travels from an optically denser to an optically rarer medium.
(d) reflection is a natural phenomena while total internal reflection is man-made.

**20.** When the angle of incidence of a light ray is greater than the critical angle it gets
(a) critically refracted
(b) totally reflected
(c) total internally reflected
(d) totally refracted

**21.** Which of the following phenomena is used in optical fibres ?
(a) Total internal reflection
(b) Scattering
(c) Diffraction
(d) Refraction

**22.** Critical angle of light passing from glass to water is minimum for
(a) red colour (b) green colour
(c) yellow colour (d) violet colour

**23.** Which of the following is not due to total internal reflection?
(a) Working of optical fibre
(b) Difference between apparent and real depth of pond
(c) Mirage on hot summer days
(d) Brilliance of diamond

**24.** Identify the wrong sign convention
(a) The magnification for virtual image formed by a convex lens is positive
(b) The magnification for real image formed by a convex lens is negative
(c) The height measured normal to the principal axis upwards is positive
(d) The magnification for virtual image formed by a concave lens is negative

**25.** The apparent flattening of the sun at sunset and sunrise is due to
(a) refraction
(b) diffraction
(c) total internal reflection
(d) interference

**26.** The speed of light in an isotropic medium depends on
(a) the nature of the source
(b) its wavelength
(c) its direction of propagation
(d) its intensity

**27.** A parallel beam of light is incident on a converging lens parallel to its principal axis. As one moves away from the lens on the other side on its principal axis, the intensity of light
(a) remains constant
(b) continuously increases
(c) continuously decreases
(d) first increases then decreases

**28.** The rays of different colours fail to converge at a point after going through a converging lens. This defect is called
(a) spherical aberration (b) distortion
(c) coma (d) chromatic aberration

**29.** What causes chromatic aberration?
(a) Marginal rays
(b) Central rays
(c) Difference in radii of curvature of its surfaces
(d) Variation of focal length of lens with colour

**30.** The focal length of a converging lens are $f_V$ and $f_R$ for violet and red light respectively. Then
(a) $f_V > f_R$
(b) $f_V = f_R$
(c) $f_V < f_R$
(d) any of the three is possible depending on the value of the average refractive index m

**31.** A narrow beam of white light goes through a slab having parallel faces
(a) the light never splits in different colours
(b) the emergent beam is white
(c) the light inside the slab is split into different colours
(d) the light inside the slab is white

**32.** Chromatic aberration in a lens is caused by
(a) reflection (b) interference
(c) diffraction (d) dispersion

**33.** Which of the following is Lens maker's formula?
(a) $\frac{\mu_2}{v} = \frac{\mu_1}{u} = \left(\frac{\mu_2 - \mu_1}{R}\right)$ (b) $\frac{1}{v} - \frac{1}{u} = \frac{1}{R}$
(c) $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$ (d) $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

**34.** The angular dispersion produced by a prism
(a) increases if the average refractive index increases
(b) increases if the average refractive index decreases
(c) remains constant whether the average refractive index increases or decreases
(d) has no relation with average refractive index.

**35.** If a glass prism is dipped in water, its dispersive power
(a) increases
(b) decreases
(c) does not change
(d) may increase or decrease depending on whether the angle of the prism is less than or greater than 60º

**36.** If D is the deviation of a normally falling light beam on a thin prism of angle A and $\delta$ is the dispersive power of the same prism then
(a) D is independent of A.
(b) D is independent of refractive Index.
(c) $\delta$ is independent of refractive index.
(d) $\delta$ is independent of A.

**37.** When white light enters a prism, it gets split into its constituent colours. This is due to
(a) high density of prism material
(b) because $\mu$ is different for different wavelength
(c) diffraction of light
(d) velocity changes for different frequency

**38.** Yellow light is refracted through a prism producing minimum deviation. If $i_1$ and $i_2$ denote the angle of incidence and emergence for this prism, then
(a) $i_1 = i_2$ (b) $i_1 > i_2$
(c) $i_1 < i_2$ (d) $i_1 + i_2 = 90^o$

**39.** By properly combining two prisms made of different materials, it is not possible to have
(a) dispersion without average deviation
(b) deviation without dispersion
(c) both dispersion and average deviation
(d) neither dispersion nor average deviation

**40.** When the incidence angle is equal to the angle of emergence of light from the prism the refracted ray inside the prism
(a) becomes parallel to the right face of prism
(b) becomes perpendicular to the base of prism
(c) becomes parallel to the base of prism
(d) becomes perpendicular to the left face of prism

**41.** The dispersive power of a prism depends on its
(a) shape
(b) size
(c) angle of prism
(d) refractive index of the monitorial of the prism

**42.** The angle of prism is 60° and angle of deviation is 30°. In the position of minimum deviation, the values of angle of incidence and angle of emergence are:
(a) $i = 45°; e = 50°$ (b) $i = 30°; e = 45°$
(c) $i = 45°; e = 45°$ (d) $i = 30°; e = 30°$

**43.** In primary rainbow what is the order of colours observed from earth ?
(a) Violet innermost, red outermost.
(b) Red innermost, violet outermost.
(c) Random.
(d) White and dark alternatively

**44.** Which light rays undergoes two internal reflection inside a raindrop, which of the rainbow is formed?
(a) Primary rainbow (b) Secondary rainbow
(c) Both (a) and (b) (d) Can't say

**45.** In secondary rainbow what is the order of colours observed from earth?
(a) Violet innermost, red outermost.
(b) Red innermost, violet outer most.
(c) Random.
(d) White and dark alternatively.

**46.** Identify the mismatch in the following
(a) Myopia - Concave lens
(b) For rear view - Concave mirror
(c) Hypermetropia - Convex lens
(d) Astigmatism - Cylindrical lens

**47.** Astigmatism is corrected using
(a) cylindrical lens (b) plano-convex lens
(c) plano-concave lens (d) convex lens

**48.** The focal length of a normal eye-lens is about
(a) 1mm (b) 2 cm
(c) 25 cm (d) 1m

**49.** A normal eye is not able to see objects closer than 25 cm because
(a) the focal length of the eye is 25 cm
(b) the distance of the retina from the eye-lens is 25 cm
(c) the eye is not able to decrease the distance between the eye-lens and the retina beyond a limit
(d) the eye is not able to decrease the focal length beyond a limit

**50.** The image formed by an objective of a compound microscope is
(a) real and diminished (b) real and enlarged
(c) virtual and enlarged (d) virtual and diminished

**51.** An astronomical telescope has a large aperture to
(a) reduce spherical aberration
(b) have high resolution
(c) increases span of observation
(d) have low dispersion

**52.** To increase the angular magnification of a simple microscope, one should increase
(a) the focal length of the lens
(b) the power of the lens
(c) the aperture of the lens
(d) the object size

**53.** In which of the following the final image is erect ?
(a) Simple microscope
(b) Compound microscope
(c) Astronomical telescope
(d) None of these

**54.** Resolving power of a telescope increases with
(a) increase in focal length of eye-piece
(b) increase in focal length of objective
(c) increase in aperture of eye piece
(d) increase in apeture of objective

**55.** An experiment is performed to find the refractive index of glass using a travelling microscope. In this experiment distances are measured by
(a) a vernier scale provided on the microscope
(b) a standard laboratory scale
(c) a meter scale provided on the microscope
(d) a screw gauge provided on the microscope

**56.** If the focal length of objective lens is increased then magnifying power of :
(a) microscope will increase but that of telescope decrease.
(b) microscope and telescope both will increase.
(c) microscope and telescope both will decrease
(d) microscope will decrease but that of telescope increase.

**57.** The light gathering power of an astronomical telescope depends upon
(a) length of tube (b) focal length of objective
(c) area of eye-piece (d) area of objective

**58.** The objective of a telescope must be of large diameter in order to
(a) remove chromatic aberration
(b) remove spherical aberration and high magnification
(c) gather more light and for high resolution
(d) increase its range of observation

## STATEMENT TYPE QUESTIONS

**59.** Which of the following statements about laws of reflection is/are correct?
I. The incident ray, the reflected ray and the normal all lie in the same plane.
II. Angle of incidence is equal to the angle of reflection.
III. After reflection, velocity, wavelength and frequency of light remains same but intensity decreases.
(a) I only (b) II only
(c) I and II (d) I, II and III

**60.** A convex mirror is used to form the image of an object. Then which of the following statements is/are true?
I. The image lies between the pole and the focus
II. The image is diminished in size
III. The image is real
(a) I only (b) II only
(c) I and III (d) I and II

**61.** In case of reflection over spherical surface, which of these are correct ?
I. Normal is taken as perpendicular of tangent at point of incidence.
II. Perpendicular to incident ray which is perpendicular to plane of incident ray.
III. Line joining centre of curvature of mirror with point of incidence.
IV. Line joining centre of curvature and pole of curved surface.
(a) I and II (b) I and III
(c) II and III (d) II and IV

**62.** If i = angle of incidence and r = angle of refraction, then the ratio $\frac{\sin i}{\sin r}$
I. is a constant for a pair of media.
II. is called refractive index of medium 2 with respect to medium 1.
III. is called absolute refractive index of medium 2.
IV. varies with temperature.
(a) I, II and III (b) II, III and IV
(c) I, II and IV (d) I, III and IV

**63.** Which of the following is/are correct relations?
I. $n_{21} = \frac{1}{n_{12}}$ II. $n_{32} = n_{31} \times n_{12}$
III. $n_{21} = \frac{n_{1a}}{n_{2a}}$ IV. $n_{21} = \frac{n_{2a}}{n_{1a}}$
(a) I, II and IV (b) I, III and IV
(c) II, III and IV (d) I, II, III and IV

**64.** Which of the following statements is/are correct about a convex lens?
I. Convex lens is converging for light for all wavelengths.
II. For virtual object, the image is also virtual.
III. For real object, the image is always real.
(a) I and II (b) II and III (c) I and III (d) Only I

**65.** Sunlight reaches to us in composite form and not in its constituent colours because
I. vacuum is non–dispersive.
II. speed of all colours is same in vacuum.
III. light behaves like a particle in vacuum.
IV. light travels in a straight line in vacuum.
(a) I and II (b) II and III (c) III and IV(d) I and IV

**66.** Which of the following statements is/are incorrect?
I. At sunset or sunrise, the sun's rays have to pass through a small distance in the atmosphere.
II. At sunset or sunrise, the sun's rays have to pass through a larger distance in the atmosphere.
III. Rayleigh scattering which is proportional to $(1/\lambda)^2$.
(a) I and II (b) I and III
(b) II and III (d) I, II and III

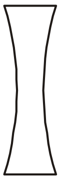
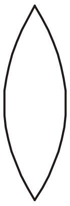
## MATCHING TYPE QUESTIONS

**67.** Match the Column-I and Column-II

| **Column – I** | **Column – II** |
|---|---|
| (A) An object is placed at focus before aconvex mirror | (1) Magnification is –∞ |
| (B) An object is placed at centre of curvature before a concave mirror | (2) Magnification is 0.5 |
| (C) An object is placed at focus before a concave mirror | (3) Magnification is +1 |
| (D) An object is placed at centre of curvature before a convex mirror | (4) Magnification is –1 |
| | (5) Magnification is 0.33 |

(a) (A) → (2); (B) → (3); (C) → (4); (D) → (5)
(b) (A) → (5); (B) → (4); (C) → (3); (D) → (1)
(c) (A) → (2); (B) → (4); (C) → (1); (D) → (5)
(d) (A) → (3); (B) → (5); (C) → (2); (D) → (4)

**68.** Match the columns I and II

| **Column – I** | **Column – II** |
|---|---|
| (A)  | (1) Planoconvex |
| (B)  | (2) Biconcave |
| (C)  | (3) Convexoconcave |
| (D)  | (4) Biconvex |

(a) (A) → (3); (B) → (1); (C) → (2); (D) → (4)
(b) (A) → (2); (B) → (3); (C) → (4); (D) → (1)
(c) (A) → (2); (B) → (4); (C) → (3); (D) → (1)
(d) (A) → (3); (B) → (2); (C) → (1); (D) → (4)

**69.** Match the columns I and II

| **Column I** | **Column II** |
|---|---|
| (A) Mirage | (1) Refraction of light by |
| (B) Apparent depth of object is lesser than the actual depth in water | (2) Scattering of sunlight |
| (C) Blue colour of sky | (3) Total internal reflection |
| (D) The formation of rainbow | (4) Dispersion of sunlight |

(a) (A) → (2); (B) → (3); (C) → (4); (D) → (1)
(b) (A) → (3); (B) → (4); (C) → (1); (D) → (2)
(c) (A) → (4); (B) → (1); (C) → (2); (D) → (3)
(d) (A) → (3); (B) → (1); (C) → (2); (D) → (4)

**70.**

| **Column I** | **Column II** |
|---|---|
| (A) Lens of power + 2.0 D | (1) Convex lens of focal length 200 cm. |
| (B) Lenses of combination of power +0.25 D and +0.25 D | (2) Concave lens of focal length 40 cm |
| (C) Lens of power –2.0 D | (3) Convex lens of focal length 50 cm |
| (D) Lenses combination of power –60 D and +3.5 D | (4) Concave lens of focal length 50 cm |

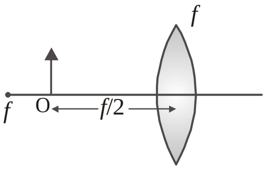
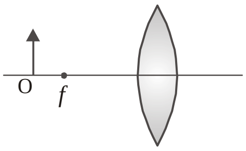
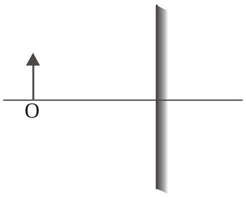
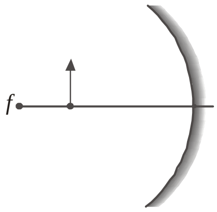
(a) (A) → (1); (B) → (2); (C) → (3); (D) → (4)
(b) (A) → (3); (B) → (1); (C) → (4); (D) → (2)
(c) (A) → (4); (B) → (3); (C) → (1); (D) → (2)
(d) (A) → (3); (B) → (4); (C) → (2); (D) → (1)

**71.** For an object placed in front of a mirror, magnification (*m*) is given in Column I, Column II gives the possible nature of the mirror or that of image. Match appropriately.

| **Column – I** | **Column – II** |
|---|---|
| (A) $m = \frac{1}{4}$ | (1) Concave mirror |
| (B) $m = -1$ | (2) Convex mirror |
| (C) $m = 2$ | (3) Plane mirror |
| (D) $m = 1$ | (4) Real |

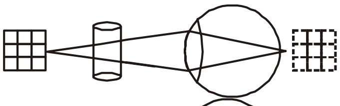
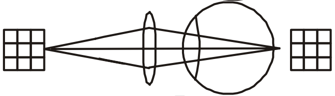
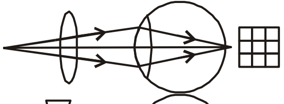
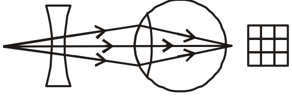
(a) (A) → (2); (B) → (1); (C) → (1); (D) → (3)
(b) (A) → (1); (B) → (2); (C) → (4); (D) → (2)
(c) (A) → (2); (B) → (4); (C) → (1); (D) → (3)
(d) (A) → (1); (B) → (4); (C) → (3); (D) → (2)

**72.** Match the following Column II gives nature of image formed in various cases given in Column I

| **Column – I** | **Column – II** |
|---|---|
| (A)  | (1) Real |
| (B)  | (2) Inverted |
| (C)  | (3) Virtual |
| (D)  | (4) Upright |
| | (5) Magnified |

(a) (A) → (1, 2, 3); (B) → (4, 5); (C) → (2); (D) → (1, 5)
(b) (A) → (3, 4, 5); (B) → (1, 2, 5); (C) → (3, 4); (D) → (3, 4, 5)
(c) (A) → (1); (B) → (2, 3); (C) → (4, 5); (D) → (1)
(d) (A) → (4); (B) → (3, 4); (C) → (2, 3); (D) → (1)

**73.**

| **Column I** | **Column II** |
|---|---|
| (A) Hypermetropia | (1)  |
| (B) Myopia | (2)  |
| (C) Astigmatism | (3)  |
| (D) Presbyopia | (4)  |

(a) (A) → (3); (B) → (1); (C) → (2); (D) → (4)
(b) (A) → (4); (B) → (3); (C) → (2); (D) → (1)
(c) (A) → (1); (B) → (2); (C) → (3); (D) → (4)
(d) (A) → (3); (B) → (4); (C) → (1); (D) → (2)

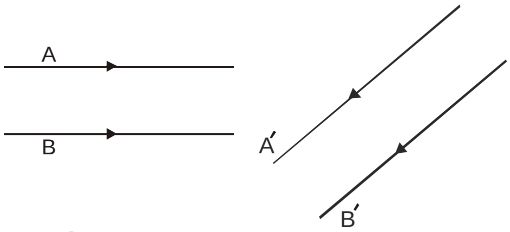
**74.** Match the columns I and II

| **Column I** | **Column II** |
|---|---|
| (i) Terrestrial telescope | (1) Final image is inverted w.r.t. the object. |
| (ii) Galileo's telescope | (2) No chromatic aberration |
| (iii) Reflecting telescope | (3) Final image is erected. |
| (iv) Astronomical telescope | (4) Uses concave lens for the eyepiece to obtain an erected image. |

(a) (A) → (3); (B) → (2); (C) → (4); (D) → (1)
(b) (A) → (1); (B) → (4); (C) → (3); (D) → (2)
(c) (A) → (3); (B) → (4); (C) → (2); (D) → (1)
(d) (A) → (2); (B) → (1); (C) → (2); (D) → (3)

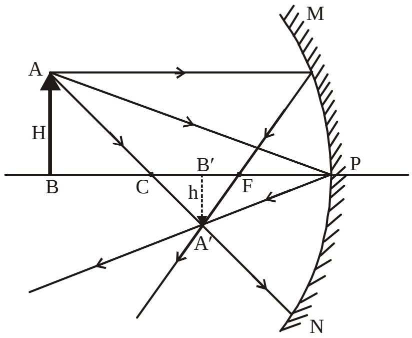
## DIAGRAM TYPE QUESTIONS

**75.** Figure shows two rays A and B being reflected by a mirror and going as A' and B'. The mirror



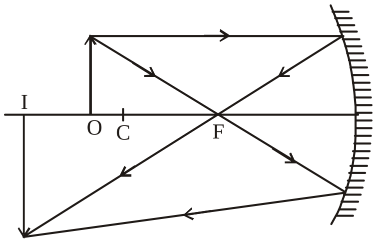
(a) is plane
(b) is convex
(c) is concave
(d) may be any spherical mirror

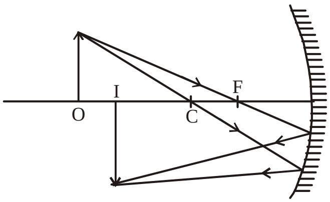
**76.** The correct sign convention for the following figure where the object is at 'c' will be

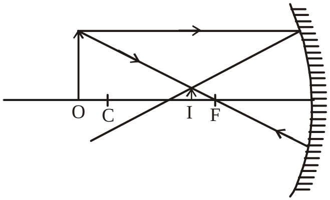


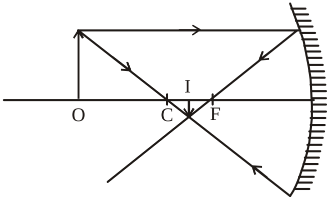
(a) $u = -ve$; $v = +ve$; H = $+ve$; $h = -ve$
(b) $u = +ve$; $v = -ve$; H= $-ve$; $h = +ve$
(c) $u = -ve$; $v = -ve$; H = $+ve$; $h = -ve$
(d) $u = +ve$; $v = +ve$; H = $-ve$; $h = +ve$

**77.** The correct image formation by a concave mirror is depicted in

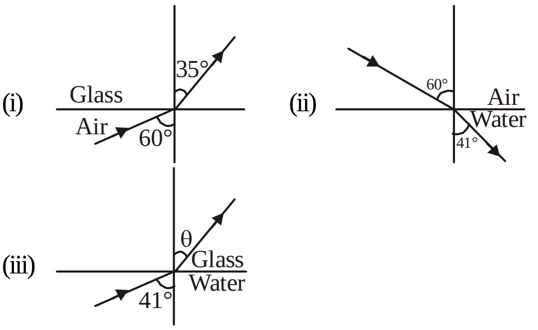
(a)


(b)


(c)


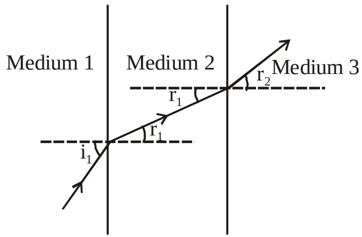
(d)


**78.** Refraction of light from air to glass and from air to water are shown in figure (i) and figure (ii) below. The value of the angle θ in the case of refraction as shown in figure (iii) will be



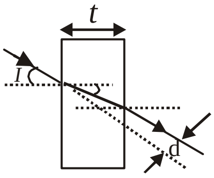
(a) 30° (b) 35° (c) 60° (d) 41°

**79.** The following figure shows refraction of light at the interface of three media



Correct the order of optical density (d) of the media is
(a) $d_1 > d_2 > d_3$ (b) $d_2 > d_1 > d_3$
(c) $d_3 > d_3 > d_2$ (d) $d_2 > d_3 > d_1$

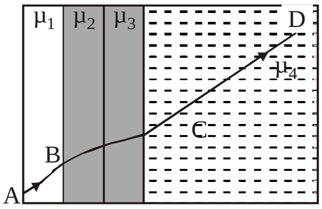
**80.** A rays of light is incident on a thick slab of glass of thickness $t$ as shown in the figure. The emergent ray is parallel to the incident ray but distance $d$. If the angles are small then $d$ is



(a) $t\left(1-\frac{i}{r}\right)$ (b) $rt\left(1-\frac{i}{r}\right)$

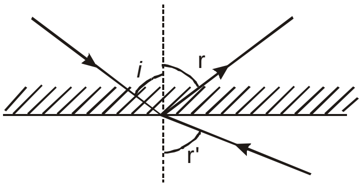
(c) $it\left(1-\frac{r}{i}\right)$ (d) $t\left(1-\frac{r}{i}\right)$

**81.** A ray of light passes through four transparent media with refractive indices $\mu_1$, $\mu_2$, $\mu_3$ and $\mu_4$ as shown in the figure. The surfaces of all media are parallel. If the emergent ray CD is parallel to the incident ray AB, we must have



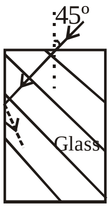
(a) $\mu_1 = \mu_2$ (b) $\mu_2 = \mu_3$ (c) $\mu_3 = \mu_4$ (d) $\mu_4 = \mu_1$

**82.** A ray of light from a denser medium strike a rarer medium at an angle of incidence $i$ (see Fig). The reflected and refracted rays make an angle of 90° with each other. The angles of reflection and refraction are $r$ and $r'$. The critical angle is



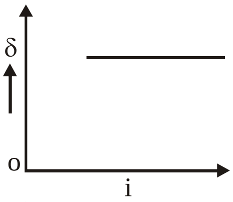
(a) $\sin^{-1}(\tan r)$ (b) $\sin^{-1}(\tan i)$
(c) $\sin^{-1}(\tan r)$ (d) $\tan^{-1}(\tan \mathrm{i})$

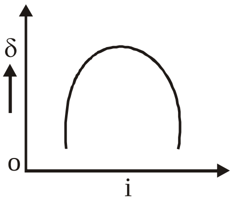
**83.** A light ray falls on a rectangular glass slab as shown. The index of refraction of the glass, if total internal reflection is to occur at the vertical face, is

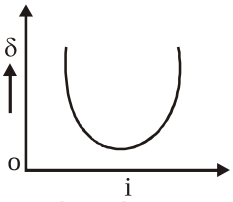


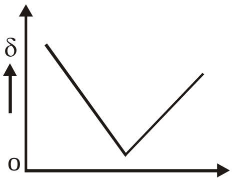
(a) $\sqrt{3/2}$ (b) $\frac{(\sqrt{3}+1)}{2}$
(c) $\frac{(\sqrt{2}+1)}{2}$ (d) $\sqrt{5}/2$

**84.** The graph between angle of deviation (δ) and angle of incidence (i) for a triangular prism is represented by

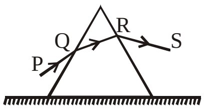
(a)


(b)


(c)


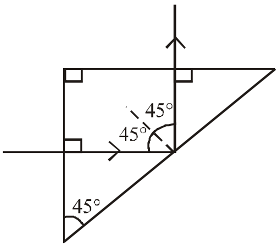
(d)


**85.** An equilateral prism is placed on a horizontal surface. A ray PQ is incident onto it. For minimum deviation



(a) PQ is horizontal
(b) QR is horizontal
(c) RS is horizontal
(d) Any one will be horizontal

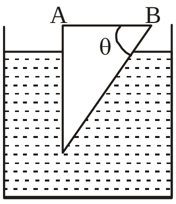
**86.** A light ray is incident perpendicularly to one face of a 90° prism and is totally internally reflected at the glass-air interface. If the angle of reflection is 45°, we conclude that the refractive index



(a) $n > \frac{1}{\sqrt{2}}$ (b) $n > \sqrt{2}$

(c) $n < \frac{1}{\sqrt{2}}$ (d) $n < \sqrt{2}$

**87.** A glass prism of refractive index 1.5 is immersed in water (refractive index 4/3). A light beam incident normally on the face AB is totally reflected to reach on the face BC if



(a) $\sin\theta \geq \frac{8}{9}$

(b) $\frac{2}{3} < \sin\theta < \frac{8}{9}$

(c) $\sin\theta \leq \frac{2}{3}$

(d) None of these

## ASSERTION - REASON TYPE QUESTIONS

**Directions :** Each of these questions contains two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

**88.** **Assertion :** Plane mirror may form real image.
**Reason :** Plane mirror forms virtual image, if object is real.

**89.** **Assertion :** The focal length of the convex mirror will increase, if the mirror is placed in water.
**Reason :** The focal length of a convex mirror of radius $R$ is equal to, $f = R/2$.

**90.** **Assertion :** The image formed by a concave mirror is certainly real if the object is virtual.
**Reason :** The image formed by a concave mirror is certainly virtual if the object is real.

**91.** **Assertion :** The image of an extended object placed perpendicular to the principal axis of a mirror, will be erect if the object is real but the image is virtual.
**Reason :** The image of an extended object, placed perpendicular to the principal axis of a mirror, will be erect if the object is virtual but the image is real.

**92.** **Assertion :** An object is placed at a distance of f from a convex mirror of focal length $f$ its image will form at infinity.
**Reason :** The distance of image in convex mirror can never be infinity.

**93.** **Assertion :** Critical angle is minimum for violet colour.
**Reason :** Because critical angle $\theta_c = \sin^{-1}\left(\frac{1}{\mu}\right)$ and $\mu \propto \frac{1}{\lambda}$.

**94.** **Assertion :** Two convex lenses joined together cannot produce an achromatic combination.
**Reason :** The condition for achromatism is $\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0$ where symbols have their usual meaning.

**95.** **Assertion :** The image of a point object situated at the centre of hemispherical lens is also at the centre.
**Reason :** For hemisphere Snell's law is not valid.

**96.** **Assertion :** When a convex lens ($\mu_g = 3/2$) of focal length $f$ is dipped in water, its focal length becomes $\frac{4}{3}f$.
**Reason :** The focal length of convex lens in water becomes $4f$.

**97.** **Assertion:** The focal length of an equiconvex lens of radius of curvature R made of material of refractive index $\mu = 1.5$, is $R$.
**Reason :** The focal length of the lens will be R/2.

**98.** **Assertion :** If the rays are diverging after emerging from a lens; the lens must be concave.
**Reason :** The convex lens can give diverging rays.

**99.** **Assertion :** A lens, whose radii of curvature are different, is forming the image of an object placed on its axis. If the lens is reversed, the position of the image will not change.
**Reason :** The focal length of a lens is given by $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$, and so focal length in both the cases is same.

**100.** **Assertion :** The resolving power of a telescope is more if the diameter of the objective lens is more.
**Reason :** Objective lens of large diameter collects more light.

**101.** **Assertion :** The optical instruments are used to increase the size of the image of the object.
**Reason :** The optical instruments are used to increase the visual angle.

## CRITICAL THINKING TYPE QUESTIONS

**102.** A rod of length 10 cm lies along the principal axis of a concave mirror of focal length 10 cm in such a way that its end closer to the pole is 20 cm away from the mirror. The length of the image is
(a) 10 cm (b) 15 cm (c) 2.5 cm (d) 5 cm

**103.** A ray of light travelling in the direction $\frac{1}{2}(\hat{i} + \sqrt{3}\hat{j})$ is incident on a plane mirror. After reflection, it travels along the direction $\frac{1}{2}(\hat{i} - \sqrt{3}\hat{j})$. The angle of incidence is
(a) 30° (b) 45° (c) 60° (d) 75°

**104.** A vessel of depth $x$ is half filled with oil of refractive index $\mu_1$ and the other half is filled with water of refractive index $\mu_2$. The apparent depth of the vessel when viewed from above is
(a) $\frac{x(\mu_1 + \mu_2)}{2\mu_1\mu_2}$ (b) $\frac{x\mu_1\mu_2}{2(\mu_1 + \mu_2)}$
(c) $\frac{x\mu_1\mu_2}{(\mu_1 + \mu_2)}$ (d) $\frac{2x(\mu_1 + \mu_2)}{\mu_1\mu_2}$

**105.** A ray of light travelling inside a rectangular glass block of refractive index $\sqrt{2}$ is incident on the glass-air surface at an angle of incidence of 45°. The refractive index of air is one. Under these conditions the ray will
(a) emerge into the air without any deviation
(b) be reflected back into the glass
(c) be absorbed
(d) emerge into the air with an angle of refraction equal to 90°

**106.** A glass slab of thickness 4 cm contains the same number of waves as 5 cm of water when both are traversed by the same monochromatic light. If the refractive index of water is 4/3, what is that of glass?
(a) 5/3 (b) 5/4 (c) 16/15 (d) 1.5

**107.** The index of refraction of diamond is 2.0. The velocity of light in diamond is approximately
(a) $1.5 \times 10^{10}$ cm/sec (b) $2 \times 10^{10}$ cm/sec
(c) $3.0 \times 10^{10}$ cm/sec (d) $6 \times 10^{10}$ cm/sec

**108.** Light travels through a glass plate of thickness t and refractive index $\mu$. If c is the speed of light in vacuum, the time taken by light to travel this thickness of glass is
(a) mtc (b) $\frac{tc}{\mu}$ (c) $\frac{t}{\mu c}$ (d) $\frac{\mu t}{c}$

**109.** One face of a rectangular glass plate 6 cm thick is silvered. An object held 8 cm in front of the first face, forms an image 12 cm behind the silvered face. The refractive index of the glass is
(a) 0.4 (b) 0.8 (c) 1.2 (d) 1.6

**110.** A beam of monochromatic blue light of wavelength 420 nm in air travels in water ($\mu = 4/3$). Its wavelength in water will be
(a) 280 nm (b) 560 nm (c) 315 nm (d) 400 nm

**111.** The frequency of a light wave in a material is $2 \times 10^{14}$ Hz and wavelength is 5000 Å. The refractive index of material will be
(a) 1.50 (b) 3.00 (c) 1.33 (d) 1.40

**112.** A ray of light travelling in a transparent medium of refractive index $\mu$, falls on a surface separating the medium from air at an angle of incidence of 45°. For which of the following value of $\mu$ the ray can undergo total internal reflection?
(a) m = 1.33 (b) m = 1.40 (c) m = 1.50 (d) m = 1.25

**113.** Light travels in two media *A* and *B* with speeds $1.8 \times 10^8$ m s$^{-1}$ and $2.4 \times 10^8$ m s$^{-1}$ respectively. Then the critical angle between them is
(a) $\sin^{-1}\left(\frac{2}{3}\right)$ (b) $\tan^{-1}\left(\frac{3}{4}\right)$
(c) $\tan^{-1}\left(\frac{2}{3}\right)$ (d) $\sin^{-1}\left(\frac{3}{4}\right)$

**114.** The critical angle for light going from medium X into medium Y is $\theta$. The speed of light in medium X is v, then speed of light in medium Y is
(a) $v(1 - \cos\theta)$ (b) $v/\sin\theta$
(c) $v/\cos\theta$ (d) $v\cos\theta$

**115.** A ray of light travelling in a transparent medium of refractive index $\mu$, falls on a surface separating the medium from air at an angle of incidence of 45°. For which of the following value of $\mu$ the ray can undergo total internal reflection?
(a) $\mu = 1.33$ (b) $\mu = 1.40$ (c) $\mu = 1.50$ (d) $\mu = 1.25$

**116.** A luminous object is placed at a distance of 30 cm from the convex lens of focal length 20 cm. On the other side of the lens, at what distance from the lens a convex mirror of radius of curvature 10 cm be placed in order to have an upright image of the object coincident with it?
(a) 12 cm (b) 30 cm (c) 50 cm (d) 60 cm

**117.** A thin glass (refractive index 1.5) lens has optical power of – 5 D in air. Its optical power in a liquid medium with refractive index 1.6 will be

(a) – 1D (b) 1 D (c) – 25 D (d) 25 D

**118.** A plano-convex lens is made of material of refractive index 1.6. The radius of curvature of the curved surface is 60 cm. The focal length of the lens is

(a) 50 cm (b) 100 cm (c) 200 cm (d) 400 cm

**119.** The radius of curvature of a thin plano-convex lens is 10 cm (of curved surface) and the refractive index is 1.5. If the plane surface is silvered, then it behaves like a concave mirror of focal length

**120.** Two identical thin plano-convex glass lenses (refractive index 1.5) each having radius of curvature of 20 cm are placed with their convex surfaces in contact at the centre. The intervening space is filled with oil of refractive index 1.7. The focal length of the combination is

(a) –25 cm (b) –50 cm (c) 50 cm (d) –20 cm

**121.** A thin convex lens made from crown glass $\left(\mu = \frac{3}{2}\right)$ has focal length f. When it is measured in two different liquids having refractive indices $\frac{4}{3}$ and $\frac{5}{3}$, it has the focal lengths $f_1$ and $f_2$ respectively. The correct relation between the focal lengths is:

(a) $f_1 = f_2 < f$

(b) $f_1 > f$ and $f_2$ becomes negative

(c) $f_2 > f$ and $f_1$ becomes negative

(d) $f_1$ and $f_2$ both become negative

**122.** A green light is incident from the water to the air - water interface at the critical angle (θ). Select the correct statement.

(a) The entire spectrum of visible light will come out of the water at an angle of 90° to the normal.

(b) The spectrum of visible light whose frequency is less than that of green light will come out to the air medium.

(c) The spectrum of visible light whose frequency is more than that of green light will come out to the air medium.

(d) The entire spectrum of visible light will come out of the water at various angles to the normal.

**123.** A plano convex lens of refractive index 1.5 and radius of curvature 30 cm. Is silvered at the curved surface. Now this lens has been used to form the image of an object. At what distance from this lens an object be placed in order to have a real image of size of the object

(a) 60 cm (b) 30 cm (c) 20 cm (d) 80 cm

**124.** A double convex lens of focal length 6 cm is made of glass of refractive index 1.5. The radius of curvature of one surface is double that of other surface. The value of small radius of curvature is

(a) 6 cm (b) 4.5 cm (c) 9 cm (d) 4 cm

**125.** An achromatic convergent doublet of two lenses in contact has a power of + 2D. The convex lens has power + 5D. What is the ratio of dispersive powers of convergent and divergent lenses ?

(a) 2 : 5 (b) 3 : 5 (c) 5 : 2 (d) 5 : 3

**126.** The dispersive power of material of a lens of focal length 20 cm is 0.08. What is the longitudinal chromatic aberration of the lens ?

(a) 0.08 cm (b) 0.08/20 cm (c) 1.6 cm (d) 0.16 cm

**127.** A planoconvex lens of focal length 16 cm, is to be made of glass of refractive index 1.5. The radius of curvature of the curved surface should be

(a) 8 cm (b) 12 cm (c) 16 cm (d) 24 cm

**128.** A man's near point is 0.5 m and far point is 3 m. Power of spectacle lenses required for (i) reading purposes, (ii) seeing distant objects, respectively, are

(a) –2 D and + 3 D (b) +2 D and –3 D

(c) +2 D and –0.33 D (d) –2 D and + 0.33 D

**129.** Two thin lenses are in contact and the focal length of the combination is 80 cm. If the focal length of one lens is 20 cm, then the power of the other lens will be

(a) 1.66 D (b) 4.00 D (c) – 100 D (d) – 3.75 D

**130.** A thin convergent glass lens ($\mu_g$ = 1.5) has a power of + 5.0 D. When this lens is immersed in a liquid of refractive index μ, it acts as a divergent lens of focal length 100 cm. The value of μ must be

(a) 4/3 (b) 5/3 (c) 5/4 (d) 6/5

**131.** For the angle of minimum deviation of a prism to be equal to its refracting angle, the prism must be made of a material whose refractive index

(a) lies between $\sqrt{2}$ and 1

(b) lies between 2 and $\sqrt{2}$

(c) is less than 1

(d) is greater than 2

**132.** The refractive index of a glass is 1.520 for red light and 1.525 for blue light. Let $D_1$ and $D_2$ be angles of minimum deviation for red and blue light respectively in a prism of this glass. Then,

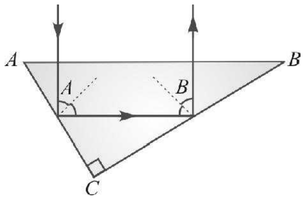
(a) $D_1 < D_2$

(b) $D_1 = D_2$

(c) $D_1$ can be less than or greater than $D_2$ depending upon the angle of prism

(d) $D_1 > D_2$

**133.** A right prism is made by selecting a proper material and the angle *A* and *B* (*B* << *A*) as shown in *fig*. It is desired that a ray of light incident on the face AB emerges parallel to the incident direction after two internal reflections.



What should be the minimum refractive index μ for this to be possible ?

(a) $\sqrt{3}$ (b) 1.5 (c) $\sqrt{2}$ (d) 1.8

**134.** The refractive index of the material of a prism is √2 and its refracting angle is 30°. One of the refracting surfaces of the prism is made a mirror inwards. A beam of monochromatic light enters the prism from the mirrored surface if its angle of incidence of the prism is

(a) 30° (b) 45° (c) 60° (d) 0°

**135.** The angle of a prism is 'A'. One of its refracting surfaces is silvered. Light rays falling at an angle of incidence 2A on the first surface returns back through the same path after suffering reflection at the silvered surface. The refractive index $\mu$, of the prism is :

(a) 2 sin A (b) 2 cos A

(c) $\frac{1}{2}\cos A$ (d) tan A

**136.** The refracting angle of a prism is 'A', and refractive index of the material of the prism is cot(A/2). The angle of minimum deviation is :

(a) 180° – 2A (b) 90° – A

(c) 180° + 2A (d) 180° – 3A

**137.** A ray of light is incident normally on one refracting surface of an equilateral prism. If the refractive index of the material of the prism is 1.5, then

(a) the emergent ray is deviated by 30°

(b) the emergent ray is deviated by 60°

(c) the emergent ray just graces the second reflecting surface

(d) the ray undergoes total internal reflection at second refracting surface

(e) the ray emerges normally from the second refracting surface

**138.** A thin prism of angle 15° made of glass of refractive index $\mu_1 = 1.5$ is combined with another prism of glass of refractive index $\mu_2 = 1.75$. The combination of the prism produces dispersion without deviation. The angle of the second prism should be

(a) 7° (b) 10° (c) 12° (d) 5°

**139.** A prism has a refracting angle of 60°. When placed in the position of minimum deviation, it produces a deviation of 30°. The angle of incidence is

(a) 30° (b) 45° (c) 15° (d) 60°

**140.** A ray of light passes through an equilateral prism such that the angle of incidence is equal to the angle of emergence and the latter is equal to 3/4th of the angle of prism. The angle of deviation is

(a) 45° (b) 39° (c) 20° (d) 30°

**141.** A telescope has an objective lens of 10 cm diameter and is situated at a distance of one kilometer from two objects. The minimum distance between these two objects, which can be resolved by the telescope, when the mean wavelength of light is 5000 Å, is of the order of

(a) 5 cm (b) 0.5 m (c) 5 m (d) 5 mm

**142.** Wavelength of light used in an optical instrument are $\lambda_1 = 4000\ \overset{\circ}{A}$ and $\lambda_2 = 5000\ \overset{\circ}{A}$, then ratio of their respective resolving powers (corresponding to $\lambda_1$ and $\lambda_2$) is

(a) 16 : 25 (b) 9 : 1 (c) 4 : 5 (d) 5 : 4.

**143.** The magnifying power of a telescope is 9. When it is adjusted for parallel rays, the distance between the objective and the eye piece is found to be 20 cm. The focal length of lenses are

(a) 18 cm, 2 cm (b) 11 cm, 9 cm

(c) 10 cm, 10 cm (d) 15 cm, 5 cm

**144.** The focal length of the objective of a telescope is 60 cm. To obtain a magnification of 20, the focal length of the eye piece should be

(a) 2 cm (b) 3 cm (c) 4 cm (d) 5 cm

**145.** The focal lengths of objective and eye lens of an astronomical telelscope are respectively 2 meter and 5 cm. Final image is formed at (i) least distance of distinct vision (ii) infinity Magnifying power in two cases will be

(a) – 48, – 40 (b) – 40, – 48

(c) – 40, + 48 (d) – 48, + 40

**146.** A simple telescope, consisting of an objective of focal length 60 cm and a single eye lens of focal length 5 cm is focussed on a distant object in such a way that parallel rays emerge from the eye lens. If the object subtends an angle of 2° at the objective, the angular width of the image is

(a) 10° (b) 24° (c) 50° (d) (1/6)°

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

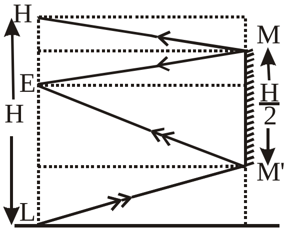
**1.** **(b)** **2.** **(a)** **3.** **(a)** **4.** **(c)**

**5.** **(a)** Virtual image formed is larger in size in case of concave mirror.

**6.** **(a)** Real, inverted and same in size because object is at the centre of curvature of the mirror.

**7.** **(d)** Convex mirror always forms, virtual, erect and smaller image.

**8.** **(a)** To see his full image in a plane mirror a person requires a mirror of at least half of his height.



**9.** **(c)**

**10.** **(c)** Because they form nearly point image of point source.

**11.** **(d)**

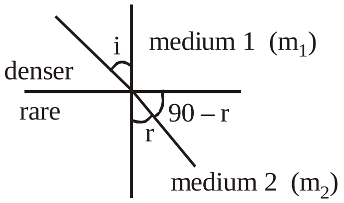
**12.** **(c)** Relation $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$ true for both concave and convex mirror.

**13.** **(b)**

**14.** **(c)** Since the refractive index is less at beam boundary, the ray at the edges of the beam move faster compared to the axis of beam. Hence the beam converges.

**15.** **(b)** According to Snell's law $\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \frac{\mu_2}{\mu_1}$

From fig. we see that



$r > i \Rightarrow v_2 > v_1$ from Snell's Law

So $v_2 = n\lambda_2 > v_1 = n\lambda_1 \Rightarrow \lambda_2 > \lambda_1$

(Frequency of wave does not change on refraction)

**16.** **(b)** Frequency does not change on refraction.

**17.** **(d)** It occurs in both reflection & refraction & the angle of bending rays is constant.

**18.** **(b)** According to Snell's Law, $\frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1}$

where r = 90º for particular incidence angle called critical angle. When the incidence angle is equal to or greater than $i_c$, then total internal reflection occurs. It takes place when ray of light travels from optically denser medium ($\mu_1 > \mu_2$) to optically rarer medium.

**19.** **(c)** For total internal reflection light ray must travel from optically denser to an optically rarer medium.

**20.** **(c)** As $i > i_c$

At $i = i_c$ angle of refraction

'$r$' = 90°

$$\therefore \frac{\sin i_c}{\sin 90°} = \mu = 1$$

**21.** **(a)** The basic principle of communication in fibre optics is based on the phenomenon of total internal reflection.

**22.** **(d)**

**23.** **(b)** Difference between apparent and real depth of a pond is due to the refraction of light, not due to the total internal reflection. Other three phenomena are due to the total internal reflection.

**24.** **(d)** The magnification for vertual image formed by concave lens is positive.

**25.** **(a)** The apparent flattening (oval shape) of the sun at sunset and sunrise is due to refraction.

**26.** **(b)** In an isotropic medium, speed of light depends on its wavelength.

**27.** **(a)**

**28.** **(d)** Since refractive index for different wave length of light is different. Hence the different colours of light forms images at different position. This phenomenon is called chromatic aberration.

**29.** **(d)** The cause of chromatic aberration is that lens focusses different colours at different points.

**30.** **(c)** Since $l_R > l_V$ $m_R < m_V$

$\left(\because \mu \propto \frac{1}{\lambda}\right) \Rightarrow f_V < f_R \left(\because \frac{1}{f} \propto (\mu - 1)\right)$

**31.** **(b,c)** If faces of prism on which light is incident & from which it emerge are parallel, then angle of prism will be zero & so deviation will also be zero i.e., the prism will act as a transparent prism.

**32.** **(d)** **33.** (d)

**34.** **(a)** The angular dispersion θ i.e., the angle between the extreme rays of light,

$\theta = (\delta_V - \delta_R)$ where $\delta_V = (\mu_V - 1)A$, $\delta_R = (\mu_V - 1)A$ & A is angle of prism.

So if refractive index increases, then δ increases & hence θ increases.

**35.** **(b)** Dispersive power of a prism $\omega = \frac{\mu_V - \mu_R}{\mu_y - 1} = \frac{d\mu}{\mu - 1}$,

where $\mu = \mu_y = \frac{\mu_V + \mu_R}{2}$

**36.** **(d)**

**37.** **(b)** Refractive index of medium is given by

$$\mu = A + \frac{B}{\lambda^2} \qquad (\text{where A and B are constant}).$$

Light has seven different colour, so its each colour has different wavelength and so different refractive index.

Due to difference in refractive index different refractive angle $\left(\mu = \frac{\sin i}{\sin r}\right)$.

So this is due to dependence on wavelength of refractive index.

**38.** **(a)** In the position of minimum deviation, $i_1 = i_2$.

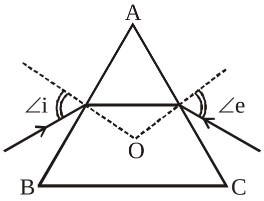
**39.** **(d)** We can combine two prisms in such a way

(i) deviation is zero but dispersion not

(ii) dispersion is zero but deviation is not.

But in any situation both deviation & dispersion can not be zero simultaneously.

**40.** **(c)** At the minimum deviation, f = $D_m$ angle of incidence ∠i = angle of emergence ∠e and inside the prism refracted ray parallel to the base of the prism



**41.** **(d)**

**42.** **(c)** In the position of minimum deviation

$$i = e = \frac{A + \delta m}{2} = \frac{60 + 30}{2} = 45°$$

**43.** **(a)**

**44.** **(b)** Secondary rainbow is formed by rays undergoing interanal reflection twice inside the drop.

**45.** **(b)**

**46.** **(b)** For rear view, Convex mirror is used in vehicle

**47.** **(a)** Cylindrical lens is used to rectify eye defect astigmatism

**48.** **(b)**

**49.** **(d)** Because, the focal length of eye lens can not decrease beyond a certain limit.

**50.** **(b)** The image formed by objective lens of compound microscope is real and enlarged, while final image formed by compound microscope is inverted, virtual, enlarged and at a distance D to infinite or from an eye, on same side of eye piece.

**51.** **(b)** The aperture of objective lens of Astronomical telescope is large to get better resolution. Since resolution of telescope power is $R = \frac{D}{1.22\lambda}$, where D is the diameter of the objective lens of Telescope.

**52.** **(b)** One should increase the power of lens i.e., decrease the focal length of a lens.

**53.** **(a)** In simple microscope the final image is erect.

**54.** **(d)** Resolving power $= \frac{\lambda}{d\lambda}$ plane transmission grating

Resolving power for telescope

$$= \frac{1}{\text{limit of resolution}} = \frac{d}{1.22\lambda} = \frac{d_0}{d_1}$$

by increasing the aperture of objective resolving power can be increased.

**55.** **(a)** To find the refractive index of glass using a travelling microscope, a vernier scale is provided on the microscope.

**56.** **(d)** Magnifying power of microscope

$$= \frac{LD}{f_0 f_e} \propto \frac{1}{f_0}$$

Hence with increase $f_0$ magnifyig power of microscope decreases.

Magnifying power of telescope $= \frac{f_0}{f_e} \propto f_0$

Hence with increase $f_0$ magnifying power of telescope increases.

**57.** **(d)** Because of large objective area more light is gathered.

As magnification $m = \frac{\beta}{\alpha}$

β = angle subtended at the eye by the final image

α = angle subtended by the object at the lens or eye

**58.** **(c)** With large diameters of objective, the ability to observe two objects distinctly, increases as more light is gathered.

## STATEMENT TYPE QUESTIONS

**59.** **(d)**

**60.** **(d)** The image formed by a convex mirror is always virtual.

**61.** **(b)** Normal is perpendicular to the tangent to surface at the point of incidence i.e., the normal is along the radius, the line joining the centre of curvature of the mirror to the point of incidence.

So, geometric centre of a spherical mirror is called its pole while that of a spherical lens is called its optical centre. The line joining the pole and the centre of curvature of the spherical mirror is known as the principal axis. In the case of spherical lenses, the pricipal axis is the line joining the optical centre with its principal focus.

**62.** **(c)** The ratio of the sine of the angle of incidence to the sine of angle of refraction is constant. Remember that the angles of incidence (*i*) and refraction (*r*) are the angles that the incident and its refracted ray make with the normal, respectively. We have,

$$\frac{\sin i}{\sin r} = n_{21} \qquad \text{...(i)}$$

where, $n_{21}$ is a constant, called the refractive index of the medium 2 w.r.t. the medium 1. Eq. (i) is the well known Snell's law of refraction. We note that $n_{21}$ is a characteristic of the pair of media (and also depends on the wavelength of light) but is independent of the angle of incidence

**63.** (a) If $n_{21}$ is the refractive index of medium 2 with respect to medium 1 and $n_{12}$ the refractive index of medium 1 with respect to medium 2, then it should be clear that

$$n_{12} = \frac{1}{n_{21}}$$

It also follows that if $n_{32}$ is the refractive index of medium 3 with respect to medium 2, then $n_{32} = n_{31} \times n_{12}$, where $n_{31}$ is the refractive index of medium III with respect to medium I.

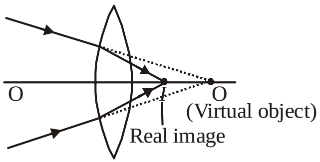
**64.** (a) Convex lens is a converging lens provided refractive index of the material of the lens is greater than the surrounding medium in which the lens is kept.

From lens maker's formula,

$$\frac{1}{f} = (\mu_2 - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

Refracting index of lens varies inversely with the wavelength of light used.

II. For virtual object, image is real for convex lens.



**65.** (a) The variation of refractive index with wavelength may be more pronounced in some media than the other. In vacuum, of course, the speed of light is independent of wavelength. Thus, vacuum (or air approximately) is a non-dispersive medium in which all colours travel with the same speed.

This also follows from the fact that sunlight reaches us in the form of white light and not as its components. On the other hand, glass is a dispersive medium.

**66.** **(b)** At sunset or sunrise the sun's rays have to pass through a larger distance in the atmosphere and most of the blue or other shorter wavelengths are removed by scattering.

## MATCHING TYPE QUESTIONS

**67.** **(c)** A-2 : For $u = -f$,

$$\frac{1}{v} + \frac{1}{-f} = \frac{1}{f}$$

$$\therefore\ v = \frac{f}{2}$$

and $M = -\frac{v}{u} = -\frac{f/2}{(-f)} = 0.5$.

B-4 : $u = -2f$, so $v = -2f$

$$M = -\frac{v}{u} = -\left(\frac{-2f}{-2f}\right) = -1$$

C-1 : In concave mirror, $u = -2f$, $v = -\infty$

$$\therefore\ M = -\frac{v}{u} = -\infty.$$

D-5 : In convex mirror $u = -2f$

so $\frac{1}{v} + \frac{1}{-2f} = \frac{1}{f} \Rightarrow v = \frac{2f}{3}$.

Now $M = -\frac{v}{u} = \frac{1}{3}$.

**68.** **(b)** **69. (d)**

**70.** **(b)** (i) $P = +2.0 \Rightarrow f = \frac{1}{+2.0} \times 100\text{ cm} = +50\text{ cm}$

(Positive power convex lens)

(ii) $P = P_1 + P_2 = (+0.25) + (+0.25) = +0.50$ D

$$f = \frac{1}{P} = \frac{1}{+0.5} \times 100\text{ cm} = 200\text{ cm}$$

(iii) $P = -2.0 \Rightarrow f = \frac{1}{-2.0} \times 100\text{ cm} = -50\text{ cm}$

(–ve power concave lens)

(iv) $P = P_1 + P_2 = (-6.0) + (+3.5) = -2.5$ Da

$$f = \frac{1}{p} = \frac{1}{-2.5} \times 100\text{ cm} = -40\text{ cm}$$

**71.** **(a)** A - (2) : $M = \frac{1}{4}$ is for erect or virtrual image and so it is possible for convex mirror.

B - (1): $m = -1$, negative magnification is possible in concave mirror.

C - (1) : $m = 2$, is possible for concave mirror when object is put between focal point and pole of the mirror.

D - (3) : $m = 1$ is possible for plane mirror.

**72.** **(b)**

**73.** **(d)** **74. (c)**

## DIAGRAM TYPE QUESTIONS

**75.** **(a)**

**76.** **(c)** According to sign-convention, distance left or below pole is – (ve) and right or above pole is +(ve).

**77.** **(d)** The ray parallel to principle axis after reflection through mirror passes through the focus and the ray passing through the centre of curvature set retr its path.

**78.** (b) $^{a}\mu_g = \frac{\sin 60°}{\sin 35°}$ ... (i)

$$^{a}\mu_w = \frac{\sin 60°}{\sin 41°} \quad \text{... (ii)}$$

$$^{w}\mu_g = \frac{\sin 41°}{\sin \theta} \quad \text{... (iii)}$$

$$^{a}\mu_w \times {}^{w}\mu_g = {}^{a}\mu_g$$

$$\frac{\sin 60°}{\sin 41°} \times \frac{\sin 41°}{\sin \theta} = \frac{\sin 60°}{\sin 35°} \quad \text{(Using (i), (ii) and (iii))}$$

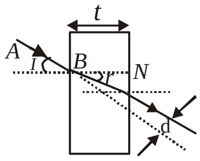
$$= \sin\theta = \sin 35° \quad \theta = 35°$$

**79.** **(d)** As $r_1 < i_1$ i.e., the incident ray bends towards the normal ⇒ medium 2 is denser than medium 1.

Or $r_2 < i_1$ ⇒ medium 3 is denser than medium 1.

Also, $r_2 > r_1$ ⇒ medium 2 is denser than medium 3.

**80.** **(c)**



From figure, in right angled $\Delta CDB$

$$\angle CBD = (i - r)$$

$\therefore\ \sin(i-r) = \frac{CD}{BC} = \frac{d}{BC}$

or $d = BC\sin(i-r)$ .... (i)

Also, in right angled $\Delta CNB$

$\cos r = \frac{BN}{BC} = \frac{t}{BC}$

or $BC = \frac{t}{\cos r}$ .... (ii)

Substitute equation (ii) in equation (i), we get

$d = \frac{t}{\cos r}\sin(i-r)$

For small angles $\sin(i-r) \approx \sin i - r$ $\cos r \approx 1$

$d = t\,(i-r),\ d = it\left[1-\frac{r}{i}\right]$

**81. (d)**

**82. (a)** ${}_2^1\mu = \frac{\sin 90°}{\sin C} = \frac{1}{\sin C}$ [For critical angle]

$\therefore\quad C = \sin^{-1}\left(\frac{1}{{}_2^1\mu}\right)$ ...(i)

Applying Snell's law at P, we get

${}_2^1\mu = \frac{\sin r'}{\sin i} = \frac{\sin(90-r)}{\sin r}$ $[\because i = r; r'+r = 90°]$

$\frac{1}{2}\mu = \frac{\cos r}{\sin r}$ ...(ii)

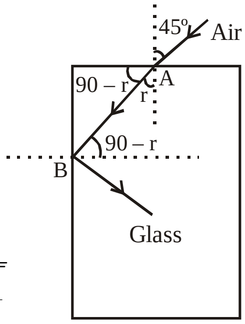
From (i) and (ii)

$C = \sin^{-1}(\tan r)$

**83. (a)** For point A, ${}_a\mu_g = \frac{\sin 45°}{\sin r} \Rightarrow \sin r = \frac{1}{\sqrt{2}\,{}_a\mu_g}$

for point B, $\sin(90-r) = {}_g\mu_a$

(90 – r) is critical angle.



$\therefore\ \cos r = {}_g\mu_a = \frac{1}{{}_a\mu_g}$

$\Rightarrow\ {}_a\mu_g = \frac{1}{\cos r}$

$= \frac{1}{\sqrt{1-\sin^2 r}} = \frac{1}{\sqrt{1-\frac{1}{2\,{}_a\mu_g{}^2}}}$

$\Rightarrow\ {}_a\mu_g{}^2 = \frac{1}{1-\frac{1}{2\,{}_a\mu_g^2}} = \frac{2\,{}_a\mu_g^2}{2\,{}_a\mu_g^2-1}$

$\Rightarrow\ 2\,{}_a\mu_g^2 - 1 = 2 \Rightarrow\ {}_a\mu_g = \sqrt{\frac{3}{2}}$

**84. (c)** For the prism as the angle of incidence (i) increases, the angle of deviation (δ) first decreases goes to minimum value and then increases.

**85. (b)** For minimum deviation, incident angle is equal to emerging angle.

$\therefore$ QR is horizontal.

**86. (b)** The incident angle is 45° incident angle > critical angle, $i > i_c$

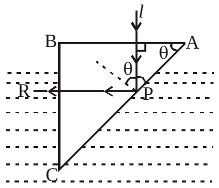
$\therefore \sin i > \sin i_c$ or $\sin 45 > \sin i_c$

$\sin i_c = \frac{1}{n}$ $\therefore \sin 45° > \frac{1}{n}$ or $\frac{1}{\sqrt{2}} > \frac{1}{n}$ $\Rightarrow n > \sqrt{2}$

**87. (a)** The phenomenon of total internal reflection takes place during reflection at P.

$\sin\theta = \frac{1}{{}_g^\omega\mu}$ ...(i)

When θ is the angle of incidence at P



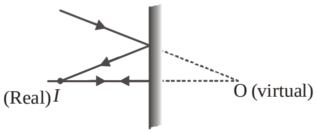
Now, ${}_g^\omega\mu = \frac{{}_g^a h}{{}_g^\omega\mu} = \frac{1.5}{4/3} = 1.125$

Putting in (i), $\sin\theta = \frac{1}{1.125} = \frac{8}{9}$

$\therefore$ sin θ should be greater than or equal to $\frac{8}{9}$.

## ASSERTION - REASON TYPE QUESTIONS

**88. (b)** Plane mirror may form real image, if object is virtual.



**89. (d)** Focal length of the spherical mirror does not depend on the medium in which it placed.

**90. (c)** The image of real object may be real in case of concave mirror.

**91. (b)**

**92. (d)** The distance of image in convex mirror is always $v \le f$.

**93. (a)** **94. (a)**

**95. (c)** The rays from centre of hemisphere cut at the centre after refraction - Snell's law is valid in each case of refraction.

**96. (d)** $f_w = f\frac{{}_a\mu_g - 1}{\left(\frac{{}_a\mu_g}{{}_a\mu_w}-1\right)} = f\frac{\left(\frac{3}{2}-1\right)}{\left(\frac{3/2}{4/3}-1\right)} = 4f$

**97. (c)** $\frac{1}{f} = (\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) = (1.5-1)\left(\frac{1}{R}-\frac{1}{-R}\right)$

or $f = R$.

**98. (d)** If the rays cross focal point of convex lens, they become diverging.

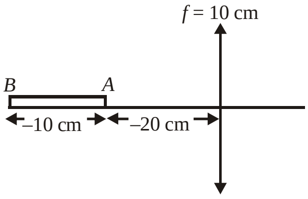
**99. (a)**

**100. (a)** RP ∝ diameter of objective.

**101. (d)**

## CRITICALTHINKING TYPE QUESTIONS

**102. (d)**



The focal length of the mirror

$$-\frac{1}{f}=\frac{1}{v}+\frac{1}{u}$$

For $A$ end of the rod the image distance

When $u_1=-20$ cm

$$\Rightarrow \frac{-1}{10}=\frac{1}{v_1}-\frac{1}{20}$$

$$\frac{1}{v_1}=\frac{-1}{10}+\frac{1}{20}=\frac{-2+1}{20}$$

$v_1=-20$ cm

For when $u_2=-30$ cm

$$\frac{1}{f}=\frac{1}{v_2}-\frac{1}{30}$$

$$\frac{1}{v_2}=\frac{-1}{10}+\frac{1}{30}=\frac{-30+10}{300}=\frac{-20}{300}$$

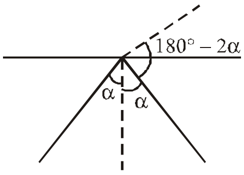
$v_2=-15$ cm

$L=v_2-v_1=-15-(-20)$

$L=5$ cm

**103. (a)** $$\cos(180°-2\alpha)=\frac{\left(\frac{\hat{i}}{2}+\frac{\sqrt{3}}{2}\hat{j}\right)\cdot\left(\frac{\hat{i}}{2}-\frac{\sqrt{3}}{2}\hat{j}\right)}{\sqrt{\left(\frac{1}{2}\right)^2+\left(\frac{\sqrt{3}}{2}\right)^2}\sqrt{\left(\frac{1}{2}\right)+\left(-\frac{\sqrt{3}}{2}\right)^2}}$$

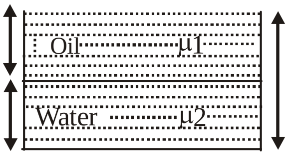
$$\therefore \cos(180°-2\alpha)=-\frac{1}{2}$$



$\therefore\ 180°-2\alpha=120° \quad \therefore\ \alpha=30°$

Option (a) is correct.

**104. (a)**



As refractive index, $\mu=\dfrac{\text{Real depth}}{\text{Apparent depth}}$

$\therefore$ Apparent depth of the vessel when viewed from above is

$$d_{\text{apparent}}=\frac{x}{2\mu_1}+\frac{x}{2\mu_2}=\frac{x}{2}\left(\frac{1}{\mu_1}+\frac{1}{\mu_2}\right)$$

$$=\frac{x}{2}\left(\frac{\mu_2+\mu_1}{\mu_1\mu_2}\right)=\frac{x(\mu_1+\mu_2)}{2\mu_1\mu_2}$$

**105. (d)** $\sin C=\dfrac{1}{\mu}=\dfrac{1}{\sqrt{2}} \quad \therefore\ C=\sin^{-1}\left(\dfrac{1}{\sqrt{2}}\right)=45°$

Now $\dfrac{\sin C}{\sin r}=\dfrac{1}{\mu}$ or $\dfrac{\sin 45°}{\sin r}=\dfrac{1}{\sqrt{2}}$

$\sin r=1$ or $r=90°$

**106. (a)** Given that ${}_w\mu_g=\dfrac{5}{4}$ and ${}_a\mu_w=\dfrac{4}{3}$

$$\therefore\ {}_a\mu_g={}_w\mu_g\times{}_a\mu_w=\frac{5}{4}\times\frac{4}{3}=\frac{5}{3}$$

**107. (a)**

**108. (d)** Total thickness = t; Refrative index = μ

Speed of light in Glass plate = $\dfrac{c}{\mu}$

$$\left[\because v=\frac{\text{Speed of light in vacuum}}{\text{R.I. of Medium}}\right]$$

Time taken = $\dfrac{t}{\frac{c}{\mu}}=\dfrac{\mu t}{c}$

(where t = thickness of glass plate)

**109. (c)** Thickness of glass plate (t) = 6 cm;

Distance of the object (u) = 8 cm. and distance of the image (v) = 12 cm.

Let x = Apparent position of the silvered surface in cm. Since the image is formed due to relfection at the silvered face and by the property of mirror image distance of object from the mirror = Distance of image from the mirror

or $x+8=12+6-x$ or $x=5$ cm.

Therefore refractive index of glass

$$=\frac{\text{Real depth}}{\text{Apparent depth}}=\frac{6}{5}=1.2.$$

**110. (c)** $v=\dfrac{c}{\mu}$ or $\lambda_m=\dfrac{\lambda_0}{\mu} \quad \therefore\ \lambda_m=\dfrac{420}{(4/3)}=315$ nm

**111. (b)** $\mu=\dfrac{\text{velocity of light in vacuum (c)}}{\text{velocity of light in medium (v)}}$

But $v=\upsilon\lambda=2\times10^{14}\times5000\times10^{-10}$

In the medium, $v=10^8$ m/s.

$$\therefore\ \mu=\frac{v_{vac}}{v_{med}}=\frac{3\times10^8}{10^8}=3.$$

**112. (c)** : For total internal reflection

$\sin i>\sin C$

where,

$i$ = angle of incidence, $C$ = critical angle

But, $\sin C=\dfrac{1}{\mu} \quad \therefore\ \sin i>\dfrac{1}{\mu}$ or $\mu>\dfrac{1}{\sin i}$

$\mu>\dfrac{1}{\sin 45°} \qquad$ ($i$ = 45° (Given))

$\mu>\sqrt{2}$

Hence, option (c) is correct.

**113. (d)** Here, $v_A=1.8\times10^8$ m s$^{-1}$

$v_B=2.4\times10^8$ m s$^{-1}$

Light travels slower in denser medium. Hence medium $A$ is a denser medium and medium $B$ is a rarer medium. Here, Light travels from medium $A$ to medium $B$. Let $C$ be the critical angle between them.

$$\therefore\ \sin C={}^A\mu_B=\frac{1}{{}^B\mu_A}$$

Refractive index of medium B w.r.t. to medium A is

$${}^A\mu_B=\frac{\text{Velocity of light in medium }A}{\text{Velocity of light in medium }B}=\frac{v_A}{v_B}$$

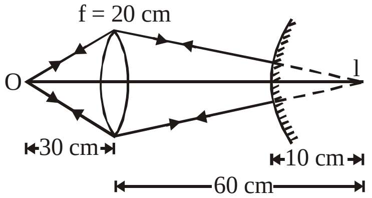
$$\therefore \ \sin C = \frac{v_A}{v_B} = \frac{1.8\times10^8}{2.4\times10^8} = \frac{3}{4} \text{ or } C = \sin^{-1}\left(\frac{3}{4}\right)$$

**114. (b)**

**115. (c)** For total internal reflection,

$$\mu \ge \frac{1}{\sin C} \ge \sqrt{2} \ge 1.414 \Rightarrow \mu = 1.50$$

**116. (c)**



$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}\ ;\ \frac{1}{v}-\frac{1}{-30}=\frac{1}{20} \Rightarrow v = 60 \text{ cm}$$

Coincidence is possible when the image is formed at the centre of curvature of the mirror. Only then the rays refracting through the lens will fall normally on the convex mirror and retrace their path to form the image at O. So the distance between lens and mirror = 60 – 10 = 50 cm.

**117. (b)** $$\frac{1}{f_a} = \left(\frac{1.5}{1}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \qquad \ldots\text{(i)}$$

$$\frac{1}{f_m} = \left(\frac{\mu_g}{\mu_m}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\frac{1}{f_m} = \left(\frac{1.5}{1.6}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \qquad \ldots\text{(ii)}$$

Dividing (i) by (ii), $\frac{f_m}{f_a} = \left(\frac{1.5-1}{\frac{1.5}{1.6}-1}\right) = -8$

$$P_a = -5 = \frac{1}{f_a} \Rightarrow f_a = -\frac{1}{5}$$

$$\Rightarrow f_m = -8\times f_a = -8\times-\frac{1}{5} = \frac{8}{5}$$

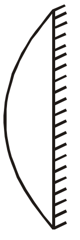
$$P_m = \frac{\mu}{f_m} = \frac{1.6}{8}\times5 = 1\text{D}$$

**118. (b)** $R_1 = 60$ cm, $R_2 = \propto$, $\mu = 1.6$

$$\frac{1}{f} = (\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\frac{1}{f} = (1.6-1)\left(\frac{1}{60}\right) \Rightarrow f = 100 \text{ cm.}$$

**119. (c)** The silvered plano convex lens behaves as a concave mirror; whose focal length is given by



$$\frac{1}{F} = \frac{2}{f_1}+\frac{1}{f_m}$$

If plane surface is silvered

$$f_m = \frac{R_2}{2} = \frac{\infty}{2} = \infty$$

$$\therefore \frac{1}{f_1} = (\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$= (\mu-1)\left(\frac{1}{R}-\frac{1}{\infty}\right) = \frac{\mu-1}{R}$$

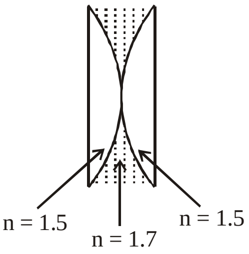
$$\therefore \ \frac{1}{F} = \frac{2(\mu-1)}{R}+\frac{1}{\infty} = \frac{2(\mu-1)}{R}$$

$$F = \frac{R}{2(\mu-1)}$$

Here R = 20 cm, $\mu = 1.5$

$$\therefore \ F = \frac{20}{2(1.5-1)} = 20\text{cm}$$

**120. (b)** Using lens maker's formula,



$$\frac{1}{f} = (\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\frac{1}{f_1} = \left(\frac{1.5}{1}-1\right)\left(\frac{1}{\infty}-\frac{1}{-20}\right)$$

$$\Rightarrow f_1 = 40\text{cm}$$

$$\frac{1}{f_2} = \left(\frac{1.7}{1}-1\right)\left(\frac{1}{-20}-\frac{1}{+20}\right)$$

$$\Rightarrow f_2 = -\frac{100}{7} \text{ cm}$$

and $\frac{1}{f_3} = \left(\frac{1.5}{1}-1\right)\left(\frac{1}{\infty}-\frac{1}{-20}\right) \Rightarrow f_3 = 40$ cm

$$\frac{1}{f_{eq}} = \frac{1}{f_1}+\frac{1}{f_2}+\frac{1}{f_3} \Rightarrow \frac{1}{f_{eq}} = \frac{1}{40}+\frac{1}{-100/7}+\frac{1}{40}$$

$\therefore$ $f_{eq} = -50$ cm

Therefore, the focal length of the combination is – 50 cm.

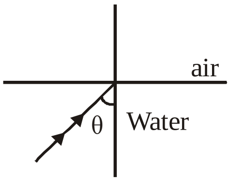
**121. (b)** By Lens maker's formula for convex lens

$$\frac{1}{f} = \left(\frac{\mu}{\mu_L}-1\right)\left(\frac{2}{R}\right)$$

for, $\mu_{L_1} = \frac{4}{3}$, $f_1 = 4R$

for $\mu_{L_2} = \frac{5}{3}$, $f_2 = -5R \Rightarrow f_2 = (-)$ ve

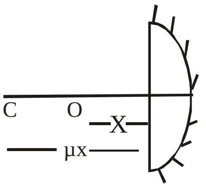
**122. (b)** For critical angle $\theta_c$,



$$\sin\theta_c = \frac{1}{\mu}$$

For greater wavelength or lesser frequency $\mu$ is less. So, critical angle would be more. So, they will not suffer reflection and come out at angles less then 90°.

**123. (c)**



For the image to be real and of same size as object, final image should be formed at the position of object itself.

Let x be the distance of object from plane surface.

Apparent distance from surface = $\mu x$

This should be centre of curve

$$\therefore \mu x = 30 \Rightarrow 1.5x = 30 \Rightarrow x = 20$$

**124. (b)** If $R_1 = R, R_2 = -2R$

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{6} = (1.5 - 1)\left(\frac{1}{R} + \frac{1}{2R}\right) = \frac{0.5 \times 3}{2R}$$

$R = 4.5\,\text{cm}$

**125. (b)** Here, $P_1 = 5\,D$

$P_2 = P - P_1 = 2 - 5 = -3\,D$

$$\frac{\omega_1}{\omega_2} = -\frac{f_1}{f_2} = \frac{-P_2}{P_1} = \frac{3}{5}$$

**126. (c)** Longitudinal chromatic aberration = $\omega f$

$= 0.08 \times 20 = 1.6\,\text{cm}$

**127. (a)** $$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{16} = (1.5 - 1)\left(\frac{1}{R} - \frac{1}{\infty}\right)$$

$$\Rightarrow \frac{1}{16} = 0.5 \times \frac{1}{R} \Rightarrow R = 8\ \text{cm}$$

**128. (c)** For reading purposes :

$u = -25$ cm, $v = -50$ cm, $f = ?$

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = -\frac{1}{50} + \frac{1}{25} = \frac{1}{50};$$

$$P = \frac{100}{f} = +2\,D$$

For distant vision, f' = distance of far point = –3 m

$$P = \frac{1}{f'} = -\frac{1}{3}D = -0.33\ D$$

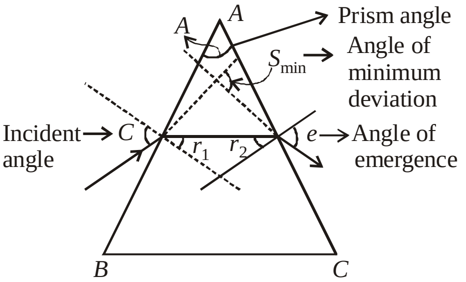
**129. (d)** $$P_2 = P - P_1 = \frac{100}{80} - \frac{100}{20} = -3.75\ D$$

**130. (b)** $$\frac{P_a}{P_1} = \frac{\left(\frac{\mu_g}{\mu_a} - 1\right)}{\left(\frac{\mu_g}{\mu_1} - 1\right)} = \frac{+5}{-100/100} = -5$$

$$-5\left(\frac{\mu_g}{\mu_1} - 1\right) = \frac{\mu_g}{\mu_a} - 1$$

$$\frac{1.5}{\mu_1} - 1 = \frac{-1}{5}(1.5 - 1) = -0.1; \quad \mu_1 = \frac{1.5}{0.9} = \frac{5}{3}$$

**131. (b)**



The angle of minimum deviation is given as

$\delta_{min} = i + e - A$

for minimum deviation

$\delta_{min} = A$ then

$2A = i + e$

in case of $\delta_{min}$ $i = e$

$$2A = 2i \quad r_1 = r_2 = \frac{A}{2}$$

$i = A = 90°$

from smell's law

$1 \sin i = n \sin r_1$

$$\sin A = n \sin \frac{A}{2}$$

$$2 \sin \frac{A}{2} \cos \frac{A}{2} = n \sin \frac{A}{2}$$

$$2 \cos \frac{A}{2} = n$$

when $A = 90° = i_{min}$

then $n_{min} = \sqrt{2}$

$i = A = 0$ $n_{max} = 2$

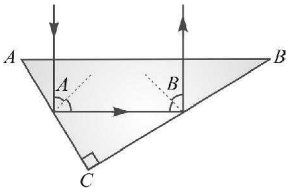
**132. (a)** For a thin prism, $D = (\mu - 1)A$

Since $\lambda_b < \lambda_r \Rightarrow \mu_r < \mu_b \Rightarrow D_1 < D_2$

**133. (c)** The ray is incident on face *AC* at an angle *A*, after reflection, it incident of face *BC* at an angle *B*. Thus

$$\angle A + \angle B = 90°.$$

As $B < A$, so the ray if totally reflected from face *BC*, it must be reflected from *AC* also. For this angle *B* should be greater than critical angle *C*. For minimum value of μ, *B* can be infinitesimally than *C*, so *B* = *C* (critical angle). We know that



$$\mu = \frac{1}{\sin C} = \frac{1}{\sin B}$$

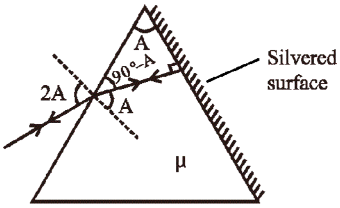
For $A = B, \quad B = 45°$

$$\therefore \quad \mu_{min} = \frac{1}{\sin 45°} = \sqrt{2}$$

**134. (b)** The angle must be equal to the critical angle,

$$C = \sin^{-1}\left(\frac{1}{\mu}\right) = \sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = 45°$$

**135. (b)**



According to Snell's law $\mu = \dfrac{\sin i}{\sin r}$

$\Rightarrow$ (1) $\sin 2A = (\mu) \sin A \Rightarrow \mu = 2\cos A$

**136. (a)** As we know, the refractive index of the material of the prism

$$\mu = \frac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin(A/2)}$$

$$\cot A/2 = \frac{\sin\left(\frac{A + \delta_m}{2}\right)}{\sin A/2} = \frac{\cos(A/2)}{\sin(A/2)}$$

$[\because \mu = \cot(A/2)]$

$\Rightarrow \text{Sin}\left(\frac{\delta_m + A}{2}\right) = \sin(90° + A/2)$

$\Rightarrow d_{min} = 180° - 2A$

**137. (d)** As we know $\mu = \frac{1}{\sin C}$

$\mu = \frac{1}{\sin 60^o} = \frac{2}{\sqrt{3}}$

For total internal reflection to take place

$\sin C = \frac{1}{\mu} = \frac{2}{3}$

$C = \sin^{-1}\frac{2}{3} \cong 42^o$

$\theta < 45^o$

Angle of incidence > critical angle, hence TIR takes place

**138. (b)** Deviation = zero

So, $\delta = \delta_1 + \delta_2 = 0$

$\Rightarrow (\mu_1 - 1)A_1 + (\mu_2 - 1) A_2 = 0$

$\Rightarrow A_2 (1.75 - 1) = -(1.5 - 1) 15°$

$\Rightarrow A_2 = -\frac{0.5}{0.75} \times 15°$

or $A_2 = -10°$.

Negative sign shows that the second prism is inverted with respect to the first.

**139. (b)** $i = \frac{A + \delta_m}{2} = \frac{60 + 30}{2} = 45°$

**140. (d)** $i_1 = i_2 = \frac{3}{4}A$

As $A + \delta = i_1 + i_2$

$\therefore \delta = i_1 + i_2 - A = \frac{3}{4}A + \frac{3}{4}A - A = \frac{A}{2} = \frac{60°}{2} = 30°$

**141. (d)** Here $\frac{x}{1000} = \frac{1.22\lambda}{D}$ or $x = \frac{1.22 \times 5 \times 10^3 \times 10^{-10} \times 10^3}{10 \times 10^{-2}}$

or $x = 1.22 \times 5 \times 10^{-3}$ m = 6.1 m

x is of the order of 5 mm.

**142. (d)** Resolving power $\alpha(1/\lambda)$.

Hence, $\frac{(R.P)_1}{(R.P)_2} = \frac{\lambda_2}{\lambda_1} = \frac{5}{4}$

**143. (a)** $\frac{f_0}{f_e} = 9$, $\therefore f_0 = 9 f_e$

Also $f_0 + f_e = 20$ ($\because$ final image is at infinity)

$9 f_e + f_e = 20, f_e = 2$ cm, $\therefore f_0 = 18$ cm

**144. (b)** In normal adjustment,

$M = \frac{f_0}{f_e} = 20$, $f_e = \frac{f_0}{20} = \frac{60}{20} = 3$ cm

**145. (a)** (i) $M = -\frac{f_0}{f_e}\left(1 + \frac{f_e}{d}\right) = -\frac{200}{5}\left(1 + \frac{5}{25}\right) = -48$

(since least distance d = 25cm)

(ii) $M = -\frac{f_0}{f_e} = -\frac{200}{5} = -40$

**146. (b)** $M = \frac{\beta}{\propto} = \frac{f_0}{f_e}$

$\therefore \beta = \frac{f_0}{f_e} \propto = \frac{60}{5} \times 2° = 24°$

# CHAPTER 25

# WAVE OPTICS

## FACT/DEFINITION TYPE QUESTIONS

**1.** The locus of all particles in a medium, vibrating in the same phase is called
(a) wavelet
(b) fringe
(c) wave front
(d) None of these

**2.** Which of the following is correct for light diverging from a point source?
(a) The intensity decreases in proportion for the distance squared.
(b) The wavefront is parabolic.
(c) The intensity at the wavelingth does depend of the distance.
(d) None of these.

**3.** Wavefront is the locus of all points, where the particles of the medium vibrate with the same
(a) phase (b) amplitude
(c) frequency (d) period

**4.** The phenomena which is not explained by Huygen's construction of wavefront
(a) reflection (b) diffraction
(c) refraction (d) origin of spectra

**5.** Huygen's concept of secondary wave
(a) allows us to find the focal length of a thick lens
(b) is a geometrical method to find a wavefront
(c) is used to determine the velocity of light
(d) is used to explain polarisation

**6.** A plane wave passes through a convex lens. The geometrical shape of the wavefront that emerges is
(a) plane (b) diverging spherical
(c) converging spherical (d) None of these

**7.** Spherical wavefronts, emanating from a point source, strike a plane reflecting surface. What will happen to these wave fronts, immediately after reflection?
(a) They will remain spherical with the same curvature, both in magnitude and sign.
(b) They will become plane wave fronts.
(c) They will remain spherical, with the same curvature, but sign of curvature reversed.
(d) They will remain spherical, but with different curvature, both in magnitude and sign.

**8.** When light suffers reflection at the interface between water and glass, the change of phase in the reflected wave is
(a) zero (b) $\pi$
(c) $\pi/2$ (d) $2\pi$

**9.** Two plane wavefronts of light, one incident on a thin convex lens and another on the refracting face of a thin prism. After refraction at them, the emerging wavefronts respectively become
(a) plane wavefront and plane wavefront
(b) plane wavefront and spherical wavefront
(c) spherical wavefront and plane wavefront
(d) spherical wavefront and spherical wavefront
(e) elliptical wavefront and spherical wavefront

**10.** When a film is illuminated by white light, its upper portion appears dark. Path difference between two reflected beams at the spot must be
(a) zero (b) $\lambda/2$
(c) $2\lambda/2$ (d) $\pi$

**11.** If two coherent sources are vibrating in phase then we have constructive interference at any point *P* whenever the path difference is
(a) $\left(n+\frac{1}{2}\right)\lambda$ (b) $\frac{n\lambda}{2}$
(c) $\left(n-\frac{1}{2}\right)\lambda$ (d) $n\lambda$

**12.** If two sources are coherent, then the phase difference ($\phi$) between the waves produced by them at any point
(a) will change with time and we will have stable positions of maxima and minima.
(b) will not change with time and we have unstable positions of maxima and minima.
(c) Positions of will not change with time and we will have stable positions of maxima and minima.
(d) will change with time and we will have unstable positions of maxima and minima.

**13.** The device which produces highly coherent sources is
(a) Fresnel biprism (b) Young's double slit
(c) Laser (d) Lloyd's mirror

**14.** Which of the following, cannot produce two coherent sources?
(a) Lloyd's mirror (b) Fresnel biprism
(c) Young's double slit (d) Prism

**15.** Coherence is a measure of
(a) capability of producing interference by wave
(b) waves being diffracted
(c) waves being reflected
(d) waves being refracted

**16.** Two sources of light are said to be coherent, when they give light waves of same
(a) amplitude and phase
(b) wavelength and constant phase difference
(c) intensity and wavelength
(d) phase and speed

**17.** Intensity of light depends on
(a) amplitude (b) frequency
(c) wavelength (d) velocity

**18.** The colour of bright fringe nearest to central achromatic fringe in the interference pattern with white light will be
(a) violet (b) red
(c) green (d) yellow

**19.** The correct formula for fringe visibility is
(a) $V = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$ (b) $V = \frac{I_{max} + I_{min}}{I_{max} - I_{min}}$
(c) $V = \frac{I_{max}}{I_{min}}$ (d) $V = \frac{I_{min}}{I_{max}}$

**20.** Laser light is considered to be coherent because it consists of
(a) many wavelengths
(b) uncoordinated wavelengths
(c) coordinated waves of exactly the same wavelength
(d) divergent beam

**21.** The interfering fringes formed by a thin oil film on water are seen in yellow light of sodium lamp. We find the fringes
(a) coloured
(b) black and white
(c) yellow and black
(d) coloured without yellow

**22.** In Young's Double slit experiment, if the distance between the slit and screen (D) is comparable with fringe width (B), the fringe pattern on screen will
(a) strictly be a parabola (b) strictly be a hyperbola
(c) be a elliptical (d) be a straight line

**23.** If Young's double slit experiment is performed in water keeping the rest of the set-up same, the fringes will
(a) increase in width (b) decrease in width
(c) remain unchanged (d) not be formed

**24.** In the Young's Double slit experiment, when we place a converging lens after the slits and place the screen at the focus of the lens, it
(a) introduces an extra path difference in the parallel beam.
(b) introduces no path difference in the parallel beam.
(c) introduces an extra phase difference in the parallel beam.
(d) introduces an extra fringe in the diffraction pattern.

**25.** The fringe width for red colours as compared to that for violet colour is approximately
(a) 3 times (b) 2 times
(c) 4 times (d) 8 times

**26.** In Young's double slit experiment, the minimum amplitude is obtained when the phase difference of super-imposing waves is (where n = 1, 2, 3, ...)
(a) zero (b) $(2n - 1)\pi$
(c) $n\pi$ (d) $(n + 1)\pi$

**27.** The fringe width in a Young's double slit experiment can be increased if we decrease
(a) width of slits
(b) separation of slits
(c) wavelength of light used
(d) distance between slits and screen

**28.** In Young's double slit experiment, one slit is covered with red filter and another slit is covered by green filter, then interference pattern will be
(a) red (b) green
(c) yellow (d) invisible

**29.** Instead of using two slits, if we use two separate identical sodium lamps in Young's experiment, which of the following will occur?
(a) General illumination
(b) Widely separate interference
(c) Very bright maxima
(d) Very dark minima

**30.** Which of the following is not essential for two sources of light in Young's double slit experiment to produce a sustained interference?
(a) Equal wavelength
(b) Equal intensity
(c) Constant phase relationship
(d) Equal frequency

**31.** In Young's double slit experiment, the locus of the point P lying in a plane with a constant path difference between the two interfering waves is
(a) a hyperbola (b) a straight line
(c) an ellipse (d) a parabola

**32.** If the width of the slit in single slit diffrection experiment is doubled, then the central maximum of diffraction pattern becomes
(a) broader and brighter (b) sharper and brighter
(c) sharper and fainter (d) broader adn fainter.

**33.** A diffraction pattern is obtained by using beam of red. light what will happen, if red light is replced by the blue light?
(a) Bands disappear.
(b) Bands become broader and farther apart.
(c) No change will take place.
(d) Diffraction bands become narrow and crowded together.

**34.** When monochromatic light is replaced by white light in Fresnel's biprism arrangement, the central fringe is

(a) coloured (b) white

(c) dark (d) None of these

**35.** The condition for observing Fraunhoffer diffraction from a single slit is that the light wavefront incident on the slit should be

(a) spherical (b) cylindrical

(c) plane (d) elliptical

**36.** The phenomenon of diffraction can be treated as interference phenomenon if the number of coherent sources is

(a) one (b) two

(c) zero (d) infinity

**37.** The diffraction effects in a microscopic specimen become important when the separation between two points is

(a) much greater than the wavelength of light used.

(b) much less than the wavelength of light used.

(c) comparable to the wavelength of light used.

(d) independent of the wavelength of light used.

**38.** What is the Brewester angle for air to glass transition?

( $\mu_g^a$ = 1.5)

(a) tan (1.5) (b) sin (1.5)

(c) $\sin^{-1}$ (1.5) (d) $\tan^{-1}$ (1.5)

**39.** When ordinary light is made incident on a quarter wave plate, the emergent light is

(a) linearly polarised (b) circulary polarised

(c) unpolarised (d) elliptically polarised

**40.** Transverse nature of light was confirmed by the phenomenon of

(a) refreaction of light (b) diffraction of light

(c) dispersion of light (d) polarization of light

**41.** In the case of linearly polarized light, the magnitude of the electric field vector

(a) is parallel to the direction of propagation

(b) does not changes with time

(c) increases linearly with time

(d) varies periodically with time

**42.** Unpolarized light is incident on a plane glass surface The angle of incidence so that reflected and refracted rays are perpendicular to each other, them

(a) $\tan i_\beta = \frac{\mu}{2}$ (b) $\tan i_\beta = \mu$

(c) $\sin i_\beta = \mu$ (d) $\cos i_\beta = \mu$

**43.** Light waves can be polarised because they

(a) have high frequencies (b) have short wavelength

(c) are transverse (d) can be reflected

**44.** Light transmitted by nicol prism is

(a) unpolarised (b) plane polarised

(c) circularly polarised (d) elliptically polarised

**45.** Optically active substances are those substances which

(a) produces polarised light

(b) produces double refraction

(c) rotate the plane of polarisation of polarised light

(d) converts a plane polarised light into circularly polarised light.

**46.** Polaroid glass is used in sun glasses because

(a) it reduces the light intensity to half on account of polarisation

(b) it is fashionable

(c) it has good colour

(d) it is cheaper.

**47.** In the propagation of light waves, the angle between the plane of vibration and plane of polarisaiton is

(a) 0° (b) 90° (c) 45° (d) 80°

**48.** In the propagation of electromagnetic waves, the angle between the direction of propagation and plane of polarisation is

(a) 0° (b) 45° (c) 90° (d) 180°

**49.** When unpolarised light is incident on a plane glass plate at Brewster's angle, then which of the following statements is correct?

(a) Reflected and refracted rays are completely polarised with their planes of polarization parallel to each other

(b) Reflected and refracted rays are completely polarised with their planes of polarization perpendicular to each other

(c) Reflected light is plane polarised but transmitted light is partially polarised

(d) Reflected light is partially polarised but refracted light is plane polarised

**50.** From Brewster's law of polarisation, it follows that the anlge of polarisaiton depends upon

(a) the wavelength of light

(b) plane of polarisation's orientation

(c) plane of vibration's orientation

(d) None of these

## STATEMENT TYPE QUESTIONS

**51.** Shape of wavefront in case of

I. light diverging from a point source is spherical

II. light emerging out of a convex lens when a point source is placed at its focus is plane

III. the portion of the wavefront of light from a distant star intercepted by the Earth is plane.

Which of the above statements are correct?

(a) I and II (b) II and III

(c) I and III (d) I, II and III

**52.** Which of the following statements is/are correct ?

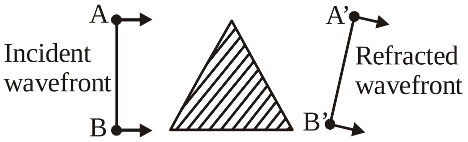
I. A point source emitting waves uniformly in all directions.

II. In spherical wave, the locus of point which have the some amplitude and vibrate in same phase are spheres.

III. At a small distance from the source, a small portion of sphere can be considered as plane wave.

(a) Only I (b) I and II
(c) Only III (d) I, II and III

**53.** Figure shows behavior of a wavefront when it passes through a prism.



Which of the following statements are correct ?

I. Lower portion of wavefront (*B*') is delayed resulting in a tilt.

II. Time taken by light to reach *A*' is equal to the time taken to reach *B*' from *B*.

III. Speed of wavefront is same everywhere.

IV. A particle on wavefront *A*' *B*' is in phase with a particle on wavefront *AB*.

(a) I and II (b) II and III
(c) III and IV (d) I and III

**54.** Which of the following cannot be explained on the basis of wave nature of light?

I Polarization II Total internal reflection
III Photoelectric effect IV Crompton effect

(a) II and III (b) III and IV
(c) IV and I (d) III only

**55.** The conditions for producing sustained interference are

I. phase difference between interfering waves remains constant with time.

II. interfering waves have nearly same amplitude levels.

III. interfering waves are of same frequency.

IV. interfering waves are moving in opposite directions.

(a) I, II and III (b) II and III
(c) III and IV (d) I and IV

**56.** Which of the following statement (s) is/are true about interference pattern due to double slits?

I. The interference pattern has equal number of bright and dark band width .

II. The pattern is obtained by superposition of two waves originating from the two narrow slits.

III. We get a minima at an angle of $\lambda/a$ where '*a*' is the distance between two slits

(a) I only (b) II only
(c) I and II only (d) I, II and III

**57.** In the double-slit experiment, the pattern on the screen is actually a superposition of ____ and ____.

I. single-slit diffraction from each slit

II. double-slit interference pattern

III. double-slit diffraction from each slit

IV. single-slit interference pattern

(a) I and II (b) I and III
(c) II and IV (d) II and III

**58.** Which of the following statements are true about the diffraction pattern?

I. It has a central bright maxima of twice the width of other maxima.

II. The first null occurs at an angle $\lambda/2a$.

III. The intensity of maxima falls as we move away from the central maxima.

IV. The bands are of decreasing width.

(a) II and III (b) I and II
(c) I, III and IV (d) I and III

**59.** Diffraction is a characteristic which is exhibited by

I. matter waves II. water waves
III. sound waves IV. light waves

(a) I and II (b) I, II and III
(c) III and IV (d) I, II, III and IV

**60.** We can listen to the sound on the other side of the wall but cannot see through it because

I. wavelength of light is greater than sound

II. wavelength of light is smaller than sound

III. wavelength of light is much smaller than the dimensions of most obstacles

IV. wavelength of sound is greater than the dimensions of most obstacles

(a) I and II (b) I, II and III
(c) II and III (d) I, III and IV

**61.** In order to observe good interference and diffraction pattern, the necessary and sufficient conditions are

I. the distance between the slits should be very small (~ mm)

II. the slit width should be very small (~ mm)

III. the distance between the slits and the screen should be large (~ cm)

IV. the distance between slits and the screen should be small (~ mm)

(a) I and II (b) I and III
(c) I, II and III (d) II and III

**62.** The resolving power of a telescope is limited by

I. the focal length of objective lens

II. the diameter of objective lens

III. the wavelength of the light used

IV. the thickness of the objective lens

(a) I and II (b) I, II and III
(c) II and III (d) I, III and IV

**63.** The magnification by objective lens of a microscope does not depend upon

I. the focal length of objective

II. the diameter of objective

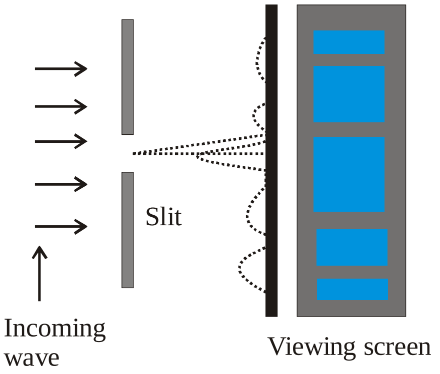
III. the angle subtended by the diameter of the objective lens at the focus of the microscope

IV. the angle subtended by the eyepiece on the eye

(a) I and II (b) II and III

(c) III only (d) IV only

**64.** Diffraction at single slit, the figure shows



I. wavelength distribution

II. intensity distribution

III. diffraction

IV. fringe pattern

(a) I and II (b) II, III and IV

(c) II and IV (d) I III and IV

**65.** Which of the given statements is/are correct for phenomenon of diffraction ?

I. For diffraction through a single–slit, the wavelength of wave must be comparable to the size of the slit.

II. The diffraction is very common in sound waves but not so common in light waves.

III. Diffraction is only observed in electromagnetic waves.

(a) Only I (b) II and III

(c) I and II (d) I, II and III

**66.** Which of the following statements is/are correct ?

I. A polaroid consist of long chain molecules aligned in a particular direction.

II. Electric vectors along the direction of the aligned molecule in a polaroid gets absorbed.

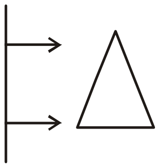
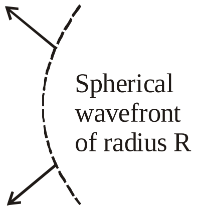
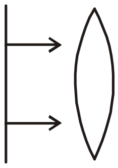
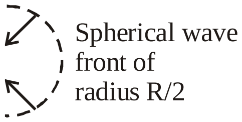
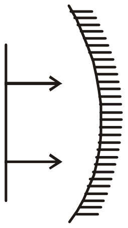
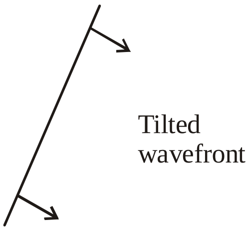
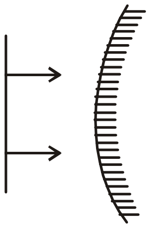
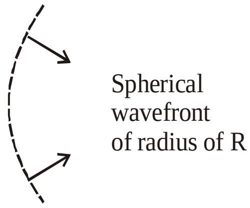
III. An unpolarised light wave is incident on polaroid, then it will get linearly polarised.

(a) Only I (b) II and III

(c) Only III (d) I, II and III

## MATCHING TYPE QUESTIONS

**67.** Match Plane wave incident on different surfaces. In column I with the emergent wavefront in Column II.

| | **Column I** | | **Column II.** |
|---|---|---|---|
| (A) |  | (1) |  |
| (B) |  | (2) |  |
| (C) |  | (3) |  |
| (D) |  | (4) |  |

(a) (A) → (1); (B) → (3); (C) → (2); (D) → (4)

(b) (A) → (3); (B) → (4); (C) → (2); (D) → (1)

(c) (A) → (2); (B) → (4); (C) → (3); (D) → (1)

(d) (A) → (4); (B) → (2); (C) → (1); (D) → (3)

**68.**

| | **Column I** | | **Column II.** |
|---|---|---|---|
| (A) | Interference of light | (1) | $I = I_0 \cos^2 \theta$ |
| (B) | Brewster's Law | (2) | Obstacle/aperture of size = l |
| (C) | Diffraction of light | (3) | $\mu = \tan i_p$ |
| (D) | Law of Malus | (4) | Coherent sources |

(a) (A) → (3); (B) → (4); (C) → (2); (D) → (1)

(b) (A) → (1); (B) → (2); (C) → (3); (D) → (4)

(c) (A) → (4); (B) → (3); (C) → (2); (D) → (1)

(d) (A) → (4); (B) → (3); (C) → (2); (D) → (1)

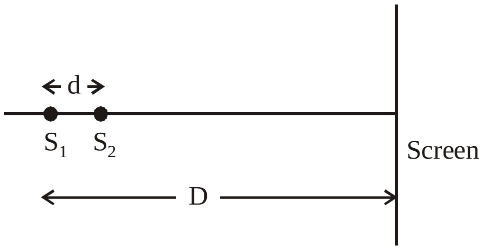
**69.**

| Column I | | Column II. |
|---|---|---|
| (A) Reflection | (1) | Used for reducing glare |
| (B) Refraction | (2) | Change in path of light without change in medium |
| (C) Interference | (3) | $\mu = \sin i/\sin r$ |
| (D) Polarization | (4) | Light added to light produces darkness |

(a) (A) → (2); (B) → (3); (C) → (4); (D) → (1)
(b) (A) → (1); (B) → (2); (C) → (3); (D) → (4)
(c) (A) → (4); (B) → (3); (C) → (2); (D) → (1)
(d) (A) → (1); (B) → (3); (C) → (2); (D) → (1)

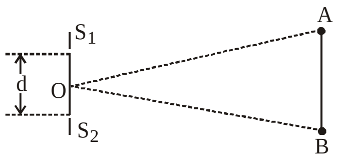
## DIAGRAM TYPE QUESTIONS

**70.** Two coherent point sources $S_1$ and $S_2$ are separated by a small distance 'd' as shown in figure. The fringes obtained on the screen will be



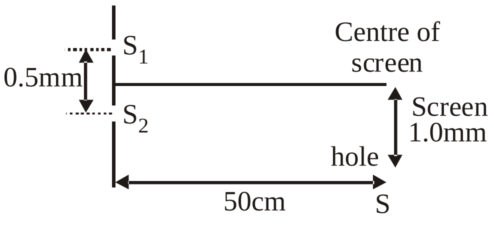
(a) points (b) straight lines
(c) semi-circles (d) concentric circles

**71.** Figure shows two coherent sources $S_1$ and $S_2$ vibrating in same phase. AB is an irregular wire lying at a far distance from the sources $S_1$ and $S_2$. Let $\frac{\lambda}{d} = 10^{-3}$ and $\angle BOA = 0.12°$. How many bright spots will be seen on the wire, including points A and B?



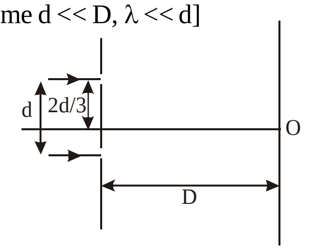
(a) 5 (b) 4 (c) 3 (d) 7

**72.** In Young's double slit experiment shown in figure $S_1$ and $S_2$ are coherent sources and S is the screen having a hole at a point 1.0mm away from the central line. White light (400 to 700nm) is sent through the slits. Which wavelength passing through the hole has strong intensity?



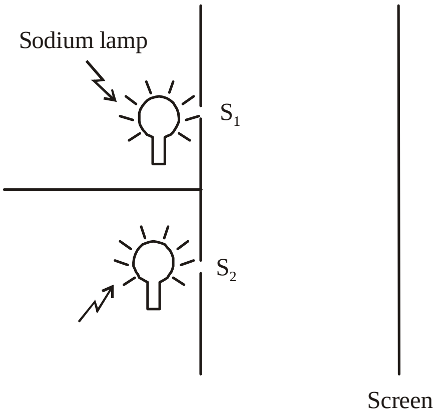
(a) 400 nm (b) 700 nm
(c) 500 nm (d) 667 nm

**73.** In the figure shown if a parallel beam of white light is incident on the plane of the slits then the distance of the nearest white spot on the screen from O is d/A. Find the value of A. (assume d << D, λ << d]



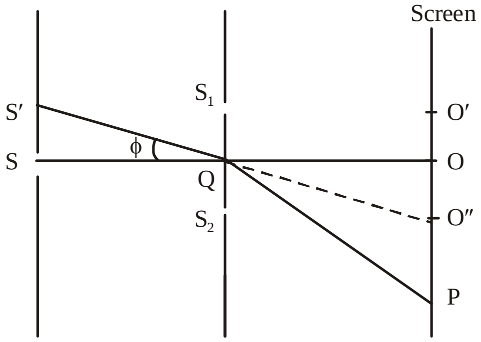
(a) 3
(b) 5
(c) 6
(d) 4

**74.** For the given arrangement, the screen will have



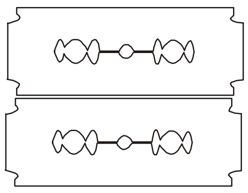
(a) interference pattern with central maxima
(b) interference pattern with central minima
(c) two separate interference patterns with central maxima
(d) doubly illuminated screen with no interference pattern at all

**75.** In the double slit experiment, the monochromatic source is shifted to a position *S′* at an angle ϕ above *SQ*. The position of central bright fringe will be



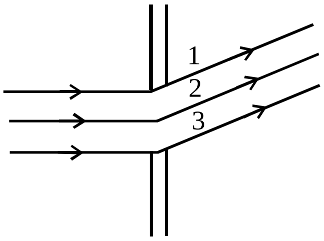
(a) at *O′* (b) at *O*
(c) at *O″* (d) at *P*

**76.** A single-slit-diffraction pattern, through following arrangement using an electric bulb as the source of light only will be



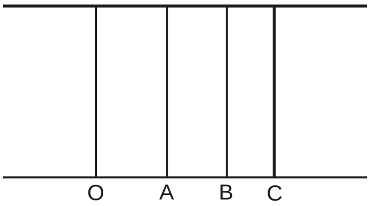
(a) central dark fringe followed by bright fringe of red colour
(b) central bright fringe followed by dark fringe than bands of varying intensity
(c) central bright fringe followed by dark fringe then wider red fringes and narrower blue fringes.
(d) central bright fringe followed by dark fringe then wider blue fringes followed by narrower red fringes.

**77.** The figure shows Fraunhoffer's diffraction due to a single slit. If first minimum is obtained in the direction shown, then the path difference between rays 1 and 3 is



(a) 0
(b) $\lambda / 4$
(c) $\lambda / 2$
(d) $\lambda$

**78.** The position of the direct image obtained at O, when a monochromatic beam of light is passed through a plane transmission grating at normal incidence as shown in Fig. The diffracted images A, B and C correspond to the first, second and third order diffraction. When the source is replaced by another source of shorter wave-length



(a) all the four will shift in the direction C to O
(b) all the four will shift in the direction O to C
(c) the images C, B and A will shift towards O
(d) the images C, B and A will shift away from O

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

**79.** **Assertion :** According to Huygen's principle, no backward wave-front is possible.
**Reason :** Amplitude of secondary wavelet is proportional to (1 + cos θ) where θ is the angle between the ray at the point of consideration and the direction of secondary wavelet.

**80.** **Assertion :** Thin film such as soap bubble or a thin layer of oil on water show beautiful colours when illuminated by white light.
**Reason :** It happens due to the interference of light reflected from upper and lower face of the thin film.

**81.** **Assertion :** No interference pattern is detected when two coherent sources are infinitely close to each other.
**Reason :** The fringe width is inversely proportional to the distance between the two sources.

**82.** **Assertion :** It is necessary to have two waves of equal intensity to study interference pattern.
**Reason :** There will be an effect on clarity if the waves are of unequal intensity.

**83.** **Assertion :** White light falls on a double slit with one slit is covered by a green filter. The bright fringes observed are of green colour.
**Reason :** The fringes observed are coloured.

**84.** **Assertion :** In YDSE, if a thin film is introduced in front of the upper slit, then the fringe pattern shifts in the downward direction.
**Reason :** In YDSE if the slit widths are unequal, the minima will be completely dark.

**85.** **Assertion :** In YDSE, if $I_1 = 9I_0$ and $I_2 = 4I_0$ then $\frac{I_{max}}{I_{min}} = 25$.
**Reason :** In YDSE $I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2$ and $I_{min} = (\sqrt{I_1} - \sqrt{I_2})^2$.

**86.** **Assertion :** In Young's double slit experiment if wavelength of incident monochromatic light is just doubled, number of bright fringe on the screen will increase.
**Reason :** Maximum number of bright fringe on the screen is inversely proportional to the wavelength of light used

**87.** **Assertion :** In YDSE number of bright fringe or dark fringe can not be unlimited
**Reason :** In YDSE path difference between the superposing waves can not be more than the distance between the slits.

**88.** **Assertion :** Interference pattern is made by using yellow light instead of red light, the fringes becomes narrower.
**Reason :** In YDSE, fringe width is given by $\beta = \frac{D\lambda}{d}$.

**89.** **Assertion :** Coloured spectrum is seen when we look through a muslin cloth.
**Reason :** It is due the diffraction of white light on passing through fine slits.

**90.** **Assertion :** Diffraction takes place for all types of waves mechanical or non-mechanical, transverse or longitudinal.
**Reason :** Diffraction's effect are perceptible only if wavelength of wave is comparable to dimensions of diffracting device.

## CRITICAL THINKING TYPE QUESTIONS

**91.** On a hot summer night, the refractive index of air is smallest near the ground and increases with height from the ground. When a light beam is directed horizontally, the Huygens' principle leads us to conclude that as it travels, the light beam :
(a) bends downwards
(b) bends upwards
(c) becomes narrower
(d) goes horizontally without any deflection

**92.** Light from two coherent sources of the same amplitude *A* and wavelength $\lambda$ illuminates the screen. The intensity of the central maximum is $I_0$. If the sources were incoherent, the intensity at the same point will be
(a) $4I_0$ (b) $2I_0$
(c) $I_0$ (d) $\frac{I_0}{2}$

**93.** Two light waves superimposing at the mid-point of the screen are coming from coherent sources of light with phase difference $3\pi$ rad. Their amplitudes are 1 cm each. The resultant amplitude at the given point will be.
(a) 5 cm (b) 3 cm
(c) 2 cm (d) zero

**94.** Two coherent sources of intensity ratio 1 : 4 produce an interference pattern. The fringe visibility will be
(a) 1 (b) 0.8
(c) 0.4 (d) 0.6

**95.** Two beams of light of intensity $I_1$ and $I_2$ interfere to give an interference pattern. If the ratio of maximum intensity to that of minimum intensity is 25/9, then $I_1/I_2$ is
(a) 5/3 (b) 4
(c) 81/625 (d) 16

**96.** In Young's double slit experiment with sodium vapour lamp of wavelength 589 nm and the slits 0.589 mm apart, the half angular width of the central maximum is
(a) $\sin^{-1}(0.01)$ (b) $\sin^{-1}(0.0001)$
(c) $\sin^{-1}(0.001)$ (d) $\sin^{-1}(0.1)$

**97.** The ratio of intensities at two points *P* and *Q* on a screen in young's double slit experiment when waves from sources $S_1$ and $S_2$ have phase difference of (a) 0° and (b) $\pi/2$ respectively, is
(a) 1 : 4 (b) 4 : 1
(c) 1 : 2 (d) 2 : 1

**98.** Laser light of wavelength 540 nm incident on a pair of slit produces interference pattern in which the bright fringes are separated by 9.00 mm. A second light on the same setup produces an interference pattern in which the fringes are separated by 8.1 mm. The wavelength of the second light is
(a) 720 nm (b) 486 nm
(c) 630 nm (d) 450 nm

**99.** In Young's double slit experiment, the source S and two slits A and B are lying in a horizontal plane. The slit A is above slit B. the fringes are obtained on a vertical screen K. The optical path from S to B is increased by putting a transparent material of higher refractive index. The path from S to A remains unchanged. As a result of this the fringe pattern moves somewhat
(a) upwards
(b) downwards
(c) towards left horizontally
(d) towards right horizontally

**100.** In a Young's double-slit experiment, let $\beta$ be the fringe width, and let $I_0$ be the intensity at the central bright fringe. At a distance x from the central bright fringe, the intensity will be
(a) $I_0 \cos\left(\frac{x}{\beta}\right)$ (b) $I_0 \cos^2\left(\frac{x}{\beta}\right)$
(c) $I_0 \cos^2\left(\frac{\pi x}{\beta}\right)$ (d) $\left(\frac{I_0}{4}\right)\cos^2\left(\frac{\pi x}{\beta}\right)$

**101.** In Young's double slit experiment, the slits are 2 mm apart and are illuminated by photons of two wavelengths $\lambda_1 = 12000$Å and $\lambda_2 = 10000$Å. At what minimum distance from the common central bright fringe on the screen 2 m from the slit will a bright fringe from one interference pattern coincide with a bright fringe from the other ?
(a) 6mm (b) 4mm (c) 3mm (d) 8mm

**102.** The maximum number of possible interference maxima for slit-separation equal to twice the wavelength in Young's double-slit experiment is
(a) three (b) five (c) infinite (d) zero

**103.** In a Young's double slit experiment the intensity at a point where the path difference is $\frac{\lambda}{6}$ ($\lambda$ being the wavelength of light used) is I. If $I_0$ denotes the maximum intensity, $\frac{I}{I_0}$ is equal to
(a) $\frac{3}{4}$ (b) $\frac{1}{\sqrt{2}}$ (c) $\frac{\sqrt{3}}{2}$ (d) $\frac{1}{2}$

**104.** In Young's double slit experiment, one of the slit is wider than other, so that amplitude of the light from one slit is double of that from other slit. If $I_m$ be the maximum intensity, the resultant intensity I when they interfere at phase difference $\phi$ is given by
(a) $\frac{I_m}{9}(4+5\cos\phi)$ (b) $\frac{I_m}{3}\left(1+2\cos^2\frac{\phi}{2}\right)$
(c) $\frac{I_m}{5}\left(1+4\cos^2\frac{\phi}{2}\right)$ (d) $\frac{I_m}{9}\left(1+8\cos^2\frac{\phi}{2}\right)$

**105.** Monochromatic light of wavelength 400 nm and 560 nm are incident simultaneously and normally on double slits apparatus whose slits separation is 0.1 mm and screen distance is 1m. Distance between areas of total darkness will be

(a) 4mm (b) 5.6mm (c) 14mm (d) 28mm

**106.** In Young's double slit experiment intensity at a point is (1/4) of the maximum intensity. Angular position of this point is

(a) $\sin^{-1}(\lambda/d)$ (b) $\sin^{-1}(\lambda/2d)$
(c) $\sin^{-1}(\lambda/3d)$ (d) $\sin^{-1}(\lambda/4d)$

**107.** In the Young's double slit experiment using a monochromatic light of wavelength λ, the path difference (in terms of an integer *n*) corresponding to any point having half the peak intensity is

(a) $(2n+1)\frac{\lambda}{2}$ (b) $(2n+1)\frac{\lambda}{4}$
(c) $(2n+1)\frac{\lambda}{8}$ (d) $(2n+1)\frac{\lambda}{16}$

**108.** Light of wavelength $6.5 \times 10^{-7}$ m is made incident on two slits 1 mm apart. The distance between third dark fringe and fifth bright fringe on a screen distant 1 m from the slits will be

(a) 0.325 mm (b) 0.65 mm
(c) 1.625 mm (d) 3.25 mm

**109.** In Young's expt., the distance between two slits is $\frac{d}{3}$ and the distance between the screen and the slits is 3 D. The number of fringes in $\frac{1}{3}$m on the screen, formed by monochromatic light of wavelength 3λ, will be

(a) $\frac{d}{9D\lambda}$ (b) $\frac{d}{27D\lambda}$
(c) $\frac{d}{81\,D\lambda}$ (d) $\frac{d}{D\lambda}$

**110.** In Young's double slit expt. the distance between two sources is 0.1 mm. The distance of the screen from the source is 20 cm. Wavelength of light used is 5460 Å. The angular position of the first dark fringe is

(a) 0.08° (b) 0.16°
(c) 0.20° (d) 0.32°

**111.** The separation between successive fringes in a double slit arrangement is x. If the whole arrangement is dipped under water what will be the new fringe separation? [The wavelenght of light being used is 5000 Å]

(a) 1.5x (b) x
(c) 0.75x (d) 2x

**112.** In Young's double slit experiment, we get 10 fringes in the field of view of monochromatic light of wavelength 4000Å. If we use monochromatic light of wavelength 5000Å, then the number of fringes obtained in the same field of view is

(a) 8 (b) 10 (c) 40 (d) 50

**113.** With a monochromatic light, the fringe-width obtained in a Young's double slit experiment is 0.133 cm. The whole set-up is immersed in water of refractive index 1.33, then the new fringe-width is

(a) 0.133 cm (b) 0.1 cm
(c) $1.33 \times 1.33$ cm (d) $\frac{1.33}{2}$cm

**114.** A beam of light of λ = 600 nm from a distant source falls on a single slit 1 mm wide and the resulting diffraction pattern is observed on a screen 2 m away. The distance between first dark fringes on either side of the central bright fringe is

(a) 1.2 cm (b) 1.2 mm
(c) 2.4 cm (d) 2.4 mm

**115.** In the Young's double-slit experiment, the intensity of light at a point on the screen where the path difference is λ is K, (λ being the wave length of light used). The intensity at a point where the path difference is λ/4, will be

(a) K (b) K/4
(c) K/2 (d) Zero

**116.** In a double slit experiment, the two slits are 1 mm apart and the screen is placed 1 m away. A monochromatic light wavelength 500 nm is used. What will be the width of each slit for obtaining ten maxima of double slit within the central maxima of single slit pattern ?

(a) 0.1 mm (b) 0.5 mm
(c) 0.02 mm (d) 0.2 mm

**117.** For a parallel beam of monochromatic light of wavelength 'λ', diffraction is produced by a single slit whose width 'a' is of the wavelength of the light. If 'D' is the distance of the screen from the slit, the width of the central maxima will be

(a) $\frac{D\lambda}{a}$ (b) $\frac{Da}{\lambda}$
(c) $\frac{2Da}{\lambda}$ (d) $\frac{2D\lambda}{a}$

**118.** Light of wavelength 5000 A° is incident normally on a slit of width $2.5 \times 10^{-4}$ cm. The angular position of second minimum from the central maximum is

(a) $\sin^{-1}\left(\frac{1}{5}\right)$ (b) $\sin^{-1}\left(\frac{2}{5}\right)$
(c) $\left(\frac{\pi}{3}\right)$ (d) $\left(\frac{\pi}{6}\right)$

**119.** In young's double-slit experiment, the intensity of light at a point on the screen where the path difference is $\lambda$ is I, $\lambda$ being the wavelength of light used. The intensity at a point where the path difference is $\frac{\lambda}{4}$ will be

(a) $\frac{I}{4}$ (b) $\frac{I}{2}$ (c) I (d) zero

**120.** In Young's double slit experiment, the fringes are displaced by a distance x when a glass plate of refractive index 1.5 is introduced in the path of one of the beams. When this plate is replaced by another plate of the same thickness, the shift of fringes is (3/2) x. The refractive index of the second plate is

(a) 1.75 (b) 1.50
(c) 1.25 (d) 1.00

**121.** In a two-slit experiment, with monochromatic light, fringes are obtained on a screen placed at some distance from the slits. If the screen is moved by $5 \times 10^{-2}$ m towards the slits, the change in fringe width is $10^{-3}$ m. Then the wavelength of light used is (given that distance between the slits is 0.03 mm)

(a) 4500 Å (b) 5000 Å
(c) 5500 Å (d) 6000 Å.

**122.** In Fresnel's biprism expt., a mica sheet of refractive index 1.5 and thickness $6 \times 10^{-6}$ m is placed in the path of one of interfering beams as a result of which the central fringe gets shifted through 5 fringe widths. The wavelength of light used is

(a) 6000 Å (b) 8000 Å
(c) 4000 Å (d) 2000 Å

**123.** A beam of light of wavelength 600 nm from a distance source falls on a single slit 1 mm wide and a resulting diffraction pattern is observed on a screen 2m away. The distance between the first dark fringes on either side of central bright fringe is

(a) 1.2 cm (b) 1.2 mm (c) 2.4 cm (d) 2.4 mm

**124.** The width of a slit is 0.012 mm. Monochromatic light is incident on it. The angular position of first bright line is 5.2°. The wavelength of incident light is
[sin 5.2° = 0.0906].

(a) 6040 Å (b) 4026 Å
(c) 5890 Å (d) 7248 Å

**125.** Light of wavelength 6328 Å is incident normally on a slit having a width of 0.2 mm. The angular width of the central maximum measured from minimum to minimum of diffraction pattern on a screen 9.0 metres away will be about

(a) 0.36 degree (b) 0.18 degree
(c) 0.72 degree (d) 0.09 degree

**126.** A plane wave of wavelength 6250 Å is incident normally on a slit of width $2 \times 10^{-2}$ cm. The width of the principal maximum on a screen distant 50 cm will be

(a) $312.5 \times 10^{-3}$ cm (b) $312.5 \times 10^{-3}$ m
(c) $312.5 \times 10^{-3}$ m (d) 312 m

**127.** A slit of width a is illuminated by red light of wavelength 6500 Å. If the first minimum falls at $\theta = 30°$, the value of a is

(a) $6.5 \times 10^{-4}$ mm (b) 1.3 micron
(c) 3250 Å (d) $2.6 \times 10^{-4}$ cm

**128.** A parallel beam of light is incident on a convex lens which has been corrected for aberrations, then the image will be

(a) focused to a line because of refraction.
(b) focused to a spot of finite area because of diffraction.
(c) focused to a spot of radius $\frac{0.16\lambda f}{a}$ because of diffraction ($f$ = focal length, $a$ = radius of lens)
(d) focused to a band pattern of radius $\frac{1.22\lambda f}{2a}$

**129.** The Fraunhoffer 'diffraction' pattern of a single slit is formed in the focal plane of a lens of focal length 1 m. The width of slit is 0.3 mm. If third minimum is formed at a distance of 5 mm from central maximum, then wavelength of light will be

(a) 5000 Å (b) 2500 Å
(c) 7500 Å (d) 8500 Å

**130.** A single slit Fraunhoffer diffraction pattern is formed with white light. For what wavelength of light the third secondary maximum in the diffraction pattern coincides with the second secondary maximum in the pattern for red light of wavelength 6500 Å?

(a) 4400 Å (b) 4100 Å
(c) 4642.8 Å (d) 9100 Å

**131.** The angle of incidence at which reflected light is totally polarized for reflection from air to glass (refractive index n), is

(a) $\tan^{-1}(1/n)$ (b) $\sin^{-1}(1/n)$
(c) $\sin^{-1}(n)$ (d) $\tan^{-1}(n)$

**132.** When an unpolarized light of intensity $I_0$ is incident on a polarizing sheet, the intensity of the light which does not get transmitted is

(a) $\frac{1}{4}I_0$ (b) $\frac{1}{2}I_0$ (c) $I_0$ (d) zero

**133.** Abeam of unpolarised light of intensity $I_0$ is passed through a polaroid A and then through another polaroid B which is oriented so that its principal plane makes an angle of 45° relative to that of A. The intensity of the emergent light is

(a) $I_0$ (b) $I_0/2$
(c) $I_0/4$ (d) $I_0/8$

**134.** A ray of light is incident on the surface of a glass plate at an angle of incidence equal to Brewster's angel $\phi$. If $\mu$ represents the refractive index of glass with respect to air, then the angle between the reflected and the refracted rays is

(a) $90° + \phi$ (b) $\sin^{-1}(\mu \cos \phi)$
(c) 90° (d) $90° - \sin^{-1}\left(\frac{\sin \phi}{\mu}\right)$

**135.** Unpolarised light of intensity 32 W $m^{-2}$ passes through three polarizers such that the transmission axis of the last polarizer is crossed with that of the first. The intensity of final emerging light is 3 W $m^{-2}$. The intensity of light transmitted by first polarizer will be

(a) 32 W $m^{-2}$ (b) 16 W $m^{-2}$
(c) 8 W $m^{-2}$ (d) 4 W $m^{-2}$

**136.** A parallel beam of monochromatic unpolarised light is incident on a transparent dielectric plate of refractive index $\frac{1}{\sqrt{3}}$. The reflected beam is completely polarised. Then the angle of incidence is

(a) 30° (b) 60°
(c) 45° (d) 75°

**137.** Two nicols are oriented with their principal planes making an angle of 60°. Then the percentage of incident unpolarised light which passes through the system is

(a) 100 (b) 50 (c) 12.5 (d) 37.5

**138.** A beam of unpolarised light passes through a tourmaline crystal A and then through another such crystal B oriented so that the principal plane is parallel to A. The intensity of emergent light is $I_0$. Now B is rotated by 45° about the ray. The emergent light will have intensity

(a) $I_0/2$ (b) $I_0/\sqrt{2}$ (c) $I_0\sqrt{2}$ (d) $2I_0$

**139.** If the polarizing angle of a piece of glass for green light is 54.74°, then the angle of minimum deviation for an equilateral prism made of same glass is
[Given, tan 54.74° = 1.414]

(a) 45° (b) 54.74°
(c) 60° (d) 30°

**140.** When the angle of incidence is 60° on the surface of a glass slab, it is found that the reflected ray is completely polarised. The velocity of light in glass is

(a) $\sqrt{2}\times10^8\,ms^{-1}$ (b) $\sqrt{3}\times10^8\,ms^{-1}$
(c) $2\times10^8\,ms^{-1}$ (d) $3\times10^8\,ms^{-1}$

**141.** Two beams, A and B, of plane polarized light with mutually perpendicular planes of polarization are seen through a polaroid. From the position when the beam A has maximum intensity (and beam B has zero intensity), a rotation of polaroid through $30°$ makes the two beams appear equally bright. If the initial intensities of the two beams are $I_A$ and $I_B$ respectively, then $\frac{I_A}{I_B}$ equals:

(a) 3 (b) $\frac{3}{2}$
(c) 1 (d) $\frac{1}{3}$

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(c)** Light is an electromagnetic wave of wavelength range 4000A° to 7800 A°

**2.** **(a)**

**3.** **(a)** Wavefront is the locus of all points, where the particles of the medium vibrate with the same phase.

**4.** **(d)** The Huygen's construction of wavefront does not explain the phenomena of origin of spectra.

**5.** **(b)** Huyghen's principle gives us a geometrical method of tracing a wavefront.

**6.** **(c)** Converging spherical

**7.** **(c)**

**8.** **(b)** Phase reversal occurs i.e. phase change = $\pi$ takes place on reflection, because glass is much denser than water.

**9.** **(c)** Emerging wavefront will be spherical from convex lens and plane wavefront from the prism.

**10.** **(b)**

**11.** **(d)** When path difference = $n\lambda$ ($n$ = 0, 1, 2...) the resultant intensity is $4I_0$.

**12.** **(c)**

**13.** **(c)** Highly coherent sources are produced using laser.

**14.** **(d)** A prism cannot produce coherent sources.

**15.** **(a)** Coherence is a measure of capability of producing interference by waves.

**16.** **(b)** For coherent sources $\lambda$ is same and phase is also same or phase diff. is constant.

**17.** **(a)** According to wave theory, intensity of light is directly proportional to square of amplitude.

**18.** **(a)** As $\beta = \frac{\lambda D}{d} \therefore \beta \propto \lambda$.

As $\lambda$ for violet is least, therefore, fringe nearest to central achromatic fringe will be violet.

**19.** **(a)** Fringe visibility (V) is given by $V = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$.

**20.** **(c)** Laser light is coherent, because it consists of coordinated (parallel) waves of exactly same wavelength (i.e monochromatic wave).

**21.** **(a)** Bright fringes are yellow and dark fringes are black.

**22.** **(b)** This time he saw a number of dark lines, regularly spaced; the first clear proof that light added to light can produce darkness.

Keeping the distance between the slits as constant, the locus of point *P* in the *xy* plane is a hyperbola

**23.** **(b)** The wavelength of light in water $\left(\lambda_w = \frac{\lambda_a}{\mu}\right)$ is less than that in air. When the set-up is immersed in water, fringe width $\beta(\propto \lambda)$ will decrease.

**24.** **(b)** Introducing a converging lens in the path of parallel beam does not introduce any extra path differences in a parallel beam. Rather it gives a more intense pattern on the screen.

**25.** **(b)** As $\lambda_r \approx 8000A^o$ and $\lambda_v \approx 4000\,\text{Å}$ and $\beta = \frac{\lambda D}{d}$ i.e.

$\beta \propto \lambda$, therefore $\beta_{red}$ is roughly double of $\beta_{violet}$.

**26.** **(b)** For minima, phase diff. = odd integral multiple of $\pi = (2n-1)\pi$.

**27.** **(a)** $\beta = \frac{\lambda D}{d}$

**28.** **(d)** Interference pattern will be invisible, because red and green are complimentary colours.

**29.** **(a)** There will be general illumination as super imposing waves do not have constant phase difference.

**30.** **(b)** Wavelength/frequency must be same and phase difference must be constant for producing sustained interference.

**31.** **(a)**

**32.** **(b)** Width of central maximum in diffraction pattern due to single slit = $\frac{2\lambda D}{d}$ where $\lambda$ is the wavelength, $D$ is the distance between screen and slit and $a$ is the slit width.

As the slit width $a$ increases, width of central maximum becomes sharper or narrower. As same energy is distributed over a smaller area. therefore central maximum becomes brigther.

**33.** **(d)** When red light is replaced by blue light the diffraction bands become narrow and crowded.

**34.** **(b)** At the centre, all colours meet in phase, hence central fringe is white.

**35.** **(c)** Because both source & screen are effectively at infinite distance from the diffractive device

**36.** **(d)** Diffraction on a single slit is equivalent to interference of light from infinite number of coherent sources contained in the slit.

**37.** **(c)** When the wavelength of light used is comparable with the separation between two points, the image of the object will be a ϕ diffraction pattern whose size will be

$$\theta = \frac{1.22\lambda}{D}$$

where λ = wavelength of light used
$D$ = diameter of the objective
Two objects whose images are closer than this distance, will not be resolved.

**38.** **(d)** As we know Bresster angle tan $i_B$ = 4 tan $i_B$ = 1.5
$i_B = \tan^{-1}(1.5)$

**39.** **(d)**

**40.** **(d)** **:** The phenomenon of polarization confirmed that light is a transverse wave.

**41.** **(d)** In the case of linearly polarised light the magnitued of th electric field vector varies periodically with time.

**42.** **(b)** Brewster's law is given by $\mu$ tan $i_\beta$

**43.** **(c)** Light waves can be polarized because they are transverse in nature.

**44.** **(b)** Light transmitted by nicol prism is plane polarised.

**45.** **(c)** Such substances rotate the plane of polarised light.

**46.** **(a)** Polaroid glass polarises light reducing the light intensity to half its original value.

**47.** **(b)** Angle between plane of vibration and plane of polarisation is 90º.

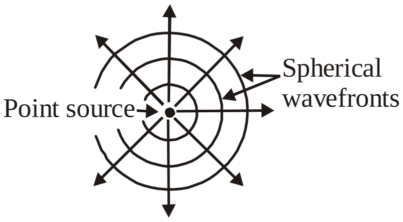
**48.** **(a)** Plane of vibration is $\perp^r$ to direction of propagation and also $\perp^r$ to plane of polarisation. Therefore, angle between plane of polarisation and direction of propagation is 0º.

**49.** **(c)** At Brewster's angle, only the reflected light is plane polarised, but transmitted light is partially polarised.

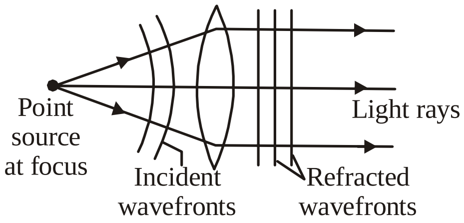
**50.** **(a)**

## STATEMENT TYPE QUESTIONS

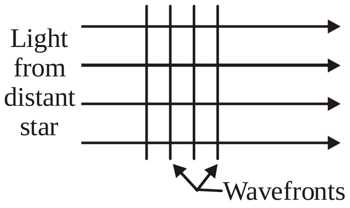
**51.** **(b)** **Case I** A light rays diverging from a point source.



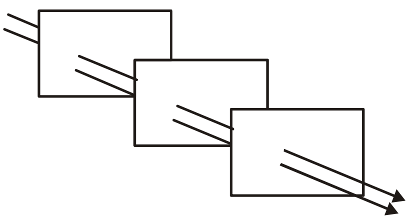
**Case II.** A light ray emerging out of convex lens when a point source is placed at its focus.



**Case III** A portion of the wavefront of light from a distant star intercepted by the Earth.



**52.** **(b)** For a point emitting waves uniformly in all direction, the locus of points which have the same amplitude and vibrate in the same phase are spheres. But at a large distance from the source, the small portion of the sphere can be considered as plane wave as shown in Figure



**53.** **(a)** When incident wavefronts passes through a prism, then lower portion of wavefront (B) is delayed resulting in a tilt. So, time taken by light to reach *A*' from *A* is equal to the time taken to reach *B*' from *B*.

**54.** **(b)**

**55.** **(a)** When interfering sources have same frequency and their phase difference remains constant with time, interference is sustained (stayed for a finite time interval).
If amplitudes are of nearby values then contrast will be more pronounced.

**56.** **(c)** The double slit interference pattern has a central maxima followed by minima. The dark and bright fringes are of equal width and intensity.

**57.** **(a)** **58.** **(d)**

**59.** **(d)** Diffraction is a general characteristics exhibited by all types of waves.

**60.** **(c)** The wavelength of sound is comparable to the size of the obstacles so the effects of diffraction can be observed and hence we can listen to the sound on the other side of the wall, while wavelength of light is much smaller (visible light 4000A° to 7800A°) than the obstacle size so the diffraction effects cannot be observed and we cannot see through the wall.

**61.** **(c)** As is clear from the relation.

Fringe with $\beta = \frac{\lambda D}{d}$

$D$ = distance between the slit and screen

$d$ = distance between the slits.

Smaller the '$d$' higher will be the value of fringe width.

**62.** **(c)** Since, $\Delta\theta \approx \frac{0.61\lambda}{a}$

where $\Delta\theta$ = angle subtended by the image of the object on focus of the length.

$\lambda$ = wavelength of light used

$a$ = aperture of the objective lens

For '$\Delta\theta$' to be small, '$a$' must be large

**63.** **(d)** The magnification produced by a microscope

$$m = \frac{v}{f} = \frac{D}{f} = 2 \tan \beta$$

**64.** **(c)**

**65.** **(c)**

I. For diffraction pattern, the size of slit should be comparable to the wavelength of wave used.

II. Diffraction phenomenon is commonly observed in our daily routine in case of sound waves (Which is a longitudinal wave) because wavelength of sound waves is large (0.1 – 1m). However, as wavelength of light waves is extremely small ($10^{-6} – 10^{-7}$ m), we do not observe diffraction of light in daily routine.

III. Diffraction is a wave phenomenon. It is observed in electromagnetic and longitudinal waves as well.

**66.** **(d)** A polaroid consists of long chain molecules aligned in a particular direction. The electric vectors (associated with the propagating light wave) along the direction of the aligned molecules get obsorbed. Thus, if an unpolarised light wave is incident on such a polaroid then the light wave will get linearly polarised with the electric vector oscillating along a direction perpendicular to the aligned molecules; this direction is known as the pass-axis of the polaroid.

## MATCHING TYPE QUESTIONS

**67.** **(b)** **68.** **(d)** **69.** **(a)**

## DIAGRAM TYPE QUESTIONS

**70.** **(d)** It will be concentric circles.

**71.** **(c)** Angular width $= \frac{\lambda}{d} = 10^{-3}$ (given)

$\therefore$ No. of fringes within 0.12° will be

$$n = \frac{0.12 \times 2\pi}{360 \times 10^{-3}} \cong [2.09]$$

$\therefore$ The number of bright spots will be three.

**72.** **(c)** Wavelength for which maximum obtained at the hole has the maximum intensity on passing. So,

$$x = \frac{n\lambda D}{d}$$

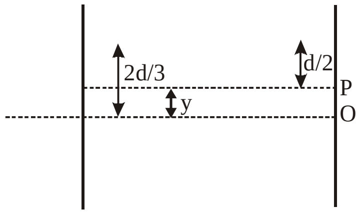
$$\lambda = \frac{xd}{nD} = \frac{1\times10^{-3} \times 0.5\times10^{-3}}{n\times50\times10^{-2}} = \frac{1\times10^{-6}}{n} = \frac{1000\text{nm}}{n}$$

$n = 1,\ \lambda = 1000$ nm $\rightarrow$ Not in the given range

$n = 2, \lambda = 500$nm

**73.** **(c)** The nearest white spot will be at P, the central maxima.

$$\therefore\ y = \frac{2d}{3} - \frac{d}{2} = \frac{d}{6}$$



**74.** **(d)** Light waves coming out of two independent sources do not have any fixed phase difference as they undergo phase changes in time of the order of $10^{-10}$s. Hence, the sources are incoherent and the intensities on the screen just add up. Hence no interference fringer will be observed on the screen.

**75.** **(c)** When the source of light shifts by angle $\phi$ then central fringe appears at angle $-\phi$ as source $S'$, the mid point $Q$, and the central fringe are in a straight line.

**76.** **(c)** The position of all the bands depends on the wavelength, higher the wavelength, wider is the band.

**77.** **(c)** In Fraunhoffer diffraction, for minimum intensity,

$$\Delta x = m\frac{\lambda}{2}$$

For first minimum, $m = 1$

$$\therefore\ \ \Delta x = \frac{\lambda}{2}$$

**78.** **(c)**

## ASSERTION- REASON TYPE QUESTIONS

**79.** **(b)** **80.** **(a)**

**81.** **(a)** $\beta = \frac{D\lambda}{d}$. When $d \to 0$, $\beta \to \infty$, and so fringes will not be seen over the screen.

**82.** **(d)** For interference, the waves may be of unequal intensities.

**83.** **(c)** Interference will take place in green light only.

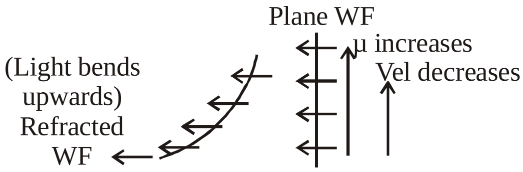
**84.** **(d)** **85.** **(b)** **86.** **(a)** **87.** **(b)**

**88.** **(a)** As $\beta = \frac{D\lambda}{d}$ and wavelength of yellow light is shorter than red, so fringe width is narrower for yellow light.

**89.** **(a)** **90.** **(b)**

## CRITICAL THINKING TYPE QUESTIONS

**91.** **(b)**



**92.** **(d)** : If source are coherent $I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\ \cos\phi$

$I_0 = I + I + 2I \cos 0° = 4I$

If source are incoherent,

$I_R = I_1 + I_2 + 2I = \frac{4I}{2} = \frac{I_0}{2}$

**93.** **(d)** : Resultant amplitude,

$A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2 \cos\phi}$

Here, $A_1 = A_2$ 1 cm, $\phi = 3\pi$ rad

$\therefore A = \sqrt{1^2 + 1^2 + 2 \times 1 \times 1 \times \cos 3\pi}$

$= \sqrt{2 + 2 \times (-1)} = 0$

**94.** **(b)** $\frac{I_1}{I_2} = \frac{1}{4} \Rightarrow I_1 = k$ and $I_2 = 4k$

$\therefore$ Fringe visibility $V = \frac{2\sqrt{I_1 I_2}}{(I_1 + I_2)} = \frac{2\sqrt{k \times 4k}}{(4 + 4k)} = 0.8$

**95.** **(d)** $\frac{I_{max}}{I_{min}} = \frac{25}{9}$ or $\left(\frac{a_1 + a_2}{a_1 - a_2}\right)^2 = \frac{25}{9}$

where a denotes amplitude.

$\frac{a_1 + a_2}{a_1 - a_2} = \frac{5}{3}$ or $5a_1 - 5a_2 = 3a_1 + 3a_2$

or, $5a_1 - 5a_2 = 3a_1 + 3a_2$ or $2a_1 = 8a_2$

or, $\frac{a_1}{a_2} = 4$ or $\left(\frac{a_1}{a_2}\right)^2 = 16 = \frac{I_1}{I_2}$.

**96.** **(c)** $\sin\theta = \frac{\lambda}{d} = \frac{589 \times 10^{-9}}{0.589 \times 10^{-3}} = 10^{-3} = \frac{1}{1000} = 0.0001$

**97.** **(d)** Intensity $I \propto 1 + \cos\phi$ where $\phi$ = phase difference

$\therefore \frac{I_P}{I_Q} = \frac{1 + \cos 0°}{1 + \cos\frac{\pi}{2}} = \frac{1 + 1}{1 + 0} = \frac{2}{1}$

**98.** **(b)** Here $\lambda_1 = 540$ nm; $\beta_1 = 9.0$ mm; $\beta_2 = 8.1$ mm, $\lambda_2 = ?$

For constant $D$ and $d$, $\beta \propto \lambda$

$\Rightarrow \frac{\beta_2}{\beta_1} = \frac{\lambda_2}{\lambda_1} \Rightarrow \lambda_2 = \frac{\beta_2\lambda_1}{\beta_1} = \frac{8.1}{9.0} \times 540 = 486$ nm

**99.** **(b)** As optical path SB of lower slit is increased, therefore, fringe pattern shifts somewhat downwards.

**100.** **(c)** $\Delta = x\frac{d}{D}$, where $\Delta$ is path difference between two waves.

$\therefore$ phase difference $= \phi = \frac{2\pi}{\lambda}\Delta.$

Let a = amplitude at the screen due to each slit.

$\therefore\ I_0 = k\,(2a)^2 = 4ka^2$, where k is a constant.

For phase difference $\phi$,

amplitude = A = $2a\cos(\phi/2)$.

[Since, $a^2 = a_1^2 + a_2^2 + 2a_1a_2\cos\phi$, here $a_1 = a_2$]

Intensity I,

$I = kA^2 = k(4a^2)\cos^2(\phi/2) = I_0\cos^2\left(\frac{\pi x}{\beta}\Delta\right)$

$= I_0\cos^2\left(\frac{\pi}{\lambda}.\frac{xd}{D}\right) = I_0\cos^2\left(\frac{\pi x}{\beta}\right)$

**101.** **(a)** $\because y = \frac{n\lambda D}{d}$

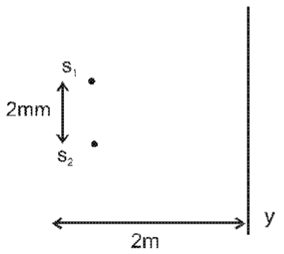
$\therefore n_1\lambda_1 = n_2\lambda_2$

$\Rightarrow n_1 \times 12000 \times 10^{-10} = n_2 \times 10000 \times 10^{-10}$

or, $n\,(12000 \times 10^{-10}) = (n + 1)\,(10000 \times 10^{-10})$

$\Rightarrow n = 5$

$\left(\because\ \lambda_1 = 12000 \times 10^{-10}\text{m};\ \lambda_2 = 10000 \times 10^{-10}\text{m}\right)$



Hence, $y_{common} = \frac{n\lambda_1 D}{d}$

$$= \frac{5\left(12000\times10^{-10}\right)\times 2}{2\times10^{-3}} \quad (\because\ d = 2\text{ mm and } D = 2\text{m})$$

$= 5 \times 12 \times 10^{-4}$ m

$= 60 \times 10^{-4}$ m

$= 6 \times 10^{-3}$m $= 6$ mm

**102. (b)** For constructive interference $d \sin\theta = n\lambda$

given $d = 2\lambda \Rightarrow \sin\theta = \frac{n}{2}$

$n = 0, 1, -1, 2, -2$ hence five maxima are possible

**103. (a)** For path difference of $\lambda$, the phase difference is $2\pi$

For path difference of $\frac{\lambda}{6}$, the phase difference is

$$\frac{2\pi\times\lambda/6}{\lambda} = \frac{\lambda}{3}$$

$\therefore$ Intensity $I = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\frac{\pi}{3}$

$\therefore$ $I = I_1 + I_2 + \sqrt{I_1}\sqrt{I_2}$

when $I_1 = I_2 = I'$ (say) then $I = 3I'$

$$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$$

$$= \left(\sqrt{I'} + \sqrt{I'}\right)^2 = \left(2\sqrt{I'}\right)^2 = 4I'$$

$$\therefore \frac{T}{I_{max}} = \frac{3}{4}$$

ALTERNATIVELY : The intensity of light at any point of the screen where the phase different due to light coming from the two slits is $\phi$ is given by

$I = I_o \cos^2\left(\frac{\phi}{2}\right)$ where to is the maximum intensity.

NOTE : This formula is applicable when $I_1 = I_2$.

Here $\phi$ $\phi = \pi/3$

$$\therefore \frac{I}{I_0} = \cos^2\frac{\pi}{6} = \left(\frac{\sqrt{3}}{2}\right)^2 = \frac{3}{4}$$

**104. (d)** Let $a_1 = a, I_1 = a_1^2 = a^2$
$a_2 = 2a, I_2 = a_2^2 = 4a^2$
$I_2 = 4I_1$
$I_r = a_1^2 + a_2^2 + 2a_1a_2\cos\phi$
$= I_1 + I_2 + 2\sqrt{I_1I_2}\cos\phi$

$I_r = I_1 + 4I_1 + 2\sqrt{4I_1^2}\cos\phi$

$\Rightarrow I_r = 5I_1 + 4I_1\cos\phi$ ...(1)

Now, $I_{max} = (a_1 + a_2)^2 = (a + 2a)^2 = 9a^2$

$I_{max} = 9I_1 \Rightarrow I_1 = \frac{I_{max}}{9}$

Substituting in equation (1)

$$I_r = \frac{5I_{max}}{9} + \frac{4I_{max}}{9}\cos\phi$$

$$I_r = \frac{I_{max}}{9}[5 + 4\cos\phi]$$

$$I_r = \frac{I_{max}}{9}\left[5 + 8\cos^2\frac{\phi}{2} - 4\right]$$

$$I_r = \frac{I_{max}}{9}\left[1 + 8\cos^2\frac{\phi}{2}\right]$$

**105. (d)** At the area of total darkness minima will occur for both the wavelength.

$$\therefore \frac{(2n+1)}{2}\lambda_1 = \frac{(2m+1)}{2}\lambda_2$$

$\Rightarrow$ $(2n+1)\lambda_1 = 2(m+1)\lambda_2$

or $\frac{(2n+1)}{(2m+1)} = \frac{560}{400} = \frac{7}{5}$

or $10n = 14m + 2$
by inspection for m = 2, n = 3
for m = 7, n = 10
the distance between them will be the distance between such points

i.e., $\Delta s = \frac{D\lambda_1}{d}\left\{\frac{(2n_2+1)-(2n_1-1)}{2}\right\}$

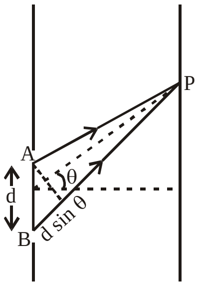
put $n_2 = 10, n_1 = 3$
on solving we get, $\Delta s = 28$ mm

**106. (c)** Let P be the point on the central maxima whose intensity is one fourth of the maximum intensity.

For interference we know that

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$$

Where I is the intensity at P and $I_1$, $I_2$ are the intensity of light originating from A and B respectively and $\phi$ is the phase difference at P.



In YDSE, $I_1 = I_2 = I$ and $I_{max} = 4\,I$

We are concentrating at a point where the intensity is one fourth of the max intensity.

$\therefore I = I + I + 2\,I\cos\phi$

$$\Rightarrow \quad -\frac{1}{2}\cos\phi \;\Rightarrow\; \phi = \frac{2\pi}{3}$$

[P1 note that we take the least value of the angle as the point is in central maxima]

For a phase difference of $2\pi$, the path difference is $\lambda$

For a phase difference of $\frac{2\pi}{3}$, the path difference is

$$\frac{\lambda}{2\pi}\times\frac{2\pi}{3} = \frac{\lambda}{3}$$

But the path difference (in terms of P and Q) is $d\sin\theta$ as shown in fig.

$$\therefore \quad d\sin\theta = \frac{\lambda}{3} \quad \Rightarrow \quad \sin\theta = \frac{\lambda}{3d}$$

$$\Rightarrow \quad \theta = \sin^{-1}\left(\frac{\lambda}{3d}\right)$$

**107. (b)** The intensity I is given as

$I = I_o\ \cos^2\frac{\phi}{2}$ where $I_o$ is the peak intensity

Here $I = \frac{I_o}{2}, \quad \therefore \frac{I_o}{2} = I_o\cos^2\frac{\phi}{2} \quad \therefore \phi = \frac{\pi}{2}(2n+1)$

For a phase difference of $2\pi$ the path difference is $\lambda$

$\therefore$ For a phase difference of (2n+1) $\frac{\pi}{2}$ the path difference is $(2n+1)\frac{\lambda}{4}$. option (b) is correct.

**108. (c)** $x_5 = n\lambda\frac{D}{d} = \frac{5\times6.5\times10^{-7}\times1}{10^{-3}} = 32.5\times10^{-4}\,m$

$$x_3 = (2n-1)\frac{1}{2}\frac{D\lambda}{d} = \frac{5\times6.5\times10^{-7}\times1}{2\times10^{-3}}$$

$$= 16.25\times10^{-4}\,m$$

$x_5 - x_3 = 16.25\times10^{-4}\,m = 1.625$ mm.

**109. (c)** $\beta = \frac{\lambda' D'}{d'} = \frac{3\lambda\,3D}{d/3} = 27\frac{\lambda D}{d}$.

No. of fringes $= \frac{1/3}{\beta} = \frac{d}{81\lambda D}$.

**110. (b)** The position of $n^{th}$ dark fringe. So position of first dark fringe in $x_1 = \lambda D/2d$.

$d = 20\,cm,\ D = 0.1mm,\ \lambda = 5460\ \text{Å},\ x_1 = 0.16$

**111. (c)** When the arrangement is dipped in water;

$$\beta' = \beta/\mu = \frac{x}{4/3} = \frac{3}{4}x = 0.75x$$

**112. (a)** As $\beta \propto \lambda$

$\therefore$ fringe width becomes $\frac{5}{4}$ times,

No, of fringes $= \frac{4}{5}\times10 = 8$

**113. (b)** $\beta' = \frac{\beta}{\mu} = \frac{0.133}{1.33} = 0.1$ cm

**114. (d)** Given: $D = 2m;\ d = 1\ mm = 1\times10^{-3}\,m$

$\lambda = 600\ nm = 600\times10^{-6}\,m$

Width of central bright fringe $(= 2\beta)$

$$= \frac{2\lambda D}{d} = \frac{2\times600\times10^{-6}\times2}{1\times10^{-3}}\,m$$

$= 2.4\times10^{-3}\,m = 2.4\,mm$

**115. (c)** For path difference $\lambda$, phase difference $= 2\pi$ rad.

For path difference $\frac{\lambda}{4}$, phase difference $= \frac{\pi}{2}$ rad.

As $K = 4I_0$ so intensity at given point where path difference is $\frac{\lambda}{4}$

$$K' = 4I_0\cos^2\left(\frac{\pi}{4}\right)\left(\cos\frac{\pi}{4} = \cos 45^o\right)$$

$$= 2I_0 = \frac{K}{2}$$

**116. (d)** Here, distance between two slits,

$d = 1mm = 10^{-3}m$

distance of screen from slits, D = 1 m

wavelength of monochromatic light used,

$\lambda = 500nm = 500 \times 10^{-9}m$

width of each slit a = ?

Width of central maxima in single slit pattern = $\frac{2\lambda D}{a}$

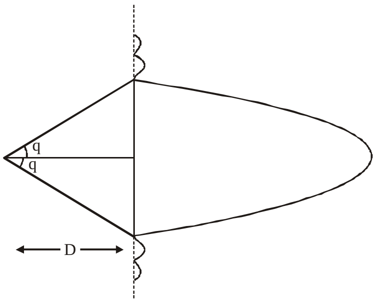
Fringe width in double slit experiment $\beta = \frac{\lambda D}{d}$

So, required condition $\frac{10\lambda D}{d} = \frac{2\lambda D}{a}$

$\Rightarrow \quad a = \frac{d}{5D} = \frac{1}{5} \times 10^{-3} m = 0.2\,mm$

**117. (d)** Linear width of central maxima

$= D(2q) = 2Dq \; \frac{2D\lambda}{a}$



**118. (d)** Let the two positive numbers be '*a*' and '*b*'. Therefore,

$a : b = 3 + 2\sqrt{2} : 3 - 2\sqrt{2}$

$\text{A. M.} = \frac{a+b}{2} = \frac{6}{2} = 3$

$\text{G.M.} = \sqrt{ab} = \sqrt{1} = 1$

$\therefore \quad \frac{\text{A.M}}{\text{G.M}} = \frac{3}{1} \quad \Rightarrow \quad \text{A.M} : \text{G.M} = 3 : 1.$

**119. (b)** For path difference λ, phase

$\text{difference} = 2\pi \left( Q = \frac{2\pi}{\lambda} x = \frac{2\pi}{\lambda}.\lambda = 2\pi \right)$

$\Rightarrow I = I_0 + I_0 + 2I_0 \cos 2\pi$

$\Rightarrow I = 4I_0 \; (\because \cos 2\pi = 1)$

For $x = \frac{\lambda}{4}$, phase difference = $\frac{\pi}{2}$

$\therefore I' = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2} \cos \frac{\pi}{2}$

If $I_1 = I_2 = I_0$ then $I' = 2I_0 = 2.\frac{I}{4} = \frac{I}{2}$

**120. (a)**

**121. (d)** Fringe width $\beta = \frac{\lambda D}{d}$

Where D is the distance between slit and the screen, d is the distance between two slits, λ is the wavelength of light.

$\therefore \Delta\beta = \frac{\lambda \Delta D}{d}$

or, $\lambda = \frac{\Delta\beta d}{\Delta D} = \frac{10^{-3} \times 0.03 \times 10^{-3}}{5 \times 10^{-2}} = \frac{10^{-3} \times 3 \times 10^{-5}}{5 \times 10^{-2}}$

$= 6 \times 10^{-7}$ m = 6000 Å.

**122. (a)** Where n is equivalent number of fringe by which the centre fringe is shifted due to mica sheet

$\lambda = \frac{(\mu - 1)t}{n} = \frac{(1.5 - 1) 6 \times 10^{-6}}{5}$

$= 6 \times 10^{-7}$ m = 6000 Å

**123. (d)** The distance between the first dark fringe on either side of the central bright fringe

= width of central maximum

$= \frac{2D\lambda}{a} = \frac{2 \times 2 \times 600 \times 10^{-9}}{10^{-3}}$

$= 2.4 \times 10^{-3}$ m = 2.4 mm

**124. (d)** It is a one of Fraunhoffer diffraction from single slit. so for bright fringe where a is the width of slit.

$a \sin\theta = (2n+1)\frac{\lambda}{2}$

$\lambda = \frac{2a\sin\theta}{2n+1} = \frac{2 \times 1.2 \times 10^{-5} \times 0.0906}{2 \times 1 + 1}$

$= 7248 \times 10^{-10}$ m = 7248Å.

**125. (a)** The angular width of central maxi. is

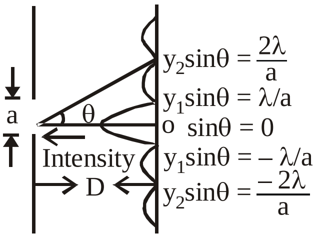
$2\theta = 2\frac{\lambda}{a} = \frac{2 \times 6328 \times 10^{-10}}{2 \times 10^{-4}}$ radian.

$= 6328 \times 10^{-6} \times \frac{180}{\pi}$ degree = 0.36°

**126. (a)** Width of central maximum

$$= \frac{2\lambda D}{a} = \frac{2\times 6250\times 10^{-10}\times 0.5}{2\times 10^{-4}}$$

$$= 3125\times 10^{-6}\text{m} = 312.5\times 10^{-3}\text{ cm.}$$



Screen position of various minima for Fraunhoffer diffraction pattern of a single slit of width a.

**127. (b)** According to principle of diffraction, a sin θ = nλ
where, n = order of secondary minimum
or, a sin 30° = 1 × (6500 × $10^{--10}$)
or, a = 1.3 × $10^{-6}$ m, or, a = 1.3 micron.

**128. (b)** According to geometrical optics, a beam of parallel light falling on convex lens will get focused to a point. However because of diffraction the beam gets focused to a spot of radius $\frac{r_0 = -0.61\lambda f}{a}$

**129. (a)** $a\sin\theta = n\lambda$

$$\frac{a\,x}{f} = 3\lambda$$

(since θ is very small so $\sin\theta \approx \tan\theta \approx \theta = x/f$ )

$$\text{or } \lambda = \frac{a\,x}{3f} = \frac{0.3\times 10^{-3}\times 5\times 10^{-3}}{3\times 1}$$

$$= 5\times 10^{-7}\text{ m} = 5000\text{ Å.}$$

**130. (c)** $x = \frac{(2n+1)\lambda\ D}{2a}$

For red light, $x = \frac{(4+1)D}{2a}\times 6500\text{Å}$

For other light, $x = \frac{(6+1)D}{2a}\times \lambda\text{Å}$

x is same for each.

$$\therefore\ 5\times 6500 = 7\times\lambda \Rightarrow \lambda = \frac{5}{7}\times 6500 = 4642.8\text{ Å.}$$

**131. (d)** The angle of incidence for total polarization is given by $\tan\theta = n \Rightarrow \theta = \tan^{-1} n$

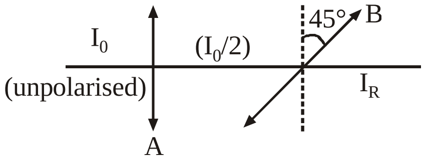
**132. (b)** $I = I_0\cos^2\theta$

Intensity of polarized light = $\frac{I_0}{2}$

⇒ Intensity of untransmitted light

$$= I_0 - \frac{I_0}{2} = \frac{I_0}{2}$$

**133. (c)**



Relation between intensities

$$I_R = \left(\frac{I_0}{2}\right)\cos^2(45°)$$

$$= \frac{I_0}{2}\times\frac{1}{2} = \frac{I_0}{4}$$

**134. (c)** ∵ $i_p$ = ϕ, therefore, angle between reflected and refracted rays is 90°.

**135. (b)** Intensity of polarised light transmitted from 1st polariser,
$I_1 = I_0\cos^2\theta$

but $(\cos^2\theta)_{av} = \frac{1}{2}$

So $I_1 = \frac{1}{2}I_0 = \frac{32}{2} = 16\text{Wm}^{-2}$

**136. (a)** When angle of incidence i is equal to angle of polarisation i.e, then reflected light is completely plane-polarised whose vibration is perpendicular to plane of incidence.

**137. (c)** Suppose intensity of unpolarised light = 100.
∴ Intensity of polarised light from first nicol prism

$$= \frac{I_0}{2} = \frac{1}{2}\times 100 = 50$$

According to law of Malus,

$$I = I_0\cos^2\theta = 50\ (\cos 60°)^2 = 50\times\left(\frac{1}{2}\right)^2 = 12.5$$

**138. (a)** According to law of Malus

$$\mathbf{I} = \mathbf{I}_0\cos^2\theta = \mathbf{I}_0(\cos 45°)^2 = \mathbf{I}_0\left(\frac{1}{\sqrt{2}}\right)^2 = \frac{\mathbf{I}_0}{2}$$

**139. (d)** By principle of polarization, $\mu = \tan\theta_p$

or $\mu = \tan 54.74°$ or $\mu = 1.414$

For an equilateral prism, $\angle A = 60°$

$$\therefore\ \mu = \frac{\sin\left(\frac{A+\delta}{2}\right)}{\sin(A/2)} = \frac{\sin\left(\frac{60°+\delta}{2}\right)}{\sin(60°/2)}$$

$$\text{or, } \frac{1.141\times 1}{2} = \sin\left(\frac{60°+\delta}{2}\right)\left[\because 1.414 = \sqrt{2}\right]$$

$$\text{or, } \frac{\sqrt{2}}{2} = \sin\left(\frac{60°+\delta}{2}\right) \text{ or } \frac{1}{\sqrt{2}} = \sin\left(\frac{60°+\delta}{2}\right)$$

$$\text{or, } \sin 45° = \sin\left(\frac{60°+\delta}{2}\right) \text{ or } 45° = \left(\frac{60°+\delta}{2}\right)$$

**140. (b)** ${}^a\mu_g = \tan\theta_P$ where $\theta_P$ = polarising angle.

or, ${}^a\mu_g = \tan 60°$

$$\text{or, } \frac{c}{v_g} = \sqrt{3}$$

$$\text{or, } v_g = \frac{c}{\sqrt{3}} = \frac{3\times 10^8}{\sqrt{3}} = \sqrt{3}\times 10^8\,\text{ms}^{-1}$$

**141. (d)** According to malus law, intensity of emerging beam is given by,

$$I = I_0\cos^2\theta$$

Now, $I_{A'} = I_A\cos^2 30^o$

$$I_{B'} = I_B\cos^2 60^o$$

As $I_{A'} = I_{B'}$

$$\Rightarrow\quad I_A \times \frac{3}{4} = I_B \times \frac{1}{4}$$

$$\frac{I_A}{I_B} = \frac{1}{3}$$

## CHAPTER 26

# DUAL NATURE OF RADIATION AND MATTER

## FACT/DEFINITION TYPE QUESTIONS

**1.** Cathode ray consists of
(a) photons (b) electrons
(c) protons (d) $\alpha$-particles

**2.** A discharge takes place between the two electrodes on applying the electric field to the gas in the discharge tube. The cause of this fluorescence was attributed to
(a) the radiations which appeared to be coming from the anode
(b) the radiation which appeared to be coming from the cathode
(c) the protons coming from the cathode
(d) the protons coming from the anode

**3.** The presently accepted value of charge/mass $\left(\frac{e}{m}\right)$ is
(a) $1.66 \times 10^{-19}$ c/kg (b) $9.1 \times 10^{11}$ c/kg
(c) $1.76 \times 10^{11}$ c/kg (d) $9.1 \times 10^{19}$ c/kg

**4.** In which of the following, emission of electrons does not take place?
(a) Thermionic emission
(b) X-rays emission
(c) Photoelectric emission
(d) Secondary emission

**5.** Photoelectric emmision occurs only when the incident light has more than a certain minimum
(a) power (b) wavelength
(c) intensity (d) frequency

**6.** Which of the following when falls on a metal will emit photoelectrons ?
(a) UV radiations (b) Infrared radiation
(c) Radio waves (d) Microwaves

**7.** Particle like behavior of light arises from the fact that each quanta of light has definite ...X... and a fixed value of ...Y.. just like a particle, Here, X and Y refer to
(a) frequency, energy
(b) shape, volume
(c) energy, frequency
(d) energy, momentum

**8.** The wave nature of light was established by
(i) Maxwell's equations (ii) Fraunhoffer's lines
(iii) Hertz experiment (iv) Einstein's theory
(a) (i) and (ii) only (b) (ii) and (iv) only
(c) (i) and (iii) only (d) (iii) and (iv) only

**9.** The work-function of a metal is
(a) the minimum current required to take out electron from the metal surface
(b) the maximum frequency required to take out electron from the metal surface
(c) the minimum amount of energy required to take out the electron from the metal surface
(d) None of these

**10.** The work function of a metal is independent of
(i) nature of the surface of the metal
(ii) dimensions of the metal
(iii) properties of the metal
(iv) abundance of the metal
(a) (i) only (b) (i) and (iii)
(c) (ii) and (iii) (d) (ii) and (iv)

**11.** The theory of quantisation of electric charge was given by
(a) William Crookes (b) J. J. Thomson
(c) R.A. Millikan (d) Wilhelm Hallwachs

**12.** In photoelectric effect, electrons are ejected from metals, if the incident light has a certain minimum
(a) wavelength (b) frequency
(c) amplitude (d) angle of incidence

**13.** Which of the following metals is not sensitive to visible light?
(a) Caesium (b) Sodium
(c) Rubidium (d) Cadmium

**14.** A photosensitive substance emits _____when illuminated by light.
(a) only protons (b) only neutrons
(c) electrons and protons (d) only electrons

**15.** The photoelectric current does not depend upon the
(i) frequency of incident light
(ii) work function of the metal
(iii) stopping potential
(iv) intensity of incident light
(a) (i) and (iv) only (b) (ii) and (iii) only
(c) (iii) only (d) (ii) only

**16.** The stopping potential is directly related to
(a) the work function of the metal
(b) intensity of incident radiation
(c) the saturation current for the given frequency
(d) the kinetic energy gained by the photoelectrons

**17.** The wave theory of light does not explain
(a) polarisation (b) diffraction
(c) photocurrent (d) interference

**18.** Photoelectric effect can be explained by
(a) wave theory of light
(b) Bohr's theory
(c) quantum theory of light
(d) corpuscular theory of light

**19.** In Einstein's picture of Photoelectric emission, the photoelectric emission does not take place by
(a) continuous emission of energy from radiation
(b) continuous absorption of energy from radiation
(c) discrete absorption of energy from radiation
(d) discrete emission of energy from radiation

**20.** The particle nature of light is not confirmed by
(a) photoelectric effect
(b) scattering of X-rays by electrons
(c) diffraction of electrons
(d) compton effect

**21.** Photons are deflected by
(a) electric field only
(b) magnetic field only
(c) electromagnetic field
(d) None of these

**22.** Electrically, photons are
(a) positively charged
(b) negatively charged
(c) neutral
(d) strongly charged, may be positive or negative

**23.** In a photon-particle collision, the quantity that does not remain conserved is
(a) total energy (b) total momentum
(c) number of photons (d) None of these

**24.** Of the following properties, the photon does not possess
(a) rest mass (b) momentum
(c) energy (d) frequency

**25.** It is essential to consider light as a stream of photons to explain
(a) diffraction of light (b) refraction of light
(c) photoelectric effect (d) reflection of light

**26.** Photoelectric effect was discovered by
(a) Hertz (b) Hallwachs
(c) Lenard (d) Millikan

**27.** The momentum of a photon of wavelength $\lambda$ is
(a) $h\lambda$ (b) $h/\lambda$ (c) $\lambda/h$ (d) $h/c\lambda$

**28.** The photoelectrons emitted from a metal surface are such that their velocity
(a) is zero for all
(b) is same for all
(c) lies between zero and infinity
(d) lies between zero and a finite maximum

**29.** Photoelectric effect shows
(a) wave like behaviour of light
(b) paritcle like behaviour of light
(c) both wavelike and paticle like behaviour
(d) neither wave like nor particle like behaviour of light

**30.** A photoelectric cell converts
(a) light energy into heat energy
(b) light energy to sound energy
(c) light energy into electric energy
(d) electric energy into light energy

**31.** Light of a particular frequency $\nu$ is incident on a metal surface. When the intensity of incident radiation is increased, the photoelectric current
(a) decreases
(b) increases
(c) remains unchanged
(d) sometimes increases and sometimes decreases

**32.** The photoelectric effect is based on the law of conservation of
(a) momentum (b) energy
(c) angular momentum (d) mass

**33.** The photoelectric effect can be understood on the basis of
(a) wave theroy of light only
(b) electromagnetic theory of light only
(c) quantum theory of light only
(d) None of these

**34.** When light is incident on a metal surface the maximum kinetic energy of emitted electrons
(a) vary with intensity of light
(b) vary with frequency of light
(c) vary with speed of light
(d) vary irregularly

**35.** The maximum energy of electrons released in a photocell is independent of
(a) the frequency of the incident light
(b) the intensity of the incident light
(c) the nature of the cathode
(d) All of the above

**36.** Einstein's photoelectric equation states that
$h\nu = W_0 + E_{k.}$
In this equatin, $E_k$ refers to the
(a) kinetic energy of all the emitted electrons
(b) mean kinetic energy of the emitted electrons
(c) maximum kinetic energy of the emitted electrons
(d) minimum kinetic energy of the emitted electrons

**37.** In the photoeletric effect, electrons are emitted
(a) at a rate that is proportional to the amplitude of the incident radiation
(b) with a maximum velocity proportional to the frequency of the incident radiation
(c) at a rate that is independent of the emitter
(d) only if the frequency of the incident radiations is above a certain threshold value

**38.** The minimum energy required to eject an electron, from the metal surface is called
(a) atomic energy (b) mechanical energy
(c) electrical energy (d) workfunction

**39.** The work function for photoelectric effect
(a) is different for different metals
(b) is same for all metals
(c) depends upon the intensity of incident light
(d) depends upon the frequency of incident light

**40.** Photoelectric effect is the phenomenon in which
(a) photons come out of a metal when it is hit by a beam of electrons.
(b) photons come out of the nucleus of an atom under the action of an electric field.
(c) electrons come out of a metal with a constant velocity
(d) which depends on the frequency and intensity of incident light wave.

**41.** A photoelectric cell is a device which
(a) converts light into electricity
(b) converts electricity into light
(c) stores light
(d) stores electricity

**42.** Einstein's work on photoelectric effect provided support for the equation
(a) $E = h\nu$ (b) $E = mc^2$
(c) $E = \frac{-Rhc}{n^2}$ (d) $K.E. = \frac{1}{2}mv^2$

**43.** Which of the following shows particle nature of light?
(a) Refraction (b) Interference
(c) Polarization (d) Photoelectric effect

**44.** Einstein's photoelectric equation is $E_k = h\nu - \phi$. In this equation $E_k$ refers to
(a) kinetic energy of all the emitted electrons
(b) mean kinetic energy of emitted electrons
(c) maximum kinetic energy of emitted electrons
(d) minimum kinetic energy of emitted electrons

**45.** A photon will have less energy, if its
(a) amplitude is higher
(b) frequency is higher
(c) wavelength is longer
(d) wavelength is shorter

**46.** The energy of photon of wavelength λ is
(a) $c\lambda/h$ (b) $h\lambda/c$
(c) $hc/\lambda$ (d) $c/h\lambda$

**47.** A photo sensitive metal is not emitting photo-electrons when irradiated. It will do so when threshold is crossed. To cross the threshold we need to increase
(a) intensity (b) frequency
(c) wavelength (d) None of these

**48.** According to Einstein's photoelectric equation, the plot of the kinetic energy of the emitted photo electrons from a metal Vs the frequency of the incident radiation gives as straight the whose slope
(a) depends both on the intensity of the radiation and the metal used
(b) depends on the intensity of the radiation
(c) depends on the nature of the metal used
(d) is the same for the all metals and independent of the intensity of the radiation

**49.** ____ and _____ led to understanding of atomic structures.
(i) Fresnel diffraction
(ii) cathode rays
(iii) X-rays
(iv) electrons
(a) (i) and (ii) (b) (ii) and (iii)
(c) (i) and (iv) (d) (iii) and (iv)

**50.** A steel ball of mass m is moving with a kinetic energy K. The de-Broglie wavelength associated with the ball is
(a) $\frac{h}{2mK}$ (b) $\sqrt{\frac{h}{2mK}}$
(c) $\frac{h}{\sqrt{2mK}}$ (d) None of these

**51.** Electron volt (ev) is the unit of
(a) energy (b) potential
(c) current (d) charge

**52.** In Heinrich Hertz's experiment on the production of electromagnetic waves by means of spark discharge, it was observed that high voltage sparks across the detector loop were _____ when the emitter plate was illuminated by _____ light

(a) degraded, infra-red (b) degraded, ultraviolet
(c) enhanced, ultraviolet (d) enhanced, infra-red

**53.** The de Broglie wavelength corresponding to a particle of mass '*m*' and charge 'q' accelerated from rest to a potential *V* is given by

(a) $\lambda = \frac{h}{mqV}$ (b) $\lambda = \frac{h}{2mqV}$

(c) $\lambda = \frac{h}{\sqrt{2mqV}}$ (d) $\lambda = \frac{h}{2mqV^2}$

**54.** For an electron accelerated from rest through a potential *V*, the de Broglie wavelength associated will be

(a) $\frac{1.772}{\sqrt{V}}$ nm (b) $\frac{1.227}{\sqrt{V}}$ μm

(c) $\frac{1.227}{\sqrt{V}}$ nm (d) $\frac{1.772}{\sqrt{V}}$ μm

**55.** According to Heisenberg's uncertainty principle, it is true that

(a) we can precisely specify the momentum and energy of an electron
(b) we cannot precisely specify the momentum and wavelength associated with an electron.
(c) we cannot precisely specify the momentum and position of electron at the same time.
(d) we can precisely specify the momentum and position of electron at the same time.

**56.** If a photon and an electron have same de-Broglie wavelength, then

(a) both have same kinetic energy
(b) proton has more K.E. than electron
(c) electron has more K.E. than proton
(d) both have same velocity

**57.** The graph of $V_0$ (stopping potential) <u>*vs*</u> ν (frequency) is

(a) a straight line with slope $\left(\frac{\phi_0}{e}\right)$

(b) a straight line with slope $\left(-\frac{h}{\nu_0}\right)$

(c) a straight line with slope $\left(-\frac{h}{e}\right)$

(d) a straight line with slope $\left(\frac{h}{e}\right)$

**58.** Which of the following experiment confirms the wave nature of electron?

(a) Millikan's oil drop experiment
(b) Davisson and Germer experiment
(c) Young's double slit experiment
(d) Geiger-Marsden experiment

**59.** In Davison-Germer experiment, an electron beam is incident on a crystal. The reflected beam consists of

(a) photons (b) protons
(c) x-rays (d) electrons

**60.** In the Davisson and Germer experiment, the velocity of electrons emitted from the electron gun can be increased by

(a) increasing the potential difference between the anode and filament
(b) increasing the filament current
(c) decreasing the filament current
(d) decreasing the potential difference between the anode and filament

## STATEMENT TYPE QUESTIONS

**61.** Which of the following is/are false regarding cathode rays?

I. They produce heating effect
II. They don't deflect in electric field
III. They cast shadow
IV. They produce fluorescence

(a) I only (b) II only
(c) I, II and III (d) I, II, III and IV

**62.** Energy required by an electron for electron emission can be supplied to a free electron by

I. hammering the metal surface
II. heating the metal surface
III. applying electric field
IV. applying magnetic field

Which of the above statements is/are correct ?

(a) Only I (b) I, II and IV
(c) II, III and IV (d) II and III

**63.** Experimental study of photoelectric effect shows that

I. Photocurrent ∝ intensity of light.
II. saturation current ∝ intensity of light.
III. photoemission occurs only at frequency greater than threshold frequency.
IV. photoemission is an instantaneous process.

The correct statements are

(a) I and II (b) I, II and III
(c) I, III and IV (d) I, II, III and IV

**64.** According to photoelectric equation $K_{\max} = h\nu - \phi_0$, The photoelectric emission will not be possible if

I. $K_{\max}$ is negative II. $\nu_0 > \nu$
III. $K_{\max}$ is positive IV. $\nu_0 < \nu$

(a) I and II (b) I and IV
(c) III and II (d) III and IV

**65.** Electromagnetic radiations with high intensity have

I. high amplitude II. high frequency
III. high wavelength IV. high speed

Which of the above is/are correct?

(a) I only (b) II and III
(c) I and II (d) IV only

**66.** Which of the following cannot be explained on the basis of photoelectric theory?

I. Instantaneous emission of photoelectrons
II. Existence of threshold frequency
III. Sufficiently intense beam of radiation can emit photoelectrons
IV. Existence of stopping potential

(a) III and IV (b) II, III and IV
(c) III only (d) II only

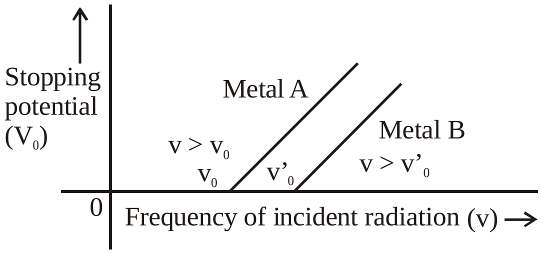
**67.** To observe the effect of intensity of light on photocurrent,

I. collector is maintained at positive potential with respect to emitter.
II. frequency of incident light is kept fixed.
III. accelerating potential is fixed.
IV. distance of surce from emitter is kept constant.

Which of the above statements are correct ?

(a) I and II (b) II and III
(c) III and IV (d) I, II and III

**68.** From the graph it is clear that



I. the stopping potential varies linearly with the frequency of incident radiation for the given metal.
II. the work function of metal *A* is greater than that for metal *B*.
III. the stopping potential is zero below the minimum cut off frequency.
IV. the stopping potential is independent of the intensity of incident radiation.

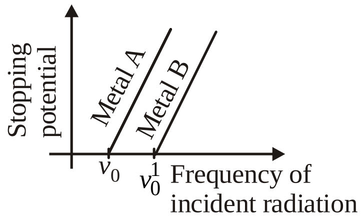
(a) I and III only (b) I, III and IV
(c) II and IV only (d) I, II and IV

**69.** Consider the following statements and select the correct Statement(s).

I. The stopping potential depends on the nature of emitter material
II. The stopping potential depends on the frequency of incident light.
III. The stopping potential depends on the intensity of incident radiation.

(a) I only (b) II only
(c) I and II (d) I, II and III

**70.** Variation of stopping potential $V_0$ with frequency $v$ of incident radiation for photosensitive materials *A* and *B* are shown.



From graph we conclude that

I. maximum kinetic energy of photoelectrons varies linearly with frequency.
II. a frequency lower than a certain frequency photoemission is not possible.
III. density of metal *A* is more than that of *B*.
IV. metal *A* contains more electrons than that of *B*.

(a) I and II (b) I and IV
(c) III and IV (d) II and III

**71.** Which of the following statements are true?

I. In the interaction with matter, radiation behaves as if it is made up of particle called photons.
II. Each photon has energy $E = h\nu$ and momentum $P = h\nu/c$.
III. photons are electrically neutral and are not deflected by electric and magnetic field.
IV. In a photon particle collision, photon number is conserved.

(a) I and II (b) I, II and III
(c) I, III and IV (d) I, II and IV

## MATCHING TYPE QUESTIONS

**72.** Match the Columns I and II.

| **Column I** | **Column II** |
|---|---|
| (A) Field emission | (1) Heat is supplied to the metal surface |
| (B) Photoelectric emission | (2) Electric field is applied to the metal surface |
| (C) Thermionic emission | (3) Light of suitable frequency illuminates the metal surface |
| (D) Secondary emission | (4) Striking fast moving electrons on the metal surface. |

(a) (A) → (2); (B) → (3); C → (1); (D) → (4)
(b) (A) → (1); (B) → (3); C → (2); (D) → (4)
(c) (A) → (4); (B) → (1); C → (3); (D) → (2)
(d) (A) → (4); (B) → (3); C → (2); (D) → (1)

**73.**

| **Column I** | **Column II** |
|---|---|
| (A) Electromagnetism | (1) Hertz |
| (B) Detection of electromagnetic waves | (2) Roentgen |
| (C) X-rays | (3) J.J. Thomson |
| (D) Electron | (4) Maxwell |

(a) (A) → 1; (B) → 4; (C) → 3; (D) → 2
(b) (A) → 2; (B) → 3; (C) → 1; (D) → 4
(c) (A) → 3; (B) → 2; (C) → 4; (D) → 1
(d) (A) → 4; (B) → 1; (C) → 2; (D) → 3

**74.**

| Column I | Column II |
|---|---|
| (A) Einstein Photoelectric equation | (1) $\lambda = \frac{h}{p}$ |
| (B) de-Broglie relation | (2) $K_{max} = hv - \phi_0$ |
| (C) Threshold frequency | (3) $\Delta x \Delta p \simeq h$ |
| (D) Heisenberg's uncertainty principle | (4) $v = \frac{\phi_0}{h}$ |

(a) (A) → (2); (B) → (3); (C) → (1); (D) → (4)
(b) (A) → (1); (B) → (3); (C) → (2); (D) → (4)
(c) (A) → (4); (B) → (1); (C) → (3); (D) → (2)
(d) (A) → (4); (B) → (3); (C) → (2); (D) → (1)

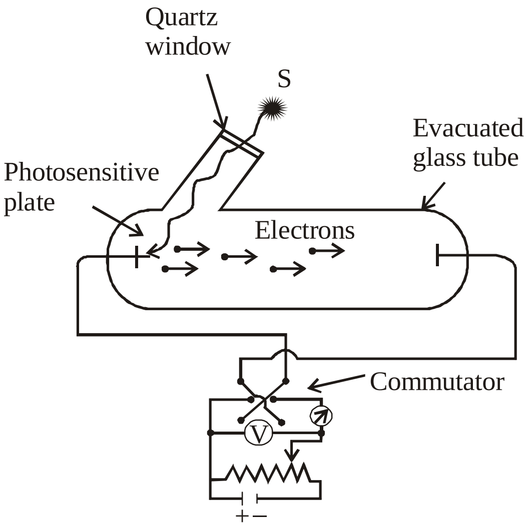
**75.** Match the quantities given in column I with their definitions in column II.

| Column I | Column II |
|---|---|
| (A) Photocurrent | (1) The minimum energy required by electron to escape from the metal surface |
| (B) Saturation current | (2) The minimum retarding potential |
| (C) Stopping potential | (3) The number of photoelectric emitted per second |
| (D) Work function | (4) The maximum number of photoelectrons emitted per second |

(a) (A) → (1); (B) → (2); (C) → (3); (D) → (4)
(b) (A) → (3); (B) → (4); (C) → (2); (D) → (1)
(c) (A) → (2); (B) → (1); (C) → (4); (D) → (1)
(d) (A) → (4); (B) → (3); (C) → (1); (D) → (2)

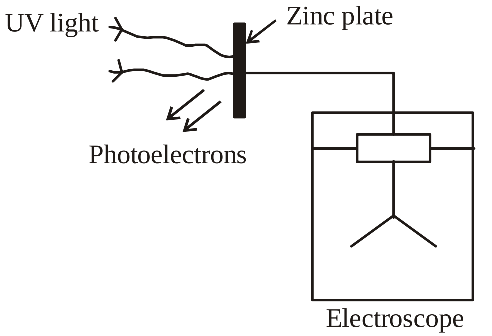
## DIAGRAM TYPE QUESTIONS

**76.** In the given set-up, the photoelectric current cannot be varied by varying the



(a) potential of plate A w.r.t. the plate C
(b) intensity of incident light
(c) material of plate A
(d) material of plate C

**77.** In Hallwach's experiment on photoelectric emission with following setup, it was observed that



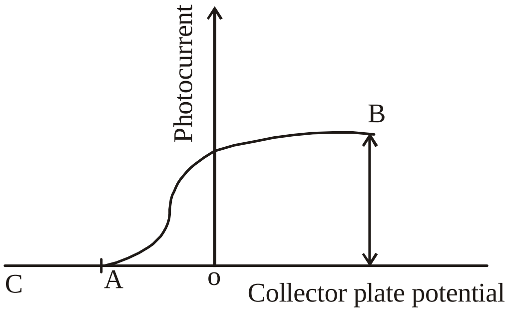
The zinc plate became _____ if initially negatively charged.

(a) positively charged (b) negatively charged
(c) uncharged (d) more positively charged

**78.** The zinc plate became _____ if initially positively charged (see fig. above).

(a) positively charged (b) more positively charged
(c) negatively charged (d) uncharged

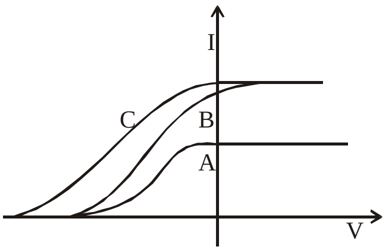
**79.** In the given graph of photoelectric current versus collector plate potential the quantities (A), (B), and (C) represent



| | | | |
|---|---|---|---|
| (i) | A | (1) | Retarding potential |
| (ii) | B | (2) | Stopping potential |
| (iii) | C | (3) | Saturation current |

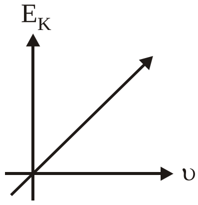
(a) (i) – 2; (ii) – 1; (iii) – 3
(b) (i) – 2; (ii) – 3; (iii) – 1
(c) (i) – 3; (ii) – 2; (iii) – 1
(d) (i) – 1; (ii) – 2; (iii) – 3

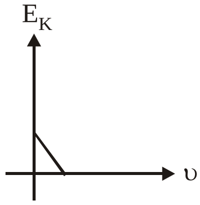
**80.** In a photoelectric experiment, anode potential (v) is plotted against plate current (I)

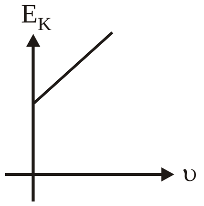


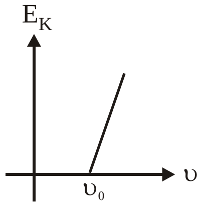
(a) A and B will have different intensities while B and C will have different frequencies
(b) B and C will have different intensities while A and C will have different frequencies
(c) A and B will have different intensities while A and C will have equal frequencies
(d) A and B will have equal intensities while B and C will have different frequencies

**81.** Which one of the following graphs represents the variation of maximum kinetic energy ($E_K$) of the emitted electrons with frequency υ in photoelectric effect correctly ?

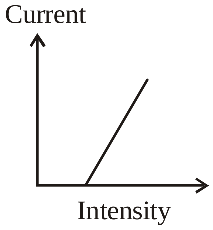
(a)


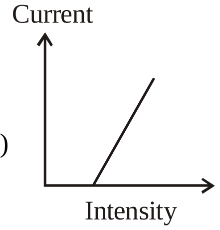
(b)


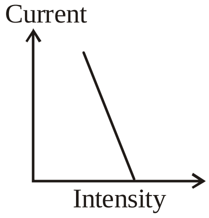
(c)


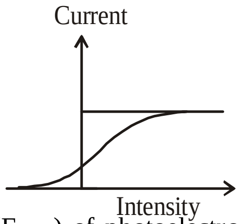
(d)


**82.** For a given photosensitive material and frequency (> threshold frequency) of incident radiation, the photoelectric current varies with the intensity of incident light as

(a)


(b)


(c)


(d)


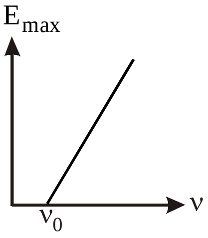
**83.** The maximum kinetic energy ($E_{max}$) of photoelectrons emitted in a photoelectric cell varies with frequency (ν) as shown in the graph. The slope of the graph is equal to

(a) charge of the electron

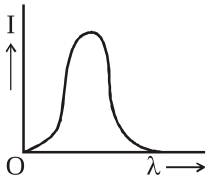
(b) $\frac{e}{m}$ of the electron

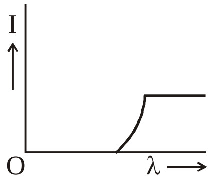
(c) work function of the emitter

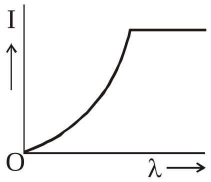
(d) Plank's constant

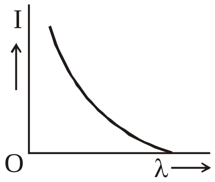


**84.** The anode voltage of a photocell is kept fixed. The wavelength λ of the light falling on the cathode is gradually changed. The plate current I of the photocell varies as follows

(a)


(b)


(c)


(d)


## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

**85.** **Assertion :** In process of photoelectric emission, all emitted electrons do not have same kinetic energy.

**Reason :** If radiation falling on photosensitive surface of a metal consists of different wavelength then energy acquired by electrons absorbing photons of different wavelengths shall be different.

**86.** **Assertion :** Though light of a single frequency (monochromatic) is incident on a metal, the energies of emitted photoelectrons are different.

**Reason :** The energy of electrons emitted from inside the metal surface, is lost in collision with the other atoms in the metal.

**87.** **Assertion :** The phtoelectrons produced by a monochromatic light beam incident on a metal surface have a spread in their kinetic energies.

**Reason :** The work function of the metal is its characteristics property.

**88.** **Assertion :** Photoelectric saturation current increases with the increase in frequency of incident light.

**Reason :** Energy of incident photons increases with increase in frequency and as a result photoelectric current increases.

**89.** **Assertion :** Photosensitivity of a metal is high if its work function is small.

**Reason :** Work function = $hf_0$ where $f_0$ is the threshold frequency.

**90.** **Assertion :** The photon behaves like a particle.

**Reason :** If E and P are the energy and momentum of the photon, then $p = E / c$.

**91.** **Assertion :** In an experiment on photoelectric effect, a photon is incident on an electron from one direction and the phtoelectron is emitted almost in the opposite direction. It violate the principle of conservation of linear momentum.

**Reason :** It does not violate the principle of conservation of linear momentum.

**92.** **Assertion :** Two sources of equal intensity always emit equal number of photons in any time interval.

**Reason :** Two sources of equal intensity may emit equal number of photons in any time interval.

**93.** **Assertion :** Two photons of equal wavelength must have equal linear momentum.

**Reason :** Two photons of equal linear momentum will have equal wavelength.

**94.** **Assertion :** The kinetic energy of photoelectrons emitted from metal surface does not depend on the intensity of incident photon.

**Reason :** The ejection of electrons from metallic surface is not possible with frequency of incident photons below the threshold frequency.

## CRITICAL THINKING TYPE QUESTIONS

**95.** In a photoelectric experiment the stopping potential for the incident light of wavelength 4000Å is 2 volt. If the wavelength be changed to 3000 Å, the stopping potential will be

(a) 2V (b) zero

(c) less than 2 V (d) more than 2 V

**96.** 4eV is the energy of incident photon and the work function is 2eV. The stopping potential will be

(a) 2V (b) 4V (c) 6V (d) $2\sqrt{2}$V

**97.** The photoelectric work function for a metal surface is 4.125 eV. The cut-off wavelength for this surface is

(a) 4125 Å (b) 3000 Å (c) 6000 Å (d) 2062 Å

**98.** A photocell is illuminated by a small bright source placed 1 m away. When the same source of light is placed 2 m away, the number of electrons emitted by photocathode are reduced by a factor of

(a) 1/8 (b) 1/16 (c) 1/2 (d) 1/4

**99.** All electrons ejected from a surface by incident light of wavelength 200nm can be stopped before travelling 1m in the direction of uniform electric field of 4N/C. The work function of the surface is

(a) 4 eV (b) 6.2 eV (c) 2 eV (d) 2.2 eV

**100.** For intensity I of a light of wavelenght 5000Å the photoelectron saturation current is 0.40 μA and stopping potential is 1.36 V, the work function of metal is

(a) 2.47 eV (b) 1.36 eV

(c) 1.10 eV (d) 0.43 eV

**101.** The maximum velocity of an electron emitted by light of wavelength $\lambda$ incident on the surface of a metal of work-function $\phi$ is

(a) $\sqrt{\frac{2(hc+\lambda\phi)}{m\lambda}}$ (b) $\frac{2(hc+\lambda\phi)}{m\lambda}$

(c) $\sqrt{\frac{2(hc-\lambda\phi)}{m\lambda}}$ (d) $\sqrt{\frac{2(h\lambda-\phi)}{m}}$

**102.** A photon of 1.7 × $10^{-13}$ joule is absorbed by a material under special circumstances. The correct statement is

(a) Electrons of the atom of absorbed material will go the higher energy states

(b) Electron and positron pair will be created

(c) Only positron will be produced

(d) Photoelectric effect will occur and electron will be produced

**103.** The frequency and work function of an incident photon are $v$ and $\phi_0$. If $v_0$ is the threshold frequency then necessary condition for the emission of photoelectron is

(a) $v < v_0$ (b) $v = \frac{v_0}{2}$

(c) $v \geq v_0$ (d) None of these

**104.** If $E_1$, $E_2$, $E_3$ are the respective kinetic energies of an electron, an alpha-particle and a proton, each having the same de-Broglie wavelength, then

(a) $E_1 > E_3 > E_2$ (b) $E_2 > E_3 > E_1$

(c) $E_1 > E_2 > E_3$ (d) $E_1 = E_2 = E_3$

**105.** The work function of aluminium is 4.2 eV. If two photons, each of energy 3.5 eV strike an electron of aluminium, then emission of electrons

(a) will be possible

(b) will not be possible

(c) Data is incomplete

(d) Depends upon the density of the surface

**106.** The magnitude of the de-Broglie wavelength ($\lambda$) of electron (e), proton (p), neutron (n) and $\alpha$-particle ($\alpha$) all having the same energy of 1 MeV, in the increasing order will follow the sequence

(a) $\lambda_e, \lambda_p, \lambda_n, \lambda_\alpha$ (b) $\lambda_e, \lambda_n, \lambda_p, \lambda_\alpha$

(c) $\lambda_\alpha, \lambda_n, \lambda_p, \lambda_e$ (d) $\lambda_p, \lambda_e, \lambda_\alpha, \lambda_n$

**107.** The potential difference that must be applied to stop the fastest photoelectrons emitted by a nickel surface, having work function 5.01 eV, when ultraviolet light of 200 nm falls on it, must be

(a) 2.4 V (b) –1.2 V

(c) –2.4 V (d) 1.2 V

**108.** In photoelectric emission process from a metal of work function 1.8 eV, the kinetic energy of most energetic electrons is 0.5 eV. The corresponding stopping potential is

(a) 1.8 V (b) 1.2 V

(c) 0.5 V (d) 2.3 V

**109.** The threshold frequency for a photosensitive metal is 3.3 × $10^{14}$ Hz. If light of frequency 8.2 × $10^{14}$ Hz is incident on this metal, the cut-off voltage for the photoelectric emission is nearly

(a) 2V (b) 3V

(c) 5V (d) 1V

**110.** Two radiations of photons energies 1 eV and 2.5 eV, successively illuminate a photosensitive metallic surface of work function 0.5 eV. The ratio of the maximum speeds of the emitted electrons is

(a) 1 : 4 (b) 1 : 2 (c) 1 : 1 (d) 1 : 5

**111.** A source $S_1$ is producing, $10^{15}$ photons per second of wavelength 5000 Å. Another source $S_2$ is producing $1.02\times10^{15}$ photons per second of wavelength 5100Å Then, (power of $S_2$) to the (power of $S_1$) is equal to :
(a) 1.00 (b) 1.02 (c) 1.04 (d) 0.98

**112.** A 200 W sodium street lamp emits yellow light of wavelength 0.6 µm. Assuming it to be 25% efficient in converting electrical energy to light, the number of photons of yellow light it emits per second is
(a) $1.5 \times 10^{20}$ (b) $6 \times 10^{18}$
(c) $62 \times 10^{20}$ (d) $3 \times 10^{19}$

**113.** Monochromatic radiation emitted when electron on hydrogen atom jumps from first excited to the ground state irradiates a photosensitive material. The stopping potential is measured to be 3.57 V. The threshold frequency of the materials is
(a) $4 \times 10^{15}$ Hz (b) $5 \times 10^{15}$ Hz
(c) $1.6 \times 10^{15}$ Hz (d) $2.5 \times 10^{15}$ Hz

**114.** For photoelectric emission from certain metal the cut-off frequency is ν. If radiation of frequency 2ν impinges on the metal plate, the maximum possible velocity of the emitted electron will be (m is the electron mass)
(a) $\sqrt{h\nu / m}$ (b) $\sqrt{2h\nu / m}$
(c) $2\sqrt{h\nu / m}$ (d) $\sqrt{h\nu / (2m)}$

**115.** Sodium and copper have work functions 2.3 eV and 4.5 eV respectively. Then the ratio of the wavelengths is nearest to
(a) 1 : 2 (b) 4 : 1 (c) 2 : 1 (d) 1 : 4

**116.** The work function of a substance is 4.0 eV. The longest wavelength of light that can cause photoelectron emission from this substance is approximately
(a) 310 nm (b) 400 nm
(c) 540 nm (d) 220 nm

**117.** The work functions of Silver and Sodium are 4.6 and 2.3 eV, respectively. The ratio of the slope of the stopping potential versus frequency plot for Silver to that of Sodium is
(a) 1 (b) 2
(c) 4 (d) zero

**118.** The photoelectric threshold of Tungsten is 2300Å. The energy of the electrons ejected from the surface by ultraviolet light of wavelength 1800Å is
(a) 0.15 eV (b) 1.5 eV (c) 15 eV (d) 150 eV

**119.** Ultraviolet radiation of 6.2 eV falls on an aluminium surface (workfunction 4.2 eV). The kinetic energy in joule of the faster electron emitted is approximately
(a) $3 \times 10^{-21}$ (b) $3 \times 10^{-19}$
(c) $3 \times 10^{-17}$ (d) $3 \times 10^{-15}$

**120.** Radiations of intensity 0.5 W/m$^2$ are striking a metal plate. The pressure on the plate is
(a) $0.166 \times 10^{-8}$ N/m$^2$ (b) $0.332 \times 10^{-8}$ N/m$^2$
(c) $0.111 \times 10^{-8}$ N/m$^2$ (d) $0.083 \times 10^{-8}$ N/m$^2$

**121.** Radiations of two photon's energy, twice and ten times the work function of metal are incident on the metal surface successsively. The ratio of maximum velocities of photoelectrons emitted in two cases is
(a) 1 : 2 (b) 1 : 3 (c) 1 : 4 (d) 1 : 1

**122.** If the momentum of electron is changed by $P$, then the de Broglie wavelength associated with it changes by 0.5%. The initial momentum of electron will be
(a) 200 $P$ (b) 400 $P$
(c) $\dfrac{P}{200}$ (d) 100 $P$

**123.** If the kinetic energy of a free electron doubles, it's de-Broglie wavelength changes by the factor
(a) 2 (b) $\dfrac{1}{2}$
(c) $\sqrt{2}$ (d) $\dfrac{1}{\sqrt{2}}$

**124.** The energy of a photon of green light of wavelength 5000Å is
(a) $3.459 \times 10^{-19}$ joule (b) $3.973 \times 10^{-19}$ joule
(c) $4.132 \times 10^{-19}$ joule (d) $8453 \times 10^{-19}$ joule

**125.** If the energy of a photon is 10 eV, then its momentum is
(a) $5.33 \times 10^{-23}$ kg m/s (b) $5.33 \times 10^{-25}$ kg m/s
(c) $5.33 \times 10^{-29}$ kg m/s (d) $5.33 \times 10^{-27}$ kg m/s

**126.** A proton and α-particle are accelerated through the same potential difference. The ratio of their de-Broglie wavelength will be
(a) 1 : 1 (b) 1 : 2 (c) 2 : 1 (d) $2\sqrt{2} : 1$

**127.** The ratio of de-Broglie wavelengths of proton and α -particle having same kinetic energy is
(a) $\sqrt{2} : 1$ (b) $2\sqrt{2} : 1$ (c) 2 : 1 (d) 4 : 1

**128.** A monochromatic source of light operating at 200 W emits $4 \times 10^{20}$ photons per second. Find the wavelength of light.
(a) 400 mm (b) 200 nm
(c) $4 \times 10^{-10}$ Å (d) None of these

**129.** The wavelength $\lambda_e$ of an electron and $\lambda_p$ of a photon are of same energy E are related by
(a) $\lambda_p \propto \lambda_e$ (b) $\lambda_p \propto \sqrt{\lambda_e}$
(c) $\lambda_p \propto \dfrac{1}{\sqrt{\lambda_e}}$ (d) $\lambda_p \propto \lambda_e^2$

**130.** A material particle with a rest mass $m_0$ is moving with speed of light c. The de-Broglie wavelength associated is given by
(a) $\dfrac{h}{m_0 c}$ (b) $\dfrac{m_0 c}{h}$ (c) zero (d) ∞

**131.** A proton has kinetic energy E = 100 keV which is equal to that of a photon. The wavelength of photon is $\lambda_2$ and that of proton is $\lambda_1$. The ratio of $\lambda_2/\lambda_1$ is proportional to
(a) $E^2$ (b) $E^{1/2}$ (c) $E^{-1}$ (d) $E^{-1/2}$

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(b)** Cathode ray consists of electrons

**2.** **(b)** The fluorescence was caused due to the radiations appeared to be coming from the cathode called cathode rays.

**3.** **(c)** **4. (b)**

**5.** **(d)** For occurence of photoelectric effect, the incident light should have frequency more than a certain minimum which is called the threshold frequency ($\nu_0$).

We have, $\frac{1}{2}mv^2 = h\nu - h\nu_0$

For photoelectric effect emission $\nu > \nu_0$
where $\nu$ is the frequency of the incident light.

**6.** **(a)** Emission of electron from a substance under the action of light is photoelectric effect. Light must be at a sufficiently high frequency. It may be visible light, U.V, X-rays. So U.V. cause electron emission.

**7.** **(d)** Einstein arrived at the important result that the light quantum can also be associated with momentum $h\nu/c$ A definite value of energy as well as momentum is a strong sign that the light quantum can be associated with a particle. This particle was later named photon.

**8.** **(c)** The Maxwell's equations of electromagnetism and Hertz experiment on the generation and detection of electromagnetic waves in 1887, strongly established the wave nature of light.

**9.** **(c)** A certain minimum amount of energy is required to pull the electron out from the surface of the metal. This minimum energy required by an electron to escape from the metal surface is called the work function of the metal.

**10.** **(d)** The work function of a metal depends upon the properties of the metal and the nature of its surface.

**11.** **(c)** R.A. Millikan's famous oil-drop experiment led him to propose the theory of quantisation of electric charge.

**12.** **(b)** The minimum frequency above which the electrons are ejected from the metal surface, is called the threshold frequency for that metal. No electrons are emitted if the frequency of the incident light is less than the threshold frequency.

**13.** **(d)** Cadmium is sensitive to ultraviolet light while the rest are sensitive even to visible light.

**14.** **(d)** All photosensitive substances emit electrons when illuminated by light.

**15.** **(c)** Beyond the threshold frequency the photoelectric current increases with increase in intensity.

**16.** **(d)** For the given frequency of incident light
$K_{max} = eV_0$
where $K_{max}$ is the maximum kinetic energy gained by photoelectron and $V_0$ is the minimum retarding potential for which the photocurrent stops.
$e$ = charge of electron.

**17.** **(c)** Photocurrent can be explained with particle nature of light.

**18.** **(d)**

**19.** **(b)** The photoelectric emission takes place by discrete absorption of energy from radiation.

**20.** **(c)** The diffraction of electrons show wave nature of electrons.

**21.** **(d)** Photons are not deflected by electric and magnetic fields as they are electrically neutral.

**22.** **(c)** Photons are quantum of light which are electrically neutral.

**23.** **(c)** In a photon – particle collision, the number of photons may not be conserved. The photon may be absorbed or a new photon may be created.

**24.** **(a)** Photon has no rest mass

**25.** **(c)** Photoelectric effect can be explained by quantum nature of light i.e. light as a stream of photons.

**26.** **(a)** Hertz discovered first the photoelectric effect in 1887.

**27.** **(b)** **28. (d)**

**29.** **(b)** Photoelectric effect is accounted by particle like bahaviour of light (i.e. by quantum theory of light)

**30.** **(c)** Photoelectric cell converts light energy into electric energy.

**31.** **(b)** The photoelectric current $\propto$ Intensity of light.

**32.** **(b)** Photoelectric effect is based on law of conservation of energy.

**33.** **(c)**

**34.** **(b)** Max. K.E. = $h\nu - W_0$ ; so Max. K.E. $\propto \nu$

**35.** **(c)** Max. K.E. of phtoelectrons emitted is independent of intensity of incident light.

**36.** **(c)** In the given relation $E_k$ stands for maximum K.E. of emitted photoelectron.

**37.** **(d)** Photoelectrons are emitted if the frequency of incident light is greater than the threshold frequency.

**38.** **(d)** The minimum energy required for the emission of electrons is called work function.

**39.** **(a)** The work function of different metals is different.

**40.** **(d)** **41. (a)**

**42.** **(a)** Einstein's photo electric effect & compton effect established particle nature of light. These effects can be explained only, when we assume that the light has particle nature (To explain, Interference & Diffraction the light must have wave nature. It means that light has both particle and wave nature, so it is called dual nature of light)

**43.** **(d)** **44. (c)**

**45.** **(c)** Energy of a photon $E = \frac{hc}{\lambda}$ ; E is less if $\lambda$ is longer

**46.** **(c)** Energy of a photon $E = hc/\lambda$

**47.** **(b)**

**48.** **(d)** From Eqn K.E = $h\nu - \phi$
slope of graph of K.E & $\nu$ is h,
which is same for all metals.

**49.** **(d)** The discovery of X-rays by Roentgen in 1895 and of electrons by J.J Thomson in 1897, were important milestones in the understanding of atomic structure.

**50.** **(c)** de-Broglie's relation, $\lambda = \frac{h}{p}$

momentum $p = \sqrt{2mE}$

$$\Rightarrow \lambda = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2mK}} \quad (\because E = K)$$

**51.** **(a)** 1 electron volt (ev) = 1.6 × $10^{-19}$ joule

**52.** **(c)** The ultraviolet light provided sufficient energy for the electrons to escape from the surface of detector (metal) loop and hence the current increased.

**53.** **(c)** The kinetic energy of the particle

$$K = \frac{1}{2}mv^2 = qV = \frac{p^2}{2m}$$

$$\Rightarrow \ p = \sqrt{2mK} = \sqrt{2mqV}$$

$$\because \ \lambda = \frac{h}{p} = \frac{h}{\sqrt{2mqV}}$$

**54.** **(c)** $\lambda = \frac{1.227}{\sqrt{V}}$ nm, as $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2meV}}$

Substituting the numerical values of *h*, *m* and *e* we get the result.

**55.** **(c)**

**56.** **(c)** $\lambda = \frac{h}{m_p v_p} = \frac{h}{m_e v_e}$; then $m_p v_p = m_e v_e$ or $\frac{v_p}{v_e} = \frac{m_e}{m_p}$

$$\frac{E_p}{E_e} = \frac{\frac{1}{2}m_p v_p^2}{\frac{1}{2}m_e v_e^2} = \frac{m_p}{m_e} \times \left(\frac{m_e}{m_p}\right)^2 = \frac{m_e}{m_p} < 1$$

$\therefore \ E_p < E_e$

**57.** **(d)** Since $eV_0 = h\nu - \phi_0$

where $V_0$ = max. potential

or $V_0 = \left(\frac{h}{e}\right)\nu - \frac{\phi}{e}$

**58.** **(b)**

**59.** **(d)** The order of time is nano second.

**60.** **(a)** In the Davisson and Germer experiment, the velocity of electrons emitted from the electron gun can be increased by increasing the potential difference between the anode and filament.

## STATEMENT TYPE QUESTIONS

**61.** **(b)** Cathode rays get deflected in the electric field.

**62.** **(d)** The minimum energy required for the electron emission from the metal surface can be supplied to the free electrons by anyone of the following physical processes.

(i) **Thermionic emission** By suitably heating, sufficient thermal energy can be imparted to the free electrons to enable them to come out of the metal.

(ii) **Photoelectric emission** When light of suitable frequency illuminates a metal surface, electrons are emitted from the metal surface. These photo (light)-generated electrons are called photoelectrons.

(iii) **Field emission** By applying a very strong electric field (of the order of $10^8$ V $m^{-1}$) to a metal, electrons can be pulled out of the metal, as in a spark plug.

**63.** **(a)** The greater the intensity of radiation the greater the amplitude of electric and magnetic field.

**64.** **(d)**

(i) For a given photosensitive material and frequency of incident radiation (above the threshold frequency), the photoelectric current is directly proportional to the intensity of incident light.

(ii) For a given photosensitive material and frequency of incident radiation, saturation current is found to be proportional to the intensity of incident radiation whereas the stopping potential is independent of its intensity.

(iii) For a given photosensitive material, there exists a certain minimum cut-off frequency of the incident radiation, called the threshold frequency, below which no emission of photoelectrons takes place, no matter how intense the incident light is. Above the threshold frequency, the stopping potential or equivalently the maximum kinetic energy of the emitted photoelectrons increases linearly with the frequency of the incident radiation but is independent of its intensity.

(iv) The photoelectric emission is an instantaneous process without any apparent time lag (~ $10^{-9}$ or less), even when the incident radiations is made exceedingly dim.

**65.** **(a)** According to Einstein's photoelectric equation $k_{max} = hv - hv_0$ if $v_0 > v$ $k_{max}$ $^{-(ve)}$

**66.** **(c)** The photoelectric equation

$K_{max} = h\nu - \phi_0$

Explains that the intensity of incident radiation will increase photocurrent only beyond the threshold frequency.

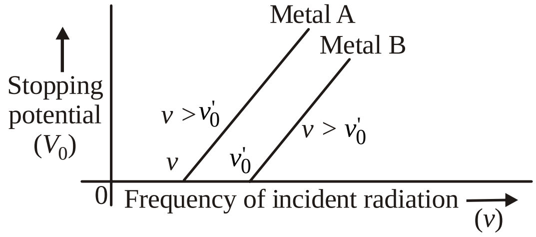
**67.** **(d)** To study effect of intensity, the collector A is maintained at a positive potential with respect to emitter C so that electrons ejected from C are attracted towards collector A. Keeping the frequency of the incident radiation and the accelerating potential fixed, the intensity of light is varied and the resulting phtoelectric current is measured each time. It is found that the photocurrrent increases linearly with intensity of incident light.

**68.** **(b)**

**69.** **(c)** The stopping potential is independent of intensity of incident radiation.

**70.** **(a)**

(i) The graph shows that the stopping potential $V_0$ varies linearly with the frequency of incident radiation for a given photosensitive material.



Variation of stopping potential $V_0$ with frequency $v$ of incident radiation for a given photosensitive material.

(ii) There exists a certain minimum cut-off frequency $v_0$ for which the stopping potential is zero.
These observations have two implications.

(iii) The maximum kinetic energy of the photoelectrons varies linearly with the frequency of incident radiation, but is independent of its intensity.

(iv) For a frequency $v$ of incident radiation lower than the cut-off frequency $v_0$, no photoelectric emission is possible even if the intensity is large.
This minimum, cut-off frequency $v_0$, is called the threshold frequency. It is different for different metals.

**71.** **(b)**

(i) In interaction of radiation with matter, radiation behaves as if it is made up of particles called photons.

(ii) Each photon has energy $E$ (= $hv$) and momentum $p$ (= $h\ v/c$) and speed c, the speed of light.

(iii) All photons of light of a particular frequency $v$, or wavelength $\lambda$ have the same energy, $E$ (= $hv = hc/\lambda$) and momentum P(= $hv/c = h/\lambda$), whatever the intensity of radiation may be. By increasing the intensity of light of given wavelength, there is only an increase in the number of photons per second crossing a given area, with each photon having the same energy.
Thus, photon energy is independent of intensity of radiation.

(iv) Photons are electrically neutral and are not deflected by electric and magnetic fields.

(v) In photon-particle collision (such as photoelectron collision), the total energy and total momentum are conserved.
however, the number of photons may not be conserved in a collision. The photon may be absorbed or a new photon may be created.

## MATCHING TYPE QUESTIONS

**72.** **(a)** (A) → (2); (B) → (3); (C) → (1); (D) → (4)
**73.** **(a)** (A) → (1); (B) → 4; (C) → (3); (D) → (2)
**74.** **(c)** (A) → (2); (B) → (1); (C) → (4); (D) → (3)
**75.** **(b)** (A) → (3); (B) → (4); (C) → (2); (D) → (1)

## DIAGRAM BASED QUESTIONS

**76.** **(c)** Changing the material of plate A will not affect the no. of photoelectrons emitted for the given material of plate C and intensity & frequency of light used.

**77.** **(c)**

**78.** **(b)** From his experiment hallwachs concluded that negatively charged particles were emitted from zinc plate under the action of ultraviolet light.

**79.** **(b)**

**80.** **(a)** From the graph it is clear that A and B have the same stopping potential and therefore the same frequency. Also B and C have the same intensity.

**81.** **(d)** $h\upsilon - h\upsilon_0 = E_K$, according to photoelectric equation, when $\upsilon = \upsilon_0$, $E_K = 0$.
Graph (d) represents $E_K - \upsilon$ relationship.

**82.** **(a)** For a given photosensitive material and ∝ frequency > threshold frequency photoelectric current ∝ intensity.

**83.** **(d)** Intensity $\propto 1/(\text{distance})^2$ ; No. of photoelectrons emitted is proportional to intensity of incident light.

**84.** **(d)** As $\lambda$ is increased, there will be a value of $\lambda$ above which photoelectrons will be cease to come out so photocurrent will become zero. Hence (d) is correct answer.

## ASSERTION- REASON TYPE QUESTIONS

**85.** **(b)** Both statement I and II are true; but even it radiation of single wavelength is incident on photosensitive surface, electrons of different KE will be emitted.

**86.** **(a)** When a light of single frequency falls on the electrons of inner layer of metal, then this electron comes out of the metal surface after a large number of collisions with atom of it's upper layer.

**87.** **(b)** The kinetic energy of emitted photoelectrons varies from zero to a maximum value. Work function depends on metal used.

**88.** **(d)** Photoelectric saturation current is independent of frequency. It only depends on intensity of light.

**89.** **(b)** Less work function means less energy is required for ejecting out the electrons.

**90.** **(a)** **91.** **(d)**

**92.** **(d)** Total number of emitted photons depends on energy of each photon. The energy of photons of two sources may be different.

**93.** **(d)** To photons of equal wavelength will have equal momentum (magnitude), but direction of momentum may be different.

**94.** **(b)**

## CRITICAL THINKING TYPE QUESTIONS

**95.** **(d)** $eV_s = \dfrac{hc}{\lambda} - W_0$. If $\lambda$ decreases, $V_s$ increases

**96.** **(a)** Einstein equation $E = h\upsilon_o + K.E$
where E = energy of incident photon.
$h\upsilon_o$ = work function of metal
K.E = max. kinetic energy of $e^-$
$\therefore 4\ eV = 2\ eV + K.E$ or $K.E = 2\ eV$
Stopping potential is the potential difference which may stop this $e^-$.
Let it be V, then $eV = 2e \Rightarrow V = 2$ volt.

**97.** **(b)** Since work function for a metal surface is $W = \dfrac{hc}{\lambda_0}$
where $\lambda_0$ is threshold wavelength or cut-off wavelength for a metal surface.
here $W = 4.125\ eV = 4.125 \times 1.6 \times 10^{-19}$ Joule

$$\text{so } \lambda_0 = \frac{6.6\times10^{-34}\times3\times10^{8}}{4.125\times1.6\times10^{-19}} = 3000\text{Å}$$

**98.** **(d)** Intensity $\propto 1/(\text{distance})^2$ ; No. of photoelectrons emitted is proportional to intensity of incident light.

**99.** **(d)** The electron ejected with maximum speed $v_{max}$ are stopped by electric field E =4N/C after travelling a distance d =1m

$$\frac{1}{2}mv_{max}^2 = eEd = 4eV$$

The energy of incident photon = $\frac{1240}{200} = 6.2$ eV

From equation of photo electric effect

$$\frac{1}{2}mv_{max}^2 = h\nu - \phi_0$$

$\therefore\ \phi_0 = 6.2 - 4 = 2.2$ eV

**100. (c)** By using $E = W_0 + K_{max}$

$E = \frac{12375}{5000} = 2.475$ eV and $K_{max} = eV_0 = 1.36$ eV

So $2.475 = W_0 + 1.36 \Rightarrow \underline{W_0 = 1.1\text{ eV}}$.

**101. (c)** $\frac{1}{2}mv^2 = \frac{hc}{\lambda} - \phi \Rightarrow v = \sqrt{\frac{2(hc - \lambda\phi)}{\lambda m}}$

**102. (b)** For electron and positron pair production, minimum energy is 1.02 MeV.

Energy of photon is given $1.7 \times 10^{-3}J = \frac{1.7 \times 10^{-13}}{1.6 \times 10^{-19}}$

= 1.06 MeV.

Since energy of photon is greater than 1.02 MeV.

so electron positron pair will be created.

**103. (c)**

**104. (a)** According to relation, $E = \frac{1}{2}mv^2$

$$\sqrt{\frac{2E}{m}} = v$$

$$\lambda = \frac{h}{\sqrt{2mE}}$$

Because $m_1 < m_3 < m_2$

So for same $\lambda$, $E_1 > E_3 > E_2$ .

**105. (b)** For emission of electrons incident energy of each photon must be greater than work function (threshold energy).

**106. (c)** $\lambda = \frac{h}{\sqrt{2mE}}$ So $h \propto \frac{1}{\sqrt{m}}$

since $m_\alpha > m_n > m_p > m_e$

so de-Broglie wave length in increasing order will be $\lambda_d$, $\lambda_m$, $\lambda_p$, $\lambda_e$

**107. (d)** $K_{max} = \frac{hc}{\lambda} - W = \frac{hc}{\lambda} - 5.01 = \frac{12375}{\lambda(\text{in Å})} - 5.01$

$$= \frac{12375}{2000} - 5.01 = 6.1875 - 5.01 = 1.17775 \simeq 1.2\,V$$

**108. (c)** The stopping potential is equal to maximum kinetic energy.

**109. (a)** K.E. = $h\nu - h\nu_{th} = eV_0$ ($V_0$ = cut off voltage)

$$\Rightarrow V_0 = \frac{h}{e}(8.2 \times 10^{14} - 3.3 \times 10^{14})$$

$$= \frac{6.6 \times 10^{-34} \times 4.9 \times 10^{14}}{1.6 \times 10^{-19}} \approx 2V.$$

**110. (b)** According to Einsten's photoelectric effect, the K.E. of the radiated electrons

$K.E_{max} = E - W$

$$\frac{1}{2}mv_1^2 = (1 - 0.5)\text{ eV} = 0.5\text{ eV}$$

$$\frac{1}{2}mv_2^2 = (2.5 - 0.5)\text{ eV} = 2\text{ eV}$$

$$\frac{v_1}{v_2} = \sqrt{\frac{0.5}{2}} = \frac{1}{\sqrt{4}} = \frac{1}{2}$$

**111. (a)** Energy emitted/sec by $S_1, P_1 = n_1\frac{hc}{\lambda_1}$

Energy emitted/sec by $S_2, P_2 = n_2\frac{hc}{\lambda_2}$

$$\therefore\ \frac{P_2}{P_1} = \frac{n_2}{n_1} \cdot \frac{\lambda_1}{\lambda_2}$$

$$= \frac{1.02 \times 10^{15}}{10^{15}} \cdot \frac{5000}{5100} = 1.0$$

**112. (a)** Give that, only 25% of 200W converter electrical energy into light of yellow colour

$$\left(\frac{hc}{\lambda}\right) \times N = 200 \times \frac{25}{100}$$

Where $N$ is the No. of photons emitted per second, $h$ = plank's constant, $c$, speed of light.

$$N = \frac{200 \times 25}{100} \times \frac{\lambda}{hc}$$

$$= \frac{200 \times 25 \times 0.6 \times 10^{-6}}{100 \times 6.2 \times 10^{-34} \times 3 \times 10^8}$$

$$= 1.5 \times 10^{20}$$

**113. (c)** $n \rightarrow 2 - 1$

$E = 10.2$ eV

$kE = E - \phi$

$Q = 10.20 - 3.57$

$h\upsilon_0 = 6.63$ eV

$$\upsilon_0 = \frac{6.63 \times 1.6 \times 10^{-19}}{6.67 \times 10^{-34}} = 1.6 \times 10^{15}\text{ Hz}$$

**114. (b)** From photoelectric equation,

$h\nu' = h\nu + K_{max}$ ...(i)

$$h.2\nu = h\nu + \frac{1}{2}\ mV^2{}_{max}[\because\ \nu' = 2\,\nu]$$

$$\Rightarrow h\nu = \frac{1}{2}\ mV^2{}_{max}$$

$$\Rightarrow V_{max} = \sqrt{\frac{2h\nu}{m}}$$

**115. (c)** $hc/\lambda_0 = W_0$ ; $\frac{(\lambda_0)_1}{(\lambda_0)_2} = \frac{(W_0)_2}{(W_0)_1} = \frac{4.5}{2.3} = 2:1.$

**116. (a)** For the longest wavelength to emit photo electron

$$\frac{hc}{\lambda} = \phi \Rightarrow \lambda = \frac{hc}{\phi}$$

$$\Rightarrow \lambda = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{4 \times 1.6 \times 10^{-19}} = 310\,\text{nm}$$

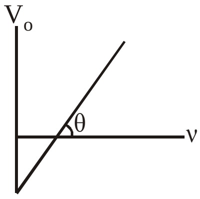
**117. (a)** For photoelectric effect

$$\frac{h\nu}{e}-\frac{\phi_o}{e}=V_o$$

The slope is

$$\tan\theta=\frac{h}{e}=\text{constant}$$

∴ The ratio will be 1.



**118. (a)** $E_k=\frac{hc}{c}\left(\frac{1}{\lambda}-\frac{1}{\lambda_0}\right)(\text{in eV})$

$$=\frac{6.6\times10^{-34}\times3\times10^{8}}{1.6\times10^{-19}}\left(\frac{10^{10}}{1800}-\frac{10^{10}}{2300}\right)=0.15\text{eV}$$

**119. (b)** $E_k=E-W_0=6.2-4.2=2.0\text{ eV}$

$=2.0\times1.6\times10^{-19}=3.2\times10^{-19}\text{ J}$

**120. (a)** We know that P = Fv or F = P/v

$$F=\frac{0.5}{3\times10^{8}}=0.166\times10^{-8}\,N/m^{2}$$

**121. (b)** $\frac{1}{2}m v_1^2=2W_0-W_0=W_0$ and

$$\frac{1}{2}m v_2^2=10W_0-W_0=9W_0$$

$$\therefore\quad \frac{v_1}{v_2}=\sqrt{\frac{W_0}{9W_0}}=\frac{1}{3}$$

**122. (a)** The de-Broglie's wavelength associated with the moving electron $\lambda=\frac{h}{P}$

Now, according to problem

$$\frac{d\lambda}{\lambda}=-\frac{dp}{P}$$

$$\frac{0.5}{100}=\frac{P}{P'}$$

$$P'=200P$$

**123. (d)** de-Broglie wavelength,

$$\lambda=\frac{h}{p}=\frac{h}{\sqrt{2.m.(K.E)}}$$

$$\therefore\quad \lambda\propto\frac{1}{\sqrt{K.E}}$$

If K.E is doubled, λ becomes $\frac{\lambda}{\sqrt{2}}$

**124. (b)** $E=hc/\lambda=6.6\times10^{-34}\times3\times10^{8}/5000\times10^{-10}$
$=3.973\times10^{-19}\text{ J}$

**125. (d)** Momentum of a photon $\propto\frac{E}{c}=\frac{10\times1.6\times10^{-19}}{3\times10^{8}}$

$=5.33\times10^{-27}\text{ kg ms}^{-1}$

**126. (d)** $qV=\frac{1}{2}mv^2$ or $mv=\sqrt{2qVm}$ ;

So $\lambda=\frac{h}{mv}=\frac{h}{\sqrt{2qVm}}$ i.e. $\lambda\propto\frac{1}{\sqrt{qm}}$ ;

so $\frac{\lambda_p}{\lambda_\alpha}=\sqrt{\frac{q_\alpha m_\alpha}{q_p m_p}}=\sqrt{2\times4}=2\sqrt{2}$

**127. (c)** de-Broglie wavelength, $\lambda=\frac{h}{\sqrt{2mE_{K.E}}}$

$$\therefore\quad \frac{\lambda_p}{\lambda_\alpha}=\sqrt{\frac{m_\alpha}{m_p}}=\sqrt{\frac{4m_p}{m_p}}\quad[\because E_{K.E(\alpha)}=E_{K.E(p)}]$$

$$\therefore\quad \frac{\lambda_p}{\lambda_\alpha}=\frac{2}{1}$$

**128. (a)** The energy of each photon $=\frac{200}{4\times10^{20}}=5\times10^{-19}\text{ J}$

Wavelength $=\lambda=\frac{hc}{E}$

$$=\frac{(6.63\times10^{-34})\times(3\times10^{8})}{5\times10^{-19}}$$

$\Rightarrow\lambda=4.0\times10^{-7}=400\text{ nm}$

**129. (d)** As $P=\frac{E}{C}$

$$\lambda_p=\frac{\hbar C}{E}\qquad ...(i)$$

$$\lambda_e^{\,2}=\frac{\hbar h}{\sqrt{2mE}}\qquad ...(ii)$$

From equations (i) and (ii)

$\lambda_p\propto\lambda_e^{\,2}$

**130. (c)** $\lambda=\frac{h}{mv}$, $v=\frac{m_0}{\sqrt{1-\left(\frac{v}{c}\right)^2}}$, $v\to c$, $m\to\infty$

hence, $\lambda\to0$.

**131. (d)** For photon E = hν

$$E=\frac{hc}{\lambda}\Rightarrow\lambda_2=\frac{hc}{E}\qquad ...(i)$$

for proton $E=\frac{1}{2}m_p v_p^2$

$$E=\frac{1}{2}\frac{m_p^2v_p^2}{m}\Rightarrow p=\sqrt{2mE}$$

From De Broglie Eqn.

$$p=\frac{h}{\lambda_1}\Rightarrow\lambda_1=\frac{h}{p}=\frac{h}{\sqrt{2mE}}\qquad ...(ii)$$

$$\frac{\lambda_2}{\lambda_1}=\frac{hc}{E\times\frac{h}{\sqrt{2mE}}}\propto E^{-1/2}$$

# CHAPTER

# 27

# ATOMS

## FACT/DEFINITION TYPE QUESTIONS

**1.** The first model of atom was proposed by
(a) Hans Geiger (b) Ernst Rutherford
(c) J.J. Thomson (b) N.H.D Bohr

**2.** The empirical atom model was given by
(a) J. J. Thomson (b) Rutherford
(c) Niels Bohr (d) Sommerfeld

**3.** Which of the following statements is correct in case of Thomson's atomic model?
(a) It explains the phenomenon of thermionic emission, photoelectric emission and ionisation.
(b) It could not explain emission of line spectra by elements.
(c) It could not explain scattering of $\alpha$-particles
(d) All of the above

**4.** Which one did Rutherford consider to be supported by the results of experiments in which $\alpha$-particles were scattered by gold foil?
(a) The nucleus of an atom is held together by forces which are much stronger than electrical or gravitational forces.
(b) The force of repulsion between an atomic nucleus and an $\alpha$-particle varies with distance according to inverse square law.
(c) $\alpha$-particles are nuclei of Helium atoms.
(d) Atoms can exist with a series of discrete energy levels

**5.** According to the Rutherford's atomic model, the electrons inside the atom are
(a) stationary (b) not stationary
(c) centralized (d) None of these

**6.** According to classical theory, the circular path of an electron in Rutherford atom model is
(a) spiral (b) circular
(c) parabolic (d) straight line

**7.** Rutherford's $\alpha$-particle experiment showed that the atoms have
(a) Proton (b) Nucleus
(c) Neutron (d) Electrons

**8.** Electrons in the atom are held to the nucleus by
(a) coulomb's force (b) nuclear force
(c) vander waal's force (d) gravitational force

**9.** The Rutherford $\alpha$-particle experiment shows that most of the $\alpha$-particles pass through almost unscattered while some are scattered through large angles. What information does it give about the structure of the atom?
(a) Atom is hollow.
(b) The whole mass of the atom is concentrated in a small centre called nucleus
(c) Nucleus is positively charged
(d) All of the above

**10.** In Rutherford's $\alpha$ -particle scattering experiment, what will be correct angle for $\alpha$ scattering for an impact parameter b = 0 ?
(a) $90^{\circ}$ (b) $270^{\circ}$ (c) $0^{\circ}$ (d) $180^{\circ}$

**11.** In the ground state in ...*A*... electrons are in stable equilibrium while in ...*B*... electrons always experiences a net force. Here, *A* and *B* refer to
(a) Dalton's theory, Rutherford model
(b) Rutherford's model, Bohr's model
(c) Thomson's model, Rutherford's model
(d) Rutherford's model, Thomson's model

**12.** The significant result deduced from the Rutherford's scattering experiment is that
(a) whole of the positive charge is concentrated at the centre of atom
(b) there are neutrons inside the nucleus
(c) $\alpha$-particles are helium nuclei
(d) electrons are embedded in the atom
(e) electrons are revolving around the nucleus

**13.** Electrons in the atom are held to the nucleus by
(a) coulomb's force (b) nuclear force
(c) vander waal's force (d) gravitational force

**14.** In a Rutherford scattering experiment when a projectile of charge $Z_1$ and mass $M_1$approaches a target nucleus of charge $Z_2$ and mass $M_2$, the distance of closest approach is $r_0$. The energy of the projectile is
(a) directly proportional to $Z_1 Z_2$
(b) inversely proportional to $Z_1$
(c) directly proportional to mass $M_1$
(d) directly proportional to $M_1 \times M_2$

**15.** According to classical theory, Rutherford's atomic model is
(a) stable (b) unstable
(c) meta stable (d) both (a) and (b)

**16.** Rutherford's atomic model was unstable because
(a) nuclei will break down
(b) electrons do not remain in orbit
(c) orbiting electrons radiate energy
(d) electrons are repelled by the nucleus

**17.** The electrons of Rutherford's model would be expected to lose energy because, they
(a) move randomly
(b) jump on nucleus
(c) radiate electromagnetic waves
(d) escape from the atom

**18.** As one considers orbits with higher values of n in a hydrogen atom, the electric potential energy of the atom
(a) decreases (b) increases
(c) remains the same (d) does not increase

**19.** Which of the following parameters is the same for all hydrogen-like atoms and ions in their ground states?
(a) Radius of the orbit
(b) Speed of the electron
(c) Energy of the atom
(d) Orbital angular momentum of the electron

**20.** The angular speed of the electron in the n$^{th}$ orbit of Bohr hydrogen atom is
(a) directly proportional to n
(b) inversely proportional to $\sqrt{n}$
(c) inversely proportional to n$^2$
(d) inversely proportional to n$^3$

**21.** According to Bohr's model of hydrogen atom
(a) the linear velocity of the electron is quantised.
(b) the angular velocity of the electron is quantised.
(c) the linear momentum of the electron is quantised.
(d) the angular momentum of the electron is quantised.

**22.** As the quantum number increases, the difference of energy between consecutive energy levels
(a) remain the same
(b) increases
(c) decreases
(d) sometimes increases and sometimes decreases.

**23.** Which of the following in a hydrogen atom is independent of the principal quantum number n? (The symbols have their usual meanings).
(a) νn (b) Er (c) En (d) νr

**24.** According to the Bohr theory of H-atom, the speed of the electron, its energy and the radius of its orbit varies with the principal quantum number n, respectively, as
(a) $\frac{1}{n}, n^2, \frac{1}{n^2}$ (b) $n, \frac{1}{n^2}, n^2$
(c) $n, \frac{1}{n^2}, \frac{1}{n^2}$ (d) $\frac{1}{n}, \frac{1}{n^2}, n^2$

**25.** In terms of Bohr radius r$_0$, the radius of the second Bohr orbit of a hydrogen atom is given by
(a) $4r_0$ (b) $8r_0$ (c) $\sqrt{2}r_0$ (d) $2r_0$

**26.** When hydrogen atom is in its first excited level, it's radius is
(a) four times, it ground state radius
(b) twice times, it ground state radius
(c) same times, it ground state radius
(d) half times, it ground state radius.

**27.** The angular momentum of the electron in hydrogen atom in the ground state is
(a) 2h (b) $\frac{h}{2}$ (c) $\frac{h}{2\pi}$ (d) $\frac{h}{4\pi}$

**28.** When an atomic gas or vapour is excited at low pressure, by passing an electric current through it then
(a) emission spectrum is observed
(b) absorption spectrucm is observed
(c) band spectrum is observed
(d) both (b) and (c)

**29.** The first spectral series was disscovered by
(a) Balmer (b) Lyman (c) Paschen (d) Pfund

**30.** When an electron jumps from the fourth orbit to the second orbit, one gets the
(a) second line of Paschen series
(b) second line of Balmer series
(c) first line of Pfund series
(d) second line of Lyman series

**31.** The Balmer series for the H-atom can be observed
(a) if we measure the frequencies of light emitted when an excited atom falls to the ground state
(b) if we measure the frequencies of light emitted due to transitions between excited states and the first excited state
(c) in any transition in a H-atom
(d) None of these

**32.** In Balmer series of emission spectrum of hydrogen, first four lines with different wavelength $H_\alpha$ $H_\beta$ Hγ and $H_\delta$ are obtained. Which line has maximum frequency out of these?
(a) $H_\alpha$ (b) $H_\beta$ (c) Hγ (d) $H_\delta$

**33.** In which of the following series, does the 121.5 nm line of the spectrum of the hydrogen atom lie ?
(a) Lyman series (b) Balmer series
(c) Paschen series (d) Brackett series.

**34.** Which of the following series in the spectrum of hydrogen atom lies in the visible region of the electromagnetic spectrum?
(a) Paschen series (b) Balmer series
(c) Lyman series (d) Brackett series

**35.** The shortest wavelength in Balmer's series for Hydrogen atom is ...*A*... and this is obtained by substituting ...*B* ... in Balmer's formula. Here, *A* and *B* refer to
(a) 656.3 nm, $n = 3$ (b) 486.1 nm, $n = 4$
(c) 410.2 nm, $n = 5$ (d) 364.6 nm, $n = \infty$

**36.** As an electron makes a transition from an excited state to the ground state of a hydrogen - like atom/ion
(a) kinetic energy decreases, potential energy increases but total energy remains same
(b) kinetic energy and total energy decrease but potential energy increases
(c) its kinetic energy increases but potential energy and total energy decrease
(d) kinetic energy, potential energy and total energy decrease

**37.** Which of the following series in the spectrum of hydrogen atom lies in the visible region of the electromagnetic spectrum?
(a) Paschen series (b) Balmer series
(c) Lyman series (d) Brackett series

**38.** In a hydrogen atom, which of the following electronic transitions would involve the maximum energy change
(a) n = 2 to n = 1 (b) n = 3 to n = 1
(c) n = 4 to n = 2 (d) n = 3 to n = 2

**39.** Hydrogen atom excites energy level from fundamental state to n = 3. Number of spectral lines according to Bohr, is

(a) 4 (b) 3 (c) 1 (d) 2

**40.** The transition from the state n = 4 to n = 3 in a hydrogen like atom results in ultraviolet radiation. Infrared radiation will be obtained in the transition from

(a) $2 \to 1$ (b) $3 \to 2$ (c) $4 \to 2$ (d) $5 \to 4$

**41.** For a given value of n, the number of electrons in an orbit is

(a) n (b) $n^2$ (c) $2n^2$ (d) 2n

**42.** Bohr's atom model is the modification of Rutherford's atom model by the application of

(a) newton's theory (b) huygen's theory
(c) maxwell's theory (d) planck's quantum theory

**43.** In Bohr's model electrons are revolving in a circular orbits around the nucleus called as

(a) stationary orbits (b) non radiating orbits
(c) Bohr's orbits (d) all of these

**44.** According to Bohr's theory of H atom, an electron can revolve around a proton indefinitely, if its path is

(a) a perfect circle of any radius
(b) a circle of an allowed radius
(c) a circle of constantly decreasing radius
(d) an ellipse with fixed focus

**45.** According to Bohr the difference between the energies of the electron in the two orbits is equal to

(a) h ν (b) hc/λ
(c) both (a) and (b) (d) neither (a) nor (b)

**46.** The angular momentum of electrons in an atom produces

(a) magnetic moment (b) ZEEMAN effect
(c) light (d) nuclear fission

**47.** According to Planck's quantum theory any electromagnetic radiation is

(a) continuously emitted
(b) continuously absorbed
(c) emitted or absorbed in discrete units
(d) None of these

**48.** The radius of 'n'th Bohr's orbit of H atom is given by

(a) $\frac{\in_0 n^2h^2}{\pi me^2}$ (b) $\frac{n^2h^2}{\in_0 \pi me^2}$ (c) $\frac{\pi me^2}{\in_0 n^2h^2}$ (d) $n^2h^2$

**49.** The linear speed of an electron, in Bohr's orbit is given by

(a) $\frac{e^2}{h}$ (b) $\frac{e^2}{2 \in_0 nh}$ (c) $\frac{2 \in_0 nh}{e}$ (d) $2\hat{I}_0 h$

**50.** Angular speed of an electron in a Bohr's orbit is given by

(a) $\omega = \frac{\pi me^4}{2 \in_0^2 n^3h^3}$ (b) $\omega = \frac{4 \in_0^2 n^3h^3}{me^4}$

(c) $\omega = \frac{me^4}{4 \in_0^2 n^3h^3}$ (d) all of these

**51.** Period of revolution of electron in the nth Bohr's orbit is given by

(a) $T = \frac{4 \in_0^2 n^3h^3}{me^4}$ (b) $T = 4 \in_0^2 n^3h^3$

(c) $T = me^4 n$ (d) $T = 2\pi$

**52.** Frequency of revolution of electron in the nth Bohr's orbit is given by

(a) $f = \frac{me^4}{4 \in_0^2 n^3h^3}$ (b) $f = 4 \in_0^2 n^3h^3$

(c) $f = \frac{me^4}{4 \in_0^2 h^2}$ (d) $f = \frac{me^4}{\in_0 n}$

**53.** The total energy of the electron in the Bohr's orbit is given by

(a) $E = -\frac{me^4}{8 \in_0^2 n^2h^2}$ (b) $E = \frac{1}{8\pi \in_0} \frac{e^2}{r}$

(c) both (a) and (b) (d) neither (a) nor (b)

**54.** If 'r' is the radius of the lowest orbit of Bohr's model of H-atom, then the radius of nth orbit is

(a) $r n^2$ (b) 2r
(c) $n^2/r$ (d) r n

**55.** The ratio of radii of the first three Bohr orbits is

(a) $1 : \frac{1}{2} : \frac{1}{3}$ (b) 1 : 2 : 3 (c) 1 : 4 : 9 (d) 1 : 8 : 27

**56.** The speed of an electron, in the orbit of a H-atom, in the ground state is

(a) c (b) $\frac{c}{2}$ (c) $\frac{c}{10}$ (d) $\frac{c}{137}$

**57.** The speed of electron in first Bohr orbit is c/137. The speed of electron in second Bohr orbit will be

(a) $\frac{2c}{137}$ (b) $\frac{4c}{137}$ (c) $\frac{c}{274}$ (d) $\frac{c}{548}$

**58.** If the angular momentum of an electron in an orbit is J then the K.E. of the electron in that orbit is

(a) $\frac{J^2}{2mr^2}$ (b) $\frac{Jv}{r}$ (c) $\frac{J^2}{2m}$ (d) $\frac{J^2}{2\pi}$

**59.** If the frequency of revolution of electron in an orbit in H atom is n then the equivalent current is

(a) $\frac{2\pi re}{n}$ (b) $\frac{en}{2\pi r}$ (c) $e^2 \pi n$ (d) en

**60.** In Bohr model of hydrogen atom, let P.E. represents potential energy and T.E. represents the total energy. In going to a higher level.

(a) P. E. decreases, T.E. increases
(b) P. E. increases, T.E. decreases
(c) P. E. decreases, T.E. decreases
(d) P. E. increases, T.E. increases

**61.** The wavelength of a spectral line emitted due to the transition of electron from outer stationary orbit to inner stationary orbit is given by

(a) $\frac{1}{\lambda} = R\left(\frac{1}{P^2} - \frac{1}{n^2}\right)$ (b) $\lambda = R\left(\frac{1}{P^2} - \frac{1}{n^2}\right)$

(c) $\lambda = R\left(\frac{1}{P^2}\right)$ (d) $\frac{1}{\lambda} = R\frac{1}{n^2}$

**62.** An electron makes a transition from outer orbit (n = 4) to the inner orbit (p = 2) of a hydrogen atom. The wave number of the emitted radiations is

(a) $\frac{2R}{16}$ (b) $\frac{3R}{16}$ (c) $\frac{4R}{16}$ (d) $\frac{5R}{16}$

**63.** Rydberg constant R is equal to

(a) $\dfrac{me^2}{8 \in_0^2 ch^3}$ (b) $\dfrac{me^4}{8 \in_0^2 ch^3}$

(c) $\dfrac{m^2e^4}{8 \in_0^2 ch^3}$ (d) $\dfrac{m^4e^4}{8 \in_0^2 ch^3}$

**64.** Which of the following are in the ascending order of wavelength?

(a) $H_\alpha$, $H_\beta$ and $H_\gamma$ lines of Balmer series
(b) Lyman limit, Balmer limit
(c) Violet, blue, yellow, red colours in solar spectrum
(d) both (b) and (c)

**65.** Rydberg's constant is

(a) same for all elements
(b) different for different elements
(c) a universal constants
(d) is different for lighter elements but same for heavier elements

**66.** The Lyman transitions involve

(a) largest changes of energy
(b) smallest changes of energy
(c) largest changes of potential energy
(d) smallest changes of potential energy

**67.** The series limit wavelength of the Balmer series for the hydrogen atom is

(a) $\dfrac{1}{R}$ (b) $\dfrac{4}{R}$ (c) $\dfrac{9}{R}$ (d) $\dfrac{16}{R}$

**68.** If R is the Rydberg's constant, the energy of an electron in the ground state H atom is

(a) $\dfrac{Rc}{h}$ (b) $\dfrac{-1}{Rhc}$ (c) $-Rhc$ (d) $\dfrac{vc}{R}$

**69.** Balmer series lies in which spectrum?

(a) visible
(b) ultraviolet
(c) infrared
(d) partially visible, partially infrared

**70.** Maximum energy evolved during which of the following transition?

(a) n = 1 to n = 2 (b) n = 2 to n = 1
(c) n = 2 to n = 6 (d) n = 6 to n = 2

## STATEMENT TYPE QUESTIONS

**71.** Rutherford's nuclear model could not explain

I. Why atoms emit light of only discrete wavelengths
II. How could an atom as simple as hydrogen consisting of a single electron and a single proton, emit a complex spectrum of specific wavelengths.

(a) I only (b) II only
(c) I and II (d) None of these

**72.** Rutherford's α-particle scattering experiment concludes that

I. there is a heavy mass at centre
II. electrons are revolving around the nucleus

(a) I only (b) II only
(c) I and II (d) None of these

**73.** The observations of Geiger–Marsden experiment are

I. many of α particles pass straight through the gold foil.
II. only about 0.14% of α-particles scatter by more than 1°
III. about 1 in 8000 of α-particles is deflected more than 90°.
IV. very few particles are reflected back.

(a) I, II and IV (b) I, II and III
(c) II, III and IV (d) I, II III and IV

**74.** Trajectroy of an α–particle in Geiger–Marsden experiment is explained by using

I. Coulomb's law II. Newton's law
III. Gauss's law IV. Faraday's law.

(a) I and II (b) I and III (c) I and IV (d) I, II and IV

**75.** Bohr's atomic model assume that

I. the nucleus is of infinite mass and is at rest.
II. electrons in a quantised orbit will not radiate the energy.
III. mass of electrons remains constant during revolution.
IV. emission or absorption of energy results to transition of electron from one orbit to another. Choose the correct option from the codes given below.

(a) Only I (b) I and II
(c) I, III and II (d) I, II, III and IV

**76.** Which of the following statements are true regarding Bohr's model of hydrogen atom?

I. Orbiting speed of electron decreases as it shifts to discrete orbits away from the nucleus
II. Radii of allowed orbits of electron are proportional to the principal quantum number
III. Frequency with which electrons orbit around the nucleus in discrete orbits is inversely proportional to the cube of principal quantum number
IV. Binding force with which the electron is bound to the nucleus increases as it shifts to outer orbits

(a) I and II (b) II and IV
(c) I, II and III (d) II, III and IV

## MATCHING TYPE QUESTIONS

**77.** Match the Column-I and Column-II.

| **Column – I** | **Column – II** |
|---|---|
| (A) J.J. Thomson | (1) Nuclear model of the atom |
| (B) E. Rutherford | (2) Plum pudding model of the atom |
| (C) Franck-Hertz | (3) Explanation of the hydrogen spectrum |
| (D) Nills Bohr | (4) Existence of discrete energy levels in an atom |

(a) (A) → (4); (B) → (1); (C) → (3); (D) → (2)
(b) (A) → (4); (B) → (1); (C) → (2); (D) → (3)
(c) (A) → (2); (B) → (1); (C) → (4); (D) → (3)
(d) (A) → (3); (B) → (2); (C) → (4); (D) → (3)

**78.** Consider Bohr's model to be valid for a hydrogen like atom with atomic number Z. Match quantities given in Column -I to those given in Column II.

| **Column – I** | **Column – II** |
|---|---|
| (A) $\dfrac{Z^3}{n^5}$ | (1) Angular speed |
| (B) $\dfrac{Z^2}{n^2}$ | (2) Magnetic field at the centre due to revolution of electron |

| | | | |
|---|---|---|---|
| (C) | $\frac{Z^2}{n^3}$ | (3) | Potential energy of an electron in n<sup></sup>th orbit |
| (D) | $\frac{Z}{n}$ | (4) | Frequency of revolution of electron |

(a) (A) → (1); (B) → (3); (C) → (2); (D) → (4)
(b) (A) → (4); (B) → (2); (C) → (1); (D) → (3)
(c) (A) → (3,4); (B) → (2,3); (C) → (1,2); (D) → (1)
(d) (A) → (1); (B) → (2); (C) → (3); (D) → (4)

**79.** Match the following Column II gives nature of image formed in various cases given in column I

| **Column – I** | **Column – II** |
|---|---|
| (A) $n = 5$ to $n = 2$ | (1) Lyman series |
| (B) $n = 8$ to $n = 4$ | (2) Brackett series |
| (C) $n = 3$ to $n = 1$ | (3) Paschen |
| (D) $n = 4$ to $n = 3$ | (4) Balmer |

(a) (A) → (2); (B) → (3); (C) → (1); (D) → (4)
(b) (A) → (4); (B) → (2); (C) → (1); (D) → (3)
(c) (A) → (3); (B) → (2); (C) → (4); (D) → (1,4)
(d) (A) → (1,3); (B) → (4); (C) → (3); (D) → (1)

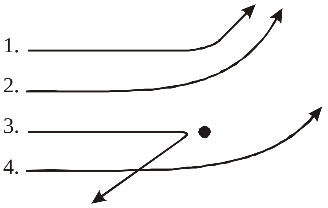
**80.** Match the Column-I and Column-II.

| **Column – I** | **Column – II** |
|---|---|
| (A) Radius of nth orbit | (1) $\frac{2\pi kze^2}{nh}$ |
| (B) Velocity of electron in nth orbit | (2) $\frac{-kze^2}{rh}$ |
| (C) Potential energy in nth orbit | (3) $\frac{kze^2}{2rh}$ |
| (D) Kinetic energy in nth orbit | (4) $\frac{n^2h^2}{4\pi kze^2 m}$ |

(a) (A) → (4); (B) → (1); (C) → (2); (D) → (3)
(b) (A) → (4); (B) → (3); (C) → (1); (D) → (2)
(c) (A) → (2); (B) → (1); (C) → (4); (D) → (3)
(d) (A) → (4); (B) → (2); (C) → (1); (D) → (3)

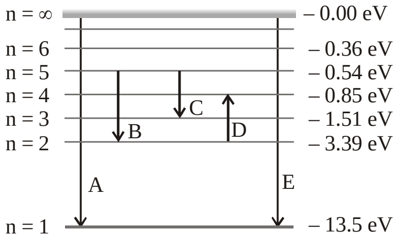
## DIAGRAM TYPE QUESTIONS

**81.** The diagram shows the path of four α-particles of the same energy being scattered by the nucleus of an atom simulateneously which of those is not physically possible?



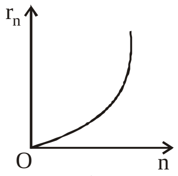
(a) 3 and 4 (b) 2 and 3 (c) 1 and 4 (d) 4 only

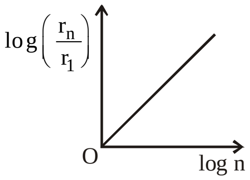
**82.** The energy levels of the hydrogen spectrum is shown in figure. There are some transitions A, B, C, D and E. Transition A, B and C respectively represent

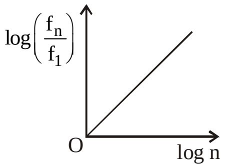


(a) first member of Lyman series, third spectral line of Balmer series and the second spectral line of Paschen series
(b) ionization potential of hydrogen, second spectral line of Balmer series, third spectral line of Paschen series
(c) series limit of Lyman series, third spectral line of Balmer series and second spectral line of Paschen series
(d) series limit of Lyman series, second spectral line of Balmer series and third spectral line of Paschen series

**83.** If in hydrogen atom, radius of nth Bohr orbit is $r_n$, frequency of revolution of electron in nth orbit is $f_n$, choose the correct option.

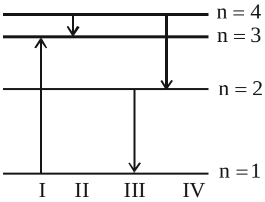
(a)


(b)


(c)


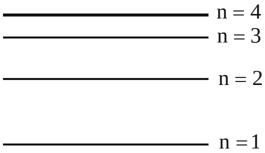
(d) Both (a) and (b)

**84.** The diagram shows the energy levels for an electron in a certain atom. Which transition shown represents the emission of a photon with the most energy?



(a) 4 (b) 3 (c) 2 (d) 1

**85.** Four lowest energy levels of H-atom are shown in the figure. The number of possible emission lines would be



(a) 3 (b) 4 (c) 5 (d) 6

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

**86. Assertion :** The force of repulsion between atomic nucleus and α-particle varies with distance according to inverse square law.

**Reason :** Rutherford did α-particle scattering experiment.

**87.** **Assertion :** According to classical theory the proposed path of an electron in Rutherford atom model will be parabolic.

**Reason :** According to electromagnetic theory an accelerated particle continuously emits radiation.

**88.** **Assertion :** Bohr had to postulate that the electrons in stationary orbits around the nucleus do not radiate.

**Reason:** According to classical physics all moving electrons radiate.

**89.** **Assertion :** Electrons in the atom are held due to coulomb forces.

**Reason :** The atom is stable only because the centripetal force due to Coulomb's law is balanced by the centrifugal force.

**90.** **Assertion :** Hydrogen atom consists of only one electron but its emission spectrum has many lines.

**Reason :** Only Lyman series is found in the absorption sepectrum of hydrogen atom whereas in the emission spectrum, all the series are found.

**91.** **Assertion :** Balmer series lies in the visible region of electromagnetic spectrum.

**Reason :** $\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$ where $n$ = 3, 4, 5.

**92.** **Statement 1 :** Between any two given energy levels, the number of absorption transitions is always less than the number of emission transitions.

**Statement 2 :** Absorption transitions start from the lowest energy level only and may end at any higher energy level. But emission transitions may start from any higher energy level and end at any energy level below it.

**93.** **Assertion :** In Lyman series, the ratio of minimum and maximum wavelength is $\frac{3}{4}$.

**Reason :** Lyman series constitute spectral lines corresponding to transition from higher energy to ground state of hydrogen atom.

## CRITICAL THINKING TYPE QUESTIONS

**94.** Ionization energy of a hydrogen-like ion A is greater than that of another hydrogen-like ion B. If r, u, E and L represent the radius of the orbit, speed of the electron, energy of the atom and orbital angular momentum of the electron respectively then in ground state

(a) $r_A > r_B$ (b) $u_A > u_B$
(c) $E_A > E_B$ (d) $L_A > L_B$

**95.** In the Bohr 's model of a hydrogen atom, the centripetal force is furnished by the coulomb attraction between the proton and the electron. If $a_0$ is the radius of the ground state orbit, m is the mass and e is charge on the electron and $\epsilon_0$ is the vacuum permittivity, the speed of the electron is

(a) Zero (b) $\frac{e}{\sqrt{\epsilon_0 a_0 m}}$
(c) $\frac{e}{\sqrt{4\pi\epsilon_0 a_0 m}}$ (d) $\sqrt{\frac{4\pi\epsilon_0 a_0 m}{e}}$

**96.** In a hydrogen atom following the Bohr's postulates the product of linear momentum and angular momentum is proportional to $(n)^x$ where 'n' is the orbit number. Then 'x' is

(a) 0 (b) 2 (c) –2 (d) 1

**97.** Doubly ionised helium atom and hydrogen ions are accelerated, from rest, through the same potential difference. The ratio of final velocities of helium and hydrogen is

(a) $1:\sqrt{2}$ (b) $\sqrt{2}:1$ (c) $1:2$ (d) $2:1$

**98.** The energy of a hydrogen atom in the ground state is – 13.6 *eV*. The energy of a $He^+$ ion in the first excited state will be

(a) –13.6 *eV* (b) – 27.2 *eV* (c) – 54.4 *eV* (d) – 6.8 *eV*

**99.** Out of the following which one is not a possible energy for a photon to be emitted by hydrogen atom according to Bohr's atomic model?

(a) 1.9 eV (b) 11.1 eV (c) 13.6 eV (d) 0.65 eV

**100.** Electron in hydrogen atom first jumps from third excited state to second excited state and then from second excited to the first excited state. The ratio of the wavelength $\lambda_1 : \lambda_2$ emitted in the two cases is

(a) 7/5 (b) 27/20 (c) 27/5 (d) 20/7

**101.** An electron of a stationary hydrogen atom passes from the fifth energy level to the ground level. The velocity that the atom acquired as a result of photon emission will be

(a) $\frac{24hR}{25m}$ (b) $\frac{25hR}{24m}$ (c) $\frac{25m}{24hR}$ (d) $\frac{24m}{25hR}$

**102.** If 13.6 eV energy is required to ionize the hydrogen atom, then the energy required to remove an electron from $n = 2$ is

(a) 10.2 eV (b) 0 eV (c) 3.4 eV (d) 6.8 eV.

**103.** Energy required for the electron excitation in $Li^{++}$ from the first to the third Bohr orbit is

(a) 36.3 eV (b) 108.8 eV (c) 122.4 eV (d) 12.1 eV

**104.** $K_\alpha$ wavelength emitted by an atom $\lambda$ is given by an atom of atomic number Z = 11 is $\lambda$. Find the atomic number for an atom that emits $K_\alpha$ radiation with wavelength $4\lambda$.

(a) Z = 6 (b) Z = 4 (c) Z = 11 (d) Z = 44

**105.** In an atom, the two electrons move round the nucleus in circular orbits of radii R and 4R. The ratio of the time taken by them to complete one revolution is

(a) 1/4 (b) 4/1 (c) 8/1 (d) 1/8

**106.** The ratio of the energies of the hydrogen atom in its first to second excited states is

(a) 1/4 (b) 4/9 (c) 9/4 (d) 4

**107.** In a hypothetical Bohr hydrogen atom, the mass of the electron is doubled. The energy $E'_0$ and radius $r'_0$ of the first orbit will be ($r_0$ is the Bohr radius)

(a) –11.2 eV (b) –6.8 eV (c) –13.6 eV (d) –27.2 eV

**108.** A 15.0 eV photon collides with and ionizes a hydrogen atom. If the atom was originally in the ground state (ionization potential =13.6 eV), what is the kinetic energy of the ejected electron?

(a) 1.4 eV (b) 13.6 eV (c) 15.0 eV (d) 28.6 eV

**109.** If the $k_\alpha$ radiation of Mo (Z = 42) has a wavelength of 0.71Å. Calculate the wavelength of the corresponding radiation of Cu (Z = 29).

(a) 1.52Å (b) 2.52Å (c) 0.52Å (d) 4.52Å

**110.** Excitation energy of a hydrogen like ion in its excitation state is 40.8 eV. Energy needed to remove the electron from the ion in ground state is

(a) 54.4 eV (b) 13.6 eV (c) 40.8 eV (d) 27.2 eV

**111.** A hydrogen atom in its ground state absorbs 10.2 eV of energy. The orbital angular momentum is increased by

(a) $1.05 \times 10^{-34}$ J-s (b) $3.16 \times 10^{-34}$ J-s

(c) $2.11 \times 10^{-34}$ J-s (d) $4.22 \times 10^{-34}$ J-s

**112.** If the atom ${}_{100}Fm^{257}$ follows the Bohr model and the radius of ${}_{100}Fm^{257}$ is $n$ times the Bohr radius, then find $n$.

(a) 100 (b) 200 (c) 4 (d) 1/4

**113.** The ratio of longest wavelengths corresponding to Lyman and Blamer series in hydrogen spectrum is

(a) $\frac{3}{23}$ (b) $\frac{7}{29}$ (c) $\frac{9}{31}$ (d) $\frac{5}{27}$

**114.** Hydrogen atom is excited from ground state to another state with principal quantum number equal to 4. Then the number of spectral lines in the emission spectra will be

(a) 2 (b) 3 (c) 5 (d) 6

**115.** The wavelength of the first spectral line in the Balmer series of hydrogen atom is 6561 A°. The wavelength of the second spectral line in the Balmer series of singly-ionized helium atom is

(a) 1215 A° (b) 1640 A° (c) 2430 A° (d) 4687 A°

**116.** The extreme wavelengths of Paschen series are

(a) 0.365 μm and 0.565 μm (b) 0.818 μm and 1.89 μm

(c) 1.45 μm and 4.04 μm (d) 2.27 μm and 7.43 μm

**117.** The third line of Balmer series of an ion equivalnet to hydrogen atom has wavelength of 108.5 nm. The ground state energy of an electron of this ion will be

(a) 3.4 eV (b) 13.6 eV (c) 54.4 eV (d) 122.4 eV

**118.** The first line of Balmer series has wavelength 6563 Å. What will be the wavelength of the first member of Lyman series

(a) 1215.4 Å (b) 2500 Å (c) 7500 Å (d) 600 Å

**119.** The energy of electron in the nth orbit of hydrogen atom is expressed as $E_n = \frac{-13.6}{n^2}$ eV. The shortest and longest wavelength of Lyman series will be

(a) 910 Å, 1213 Å (b) 5463 Å, 7858 Å

(c) 1315 Å, 1530 Å (d) None of these

**120.** Taking Rydberg's constant $R_H = 1.097 \times 10^7$m, first and second wavelength of Balmer series in hydrogen spectrum is

(a) 2000 Å, 3000 Å (b) 1575 Å, 2960 Å

(c) 6529 Å, 4280 Å (d) 6563 Å, 4861 Å

**121.** If $\upsilon_1$ is the frequency of the series limit of Lyman series, $\upsilon_2$ is the frequency of the first line of Lyman series and $\upsilon_3$ is the frequency of the series limit of the Balmer series then

(a) $\upsilon_1 - \upsilon_2 = \upsilon_3$ (b) $\upsilon_1 = \upsilon_2 - \upsilon_3$

(c) $\frac{1}{\upsilon_2} = \frac{1}{\upsilon_1} + \frac{1}{\upsilon_3}$ (d) $\frac{1}{\upsilon_1} = \frac{1}{\upsilon_2} + \frac{1}{\upsilon_3}$

**122.** The wavelength of the first line of Lyman series for hydrogen atom is equal to that of the second line of Balmer series for a hydrogen like ion. The atomic number Z of hydrogen like ion is

(a) 3 (b) 4 (c) 1 (d) 2

**123.** According to Bohr's theory, the wave number of last line of Balmer series is (Given $R = 1.1 \times 10^7$ m$^{-1}$)

(a) $5.5 \times 10^5$ m$^{-1}$ (b) $4.4 \times 10^7$ m$^{-1}$

(c) $2.75 \times 10^6$ m$^{-1}$ (d) $2.75 \times 10^8$ m$^{-1}$

**124.** The first line of the Lyman series in a hydrogen spectrum has a wavelength of 1210 Å. The corresponding line of a hydrogen-like atom of Z = 11 is equal to

(a) 4000 Å (b) 100 Å (c) 40 Å (d) 10 Å

**125.** What is the ratio of the shortest wavelength of the Balmer series to the shortest wavelength to the Lyman series ?

(a) 4 : 1 (b) 4 : 3 (c) 4 : 9 (d) 5 : 9

**126.** If the wavelength of the first line of the Balmer series of hydrogen is 6561 Å, the wavelength of the second line of the series should be

(a) 13122 Å (b) 3280 Å (c) 4860 Å (d) 2187 Å

**127.** The radiation corresponding to $3 \rightarrow 2$ transition of hydrogen atom falls on a metal surface to produce photoelectrons. These electrons are made to enter a magnetic field of $3 \times 10^{-4}$ T. If the radius of the largest circular path followed by these electrons is 10.0 mm, the work function of the metal is close to:

(a) 1.8 eV (b) 1.1 eV (c) 0.8 eV (d) 1.6 eV

**128.** Hydrogen $\left({}_1H^1\right)$, Deuterium $\left({}_1H^2\right)$, singly ionised Helium $\left({}_2He^4\right)^+$ and doubly ionised lithium $\left({}_3Li^6\right)^{++}$ all have one electron around the nucleus. Consider an electron transition from n = 2 to n = 1. If the wavelengths of emitted radiation are $\lambda_1, \lambda_2, \lambda_3$ and $\lambda_4$ respectively then approximately which one of the following is correct?

(a) $4\lambda_1 = 2\lambda_2 = 2\lambda_3 = \lambda_4$

(b) $\lambda_1 = 2\lambda_2 = 2\lambda_3 = \lambda_4$

(c) $\lambda_1 = \lambda_2 = 4\lambda_3 = 9\lambda_4$

(d) $\lambda_1 = 2\lambda_2 = 3\lambda_3 = 4\lambda_4$

**129.** The energy of an excited state of H atom is –0.85 eV. What will be the quantum number of the orbit, if the ground state energy for hydrogen is –13.6 eV?

(a) 4 (b) 3 (c) 2 (d) 1

**130.** An electron jumps from the 4th orbit to the 2nd orbit of hydrogen atom. Given the Rydberg's constant $R = 10^5$cm$^{-1}$. The frequency in Hz of the emitted radiation is

(a) $\frac{3}{16} \times 10^5$ (b) $\frac{3}{16} \times 10^{15}$

(c) $\frac{9}{16} \times 10^{15}$ (d) $\frac{3}{4} \times 10^{15}$

**131.** The longest wavelength of the Balmer series is 6563 Å. The Rydberg's constant is

(a) $1.09 \times 10^5$ m$^{-1}$ (b) $1.09 \times 10^6$ m$^{-1}$

(c) $1.09 \times 10^7$ m$^{-1}$ (d) $1.09 \times 10^8$ m$^{-1}$

**132.** If the radius of hydrogen atom in its ground state is $5.3 \times 10^{-11}$ m. After collision with an electron it is found to have a radius of $21.2 \times 10^{-11}$ m. The principle quantum number of the final orbit is

(a) n = 4 (b) n = 3 (c) n = 2 (d) n = 16

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(c)** **2.** **(a)** **3.** **(c)** **4.** **(b)** **5.** **(b)** **6.** **(a)**

**7.** **(b)** **8.** **(a)** **9.** **(d)**

**10.** **(d)** When b = 0, scattering angle, θ = 180°

**11.** **(c)** In Thomson's modle, electrons are in stable equilibrium i.e., no force or no net force, while, in Rutherford's model, there is always a centripetal force acting on electron towards nucleus.

**12.** **(a)** The significant result deduced from the Rutherford's scattering is that whole of the positive charge is concentrated at the centre of atom i.e. nucleus.

**13.** **(a)**

**14.** **(a)** The kinetic energy of the projectile is given by

$$\frac{1}{2}mv^2 = \frac{Ze(2e)}{4\pi\varepsilon_0 r_0} = \frac{Z_1 Z_2}{4\pi\varepsilon_0 r_0}$$

Thus energy of the projectile is directly proportional to $Z_1$, $Z_2$

**15.** **(d)** **16.** **(b)** **17.** **(c)** **18.** **(b)**

**19.** **(d)** The orbital angular momentum of electron is independent of mass of orbiting particle & mass of nuclei.

**20.** **(d)** **21.** **(d)** **22.** **(c)**

**23.** **(b)** $v = \frac{ke^2}{n\hbar}, r = \frac{n^2\hbar^2}{mke^2}, \nu = \frac{1}{T} = \frac{v}{2\pi r}, E = \frac{me^4}{8\varepsilon_0 n^2 h^2}$

**24.** **(d)**

**25.** **(a)** As $r \propto n^2$, therefore, radius of 2nd Bohr's orbit = 4 $r_0$

**26.** **(a)** $r_n = r_o.n^2$, where $r_o$ is radius of ground-state & $r_n$ is radius of $n^{th}$ state. (For first excited state n = 2).

**27.** **(c)** According to Bohr's theory,

Angular momentum, $mvr = \frac{nh}{2\pi}$

So in ground state, angular momentum = $\frac{h}{2\pi}$.

**28.** **(a)**

**29.** **(a)** In 1885, the first spectral series were observed by a Swedish school teacher Johann Jakob Balmer, This series is called the Balmer series.

**30.** **(b)** Jump to second orbit leads to Balmer series. When an electron Jumps from $4^{th}$ orbit to $2^{nd}$ orbit shall give rise to second line of Balmer series.

**31.** **(b)**

**32.** **(d)** Since out of the given four lines $H_\delta$ line has smallest wavelength. Hence the frequency of this line will be maximum.

**33.** **(a)** Since 121.5 nm line of spectrum of hydrogen atom lies in ultraviolet region, therefore it is Lyman series.

**34.** **(b)** Transition from higher states to n = 2 lead to emission of radiation with wavelengths 656.3 nm and 365.0 nm. These wavelengths fall in the visible region and constitute the Balmer series.

**35.** **(d)** The shortest wavelength occurs when an electron makes a transitions from $n = \infty$ to $n = 2$ state.

$$\therefore \quad \frac{1}{\lambda_{min}} = R\left(\frac{1}{2^2} - \frac{1}{\infty}\right) = \frac{R}{4}$$

**36.** **(c)** $U = -K\frac{ze^2}{r}$ ; T.E $= -\frac{k}{2}\frac{ze^2}{r}$

K.E $= \frac{k}{2}\frac{ze^2}{r}$. Here r decreases

**37.** **(b)** Transition from higher states to n = 2 lead to emission of radiation with wavelengths 656.3 nm and 365.0 nm. These wavelengths fall in the visible region and constitute the Balmer series.

**38.** **(b)**

**39.** **(b)** No. of lines $N_E = \frac{n(n-1)}{2} = \frac{3(3-1)}{2} = 3$

**40.** **(d)** $\lambda_{IR} > \lambda_{UV}$ also wavelength of emitted radiation $\lambda \propto \frac{1}{\Delta E}$.

**41.** **(c)** **42.** **(d)** **43.** **(d)** **44.** **(b)** **45.** **(c)** **46.** **(a)**

**47.** **(c)** **48** **(a)** **49.** **(b)** **50.** **(a)** **51.** **(a)** **52.** **(a)**

**53.** **(c)** **54.** **(a)** **55.** **(c)** **56.** **(d)**

**57.** **(c)** $v_n = \frac{v_1}{n}$

$$\therefore v_2 = \frac{c}{137 \times 2} = \frac{c}{274}$$

**58.** **(a)** Angular momentum = mrv = J

$$\therefore v = \frac{J}{mr}$$

K. E. of electron $= \frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{J}{mr}\right)^2 = \frac{J^2}{2mr^2}$

**59.** **(d)** $I = \frac{q}{t} = qn = en \qquad \left(\because \frac{1}{t} = n \,\&\, q = e\right)$

**60.** **(d)** **61.** **(a)** **62.** **(b)** **63.** **(b)** **64.** **(d)** **65.** **(b)**

**66.** **(a)**

**67.** **(b)** For series limit of Balmer series,
p = 2 and n = ∞.

$$\frac{1}{\lambda} = R\left(\frac{1}{p^2} - \frac{1}{n^2}\right) = R\left(\frac{1}{4} - \frac{1}{\infty}\right)$$

$$\therefore \quad \lambda = \frac{4}{R}$$

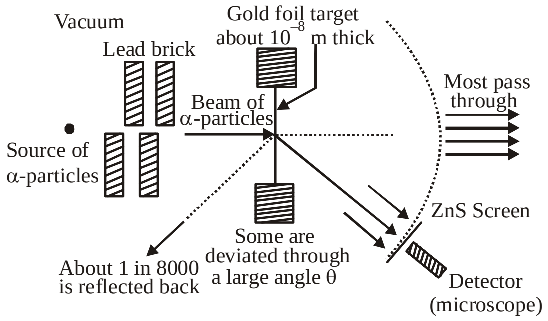
**68.** **(c)** **69.** **(a)** **70.** **(b)**

## STATEMENT TYPE QUESTIONS

**71.** **(c)**

**72.** **(a)** Heavy mass at the centre of atom is responsible for large angle scattering of alpha particles

**73.** **(d)** Many of the α-particles pass through the foil. It means that they do not suffer any collisions.



Schematic arrangement of the Geiger-Marsden experiment

Only about 0.14% of the incident α-particles scatter by more than 1° and about 1 in 8000 deflected by more than 90°.32.

**74.** **(a)** Trajectory of α-particle can be experienced by using Coulomb's law and Newton's II$^{nd}$ law of motion.

**75.** **(d)** All assumptions are necessary for Bohr's model.

**76.** **(a)** Orbital speed varies inversely as the radius of the orbit.

$$v \propto \frac{1}{n}$$

## MATCHING TYPE QUESTIONS

**77.** **(c)** (A) → (2); (B) → (1); (C) → (4); (D) → (3)

**78.** **(a)** (A) → (1); (B) → (3); (C) → (2); (D) → (4)

**79.** **(b)** (A) → (4); (B) → (2); (C) → (1); (D) → (3)

**80.** **(a)** (A) → (4); (B) → (1); (C) → (2); (D) → (3)

## DIAGRAM TYPE QUESTIONS

**81.** **(d)** α-particle cannot be attracted by the nucleus.

**82.** **(c)** Transition A (n = ∞ to 1) : Series lime of Lyman series
Transition B (n = 5 to n = 2) : Third spectral lien of Balmer series
Transition C (n = 5 to n = 3) : Second spectral line of Paschen series

**83.** **(d)** Radius of n$^{th}$ orbit $r_n \propto n^2$, graph between $r_n$ and n is a parabola. Also, $\frac{r_n}{r_1} = \left(\frac{n}{1}\right)^2 \Rightarrow \log_e\left(\frac{r_n}{r_1}\right) = 2\log_e(n)$

Comparing this equation with y = mx + c,

Graph between $\log_e\left(\frac{r_n}{r_1}\right)$ and $\log_e(n)$ will be a straight line, passing from origin.

Similarly it can be proved that graph between $\log_e\left(\frac{f_n}{f_1}\right)$ and $\log_e n$ is a straight line. But with negative slops.

**84.** **(b)**

**85.** **(d)** Number of possible emission lines = $\frac{n(n-1)}{2}$

## ASSERTION- REASON TYPE QUESTIONS

**86.** **(b)** Rutherford confirmed that the repulsive force of α–particle due to nucleus varies with distance according to inverse square law and that the positive charges are concentrated at the centre and not distributed throughout the atom.

**87.** **(d)** According to classical electromagnetic theory, an accelerated charged particle continuously emits radiation. As electrons revolving in circular paths are constantly experiencing centripetal acceleration, hence they will be losing their energy continuously and the orbital radius will go on decreasing, form spiral and finally the electron will fall in the nucleus.

**88.** **(b)** Bohr postulated that electrons in stationary orbits around the nucleus do not radiate.
This is the one of Bohr's postulate, According to this the moving electrons radiates only when they go from one orbit to the next lower orbit.

**89.** **(c)** According to postulates of Bohr's atom model the electron revolves around the nucleus in fixed orbit of definite radii. As long as the electron is in a certain orbit it does not radiate any energy.

**90.** **(b)** When the atom gets appropriate energy from outside, then this electron rises to some higher energy level. Now it can return either directly to the lower energy level or come to the lowest energy level after passing through other lower energy levels hence all possible transitions take place in the source and many lines are seen in the spectrum.

**91.** **(a)** The wavelength in Balmer series is given by

$$\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{n^2}\right], \quad n = 3, 4, 5,.....$$

$$\frac{1}{\lambda_{max}} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$$

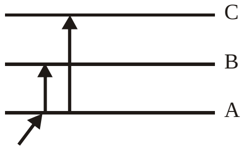
$$\lambda_{max} = \frac{36}{5R} = \frac{36}{5 \times 1.097 \times 10^7} = 6563 \text{ Å}$$

and $$\frac{1}{\lambda_{min}} = R\left[\frac{1}{2^2} - \frac{1}{\infty^2}\right]$$

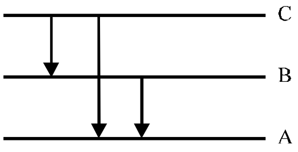
$$\lambda_{min} = \frac{4}{R} = \frac{36}{1.097 \times 10^7} = 3646 \text{ Å}$$

The wavelength 6563 Å and 3646 Å lie in visible region. Therefore, Balmer series lies in visible region.

**92.** **(a)** Absorption transition



Two possibilities in absorption transition.



Three possibilities in emission transition.
Therefore, absorption transition < emission.

**93.** **(b)**

## CRITICAL THINKING TYPE QUESTIONS

**94.** **(b)**

**95.** **(c)** Centripetal force = force of attraction of nucleus on electron

$$\frac{mv^2}{a_0} = \frac{1}{4\pi\varepsilon_o}\frac{e^2}{a_0^2} \qquad v = \frac{e}{\sqrt{4\pi\varepsilon_o m a_0}}$$

**96.** **(a)**

**97.** **(a)** $qV = \frac{1}{2}mv^2$ or $v = \sqrt{\frac{2qV}{m}}$ i.e. $v \propto \sqrt{\frac{q}{m}}$

$$\therefore \quad \frac{v_{He}}{v_H} = \sqrt{\frac{q_{He}}{q_H} \times \frac{m_H}{m_{He}}} = \sqrt{\frac{2e}{e} \times \frac{m}{4m}} = \frac{1}{\sqrt{2}}$$

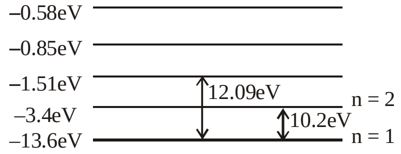
**98.** **(a)** Energy of a H-like atom in it's n$^{th}$ state is given by

$$E_n = -Z^2 \times \frac{13.6}{n^2} eV$$

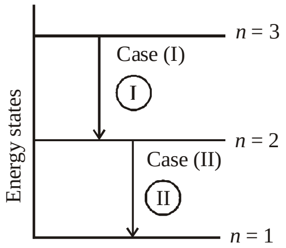
For, first excited state of He$^+$, n = 2, Z = 2

$$\therefore \quad E_{He^+} = -\frac{4}{2^2} \times 13.6 = -13.6 eV$$

**99.** **(b)** Obviously, difference of 11.1eV is not possible.



**100.** **(c)**



The wave number $(\overline{v})$ of the radiation = $\frac{1}{\lambda}$

$$= R_\infty\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

Now for case (I) $n_1 = 3, n_2 = 2$

$$\frac{1}{\lambda_1} = R_\infty\left[\frac{1}{9}\frac{-1}{4}\right], R_\infty = \text{ Rydberg constant}$$

$$\frac{1}{\lambda_1} = R_\infty\left[\frac{4-9}{36}\right] = \frac{-5R_\infty}{36} \Rightarrow \lambda_1 = \frac{-36}{5R_\infty}$$

$$\frac{1}{\lambda_2} = R_\infty\left[\frac{1}{4} - \frac{1}{1}\right] = \frac{-3R_\infty}{4}$$

$$\lambda_2 = \frac{-4}{3R_\infty} \Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{-36}{5R_\infty} \times \frac{3R_\infty}{-4}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{27}{5}$$

**101.** **(a)** For emission, the wave number of the radiation is given as

$$\frac{1}{\lambda} = Rz^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$R$ = Rydberg constant, $Z$ = atomic number

$$= R\left(\frac{1}{1^2} - \frac{1}{5^2}\right) = R\left(1 - \frac{1}{25}\right) \Rightarrow \frac{1}{\lambda} = R\frac{24}{25}$$

linear momentum

$$P = \frac{h}{\lambda} = h \times R \times \frac{24}{25} \text{ (de-Broglie hypothesis)}$$

$$\Rightarrow mv = \frac{24hR}{25} \Rightarrow V = \frac{24hR}{25m}$$

**102.** **(c)** $E_n = -\frac{13.6}{n^2} \Rightarrow E_2 = -\frac{13.6}{2^2} = -3.4$ eV.

**103.** **(b)** Energy of excitation,

$$\Delta E = 13.6\,\pi^2\left(\frac{1}{\eta_1} - \frac{1}{\eta_2}\right) eV$$

$$\Rightarrow \Delta E = 13.6\,(3)^2\left(\frac{1}{1^2} - \frac{1}{3^2}\right) = 108.8\,eV$$

**104.** **(a)** According the Moseley's law

$$\sqrt{f} = a(z-b) \Rightarrow f = a^2(z-b)^2$$

$$\Rightarrow \frac{c}{\lambda} = a^2(z-b)^2 \qquad \ldots(i)$$

for $k_\alpha$ line, b = 1

From (i), $\frac{\lambda_2}{\lambda_1} = \frac{(z_1-1)^2}{(z_2-1)^2} \Rightarrow \frac{4\lambda}{\lambda} = \frac{(11-1)^2}{(z_2-1)^2}$

$$\Rightarrow z_2 - 1 = \frac{10}{2} \Rightarrow z_2 = 6$$

**105.** **(d)** $\frac{R_1}{R_2} = \frac{n_1^2}{n_2^2} = \frac{1}{4} \quad \therefore \frac{n_1}{n_2} = \frac{1}{2}$

$$\frac{T_1}{T_2} = \left(\frac{n_1}{n_2}\right)^3 = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$$

**106.** **(c)** Ist excited state corresponds to n = 2
2nd excited state corresponds to n = 3

$$\therefore \quad \frac{E_1}{E_2} = \frac{n_2^2}{n_1^2} = \frac{3^2}{2^2} = \frac{9}{4}$$

**107.** **(d)** As $r \propto \frac{1}{m} \qquad \therefore r_0' = \frac{1}{2}r_0$

As $E \propto m \qquad \therefore E_0' = 2(-13.6) = -27.2$ eV

**108.** **(a)** Conservation of energy requires that the 15.0 eV photon energy first provides the ionization energy to unbind the electron, and then allows any excess energy to become the electron's kinetic energy. The kinetic energy in this case is 15.0 eV – 13.6 eV = 1.4 eV.

**109.** **(a)** From Mosley's law, we have,

$$(Z-1)^2 \propto \nu \therefore (Z-1)^2 = A\frac{c}{\lambda_{k_\alpha}}$$

where A is some constant,

$$\therefore \frac{(Z_{MO}-1)^2}{(Z_{Cu}-1)^2} = \frac{\lambda_{Cu}}{\lambda_{MO}} \text{ or } \left(\frac{41}{28}\right)^2 = \frac{\lambda_{Cu}}{0.71}$$

$$\therefore \lambda_{Cu} = 0.71 \times \left(\frac{41}{28}\right)^2 = 1.52Å$$

**110. (a)** Excitation energy $\Delta E = E_2 - E_1 = 13.6\ Z^2\left[\frac{1}{1^2}-\frac{1}{2^2}\right]$

$\Rightarrow 40.8 = 13.6\times\frac{3}{4}\times Z^2 \Rightarrow Z = 2.$

Now required energy to remove the electron from ground state $= \frac{+13.6Z^2}{(1)^2} = 13.6(Z)^2 = 54.4$ eV.

**111. (a)** Electron after absorbing 10.2 eV energy goes to its first excited state (n = 2) from ground state (n = 1).

$\therefore$ Increase in momentum $= \frac{h}{2\pi}$

$= \frac{6.6\times10^{-34}}{6.28} = 1.05\times10^{-34}$ J-s.

**112. (d)** For an atom following Bohr's model, the radius is given by $r_m = \frac{r_0 m^2}{Z}$ where $r_0$ = Bohr's radius and $m$ = orbit number.

For *Fm*, *m* = 5 (Fifth orbit in which the outermost electron is present)

$\therefore\ r_m = \frac{r_0 5^2}{100} = nr_0$ (given) $\Rightarrow n = \frac{1}{4}$

**113. (d)** For Lyman series $(2\to1)$

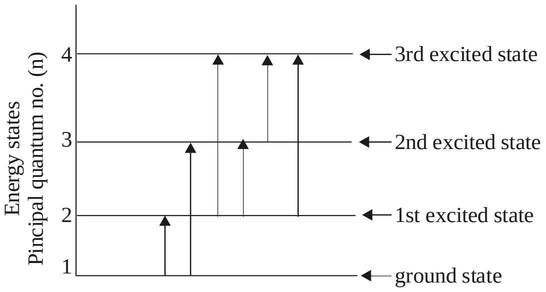
$\frac{1}{\lambda_L} = R\left[1-\frac{1}{2^2}\right] = \frac{3R}{4}$

For Balmer series $(3\to2)$

$\frac{1}{\lambda_B} = R\left[\frac{1}{4}-\frac{1}{9}\right] = \frac{5R}{36}$

$\Rightarrow \frac{\lambda_L}{\lambda_B} = \frac{\frac{4}{3R}}{\frac{36}{5R}} = \frac{4}{36}\left(\frac{5}{3}\right) = \frac{5}{27}$

**114. (d)** For ground state, the principal quantum no (*n*) = 1. There is a 3rd excited state for principal quantum number.



Possible number of spectral lines

The possible number of the spectral lines is given

$= \frac{n(n-1)}{2} = \frac{4(4-1)}{2} = 6$

**115. (a)** We know that $\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$

The wave length of first spectral line in the Balmer series of hydrogen atom is 6561Å. Here $n_2 = 3$ and $n_1 = 2$

$\therefore\ \frac{1}{6561} = R(1)^2\left(\frac{1}{4}-\frac{1}{9}\right) = \frac{5R}{36}$ ...(i)

For the second spectral line in the Balmer series of singly ionised helium ion $n_2 = 4$ and $n_1 = 2$ ; Z = 2

$\therefore\ \frac{1}{\lambda} = R(2)^2\left[\frac{1}{4}-\frac{1}{16}\right] = \frac{3R}{4}$ ...(ii)

Dividing equation (i) and equation (ii) we get

$\frac{\lambda}{6561} = \frac{5R}{36}\times\frac{4}{3R} = \frac{5}{27}$

$\therefore\ \lambda = 1215$ Å

**116. (b)** In Paschen series $\frac{1}{\lambda_{\max}} = R\left[\frac{1}{(3)^2}-\frac{1}{(4)^2}\right]$

$\Rightarrow \lambda_{\max} = \frac{144}{7R} = \frac{144}{7\times1.1\times10^7} = 1.89\times10^{-6}\text{m} = 1.89\ \mu\text{m}$

Similarly $\lambda_{\min} = \frac{9}{R} = \frac{9}{1.1\times10^7} = 0.818\ \mu\text{m}$

**117. (c)** For third line of Balmer series $n_1 = 2, n_2 = 5$

$\therefore\ \frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$ gives $Z^2 = \frac{n_1^2 n_2^2}{(n_2^2 - n_1^2)\lambda R}$

On putting values Z = 2

From $E = -\frac{13.6Z^2}{n^2} = \frac{-13.6(2)^2}{(1)^2} = -54.4$ eV

**118. (a)** $\frac{1}{\lambda_{\text{Balmer}}} = R\left[\frac{1}{2^2}-\frac{1}{3^2}\right] = \frac{5R}{36}, \frac{1}{\lambda_{\text{Lyman}}} = R\left[\frac{1}{1^2}-\frac{1}{2^2}\right] = \frac{3R}{4}$

$\therefore\ \lambda_{\text{Lyman}} = \lambda_{\text{Balmer}}\times\frac{5}{27} = 1215.4\text{Å}$

**119. (a)** $\frac{1}{\lambda_{\max}} = R\left[\frac{1}{(1)^2}-\frac{1}{(2)^2}\right] \Rightarrow \lambda_{\max} = \frac{4}{3R} \approx 1213\text{Å}$

and $\frac{1}{\lambda_{\min}} = R\left[\frac{1}{(1)^2}-\frac{1}{\infty}\right] \Rightarrow \lambda_{\min} = \frac{1}{R} \approx 910\text{Å}.$

**120. (d)** $\frac{1}{\lambda} = R\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$. For first wavelength, $n_1 = 2, n_2 = 3$

$\Rightarrow \lambda_1 = 6563$ Å. For second wavelength, $n_1 = 2, n_2 = 4$

$\Rightarrow \lambda_2 = 4861$ Å

**121. (a)** For Lyman series

$\upsilon = R_C\left[\frac{1}{1^2}-\frac{1}{n^2}\right]$

where *n* = 2, 3, 4, .......

For the series limit of Lyman series, *n* = ∞

$\therefore\ \upsilon_1 = R_C\left[\frac{1}{1^2}-\frac{1}{\infty^2}\right] = R_C$ ...(i)

For the first line of Lyman series, *n* = 2

$\therefore\ \upsilon_2 = R_C\left[\frac{1}{1^2}-\frac{1}{2^2}\right] = \frac{3}{4}R_C$ ...(ii)

For Balmer series

$\upsilon = R_C\left[\frac{1}{2^2}-\frac{1}{n^2}\right]$

where *n* = 3, 4, 5 .....

For the series limit of Balmer series, *n* = ∞

$\therefore\ \upsilon_3 = R_C\left[\frac{1}{2^2}-\frac{1}{\infty^2}\right] = \frac{R_C}{4}$ ...(iii)

From equation (i), (ii) and (iii), we get

$\upsilon_1 = \upsilon_2 + \upsilon_3$ or $\upsilon_1 - \upsilon_2 = \upsilon_3$

**122. (d)** The wavelength of the first line of lyman series for hydrogen atom is

$$\frac{1}{\lambda} = R\left[\frac{1}{1^2}-\frac{1}{2^2}\right]$$

The wevelength of the second line of Balmer series for like ion is

$$\frac{1}{\lambda'} = Z^2R\left[\frac{1}{2^2}-\frac{1}{4^2}\right]$$

According to question = $\lambda = \lambda'$

$$\Rightarrow \quad R\left[\frac{1}{1^2}-\frac{1}{2^2}\right] = Z^2R\left[\frac{1}{2^2}-\frac{1}{4^2}\right]$$

or $\frac{3}{4} = \frac{3Z^2}{16}$ or $Z^2 = 4$ or $Z = 2$

**123. (c)** For last line Balmer series, $n_1 = 2$ and $n_2 = \infty$

$$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right] = \frac{1.1\times10^7}{4}\ \text{m}^{-1}$$

$= 2.75 \times 10^6\ \text{m}^{-1}$

**124. (d)** : By Bohr's formula

$$\frac{1}{\lambda} = Z^2R\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$$

For first line of Lyman series $n_1 = 1$, $n_2 = 2$

$$\therefore \quad \frac{1}{\lambda} = Z^2R\frac{3}{4}$$

In the case of hydrogen atom, Z = 1

$$\frac{1}{\lambda} = R\frac{3}{4}$$

For hydrogen like atom, Z = 11

$$\frac{1}{\lambda'} = 121R\frac{3}{4} \Rightarrow \frac{\lambda}{\lambda'} = \frac{3R}{4}\times\frac{4}{121R\times3} = \frac{1}{121}$$

$$\lambda' = \frac{\lambda}{121} = \frac{1210}{121} = 10\ \text{Å}$$

**125. (a)** **:** For a Balmer series

$$\frac{1}{\lambda_B} = R\left[\frac{1}{2^2}-\frac{1}{n^2}\right] \qquad \text{...(i)}$$

where $n = 3, 4, .......$

By putting $n = \infty$ in eauaton (i), we obtain the series limit of the Balmer series. This is the shortest wavelength of the Balmer series.

$$\text{or} \quad \lambda_B = \frac{4}{R} \qquad \text{...(ii)}$$

For a Lyman series

$$\frac{1}{\lambda_L} = R\left[\frac{1}{1^2}-\frac{1}{n^2}\right] \qquad \text{...(iii)}$$

where $n = 2, 3, 4, .....$

By putting $n = \infty$ in equation (iii), we obtain the series limit of the Balmer series. This is the shortest wavelength of the Lyman series.

$$\text{or} \quad \lambda_L = \frac{1}{R} \qquad \text{...(iv)}$$

Dividing (ii) by (iv), we get

$$\frac{\lambda_B}{\lambda_L} = \frac{4}{1}$$

**126. (c)** For Balmer series, $n_1 = 2$, $n_2 = 3$ for 1st line and $n_2 = 4$ for second line.

$$\frac{\lambda_1}{\lambda_2} = \frac{\left(\frac{1}{2^2}-\frac{1}{4^2}\right)}{\left(\frac{1}{2^2}-\frac{1}{3^2}\right)} = \frac{3/16}{5/36} = \frac{3}{16}\times\frac{36}{5} = \frac{27}{20}$$

$$\lambda_2 = \frac{20}{27}\lambda_1 = \frac{20}{27}\times6561 = 4860\ \text{Å}$$

**127. (b)** Radius of circular path followed by electron is given by,

$$r = \frac{m\upsilon}{qB} = \frac{\sqrt{2meV}}{eB} = \frac{1}{B}\sqrt{\frac{2m}{e}V}$$

$$\Rightarrow \quad V = \frac{B^2r^2e}{2m} = 0.8V$$

For transition between 3 to 2.

$$E = 13.6\left(\frac{1}{4}-\frac{1}{9}\right) = \frac{13.6\times5}{36} = 1.88eV$$

Work function = 1.88 eV – 0.8 eV = 1.08 eV ≈ 1.1eV

**128. (c)** Wave number $\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2}-\frac{1}{n^2}\right] \Rightarrow \lambda \propto \frac{1}{Z^2}$

By question n = 1 and $n_1 = 2$

Then, $\lambda_1 = \lambda_2 = 4\lambda_3 = 9\lambda_4$

**129. (a)** $\text{E}_\text{n} = \frac{\text{E}_1}{\text{n}^2}$

$$\therefore \ \text{n}^2 = \frac{\text{E}_1}{\text{E}_\text{n}} = \frac{-13.6}{-0.85} = 16$$

**130. (c)** $\nu = \frac{\text{c}}{\lambda} = \text{cR}\left(\frac{1}{\text{p}^2}-\frac{1}{\text{n}^2}\right) = \text{cR}\left(\frac{1}{4}-\frac{1}{16}\right)$

$$= \frac{3\times10^8\times10^7\times12}{64} = \frac{9}{16}\times10^{15}\,\text{Hz}$$

**131. (c)** For longest wavelength of Balmer series, p = 2 and n = 3

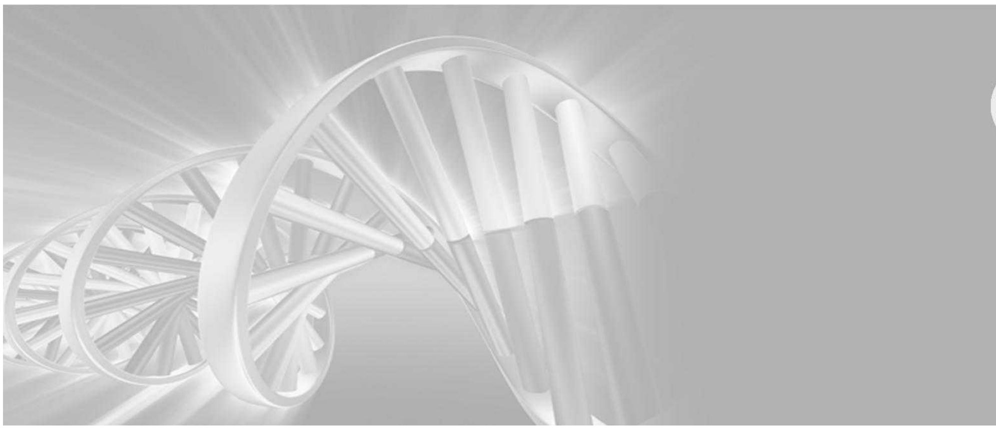
$$\frac{1}{\lambda} = \text{R}\left(\frac{1}{\text{p}^2}-\frac{1}{\text{n}^2}\right) = \text{R}\left(\frac{1}{4}-\frac{1}{9}\right) = \frac{5\text{R}}{36}$$

$$\therefore \ \text{R} = \frac{36}{5\lambda} = \frac{36}{5\times6.563\times10^{-7}} = 1.09\times10^7\,\text{m}^{-1}$$

**132. (c)** $\text{r}_\text{n} = \text{r}_1\,\text{n}^2$

$$\therefore \ \text{n}^2 = \frac{\text{r}_\text{n}}{\text{r}_1} = \frac{21.2\times10^{-11}}{5.3\times10^{-11}} = 4$$

$\therefore$ n = 2



# CHAPTER 28

# NUCLEI

## FACT/DEFINITION TYPE QUESTIONS

**1.** Chadwick was awarded the 1935 nobel prize in physics for his discovery of the

(a) electron (b) proton

(c) neutron (d) positron

**2.** The element gold has

(a) 16 isotopes (b) 32 isotopes

(c) 96 isotopes (d) 173 isotopes

**3.** The nuclear radius is of the order of

(a) $10^{-10}$ m (b) $10^{-6}$ m

(c) $10^{-15}$ m (d) $10^{-14}$ m

**4.** Particles which can be added to the nucleus of an atom without changing its chemical properties are called

(a) neutrons (b) electrons

(c) protons (d) alpha particles

**5.** The radius of a nucleus is

(a) directly proportional to its mass number

(b) inversely proportional to its atomic weight

(c) directly proportional to the cube root of its mass number

(d) None of these

**6.** Nucleus of an atom whose atomic mass is 24 consists of

(a) 11 electrons, 11 protons and 13 neutrons

(b) 11 electrons, 13 protons and 11 neutrons

(c) 11 protons and 13 neutrons

(d) 11 protons and 13 electrons

**7.** The electrons cannot exist inside the nucleus because

(a) de-Broglie wavelength associated with electron in $\beta$-decay is much less than the size of nucleus

(b) de-Broglie wavelength associated with electron in $\beta$-decay is much greater than the size of nucleus

(c) de-Broglie wavelength associated with electron in $\beta$-decay is equal to the size of nucleus

(d) negative charge cannot exist in the nucleus

**8.** In ...*X*... water is circulated though the reactor vessel and transfers energy to steam generator in the ...*Y*... Here, *X* and *Y* refer to

(a) primary loop, secondary loop

(b) reactor core, turbine

(c) secondary loop, primary loop

(d) turbine, reactor core

**9.** A nuclei having same number of neutron but different number of protons / atomic number are called

(a) isobars (b) isomers

(c) isotones (d) isotopes

**10.** Which one of the following has the identical property for isotopes?

(a) Physical property (b) Chemical property

(c) Nuclear property (d) Thermal property

**11.** The number of protons in an atom of atomic number Z and mass number A is

(a) zero (b) Z

(c) A – Z (d) A

**12.** When the number of nucleons in nuclei increases, the binding energy per nucleon

(a) increases continuously with mass number

(b) decreases continuously with mass number

(c) remains constant with mass number

(d) first increases and then decreases with increase of mass number

**13.** $M_p$ denotes the mass of a proton and $M_n$ that of a neutron. A given nucleus, of binding energy B, contains Z protons and N neutrons. The mass M(N, Z) of the nucleus is given by (c is the velocity of light)

(a) $M(N, Z) = NM_n + ZM_p + B/c^2$

(b) $M(N, Z) = NM_n + ZM_p - Bc^2$

(c) $M(N, Z) = NM_n + ZM_p + Bc^2$

(d) $M(N, Z) = NM_n + ZM_p - B/c^2$

**14.** Mass energy equation was propounded by

(a) Newton (b) Madam Curie

(c) C. V. Raman (d) Einstein

**15.** The mass of an atomic nucleus is less than the sum of the masses of its constituents. This mass defect is converted into

(a) heat energy

(b) light energy

(c) electrical energy

(d) energy which binds nucleons together

**16.** Which of the following statement is not true regarding Einsteins mass energy relation?
(a) Mass disappears to reappear as energy.
(b) Energy disappears to reappear as mass.
(c) Mass and energy are two different forms of the same entity.
(d) Mass and energy can never be related to each other.

**17.** The curve of binding energy per nucleon as a function of atomic mass number has a sharp peak for helium nucleus. This implies that helium
(a) can easily be broken up
(b) is very stable
(c) can be used as fissionable meterial
(d) is radioactive

**18.** Nuclear forces are
(a) spin dependent and have no non-central part
(b) spin dependent and have a non-central part
(c) spin independent and have no non-central part
(d) spin independent and have a non-central part

**19.** Nuclear forces exists between
(a) neutron - neutron (b) proton - proton
(c) neutron - proton (d) all of these

**20.** The antiparticle of electron is
(a) positron (b) $\alpha$-particle
(c) proton (d) $\beta$-particle

**21.** Neutron decay in free space is given as follows

$${}_0n^1 \rightarrow {}_1H^1 + {}_{-1}e^0 + [\ ]$$

Then the parenthesis [ ] represents a
(a) neutrino (b) photon
(c) antineutrino (d) graviton

**22.** Radioactivity is
(a) irreversible process
(b) self disintegration process
(c) spontaneous
(d) all of the above

**23.** $\gamma$-rays are deflected by
(a) an electric field but not by a magnetic field
(b) a magnetic field but not by an electric field
(c) both electric and magnetic field
(d) neither by electric field nor by magnetic field

**24.** Beta rays emitted by a radioactive material are
(a) electromagnetic radiations
(b) the electrons orbiting around the nucleus
(c) charged particles emitted by nucleus
(d) neutral particles

**25.** Which of the following is not a mode of radioactive decay ?
(a) Positron emission (b) Electron capture
(c) Fusion (d) Alpha decay

**26.** The half-life period and the mean life period of a radioactive element are denoted respectively by $T_h$ and $T_m$. Then
(a) $T_h = T_m$ (b) $T_h > T_m$
(c) $T_h < T_m$ (d) $T_h \geq T_m$

**27.** In $\gamma$ ray emission from a nucleus
(a) only the proton number changes
(b) both the neutron number and the proton number change
(c) there is no change in the proton number and the neutron number
(d) only the neutron number changes

**28.** Artificial radioactivity was discovered by
(a) Klaproth (b) Rontgen
(c) Irene Curie and Joliot (d) P. Curie and M. Curie

**29.** Radioactive samples are stored in lead boxes because it is
(a) heavy (b) strong
(c) good absorber (d) bad conductor

**30.** The process of radioactive radiations remains unaffected due to
(a) physical changes
(b) chemical changes
(c) electric or magnetic fields
(d) all of the above

**31.** A radioactive material undergoes decay by ejecting electrons. The electron ejected in this process is
(a) the electron from the decay of a neutron
(b) the electron present in the nucleus
(c) the resulting from the conversion of $\gamma$ photon
(d) an orbital electron

**32.** The same radioactive nucleus may emit
(a) all the three $\alpha$, $\beta$ and $\gamma$ one after another
(b) all the three $\alpha$, $\beta$ and $\gamma$ radiations simultaneously
(c) only $\alpha$ and $\beta$ simultaneously
(d) only one $\alpha$, $\beta$ and $\gamma$ at a time

**33.** Which of the following of a radioactive material is a measure of its instability?
(a) Full life (b) Mean life
(c) Half life (d) None of these

**34.** The rate of disintegration at a given instant, is directly proportional to the number of atoms present at that instant. This is the statement of
(a) law of radioactive decay
(b) half life
(c) law of radioactive transformation
(d) group displacement law

**35.** N atoms of a radioactive substance emit na-particles per second. The half life of the radioactive substance is
(a) $\frac{n}{N}$ sec (b) $\frac{N}{n}$ sec
(c) $\frac{0.693N}{n}$ sec (d) $\frac{0.693n}{N}$ sec

**36.** Three specimens A, B, C of same radioactive element has activities 1 microcurie, 1 rutherford and 1 becquerel respectively. Which specimen has maximum mass?
(a) A (b) B
(c) C (d) all have equal masses

**37.** Charge on an $\alpha$-particle is
(a) $1.6 \times 10^{-19}$ C (b) $3.2 \times 10^{-19}$ C
(c) $1.6 \times 10^{-20}$ C (d) $4.8 \times 10^{-19}$ C

**38.** If a radioactive element is placed in an evacuated chamber, then the rate of radioactive decay will
(a) decrease (b) remains unchanged
(c) increase (d) none of these

**39.** The $\gamma$ radiations are
(a) electromagnetic radiation with high energy
(b) electromagnetic radiation with low energy
(c) charged particles emitted by the nucleus
(d) electrons orbiting the nucleus

**40.** Radioactive substance emits
(a) $\alpha$-rays (b) $\beta$-rays
(c) $\gamma$-rays (d) All of the above

**41.** The 'rad' is the correct unit used to report the measurement of
(a) the ability of a beam of gamma ray photons to produce ions in a target
(b) the energy delivered by radiation to a target
(c) the biological effect of radiation
(d) the rate of decay of a radioactive source

**42.** One curie is equal to
(a) $3.7 \times 10^{10}$ disintegration/sec
(b) $3.2 \times 10^{8}$ disintegration/sec
(c) $2.8 \times 10^{10}$ disintegration/sec
(d) None of these

**43.** Half life of radioactive element depends upon
(a) amount of element present
(b) temperature
(c) pressure
(d) nature of element

**44.** A nuclear reaction is given by

${}_Z X^A \to {}_{Z+1}Y^A + {}_{-1}e^0 + \bar{\nu}$, represents
(a) fission (b) $\beta$-decay
(c) $\sigma$-decay (d) fusion

**45.** Fusion reaction occurs at temperatures of the order of
(a) $10^3$ K (b) $10^7$ K (c) 10 K (d) $10^4$ K

**46.** Control rods used in nuclear reactors are made of
(a) stainless steel (b) graphite
(c) cadmium (d) plutonium

**47.** Boron rods in a nuclear reactor are used to
(a) absorb excess neutrons
(b) absorb alpha particle
(c) slow down the reaction
(d) speed up the reaction

**48.** A moderator is used in nuclear reactors in order to
(a) slow down the speed of the nuetrons
(b) acceleerate the neutrons
(c) increase the number of neutrons
(d) decrease the number of neutrons

**49.** Fusion reactions take place at high temperature because
(a) atoms are ionised at high temperature
(b) molecules break up at high temperature
(c) nuclei break up at high temperature
(d) kinetic enrgy is high enough to overcome repulsion between nuclei

**50.** For a nuclear fusion process, suitable nuclei are
(a) any nuclei
(b) heavy nuclei
(c) lighter nuclei
(d) nuclei lying in the middle of periodic table

## STATEMENT TYPE QUESTIONS

**51.** Consider the following statements and select the correct statement(s).
I. The relative abundance of different isotopes differs from element to element.
II. Atomic species of the same element differing in mass are called isotopes.
III. Hydrogen has two isotopes.
(a) I only (b) II only
(c) I and II (d) I, II and III

**52.** Which of the following statements are correct?
I. Atoms of isotopes have same electronic structure.
II. Atoms of isotopes occupies same place in periodic table.
III. Atoms of isotopes have same number of protons.
IV. Atoms of isotopes have same number of neutrons.
(a) I and II (b) I, II and III
(c) I, II III and IV (d) II and IV

**53.** Which of the following statements are correct ?
I. Nuclear density is a constant for all matter.
II. Nuclear density is around $2.3 \times 10^{17}$ kg/m$^3$.
II. Nuclear density is very large compared to ordinary matter.
IV. Mass of ordinary matter is mainly due to nucleus.
(a) I, II and III (b) II and III
(c) I and II (d) I, II, III and IV

**54.** For binding energy per nucleon *versus* mass number curve, which of the following are correct ?
I. Binding energy per nucleon $E_{bn}$ is independent of mass number range $30 < A < 170$.
II. Binding energy is lower for both light nucei ($A < 30$) and heavy nuclei ($A < 170$).
III. Binding energy is maximum of about 8.75 MeV for $A = 56$.
IV. In region $0 < A < 80$, binding energy increases with mass number.
(a) I, II, III and IV (b) I, II and IV
(c) II, III and IV (d) I, II and III

**55.** In one half-life time duration
I. activity of a sample reduced to half of its initial value.
II. total number of nuclei present are reduced to half of its initial value.
III. number of radio active nuclei present is reduced to half of its initial value.
IV. mass of sample is reduced to half of its initial value.
Out of these, correct statements are
(a) I and II (b) I and II
(c) II and IV (d) II and III

**56.** At a specific instant emission of radioactive compound is deflected in a magnetic field. The compound can emit

| | | | |
|---|---|---|---|
| I | electrons | II | protons |
| III | $He^{2+}$ | IV | neutrons |

The emission at instant can be

(a) I, II and III (b) I, II, III and IV
(c) IV only (d) II and III

## MATCHING TYPE QUESTIONS

**57.** Match the Column I and Column II.

| | **Column – I** | | **Column – II** |
|---|---|---|---|
| (A) | Isotopes | (1) | Mass number same but different atomic number |
| (B) | Isobars | (2) | Atomic number same but different mass number. |
| (C) | Isotones | (3) | Number of nentrons plus number of protons |
| (D) | Nucleons | (4) | Number of nentrons same but different atomic number |

(a) (A) → (3); (B) → (1); (C) → (2); (D) → (4)
(b) (A) → (2); (B) → (1); (C) → (4); (D) → (3)
(c) (A) → (1); (B) → (2); (C) → (3); (D) → (4)
(d) (A) → (1); (B) → (3); (C) → (2); (D) → (4)

**58.** Match Column I of the nuclear processes with Column II containing parent nucleus and one of the end products of each process.

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Alpha decay | (1) | ${}^{15}_{8}O \to {}^{15}_{7}N + ...$ |
| (B) | $\beta^+$ decay | (2) | ${}^{238}_{92}U \to {}^{234}_{90}Th + ...$ |
| (C) | Fission | (3) | ${}^{185}_{83}Bi \to {}^{184}_{82}Pb + ...$ |
| (D) | Proton emission | (4) | ${}^{239}_{94}Pu \to {}^{140}_{57}La + ...$ |

(a) (A) → (1); (B) → (3); (C) → (2); (D) → (4)
(b) (A) → (4); (B) → (3); (C) → (2); (D) → (1)
(c) (A) → (2); (B) → (1); (C) → (4); (D) → (3)
(d) (A) → (3); (B) → (1); (C) → (2); (D) → (4)

**59.**

| | **Column – I** | | **Column – II** |
|---|---|---|---|
| (A) | Nuclear fusion | (1) | $E = mc^2$ |
| (B) | Nuclear fission | (2) | Generally possible for nuclei with low atomic number |
| (C) | β-decay | (3) | Generally possible for nuclei with higher atomic number |
| (D) | Mass-energy equivalence | (4) | Essentially proceeds by weak reaction nuclear forces |

(a) (A) → (2); (B) → (3); (C) → (4); (D) → (1)
(b) (A) → (4); (B) → (1); (C) → (2); (D) → (4)
(c) (A) → (1); (B) → (3); (C) → (2); (D) → (4)
(d) (A) → (3); (B) → (4); (C) → (2); (D) → (1)

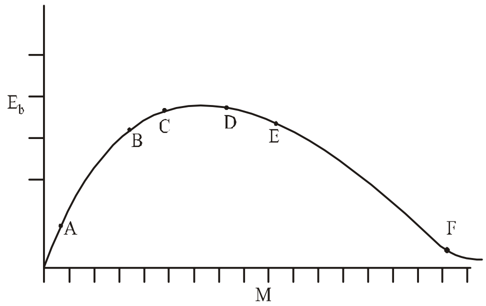
**60.**

| | **Column – I** | | **Column – II** |
|---|---|---|---|
| (A) | Hydrogen bomb | (1) | Fission |
| (B) | Atom bomb | (2) | Fusion |
| (C) | Binding energy | (3) | Critical mass |
| (D) | Nuclear reactor | (4) | Mass defect |

(a) (A) → (3); (B) → (2); (C) → (1); (D) → (4)
(b) (A) → (2); (B) → (1); (C) → (4); (D) → (3)
(c) (A) → (3); (B) → (1); (C) → (2); (D) → (4)
(d) (A) → (4); (B) → (2); (C) → (3); (D) → (1)

## DIAGRAM TYPE QUESTIONS

**61.** There is a plot of binding energy per nucleon $E_b$, against the nuclear mass *M*; *A*, *B*, *C*, *D*, *E*, *F* correspond to different nuclei.



Consider four reactions

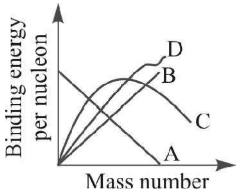
(i) $A + B \to C + \varepsilon$ (ii) $C \to A + B + \varepsilon$
(iii) $D + E \to F + \varepsilon$ and (iv) $F \to D + E + \varepsilon$,

where ε is the energy released? In which reactions is ε positive?

(a) (i) and (iii) (b) (ii) and (iv)
(c) (ii) and (iii) (d) (i) and (iv)

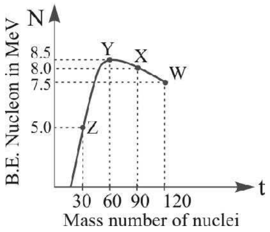
**62.** Binding energy per nucleon plot against the mass number for stable nuclei is shown in the figure. Which curve is correct?

(a) A
(b) B
(c) C
(d) D

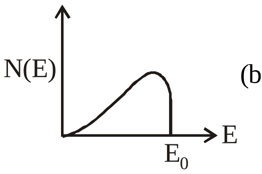


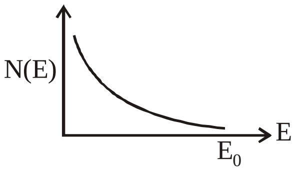
**63.** Binding energy per nucleon versus mass number curve for nuclei is shown in the figure. W, X, Y and Z are four nuclei indicated on the curve. The process that would release energy is

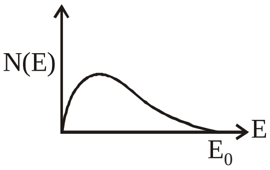
(a) Y → 2Z
(b) W → X + Z
(c) W → 2Y
(d) X → Y + Z

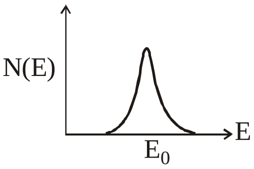


**64.** The energy spectrum of β-particles [number N(E) as a function of β-energy E] emitted from a radioactive source is

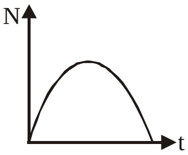
(a)


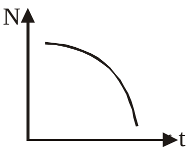
(b)


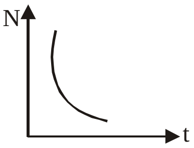
(c)


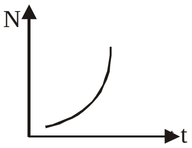
(d)


**65.** Radioactive element decays to form a stable nuclide, then the rate of decay of reactant is

(a)


(b)


(c)


(d)


## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

**66.** **Assertion :** Density of all the nuclei is same.
**Reason :** Radius of nucleus is directly proportional to the cube root of mass number.

**67.** **Assertion :** Neutrons penetrate matter more readily as compared to protons.
**Reason :** Neutrons are slightly more massive than protons.

**68.** **Assertion :** The mass number of a nucleus is always less than its atomic number.
**Reason :** Mass number of a nucleus may be equal to its atomic number.

**69.** **Assertion :** The binding energy per nucleon, for nuclei with atomic mass number A > 100, decrease with A.
**Reason :** The forces are weak for heavier nuclei.

**70.** **Assertion :** Radioactivity of $10^8$ undecayed radioactive nuclei of half life of 50 days is equal to that of $1.2 \times 10^8$ number of undecayed nuclei of some other material with half life of 60 days.
**Reason :** Radioactivity is proportional to half-life.

**71.** **Assertion :** The ionising power of β-particle is less compared to α-particles but their penetrating power is more.
**Reason :** The mass of β-particle is less than the mass of α-particle.

**72.** **Assertion :** Radioactive nuclei emit $\beta^{-1}$ particles.
**Reason :** Electrons exist inside the nucleus.

**73.** **Assertion :** $_ZX^A$ undergoes 2α, 2β- particles and 2γ-rays, the daughter product is $_{Z-2}Y^{A-8}$.
**Reason :** In α- decay the mass number decreases by 4 and atomic number decreases by 2. In β-decay the mass number remains unchanged, but atomic number increases by 1.

**74.** **Assertion :** The heavier nuclei tend to have larger N/Z ratio because neutron does not exert electric force.
**Reason :** Coulomb forces have longer range compared to the nuclear force.

**75.** **Assertion :** A free neutron decays to a proton but a free proton does not decay to a neutron. This is because neutron is an uncharged particle and proton is a charged particle.
**Reason :** Neutron has larger rest mass than the proton.

**76.** **Assertion :** Cobalt-60 is useful in cancer therapy.
**Reason :** Cobalt -60 is source of γ- radiations capable of killing cancerous cells.

**77.** **Assertion :** It is not possible to use $^{35}$Cl as the fuel for fusion energy.
**Reason :** The binding energy of $^{35}$Cl is to small.

**78.** **Assertion :** Energy is released when heavy nuclei undergo fission or light nuclei undergo fusion and
**Reason :** For heavy nuclei, binding energy per nucleon increases with increasing Z while for light nuclei it decreases with increasing Z.

## CRITICAL THINKING TYPE QUESTIONS

**79.** The mass number of He is 4 and that for sulphur is 32. The radius of sulphur nuclei is larger than that of helium by

| | |
|---|---|
| (a) $\sqrt{8}$ | (b) 4 |
| (c) 2 | (d) 8 |

**80.** A nucleus splits into two nuclear parts which have their velocity ratio equal to 2 : 1. What will be the ratio of their nuclear radius?

| | |
|---|---|
| (a) $2^{1/3} : 1$ | (b) $1 : 2^{1/3}$ |
| (c) $3^{1/2} : 1$ | (d) $1 : 3^{1/2}$ |

**81.** If radius of the $^{27}_{13}\text{Al}$ nucleus is estimated to be 3.6 fermi then the radius of $^{125}_{52}\text{Te}$ nucleus be nearly

| | |
|---|---|
| (a) 8 fermi | (b) 6 fermi |
| (c) 5 fermi | (d) 4 fermi |

**82.** If $M_O$ is the mass of an oxygen isotope $_8O^{17}$, $M_P$ and $M_N$ are the masses of a proton and a neutron respectively, the nuclear binding energy of the isotope is

(a) $(M_O - 17M_N)c^2$ (b) $(M_O - 8M_P)c^2$

(c) $(M_O - 8M_P - 9M_N)c^2$ (d) $M_O c^2$

**83.** In the options given below, let E denote the rest mass energy of a nucleus and *n* neutron. Then the correct option is

(a) $E\left({}^{236}_{92}U\right) > E\left({}^{137}_{53}I\right) + E\left({}^{97}_{39}Y\right) + 2E(n)$

(b) $E\left({}^{236}_{92}U\right) < E\left({}^{137}_{53}I\right) + E\left({}^{97}_{39}Y\right) + 2E(n)$

(c) $E\left({}^{236}_{92}U\right) < E\left({}^{140}_{56}Ba\right) + E\left({}^{94}_{36}Kr\right) + 2E(n)$

(d) $E\left({}^{236}_{92}U\right) = E\left({}^{140}_{56}Ba\right) + E\left({}^{94}_{36}Kr\right) + 2E(n)$

**84.** If the total binding energies of ${}^{2}_{1}H$, ${}^{4}_{2}He$, ${}^{56}_{26}Fe$ & ${}^{235}_{92}U$ nuclei are 2.22, 28.3, 492 and 1786 MeV respectively, identify the most stable nucleus of the following.

(a) ${}^{56}_{26}Fe$ (b) ${}^{2}_{1}H$ (c) ${}^{235}_{92}U$ (d) ${}^{4}_{2}He$

**85.** The mass of a ${}^{7}_{3}Li$ nucleus is 0.042 u less than the sum of the masses of all its nucleons. The binding energy per nucleon of ${}^{7}_{3}Li$ nucleus is nearly

(a) 46 MeV (b) 5.6 MeV

(c) 3.9 MeV (d) 23 MeV

**86.** The mass defect in a particular nuclear reaction is 0.3 grams. The amount of energy liberated in kilowatt hour is (Velocity of light = $3 \times 10^8$ m/s)

(a) $1.5 \times 10^6$ (b) $2.5 \times 10^6$

(c) $3 \times 10^6$ (d) $7.5 \times 10^6$

**87.** The binding energies per nucleon for a deuteron and an α-particle are $x_1$ and $x_2$ respectively. What will be the energy Q released in the reaction $_1H^2 + {}_1H^2 \rightarrow {}_2He^4 + Q$

(a) $4(x_1 + x_2)$ (b) $4(x_2 - x_1)$

(c) $2(x_1 + x_2)$ (d) $2(x_2 - x_1)$

**88.** A heavy nucleus having mass number 200 gets disintegrated into two small fragments of mass number 80 and 120. If binding energy per nucleon for parent atom is 6.5 MeV and for daughter nuclei is 7 MeV and 8 MeV respectively, then the energy released in the decay is X × 110 MeV. Find the value of X

(a) 3 (b) 4 (c) 2 (d) 1

**89.** The masses of neutron and proton are 1.0087 a.m.u. and 1.0073 a.m.u. respectively. If the neutrons and protons combine to form a helium nucleus (alpha particles) of mass 4.0015 a.m.u the binding energy of the helium nucleus will be (1 a.m.u. = 931 MeV)

(a) 28.4 MeV (b) 20.8 MeV

(c) 27.3 MeV (d) 14.2 MeV

**90.** If 1 mg of $U^{235}$ is completely annihilated, the energy liberated is

(a) $9 \times 10^{10}$ J (b) $9 \times 10^{19}$ J

(c) $9 \times 10^{18}$ J (d) $9 \times 10^{17}$ J

**91.** A radioactive substance has a half life of four months. Three fourth of the substance will decay in

(a) three months (b) four months

(c) eight months (d) twelve months

**92.** In the uranium radioactive series, the initial nucleus is $_{92}U^{238}$ and that the final nucleus is $_{82}Pb^{206}$. When uranium nucleus decays to lead, the number of α particles and β particles emitted are

(a) $8\alpha, 6\beta$ (b) $6\alpha, 7\beta$

(c) $6\alpha, 8\beta$ (d) $4\alpha, 3\beta$

**93.** A radioactive nucleus undergoes $\alpha$-emission to form a stable element. What will be the recoil velocity of the daughter nucleus if v is the velocity of $\alpha$ emission?

(a) $\frac{4v}{A-4}$ (b) $\frac{2v}{A-4}$

(c) $\frac{4v}{A+4}$ (d) $\frac{2v}{A+4}$

**94.** A radioactive element forms its own isotope after three consecutive disintegrations. The particles emitted are

(a) 3 β–particles

(b) 2 β–particles and 1 α–particle

(c) 3 β–particles and 1 α–particle

(d) 2 α–particles and 1 β–particle.

**95.** The ratio of half-life times of two elements A and B is $\frac{T_A}{T_B}$.

The ratio of respective decay constant $\frac{\lambda_A}{\lambda_B}$, is

(a) $T_B / T_A$ (b) $T_A / T_B$

(c) $\frac{T_A + T_B}{T_A}$ (d) $\frac{T_A - T_B}{T_A}$

**96.** A radioactive nucleus undergoes a series of decay according to the scheme

$$A \xrightarrow{a} A_1 \xrightarrow{\beta} A_2 \xrightarrow{\alpha} A_3 \xrightarrow{\gamma} A_4$$

If the mass number and atomic number of 'A' are 180 and 72 respectively, then what are these numbers for $A_4$

(a) 172 and 69 (b) 174 and 70

(c) 176 and 69 (d) 176 and 70

**97.** The radioactivity of a sample is $R_1$ at a time $T_1$ and $R_2$ at a time $T_2$. If the half-life of the specimen is T, the number of atoms that have disintegrated in the time $(T_1 - T_2)$ is proportional to

(a) $(R_1T_1 - R_2T_2)$ (b) $(R_1 - R_2)$

(c) $(R_1 - R_2)/T$ (d) $(R_1 - R_2)\,T$

**98.** Actinium 231, $^{231}AC_{89}$, emit in succession two β particles, four α-particles, one β and one α plus several γ rays. What is the resultant isotope?

(a) $^{221}Au_{79}$ (b) $^{211}Au_{79}$

(c) $^{221}Pb_{82}$ (d) $^{211}Pb_{82}$

**99.** The activity of a radioactive sample is measured as 9750 counts per minute at t = 0 & 975 counts per minute at T = 5 minutes. The decay constant is approximately.

(a) 0.922 per minutes (b) 0.691 per minutes

(c) 0.461 per minutes (d) 0.230 per minutes

**100.** Half lives of two radio active substance A & B are respectively 20 minutes & 40 minutes. Initially the samples of A & B have equal numbers of nulcei. After 80 minutes the ratio of remaining numbers of A & B nuclei is

(a) 1 : 16 (b) 4 : 1

(c) 1 : 4 (d) 1 : 1

**101.** The activity of a radioactive sample is measured as $N_0$ counts per minute at $t = 0$ and $N_0/e$ counts per minute at $t = 5$ minutes. The time (in minutes) at which the activity reduces to half its value is

(a) $\log_e 2/5$ (b) $\frac{5}{\log_e 2}$

(c) $5 \log_{10} 2$ (d) $5 \log_e 2$

**102.** A radioactive nucleus of mass M emits a photon of frequency ν and the nucleus recoils. The recoil energy will be

(a) $Mc^2 - h\nu$ (b) $h^2\nu^2 / 2Mc^2$

(c) zero (d) hν

**103.** Two radioactive nuclei P and Q, in a given sample decay into a stable nucleus R. At time t = 0, number of P species are 4 $N_0$ and that of Q are $N_0$. Half-life of P (for conversion to R) is 1 minute where as that of Q is 2 minutes. Initially there are no nuclei of R present in the sample. When number of nuclei of P and Q are equal, the number of nuclei of R present in the sample would be

(a) $3N_0$ (b) $\frac{9N_0}{2}$

(c) $\frac{5N_0}{2}$ (d) $2N_0$

**104.** The half life of a radioactive nucleus is 50 days. The time interval $(t_2 - t_1)$ between the time $t_2$ when $\frac{2}{3}$ of it has decayed and the time $t_1$ when $\frac{1}{3}$ of it had decayed is

(a) 30 days (b) 50 days

(c) 60 days (d) 15 days

**105.** A mixture consists of two radioactive materials $A_1$ and $A_2$ with half lives of 20 s and 10 s respectively. Initially the mixture has 40 g of $A_1$ and 160 g of $A_2$. The amount of the two in the mixture will become equal after

(a) 60 s (b) 80 s

(c) 20 s (d) 40 s

**106.** The half life of a radioactive isotope 'X' is 20 years. It decays to another element 'Y' which is stable. The two elements 'X' and 'Y' were found to be in the ratio of 1 : 7 in a sample of a the given rock. The age of the rock is estimated to be

(a) 60 years (b) 80 years

(c) 100 years (d) 40 years

**107.** If $N_0$ is the original mass of the substance of half-life period $t_{1/2}$ = 5 years, then the amount of substance left after 15 years is

(a) $N_0/8$ (b) $N_0/16$

(c) $N_0/2$ (d) $N_0/4$

**108.** When a $U^{238}$ nucleus originally at rest, decays by emitting an alpha particle having a speed 'u', the recoil speed of the residual nucleus is

(a) $\frac{4u}{238}$ (b) $-\frac{4u}{234}$

(c) $\frac{4u}{234}$ (d) $-\frac{4u}{238}$

**109.** A radioactive sample at any instant has its disintegration rate 5000 disintegrations per minute. After 5 minutes, the rate is 1250 disintegrations per minute. Then, the decay constant (per minute) is

(a) 0.4 ln 2 (b) 0.2 ln 2

(c) 0.1 ln 2 (d) 0.8 ln 2

**110.** $^{221}_{87}Ra$ is a radioactive substance having half life of 4 days. Find the probability that a nucleus undergoes decay after two half lives

(a) 1 (b) $\frac{1}{2}$

(c) $\frac{3}{4}$ (d) $\frac{1}{4}$

**111.** The activity of a freshly prepared radioactive sample is $10^{10}$ disintegrations per second, whose mean life is $10^9$ s. The mass of an atom of this radioisotope is $10^{-25}$ kg. The mass (in mg) of the radioactive sample is

(a) 1 (b) 3

(c) 5 (d) 6

**112.** The half life of the radioactive substance is 40 days. The substance will disintegrate completely in

(a) 40 days (b) 400 days

(c) 4000 days (d) infinite time

**113.** A radioactive substance contains 10000 nuclei and its half-life period is 20 days. The number of nuclei present at the end of 10 days is

(a) 7070 (b) 9000

(c) 8000 (d) 7500

**114.** The half-life of radioactive Radon is 3.8 days. The time at the end of which (1/20)th of the Radon sample will remain undecayed is (given $\log_{10}e = 0.4343$)

(a) 13.8 days (b) 16.5 days
(c) 33 days (d) 76 days

**115.** A freshly prepared radioactive source of half life 2 hr emits radiation of intensity which is 64 times the permissible safe level. The minimum time after which it would be possible to work safely with this source is

(a) 6 hr (b) 12 hr
(c) 24 hr (d) 128 hr

**116.** At time t = 0, $N_1$ nuclei of decay constant $\lambda_1$ and $N_2$ nuclei of decay constant $\lambda_2$ are mixed. The decay rate of mixture is

(a) $-N_1N_2e^{-(\lambda_1+\lambda_2)t}$

(b) $-\left(\frac{N_1}{N_2}\right)e^{-(\lambda_1+\lambda_2)t}$

(c) $-(N_1\lambda_1e^{-\lambda_1{}^t}+N_1\lambda_2e^{-\lambda_2{}^t})$

(d) $-N_1\lambda_1N_2\lambda_2e^{(-\lambda_1+\lambda_2)t}$

**117.** Radium $^{226}Ra$, spontaneously decays to radon with the emission of an α-particle and a γ ray. If the speed of the α particle upon emission from an initially stationary radium nucleus is $1.5 \times 10^7$ m/s, what is the recoil speed of the resultant radon nucleus? Assume the momentum of γ ray is negligible compared to that of α particle.

(a) $2..0 \times 10^5$ m/s (b) $2.7 \times 10^5$ m/s
(c) $3.5 \times 10^5$ m/s (d) $1.5 \times 10^7$ m/s

**118.** The fossil bone has a $^{14}C : ^{12}C$ ratio, which is $\left[\frac{1}{16}\right]$ of that in a living animal bone. If the half-life of $^{14}C$ is 5730 years, then the age of the fossil bone is

(a) 11460 years (b) 17190 years
(c) 22920 years (d) 45840 years

**119.** An archaeologist analyses the wood in a prehistoric structure and finds that $C^{14}$ (Half life = 5700 years) to $C^{12}$ is only one-fourth of that found in the cells of buried plants. The age of the wood is about

(a) 5700 years (b) 2850 years
(c) 11,400 years (d) 22,800 years

**120.** Atomic weight of boron is 10.81 and it has two isotopes $_5B^{10}$ and $_5B^{11}$. Then ratio of $_5B^{10} : {}_5B^{11}$ in nature would be

(a) 19 : 81 (b) 10 : 11
(c) 15 : 16 (d) 81 : 19

**121.** A radioactive element X converts into another stable element Y. Half life of X is 2 hrs. Initially only X is present. After time t, the ratio of atoms of X and Y is found to be 1 : 4, then t in hours is

(a) 2 (b) 4
(c) between 4 and 6 (d) 6

**122.** After 150 days, the activity of a radioactive sample is 5000 dps. The activity becomes 2500 dps after another 75 days. The initial activity of the sample is

(a) 20000 dps (b) 40000 dps
(c) 7500 dps (d) 10000 dps

**123.** At any instant, the ratio of the amount of radioactive substances is 2 : 1. If their half lives be respectively 12 and 16 hours, then after two days, what will be the ratio of the substances ?

(a) 1 : 1 (b) 2 : 1 (c) 1 : 2 (d) 1 : 4

**124.** Half lives for α and β emission of a radioactive material are 16 years and 48 years respectively. When material decays giving α and β emission simultaneously, time in which 3/4th material decays is

(a) 29 years (b) 24 years
(c) 64 years (d) 12 years

**125.** In a given reaction

$${}_zA^A \to {}_{z+1}Y^A \to {}_{z-1}K^{A-4} \to {}_{z-1}K^{A-4}$$

Radioactive radiations are emitted in the sequence of

(a) α, β, γ (b) γ, α, β
(c) β, α, γ (d) γ, β, α

**126.** An element A decays into an element C by a two step process $A \to B + 2He^4$ and $B \to C + 2e^-$. Then,

(a) A and C are isotopes (b) A and C are isobars
(c) B and C are isotopes (d) A and B are isobars

**127.** In which sequence the radioactive radiations are emitted in the following nuclear reaction?

$${}_ZX^A \longrightarrow {}_{Z+1}Y^A \longrightarrow {}_{Z-1}K^{A-4}$$

(a) γ and β (b) α and γ
(c) β and α (d) β and γ

**128.** Half life of a radioactive substance is 20 minute. Difference between points of time when it is 33% disintegrated and 67% disintegrated is approximately

(a) 40 minute (b) 10 minute
(c) 15 minute (d) 20 minute

**129.** A nucleus ${}^m_nX$ emits one α-particle and two β-particles. The resulting nucleus is

(a) ${}^{m-6}_{n-4}Z$ (b) ${}^{m-6}_{n}Z$

(c) ${}^{m-4}_{n}X$ (d) ${}^{m-4}_{n-2}Y$

**130.** A nucleus with Z= 92 emits the following in a sequence:

$$\alpha, \beta^-, \beta^- \alpha, \alpha, \alpha, \alpha, \alpha, \beta^-, \beta^-, \alpha, \beta^+, \beta^+, \alpha$$

Then Z of the resulting nucleus is

(a) 76 (b) 78
(c) 82 (d) 74

**131.** The half-life period of a radio-active element X is same as the mean life time of another radio-active element Y. Initially they have the same number of atoms. Then

(a) X and Y decay at same rate always

(b) X will decay faster than Y

(c) Y will decay faster than X

(d) X and Y have same decay rate initially

**132.** A radioactive nucleus (initial mass number *A* and atomic number *Z* emits 3 $\alpha$ - particles and 2 positrons. The ratio of number of neutrons to that of protons in the final nucleus will be

(a) $\frac{A-Z-8}{Z-4}$

(b) $\frac{A-Z-4}{Z-8}$

(c) $\frac{A-Z-12}{Z-4}$

(d) $\frac{A-Z-4}{Z-2}$

**133.** A nuclear transformation is denoted by X (n, $\alpha$ ) $^7_3\text{Li}$ . Which of the following is the nucleus of element X ?

(a) $^{10}_{5}\text{Be}$

(b) $^{12}\text{C}_6$

(c) $^{11}_{4}\text{Be}$

(d) $^{9}_{5}\text{B}$

**134.** In a fission reaction

$$^{236}_{92}\text{U} \to {}^{117}\text{X} + {}^{117}\text{Y} + \text{n} + \text{n}$$

the binding energy per nucleon of X & Y is 8.5 MeV. Whereas of $^{236}$U is 7.6 MeV. The total energy liberated will be about

(a) 2000 MeV

(b) 200 MeV

(c) 2 MwV

(d) 200 KeV

**135.** If a star can convert all the He nuclei completely into oxygen nuclei. The energy released per oxygen nuclei is [Mass of He nucleus is 4.0026 amu and mass of Oxygen nucleus is 15.9994 amu]

(a) 7.6 MeV

(b) 56.12 MeV

(c) 10.24 MeV

(d) 23.9 MeV

**136.** The energy released per fission of a $_{92}\text{U}^{235}$ nucleus is nearly

(a) 200 eV

(b) 20 eV

(c) 200 MeV

(d) 2000 eV

**137.** If 200 MeV energy is released in the fission of a single U$^{235}$ nucleus, the number of fissions required per second to produce 1 kilowatt power shall be (Given 1eV = $1.6 \times 10^{-19}$ J)

(a) $3.125 \times 10^{13}$

(b) $3.125 \times 10^{14}$

(c) $3.125 \times 10^{15}$

(d) $3.125 \times 10^{16}$

**138.** A certain mass of Hydrogen is changed to Helium by the process of fusion. The mass defect in fusion reaction is 0.02866 a.m.u. The energy liberated per a.m.u. is

(Given : 1 a.m.u = 931 MeV)

(a) 26.7 MeV

(b) 6.675 MeV

(c) 13.35 MeV

(d) 2.67 MeV

**139.** The binding energy per nucleon of deuteron $\left({}^2_1\text{H}\right)$ and helium nucleus $\left({}^4_2\text{He}\right)$ is 1.1 MeV and 7 MeV respectively. If two deuteron nuclei react to form a single helium nucleus, then the energy released is

(a) 23.6 MeV

(b) 26.9 MeV

(c) 13.9 MeV

(d) 19.2 MeV

**140.** If the binding energy per nucleon in $^7_3\text{Li}$ and $^4_2\text{He}$ nuclei are 5.60 MeV and 7.06 MeV respectively, then in the reaction

$$\text{p} + {}^7_3\text{Li} \longrightarrow 2\,{}^4_2\text{He}$$

energy of proton must be

(a) 28.24 MeV

(b) 17.28 MeV

(c) 1.46 MeV

(d) 39.2 MeV

**141.** Assume that a neutron breaks into a proton and an electron. The energy released during this process is : (mass of neutron = $1.6725 \times 10^{-27}$ kg, mass of proton = $1.6725 \times 10^{-27}$ kg, mass of electron = $9 \times 10^{-31}$ kg).

(a) 0.511 MeV

(b) 7.10 MeV

(c) 6.30 MeV

(d) 5.4 MeV

# HINTS AND SOLUTIONS

## FACT / DEFINITION TYPE QUESTIONS

**1.** **(c)**

**2.** **(b)** Gold has 32 isotopes ranging from A = 173 to A = 204

**3.** **(d)** Nuclear radius = $10^{-14}$ m.

**4.** **(a)** Chemical properties are unaffected with addition of neutrons to the nucleus.

**5.** **(c)** Radius of nucleus $R = R_0 A^{1/3}$ where A is the mass number of nucleus.

$\therefore$ Volume of nucleus $= \frac{4}{3}\pi R^3 = \left(\frac{4}{3}\pi R_0^3\right)A$

$\therefore$ Volume is proportional to A.

**6.** **(c)** Nucleus does not contain electron.

**7.** **(b)**

**8.** **(a)** In pressurised-water, nuclear reactor, in primary loop water is circulated through the reactor vessel and transfers energy to steam generator in secondary loop.

**9.** **(c)** **10.** **(b)** **11.** **(b)**

**12.** **(d)** Average BE/nucleon increases first, and then decreases, as is clear from BE curve.

**13.** **(d)** Mass defect $= \frac{B.E}{c^2}$

Mass of nucleus = Mass of proton
+ mass of neutron – mass defect

**14.** **(d)** **15.** **(d)** **16.** **(d)** **17.** **(b)**

**18.** **(b)** **19.** **(d)**

**20.** **(a)** Antiparticle of electron $({}_{-1}e^0)$ is positron $({}_{+1}e^0)$

**21.** **(c)** An electron is accompanied by an antineutrino.

**22.** **(d)** All the characteristics given are true for radioactivity.

**23.** **(d)** γ-rays carry no charge. They are neither deflected by an electric field nor by a magnetic field.

**24.** **(c)** β-rays are charged particles emitted by nucleus.

**25.** **(c)** Fusion is not a mode of decay.

**26.** **(c)** Half life $T_h = \frac{0.693}{\lambda}$, $T_m = \frac{1}{\lambda}$ Clearly, $T_h < T_m$.

**27.** **(c)** **28.** **(c)** **29.** **(c)** **30.** **(d)** **31.** **(a)**

**32.** **(d)** **33.** **(c)** **34.** **(a)**

**35.** **(c)** Number of a-particles emitting

per second $= \frac{dN}{dt}$

$= \lambda N = n$

$\therefore \quad \lambda = \frac{n}{N}$

$\therefore \quad T = \frac{0.693}{\lambda}$

$= \frac{0.693N}{n}$

**36.** **(b)** Activity is proportional to mass. Activity of specimen B is maximum. Thus, mass of specimen B is also maximum.

**37.** **(b)** **38.** **(b)** **39.** **(a)** **40.** **(d)**

**41.** **(c)** The risk posed to a human being by any radiation exposure depends partly upon the absorbed dose, the amount of energy absorbed per gram of tissue. Absorbed dose is expressed in rad. A rad is equal to 100 ergs of energy absorbed by 1 gram of tissue. The more modern, internationally adopted unit is the gray (named after the English medical physicist L. H. Gray); one gray equals 100 rad.

**42.** **(a)**

**43.** **(d)** Half life of a substance doesn't depends upon amount, temperature and pressure. It depends upon the nature of the substance.

**44.** **(b)** ${}_{-1}e^0$ is known as $\beta^-$ particle & $\overline{\nu}$ is known as antineutrino. Since in this reaction $\overline{\nu}$ is emitted with ${}_{-1}e^0$ ($\beta^-$ particle or electron), so it is known as β-decay.

**45.** **(b)**

**46.** **(c)** Control rods are made of cadmium.

**47.** **(a)** Boron rods absorb excess neutrons.

**48.** **(c)** Moderator slows down neutrons.

**49.** **(d)** Extremely high temps needed for fusion make K.E. large enough to overcome repulsion between nuclei.

**50.** **(c)**

## STATEMENT TYPE QUESTIONS

**51.** **(c)** Hydrogen has three isotopes Hydrogen $\left({}_1^1H\right)$, Denterium $\left({}_1^2H\right)$, and Tritium $\left({}_1^3H\right)$.

**52.** **(b)** The chemical properties of elements depend on their electronic structure. As the atoms of isotopes have identical electronic structure they have identical chemical behaviour and are placed in the same location in the periodic table.

**53.** **(d)** As $R \propto A^{1/3}$ and volume of nucleus is proportional to $R^3$ is proportional to A. Thus, the density of nucleus is a constant, independent of A, for all nuclei. Different nuclei are likes drop of liquid of constant density. The density of nuclear matter is approximately 2.3 × $10^{17}$ kg $m^{-3}$.

This density is very large compared to ordinary matter, say water which is $10^{23}$ kg $m^{-3}$. This is understandable, as we have already seen that most of the atom is empty. Ordinary matter consisting of atoms has a large amount of empty space.

**54.** **(d)** For $0 < A < 80$, $E_{bn}$ first increases then decreases.

**55.** **(b)** The common time measure of how long any given type of radionuclide lasts is the half-life $T_{1/2}$ of a radionuclide, Which is the time at which both N and R have been reduced to one-half their initial values. A sample may have nuclei which are not radioactive.

**56.** **(a)** Neutrons can't be deflected by a magnetic field.

## MATCHING TYPE QUESTIONS

**57.** **(b)** (A) → (2); (B) → (1); (C) → (4); (D) → (3)

**58.** **(c)** (A) → (2); (B) → (1); (C) → (4); (D) → (3)

$$^{15}_{8}\text{O} \longrightarrow {}^{15}_{7}\text{N} + \underset{\beta^+ \text{ particle}}{{}^{0}_{1}\beta}$$

$$^{238}_{92}\text{U} \longrightarrow {}^{234}_{90}\text{Th} + \underset{\alpha-\text{particle}}{{}^{4}_{2}\text{He}}$$

$$^{185}_{83}\text{Bi} \longrightarrow {}^{184}_{82}\text{Pb} + \underset{\text{proton}}{{}^{1}_{1}\text{H}}$$

$$^{239}_{94}\text{Pu} \longrightarrow {}^{140}_{57}\text{La} + {}^{99}_{37}\text{X}$$

(c) is the correct option.

**59.** **(a)** (A) → (2); (B) → (3); (C) → (4); (D) → (1)

**60.** **(b)** (A) → (2); (B) → (1); (C) → (4); (D) → (3)

## DIAGRAM TYPE QUESTIONS

**61.** **(d)** For $A + B \to C + \varepsilon$, $\varepsilon$ is the positive. This is because $E_b$ for D and E is greater then $E_b$ for F.

**62.** **(c)**

**63.** **(c)** Energy is released in a process when total binding energy (BE) of products is more than the reactants. By calculations we can see that this happens in option (c).

Given $W = 2Y$

BE of reactants = 120 × 7.5 = 900 MeV

BE of products = 2 × (60 × 8.5) = 1020 MeV.

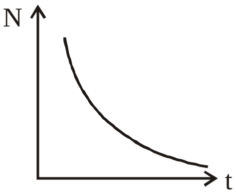
**64.** **(c)** The range of energy of β-particles is from zero to some maximum value.

**65.** **(c)** No. of nuclide at time t is given by $N = N_o e^{-\lambda t}$

Where $N_o$ = initial nuclide

thus this equation is equivalent to $y = ae^{-kx}$

thus correct graph is



## ASSERTION- REASON TYPE QUESTIONS

**66.** **(a)** 
$$\rho = \frac{M}{V} = \frac{A}{\frac{4}{3}\pi r^3}$$
$$= \frac{A}{\frac{4}{3}\pi(r_0A^{1/3})^3} = \frac{1}{\left(\frac{4}{3}\pi r_0^3\right)} = \text{constant}$$

**67.** **(b)** Both statements are separately correct.

**68.** **(d)** In case of hydrogen atom mass number and atomic number are equal.

**69.** **(c)** Nuclear force is nearly same for all nucleus.

**70.** **(c)** Radioactivity $= -\frac{dN}{dt} = \lambda N = \frac{0.693N}{T_{1/2}}$

$$= \frac{0.693\times10^8}{50} = \frac{0.693\times1.2\times10^8}{60} = 0.693\times2\times10^6.$$

Radioactivity is proportional to $1/T_{1/2,}$ and not to $T_{1/2.}$

**71.** **(b)** β-particles, being emitted with very high speed compared to α-particles, pass for very little time near the atoms of the medium. So the probability of the atoms being ionised is comparatively less. But due to this reason, their loss of energy is very slow and they can penetrate the medium through a sufficient depth.

**72.** **(c)** Electrons are not inside nucleus.

**73.** **(a)** **74. (a)** **75. (d)** **76. (d)** **77. (c)**

**78.** **(d)** We know that energy is released when heavy nuclei undergo fission or light nuclei undergo fusion. Therefore statement (1) is correct.

The second statement is false because for heavy nuclei the binding energy per nucleon decreases with increasing Z and for light nuclei, B.E/nucleon increases with increasing Z.

## CRITICAL THINKING TYPE QUESTIONS

**79.** **(c)** $\frac{R_s}{R_{He}} = \left(\frac{A_s}{A_{He}}\right)^{1/3} = \left(\frac{32}{4}\right)^{1/3} = 2$

**80.** **(b)** As momentum is conserved, therefore,

$$\frac{m_1}{m_2} = \frac{A_1}{A_2} = \frac{v_2}{v_1} = \frac{1}{2}$$

$$\therefore \quad \frac{R_1}{R_2}=\left(\frac{A_1}{A_2}\right)^{1/3}=\left(\frac{1}{2}\right)^{1/3}=1:2^{1/3}$$

**81.** **(b)** $R = R_0(A)^{1/3}$

$$\therefore \frac{R_1}{R_2}=\left(\frac{A_1}{A_2}\right)^{1/3}=\left(\frac{27}{125}\right)^{1/3}=\frac{3}{5}$$

$$R_2=\frac{5}{3}\times 3.6 = 6 \text{ fermi}$$

**82.** **(c)** Binding energy

$= [ZM_P + (A – Z)M_N – M]c^2$

$= [8M_P + (17 – 8)M_N – M]c^2$

$= [8M_P + 9M_N – M]c^2$

$= [8M_P + 9M_N – M_o]c^2$

**83.** **(a)** Iodine and Yttrium are medium sized nuclei and therefore have more binding energy per nucleon as compared to Uranium which has a big nucleus and less B.E. / nucleon. In other words, Iodine and Yttrium are more stable and therefore, possess less energy and less rest mass. Also, when Uranium nuclei explodes, it will convert into I and Y nuclei having kinetic energies.

**84.** **(a)** $B.E_H=\frac{2.22}{2}=1.11$

$$B.E_{He}=\frac{28.3}{4}=7.08$$

$$B.E_{Fe}=\frac{492}{56}=8.78=\text{maximum}$$

$$B.E_U=\frac{1786}{235}=7.6$$

${}^{56}_{26}Fe$ is most stable as it has maximum binding energy per nucleon.

**85.** **(b)** $B.E. = 0.042 \times 931 \simeq 42 \text{ MeV}$

Number of nucleons in ${}^{7}_{3}Li$ is 7.

$$\therefore \quad \text{B.E./ nucleon} = \frac{42}{7} = 6 \text{ MeV} \simeq 5.6 \text{ MeV}$$

**86.** **(d)** $E=\Delta m.c^2 \Rightarrow E=\frac{0.3}{1000}\times(3\times10^8)^2=2.7\times10^{13}\text{J}$

$$=\frac{2.7\times10^{13}}{3.6\times10^6}=7.5\times10^6\text{kWh.}$$

**87.** **(b)** $Q = 4 (x_2 – x_1)$

**88.** **(c)** Energy released = $(80 \times 7 + 120 \times 8 – 200 \times 6.5)$

**89.** **(a)** $B.E. = \Delta mc^2 = \Delta \times 931$ MeV

$= [2(1.0087 + 1.0073) – 4.0015] \times 931 = 28.4$ MeV

**90.** **(a)** $E = mc^2 = 10^{–6} \times (3 \times 10^8)^2 = 10^{–6} \times 9 \times 10^{16} = 9 \times 10^{10}$ J

**91.** **(c)** Substance left undecayed, $N_0-\frac{3}{4}N_0=\frac{1}{4}N_0$

$$\frac{N}{N_0}=\frac{1}{4}=\left(\frac{1}{2}\right)^n$$

$\therefore$ Number of atoms left undecayed,

n = 2 i.e. in two half lives

$\therefore$ $t = nT = 2 \times 4 = 8$ months

**92.** **(a)** Let no. of α-particles emitted be x and no. of β particles emitted be y.

Diff. in mass no. $4x = 238 – 206 = 32 \Rightarrow x = 8$

Diff. in charge no. $2x – 1y = 92 – 82 = 10$

$16 – y = 10, y = 6$

**93.** **(a)** We assume that mass number of nucleus when it was at rest = A

$\because$ mass number of $\alpha$ -particle = 4

$\therefore$ mass number of remaining nucleus = A - 4

As there is no external force, so momentum of the system will remain conserved

$$\Rightarrow 0=(A-4)v'+4v \;\Rightarrow v'=-\frac{4v}{(A-4)}$$

negative sign represents that direction is opposite to the direction of motion of $\alpha$ -particle.

**94.** **(b)** A nucleus is denoted by ${}_ZX^A$

An isotope should have same Z.

α–particle = ${}_2He^4$; β–particle = ${}_{-1}\beta^0$

The emission of one α particle and the emission of two β particles maintain the Z same.

Hence, for isotope formation 2β particles and one α particle are emitted.

**95.** **(a)** $T_{1/2}=\frac{\ln 2}{\lambda}\therefore \lambda=\frac{\ln 2}{T_{1/2}}$

$$\Rightarrow \lambda_A=\frac{In2}{T_A},\lambda_B=\frac{\ln 2}{T_B}\Rightarrow\frac{\lambda_A}{\lambda_B}=\frac{T_B}{T_A}.$$

**96.** **(a)** ${}_{72}A^{180}\xrightarrow{\alpha}{}_{70}A_1^{176}\xrightarrow{\beta}{}_{71}A_2^{176}$

$$\xrightarrow{\alpha}{}_{69}A_3^{172}\xrightarrow{\gamma}{}_{69}A_4^{172}$$

**97.** **(d)** Radioactivity at $T_1$ , $R_1 = \lambda N_1$

Radioactivity at $T_2$, $R_2 = \lambda N_2$

$\therefore$ Number of atoms decayed in time

$(T_1 – T_2) = (N_1 –N_2)$

$$= \frac{(R_1 - R_2)}{\lambda} = \frac{(R_1 - R_2)T}{0.693} \propto (R_1 - R_2)T$$

**98.** **(d)**

**99.** **(c)** $\frac{dN}{dt} = \lambda N = \text{activity } R$

$R_0 = \lambda N_0$ at $t = 0$, $R_1 = \lambda N_1$ at $t = 5$ minutes

where $\lambda = \frac{2.303}{t} \log \frac{N_0}{N_1}$

**100.** **(c)** $\frac{N_A}{N_B} = \frac{(1/2)^{n_A}}{(1/2)^{n_B}} = \frac{(1/2)^4}{(1/2)^2} = \frac{1}{4}$, where $n_A$ & $n_B$ are number of half lives of samples A & B respectively. $N_A$ & $N_B$ are the remaining numbers of A & B after 80 minutes in this case.

**101.** **(d)** $N = N_0 e^{-\lambda t}$

Here, $t = 5$ minutes

$$\frac{N_0}{e} = N_0 \cdot e^{-5\lambda}$$

$$\Rightarrow \quad 5\lambda = 1, \text{ or } \quad \lambda = \frac{1}{5},$$

Now, $T_{1/2} = \frac{\ell n 2}{\lambda} = 5 \ \ell n 2$

**102.** **(b)** Momentum

$$Mu = \frac{E}{c} = \frac{h\nu}{c}$$

Recoil energy

$$\frac{1}{2} Mu^2 = \frac{1}{2} \frac{M^2 u^2}{M} = \frac{1}{2M}\left(\frac{h\nu}{c}\right)^2 = \frac{h^2 \nu^2}{2Mc^2}$$

**103.** **(b)** Initially $P \rightarrow 4N_0$

$Q \rightarrow N_0$

Half life $T_P = 1$ min.

$T_Q = 2$ min.

Let after time t number of nuclei of P and Q are equal, that is

$$\frac{4N_0}{2^{t/1}} = \frac{N_0}{2^{t/2}} \Rightarrow \frac{4N}{2^{t/1}} = \frac{1}{2^{t/2}} \Rightarrow 2^{t/1} = 4.2^{t/2}$$

$$2^2.2^{t/2} = 2^{(2 + t/2)}$$

$$\Rightarrow \frac{t}{1} = 2 + \frac{t}{2} \Rightarrow \frac{t}{2} = 2 \Rightarrow t = 4 \text{ min}$$

$$N_P = \frac{(4N_0)}{2^{4/1}} = \frac{N_0}{4}$$

at $t = 4$ min.

$$N_0 = \frac{N_0}{4} = \frac{N_0}{4}$$

or population of R

$$\left(4N_0 - \frac{N_0}{4}\right) + \left(N_0 - \frac{N_0}{4}\right) = \frac{9N_0}{2}$$

**104.** **(b)** $N_1 = N_0 \, e^{-\lambda t} \qquad N_1 = \frac{1}{3} N_0$

$$\frac{N_0}{3} = N_0 e^{-\lambda t_2}$$

$$\Rightarrow \quad \frac{1}{3} = e^{-\lambda t^2} \qquad \text{...(i)}$$

$$N_2 = \frac{2}{3} N_0$$

$$\frac{2}{3} N_0 = N_0 e^{-\lambda t_1}$$

$$\Rightarrow \quad \frac{2}{3} = e^{-\lambda t_1} \qquad \text{...(ii)}$$

Dividing equation (i) by equation (ii)

$$\frac{1}{2} = e^{-\lambda(t_2 - t_1)}$$

$$\lambda(t_2 - t_1) = \ln 2$$

$$t_2 - t_1 = \frac{\ln 2}{\lambda} = T_{1/2} = 50 \text{ days}$$

**105.** **(d)** Let, the amount of the two in the mixture will become equal after *t* years.

The amount of $A_1$, which remains after *t* years

$$N_1 = \frac{N_{01}}{(2)^{t/20}}$$

The amount of $A_2$, which remains, after *t* years

$$N_2 = \frac{N_{02}}{(2)^{t/10}}$$

According to the problem

$N_1 = N_2$

$$\frac{40}{(2)^{t/20}} = \frac{160}{(2)^{t/10}}$$

$$2^{t/20} = 2^{\left(\frac{t}{10}-2\right)}$$

$$\frac{t}{20} = \frac{t}{10} - 2$$

$$\frac{t}{20} - \frac{t}{10} = 2$$

$$\frac{t}{20} = 2$$

$t = 40$ s

**106. (a)** The value of x is $\frac{1}{8}$

$$= \frac{x_0}{8} = \frac{x_0}{2^3} \Rightarrow t = 3T = 3 \times 20 = 60 \text{ years}$$

Hence the estimated age of the rock is 60 years

ALTERNATE : X $\rightarrow$ $Y_0$

at t = 0 $N_0$ 0

at t = t N $N_0 - N$

$$\frac{N}{N_0 - N} = \frac{1}{7} = \frac{N}{N_0} = \frac{1}{8}$$

t = 3T

= 3 × 20 = 60 years

**107. (a)** Amount left = $N_0/2^n = N_0/8$ (Here n=15/5=3)

**108. (a)** Applying the principle of conservation of linear momentum

$$(4)(u) = (v)(238) \Rightarrow v = \frac{4u}{238}$$

**109. (a)** $K = \frac{1}{t}\ell n\left(\frac{N_0}{N}\right) \Rightarrow K = \frac{1}{5}\ell n\left(\frac{5000}{1250}\right)$

$$\frac{1}{5}\ell n(4) = \frac{2}{5}\ell n2 = 0.4\ell n2$$

**110. (b)** Radioactive decay is a random process. Each decay is a completely independent event. Therefore, which particular nucleus will decay at a given instant of time cannot be predicted. In other words when a particular nucleus will decay cannot be predicted. Each nucleus has same probability of disintegration.

**111. (a)** We know that, $\left|\frac{dN}{dt}\right| = \lambda N = \frac{1}{T_{mean}} N$

$$\therefore \quad 10^{10} = \frac{1}{10^9} \times N$$

$$\therefore \quad N = 10^{19}$$

*i.e.* $10^{19}$ radioactive atoms are present in the freshly prepared sample.

The mass of the sample

$= 10^{19} \times 10^{-25}$ kg $= 10^{-6}$kg = 1 mg

**112. (d)** Time taken to disintegrate completely by a substance is infinity as $\log \frac{N_0}{N} = \lambda t$

$$\Rightarrow \log \frac{N_0}{0} = \lambda t$$

$$\log \infty = \lambda t$$

hence when $N \rightarrow 0,\ t \rightarrow \infty$.

**113. (a)** $\frac{N}{N_0} = \left(\frac{1}{2}\right)^{\frac{t}{T}}$ or $\frac{N}{10000} = \left(\frac{1}{2}\right)^{\frac{10}{20}}$

or $N = \frac{10000 \times 1}{\sqrt{2}} = \frac{10000}{1.414} = 7070.$

**114. (b)** $\left(\frac{1}{2}\right)^n = \frac{N}{N_0} = \frac{1}{20}$ gives n = 4.32

t = nT = 4.3 × 3.8 = 16.5 days

**115. (b)** To work safely, intensity must reduce by 1/64

$$\therefore \frac{N}{N_0} = \frac{1}{64} = \left(\frac{1}{2}\right)^{t/T} \text{ i.e.} \left(\frac{1}{2}\right)^6 = \left(\frac{1}{2}\right)^{t/T}$$

or $\frac{t}{T} = 6$ or t = 6 T = 12 hrs

**116. (d)**

**117. (b)** Conservation of linear momentum requires:

$m_{radon}v_{radon} = m_{helium}v_{helium}$ with helium identified as the alpha particle. The nuclear masses can be approximated by their mass numbers (222 and 4). Thus, the recoil speed of the radon is (4/222) × 1.5 × $10^7$ m/s = 2.7 x $10^5$ m/s.

**118. (c)** $\frac{^{14}C}{^{12}C} = \frac{1}{16} = \frac{N}{N_0}$

$$\because \quad \frac{N}{N_0} = \left(\frac{1}{2}\right)^n$$

$$\Rightarrow \frac{1}{16} = \left(\frac{1}{2}\right)^n \Rightarrow \left(\frac{1}{2}\right)^4 = \left(\frac{1}{2}\right)^n$$

or, n = 4

or $\frac{t}{T} = 4$

or $t = 4 \times T = 4 \times 5730 = 22920$ years

**119. (c)**

$$\frac{C_{14}}{C_{12}} = \frac{1}{4} = \left(\frac{1}{2}\right)^{t/5700} \Rightarrow \frac{t}{5700} = 2 \Rightarrow t = 11400 \text{ years}$$

**120. (a)** Let the percentage of $B^{10}$ atoms be x, then average atomic weight

$$= \frac{10x + 11(100 - x)}{100} = 10.81 \Rightarrow x = 19$$

$$\therefore \frac{N_{B^{10}}}{N_{B^{11}}} = \frac{19}{81}$$

**121. (c)** Let $N_0$ be the number of atoms of X at time t = 0.
Then at t = 4 hrs (two half lives)

$$N_x = \frac{N_0}{4} \text{ and } N_y = \frac{3N_0}{4}$$

$\therefore$ $N_x/N_y = 1/3$
and at t = 6 hrs (three half lives)

$$N_x = \frac{N_0}{8} \text{ and } N_y = \frac{7N_0}{8}$$

$$\text{or } \frac{N_x}{N_y} = \frac{1}{7}$$

The given ratio $\frac{1}{4}$ lies between $\frac{1}{3}$ and $\frac{1}{7}$.

Therefore, t lies between 4 hrs and 6 hrs.

**122. (a)** Activity of sample becomes 2500 from 5000 in 75 days therefore its half life is 75 days, so

$$R = \frac{R_0}{2^{\frac{150}{75}}} = 5000 \Rightarrow R_0 = 5000 \times 4 = 20,000$$

**123. (a)** For substance A :

$$2N_0 \to N_A = 2N_0\left(\frac{1}{2}\right)^{48/12} = \frac{N_0}{2^3} = \frac{N_0}{8}$$

For substance B :

$$N_0 \to N_B = N_0\left(\frac{1}{2}\right)^{48/16} = \frac{N_0}{2^3} = \frac{N_0}{8}$$

$N_A : N_B = 1 : 1$

**124. (b)** Effective half life is calculated as

$$\frac{1}{T} = \frac{1}{T_1} + \frac{1}{T_2}$$

$$\frac{1}{T} = \frac{1}{16} + \frac{1}{48} \Rightarrow T = 12 \text{ years}$$

Time in which $\frac{3}{4}$ will decay is 2 half lives = 24 years

**125. (c)** **126. (a)** **127. (c)** **128. (d)**

**129. (c)** When ${}^{m}_{n}X$ emits one α-particle then its atomic mass decreases by 4 units and atomic number by 2. Therefore, the new nucleus becomes ${}^{m-4}_{n-2}Y$. But as it emits two $\beta^-$ particles, its atomic number increases by 2. Thus the resulting nucleus is ${}^{m-4}_{n}X$.

**130. (b)** No. of α particles emitted = 8
No. of $\beta^-$ particles emitted = 4
No. of $\beta^+$ particles emitted = 2
$Z = 92 - 2 \times 8 + 4 - 2 = 78$

**131. (c)** According to question,
Half life of X, $T_{1/2} = \tau_{av}$, mean life of Y

$$\Rightarrow \frac{0.693}{\lambda_X} = \frac{1}{\lambda_Y}$$

$$\Rightarrow \lambda_X = (0.693).\lambda_Y$$

$$\therefore \lambda_X > \lambda_Y.$$

Now, the rate of decay is given by

$$-\left(\frac{dN}{dt}\right) = \lambda_X N_0$$

$$-\left(\frac{dN}{dt}\right)_4 = \lambda_4 N_0$$

Y will decay faster than X.

**132. (b)** As a result of emission of 1 α-particle, the mass number decreases by 4 units and atomic number decreases by 2 units. And by the emission of 1 positron the atomic number decreases by 1 unit but mass number remains constant.

$\therefore$ Mass number of final nucleus $= A - 12$

Atomic number of final nucleus $= Z - 8$

$\therefore$ Number of neutrons $= (A - 12) - (Z - 8)$

$= A - Z - 4$

Number of protons $= Z - 8$

$\therefore$ Required ratio $= \dfrac{A - Z - 4}{Z - 8}$

**133. (a)** ${}_{Z}X^{A} + {}_{0}n^{1} \longrightarrow {}_{3}Li^{7} + {}_{2}He^{4}$

On comparison,
$A = 7 + 4 - 1 = 10, z = 3 + 2 - 0 = 5$
It is boron ${}_{5}B^{10}$

**134. (b)** Liberated energy $Q = 117 \times 8.5 + 117 \times 8.5 - 236 \times 7.6 =$ 200 MeV. Thus, in fission of one Uranium nuclei nearly 200 MeV energy is liberated.

**135. (c)** $4\,{}^{4}_{2}He \longrightarrow {}^{16}_{8}O$

$B.E = \Delta M \times 931.5 \text{ MeV}$
$= (4 \times 4.0026 - 15.9994) \times 931.5 = 10.24 \text{ MeV}$

**136.** **(c)** Energy released per fission is ≈ 200 MeV

**137.** **(a)** $P = n\left(\frac{E}{t}\right) \Rightarrow 1000 = \frac{n \times 200 \times 10^6 \times 1.6 \times 10^{-19}}{t}$

$\Rightarrow \frac{n}{t} = 3.125 \times 10^{13}.$

**138.** **(b)** Mass defect $\Delta m = 0.02866$ a.m.u.

Energy $= 0.02866 \times 931 = 26.7$ MeV

As ${}_1H^2 + {}_1H^2 \longrightarrow {}_2He^4$

Energy liberated per a.m.u = 13.35/2 MeV

= 6.675 MeV

**139.** **(a)** The chemical reaction of process is $2{}_1^2H \rightarrow {}_2^4He$

Energy released $= 4 \times (7) - 4(1.1) = 23.6$ eV

**140.** **(b)** Let E be the energy of proton, then

$E + 7 \times 5.6 = 2 \times [4 \times 7.06]$

$\Rightarrow E = 56.48 - 39.2 = 17.28 \text{MeV}$

**141.** **(a)** ${}_0^1n \longrightarrow {}_1^1H + {}_{-1}e^0 + \bar{\nu} + Q$

The mass defect during the process

$\Delta m = m_n - m_H - m_e$

$= 1.6725 \times 10^{-27} - (1.6725 \times 10^{-27} + 9 \times 10^{-31} \text{kg})$

$= -9 \times 10^{-31}$ kg

The energy released during the process

$E = \Delta mc^2$

$E = 9 \times 10^{-31} \times 9 \times 10^{16} = 81 \times 10^{-15}$ Joules

$E = \frac{81 \times 10^{-15}}{1.6 \times 10^{-19}} = 0.511 \text{MeV}$

## CHAPTER 29

# SEMICONDUCTOR ELECTRONICS : MATERIALS, DEVICES AND SIMPLE CIRCUITS

## FACT/DEFINITION TYPE QUESTIONS

**1.** In a semiconductor
(a) there are no free electrons at 0 K
(b) there are no free electrons at any temperature
(c) the number of free electrons increases with pressure
(d) the number of fre electrons is more than that in a conductor

**2.** Let $n_h$ and $n_e$ be the number of holes and conduction electrons in an extrinsic semiconductor. Then
(a) $n_h > n_e$ (b) $n_h = n_e$ (c) $n_h < n_e$ (d) $n_h \neq n_e$

**3.** A p-type semiconductor is
(a) positively charged
(b) negatively charged
(c) uncharged
(d) uncharged at 0K but charged at higher temperatures

**4.** Electric conduction in a semiconductor takes place due to
(a) electrons only
(b) holes only
(c) both electrons and holes
(d) neither electrons nor holes

**5.** The impurity atoms with which pure silicon may be doped to make it a p-type semiconductor are those of
(a) phosphorus (b) boron
(c) antimony (d) nitrogen

**6.** The electrical conductivity of pure germanium can be increased by
(a) increasing the temperature
(b) doping acceptor impurities
(c) doping donor impurities
(d) All of the above

**7.** The resistivity of a semiconductor at room temperature is in between
(a) $10^{-2}$ to $10^{-5}$ $\Omega$ cm (b) $10^{-3}$ to $10^{6}$ $\Omega$ cm
(c) $10^{6}$ to $10^{8}$ $\Omega$ cm (d) $10^{10}$ to $10^{12}$ $\Omega$ cm

**8.** Number of electrons in the valence shell of a pure semiconductor is
(a) 1 (b) 2 (c) 3 (d) 4

**9.** In a semiconductor, the forbidden energy gap between the valence band and the conduction band is of the order is
(a) 1 MeV (b) 0.1 Mev
(c) 1 eV (d) 5 eV

**10.** The forbidden energy gap for germanium crystal at 0 K is
(a) 0.071 eV (b) 0.71 eV
(c) 2.57 eV (d) 6.57 eV

**11.** In an insulator, the forbidden energy gap between the valence band and conduction band is of the order of
(a) 1 MeV (b) 0.1 MeV
(c) 1 eV (d) 5 eV

**12.** What is the resistivity of a pure semiconductor at absolute zero ?
(a) Zero
(b) Infinity
(c) Same as that of conductors at room temperature
(d) Same as that of insulators at room temperature

**13.** Temperature coefficient of resistance of semiconductor is
(a) zero (b) constant
(c) positive (d) negative

**14.** In a p-type semiconductor, the acceptor valence band is
(a) close to the valence band of the host crystal
(b) close to conduction band of the host crystal
(c) below the conduction band of the host crystal
(d) above the conduction band of the host crystal

**15.** In an n-type semiconductor, donor valence band is
(a) above the conduction band of the host crystal
(b) close to the valence band of the host crystal
(c) close to the conduction band of the host crystal
(d) below the valence band of the host crystal

**16.** The mobility of free electrons is greater than that of free holes because
(a) they are light
(b) they carry negative charge
(c) they mutually colllide less
(d) they require low energy to continue their motion

**17.** The relation between number of free electrons (n) in a semiconductor and temperature (T) is given by
(a) $n \propto T$ (b) $n \propto T^2$
(c) $n \propto \sqrt{T}$ (d) $n \propto T^{3/2}$

**18.** In semiconductors, at room temperature
(a) the conduction band is completely empty
(b) the valence band is partially empty and the conduction band is partially filled
(c) the valence band is completely filled and the conduction band is partially filled
(d) the valence band is completely filled

**19.** At absolute zero, Si acts as
(a) non-metal (b) metal
(c) insulator (d) None of these

**20.** One serious drawback of semi-conductor devices is
(a) they do not last for long time.
(b) they are costly
(c) they cannot be used with high voltage.
(d) they pollute the environment.

**21.** When an impurity is doped into an intrinsic semiconductor, the conductivity of the semiconductor
(a) increases (b) decreases
(c) remains the same (d) becomes zero

**22.** An electric field is applied to a semiconductor. Let the number of charge carriers be n and the average drift speed be v. If the temperature is increased
(a) both n and v will increase
(b) n will increase but v will decrease
(c) v will increase but n will decrease
(d) both n and v will decrease

**23.** If a small amount of antimony is added to germanium crystal
(a) it becomes a p–type semiconductor
(b) the antimony becomes an acceptor atom
(c) there will be more free electrons than holes in the semiconductor
(d) its resistance is increased

**24.** By increasing the temperature, the specific resistance of a conductor and a semiconductor
(a) increases for both (b) decreases for both
(c) increases, decreases (d) decreases, increases

**25.** A strip of copper and another of germanium are cooled from room temperature to 80K. The resistance of
(a) each of these decreases
(b) copper strip increases and that of germanium decreases
(c) copper strip decreases and that of germanium increases
(d) each of these increases

**26.** Carbon, Silicon and Germanium atoms have four valence electrons each. Their valence and conduction bands are separated by energy band gaps represented by $(E_g)_C$, $(E_g)_{Si}$ and $(E_g)_{Ge}$ respectively. Which one of the following relationship is true in their case?
(a) $(E_g)_C > (E_g)_{Si}$ (b) $(E_g)_C < (E_g)_{Si}$
(c) $(E_g)_C = (E_g)_{Si}$ (d) $(E_g)_C < (E_g)_{Ge}$

**27.** A semiconductor device is connected in a series circuit with a battery and a resistance. A current is found to pass through the circuit. If the polarity of the battery is reversed, the current drops to almost zero. The device may be a/an
(a) intrinsic semiconductor
(b) p-type semiconductor
(c) n-type semiconductor
(d) p-n junction diode

**28.** If the two ends of a p-n junction are joined by a wire
(a) there will not be a steady current in the circuit
(b) there will be a steady current from the n-side to the p-side
(c) there will be a steady current from the p-side to the n-side
(d) there may or may not be a current depending upon the resistance of the connecting wire

**29.** The drift current in a p-n junction is from the
(a) n-side to the p-side
(b) p-side to the n-side
(c) n-side to the p-side if the junction is forward-biased and in the opposite direction if it is reverse biased
(d) p-side to the n-side if the junction is forward-biased and in the opposite direction if it is reverse-biased

**30.** The diffusion current in a p-n junction is from the
(a) n-side to the p-side
(b) p-side to the n-side
(c) n-side to the p-side if the junction is forward-biased and in the opposite direction if it is reverse-biased
(d) p-side to the n-side if the junction is forward-biased and in the opposite direction if it is reverse-biased

**31.** Diffusion current in a p-n junction is greater than the drift current in magnitude
(a) if the junction is forward-biased
(b) if the junction is reverse-biased
(c) if the junction is unbiased
(d) in no case

**32.** Forward biasing is that in which applied voltage
(a) increases potential barrier
(b) cancels the potential barrier
(c) is equal to 1.5 volt
(d) None of these

**33.** In V-I characteristic of a p-n junction, reverse biasing results in
(a) leakage current
(b) the current barrier across junction increases
(c) no flow of current
(d) large current

**34.** In reverse biasing
(a) large amount of current flows
(b) potential barrier across junction increases
(c) depletion layer resistance increases
(d) no current flows

**35.** Zener diode is used for
(a) amplification (b) rectification
(c) stabilisation (d) all of the above

**36.** Filter circuit
(a) eliminates a.c. component
(b) eliminates d.c. component
(c) does not eliminate a.c. component
(d) None of these

**37.** For a junction diode the ratio of forward current ($I_f$) and reverse current ($I_r$) is
[e = electronic charge,
V = voltage applied across junction,
k = Boltzmann constant,
T = temperature in kelvin]
(a) $e^{-V/kT}$ (b) $e^{V/kT}$
(c) $(e^{-eV/kT} + 1)$ (d) $(e^{eV/kT} - 1)$

**38.** In a semiconductor diode, the barrier potential offers opposition to
(a) holes in P-region only
(b) free electrons in N-region only
(c) majority carriers in both regions
(d) majority as well as minority carriers in both regions

**39.** In a P -N junction
(a) the potential of P & N sides becomes higher alternately
(b) the P side is at higher electrical potential than N side.
(c) the N side is at higher electric potential than P side.
(d) both P & N sides are at same potential.

**40.** Barrier potential of a P-N junction diode does not depend on
(a) doping density (b) diode design
(c) temperature (d) forward bias

**41.** Reverse bias applied to a junction diode
(a) increases the minority carrier current
(b) lowers the potential barrier
(c) raises the potential barrier
(d) increases the majority carrier current

**42.** In forward biasing of the p–n junction
(a) the positive terminal of the battery is connected to p–side and the depletion region becomes thick
(b) the positive terminal of the battery is connected to n–side and the depletion region becomes thin
(c) the positive terminal of the battery is connected to n–side and the depletion region becomes thick
(d) the positive terminal of the battery is connected to p–side and the depletion region becomes thin

**43.** When p-n junction diode is forward biased then
(a) both the depletion region and barrier height are reduced
(b) the depletion region is widened and barrier height is reduced
(c) the depletion region is reduced and barrier height is increased
(d) Both the depletion region and barrier height are increased

**44.** The cause of the potential barrier in a p-n junction diode is
(a) depletion of positive charges near the junction
(b) concentration of positive charges near the junction
(c) depletion of negative charges near the junction
(d) concentration of positive and negative charges near the junction

**45.** The ratio of forward biased to reverse biased resistance for pn junction diode is
(a) $10^{-1} : 1$ (b) $10^{-2} : 1$
(c) $10^{4} : 1$ (d) $10^{-4} : 1$

**46.** In the middle of the depletion layer of a reverse- biased p-n junction, the
(a) electric field is zero (b) potential is maximum
(c) electric field is maximum (d) potential is zero

**47.** Bridge type rectifier uses
(a) four diodes (b) six diodes
(c) two diodes (d) one diode

**48.** The average value of output direct current in a half wave rectifier is
(a) $I_0/\pi$ (b) $I_0/2$
(c) $\pi I_0/2$ (d) $2 I_0/\pi$

**49.** The average value of output direct current in a full wave rectifier is
(a) $I_0/\pi$ (b) $I_0/2$
(c) $\pi I_0/2$ (d) $2 I_0/\pi$

**50.** In a half wave rectifier, the r.m.s. value of the a.c. component of the wave is
(a) equal to d.c. value (b) more than d.c. value
(c) less than d.c. value (d) zero

**51.** In a transistor
(a) the emitter has the least concentration of impurity
(b) the collector has the least concentration of impurity
(c) the base has the least concentration of impurity
(d) all the three regions have equal concentrations of impurity

**52.** Current gain in common emitter configuration is more than 1 because
(a) $I_c < I_b$ (b) $I_c < I_e$ (c) $I_c > I_e$ (d) $I_c > I_b$

**53.** Current gain in common base configuration is less than 1 because
(a) $I_e < I_b$ (b) $I_b < I_e$ (c) $I_c < I_e$ (d) $I_e < I_c$

**54.** Operating point of a transistor is
(a) zero signal value of $V_{CC}$ and $I_b$
(b) zero signal value of $I_c$
(c) zero signal value of $V_{cc}$
(d) zero signal value of $I_c$ and $V_{CE}$

**55.** A transistor is essentially
(a) a current operated device
(b) power driven device
(c) a voltage operated device
(d) resistance operated device

**56.** Amplifier may be
(a) multi stage (b) single stage
(c) both (a) and (b) (d) None of these

**57.** In common emitter circuit, current gain is
(a) zero
(b) same as in other configuration
(c) lowest (d) highest

**58.** In common base circuit, output resistance is
(a) very high (b) low
(c) very low (d) moderate

**59.** In common collector circuit, voltage gain is
(a) very high (b) moderate
(c) low (d) very low

**60.** In a transistor
(a) both emitter and collector have same length
(b) length of emitter is greater than that of collector
(c) length of collector is greater than that of emitter
(d) any one of emitter and collector can have greater length

**61.** In a transistor, the base is
(a) a conductor of low resistance
(b) a conductor of high resistance
(c) an insulator
(d) an extrinsic semiconductor

**62.** Negative feed back
(a) increases stability (b) decreases stability
(c) produces oscillation (d) stops current in the tube

**63.** The part of a transistor which is most heavily doped to produce large number of majority carriers is
(a) emmiter
(b) base
(c) collector
(d) can be any of the above three.

**64.** In a common base amplifier, the phase difference between the input signal voltage and output voltage is
(a) $\pi$ (b) $\frac{\pi}{4}$
(c) $\frac{\pi}{2}$ (d) 0

**65.** The current gain $\beta$ may be defined as
(a) the ratio of change in collector current to the change in emitter current for a constant collector voltage in a common base arrangement.
(b) the ratio of change in collector current to the change in the base current at constant collector voltage in a common emitter circuit
(c) the ratio of change in emitter current to the change in base current for constant emitter voltage in common emitter circuit.
(d) the ratio of change in base current to the change in collector current at constant collector voltage in common emitter circuit.

**66.** The transistor are usually made of
(a) metal oxides with high temperature coefficient of resistivity
(b) metals with high temperature coefficient of resistivity
(c) metals with low temperature coefficient of resistivity
(d) semiconducting materials having low temperature coefficient of resistivity

**67.** A transistor has three impurity regions. All the three regions have different doping levels. In order of increasing doping level, the regions are
(a) emitter, base and collector
(b) collector, base and emitter
(c) base, emitter and collector
(d) base, collector and emitter

**68.** To use a transistor as an amplifier, emitter-base junction is kept in ...*X*... and base-collector junction is kept in ...*Y*... Here, *X* and *Y* refer to
(a) forward bias, forward bias
(b) reverse bias, reverse bias
(c) reverse bias, forward bias
(d) forward bias, reverse bias

**69.** When npn transistor is used as an amplifier
(a) electrons move from collector to base
(b) holes move from emitter to base
(c) electrons move from base to collector
(d) holes move from base to emitter

**70.** An oscillator is nothing but an amplifier with
(a) positive feedback
(b) large gain
(c) negative feedback
(d) no feedback

**71.** What is the value of A.C + A.B.C where A, B and C are inputs ?
(a) A.C (b) A.B
(c) A (d) B

**72.** In Boolean algebra, Y = A + B implies that
(a) output Y exists when both inputs A and B exist
(b) output Y exists when either input A exists or input B exists or both inputs A and B exist
(c) output Y exists when either input A exists or input B exists but not when both inputs A and B exist
(d) output Y exists when both inputs A and B exists but not when either input A or B exist

**73.** The gate for which output is high if atleast one input is low?
(a) NAND (b) NOR
(c) AND (d) OR

**74.** The truth-table given below is for which gate?

| A | B | C |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

(a) XOR (b) OR
(c) AND (d) NAND

**75.** NAND and NOR gates are called universal gates primarily because they
(a) are available universally
(b) can be combined to produce OR, AND and NOT gates
(c) are widely used in Integrated circuit packages
(d) are easiest to manufacture

## STATEMENT TYPE QUESTIONS

**76.** Select the correct statement(s) from the following.
I. In conductors, the valence and conduction bands may overlap.
II. Substances with energy gap of the order of 10 eV are insulators.
III. The resistivity of a semiconductor increases with increase in temperature.
IV. The conductivity of a semiconductor increases with increase in temperature.
(a) I and II only (b) I and III only
(c) I, II and IV (d) I, II, III and IV

**77.** Which of the following statements is/are correct ?
I. Pure Si doped with trivalent impurities gives a p-type semiconductor
II. Majority carriers in a n-type semiconductor are holes
III. Minority carriers in a p-type semiconductor are electrons
IV. The resistance of intrinsic semiconductor decreases with increase of temperature
(a) I only (b) I, III and IV
(c) I and IV (d) II only

**78.** In a n-type semiconductor, which of the following statements are incorrect?
I. Electrons are minority carriers and pentavalent atoms are dopants.
II. Holes are minority carriers and pentavalent atoms are dopants.
III. Holes are majority carriers and trivalent atoms are dopants.
IV Electrons are majority carriers and trivalent atoms are dopants.
(a) I and II (b) I, III and IV
(c) III and IV (d) I, II and III

**79.** In a solid-state semiconductor, the number of mobile charge carriers can be changed by
I. using light for excitation.
II. using heat for excitation.
III. using sound for excitation.
IV. using applied voltage for excitation.
(a) I, II, III and IV (b) I, II and IV
(c) I, II and III (d) I and II only

**80.** Which of these are used for doping?
I. A trivalent impurity.
II. A tetravalent impurity.
III. A pentavalent impurity.
IV. A monovalent impurity.
(a) I and II (b) II and IV
(c) II and III (d) I and III

**81.** Due to diffusion of electrons from *n* to *p*-side
I. electron hole combination across *p*-*n* junction occurs.
II. an ionised acceptor is left in the p-region.
III. an ionised donor is left in the n-region.
IV. electrons of n-sdie comes to p-side and electron-hole combination takes place in p-side
Select the correct option from the following.
(a) I and II (b) II and III
(c) II and IV (d) I, III and IV

**82.** Which of these are correct ?
I. In forward biasing holes from *p*-sdie crosses junction and reach *n*-side.
II. In forward biasing electrons from *n*-sdie crosses junction and reach *p*-side.
III. In *n*-side holes are minority carriers.
IV. In *p*-side electrons are minority carriers.
(a) I, II and III (b) I, III and IV
(c) II, III and IV (d) I, II, III and IV

**83.** For transistor action, which of the following statements are correct ?
I. Base emitter and collector region have similar size and doping concentrations.
II. The base must be very thin and lightly doped.
III. The emitter junction is forward biased and collector junction is reverse biased.
IV. Both emitter and collector junctions are forward biased.
(a) I and II (b) II and III
(c) III and IV (d) I and IV

## MATCHING TYPE QUESTIONS

**84.** Match the column I and Column II

| | **Column I** | | **Column II**<br>(Rnge of resistivity, ρ) |
|---|---|---|---|
| (A) | Metals | (1) | $10^{11} - 10^{19}\ \Omega$ m |
| (B) | Semiconductors | (2) | $10^{-5} - 10^{6}\ \Omega$ m |
| (C) | Insulators | (3) | $10^{-2} - 10^{-8}\ \Omega$ m |
| | | (4) | $10^{-20} - 10^{25}\ \Omega$ m |

(a) (A) → (3); (B) → (2); (C) → (1)
(b) (A) → (1,4); (B) → (2); (C) → (3)
(c) (A) → (1); (B) → (2); (C) → (3,4)
(d) (A) → (1); (B) → (2,4); (C) → (3)

**85.** Match the elements in column I, with their respective energy gaps in column II.

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Diamond | (1) | 1.1 ev |
| (B) | Aluminium | (2) | 0.71 ev |
| (C) | Germatium | (3) | 0.03 ev |
| (D) | Silicon | (4) | 6 ev |

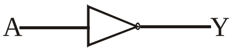
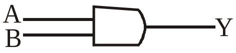
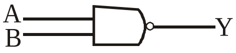
(a) (A) → (1); (B) → (2); (C) → (3); (D) → (4)
(b) (A) → (1); (B) → (2); (C) → (2); (D) → (3)
(c) (A) → (4); (B) → (2); (C) → (3); (D) → (1)
(d) (A) → (4); (B) → (3); (C) → (2); (D) → (1)

**86.**

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Moderate size and heavily doped | (1) | Base |
| (B) | Very thin and lightly doped | (2) | Collector |
| (C) | Moderately doped and of large size | (3) | Emitter |
| (D) | Dopped with penta valent impurity | (4) | N-type semmiconductor |

(a) (A) → (2); (B) → (1); (C) → (4); (D) → (3)
(b) (A) → (1); (B) → (2); (C) → (4); (D) → (3)
(c) (A) → (3); (B) → (1); (C) → (2); (D) → (4)
(d) (A) → (2); (B) → (1); (C) → (3); (D) → (4)

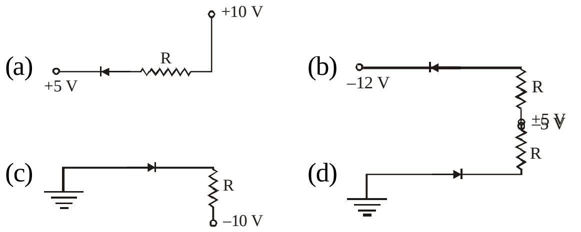
**87.**

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | OR gate | (1) |  |
| (B) | AND gate | (2) |  |
| (C) | NOT gate | (3) |  |
| (D) | NAND gate | (4) |  |

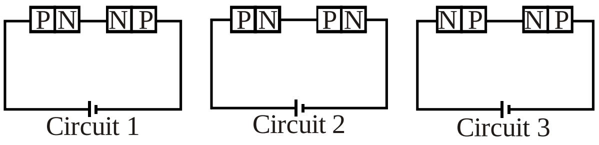
(a) (A) → (3); (B) → (2); (C) → (1); (D) → (4)
(b) (A) → (1); (B) → (2); (C) → (4); (D) → (3)
(c) (A) → (3); (B) → (1); (C) → (2); (D) → (4)
(d) (A) → (2); (B) → (1); (C) → (3); (D) → (4)

## DIAGRAM TYPE QUESTIONS

**88.** Of the diodes shown in the following diagrams, which one is reverse biased ?



**89.** Two identical pn junctions may be connected in series, with a battery in three ways as shown in figure. The potential drops across the two pn junctions are equal in



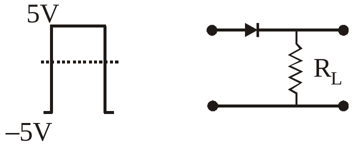
(a) circuit 1 and circuit 2

(b) circuit 2 and circuit 3

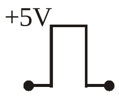
(c) circuit 3 and circuit 1

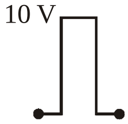
(d) circuit 1 only

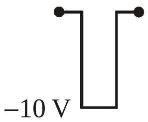
**90.** If in a p-n junction diode, a square input signal of 10 V is applied as shown

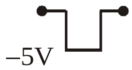


Then the output signal across $R_L$ will be

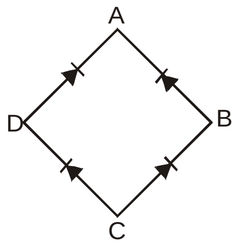
(a)


(b)


(c)


(d)


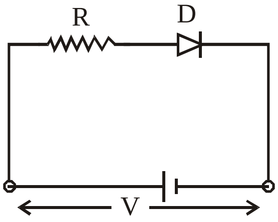
**91.** In bridge rectifier circuit, (see fig.), the input signal should be connected between



(a) A and D (b) B and C

(c) A and C (d) B and D

**92.** A d.c. battery of V volt is connected to a series combination of a resistor R and an ideal diode D as shown in the figure below. The potential difference across R will be



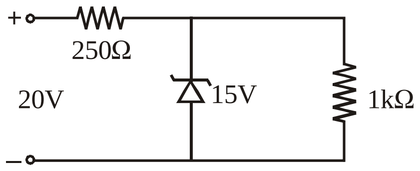
(a) 2V when diode is forward biased

(b) zero when diode is forward biased

(c) V when diode is reverse biased

(d) V when diode is forward biased

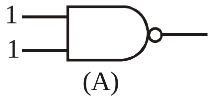
**93.** A zener diode, having breakdown voltage equal to 15V, is used in a voltage regulator circuit shown in figure. The current through the diode is

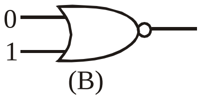


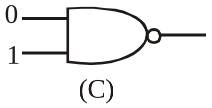
(a) 10 mA (b) 15 mA

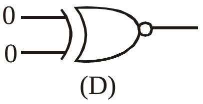
(c) 20 mA (d) 5 mA

**94.** Which of the following gates will have an output of 1?





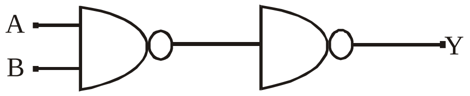




(a) D (b) A

(c) B (d) C

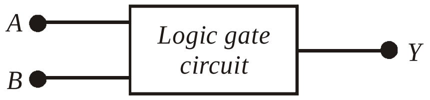
**95.** Following diagram performs the logic function of

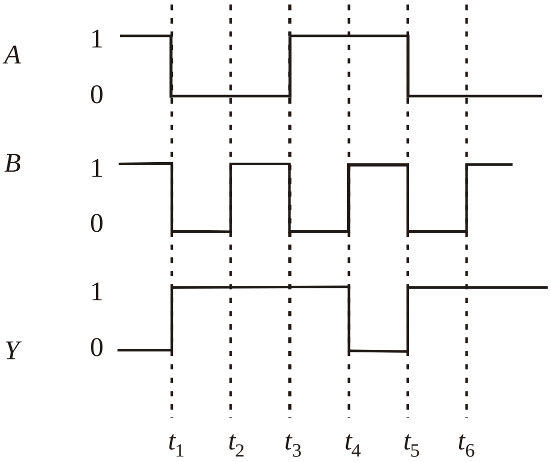


(a) XOR gate (b) AND gate

(c) NAND gate (d) OR gate

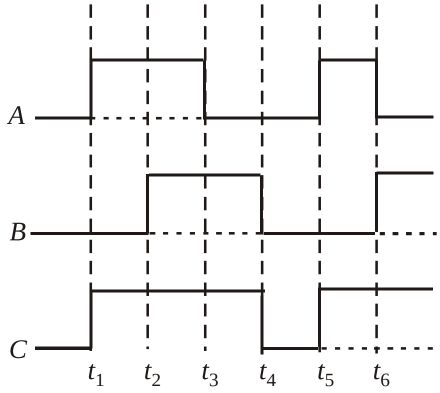
**96.** The following figure shows a logic gate circuit with two inputs *A* and *B* and the output *Y*. The voltage waveforms of A, B and Y are given. The logic gate is





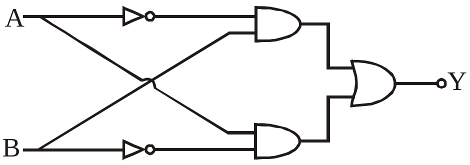
(a) NAND (b) NOR
(c) XOR (d) OR

**97.** The figure shows a logic circuit with two inputs *A* and *B* and the output *C*. The voltage wave forms across *A*, *B* and *C* are as given. The logic gate circuit is:



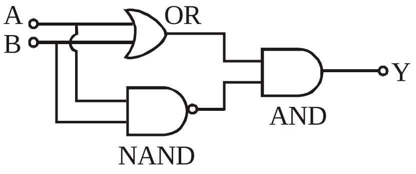
(a) OR gate (b) NOR gate
(c) AND gate (d) NAND gate

**98.** The following circut represents



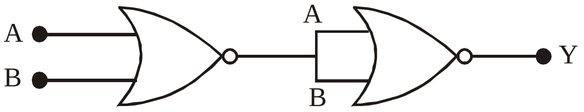
(a) OR gate (b) XOR gate
(c) AND gate (d) NAND gate

**99.** The following configuration of gate is equivalent to



(a) NAND gate (b) XOR gate
(c) OR gate (d) NOR gate

**100.** In the following circuit, the output Y for all possible inputs A and B is expressed by the truth table.



(a)

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

(b)

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

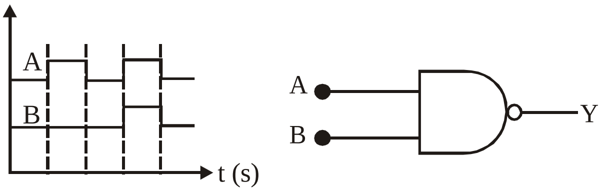
(c)

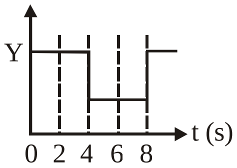
| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

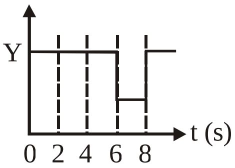
(d)

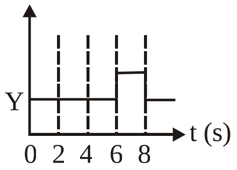
| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

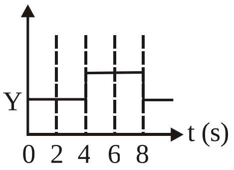
**101.** The real time variation of input signals A and B are as shown below. If the inputs are fed into NAND gate, then select the output signal from the following.



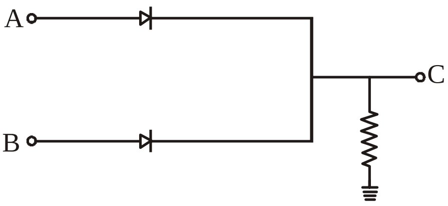
(a)


(b)


(c)


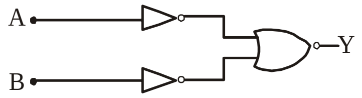
(d)


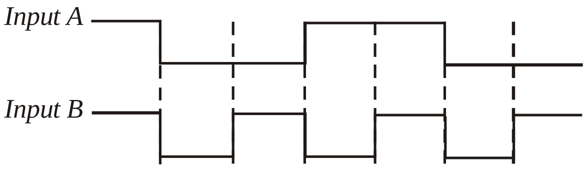
**102.** In the circuit below, A and B represent two inputs and C represents the output.



The circuit represents
(a) NOR gate (b) AND gate
(c) NAND gate (d) OR gate

**103.** The logic circuit shown below has the input waveforms '*A*' and '*B*' as shown. Pick out the correct output waveform.

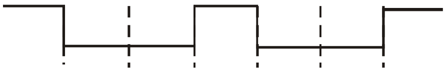


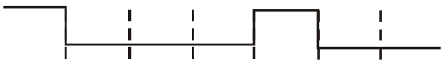


Output is

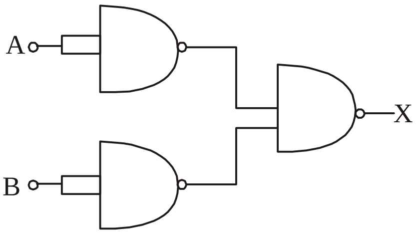
(a)


(b)


(c)


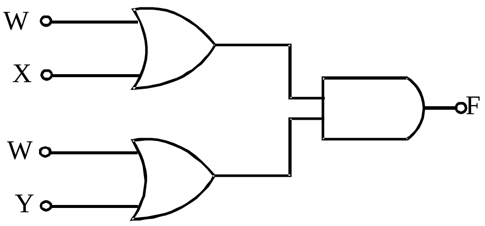
(d)


**104.** The combination of gates shown below yields



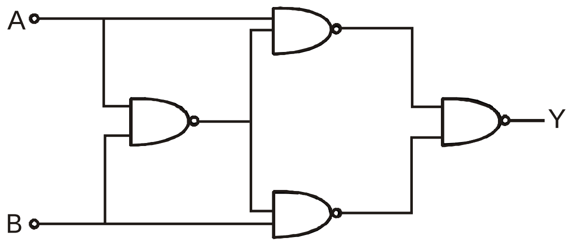
(a) OR gate (b) NOT gate
(c) XOR gate (d) NAND gate

**105.** The diagram of a logic circuit is given below. The output F of the circuit is represented by



(a) W . (X + Y) (b) W . (X . Y)
(c) W + (X . Y) (d) W + (X + Y)

**106.** Truth table for system of four NAND gates as shown in figure is



(a)

| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

(b)

| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

(c)

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

(d)

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

**107. Assertion :** A pure semiconductor has negative temperature coefficient of resistance.
**Reason :** In a semiconductor on raising the temperature, more charge carriers are released, conductance increases and resistance decreases.

**108. Assertion :** If the temperature of a semiconductor is increased then its resistance decreases.
**Reason :** The energy gap between conduction band and valence band is very small.

**109. Assertion :** In semiconductors, thermal collisions are respossible for taking a valence electron to the conduction band.
**Reason :** The number of conduction electrons go on increasing with time as thermal collisions continuously take place.

**110. Assertion :** A p-type semiconductors is a positive type crystal.
**Reason :** A p- type semiconductor is an uncharged crystal.

**111. Assertion :** Silicon is preferred over germanium for making semiconductor devices.
**Reason :** The energy gap in germanium is more than the energy gap in silicon.

**112. Assertion :** Electron has higher mobility than hole in a semiconductor.
**Reason :** The mass of electron is less than the mass of the hole.

**113. Assertion :** The number of electrons in a p-type silicon semiconductor is less than the number of electrons in a pure silicon semiconductor at room temperature.
**Reason :** It is due to law of mass action.

**114. Assertion :** When two semi conductor of *p* and *n* type are brought in contact, they form *p-n* junction which act like a rectifier.
**Reason :** A rectifier is used to convent alternating current into direct current.

**115. Assertion :** Diode lasers are used as optical sources in optical communication.
**Reason :** Diode lasers consume less energy.

**116. Assertion :** The diffusion current in a p-n junction is from the p-side to the n-side.
**Reason :** The diffusion current in a p-n junction is greater than the drift current when the junction is in forward biased.

**117. Assertion :** The drift current in a p-n junction is from the n-side to the p-side.
**Reason :** It is due to free electrons only.

**118. Assertion :** A p-n junction with reverse bias can be used as a photo-diode to measure light intensity.
**Reason :** In a reverse bias condition the current is small but it is more sensitive to changes in incident light intensity.

**119. Assertion :** A transistor amplifier in common emitter configuration has a low input impedence.
**Reason :** The base to emitter region is forward biased.

**120. Assertion :** NOT gate is also called invertor circuit.
**Reason :** NOT gate inverts the input order.

**121. Assertion :** NAND or NOR gates are called digital building blocks.
**Reason :** The repeated use of NAND (or NOR) gates can produce all the basis or complicated gates.

## CRITICAL THINKING TYPE QUESTIONS

**122.** Pure Si at 500K has equal number of electron ($n_e$) and hole ($n_h$) concentrations of $1.5 \times 10^{16}$ m$^{-3}$. Doping by indium increases $n_h$ to $4.5 \times 10^{22}$ m$^{-3}$. The doped semiconductor is of
(a) n–type with electron concentration $n_e = 5 \times 10^{22}$ m$^{-3}$
(b) p–type with electron concentration $n_e = 2.5 \times 10^{10}$ m$^{-3}$
(c) n–type with electron concentration $n_e = 2.5 \times 10^{23}$ m$^{-3}$
(d) p–type having electron concentration $n_e = 5 \times 10^{9}$ m$^{-3}$

**123.** On doping germanium with donor atoms of density $10^{17}$ cm$^{-3}$ its conductivity in mho/cm will be
[Given : $\mu_e = 3800$ cm$^2$/V–s and $n_i = 2.5 \times 10^{13}$ cm$^{-13}$]
(a) 30.4 (b) 60.8
(c) 91.2 (d) 121.6

**124.** The ratio of electron and hole currents in a semiconductor is 7/4 and the ratio of drift velocities of electrons and holes is 5/4, then the ratio of concentrations of electrons and holes will be
(a) 5/7 (b) 7/5
(c) 25/49 (d) 49/25

**125.** The intrinsic conductivity of germanium at 27° is 2.13 mho m$^{-1}$ and mobilities of electrons and holes are 0.38 and 0.18 m$^2$V$^{-1}$s$^{-1}$ respectively. The density of charge carriers is
(a) $2.37 \times 10^{19}$ m$^{-3}$ (b) $3.28 \times 10^{19}$ m$^{-3}$
(c) $7.83 \times 10^{19}$ m$^{-3}$ (d) $8.47 \times 10^{19}$ m$^{-3}$

**126.** What is the conductivity of a semiconductor if electron density = $5 \times 10^{12}$/cm$^3$ and hole density = $8 \times 10^{13}$/cm$^3$ ($\mu_e = 2.3$ m$^2$ V$^{-1}$ s$^{-1}$, $\mu_h = 0.01$ m$^2$V$^{-1}$ s$^{-1}$)
(a) 5.634 $\Omega^{-1}$ m$^{-1}$ (b) 1.968 $\Omega^{-1}$ m$^{-1}$
(c) 3.421 $\Omega^{-1}$ m$^{-1}$ (d) 8.964 $\Omega^{-1}$ m$^{-1}$

**127.** In a p-type semiconductor the acceptor level is situated 60 meV above the valence band. The maximum wavelength of light required to produce a hole will be
(a) $0.207 \times 10^{-5}$ m (b) $2.07 \times 10^{-5}$ m
(c) $20.7 \times 10^{-5}$ m (d) $2075 \times 10^{-5}$ m

**128.** If the ratio of the concentration of electrons to that of holes in a semiconductor is $\frac{7}{5}$ and the ratio of currents is $\frac{7}{4}$, then what is the ratio of their drift velocities?
(a) $\frac{5}{8}$ (b) $\frac{4}{5}$
(c) $\frac{5}{4}$ (d) $\frac{4}{7}$

**129.** In a p-n junction having depletion layer of thickness $10^{-6}$ m the potential across it is 0.1 V. The electric field is
(a) $10^7$ V/m (b) $10^{-6}$ V/m
(c) $10^5$ V/m (d) $10^{-5}$ V/m

**130.** In a reverse biased diode when the applied voltage changes by 1 V, the current is found to change by 0.5 μA. The reverse bias resistance of the diode is
(a) $2 \times 10^5$ Ω (b) $2 \times 10^6$ Ω
(c) 200 Ω (d) 2 Ω.

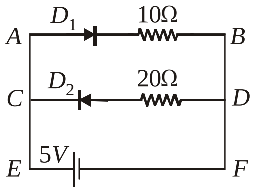
**131.** When the forward bias voltage of a diode is changed from 0.6 V to 0.7 V, the current changes from 5 mA to 15 mA. Then its forward bias resistance is
(a) 0.01 Ω (b) 0.1 Ω
(c) 10 Ω (d) 100 Ω

**132.** A diode having potential difference 0.5 V across its junction which does not depend on current, is connected in series with resistance of 20Ω across source. If 0.1 A current passes through resistance then what is the voltage of the source?
(a) 1.5 V (b) 2.0 V
(c) 2.5 V (d) 5 V

**133.** If the forward bias on p-n junction is increased from zero to 0.045 V, then no current flows in the circuit. The contact potential of junction i.e. $V_B$ is
(a) zero (b) 0.045 V
(c) more than 0.045 V (d) less than 0.045 V

**134.** The peak voltage in the output of a half-wave diode rectifier fed with a sinusoidal signal without filter is 10V. The d.c. component of the output voltage is
(a) 20/πV (b) 10/√2 V
(c) 10/πV (d) 10V

**135.** Two ideal diodes are connected to a battery as shown in the circuit. The current supplied by the battery is



(a) 0.75 A (b) zero
(c) 0.25 A (d) 0.5 A

**136.** In the half wave rectifier circuit operating from 50 Hz mains frequency, the fundamental frequency in the ripple would be

(a) 25 Hz (b) 50 Hz
(c) 70.7 Hz (d) 100 Hz

**137.** In a full wave rectifier circuit operating from 50 Hz mains frequency, the fundamental frequency in the ripple would be

(a) 25 Hz (b) 50 Hz
(c) 70.7 Hz (d) 100 Hz

**138.** A half-wave rectifier is being used to rectify an alternating voltage of frequency 50 Hz. The number of pulses of rectified current obtained in one second is

(a) 50 (b) 25
(c) 100 (d) 2000

**139.** For a transistor amplifier in common emitter configuration for load impedance of 1k $\Omega$ ($h_{fe} = 50$ and $h_{oe} = 25\mu s$) the current gain is

(a) – 24.8 (b) – 15.7
(c) – 5.2 (d) – 48.78

**140.** In a common base mode of a transistor, the collector current is 5.488 mA for an emitter current of 5.60 mA. The value of the base current amplification factor (β) will be

(a) 49 (b) 50
(c) 51 (d) 48

**141.** A transistor has a base current of 1 mA and emitter current 90 mA. The collector current will be

(a) 90 mA (b) 1 mA
(c) 89 mA (d) 91 mA

**142.** In a common emitter transistor amplifier $\beta = 60$, $R_o = 5000\ \Omega$ and internal resistance of a transistor is 500 Ω. The voltage amplification of amplifier will be

(a) 500 (b) 460
(c) 600 (d) 560

**143.** For a common base amplifier, the values of resistance gain and voltage gain are 3000 and 2800 respectively. The current gain will be

(a) 1.1 (b) 0.98
(c) 0.93 (d) 0.83

**144.** What is the voltage gain in a common emitter amplifier, where input resistance is 3 Ω and load resistance 24 Ω, β = 0.6 ?

(a) 8 . 4 (b) 4 . 8
(c) 2 . 4 (d) 480

**145.** The current gain of a transistor in common base mode is 0.995. The current gain of the same transistor in common emitter mode is

(a) 197 (b) 201
(c) 198 (d) 199

**146.** In a npn transistor $10^{10}$ electrons enter the emitter in $10^{-6}$ s. 4% of the electrons are lost in the base. The current transfer ratio will be

(a) 0.98 (b) 0.97
(c) 0.96 (d) 0.94

**147.** The transfer ratio β of transistor is 50. The input resistance of a transistor when used in C.E. (Common Emitter) configuration is 1kΩ. The peak value of the collector A.C current for an A.C input voltage of 0.01V peak is

(a) 100 μA (b) .01 mA
(c) .25 mA (d) 500 μA

**148.** In a transistor, the change in base current from 100 μA to 125 μA causes a change in collector current from 5 mA to 7.5 mA, keeping collector-to-emitter voltage constant at 10 V. What is the current gain of the transistor?

(a) 200 (b) 100
(c) 50 (d) 25

**149.** In common emitter amplifier, the current gain is 62. The collector resistance and input resistance are 5 kΩ an 500Ω respectively. If the input voltage is 0.01 V, the output voltage is

(a) 0.62 V (b) 6.2 V
(c) 62 V (d) 620 V

**150.** A common emitter amplifier has a voltage gain of 50, an input impedance of 100Ω and an output impedance of 200Ω. The power gain of the amplifier is

(a) 500 (b) 1000
(c) 1250 (d) 50

**151.** A transistor is operated in common emitter configuration at $V_C = 2V$ such that a change in the base current from 100 μA to 300 μA produces a change in the collector current from 10mA to 20 mA. The current gain is

(a) 50 (b) 75
(c) 100 (d) 25

**152.** In a *CE* transistor amplifier, the audio signal voltage across the collector resistance of 2kΩ is 2V. If the base resistance is 1kΩ and the current amplification of the transistor is 100, the input signal voltage is

(a) 0.1 V (b) 1.0 V
(c) 1mV (d) 10 mV

**153.** The input resistance of a silicon transistor is 100 W. Base current is changed by 40 $\mu A$ which results in a change in collector current by 2 mA. This transistor is used as a common emitter amplifier with a load resistance of 4 KΩ. The voltage gain of the amplifier is

(a) 2000 (b) 3000
(c) 4000 (d) 1000

**154.** In a common emitter (CE) amplifier having a voltage gain G, the transistor used has transconductance 0.03 mho and current gain 25. If the above transistor is replaced with another one with transconductance 0.02 mho and current gain 20, the voltage gain will be

(a) 1.5G (b) $\frac{1}{3}$G
(c) $\frac{5}{4}$G (d) $\frac{2}{3}$G

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1. (a)**

**2. (d)** In extrinsic semi conductor the number of holes are not equal to number of electrons i.e.,

$$n_h \neq n_e$$

In p - type $\quad n_h > n_e$

In n - type $\quad n_e > n_h$

**3. (c)** By doping, the band gap reduce from 1eV to 0.3 to 0.7 eV & electron can achieve this energy (0.3eV to 0.7eV) at room temperature & reach in C.B (conduction band).

**4. (c)** Electric conduction, in a semi conductors occurs due to both electrons & holes.

**5. (b)** **6. (d)**

**7. (b)** Resistivity of a semiconductor at room temp. is in between $10^{-5}\ \Omega m$ to $10^4\ \Omega m$ i.e. $10^{-3}$ to $10^6\ \Omega cm$

**8. (d)** The valency of semiconductor (Ge or Si) is four, hence it has 4 valence electrons in the outermost orbit of the Ge or Si-atom

**9. (c)**

**10. (b)** The forbidden energy gap for germanium crystal is 0.71 eV.

**11. (d)**

**12. (b)** The electrical conductivity of a semiconductor at 0 K is zero. Hence resistivity (= 1/electrical conductivity) is infinity.

**13. (d)** The temperature coefficient of resistance of a semiconductor is negative. It means that resistance decrease with increase of temperature.

**14. (a)** The acceptor valence band is close to the valence band of host crystal

**15. (c)** The donor valence band lies little below the conduction band of the host crystal

**16. (a)**

**17. (d)** For semiconductor, $n = AT^{3/2} e^{-\frac{E_g}{2KT}}$ ;

so $\quad n \propto T^{3/2}$

**18. (c)**

**19. (c)** Semiconductors are insulators at low temperature

**20. (c)** **21. (a)** **22. (a)**

**23. (c)** When small amount of antimony (pentavalent) is added to germanium crystal then crystal becomes n-type semi conductor. Therefore, there will be more free electrons than holes in the semiconductor.

**24. (c)** The resistivity of conductor increases with increase in temperature. The resistivity of semiconductor decreases as the temperature increases.

**25. (c)** Copper is a conductor so its resistance decreases on decreasing temperature as thermal agitation decreases whereas germanium is semiconductor therefore on decreasing temperature resistance increases.

**26. (a)** Due to strong electronegativity of carbon.

**27. (d)** **28. (a)** **29. (a)** **30. (b)** **31. (a)**

**32. (b)** Forward bias opposes the potential barrier and if the applied voltage is more than knee voltage it cancels the potential barrier.

**33. (a)** Leakage current is the name given to the reverse current.

**34. (b)** In the reverse biasing of p-n junction, the voltage applied supports the barrier voltage across junction, which increases the width of depletion layer and hence increases its resistance.

**35. (c)** Zener diode is used as a voltage regulator i.e. for stabilization purposes.

**36. (a)** filter circuit eliminates a.c. component of rectified voltage obtained from p-n junction as a rectifier.

**37. (d)** Current in junction diode, $I = I_0 (e^{eV/kT} - 1)$

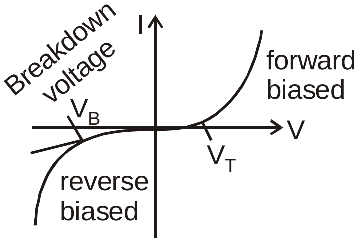
In forward biasing, V is positive ; In reverse bias V is negative. Then $I_r = I_0$

$$\frac{I_F}{I_r} = \frac{I_0 (e^{eV/kT} - 1)}{I_0} = (e^{eV/kT} - 1)$$

**38. (c)**

**39. (b)** For easy flow of current the P side must be connected to +ive terminal of battery i.e., it is connected to higher potential in comparison to N. This connection is called forward biased. In this case the input resistance is very low.

In reverse-biased, the P-side is connected to –ive terminal & N side to (+ive) terminal to battery. In this case input resistance is very high.



**40. (b)** Barrier potential depends on, doping density, temperature, forward/reverse bias but does not depend on diode design.

**41. (c)** In reverse biasing, the conduction across the p-n junction does not take place due to majority carriers, but takes place due to minority carriers if the voltage of external battery is large. The size of the depletion region increases thereby increasing the potential barrier.

**42. (d)** In forward biasing of the p-n junction, the positive terminal of the battery is connected to p-side and the negative terminal of the battery is connected to n-side. The depletion region becomes thin.

**43. (a)** Both the depletion region and barrier height are reduced.

**44. (d)** During the formation of a junction diode, holes from p-region diffuse into n-region and electrons from n-region diffuse into p-region. In both cases, when an electrons meets a hole, they cancel the effect at each other and as a result, a thin layer at the junction becomes free from any of charges carriers. This is called depletion layer. There is a potential gradient in the depletion layer, negative on the p-side, and positive on the n-side. The potential difference thus developed across the junction is called potential barrier.

**45. (d)** **46. (c)** **47. (a)**

**48. (a)** The average value of output direct current in a half wave rectifier is = (average value of current over a cycle)/2 = $(2\,I_0/\pi)/2 = I_0/\pi$

**49. (d)** The average value of output direct current in a full wave rectifier = average value of current over a cycle = $2\,I_0/\pi$

**50. (b)** The r.m.s. value of a.c. component of wave is more than d.c. value due to barrier voltage of p-n junction used as rectifier.

**51. (c)** In transistor base is least doped, so that most of electrons emitted (in case of npn) from emitter reach to collector & less number of electrons are destroyed due to recombination with holes in base.

**52. (d)** $\beta = \frac{I_c}{I_b} > 1$ or $I_c > I_b$

**53. (c)** $\alpha = \frac{I_c}{I_e} < 1$ or $I_c < I_e$

**54. (d)** Operating point of a transistor is zero signal value of $I_c$ and $V_{CE}$.

**55. (d)** A transistor is a current operating device in which the emitter current controls the collector current

**56. (c)** An amplifier can be both a single stage and multistage

**57. (d)** In common emitter circuit, the current gain is highest

**58. (d)** **59. (a)**

**60. (c)** The size (or length) of collector is large in comparison to emitter (base is very small in comarison to both collector & emitter) to dissipate the heat.

**61. (d)**

**62. (a)** Negative feed back to a transistor increases stability in the working of transistor.

**63. (a)**

**64. (d)** Zero; In common base amplifier circuit, input and output voltage are in the same phase.

**65. (b)**

**66. (a)** Metal oxides with high temperature coefficient of resistivity.

**67. (d)**

**68. (d)** The biasing of the transistor is done differently for different uses. The transistor works as an amplifier with its emitter-base junction forward biased and the base-collector junction reverse biased.

**69. (d)** Holes move from base to emmitter.

**70. (a)** **71. (b)** **72. (a)**

**73. (d)** Relation between A, B and C shows that $C = \overline{AB}$
So NAND Gate

**74. (d)** The given truth table is for NAND gate.

**75. (b)** Combination of NAND & NOR gates can produce OR, AND & NOT gates

## STATEMENT TYPE QUESTIONS

**76. (c)**

**77. (b)** Majority carriers in an n-type semiconductor are electrons.

**78. (b)** In a n-type semiconductor holes are minority carriers and pentavalent atoms are dopants.

**79. (b)** Simple excitations like light, heat or small applied voltage can change the number of mobile charges in a semiconductor. In general energy of sound is not sufficient to excite electrons.

**80. (d)** A necessary condition to attain this is that the sizes of the dopant and the semiconductor atoms should be nearly the same.

There are two types of dopants used in doping the tetravalent Si or Ge :

(i) Pentavalent (valency 5) like Arsenic (As), Antimony (Sb), Phosphorous (P), etc.

(iii) Trivalent (valency 3) like Indium (In), Boron (B) , Aluminium (Al), etc.

**81. (d)** When an electlron diffuses from $n \to$ P, it leaves behind an ionised donor (species which has becomes ion by donating electron) on *n*-side. This ionised donor (positive charge) is immobile as it is bonded to the surrounding atoms. As the electrons continue to diffuse from *n*-P, a layer of positive charge (or positive space-charge region) on n-side of the juction is developed. On P-side atom receiving electrons is ionised acceptor.

**82. (d)** In forward biasing due to the applied voltage, electrons from n-sdie cross the depletion region and reach P-side (where they are minority carriers).

**83. (b)** Base of a transistor is thin and lightly doped, base-emitter region is in forward biased whereas collector is in reverse biased.

## MATCHING TYPE QUESTIONS

**84. (a)** (A) → (3); (B) → (2); (C) → (1)

**85. (d)** (A) → (4); (B) → (3); (C) → (2); (D) → (1)

**86. (c)** (A) → (3); (B) → (1); (C) → (2); (D) → (4)

**87. (b)** (A) → (3); (B) → (2); (C) → (1); (D) → (4)

## DIAGRAM TYPE QUESTIONS

**88. (d)** Positive terminal is at lower potential (0V) and negative terminal is at higher potential 5V.

**89. (b)** In circuit 2, each p-n junction is forward biased, hence same current flows giving same potential difference across p-n junction.

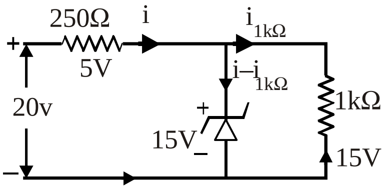
In circuit 3, each p-n junction is reverse biased, and due to the flow of same leakage current, giving equal potential difference across p-n junction.

**90. (a)** The current will flow through $R_L$ when the diode is forward biased.

**91. (d)** The input signal should be connected between two points of bridge rectifier such that in positive half wave of input signal, one p-n junction should be forward biased and other should be reverse biased and in negative half wave of input signal, the reverse should take place. It will be so when input is connected between B and D.

**92. (d)** In forward biasing, the diode conducts. For ideal junction diode, the forward resistance is zero; therefore, entire applied voltage occurs across external resistance R i.e., there occur no potential drop, but potential across R is V in forward biased.

**93. (d)** Voltage across zener diode is constant.



Current in 1kΩ resistor,

$$(i)_{1k\Omega}=\frac{15\text{volt}}{1k\Omega}=15\,mA$$

Current in 250Ω resistor,

$$(i)_{250\Omega}=\frac{(20-15)V}{250\Omega}=\frac{5V}{250\Omega}$$

$$=\frac{20}{1000}A=20\,mA$$

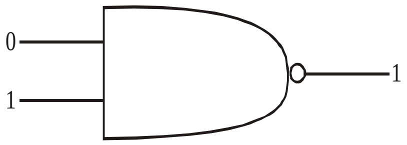
$$\therefore\ (i)_{\text{zener diode}}=(20-15)=5\,mA.$$

**94. (d)** (A) is a NAND gate so output is $\overline{1\times1}=\bar{1}=0$

(B) is a NOR gate so output is $\overline{0+1}=\bar{1}=0$

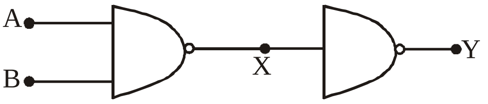
(C) is a NAND gate so output is $\overline{0\times1}=\bar{0}=1$

(D) is a XOR gate so output is $0\oplus0=0$



Following is NAND Gate $Y=\overline{AB}$

**95. (b)**



$X=\overline{AB}$

$\therefore Y=\overline{X}=\overline{\overline{AB}}$

Y = AB by Demorgan theorem

$\therefore$ This diagram performs the function of AND gate.

**96. (a)** From the given waveforms, the truth table is as follows.

| *A* | *B* | *Y* |
|---|---|---|
| 1 | 1 | 0 |
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |

The above truth table is for NAND gate.

Therefore, the logic gate is NAND gate.

**97. (a)**

| | | | | |
|---|---|---|---|---|
| A | 0 | 1 | 1 | 0 |
| B | 0 | 0 | 1 | 1 |
| C | 1 | 1 | 1 | 1 |

OR gate

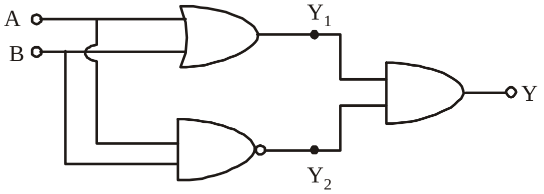
**98. (b)** Output of upper AND gate = $\bar{A}B$

Output of lower AND gate = $A\bar{B}$

$\therefore$ Output of OR gate, $Y=A\bar{B}+B\bar{A}$

This is boolean expression for XOR gate.

**99. (b)**



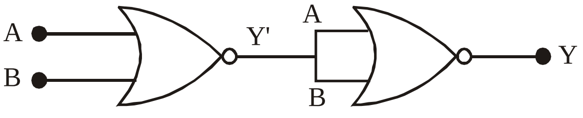
$$Y_1=A+B,\ Y_2=\overline{A.B}$$

$$Y=(A+B)\bullet\overline{AB}=A\bullet\bar{A}+A\bullet\bar{B}+B\bullet\bar{A}+B\bullet\bar{B}$$

$$=0+A\bullet\bar{B}+B\bullet\bar{A}+0=A\bullet\bar{B}+B\bullet\bar{A}$$

This expression is for XOR

**100. (c)**



$Y'=\overline{A+B}.\quad Y=\overline{\overline{A+B}}=A+B.$

Truth table of the given circuit is given by

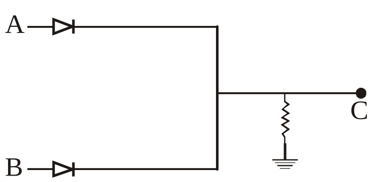
| A | B | Y' | Y |
|---|---|---|---|
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 1 |
| 1 | 0 | 0 | 1 |
| 1 | 1 | 0 | 1 |

**101. (b)** From input signals, we have,

| A | B | Output NAND gate |
|---|---|---|
| 0 | 0 | 1 |
| 1 | 0 | 1 |
| 0 | 0 | 1 |
| 1 | 1 | 0 |
| 0 | 0 | 1 |

The output signal is shown at B.

**102. (d)**



The truth table for the above logic gate is :

| A | B | C |
|---|---|---|
| 1 | 1 | 1 |
| 1 | 0 | 1 |
| 0 | 1 | 1 |
| 0 | 0 | 0 |

This truth table follows the boolean algebra

C = A + B which is for OR gate

**103. (d)** Here $Y = (\overline{\overline{A} + \overline{B}}) = \overline{\overline{A}}.\overline{\overline{B}} = A \cdot B$. Thus it is an AND gate for which truth table is

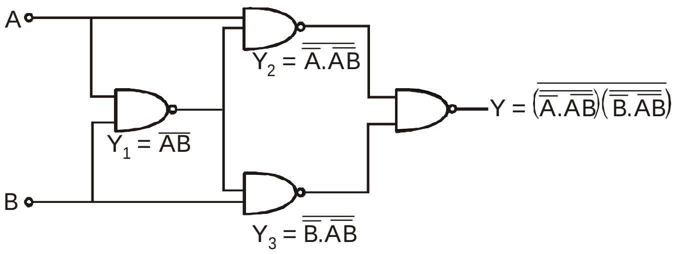
| $A$ | $B$ | $Y$ |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

**104. (a)** The final boolean expression is,

$$X = \overline{\left(\overline{A}.\overline{B}\right)} = \overline{\overline{A}} + \overline{\overline{B}} = A + B \Rightarrow \text{OR gate}$$

**105. (c)** (W + X) . (W + Y) = W + (X . Y)

**106. (a)**



By expanding this Boolen expression

$$Y = A.\overline{B} + B.\overline{A}$$

Thus the truth table for this expression should be (a).

## ASSERTION- REASON TYPE QUESTIONS

**107. (a)** In semiconductors, by increasing temperature, covalent bond breaks and conduction hole and electrons increase.

**108. (a)** In semiconductors the energy gap between conduction band and valence band is small (≈1 eV). Due to temperature rise, electron in the valence band gain thermal energy and may jumpy across the small energy gap, (to the conduction band). Thus conductivity increases and hence resistance decreases.

**109. (c)**

**110. (d)** There is no charge on P-type semiconductor, because each atom of semiconductor is itself neutral.

**111. (c)** Silicon is cheaper than germanium, so it is preferred over germanium. But energy gap in germanium is smaller than silicon.

**112. (a)** **113. (a)**

**114. (b)** Study of junction diode characteristics shows that the junction diode offers a low resistance path, when forward biased and high resistance path when reverse biased. This feature of the junction diode enables it to be used as a rectifier.

**115. (c)** Statement - 1 is True, Statement- 2 is False

**116. (b)** Diffusion current is due to the migration of holes and electrons into opposite regions, so it will be from p-side to n-side. Also in forward bias it will increases.

**117. (a)** **118. (a)**

**119. (a)** Input impedance of common emitter configuration.

$$= \left|\frac{\Delta V_{BE}}{\Delta i_B}\right|_{V_{CE} = \text{constant}}$$

where $\Delta V_{BE}$ = voltage across base and emitter (base emitter region is forward biased)

$\Delta i_B$ = base current which is order of few microampere.

**120. (a)** A NOT gate puts the input condition in the opposite order, means for high input it give low output and for low input it give high output. For this reason NOT gate is known as invertor circuit.

**121. (a)** These gates are called digital building blocks because using these gates only (either NAND or NOR) we can compile all other gates also (like OR, AND, NOT, XOR)

## CRITICAL THINKING TYPE QUESTIONS

**122. (d)** $n_i^2 = n_e n_h$

$(1.5\times10^{16})^2 = n_e(4.5\times10^{22})$

$\Rightarrow \quad n_e = 0.5\times10^{10}$

or $\quad n_e = 5\times10^{9}$

Given $\quad n_h = 4.5\times10^{22}$

$\Rightarrow n_h >> n_e$

$\therefore$ Semiconductor is p-type and

$n_e = 5\times10^{9}\,\text{m}^{-3}$.

**123. (b)** Conductivity $\sigma = n_i e\mu_e = 10^{17}\times(1.6\times10^{-19})\times3800$

= 60.8 mho/cm

**124. (b)** $I = nA\,ev_d$ or $I \propto nv_d$

$$\therefore \quad \frac{I_e}{I_h}=\frac{n_e v_e}{n_h v_h} \text{ or } \frac{n_e}{n_h}=\frac{I_e}{I_h}\times\frac{v_h}{v_e}=\frac{7}{4}\times\frac{4}{5}=\frac{7}{5}$$

**125. (a)** Conductivity, $\sigma=\frac{1}{\rho}=e(n_e\mu_e+n_h\mu_h)$

ie, $2.13 = 1.6\times10^{-19}(0.38+0.18)\,n_i$

(Since in intrinsic semi-conductor, $n_e = n_h = n_i$)

$\therefore$ density of charge carriers, $n_i$

$$=\frac{2.13}{1.6\times10^{-19}\times0.56}=2.37\times10^{19}\,\text{m}^{-3}$$

**126. (b)** Given : $\mu_e = 2.3\,\text{m}^2\,\text{V}^{-1}\,\text{s}^{-1}$

$\mu_h = 0.01\,\text{m}^2\,\text{V}^{-1}\,\text{s}^{-1}$, $n_e = 5\times10^{12}/\text{cm}^3$

$= 5\times10^{18}/\text{m}^3$ $n_h = 8\times10^{13}/\text{cm}^3 = 8\times10^{19}/\text{m}^3$.

Conductivity $\sigma = e[n_e\mu_e + n_h\mu_h]$

$= 1.6\times10^{-19}[5\times10^{18}\times2.3 + 8\times10^{19}\times0.01]$

$= 1.6\times10^{-1}[11.5+0.8]$

$= 1.6\times10^{-1}\times12.3 = 1.968\,\Omega^{-1}\,\text{m}^{-1}$.

**127. (b)** $$\lambda=\frac{hc}{E}=\frac{6.62\times10^{-34}\times3\times10^{8}}{(60\times10^{-3}\times1.6\times10^{-19})}=2.07\times10^{-5}\text{ m}$$

**128. (c)** $$\frac{I_e}{I_h}=\frac{n_e eAv_e}{n_h eAv_h}\Rightarrow\frac{7}{4}=\frac{7}{5}\times\frac{v_e}{v_h}$$

$$\Rightarrow\frac{v_e}{v_h}=\frac{5}{4}$$

**129. (c)** $$E=\frac{V}{d}=\frac{0.1}{10^{-6}}=10^{5}\,\text{V/m}$$

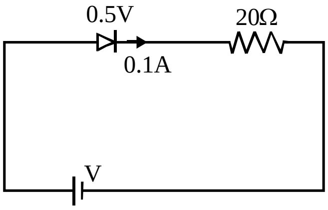
**130. (b)** Reverse resistance

$$=\frac{\Delta V}{\Delta I}=\frac{1}{0.5\times10^{-6}}=2\times10^{6}\,\Omega$$

**131. (c)** Forward bias resistance $=\frac{\Delta V}{\Delta I}$

$$=\frac{(0.7-0.6)V}{(15-5)\text{mA}}=\frac{0.1}{10\times10^{-3}}=10\,\Omega.$$

**132. (c)** $V' = V + IR = 0.5 + 0.1\times20 = 2.5\,V$



**133. (c)** When no current flows at the junction plane, then contact potential of junction plane is equal to the forward voltage applied = 0.045 V

**134. (c)** $$V=\frac{V_o}{\pi}=\frac{10}{\pi}V$$

**135. (d)** Here $D_1$ is in forward bias and $D_2$ is in reverse bias so, $D_1$ will conduct and $D_2$ will not conduct. Thus, no current will flow through *DC*.

$$I=\frac{V}{R}=\frac{5}{10}=\frac{1}{2}\text{Amp.}$$

**136. (b)** In half wave rectifier, we get the output only in one half cycle of input a.c. therefore, the frequency of the ripple of the output is same as that of input a.c. i.e. 50 Hz

**137. (d)** In full wave rectifier, we get the output for the positive and negative cycle of input a.c. Hence the frequency of the ripple of the output is twice than that of input a.c. i.e. 100 Hz

**138. (b)** In half wave rectifier only half of the wave is rectified

**139. (d)** In common emitter configuration current gain

$$A_i=\frac{-h_{fe}}{1+h_{oe}R_L}=\frac{-50}{1+25\times10^{-6}\times1\times10^{3}}=-48.78$$

Where $h_{fe}$= forward current ratio

$h_{oe}$= output admittance.

**140. (a)** $I_C = 5.488$ mA, $I_e = 5.6$ mA

$$\alpha=\frac{5.488}{5.6},\ \beta=\frac{\alpha}{1-\alpha}=49$$

**141. (c)** $I_C = I_E - I_B = 90 - 1 = 89$ m A

**142. (c)** Voltage amplification $A_v=\beta\frac{R_o}{R_i}=60\times\frac{5000}{500}=600$

**143. (c)** Current gain, $\alpha=\frac{A_V}{A_R}=\frac{2800}{3000}=0.93$

**144. (b)** Voltage gain, $A_v=\beta\frac{R_L}{R_i}=0.6\times\frac{24}{3}=4.8$

**145. (d)** Current gain in common emitter mode

$$=\frac{\alpha}{1-\alpha}=\frac{0.995}{1-0.995}=\frac{0.995}{0.005}=199.$$

**146. (c)** No. of electrons reaching the collector,

$$n_C = \frac{96}{100} \times 10^{10} = 0.96 \times 10^{10}$$

Emitter current, $I_E = \frac{n_E \times e}{t}$

Collector current, $I_C = \frac{n_C \times e}{t}$

$\therefore$ Current transfer ratio,

$$\alpha = \frac{I_C}{I_E} = \frac{n_C}{n_E} = \frac{0.96 \times 10^{10}}{10^{10}} = 0.96$$

**147. (d)** $i_B = \frac{V_s}{R_{in}} = \frac{0.01}{10^3} = 1 \times 10^{-5}\,A$

Now β of transistor is defined as $\beta_{ac} = \frac{i_c}{i_b}$

or $i_c = 50 \times 10^{-5} = 500\mu A$ ]

**148. (b)** Current gain $= \frac{\Delta I_C}{\Delta I_B}$ when $V_{CE}$ is constant.

$$= \frac{2.5 \times 10^{-3}}{25 \times 10^{-6}} = 0.1 \times 10^3 = 100$$

$[\Delta I_B = 125\,\mu A - 100\,\mu A = 25\,\mu A$

$\Delta I_C = 7.5\,mA - 5\,mA = 2.5\,mA]$

**149. (b)** $\frac{V_o}{V_{in}} = \frac{R_o}{R_{in}} \times \beta = \frac{5 \times 10^3 \times 62}{500} = 10 \times 62 = 620$

$V_o = 620 \times V_{in} = 620 \times 0.01 = 6.2\,V$

$\therefore V_o = 6.2$ volt.

**150. (c)** Power gain = voltage gain × current gain

$$= V_G \cdot I_G = \frac{V_0}{V_i} \cdot \frac{I_0}{I_i}$$

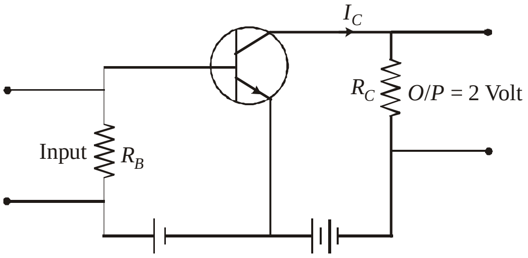
$$= \frac{V_0^2}{V_i^2} \cdot \frac{R_i}{R_0} = 50 \times 50 \times \frac{100}{200}$$

$$= \frac{2500}{2} = 1250$$

**151. (a)** The current gain

$$\beta = \frac{\Delta I_C}{\Delta I_B} = \frac{10mA}{200\mu A} = \frac{10 \times 10^3}{200} = 50$$

**152. (d)**



The output voltage, across the load $R_C$

$V_0 = I_C R_C = 2$

The collector current ($I_C$)

$$I_C = \frac{2}{2 \times 10^3} = 10^{-3}\text{ Amp}$$

Current gain (β)

(β) current gain $= \frac{I_C}{I_B} = 100$

$$I_B = \frac{I_C}{100} = \frac{10^{-3}}{100} = 10^{-5}\text{ Amp}$$

Input voltage ($V_i$)

$V_i = R_B I_B = 1 \times 10^3 \times 10^{-5} = 10^{-2}$ Volt

$V_i = 10\,mV$

**153. (a)** Voltage gain $(A_V) = \frac{V_{out}}{V_{in}} = \frac{I_{out}}{I_{in}} \times \frac{R_{out}}{R_{in}}$

$$A_V = \frac{2 \times 10^{-3}}{40 \times 10^{-6}} \times \frac{4 \times 10^3}{100} = 2 \times 100 = 2000$$

**154. (d)** Voltage gain $\Delta_V = \beta\,\frac{R_{out}}{R_{in}}$

$\Rightarrow G = 25\,\frac{R_{out}}{R_{in}}$ ...(i)

Transconductance $g_m = \frac{\beta}{R_{in}}$

$\Rightarrow R_{in} = \frac{\beta}{g_m} = \frac{25}{0.03}$

Putting this value of $R_{in}$ in eqn. (i)

$G = 25\,\frac{R_{out}}{25} \times 0.03$ ...(ii)

$\therefore$ $G' = 20\,\frac{R_{out}}{20} \times 0.02$ ...(iii)

From eqs. (ii) and (iii)

Voltage gain of new transistor $G' = \frac{2}{3}\,G$

## CHAPTER
## 30

# COMMUNICATION SYSTEMS

## FACT/DEFINITION TYPE QUESTIONS

**1.** Communication is the process of
(a) keeping in touch
(b) exchange information
(c) broad casting
(d) entertainment by electronics

**2.** Which of the following is the element of a communication system?
(a) Transmitter (b) channel
(c) Receiver (d) All of the above

**3.** Telephony is an example of ________ mode of communication
(a) point-to-point (b) broadcast
(c) both (a) and (b) (d) None of these

**4.** A transducer used at the transmitting end, serves the purpose of converting
(a) electrical signal to sound form
(b) sound signal to electrical form
(c) electrical signal to magnetic form
(d) sound signal to magnetic form

**5.** During the process of transmission and reception the signal gets deteriorated due to
(a) noise introduced in the system
(b) distortion in the system
(c) both (a) and (b)
(d) neigher (a) nor (b)

**6.** Reception of information involves
(a) decoding of signal (b) storage of signal
(c) interpretation of signal (d) All of the above

**7.** The term channel is used to indicate
(a) the amplitude range allocated to a given source
(b) the frequency range allocated to a given source
(c) the voltage-range allocated to a given source
(d) All of the above

**8.** Buffer amplifier is used at the transmitting end to
(a) feed carrier frequency to master oscillator
(b) amplify carrier frequency
(c) mix modulating signal with carrier frequency
(d) isolate master oscillator from other stages of transmitter.

**9.** The purpose of a detector at the receiving end is
(a) to amplify signal
(b) to reduce its frequency level
(c) to modulate signal
(d) to demodulate signal

**10.** The phenomenon by which light travels in an optical fibres is
(a) reflection (b) refraction
(c) rotal internal reflection (d) transmission

**11.** The purpose of ...*A*... is to convert the message signal produced by the source of information into a form suitable for transmission through the ...*B*... Here, *A* and *B* refer to
(a) channel, transmitter (b) transmitter, channel
(c) receiver, transmitter (d) receiver, channel

**12.** Range of communication is extended by using
(a) transmitter (b) transducer
(c) processor (d) repeater

**13.** Modem is a short form of
(a) modulator-demodulator
(b) multiplexer-demultiplexer
(c) multivibrator-degenerator
(d) None of these

**14.** Optical fibre are used for long distance communication because
(a) it amplifies signals to be transmitted
(b) it transfer signals faster than electrical cables
(c) it pre-emphasise weak signals
(d) it provide little attenuation as compared to electrical cable for light propagation

**15.** If the output of the information source is a non-electrical signal like a voice signal, a ...*A*... converts it to ...*B*.. form before giving it as an input to the ...*C*... . Here, *A*, *B* and *C* refer to
(a) receiver, electrical, channel
(b) channel, magnetic, transducer
(c) transducer, electrical, channel
(d) transducer, electrical, transmitter

**16.** For transmission of speeches, talks, music, dramas etc-------- is used
(a) radio broadcast transmitter
(b) radio telegraph transmitter
(c) navigation transmitter
(d) None of these

**17.** Electromagnetic waves of audible frequency ranges from
(a) 10 Hz to 10,000 Hz (b) 20 Hz to 20,000 Hz
(c) 30 Hz to 30,000 Hz (d) None of these.

**18.** E.m.wave of audible frequency cannot be directly propagated over a long distance because
(a) they have vary small energy content
(b) the length of antenna required for transmission of these wave is too large
(c) both ( a) and (b)
(d) neither (a) nor (b)

**19.** There is a need of translating the information contained in our original low frequency baseband signal into ...*X*... or ...*X*... frequencies before transmission . Here, *X* and *Y* refere to
(a) low, radio (b) high, radio
(c) low, audio (d) high, video

**20.** Bandwidth of optical fibre communication is
(a) $10^6$ to $10^9$ Hz (b) $10^{13}$ to $10^{15}$ Hz
(c) $10^9$ to $10^{11}$ Hz (d) none of these

**21.** Ground wave propagation is possible for
(a) low radio frequency over a short range
(b) high radio frequency over a short range
(c) high radio frequency over a long range
(d) low radio frequency over a short range.

**22.** Long range transmission of TV-signal is done by
(a) space-wave (b) sky waves
(c) ground wave (d) artificial satellite.

**23.** Which mode of communication is most suitable for carrier wave of frequencies around 100 MHz?
(a) Satellite (b) Ground wave
(c) Line of sight (d) Ionospheric

**24.** Communication on ground is through electromagnetic waves of wavelength
(a) larger than 600 m
(b) between 200 and 600 m
(c) between 1 and 5 m
(d) between $10^{-3}$ and 0.1

**25.** Ground waves are polarised
(a) parallel to the earth's surface
(b) normal to the earth's surface
(c) at an angle 45° from earth's surface
(d) in any direction.

**26.** Field strength of tropospheric TV signal is proportional to
(a) $\frac{1}{\lambda}$ (b) $\lambda$ (c) $\frac{1}{\lambda^2}$ (d) $\lambda^2$

**27.** Long distance short-wave radio broadcasting uses
(a) ground wave (b) ionospheric wave
(c) direct wave (d) sky wave

**28.** Space wave communication is limited
(a) to the line of sight distance
(b) by earth’s curvature
(c) either (a) or (b)
(d) both (a) and (b)

**29.** Sky wave propagation is not possible for frequencies
(a) equal to 30 MHz (b) less than 30 MHz
(c) greater than 30 MHz (d) None of these

**30.** In sky-wave propagation, skip-distance depends on
(a) frequency of e.m. waves transmitted
(b) critical frequency of the layer
(c) height of layer above earth’s surface
(d) all of the above

**31.** Ionosphere as a whole is
(a) +vely charges (b) –vely charges
(c) electrically neutral (d) can't say

**32.** During ground wave propagation the transmitted waves gets attenuated because
(a) earth surface absorbs the waves
(b) frequency of the waves are too low
(c) energy content of these waves are high
(d) earth surface offers resistance.

**33.** Long range propagation is not possible by space wave propagation because
(a) height of troposhere is quite small
(b) height of troposhere is large
(c) troposphere absorbs transmitted wave
(d) None of these.

**34.** Sky wave propagation is not possible for waves of frequency > 30 MHz because
(a) these waves do not have much energy to reach ionosphere
(b) they are not reflected by ionosphere
(c) they get absorbed by troposphere
(d) they get reflected by stratosphere

**35.** Intensity of electric field obtained at receiver antenna for a space wave propagation is
(a) directly proportional to the perpendicular-distance from transmitter to antenna
(b) inversely proportional to the perpendicular-distance from transmitter to antenna
(c) directly proportional to the square perpendicular-distance from transmitter to antenna
(d) inversely proportional to the square perpendicular-distance from transmitter to antenna

**36.** Critical frequency that gets reflected back from ionosphere is
(a) same for all layers of the ionosphere
(b) different for different layers of the ionosphere
(c) not dependent on layers of the ionosphere
(d) None of these

**37.** The electron density in all the layers of ionosphere
(a) is the same
(b) decreases with altitude
(c) increases with altitude
(d) sometimes decreases sometimes increases

**38.** Encoding of signal is required for
(a) modulation at transmitting end
(b) modulation at receiving end
(c) demodulation at receiving end
(d) demodulation at transmitting end

**39.** For transmission of e.m.wave of audible frequency, these waves are superimposed with waves of
(a) frequency less than 20 Hz
(b) frequency less than 10 KHz.
(c) frequency in the audible range.
(d) radio-frequency.

**40.** Broadcasting antennas are generally
(a) omnidirectional type (b) vertical type
(c) horizontal type (d) None of these

**41.** In which of the following remote sensing technique is not used?
(a) Forest density (b) Pollution
(c) Wetland mapping (d) Medical treatment

**42.** For transmission of TV- signal, sound-part is
(a) amplitude modulated (b) frequency modulated
(c) phase modulated (d) pulse modulated

**43.** Picture signal of TV-signal is
(a) amplitude modulated
(b) frequency modulated
(c) phase modulated
(d) pulse modulated

**44.** Wave obtained on superimposition of audible frequency e.m. wave is known as
(a) carrier wave (b) high frequency wave
(c) modulating wave (d) modulated wave

**45.** An antenna behaves as resonant circuit only when its length is
(a) $\frac{\lambda}{2}$ (b) $\frac{\lambda}{4}$
(c) $\lambda$
(d) $\frac{\lambda}{2}$ or integral multiple of $\frac{\lambda}{2}$

**46.** A geosynchronous satellite is
(a) located at a height of 34860 km to ensure global coverage
(b) appears stationary over a place on earth's magnetic pole
(c) not really stationary at all, but orbits the earth within 24 hours.
(d) always at fixed location in space and simply spins about its own axis

**47.** Global communication is achieved by using
(a) single geostationary satellite
(b) minimum two geostationary satellite 180° apart
(c) minimum three geostationary satellite 120° apart
(d) minimum four geostationary satellite 90° apart

**48.** The layer of atmosphere which contains water vapour is
(a) stratosphere (b) mesospshere
(c) troposphere (d) ionosphere

**49.** The waves used in telecommunication are
(a) IR (b) UV
(c) Microwave (d) Cosmic rays

**50.** The losses in transmission lines are
(a) radiation losses only
(b) conductor heating only
(c) dielectric heating only
(d) all of these

**51.** In space communication, the sound waves can be sent from one place to another
(a) through space
(b) through wires
(c) by superimposing it on undamped electromagnetic waves
(d) by superimposing it on damped electromagnetic waves

**52.** As the height of satellite orbit gets lower, the speed of the satellite
(a) increases (b) decreases
(c) remain same (d) both (a) and (b)

**53.** Which of the following is drawback of amplitude modulation?
(a) low efficiency (b) noise reception
(c) operating range is small (d) all of these

**54.** Basic components of transmitter are
(a) message signal generator and antenna
(b) modulator and antenna
(c) signal generator and modulator and antenna
(d) message signal generator, modulator and antenna

**55.** Which of the following device is fully duplex?
(a) Mobile phone (b) Walky-talky
(c) Loud speaker (d) Radio

**56.** A radio station has two channels. One is AM at 1020 kHz and the other FM at 89.5 MHz. For good results you will use
(a) longer antenna for the AM channel and shorter for the FM
(b) shorter antenna for the AM channel and longer for the FM
(c) same length antenna will work for both
(d) information given is not enough to say which one to use for which

**57.** In Laser communication there is
(a) low loss of signal (b) loss of signal
(c) no signal security (d) low band width

**58.** In optical fibre refractive index of core is
(a) less than R.I of cladding
(b) more than R.I of cladding
(c) equal to R.I of cladding
(d) halfed to R.I of cladding

**59.** The cellular mobile radio frequency band is
(a) 88 – 108 MHz (b) 54 – 72 MHz
(c) 540 – 1600 KHz (d) 840 – 935 MHz

**60.** The AM wave is equivalent to the summation of
(a) two sinusoidal waves
(b) three sinusoidal waves
(c) four sinusoidal waves
(d) None of these

**61.** Citizen's band ratio is the application of
(a) amplitude modulation (b) frequency modulation
(c) phase modulation (d) None of these

**62.** Frequency of carrier signal is
(a) $5 \times 10^6$Hz (b) 1000 Hz
(c) $2.50 \times 10^3$ Hz (d) $2.5 \times 10^6$ Hz

**63.** Frequencies of sideband is
(a) $2.50005 \times 10^6$ Hz, $2.49995 \times 10^6$ Hz
(b) $2.505 \times 10^6$ Hz, $2.495 \times 10^6$ Hz
(c) $2.505 \times 10^6$ kHz, $2.495 \times 10^6$ kHz
(d) 2.505 MHz, 2.495 kHz

**64.** The picture signal in TV-broadcast is modulated in
(a) SSB (b) VSB (c) FM (d) DSB

**65.** The process of superimposing signal frequency (i.e., audio wave) on the carrier wave is known as
(a) Transmission (b) Reception
(c) Modulation (d) Detection

**66.** In frequency modulation
(a) the amplitude of modulated wave varies as frequency of carrier wave
(b) the frequency of modulated wave varies as amplitude of modulating wave
(c) the frequency of modulated wave varies as frequency of modulating wave
(d) the frequency of modulated wave varies as frequency of carrier wave

**67.** Of the following which is preferred modulation scheme for digital communication?
(a) Pulse Code Modulation (PCM)
(b) Pulse Amplitude Modulation (PAM)
(c) Pulse Position Modulation (PPM)
(d) Pulse Width Modulation (PWM)

**68.** What is the modulation index of an over modulated wave
(a) 1 (b) Zero
(c) $< 1$ (d) $> 1$

**69.** The maximum line-of-sight distance $d_M$ between two antennas having heights $h_T$ and $h_R$ above the earth is
(a) $\sqrt{R(h_T + h_R)}$ (b) $\sqrt{2R/(h_T + h_R)}$
(c) $\sqrt{Rh_T} + \sqrt{2Rh_R}$ (d) $\sqrt{2Rh_T} + \sqrt{2Rh_R}$

**70.** In AM waves, the amplitude of each side band frequency is
(a) $E_c$ (b) $mE_c$
(c) $\frac{mE_c}{2}$ (d) 2mE

**71.** For good demodulation of AM signal of carrier frequency *f*, the value of RC should be
(a) $RC = \frac{1}{f}$ (b) $RC < \frac{1}{f}$
(c) $RC \geq \frac{1}{f}$ (d) $RC >> \frac{1}{f}$

**72.** If a number of sine waves with modulation indices $n_1$, $n_2$, $n_3$..... modulate a carrier wave, then the total modulation index (n) of the wave is
(a) $n_1 + n_2 ... + 2(n_1 + n_2 ....)$ (b) $\sqrt{n_1 - n_2 + n_3 ......}$
(c) $\sqrt{n_1^2 + n_2^2 + n_3^2 ......}$ (d) $\sqrt{n_1 + n_2 + ......}$

**73.** Television signals are
(a) frequency modulated
(b) amplitude modulated
(c) both frequency and amplitude modulated
(d) phase modulated

**74.** For a single side band transmission a balanced modulator is used to
(a) increase power of carrier wave
(b) increase amplitude of carrier wave
(c) suppress audio signal
(d) suppress carrier component

**75.** Which of the following AM-scheme requires the minimum transmitted power & minimum channel bandwidth?
(a) VSB (b) DSB-SC (c) AM (d) SSB

**76.** In FM, when frequency deviation is doubled, then
(a) modulation is halved
(b) carrier swing is halved
(c) modulation is doubled
(d) modulation index is decreased

**77.** In PCM if the transmission path is very long
(a) pulse spacing is reduced
(b) pulse amplitude is increased
(c) pulse width is increased
(d) repeater stations are used.

**78.** The function of an amplitude limitter in an FM-receiver is
(a) to reduce the amplitude of the signal to suit IF amplifier
(b) to amplify low frequency signal
(c) to eliminate any change in amplitude of receiver FM signal
(d) None of these

**79.** Which of the following pair is correctly matched
(a) Radio telegraph-VSB (b) Television-SSB
(c) Radio broadcast-AM (d) Radar-AM

**80.** Depth of modulation in terms of $E_{max}$ and $E_{min}$ is
(a) $m_a = E_{max} + E_{min}/E_{min}$
(b) $ma = E_{max} - E_{min}/E_{max}$
(c) $m_a = E_{max} - E_{min}/E_{max} + E_{min}$
(d) $ma = E_{max} + E_{min}/E_{max} - E_{min}$

**81.** In an ionized medium, the phase velocity $v_p$, group velocity $v_g$ and the speed of light are related as
(a) $v_p > v_g > c$ (b) $v_p = v_g = c$
(c) $v_p < v_g < c$ (d) $v_p > c,\ v_g < c$ .

**82.** For a radio wave reaching the ionised medium
(a) will bend away from normal
(b) will bend towards normal
(c) will bend follow a straight-path
(d) None of these.

**83.** The tank circuit used in a radio transmitter should have
(a) high effective Q
(b) low effective Q
(c) loosely coupled load
(d) Both (a) and (c)

**84.** Audio signal cannot be transmitted because
(a) the signal has more noise
(b) the signal cannot be amplified for distance communication
(c) the transmitting antenna length is very small to design
(d) the transmitting antenna length is very large and impracticable

**85.** The fundamental radio antenna is a metal rod which has a length equal to

(a) λ in free space at the frequency of operation
(b) λ/2 in free space at the frequency of operation
(c) λ/4 in free space at the frequency of operation
(d) 3λ/4 in free space at the frequency of operation

**86.** The service area of space wave communication increases by

(a) increasing the height of transmitting antenna
(b) decreasing the height of receiving antenna
(c) increasing the height of both transmitting and receiving antenna
(d) decreasing the distance between transmitting and receiving antenna

**87.** 100% modulation in FM means

(a) actual frequency deviation > maximum allowed frequency deviation
(b) actual frequency deviation = maximum allowed frequency deviation
(c) actual frequency deviation ≥ maximum allowed frequency deviation
(d) actual frequency deviation < maximum allowed frequency deviation

**88.** Pre-emphasis in FM system is done to

(a) compress modulating signal
(b) expand modulating signal
(c) amplify lower frequency component of the modulating signal
(d) amplify higher frequency component of the modulating signal

**89**. The ratio of $E_{max} - E_{min}$ to $E_{max} + E_{min}$ is known as

(a) range of modulating signal
(b) amplitude variation of modulating signal
(c) depth of modulation
(d) None of these.

**90.** In an AM wave, the information is contained within

(a) r.f. carrier wave
(b) only lower and upper side frequencies
(c) both r.f. carrier and side frequencies
(d) None of these

## STATEMENT TYPE QUESTIONS

**91.** Consider telcommunication through optical fibres. Which of the following statements is/are correct?

I. Optical fibres may have homogeneous core with a suitable cladding
II. Optical fibres can be of graded refractive index
III. Optical fibres are subject to electromagnetic interference from outside
IV. Optical fibres have extremely low transmission loss

(a) I and II
(b) I and III
(c) I, II and IV
(d) I, II, III and IV

**92.** Digital signals

I. represent values as discrete values.
II. can utilise binary system
III. can utilise decimal as well as binary systems.

Which of the above statements are correct ?

(a) I and II
(b) II and III
(c) I, II and III
(d) I and III

**93.** In statellite communication

I. the frequency used lies between 5 MHz and 1 MHz.
II. the uplink and downlink frequencies are different.
III. the orbit of geostationary satellite lies in the equatorial plane at inclination of 0.

Which of the above statement(s) is/are correct?

(a) II and III
(b) I and II
(c) Only I
(d) I, II, III and IV

**94.** Which of the following statements are correct ?

I. At longer wavelength (i.e., at lower frequencies) the antennas have large physical size.
II. They are located on or very near to the ground.
III. In standard AM broadcast, ground based vertical towers are generally used as transmitting antennas.

(a) I and II
(b) I, II, and III
(c) II and III
(d) I and III

**95.** Amplitude modulated waves

I. contain frequencies $(w_c - w_m)$, $w_c$ and $(w_c + w_m)$
II. can be produced by application of the message signal and the carrier wave to a non-linear device followed by a band pass filter.

Which of the above statements is/are correct?

(a) I only
(b) II only
(c) I and II
(d) None of these

## MATCHING TYPE QUESTIONS

**96.** Match the Columns I and II.

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | Attenuation | (1) | The process of increasing the amplitude |
| (B) | Amplification | (2) | The loss of strength of a signal |
| (C) | Bandwidth | (3) | The process of retrieval of information from the carrier wave |
| (D) | Demodulation | (4) | The frequency range over which an equipment operates |

(a) (A) → (2); (B) → (1); (C) → (4); (D) → (3)
(b) (A) → (4); (B) → (2); (C) → (1); (D) → (3)
(c) (A) → (3); (B) → (1); (C) → (4); (D) → (2)
(d) (A) → (1); (B) → (3); (C) → (4); (D) → (2)

**97.**

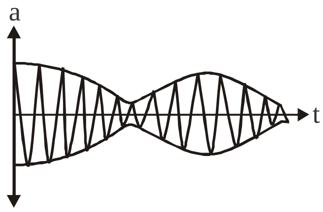
| **Column I** | **Column II** |
|---|---|
| (Name of the stratum) | (Frequencies most affected) |
| (A) Troposphere | (1) Efficiently reflects HF waves |
| (B) Stratosphere | (2) Partially absorbs HF waves |
| (C) Mesosphere | (3) V H F upto several GHZ |
| (D) Thermosphere | (4) Reflects LF absorbs MF and HF to some degree |

(a) (A) → (2); (B) → (1); (C) → (4); (D) → (3)
(b) (A) → (4); (B) → (2); (C) → (1); (D) → (3)
(c) (A) → (3); (B) → (4); (C) → (2); (D) → (1)
(d) (A) → (1); (B) → (3); (C) → (4); (D) → (2)

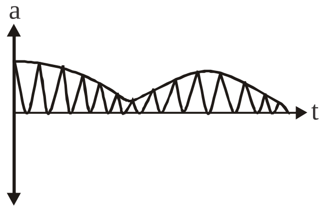
## DIAGRAM TYPE QUESTIONS

**98.** Which one of the following represents rectified wave?

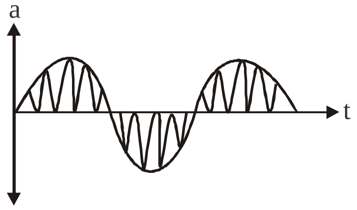
(a)



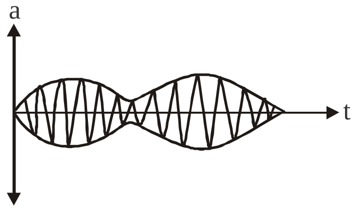
(b)



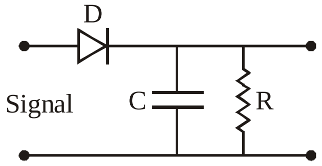
(c)



(d)



**99.** A diode detector is used to detect an amplitude modulated wave of 60% modulation by using a condenser of capacity 250 picofarad in parallel with a load resistance 100 kilo ohm. Find the maximum modulated frequency which could be detected by it.



(a) 10.62 MHz (b) 10.62 kHz
(c) 5.31 MHz (d) 5.31 kHz

## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

**100.** **Assertion :** Amplification is necessary to compensate for the attenuation of the signal in communication system.
**Reason :** Amplification is the process of increasing the amplitude and consequntly the strength of signal using an electronic circuit.

**101.** **Assertion :** The loss of strength of a signal while propagating through a medium is known as attenuation.
**Reason :** Transmitter helps to avoid attenuation.

**102.** **Assertion :** Telephony is an example of point-to-point communication mode.
**Reason :** In point-to-point communication modes, communication takes places over a link between a single transmitter and a receiver.

**103.** **Assertion :** The information contained in our original low frequency baseband signal is to be translated into high or radio frequencies before transmission.
**Reason :** For transmitting a signal, the antenna should have a size comparable to the wavelength of the signal.

**104.** **Assertion :** When the height of a TV transmission tower is increased by three times, the range covered is doubled.
**Reason :** The range covered is proportional to the height of the TV transmission tower.

**105.** **Assertion :** Microwave communication is preferred over optical communication.
**Reason :** Information carrying capacity is directly proportional to bandwidth.

**106.** **Assertion :** Long distance communication between two points on the earth is achieved by using sky waves.
**Reason :** Sky wave propagation takes place above the frequency of 30 MHz.

**107.** **Assertion :** The television signals are propagated through sky waves.
**Reason :** Television signals have frequency in the range of 1000 MHz to 2000 MHz range.

**108.** **Assertion :** Space waves are used for line-of-sight communication.
**Reason :** Space wave travels in a straight line from transmitting anttena to receiving antenna.

**109.** **Assertion :** The ionosphere layer acts as a reflector for all range of frequencies.

**Reason :** Ionosphere does not allow electromagnetic wave to penetrate and escape.

**110.** **Assertion :** The process of retrival of information from the carrier wave at the receiver is termed as modulation.

**Reason :** Repeater helps to modulate the signals.

**111.** **Assertion :** AM detection is the process of recovering the modulating signal from amplitude modulated waveform, which is carried out using a rectifier and an envelope detector.

**Reason :** Amplitude modulated waves can be produced by application of the message signal and the carrier wave to a non-linear device followed by band pass filter.

## CRITICAL THINKING TYPE QUESTIONS

**112.** A broadcast radio transmitter radiates 12 kW when percentage of modulation is 50%, then the unmodulated carrier power is

(a) 5.67 kW (b) 7.15 kW

(c) 9.6 kW (d) 12 kW

**113.** A transmitter radiates 10 kW of power with the carrier unmodulated and 11.8 kW with the carrier sinusoidally modulated. The modulation factor is

(a) 56% (b) 60 % (c) 72 % (d) 84%

**114.** What will be the image frequency of an FM radio receiver that is tuned to 98.6 MHz broadcast station?

(a) 111.8 MHz (b) 108 MHz

(c) 121.6 MHz (d) 132 MHz

**115.** A 1 kW carrier is modulated to a depth of 80%. The total power in the modulated wave is

(a) 1.32 (b) 1.56 (c) 1.84 (d) 1.96

**116.** The frequency deviation in a FM transmission is 18.75 KHz. If it broadcasts in 88-108 MHz band, then the percent modulation is

(a) 10 % (b) 25 % (c) 50 % (d) 75 %

**117.** A 10 kW carrier is sinusoidally modulated by two carriers corresponding to a modulation index of 30% and 40% respectively then total power radiated by the modulator is

(a) 10.25 kW (b) 11.25 kW

(c) 12.75 kW (d) 17 kW

**118.** An FM signal has a resting frequency of 105 MHz and highest frequency of 105.03 MHz when modulated by a signal of frequency 5 kHz. The carrier swing is

(a) 25 kHz (b) 54 kHz (c) 60 kHz (d) 75 kHz

**119.** 12 signals each band limited to 5 kHz are to be transmitted by frequency-division multiplexer. If AM-SSB modulation guard band of 1 kHz is used then the bandwidth of multiplexed signal is

(a) 101 kHz (b) 99 kHz (c) 84 kHz (d) 71 kHz

**120.** A device with input x(t) and outputy(t) is characterized by: $y(t) = x^2(t)$. An FM signal with frequency deviation of 90 kHz and modulating signal bandwidth of 5 kHz is applid to this device. The bandwidth of the output signal is

(a) 370 kHz (b) 190 kHz

(c) 380 kHz (d) 95 kHz.

**121.** An audio frequency of 10 kHz is transmitted by SSB after AM with carrier waves of frequency 1MHz. The frequency of current in output load is

(a) 1010 kHz or 990 kHz (b) 1010 MHz or1010 MHz

(c) 110 kHz or 990 kHz (d) 110 MHz or 990 MHz

**122.** An AM wave is expressed as $e = 10\,(1 + 0.6 \cos 2000\,\pi\, t) \cos 2 \times 10^8 \pi t$ volts, the minimum and maximum value of modulated carrier wave are respectively.

(a) 10 V and 20 V (b) 4V and 8V

(c) 16 V and 4V (d) 8 V and 20 V

**123.** An AM wave varies from 10V to 4V. Its percentage modulation is

(a) 36% (b) 42.8% (c) 54% (d) 68 %

**124.** An audio signal represented as $25 \sin 2\pi\,(2000\,t)$ amplitude modulated by a carrier wave : $60 \sin 2\pi\,(100,\,000)t$. The modulation index of the modulated signal is

(a) 25% (b) 41.6 % (c) 50 % (d) 75 %

**125.** For an AM wave, the maximum voltage was found to be 10 V and minimum voltage was 4 V. The modulation index of the wave is

(a) 0.33 (b) 0.43 (c) 0.56 (d) 0.64

**126.** For an AM-system the total power of modulated signal is 600 W and that of carrier is 400 W, the modulation index is

(a) 0.25 (b) 0.36 (c) 0.54 (d) 1

**127.** The rms value of a carrier voltage is 100 volts. Compute its rms value when it has been amplitude modulated by a sinusoidal audio voltage to a depth of 30%.

(a) 94 V (b) 104 .5V (c) 114.4 V (d) 124 V

**128.** Calculate the power developed by an amplitude modulated wave in a load resistance of 100 Ω, if the peak voltage of carrier wave is 100 V and modulation index is 0.4.

(a) 50 watt (b) 54 watt

(c) 104 watt (d) 4 watt

**129.** The maximum and minimum amplitude of an AM wave are 90 mV and 30 mV respectively. The depth of modulation is

(a) 0.6 (b) 0.5 (c) 0.4 (d) 0.3

**130.** For 100% modulation (AM), the useful part of the total power radiated is

(a) $\frac{1}{2}$ of the total power (b) $\frac{1}{3}$ of the total power

(c) $\frac{1}{4}$ of the total power (d) $\frac{2}{3}$ of the total power

**131.** Consider the following amplitude modulated (AM) signal , where $f_m < B\, x_{AM}(t) = 10\,(1 + 0.5 \sin 2\pi f_m t) \cos 2\pi f_c t$

The average side-band power for the AM signal given above is

(a) 25 (b) 12.5 (c) 6.25 (d) 3.125

**132.** An AM- signal is given as

$$x_{AM}(t) = 100\,[p(t) + 0.5g(t)] \cos \omega_c t$$

in interval $0 \le t \le 1$. One set of possible values of the modulating signal and modulation index would be

(a) t, 0.5 (b) t, 1.0 (c) t, 1.5 (d) $t^2$, 2.0

**133.** A sinusoidal carrier voltage of frequency 10 MHz and amplitude 200 volts is amplitude modulated by a sinusoidal voltage of frequency 10 kHz producing 40% modulation. Calculate the frequency of upper and lower sidebands.

(a) 10010 kHz, 9990 kHz (b) 1010 kHz, 990 kHz

(c) 10100 Hz,9990 Hz (d) 1010 MHz, 990 MHz

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

**1.** **(b)** **2.** **(d)** **3.** **(a)**

**4.** **(b)** The message from the information source may not be in electrical form so to convert these information i.e. in form of sound to electrical form a transducer like a microphone is used.

**5.** **(c)** Noise the unwanted energy and distortion both occuring at various stage of a system leads to deterioration of signal as signal to noise ratio becomes so poor that signal becomes unintelligble and useless.

**6.** **(d)** The received signals is either AM or FM so it needs to be demodulated ie. decoded to get back original signal. It also needs to be stored and interpreted at receiving end.

**7.** **(b)** Channel indicate frequency range at which different R.F. signals all transmitted.

**8.** **(d)** Buffer amplifier isolate master oscillator from the influence of modulation done at a later stage.

**9.** **(d)** The RF-signal coming from the transmitter needs to be demodulated by a detector inorder to remove the carrier frequency and receive back the low-frequency original signal.

**10.** **(c)** In optical fibre, light travels inside it, due to total internal reflection.

**11.** **(b)** The purpose of transmitter is to convert the message signal produced by source of information into a form suitable for transmission through the channel.

**12.** **(d)** **13.** **(a)** **14.** **(d)**

**15.** **(d)** If the output of information source is non-electrical signal like a voice signal, a transducer converts it to electrical form before giving it as an input to the transmitter.

**16.** **(a)** Radio broadcast transmitter are used for above purpose. AM transmitter operating on long wave, medium & short wave are used.

**17.** **(b)** Sound waves such as speech or song etc. that a human being can hear ranges from 20 Hz to 20 kHz frequencies above 20 kHz can not be heard by human ear.

**18.** **(c)** Electromagnetic wave of audible frequency have vary small energy content $\approx 10^{-12}$ eV and their amplitude is greatly reduced due to dissipations of ennergy in travelling a long distance.

Secondly for frequency range 20 Hz to 20kHz the length of antenna required is of the order of wavelength of wave to be transmited

i.e. length of antenna $\approx \lambda = c/\nu(m) = 1.5 \times 10^7$m

for $\nu$ in the range 20 to 20 kHz

and $c = 3 \times 10^8$ m/s.

An antenna of length $1.5 \times 10^4$ m is not practically possible.

**19.** **(b)** There is a need of translating the information contained in our original low frequency baseband signal into high or radio frequencies before transmission.

**20.** **(b)**

**21.** **(a)** Since the attenuation of ground waves increases with increase in frequencies so only low frequency- radio waves uses this mode of propagation for short distances.

**22.** **(d)** TV-signal ( 30 MHz -300 MHz) are not reflected by ionosphere. Therefore, sky-wave propagation is not possible and similarly ground & space wave is also not feasible hence they are transmitted to artificial satellite from where they are transmitted back to the earth.

**23.** **(c)** **24.** **(d)** **25.** **(b)**

**26.** **(a)** **27.** **(c)**

**28.** **(d)** The space wave propagation is limited due to the line of sight distance and by the curvature of the earth.

**29.** **(c)** Sky wave propagation is not possible for frequency > 30 MHz because they are not reflected by ionosphere.

**30.** **(d)** Skip distance is the minimum distance on earth's surface from the transmitter where e.m. wave of a definite frequency can reach after reflection from the ionosphere

It is given by $D_{skip} = 2h\sqrt{\frac{f^2}{f_c^2} - 1}$

$\Rightarrow$ Dskip is dependent on h, f and fc.

**31.** **(c)** Ionsphere contain free electron & + ve ions. In equillibrium, the no. of free electron is equal to the number of positive ions. So as a whole it is elecrically neutral.

**32.** **(d)** During ground wave propagation of radio waves, a charge induced on the earth's surface which takes the form of current as the wave propagate. The earth offers resistance in the flow of induced current due to which the waves are attenuated.

**33.** **(a)** space wave propagation takes place in such a way that the radio waves transmitted at an angle from earth's surface gets reflected by the troposphere and then reaches the receiving antenna since the height of troposphere is quite small, long-range propagation by this mode is not possible.

**34.** **(b)** Stratosphere and troposphere allows the radio waves to pass through it but they are not reflected back to earth's surface by ionosphere.
Only frequency 1500 kHz to 30 MHz can be propagated by this mode.

**35.** **(d)**

**36.** **(b)** Critical frequency $f_c = 9\sqrt{N_m}$

where $N_m$ represents election density of layers

$\because f_c \propto \sqrt{N_m}$

$\Rightarrow f_c$ is different for different layers.

**37.** **(c)** Electron density of each layer of ionosphere is different from the other. i.e. they are stratified. As we move upward density increases.

**38.** **(a)** Encoding modulation of signal i.e. to be transmitted is done with carrier frequency at transmitting end to avoid interference with other signals that are also transmitted.

**39.** **(d)** Since radio frequency waves can travel long distances because these waves are of wave length of the order of 100 m and their energy content is quite large therefore e.m.wave of audible frequency are superimposed with radio frequency waves.

**40.** **(b)**

**41.** **(d)** Remote sensing is the technique to collect information about an object in respect of its size, colour, nature, location, temperature etc. without physically touching it. There are some areas or locations which are inaccessible. So to explore these areas or locations, a technique known as remote sensing is used. Remote sensing is done through a satellite.

**42.** **(b)** Due to several advantage of FM over AM, to get better quality signal the sound part of TV-signal is frequency modulated.

**43.** **(a)** Picture signal in amplitude modulated to avoid complication in development of transmitter & receiver structure.

**44.** **(d)** On superimposition of two waves the audible frequency wave is the modulating wave and radio-wave is the carrier wave, thus the resultant wave obtained is known as modulated wave as it is obtained by the process of modulation.

**45.** **(d)** **46.** **(c)** **47.** **(c)**

**48.** **(c)** **49.** **(c)** **50.** **(d)** **51.** **(c)**

**52.** **(b)** **53.** **(d)** **54.** **(d)**

**55.** **(a)** Duplex or full duplex refers to the simultaneous transmission of data in two directions. A mobile phone is a full duplex device because both people can talk at once and hear each at the same time. Walky-talky is a half duplex device because only one person can talk at a time.

**56.** **(b)** The frequency of AM channel is 1020 kHz whereas for the FM it is 89.5 MHz (given). For higher frequencies (MHz), space wave communication is needed. Very tall towers are used as antennas.

**57.** **(a)** **58.** **(b)** **59.** **(d)** **60.** **(b)** **61.** **(a)**

**62.** **(d)** $\omega_c = \frac{5\times10^6\pi}{2\pi} = 2.5\times10^6$ Hz

**63.** **(a)** $\omega_c + \omega_m$
$= 2.5 \times 10^6 + 0.0005 \times 10^6$Hz
$\omega_c - \omega_m$
$= 2.5 \times 10^6 - 0.0005 \times 10^6$ Hz
$= 2.4995 \times 10^6$ Hz

**64.** **(b)**

**65.** **(c)** Carrier + signal → modulation.

**66.** **(b)** In frequecy modulation the frequency of the modulated wave is the linear function of the amplitude of the modulating wave.

**67.** **(a)**

**68.** **(d)** When $m_a > 1$ then carrier is said to be over modulated.

**69.** **(d)** The maximum line-of-sight distance $d_M$ is given by

$$d_M = \sqrt{2Rh_T} + \sqrt{2Rh_R}$$

**70.** **(c)**

**71.** **(d)** For good demodulation,

$$\frac{1}{f} << RC \text{ or, } RC >> \frac{1}{f}$$

**72.** **(c)**

**73.** **(c)** TV signal comprises of video and audio signals.
Video signal is AM and sound signal is FM.

**74.** **(d)** Since maximum part of the power of modulated wave is contained with the carrier wave which does not transmit any desired information, hence to avoid wastage of power to suppress carrier balanced modulator is used.

**75.** **(d)** Since in SSB transmision only one side band is transmitted while in other 3-cases more than a side band is transmitted, so minimum power is transmitted for SSB. Similarly SSB bandwidth is minimum BW= $\omega_m$.

**76.** **(c)** $m = \frac{(\Delta f)_{actual}}{(\Delta f)_{max}} \times 100 \Rightarrow m \infty (\Delta f)_{actual}$

i.e. if frequency deviation is doubled then modulation is doubled.

**77.** **(d)** When transmission path is long more repeater stations are needed at intermediate points as repeater receives signal, remove the noise, amplify it and retransmit it along the channel.

**78.** **(c)** The limitter removes from the carrier all amplitude variations which may caused by changes in the transmission path, by man-made static or natural static. This suppression of amplitude variation is necessary because FM-receives, a vary large improvement in S/N results from this.

**79.** **(c)** Radio telegraph–AM and FM is used
Television–VSB is used
Radar–PM or FM is used
and Radio broadcast–AM and FM is used
So correct pair is (c).

**80.** **(c)**

**81.** **(d)** Phase velocity of e.m.wave in free space $c = \frac{1}{\sqrt{\mu_0 \in_0}}$

Phase velocity of e.m.wave in ionised medium

$$v_p = \frac{1}{\sqrt{\mu_0\varepsilon_0\left(1 - \frac{Ne^2}{\varepsilon_0 m\omega^2}\right)}}$$

$\therefore$ $v_p > c$ but $v_g < c$ in ionised medium.

**82.** **(a)** Radio wave enters from an un-ionised medium to an ionised medium, the wave incident on the boundary of the medium deviates from its straight path i.e. will bend away from normal because ionised medium behaves as a rarer medium w.r.t. to unionised medium.

**83.** **(d)**

**84.** **(d)** Following are the problems which are faced while transmitting audio signals directly,
(i) These signals are relatively of short range.
(ii) If every body started transmitting these low frequency signals directly, mutual interference will render all of them ineffective.
(iii) Size of antenna required for their efficient radiation would be larger, *i.e.*, about 75 km.

**85.** **(c)**

**86.** **(c)** Maximum range of space wave propagation

$$d = \frac{4}{3} \times 1.23\left[\sqrt{H_t} + \sqrt{H_r}\right]$$

$\Rightarrow$ $d \infty H_t$

$d \infty H_r$

$\therefore$ d increases if $H_t$ and $H_r$ i.e. height of transmitting and receiving antenna increases.

**87.** **(b)** $$m = \frac{\text{actual frequency deviation}}{\text{max . allowed frequency deviation}} \times 100\%$$

$$= \frac{(\Delta f)\text{actual}}{(\Delta f)\text{max}} \times 100\%$$

if $(\Delta f)$ actual = $(\Delta f)$ max
m = 100 %

**88.** **(d)** Pre-emphasis of higher frequency component is required in FM-system because high frequency terms of modulating signal have small amplitude and therefore small power relative to those of low frequency term. In the reproduced program at the o/p, these high frequency terms have poor S/N ratio and at time noise may completely mask the signal at these high frequencies, so it is necessary to provide pre-emphasis of high frequencies.

**89.** **(c)** $\frac{E_{max} - E_{min}}{E_{max} + E_{min}} = m_a$ -Depth of modulation.

**90.** **(b)** The modulated voltage comprises of
(i) Carrier wave of frequency $\omega_c$
(ii) Lower side frequency $(\omega_c - \omega_m)$ wave
(iii) Upper side frequency $(\omega_c + \omega_m)$ wave
Thus in an AM wave information is contained in lower $(\omega_c - \omega_m)$ and upper $(\omega_c + \omega_m)$ side frequencies.

## STATEMENT TYPE QUESTIONS

**91.** **(c)** Optical fibres are not subjected to electromagnetic interference from outside.

**92.** **(a)** Digital signals are the values in the form of 0 or 1. It represents discrete values in the binary bits which are non-continuous set of values.

**93.** **(a)** In statellite communication, the frequency used is more than 40 MHz. The uplink and downlink frequencies are different to avoid distortion of signal and the orbit of geostationary satellite lies in the equatorial plane at an inclination of 0°.

**94.** **(b)** At longer wavelengths (i.e., at lower frequencies), the antennas have large physical size and they are located on or very near to the ground. In standard AM broadcast, ground based vertical towers are generally used as transmitting antennas. For such antennas ground has a strong influence on the propagation of the signal.

**95.** **(c)**

## MATCHING TYPE QUESTIONS

**96.** **(a)** (A) → (2); (B) → (1); (C) → (4); (D) → (3)
**97.** **(c)** (A) → (3); (B) → (4); (C) → (2); (D) → (1)

## DIAGRAM BASED QUESTIONS

**98.** **(b)**

**99.** **(b)** **Given :** Resistance R = 100 kilo ohm
$= 100 \times 10^3\,\Omega$
Capacitance C = 250 picofarad
$= 250 \times 10^{-12}$F
$\tau = RC = 100 \times 10^3 \times 250 \times 10^{-12}$ sec
$= 2.5 \times 10^7 \times 10^{-12}$ sec
$= 2.5 \times 10^{-5}$ sec

The higher frequency whcih can be detected with tolerable distortion is

$$f = \frac{1}{2\pi m_a RC} = \frac{1}{2\pi \times 0.6 \times 2.5 \times 10^{-5}} Hz$$

$$= \frac{100 \times 10^4}{25 \times 1.2\pi} Hz = \frac{4}{1.2\pi} \times 10^4 Hz$$

$$= 10.61 \text{ KHz}$$

This condition is obtained by applying the condition that rate of decay of capacitor voltage must be equal or less than the rate of decay modulated singnal voltage for proper detection of mdoulated signal.

## ASSERTION- REASON TYPE QUESTIONS

**100. (a)** : Amplification is necessary to compensate for the attenuation of the signal in communication systems.

**101. (c)** : A transmitter processes the incoming message signal, so as make it suitable for transmission through a channel and subseqeuent reception.

**102. (a)**

**103. (a)** : For transmitting a signal, we need an antenna or an aerial. This antenna should have a size comparable to the wavelength of the signal so that the antenna properly senses the time variation of the signal. For an electromagnetic wave frequency 20 kHz, the wavelength is 15 km. Obviously such a long antenna is not possible to cosntruct and operate. Hence direct transmission of such baseband signals is not practical. Therefore there is a need of translating the information constained in our original low frequency baseband signal into high or radio frequencies before trasnsmission.

**104. (c)** : The range covered is not proportional to the height of the TV transmission tower. The range depends directly on square root of the height of the antenna *i.e.*

$$S \propto \sqrt{h} \cdot$$

Let the height of the TV transmission tower be *h* and *h*' which covers the range *S* and *S*′ respectively.

$\therefore \quad S = \sqrt{2hR}$ and $S' = \sqrt{2h'R}$

For $S' = 2S$ *i.e.* $\sqrt{2h'R} = 2\sqrt{2h'R}$

**105. (a) :** Microwave communication is preferred over optical communication because microwave provide large number of channels and wide badwidth compared to optical signals as infromation carrying capacity is directly proportional to bandwidth. So wider the bandwidth greater the information carrying capacity.

**106. (c)** : Long distance communication between two points on the earth is achieved through reflection of electromagnetic waves by ionosphere. Such waves are called sky waves Sky wave propagation takes place up to frequency of about 30 MHz.

**107. (d)** : As television signals being of frequency 100 MHz to 200 MHz cannot be reflected by ionosphere but they penetrate it, so they are not propagated through sky waves. In fact, television signals are propagated through space wave propagation.

**108. (a)** : A space wave travels in a straight line from transmitting antenna to the receiving antenna. Space waves are used for line-of-sight communication as well as satellite communication. At frequencies above 40 MHz communication is essentially limited to line of sight paths.

**109. (d)** : The ionosphere layer acts as a reflector for a certain range of frequencies *i.e.* 3 to 30 MHz.Electromagnetic waves of frequencies higher than 30 MHz penetrate the ionosphere and escape.

**110. (d)** : The process of retrieval of information from the carrier wave at the receiver is termed as demodulation. Repeater is a combination of a receiver and a transmitter, a repeater picks up the signal from the transmitter, amplifies and retransmist it to the receiver sometimes with a change in carrier frequency.

**111. (b)**

## CRITICAL THINKING TYPE QUESTIONS

**112. (c)** $P_c = \dfrac{P_t}{1+\dfrac{m_a^2}{2}} = \dfrac{12}{1+\dfrac{(0.5)^2}{2}} = \dfrac{12}{1.25} = 9.6 \text{ kW}$

**113. (b)** $P_c = P_t\left(1+\dfrac{m^2}{2}\right)$

$$\Rightarrow \quad 11.8 = 10\left(1+\frac{m^2}{2}\right)$$

$$\Rightarrow \quad m = 0.6 \Rightarrow \% \text{ modulation} = 60\%.$$

**114. (c)** FM (I.F)=11.5MHz

$F(\text{image}) = f_s + 2 f_{IF} = 98.6 + 2 \times 11.5 = 121.6 \text{ MHz}$

**115. (a)** $P = P_c\left[1+\dfrac{m_a{}^2}{2}\right] = 1\left[1+\dfrac{(0.8)^2}{2}\right] = 1.32\text{kW}.$

**116. (b)** For given transmission band 88-108 MHz

$(\Delta f)_{max} = 75 \text{ kHz}$

given $(\Delta f)_{actual} = 18.75 \text{ kHz}$

$$\therefore \ \% \text{ modulation } m = \frac{(\Delta f)_{actual}}{(\Delta f)_{max}} \times 100 = \frac{18.75}{75} = 25\%$$

**117. (b)** $P_c = \frac{E_c{}^2}{2} = 10\text{ kW}$

$m_a = \sqrt{m_1^2 + m_2^2} = \sqrt{0.30^2 + 0.40^2} = 0.50$

$\therefore\ P_t = P_c\left(1+\frac{m_a{}^2}{2}\right) = 10\left(1+\frac{(0.5)^2}{2}\right) = 11.25\text{ kW}$

**118. (c)** Carrier Swing $= 2\times\Delta f$

$= 2\times 105.03 - 105 = 2\times 0.03\text{ MHz}$

$= 0.06\text{ MHz} = 60\text{ kHz}$

**119. (d)** Total signal B.W= $12\times 5 = 60\text{ kHz}$

11 guard band are required between 12 signal

$\therefore$ guard bandwidth $= 11\times 1\text{kHz} = 11\text{kHz}$

$\therefore$ total bandwidth = $60 + 11 = 71\text{kHz}$

**120. (c)** For x(t), BW = $2(\Delta\omega + \omega)$

$\Delta\omega$ is deviation and $\omega$ is the band width of modulating signal.

$\therefore\quad BW = 2(90 + 5) = 190$

For $x^2(t)$, $BW = 2 \times 190 = 380$

**121. (a)** SSB transmission to signal are possible at load

$\omega_c + \omega_m$ or $\omega_c - \omega_m$

$\Rightarrow$ (1000 + 10) kHz or (100 – 10) kHz.

$\Rightarrow$ 1010 kHz or 990 kHz

**122. (c)** $E_{max} = (1 + m_a)\,E_c = (1 + 0.6) \times 10 = 16\text{ V}$

$E_{min} = (1 - m_a)\,E_c = (1 - 0.6) \times 10 = 4\text{V}.$

**123. (b)** $m_a = \frac{E_{max} - E_{min}}{E_{max} + E_{min}} = \frac{10-4}{10+4} = \frac{6}{14} = 0.428 = 42.8\%$

**124. (b)** Modulation index $= \frac{B}{A}$

B = 25, A = 60

$\Rightarrow$ M.I. $= \frac{25}{60} = 0.416 \Rightarrow m\% = 41.6\%$

**125. (b)** $m_a = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} = \frac{10-4}{10+4} = \frac{6}{14} = 0.43$

**126. (d)** $P_T = P_C\left(1+\frac{m_a{}^2}{2}\right)$

$\therefore\ 600 = 400\left(1+\frac{m_a{}^2}{2}\right) \Rightarrow \frac{3}{2} = 1 + \frac{m_a{}^2}{2}$

or $\frac{m_a{}^2}{2} = \frac{1}{2} \Rightarrow m_a = 1$

**127. (b)** $P_t = P_c\left[1+\frac{m_a{}^2}{2}\right] \Rightarrow \frac{V^2{}_{rms}}{2} = \frac{V^2{}_c}{2}\left[1+\frac{m_a{}^2}{2}\right]$

$V^2{}_{rms} = V^2{}_c\left[1+\frac{m_a{}^2}{2}\right]$

$\Rightarrow V_{rms} = V_c\sqrt{1+\frac{m_a{}^2}{2}} \Rightarrow V_{rms} = 100\sqrt{1+\frac{(0.3)^2}{2}}$

= 104.5 volts.

**128. (b)** $E_c = 100\text{ V},\ m_a = 0.4,\ R = 100\,\Omega,$

$P_c = \frac{E_c{}^2}{2R} = \frac{(100)^2}{2\times 100} = 50\text{ watt}$

$P = \left(1+\frac{m_a{}^2}{2}\right)P_c = \left[1+\frac{(0.4)^2}{2}\right]\times 50 = 54\text{ watt}$

**129. (b)** $m_a = \frac{E_{max} - E_{min}}{E_{max} + E_{min}} = \frac{90-30}{90+30} = \frac{60}{120} = \frac{6}{12} = 0.5$

**130. (b)** 100% modulation $\Rightarrow m_a = 1$

$\frac{\text{useful power}}{\text{total power radiated}} = \frac{m_a{}^2}{2 + m_a{}^2} = \frac{1}{2+1} = \frac{1}{3}$

$\Rightarrow\ \text{Useful power} = \frac{1}{3}(\text{total power radiated})$

**131. (c)** Average side-band power $P_{av} = \frac{m_a}{4}P_c{}^2$

Here $m_a = 0.5$

$P_c = 10$

$\therefore P_{av} = \frac{0.5\times 10\times 10}{4} = 6.25$

**132. (a)** Comparing $(x_{AM})t = 100\,[1 + 0.5\,t]\cos\omega_c t$ for $0<t<1$ with standard AM signal $x_{AM} = E_c\,[1 + m_a\cos\omega_m t]\cos\omega_c t$

We have modulating signal t and $m_a = 0.5$.

**133. (a)** Modulating signal frequency $\rightarrow$ 10kHz

Carrier signal frequency$\rightarrow$ 10 MHz

$\therefore$ Side band frequency are

USB = 10 MHz + 10 kHz = 10010 kHz

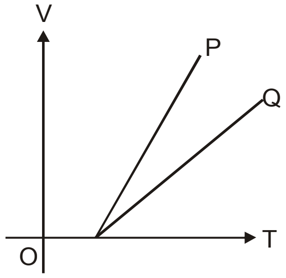
LSB = 10MHz – 10 kHz = 9990 kHz

# Mock Test-1

**Time : 1 hr** **Max. Marks -180**

**1.** The physical quantity that does not have the dimensional formula $[ML^{-1}T^{-2}]$ is
(a) force
(b) pressure
(c) stress
(d) modulus of elasticity.

**2** Figure shows the v-t graph for two particles P and Q. Which of the following statements regarding their relative motion is true?
Their relative velocity



(a) is zero
(b) is non-zero but constant
(c) continuously decreases
(d) continuously increases

**3.** Time required to boil 2 litres of water initially at 20°C by a heater coil which works at 80% efficiency spending 500 joule/s is
(a) 82 minutes (b) 50 minutes
(c) 28 minutes (d) 37 minutes

**4.** A monoatomic gas at 27°C is compressed adiabatically to $\frac{8}{27}$ of its original volume. The rise in temperature will be
(a) 300°C (b) 350°C
(c) 375°C (d) 400°C

**5.** A man projects a coin upwards from the gate of a uniformly moving train. The path of coin for the man will be
(a) parabolic
(b) inclined straight line
(c) vertical straight line
(d) horizontal straight line

**6.** What is the disintegration constant of radon, if the number of its atoms diminishes by 18% in 24 h?
(a) $2.1 \times 10^{-3}\ s^{-1}$ (b) $2.1 \times 10^{-4}\ s^{-1}$
(c) $2.1 \times 10^{-5}\ s^{-1}$ (d) $2.1 \times 10^{-6}\ s^{-1}$

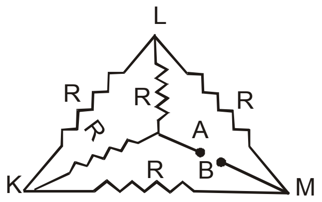
**7.** The resistance R of a wire is given by the relation $R = \frac{\rho \ell}{\pi r^2}$. Percentage error in the measurement of r, $\ell$ and r is 1%, 2% and 3% respectively. Then the percentage error in the measurement of *R* is
(a) 6 (b) 9
(c) 8 (d) 10

**8.** A galvanometer can be changed into an ammeter by using
(a) low resistance shunt in series
(b) low resistance shunt in parallel
(c) high resistance shunt in series
(d) high resistance shunt in parallel

**9.** Which of the following statements is false for a particle moving in a circle with a constant angular speed ?
(a) The acceleration vector points to the centre of the circle
(b) The acceleration vector is tangent to the circle
(c) The velocity vector is tangent to the circle
(d) The velocity and acceleration vectors are perpendicular to each other.

**10.** A mass is tied to a string and rotated in a vertical circle, the minimum velocity of the body at the top is
(a) $\sqrt{gr}$ (b) $g/r$
(c) $\left(\frac{g}{r}\right)^{3/2}$ (d) gr

**11.** Each of the resistance in the network shown is equal to R. The resistance between the terminals A and B is



(a) R (b) 5R
(c) 3R (d) 6R

**12.** The energy of hydrogen atom in the nth orbit is $E_n$, then the energy in the nth orbit of single ionised helium atom is
(a) $\frac{E_n}{2}$ (b) $2E_n$
(c) $4E_n$ (d) $\frac{E_n}{4}$

**13.** Two identical particles move towards each other with velocity 2v and v respectively. The velocity of centre of mass is
(a) v (b) v/3
(c) v/2 (d) zero.

**14.** The mass number of He is 4 and that for sulphur is 32. The radius of sulphur nuclei is larger than that of helium by
(a) $\sqrt{8}$ (b) 4
(c) 2 (d) 8

**15.** According to Newton’s law of cooling, the rate of cooling of a body is proportional to $(\Delta\theta)^n$, where $\Delta\theta$ is the difference of the temperature of the body and the surroundings, then n is equal to

(a) two (b) three
(c) four (d) one

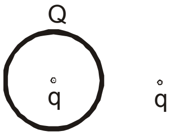
**16.** A body having initial velocity of 10 m/s moving on a rough surface comes to rest after moving 50 m. What is coefficient of friction between the body and surface? ($g = 10\ m/s^2$)

(a) 0.5 (b) 0.2
(c) 0.3 (d) 0.1

**17.** The separation between successive fringes in a double slit arrangement is x. If the whole arrangement is dipped under water what will be the new fringe separation? [The wavelenght of light being used is 5000 Å]

(a) 1.5x (b) x
(c) 0.75x (d) 2x

**18.** A thin, metallic spherical shell contains a charge Q on it. A point charge q is placed at the cente of the shell and another charge $q_1$ is placed outside it as shown in figure. All the three charges are positive. The force on the charge at the centre is



(a) towards left (b) towards right
(c) upward (d) zero

**19.** A charge *q* is moving with a velocity *v* parallel to a magnetic field *B*. Force on the charge due to magnetic field is

(a) *q v B* (b) *q B/v*
(c) zero (d) *B v/q*

**20.** A bucket full of hot water is kept in a room and it cools from 75ºC to 70ºC in $T_1$ minutes, from 70ºC to 65ºC in $T_2$ minutes and from 65ºC to 60ºC in $T_3$ minutes. Then

(a) $T_1 = T_2 = T_3$ (b) $T_1 < T_2 < T_3$
(c) $T_1 > T_2 > T_3$ (d) $T_1 < T_2 > T_3$

**21.** In uniform circular motion, the velocity vector and acceleration vector are

(a) perpendicular to each other
(b) in same direction
(c) in opposite direction
(d) not related to each other

**22.** The current in a coil of L = 40 mH is to be increased uniformly from 1A to 11A in 4 milli sec. The induced e.m.f. will be

(a) 100 V (b) 0.4 V
(c) 440 V (d) 40 V

**23.** Two capacitors when connected in series have a capacitance of 3 μF, and when connected in parallel have a capacitance of 16 μF. Their individual capacities are

(a) 1 μF, 2 μF (b) 6 μF, 2 μF
(c) 12 μF, 4 μF (d) 3 μF, 16 μF

**24.** The weight of a body will be the least at

(a) poles
(b) equator
(c) at height equal to R
(d) centre of the earth

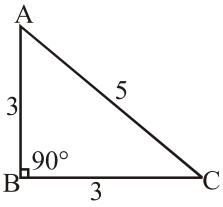
**25.** When a tuning fork produces sound waves in air, which one of the following is same in the material of tuning fork as well as in air?

(a) Wavelength (b) Frequency
(c) Velocity (d) Amplitude

**26.** The fermi energy for a substance is

(a) independent of T
(b) directly proportional to $\sqrt{T}$
(c) directly proportional to T
(d) directly proportional to $T^2$

**27.** ABC is a triangular plate of uniform thickness. The sides are in the ratio shown in the figure. $I_{AB}$, $I_{BC}$ and $I_{CA}$ are the moments of inertia of the plate about AB, BC and CA as axes respectively. Which one of the following relations is correct?



(a) $I_{AB} > I_{BC}$ (b) $I_{BC} > I_{AB}$
(c) $I_{AB} + I_{BC} = I_{CA}$ (d) $I_{CA}$ is maximum

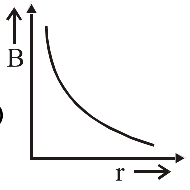
**28.** Consider the following statement:
When jumping from some height, you should bend your knees as you come to rest, instead of keeping your legs stiff. Which of the following relations can be useful in explaining the statement? Where symbols have their usual meanings.

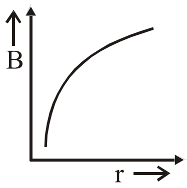
(a) $\Delta\vec{p}_1 = -\Delta\vec{p}_2$ (b) $\Delta E = \Delta(PE + KE) = 0$
(c) $\vec{F}\Delta t = m\Delta\vec{v}$ (d) $\Delta x \propto \Delta F$

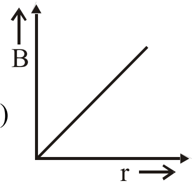
**29.** The amplitude of magnetic field of an electromagnetic wave is $2 \times 10^{-7}$T. It's electric field amplitude if the wave is travelling in free space is

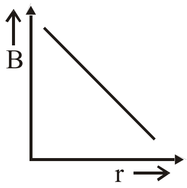
(a) $6\,Vm^{-1}$ (b) $60\,Vm^{-1}$
(c) $10/6\,Vm^{-1}$ (d) None of these

**30.** The magnetic flux density B at a distance r from a long straight wire carrying a steady current varies with distance r as

(a)


(b)


(c)


(d)


**31.** A metal piece is heated upto T° abs. The temperature of the surrounding is t° abs.The heat in the surrounding due to radiation is proportional to
(a) $(T-T)^4$ (b) $T^4-t^4$
(c) $(T-t)^{1/4}$ (d) $T^2-t^2$

**32.** Given, $_a\mu_g = \frac{3}{2}$, $_a\mu_w = \frac{4}{3}$, if a convex lens of focal length 10 cm is placed in water, then its focal length in water is
(a) equal to 40 cm (b) equal to 20 cm
(c) equal to 10 cm (d) None of these

**33.** If an alternating current is flowing in a spring, then the spring will be changing
(a) in a straight line (b) periodically
(c) elliptically (d) first (c) then (a)

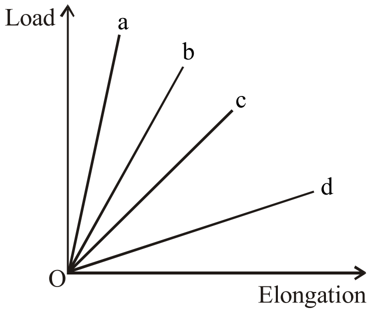
**34.** The unit vector along 2i – 3j + k is
(a) $\frac{2i-3j+k}{\sqrt{14}}$ (b) $\frac{2i-3j+k}{5}$
(c) $\frac{2i-3j+k}{\sqrt{15}}$ (d) None of these

**35.** An iron rod of length 2m and cross-sectional area of 50 $mm^2$ is stretched by 0.5 mm, when a mass of 250 kg is hung from its lower end. Young's modulus of iron rod is
(a) $19.6\times10^{20}\ N/m^2$ (b) $19.6\times10^{18}\ N/m^2$
(c) $19.6\times10^{10}\ N/m^2$ (d) $19.6\times10^{15}\ N/m^2$

**36.** A particle of mass 1 kg is moving in S.H.M. with an amplitude 0.02 and a frequency of 60 Hz. The maximum force acting on the particle is
(a) $144\pi^2$ (b) $188\pi^2$
(c) $288\pi^2$ (d) None of these

**37.** According to Maxwell's hypothesis, a changing electirc field gives rise to
(a) an e.m.f (b) magnetic field
(c) electric current (d) pressure gradient.

**38.** The load versus elongation graph for four wires has been shown in the figure. The thinest wire is



(a) a (b) b
(c) c (d) d

**39.** A ray of light is incident on the surface of separation of a medium with the velocity of light at an angle 45° and is refracted in the medium at an angle 30°. Velocity of light in the medium will be (velocity of light in air = $3\times10^8$ m/s)
(a) $3.8\times10^8$ m/s (b) $3.38\times10^8$ m/s
(c) $2.12\times10^8$ m/s (d) $1.56\times10^8$ m/s

**40.** The rain drops are in spherical shape due to
(a) residual pressure (b) thrust on drop
(c) surface tension (d) viscosity

**41.** A dip circle is so set that its needle moves freely in the magnetic meridian. In this position, the angle of dip is 40°. Now the dip circle is rotated so that the plane in which the needle moves makes an angle of 30° with the magnetic meridian. In this position, the needle will dip by an angle
(a) 40° (b) 30°
(c) more than 40° (d) less than 40°

**42.** If the critical angle for total internal reflection from a medium to vacuum is 30°. Then velocity of light in the medium is
(a) $1.5\times10^8\ m/s$ (b) $2\times10^8\ m/s$
(c) $3\times10^8\ m/s$ (d) $0.75\times10^8\ m/s$

**43.** An oscillator is nothing but an amplifier with
(a) positive feedback (b) large gain
(c) no feedback (d) negative feedback

**44.** For an AM-system the total power of modulated signal is 600 W and that of carrier is 400 W, the modulation index is
(a) 0.25 (b) 0.36
(c) 0.54 (d) 1

**45.** The drift current in a p-n junction is
(a) from the n-side to the p-side
(b) from the p-side to the n-side
(c) from the n-side to the p-side if the junction is forward-baised and in the opposite direction if it is reverse biased
(d) from the p-side to the n-side if the junction is forward-baised and in the opposite direction if it is reverse-baised

## ANSWER KEY

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** (a) | **2.** (d) | **3.** (c) | **4.** (c) | **5.** (b) | **6.** (d) | **7.** (b) | **8.** (b) | **9.** (b) | **10.** (a) |
| **11.** (a) | **12.** (c) | **13.** (c) | **14.** (c) | **15.** (d) | **16.** (d) | **17.** (c) | **18.** (d) | **19.** (c) | **20.** (b) |
| **21.** (a) | **22.** (a) | **23.** (c) | **24.** (d) | **25.** (b) | **26.** (a) | **27.** (b) | **28.** (c) | **29.** (b) | **30.** (a) |
| **31.** (b) | **32.** (a) | **33.** (b) | **34.** (a) | **35.** (c) | **36.** (c) | **37.** (b) | **38.** (d) | **39.** (c) | **40.** (c) |
| **41.** (d) | **42.** (a) | **43.** (a) | **44.** (d) | **45.** (a) | | | | | |

# HINTS & SOLUTIONS

**1.** (a) Force = mass × acceleration

$$= [MLT^{-2}]$$

The dimension of force are $[MLT^{-2}]$

**2.** (d) The difference in velocities is increasing with time as both of them have more constant but different acceleration.

**3.** (c) Heat required to boil water = $mc\Delta\theta$

$$= 2 \times 4200 \times (100 - 20)$$

$$= 6.72 \times 10^3 \text{ J}$$

If t be the time of boil then

$\eta \times 500 \times t = 6.72 \times 10^3$

$$\text{or} \quad t = \frac{6.72 \times 10^3}{0.8 \times 500} = 28 \text{ minutes.}$$

**4.** (c) $T_1 = 27°C = 300\text{ K}$

$V_1 = V$ and $V_2 = \frac{8V}{27}$

Ratio of specific heats for monoatomic gas, $\gamma = \frac{5}{3}$

In an adiabatic process,

$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$

$$\text{or} \quad T_2 = \left(\frac{V_1}{V_2}\right)^{\gamma-1} \times T,$$

$$T_2 = 300 \times \left(\frac{1}{8/27}\right)^{(5/3)-1}$$

$$= 300 \times \left(\frac{27}{8}\right) = 300 \times \left(\frac{9}{4}\right) = 675\text{ K}$$

$$= 402°C$$

Hence, rise in temperature

$$= T_2 - T_1 = 402 - 27 = 375°C$$

**6.** (d) For nuclear disintegration

$$\lambda = \frac{2.303}{t} \log \frac{N_o}{N_o - N}$$

$$= \frac{2.303}{24 \times 60 \times 60} \log \frac{100}{82} = 2.1 \times 10^{-6} \text{sec}^{-1}$$

**7.** (b) Given = $R = \frac{\rho \ell}{\pi r^2}$, then

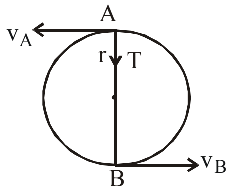
$$\frac{\Delta R}{R} \times 100 = \frac{\Delta \rho}{\rho} \times 100 + \frac{\Delta \ell}{\ell} \times 100 + 2\frac{\Delta r}{r} \times 100$$

$$= 1\% + 2\% + 2 \times 3\% = 9\%$$

**8.** (b) A galvanometer can be changed into an ammeter by the use of low resistance in parallel. So that ammeter does not draw much current which may change the magnitude of main current.

**9.** (b) Acceleration vector is always radial (i.e . towards the center) for uniform circular motion.

**10.** (a) Let velocity at $A = v_A$ and velocity at $B = v_B$



Applying conservation of energy at A & B

$$\frac{1}{2}mv_A^2 + 2gmr = \frac{1}{2}mv_B^2$$

$$v_B^2 = v_A^2 + 4gr .........(i)$$

Now as it is moving in circular path it has centripetal force.

$$\text{At point } A \Rightarrow T + mg = \frac{mv_A^2}{r}$$

for minimumvelocity $T \geq 0$

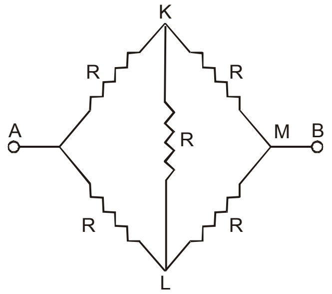
$$\text{or} \quad \frac{mv_A^2}{r} \geq mg \Rightarrow v_A^2 \geq gr \Rightarrow v_A \geq \sqrt{gr}$$

**11.** (a) The equivalent circuit is shown in fig. Since the Wheatstone's bridge is balanced, therefore no current will flow through the arm KL. Equivalent resistance between

AKM = R + R = 2 R

Equivalent resistance between ALM = R + R = 2 R

The two resistances are in parallel. Hence equivalent resistance between A and B is given by



$$\frac{1}{R'}=\frac{1}{2R}+\frac{1}{2R}=\frac{2}{2R}=\frac{1}{R}$$

i.e., $R'=R$

**12.** (c) For $n^{th}$ orbit, energy, $E_n=\frac{2\pi^2 em^4z^2}{n^2h^2}$

For hydrogen (z = 1), $E_n=\frac{2\pi^2 em^4}{n^2h^2}$

For helium (z = 2),

So, $E=\frac{2\pi^2em^4\times 4}{n^2h^2}$

$\frac{E}{E_n}=\frac{4}{1}\Rightarrow E=4E_n$

**13.** (c) Conserving Linear Momentum

$2Mv_c = 2Mv - Mv \Rightarrow v_c = v/2.$

**14.** (c) $\frac{R_s}{R_\alpha}=\left(\frac{A_s}{A_\alpha}\right)^{1/3}=\left(\frac{32}{4}\right)^{1/3}=2$

**15.** (d) $\frac{dH}{dt}\propto(\theta_2-\theta_1)=(\Delta\theta)^n \Rightarrow n=1$

**16.** (d) Use $a = \mu g$ and $v^2 = u^2 + 2as$

**17.** (c) When the arrangement is dipped in water;

$\beta'=\beta/\mu=\frac{x}{4/3}=\frac{3}{4}x=0.75x$

**18.** (d) The charge q, which is kept at the centre of metallic spherical shell transfered to the outer surface of shell & inside the shell the electric field is zero & hence force is also zero.

**19.** (c) $F_n=q(\vec{v}\times\vec{B})$

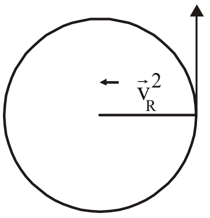
$=qvB\sin\theta=0$ (because $\theta = 0^o$ )

**20.** (b) The time of cooling increases as the difference between the temperature of body & surrounding is reduced. So $T_1<T_2<T_3$ (according to Newton's law of cooling).

**21.** (a) In uniform circular motion speed is constant. So, no tangential acceleration.

It has only radial acceleration

$a_R=\frac{v^2}{R}$ [directed towards center]



and its velocity is always in tangential direction. So these two are perpendicular to each other.

**22.** (a) $e=\frac{LdI}{dt}=\frac{40\times10^{-3}(11-1)}{4\times10^{-3}}=100V$

**23.** (c) $C_s=\frac{C_1C_2}{C_1+C_2}=3$

$C_p= C_1+ C_2= 16 \therefore C_1C_2=48$

$C_1-C_2=\sqrt{(C_1+C_2)^2-4C_1C_2}$

$=\sqrt{16^2-4\times48}=\sqrt{64}=8$

$\therefore C_1=12\mu F$ and $C_2=4\mu F$

**24.** (d) At the centre of the earth gravity is zero.

**25.** (b) Frequency does not depend upon the medium, so, it will remain same in the material of the tuning fork and in air.

**26.** (a) The highest energy level occupied by an electron in the energy band at zero kelvin is called Fermi level and the energy associated is known as Fermi energy. So, it is independent of T.

**27.** (b) The intersection of medians is the centre of mass of the triangle. Since distances of centre of mass from the sides are related as : $x_{BC}<x_{AB}<x_{AC}$ therefore $I_{BC}>I_{AB}>I_{AC}$ or $I_{BC}>I_{AB.}$

**28.** (c) If $\vec{F}$ force acts for short interval $\Delta t$, then

$\vec{F}\ \Delta T=m\Delta\vec{v}$.

**29.** (b) For electromagnetic wave,

$F_E=F_M\Rightarrow eE=BeC\Rightarrow E=B.C$

$=2\times10^{-7}\times3\times10^8=60\ V/m$

**30.** (a) According to Biot Savart's law

$dB=\frac{\mu_0}{4\pi}.\frac{Id\ell\sin\theta}{r^2}$

$dB\propto\frac{1}{r^2}$

So, graph (a) is correct.

**31.** **(b)** According to Stefan' law heat emitted per second per unit area $\alpha(T_1^4-T_2^4)$ where $T_1$ is the temperature of body & $T_2$ is the temperature of surrounding ($T_1$ & $T_2$ are on Kelvin scale).

**32.** (a) $\frac{1}{f_\omega}=({}^{\omega}\mu_g-1)\left(\frac{1}{r_1}-\frac{1}{r_2}\right)$

[ $f_\omega$ is focal length of lens in water]

$\frac{1}{f}=({}^{a}\mu_g-1)\left(\frac{1}{r_1}-\frac{1}{r_2}\right)$

[f is focal length of lens in air]

Dividing,

$\frac{f}{f_\omega}=\frac{({}^{\omega}\mu_g-1)}{({}^{a}\mu_g-1)};{}^{\omega}\mu_g=\frac{{}^{a}\mu_g}{{}^{a}\mu_w}$

$=\frac{3/2}{4/3}=\frac{3}{2}\times\frac{3}{4}=\frac{9}{8}$

$\frac{f}{f_w}=\frac{9/8-1}{\frac{3}{2}-1}=\frac{1/8}{1/2}=\frac{1}{4}$

$f_w=4\times f=4\times10=40\text{ cm.}$

**33.** (b) If current passes through a spring, it shrinks as in two adjacent wire, current is flowing in the same direction. Even if direction of current is reversed still the spring will shrink. As AC current is a periodically changing current, the process of shrinking will also be periodic in nature.

**35.** (c) $Y = \frac{F/A}{\Delta\ell/\ell} = \frac{\frac{250 \times 10}{50 \times 10^{-6}}}{\frac{0.5 \times 10^{-3}}{2}}$

$= \frac{250 \times 9.8}{50 \times 10^{-6}} \times \frac{2}{0.5 \times 10^{-3}}$

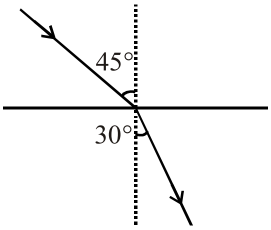
$\Rightarrow 19.6 \times 10^{10}\,N/m^2$

**36.** (c) Max. force = mass × max. acceleration

$= m\,4\pi^2\nu^2 a = 1 \times 4 \times \pi^2 \times (60)^2 \times 0.02 = 288\,\pi^2$

**37.** (b) Changing electric field gives rise to displacement current which creates magnetic field around it.

**39.** (c)



Refractive index, $\mu = \frac{\sin 45^\circ}{\sin 30^\circ}$

$\mu = \frac{1}{\sqrt{2}} \times 2 = \sqrt{2}$

Now, $\mu = \frac{\text{Velocity of light in air}}{\text{Velocity of light in medium}} = \sqrt{2}$

Velocity of light in medium

$= 3 \times 10^8 \times \frac{1}{\sqrt{2}} = 2.12 \times 10^8\,m/sec$

**40.** (c) Rain drops are in spherical shape due to surface tension.

**41.** (d) $\delta_1 = 40^\circ, \delta_2 = 30^\circ, \delta = ?$

$\cot\delta = \sqrt{\cot^2\delta_1 + \cot^2\delta_2} = \sqrt{\cot^2 40^\circ + \cot^2 30^\circ}$

$\cot\delta = \sqrt{1.19^2 + 3} = 2.1$

$\therefore\ \delta = 25^\circ$ i.e. $\delta < 40^\circ$.

**42.** (a) $\mu = \frac{1}{\sin C} = \frac{1}{\sin 30^\circ} = \frac{1}{1/2} = 2$

Velocity of light in the medium

$= \frac{3 \times 10^8}{2} = 1.5 \times 10^8\,m/sec$

**44.** (d) $P_T = P_C\left(1 + \frac{{m_a}^2}{2}\right)$

$\therefore\ 600 = 400\left(1 + \frac{{m_a}^2}{2}\right) \Rightarrow \frac{3}{2} = 1 + \frac{{m_a}^2}{2}$

or $\frac{{m_a}^2}{2} = \frac{1}{2} \Rightarrow m_a = 1$

# Mock Test-2

**Time : 1 hr** **Max. Marks -180**

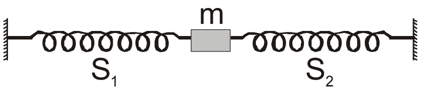
**1.** A heater of 220 V heats a volume of water in 5 minutes time. A heater of 110 V heats the same volume of water in

(a) 5 minutes (b) 8 minutes
(c) 10 minutes (d) 20 minutes

**2.** Error in the measurement of radius of a sphere is 1%. Then error in the measurement of volume is

(a) 1% (b) 5%
(c) 3% (d) 8%

**3.** In the fig. $S_1$ and $S_2$ are identical springs. The oscillation frequency of the mass m is f. If one spring is removed, the frequency will become



(a) f (b) $f \times 2$
(c) $f \times \sqrt{2}$ (d) $f / \sqrt{2}$

**4.** A body of mass 2 kg is rotating on a circular path of radius 0.8 m with an angular velocity 44 rad/sec. If radius of path becomes 1 m then value of angular velocity will be

(a) 35.28 rad/sec (b) 14.08 rad/sec
(c) 28.16 rad/sec (d) 24.08 rad/sec

**5.** The motion of particle is described by the equation $x = a + bt^2$, where a = 15 cm and b = 3 cm/sec$^2$. Its instant velocity at time 3 sec will be

(a) 36 cm/sec (b) 9 cm/sec
(c) 4.5 cm/sec (d) 18 cm/sec

**6.** The perfect gas equation for 4 gram of hydrogen gas is

(a) PV=RT (b) PV=2RT
(c) $PV = \frac{1}{2} RT$ (d) PV=4RT

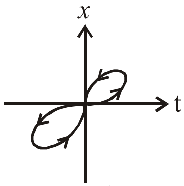
**7.** A coil of insulated wire is connected to a battery. If it is taken to galvanometer, its pointer is deflected, because

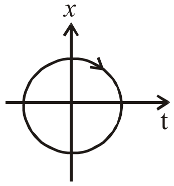
(a) induced current is produced
(b) the coil acts like a magnet
(c) the number of turns in the coil of the galvanometer are changed
(d) None of these

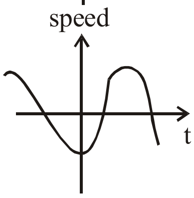
**8.** The dimensions of magnetic field in M, L, T and C (coulomb) is given as

(a) $[MLT^{-1}C^{-1}]$ (b) $[MT^2C^{-2}]$
(c) $[MT^{-1}C^{-1}]$ (d) $[MT^{-2}C^{-1}]$

**9.** Which of the following graph cannot possibly represent one dimensional motion of a particle?

(a)


(b)


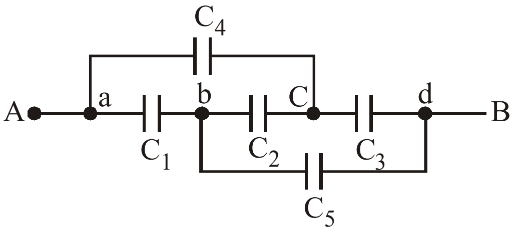
(c)


(d) All of the above

**10.** Minimum excitation potential of Bohr's first orbit in hydrogen atom will be

(a) 3.4 eV (b) 3.6 eV
(c) 10.2 eV (d) 13.6 eV

**11.** In the given figure, the capacitors $C_1, C_3, C_4$ and $C_5$ have a capacitance of 4μF each. If the capacitor $C_2$ has a capacitance of 10μF, then effective capacitance between A and B is



(a) 8μF (b) 6μF
(c) 4μF (d) 2μF

**12.** According to Einstein's photoelectric equation, the plot of the kinetic energy of the emitted photoelectrons from a metal vs the frequency of the incident radiation gives a straight line whose slope

(a) depends on the intensity of the radiation
(b) depends of the mature of the metal used
(c) depends both on the intensity of the radiation and the metal used
(d) is the same for all metals and independent of the intensity of the radiation

**13.** The moment of inertia of a rigid body, depends upon

(a) distribution of mass from axis of rotation
(b) angular velocity of the body
(c) angular acceleration of the body
(d) mass of the body.

**14.** In a nuclear fission, 0.1% mass is converted into energy. The energy released by the fission of 1 kg mass will be

(a) $9 \times 10^{19}$ J (b) $9 \times 10^{17}$ J
(c) $9 \times 10^{16}$ J (d) $9 \times 10^{13}$ J

**15.** If the coefficient of cubical expansion is x times of the coefficient of superficial expansion, then value of x is

(a) 3 (b) 2.5

(c) 1.5 (d) 2

**16.** When a bus suddenly takes a turn, the passengers are thrown outwards because of

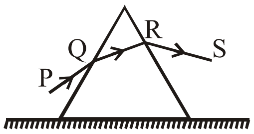
(a) speed of motion

(b) inertia of motion

(c) acceleration of motion

(d) None of these

**17.** An equilateral prism is placed on a horizontal surface. A ray PQ is incident onto it. For minimum deviation



(a) PQ is horizontal

(b) QR is horizontal

(c) RS is horizontal

(d) any one will be horizontal

**18.** A tin nucleus (atomic number $Z = 50$) has a radius of $6.6 \times 10^{-15}$ m. The potential on its surface will be (the charge on the proton = $1.6 \times 10^{-19}$ C)

(a) $1.1 \times 10^7$ V (b) $2.1 \times 10^7$ V

(c) $3.1 \times 10^7$ V (d) $0.15 \times 10^7$ V

**19.** A relation between Faraday's constant F, chemical equivalent E and electrochemical equivalent Z is

(a) $F = EZ^2$ (b) $F = \frac{E}{Z^2}$

(c) $F = \frac{E^2}{Z}$ (d) $F = \frac{E}{Z}$

**20.** Two rods of the same length and areas of cross-section $A_1$ and $A_2$ have their ends at the same temperature $K_1$ and $K_2$ are the thremal conductivities of the two rods. The rate of flow of heat is same in both rods if

(a) $\frac{A_1}{A_2} = \frac{K_1}{K_2}$

(b) $\frac{A_1}{A_2} = \frac{K_2}{K_1}$

(c) $A_1A_2 = K_1K_2$

(d) $A_1 K_1^2 = A_2 K_2^2$

**21.** A stone is just released from the window of a train moving along a horizontal straight track. The stone will hit the ground following a

(a) straight line path

(b) circular path

(c) parabolic path

(d) hyperbolic path

**22.** Lenz's law is a consequence of the law of conservation of

(a) charge (b) mass

(c) energy (d) momentum

**23.** An equipotential surface is that surface

(a) on which each and every point has the same potential

(b) which has negative potential

(c) which has positive potential

(d) which has zero potential

**24.** The kinetic energy of a body becomes four times its inital value. The new momentum will be

(a) same as initial value

(b) twice the initial value

(c) thrice the initial value

(d) four times the initial value

**25.** An observer moves towards a stationary source of sound with a speed 1/5th ofthe speed of sound. The wavelength and frequency of the source emitted any $\lambda$ and f respectively. The apparent frequency and wavelength recorded by the observer are respectively

(a) 0.8f, 0.8$\lambda$ (b) 1.2f, 1.2$\lambda$

(c) 1.2f, $\lambda$ (d) f, 1.2$\lambda$

**26.** The photoelectric effect is based upon the law of conservation of

(a) momentum

(b) energy

(c) angular momentum

(d) mass

**27.** A choke is preferred to a resistance for limiting current in AC circuit because

(a) choke is cheap

(b) there is no wastage of power

(c) choke is compact in size

(d) choke is a good absorber of heat

**28.** If a body of mass 3 kg is dropped from the top of a tower of height 25m. Then its kinetic energy after 3 sec is

(a) 557 J

(b) 748 J

(c) 1050 J

(d) 1296 J

**29.** A gymnast takes turns with her arms & legs stretched. When she pulls her arms & legs in

(a) the angular velocity decreases

(b) the moment of inertia decreases

(c) the angular velocity stays constant

(d) the angular momentum increases

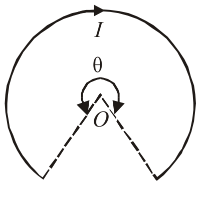
**30.** A current of $I$ ampere flows in a wire forming a circular arc of radius $r$ metres subtending an angle $\theta$ at the centre as shown. The magnetic field at the centre $O$ in tesla is

(a) $\frac{\mu_0 I\theta}{4\pi r}$

(b) $\frac{\mu_0 I\theta}{2\pi r}$

(c) $\frac{\mu_0 I\theta}{2r}$

(d) $\frac{\mu_0 I\theta}{4r}$



**31.** The number of degrees of freedom for each atom of a monoatomic gas is

(a) 3 (b) 5

(c) 6 (d) 1

**32.** Ability of the eye to see objects at all distances is called

(a) binocular vision

(b) myopia

(c) hypermetropia

(d) accommodation

**33.** The velocity of electromagnetic radiation in a medium of permittivity $\varepsilon_0$ and permeability $\mu_0$ is given by

(a) $\sqrt{\frac{\in_0}{\mu_0}}$ (b) $\sqrt{\mu_0 \in_0}$

(c) $\frac{1}{\sqrt{\mu_0 \in_0}}$ (d) $\sqrt{\frac{\mu_0}{\in_0}}$

**34.** The numerical ratio of displacement to distance is
(a) always less than one
(b) always equal to one
(c) always more than one
(d) equal to or less than one

**35.** The change in the value of 'g' at a height 'h' above the surface of the earth is the same as at a depth 'd' below the surface of the earth. When both 'd' and 'h' are much smaller than the radius of earth, then which one of the following is correct?

(a) $d = \frac{3h}{2}$ (b) $d = \frac{h}{2}$
(c) $d = h$ (d) $d = 2h$

**36.** Pressure exerted by a perfect gas is equal to
(a) mean kinetic energy per unit volume
(b) half of mean kinetic energy per unti volume
(c) two third of mean kinetic energy per unit volume
(d) one third of mean kinetic energy per unit volume

**37.** Transformer is based upon the principle of
(a) self induction (b) mutual induction
(c) eddy current (d) None of these

**38.** A spherical ball of iron of radius 2 mm is falling through a column of glycerine. If densities of glycerine and iron are respectively $1.3 \times 10^3$ kg/m$^3$ and $8 \times 10^3$ kg/m$^3$, $\eta$ for glycerine = 0.83 Nm$^{-2}$ sec, then the terminal velocity is
(a) 0.7 m/s (b) 0.07 m/s
(c) 0.007 m/s (d) 0.0007 m/s

**39.** The time taken by light to pass through 4 mm thick glass slab of refractive index 1.5 will be (velocity of light in air = $3 \times 10^8$ m/s)
(a) $8 \times 10^{-11}$ s (b) $2 \times 10^{-11}$ s
(c) $8 \times 10^{-8}$ s (d) $8 \times 10^{-8}$ s

**40.** Surface tension of a solution is $30 \times 10^{-2}$ N/m. The radius of the soap bubble is 5 cm. The surface energy of soap bubble is
(a) $1.8 \times 10^1$ J (b) $1.8 \times 10^2$ J
(c) $1.0 \times 10^{-1}$ J (d) $1.8 \times 10^{-2}$ J

**41.** A cylindrical resonance tube, open at both ends, has a fundamental frequency f in air. If half of the length is dipped vertically in water, the fundamental frequency of the air column will be

(a) $\frac{3f}{2}$ (b) 2f

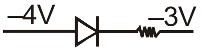
(c) f (d) $\frac{f}{2}$

**42.** Which of the following waves have the maximum wavelength ?
(a) Infrared rays (b) UV rays
(c) Radio waves (d) X – rays

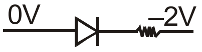
**43.** In an p-n-p transistor working as a common base amplifier current gain is 0.96 and emitter current is 7.2 mA. The base current is
(a) 0.2 mA (b) 0.29 mA
(c) 0.35 mA (d) 0.4 mA

**44.** The forward biasd diode is

(a) 

(b) 

(c) 

(d) 

**45.** In V-I characteristic of a p-n junction reverse biasing results in
(a) leakage current
(b) the current barrier across junction increases
(c) no flow of current
(d) large current

## ANSWER KEY

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** (d) | **2.** (c) | **3.** (d) | **4.** (c) | **5.** (d) | **6.** (b) | **7.** (a) | **8.** (c) | **9.** (d) | **10.** (c) |
| **11.** (c) | **12.** (d) | **13.** (a) | **14.** (d) | **15.** (c) | **16.** (b) | **17.** (b) | **18.** (a) | **19.** (d) | **20.** (b) |
| **21.** (c) | **22.** (c) | **23.** (a) | **24.** (b) | **25.** (c) | **26.** (b) | **27.** (b) | **28.** (b) | **29.** (b) | **30.** (a) |
| **31.** (a) | **32.** (d) | **33.** (c) | **34.** (d) | **35.** (d) | **36.** (c) | **37.** (b) | **38.** (b) | **39.** (b) | **40.** (d) |
| **41.** (c) | **42.** (c) | **43.** (b) | **44.** (d) | **45.** (a) | | | | | |

# HINTS & SOLUTIONS

1. (d) Heat produced, $H = \frac{V^2 t}{R}$. When voltage is halved, the heat produced becomes one fourth. Hence time taken to heat the water becomes four times.

2. (c) $V = \frac{4}{3}\pi r^3$;

$$\frac{\Delta V}{V} \times 100 = 3\left(\frac{\Delta r}{r}\right) \times 100 = 3 \times 1\% = 3\%$$

3. (d) Here effective spring factor, $k_{eff} = 2\,k$;

Frequency of oscillation, $f = \frac{1}{2\pi}\sqrt{\frac{2k}{m}}$ ; when one spring is removed, then spring factor = k ;

New frequency of oscillation $f' = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{f}{\sqrt{2}}$

4. (c) We shall apply conservation of angular momentum; that is

$$I_1\omega_1 = I_2\omega_2$$

$$\Rightarrow mv_1r_1 = mv_2r_2 \Rightarrow \omega_1 {r_1}^2 = \omega_2 {r_2}^2$$

$$\Rightarrow 44 \times (0.8)^2 = \omega_2 \times (1)^2$$

$$\Rightarrow \omega_2 = 44 \times 0.8 \times 0.8 = 28.16 \text{ radian/sec}$$

5. (d) $x = a + bt^2 = 15 + 3t^2$

$$v = \frac{dx}{dt} = 3 \times 2t = 6t \Rightarrow v|_{t=3s} = 6 \times 3 = 18 \text{cm/s}$$

6. (b) $n = \frac{4}{2} = 2 \therefore PV = 2RT$

8. (c) We know that F = q v B

$$\therefore B = \frac{F}{qv} = \frac{MLT^{-2}}{C \times LT^{-1}} = [MT^{-1}C^{-1}]$$

9. (d) In (a), at the same time particle has two positions which is not possible. In (b), particle has two velocities at the same time. In (c), speed is negative which is not possible.

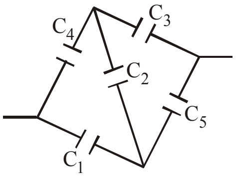
10. (c) Minimum excitation energy will be difference between ground level energy (n = 1) & first excited state (n = 2)

Now, $E_1 = -13.6\,\text{eV}$

$$E_2 = \frac{13.6}{2^2}\text{eV} = -3.4\,\text{eV}$$

Difference = – 3.4 + 13.6 = 10.2 eV

11. (c) The arrangement forms Wheatstone bridge as shown below :



It is balanced because

$$\frac{C_4}{C_1} = \frac{C_3}{C_5} = 1$$

So, we can neglect $C_2$.

Now $C_4$ & $C_3$ are in series, $C_1$ & $C_5$ are in series so their resultant capacitance of each combination = $\frac{4 \times 4}{4+4} = \frac{16}{8} = 2\mu F$

These combinations are in parallel, so, total capacitance = 2 + 2 = 4μF

12. (d) $h\nu = \phi + \frac{1}{2}mv^2 \Rightarrow h\nu = \phi + \text{K.E.}$

$$\nu = \phi + \frac{1}{h}\text{K.E.}$$

This is equation of a straight line, if we plot ν, K-E curve. The slope of this curve is $\frac{1}{h}$ which is constant. So, it is independent of metals used.

Option (d) is correct.

13. (a) Moment of inertia of a body is given by the expression

$$I = \sum_{i=1}^{n} m_i r_i^2$$

This is the sum of product of mass of each particle and square of its distance from the axis. Naturally if distribution of mass changes, value of r will change & hence I will change.

14. (d) 0.1% of 1 kg = 0.001 kg

From the formula, $E = mc^2$

Energy released = $0.001 \times (3 \times 10^8)^2$ joules

$$= 9 \times 10^{16} \times 10^{-3} = 9 \times 10^{13} \text{J}$$

15. (c) $3k = x.2k$

[Here α is coefficient of linear expansion so coefficient of cubical expansion = 3α & coefficient of superfacial expansion = 2α]

$$x = \frac{3}{2} = 1.5$$

16. (b) When a bus suddenly take a turn, the passengers are thrown outwards because of inertia of motion.

17. (b) For minimum deviation, incident angle is equal to emerging angle.

∴ QR is horizontal.

18. (a) Charge on the tin nucleus = n.Q

$= (1.6 \times 10^{-19} \times 50)\,\text{C} = 8 \times 10^{-18}\text{C}$

This charge is supposed to be concentrated at its centre. Hence, potential on the surface,

$$V = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r} = \frac{9 \times 10^9 \times 8 \times 10^{-18}}{6.6 \times 10^{-15}} = 1.1 \times 10^7 \text{V}$$

19. (d) One faraday charge is required to losing about electrolysis of one gram equivalent of a body. Now using this information in the relation,

$$m = ZQ$$

$$E = ZF \Rightarrow F = \frac{E}{Z}$$

21. (c) The horizontal velocity of the stone will be the same as that of the train. In this way, the horizontal motion will be uniform. The vertical motion will be controlled by the force of gravity. Hence it is accelerated motion. The resultant motion is a parabolic trajectory.

24. (b) $K = \frac{P^2}{2m} \Rightarrow P = \sqrt{2Km}$

as K is made four times P will become two times.

25. (c) $f_{\text{apparent}} = \left(\frac{u + u/5}{u}\right) f = \frac{6}{5} f = 1.2f$

wavelength remains constant (unchanged) in this case.

26. (b) Photoelectric effect is based on law of conservation of energy

27. (b) Choke coil is a device having high inductance and negligible resistance. It is used to control current in ac circuits and the power loss in a circuit containing choke coil is least.

28. (b) After 3 sec its velocity

$$v^2 = u^2 + 2gh = 0 + 2 \times 9.8 \times 25$$

$$\text{K.E} = \frac{1}{2} mv^2 = \frac{1}{2} \times 3 \times 2 \times 9.8 \times 25 = 75 \times 9.8 = 748 \text{ J.}$$

29. (b) Since no external torque action gymnast, so angular momentum (L = Iω) is conserved. After pulling her arms & legs, the angular velocity increases but moment of inertia of gymnast, decreases in, such a way that angular momentum remains constant.

30. (a) $B = \frac{\mu_0 I}{2r} \times \frac{\theta}{2\pi} = \frac{\mu_0 I\theta}{4\pi r}$

32. (d) Ability of the eye to see object at all distance is called accommodation. This is the power of the eye to change the focal length of eye lens so that it can focus rays coming from different distances.

33. (c) The velocity of electromagnetic radiation in a medium of permittivity $\in_0$ and permeability $\mu_0$ is equal to

$$\frac{1}{\sqrt{\mu_0 \in_0}}.$$

34. (d) As displacement ≤ distance, therefore, the ratio is equal to or less than one.

35. (d) Variation of g with altitude is, $g_h = g\left[1 - \frac{2h}{R}\right]$;

variation of g with depth is, $g_d = g\left[1 - \frac{d}{R}\right]$

Equating $g_h$ and $g_d$, we get d = 2h

36. (c) $P = \frac{2/3(½ mN\ v_{rms}^2)}{V}$ where m is mass of molecule of gas, N is number of molecules in gas & $v_{rms}$ is root mean squar velocity of the molecule.

37. (b) Transformer is based upon the principle of mutual induction. Current is induced in the secondary coil due to change in current in primary coil of the transformer.

38. (b) Terminal velocity, $v_0 = \frac{2\,r^2(\rho-\rho_0)g}{9\eta}$

$$= \frac{2\times(2\times10^{-3})^2\times(8-1.3)\times10^3\times9.8}{9\times0.83} = 0.07\ \text{ms}^{-1}$$

39. (b) Velocity of light in glass $= \frac{3\times10^8}{1.5} = 2\times10^8\ \text{m/sec}$

Time taken $= \frac{\text{distance}}{\text{velocity}} = \frac{4\times10^{-3}}{2\times10^8} = 2\times10^{-11}\ \text{sec}$

40. (d) Surface tension of solution

$(T) = 30\times10^{-12}\ \text{N/m}$

Radius of the soap bubble (r) = 5 cm = 0.05 m

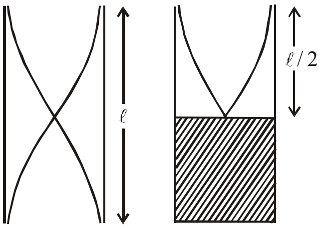
Since, the bubble has two spherical surface,

hence, $\Delta A = 2\times\text{surface area} = 2\times\ 4\pi r^2$

Therefore, surface energy $= T\times\ \Delta A$

$= 30\times10^{-2}\times2\times[4\,\pi\,(0.05)^2] = 1.8\times10^{-2}\ \text{J}$

41. (c)



From the figure it is clear that in both the cases wavelength is same. So, frequency of fundamental tone will also be same. Hence the answer will be (c).

42. (c) Radio waves are low frequency electro-magnetic waves. So, their wavelength will be comparatively large.

43. (b) For common base

Current gain $= \frac{I_c}{I_e} = 0.96$

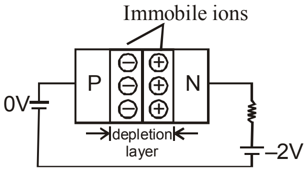
$I_c = I_e\times0.96 = 0.96\times7.2 = 6.912$

$I_b = I_e - I_c = 7.2 - 6.912$

$= 0.288 \approx 0.29\ \text{mA}$

44. (d) 

It can be sketched as



45. (a) Leakage current is the name given to the reverse current

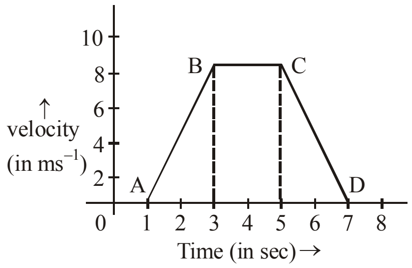
# Mock Test-3

**Time : 1 hr** **Max. Marks -180**

**1.** Stopping distance of a moving vehicle is directly proportional to
(a) the initial velocity
(b) the initial acceleration
(c) the square of initial velocity
(d) square of initial acceleration

**2.** An eye specialist prescribes spectacles having combination of convex lens of focal length 40 cm in contact with a concave lens of focal length 25 cm. The power of this lens combination in diopter is
(a) $+1.5$ (b) $-1.5$
(c) $+6.67$ (d) $-6.67$

**3.** For the velocity time graph shown in the figure below the distance covered by the body in the last two seconds of its motion is what fraction of the total distance travelled by it in all the seven seconds?



(a) $\frac{1}{2}$ (b) $\frac{1}{4}$ (c) $\frac{2}{3}$ (d) $\frac{1}{3}$

**4.** A boat is sent across a river with a velocity of 8 km h$^{-1}$. If the resultant velocity of boat is 10 km h$^{-1}$, then the velocity of the river is
(a) 12.8 km h$^{-1}$ (b) 6 km h$^{-1}$
(c) 8 km h$^{-1}$ (d) 10 km h$^{-1}$

**5.** The effective acceleration of a body when thrown upwards with acceleration $a$ is
(a) $(g + a)$ (b) $(a - g)$
(c) $\sqrt{(g^2 + a^2)}$ (d) $(g - a^2/g)$

**6.** Which one of the following statements is false ?
(a) A vector has only magnitude, whereas a scalar has both magnitude and direction
(b) Distance is a scalar quantity but displacement is a vector quantity
(c) Momentum, force and torque are vector quantities
(d) Mass, speed and energy are scalar quantities

**7.** Out of the following pair , which one does NOT have identical dimensions
(a) impulse and momentum
(b) angular momentum and planck's constant
(c) work and torque
(d) moment of inertia and moment of a force

**8.** If $Q$, $E$ and $W$ denote respectively the heat added, change in internal energy and the work done in a closed cyclic process, then
(a) $W = 0$ (b) $Q = W = 0$
(c) $E = 0$ (d) $Q = 0$

**9.** The moment of inertia of disc about a tangent axis in its plane is
(a) $\frac{MR^2}{4}$ (b) $\frac{3MR^2}{2}$
(c) $\frac{5}{4}MR^2$ (d) $\frac{7MR^2}{4}$

**10.** The angles which the vector $\vec{A} = 3\hat{i} + 6\hat{j} + 2\hat{k}$ makes with the co-ordinate axes are
(a) $\cos^{-1}\frac{3}{7}, \cos^{-1}\frac{4}{7}, \cos^{-1}\frac{1}{7}$
(b) $\cos^{-1}\frac{3}{7}, \cos^{-1}\frac{6}{7}, \cos^{-1}\frac{2}{7}$
(c) $\cos^{-1}\frac{4}{7}, \cos^{-1}\frac{5}{7}, \cos^{-1}\frac{3}{7}$
(d) None of these

**11.** How many electrons make up a charge of 20 μC?
(a) $1.25 \times 10^{14}$ (b) $2.23 \times 10^{14}$
(c) $3.25 \times 10^{14}$ (d) $5.25 \times 10^{14}$

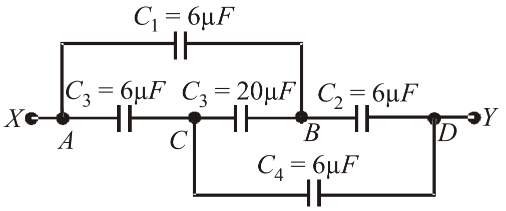
**12.** Two masses $A$ and $B$ each of mass $M$ are fixed together by a massless spring. A force acts on the mass $B$ as shown in fig. At the instant the mass $A$ has acceleration '$a$'. What is the acceleration of mass $B$ ?

(a) $(F/M) - a$ (b) $a$
(c) $-a$ (d) $(F/M)$

**13.** When sound waves travel from air to water, which one of the following remains constant?
(a) Time period (b) Frequency
(c) Velocity (d) Wavelength

**14.** An ideal gas $A$ and a real gas $B$ have their volumes increased from $V$ to $2V$ under isothermal conditions. The increase in internal energy
(a) will be same in both $A$ and $B$
(b) will be zero in both the gases
(c) of $B$ will be more than that of $A$
(d) of $A$ will be more than that of $B$

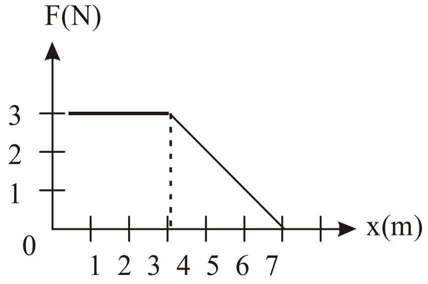
**15.** What is the effective capacitance between points $X$ and $Y$?



(a) 24 $\mu F$ (b) 18 $\mu F$
(c) 12 $\mu F$ (d) 6 $\mu F$

**16.** A particle of mass $m_1$ is moving with a velocity $v_1$ and another particle of mass $m_2$ is moving with a velocity $v_2$. Both of them have the same momentum but different kinetic energies are $E_1$ and $E_2$ respectively. If $m_1 > m_2$ then
(a) $E_1 = E_2$ (b) $E_1 < E_2$
(c) $\frac{E_1}{E_2} = \frac{m_1}{m_2}$ (d) $E_1 > E_2$

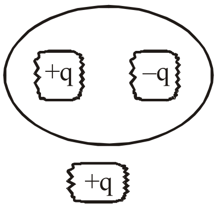
**17.** A force F acting on an object varies with distance $x$ as shown here. The force is in N and $x$ in $m$. The work done by the force in moving the object from $x = 0$ to $x = 6$ m is



(a) 18.0 J (b) 13.5 J
(c) 9.0 J (d) 4.5 J

**18.** If a spherical ball rolls on a table without slipping the fraction of its total energy associated with rotational energy is
(a) $\frac{3}{5}$ (b) $\frac{2}{7}$
(c) $\frac{2}{5}$ (d) $\frac{3}{7}$

**19.** Shown below is a distribution of charges. The flux of electric field due to these charges through the surfaces S is
(a) $3q/\varepsilon_0$
(b) $2q/\varepsilon_0$
(c) $q/\varepsilon_0$
(d) zero



**20.** 10 cm is a wavelength corresponding to the spectrum of
(a) infrared rays (b) ultraviolet rays
(c) microwaves (d) $\gamma$-rays

**21.** The transformer voltage induced in the secondary coil of a transformer is mainly due to
(a) a varying electric field
(b) a varying magnetic field
(c) the vibrations of the primary coil
(d) the iron core of the transformer

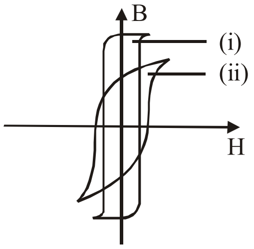
**22.** The escape velocity for a body projected vertically upwards from the surface of earth is 11 km/s. If the body is projected at an angle of 45° with the vertical, the escape velocity will be
(a) $11\sqrt{2}$ km/s (b) 22 km/s
(c) 11 km/s (d) $\frac{11}{\sqrt{2}}$ km/s

**23.** An open U-tube contains mercury. When 11.2 cm of water is poured into one of the arms of the tube, how high does the mercury rise in the other arm from its initial level?
(a) 0.56 cm (b) 1.35 cm
(c) 0.41 cm (d) 2.32 cm

**24.** A steel wire of length 20 cm and uniform cross-section 1 mm$^2$ is tied rigidly at both the ends. The temperature of the wire is altered from 40°C to 20°C. Coefficient of linear expansion for steel $\alpha = 1.1 \times 10^{-5}$/°C and $Y$ for steel is $2.0 \times 10^{11}$ N/m$^2$. The change in tension of the wire is
(a) $2.2 \times 10^6$ newton (b) 16 newton
(c) 8 newton (d) 44 newton

**25.** The fastest mode of transfer of heat is
(a) conduction (b) convection
(c) radiation (d) None of these

**26.** The B – H curve (i) and (ii) shown in fig associated with

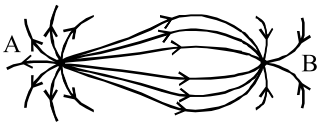


(a) (i) diamagnetic and (ii) paramagnetic substance
(b) (i) paramagnetic and (ii) ferromagnetic substance
(c) (i) soft iron and (ii) steel
(d) (i) steel and (ii) soft iron

**27.** The pressure P of an ideal gas and its mean K.E. per unit volume are related as
(a) $P = \frac{E}{2}$ (b) $P = E$
(c) $P = \frac{3E}{2}$ (d) $P = \frac{2E}{3}$

**28.** A body cools from 50.0°C to 48°C in 5s. How long will it take to cool from 40.0°C to 39°C? Assume the temperature of surroundings to be 30.0°C and Newton's law of cooling to be valid.
(a) 2.5 s (b) 10 s
(c) 20 s (d) 5 s

**29.** The spatial distribution of the electric field due to two charges (A, B) is shown in figure. Which one of the following statements is correct ?



(a) A is +ve and B –ve; |A| > |B|
(b) A is –ve and B +ve; |A| = |B| :
(c) Both are +ve but A > B
(d) Both are –ve but A > B

**30.** The equation of plane wave is given by

$$y = 2\sin\pi\left(200t - \frac{x}{15}\right)$$

where displacement y is given in cm and time t in second, then the velocity of the wave is
(a) 3000 cm/sec (b) 200 cm/sec

(c) 150 cm/sec (d) 2 cm /sec

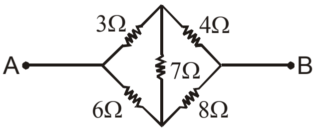
**31.** A primary cell has an e.m.f. of 1.5 volt. When short-circuited it gives a current of 3 ampere. The internal resistance of the cell is

(a) 4.5 ohm (b) 2 ohm
(c) 0.5 ohm (d) (1/4.5) ohm

**32.** The magnetic lines of force inside a bar magnet

(a) are from *N*-pole to *S*-pole of magnet
(b) do not exist
(c) depend upon the area of cross-section of bar magnet
(d) are from *S*-pole to *N*-pole of magnet

**33.** Five resistances have been connected as shown in the figure. The effective resistance between A and B is



(a) 14/3Ω (b) 20/3Ω
(c) 14Ω (d) 21Ω

**34.** Yellow light is used in a single slit diffraction experiment with slit width of 0.6 mm. If yellow light is replaced by X–rays, then the observed pattern will reveal,

(a) that the central maximum is narrower
(b) more number of fringes
(c) less number of fringes
(d) no diffraction pattern

**35.** Which one is possible?

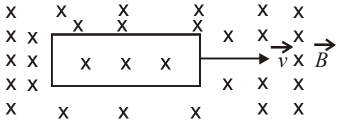
(a) ${}_7N^{19} + {}_0n^1 \rightarrow {}_7N^{16} + {}_1H^1$

(b) ${}_{16}S^{32} + {}_1H^1 \rightarrow {}_{17}Cl^{35} + {}_2He^4$

(c) ${}_8O^{16} + {}_0n^1 \rightarrow {}_7N^{14} + 3\,{}_1H^1 + 2\,{}_{-1}\beta^0$

(d) ${}_1H^1 + {}_1H^1 \rightarrow {}_2He^4$

**36.** A conducting square loop of side *L* and resistance *R* moves in its plane with a uniform velocity *v* perpendicular to one of its side. A magnetic induction *B* constant in



time and space, pointing perpendicular and into the plane of the loop exists everywhere. The current induced in the loop is

(a) $\frac{Blv}{R}$ clockwise

(b) $\frac{Blv}{R}$ anti-clockwise

(c) $\frac{2Blv}{R}$ anti – clockwise

(d) zero

**37.** When a ray of light enters a glass slab from air,

(a) its wavelength decreases
(b) its wavelength increases
(c) its frequency decreases
(d) neither its wavelength nor its frequency changes.

**38.** Main function of the RF amplifiers in a superheterodyne receiver is to

(a) amplify signal
(b) reject unwanted signal
(c) discriminate against image frequency signal and IF-signal
(d) All the above

**39.** An electric fan and a heater are marked as 100 W, 220 V and 1000 W, 220 V respectively. The resistnace of heater is

(a) equal to that of fan
(b) lesser than that of fan
(c) greater than that of fan
(d) zero

**40.** A straight wire of length 0.5 metre and carrying a current of 1.2 ampere is placed in uniform magnetic field of induction 2 tesla. The magnetic field is perpendicular to the length of the wire. The force on the wire is

(a) 2.4 N (b) 1.2 N
(c) 3.0 N (d) 2.0 N

**41.** Monochromatic light of frequency $6.0 \times 10^{14}$ Hz is produced by a laser. The power emitted is $2 \times 10^{-3}$ W. The number of photons emitted, on the average, by the source per second is

(a) $5 \times 10^{16}$ (b) $5 \times 10^{17}$
(c) $5 \times 10^{14}$ (d) $5 \times 10^{15}$

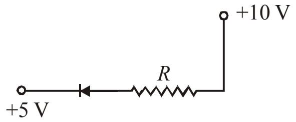
**42.** Of the various series of the hydrogen spectrum, the one which lies wholly in the ultraviolet region is

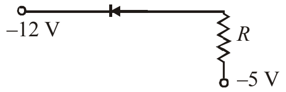
(a) Lyman series (b) Balmer series
(c) Paschen series (d) Bracket series

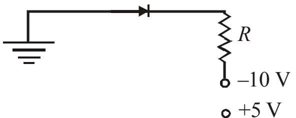
**43.** An artificial satellite moving in a circular orbit around the earth has a total (kinetic + potential) energy $E_0$. Its potential energy is

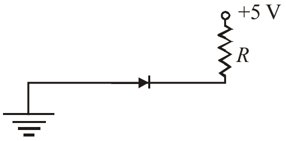
(a) $-E_0$ (b) $1.5\,E_0$
(c) $2E_0$ (d) $E_0$

**44.** Of the diodes shown in the following diagrams, which one is reverse biased ?

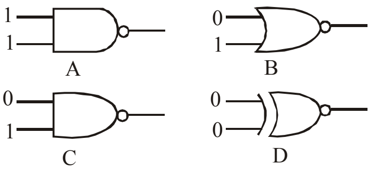
(a)


(b)


(c)


(d)


**45.** Which of the following gates will have an output of 1?



(a) D (b) A
(c) B (d) C

## ANSWER KEY

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** (c) | **2.** (b) | **3.** (b) | **4.** (b) | **5.** (b) | **6.** (a) | **7.** (d) | **8.** (c) | **9.** (c) | **10.** (b) |
| **11.** (a) | **12.** (a) | **13.** (b) | **14.** (b) | **15.** (d) | **16.** (b) | **17.** (b) | **18.** (b) | **19.** (d) | **20.** (c) |
| **21.** (b) | **22.** (c) | **23.** (c) | **24.** (d) | **25.** (c) | **26.** (c) | **27.** (d) | **28.** (b) | **29.** (a) | **30.** (a) |
| **31.** (c) | **32.** (d) | **33.** (a) | **34.** (d) | **35.** (c) | **36.** (d) | **37.** (c) | **38.** (d) | **39.** (b) | **40.** (b) |
| **41.** (d) | **42.** (a) | **43.** (c) | **44.** (d) | **45.** (d) | | | | | |

# HINTS & SOLUTIONS

1. (c) As $v^2 - u^2 = 2as$

$0 - u^2 = 2as$

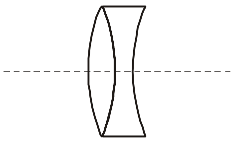
stopping distance , $s = \frac{-u^2}{2a}$

2. (b) $f_1 = +40$ cm (for convex lens)

$= 0.4$ m

$f_2 = -25$ cm (for concave lens)

$= -0.25$ m



$\therefore$ Focal length ($f$) of the combination

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{0.40} - \frac{1}{0.25} = \frac{0.25 - 0.4}{0.40 \times 0.25}$$

$$= -\frac{0.15}{0.1} = -1.5 \text{ dioptre.}$$

$$\Rightarrow \quad P = \frac{1}{f} = -1.5 \text{ dioptre}$$

3. (b) Distance in last two second

$$= \frac{1}{2} \times 10 \times 2 = 10 \text{ m.}$$

Total distance $= \frac{1}{2} \times 10 \times (6+2) = 40$ m.

4. (b) $v_r = \sqrt{v_R^2 - v_B^2} = \sqrt{10^2 - 8^2} = 6 \text{ km h}^{-1}$

5. (b) Effective acceleration of a body $= [a - g]$.

6. (a) Vector has both magnitude and direction so, statement (a) is wrong.

7. (d) Moment of inertia, $I = Mr^2$

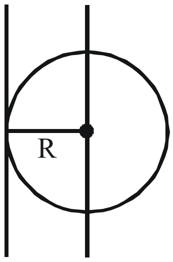
$[I] = [ML^2]$

Moment of force, $\vec{\tau} = \vec{r} \times \vec{F}$

$[\vec{\tau}] = [L][MLT^{-2}] = [ML^2T^{-2}]$

8. (c) In a cyclic process, the initial state coincides with the final state. Hence, the change in internal energy is zero, as it depends only on the initial and final states. But $Q$ & $W$ are non-zero during a cycle process.

9. (c)



Moment of inertia of a disc about a diameter

$$= \frac{1}{2} \times \frac{1}{2} MR^2 = \frac{1}{4} MR^2 \qquad [I_x + I_y = I_z = \frac{1}{2} MR^2]$$

Applying theorem of parallel axis.

$$I_z = \frac{1}{4} MR^2 + MR^2 = \frac{5}{4} MR^2$$

10. (b) $\hat{A} = \frac{3\hat{i} + +b\hat{j} + 2\hat{k}}{\sqrt{9+36+4}} = \left(\frac{3}{7}\hat{i} + \frac{6}{7}\hat{j} + \frac{2}{7}\hat{k}\right)$. If $\alpha$, $\beta$ and $\gamma$ are angles made by $\vec{A}$ with coordinate axes, then

$$\cos\alpha = \frac{3}{7}, \cos\beta = \frac{6}{7} \text{ and } \cos\gamma = \frac{2}{7}.$$

11. (a) Charge on an electron

$= 1.6 \times 10^{-19}$ coulomb

No. of electrons required $= \frac{20 \times 10^{-6}}{1.6 \times 10^{-19}}$

$$= \frac{20}{1.6} \times 10^{13} = 1.25 \times 10^{14}$$

12. (a) Let $T$ be the tension in the string. Equation of motion of $A$ is; $T = Ma$ .... (i). If $a'$ is the acceleration of $B$, the equation of motion of $B$ can be written as

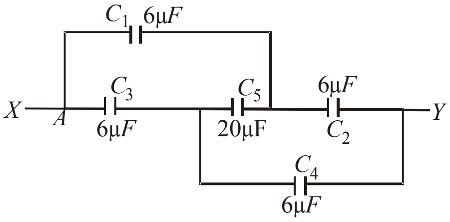
$Ma' = F - T = F - Ma$

$a' = (F/M) - a$

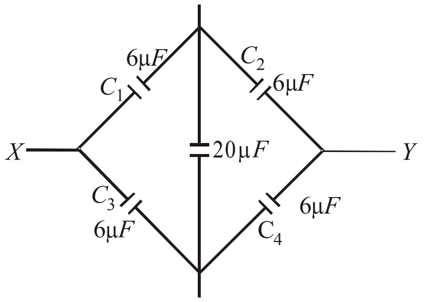
13. (b) When sound travels from one medium to another its speed changes due to change in wavelength. Its frequency remains constant.

14. (b) Under isothermal conditions, there is no change in internal energy.

15. (d)

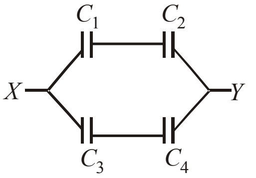


Equivalent circuit



Here, $\frac{C_1}{C_3} = \frac{C_2}{C_4}$

Hence, no charge will flow through 20$\mu F$



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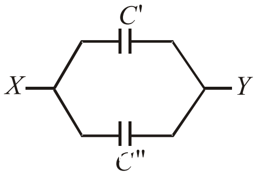


$C_1$ and $C_2$ are in series, also $C_3$ and $C_4$ are in series.

Hence, $C' = 3\ \mu F$, $C'' = 3\ \mu F$

$C'$ and $C''$ are in parallel.

Hence net capacitance $= C' + C'' = 3 + 3$

$= 6\ \mu F$

16. (b) $E = \frac{p^2}{2m}$

or, $E_1 = \frac{p_1^2}{2m_1}, E_2 = \frac{p_2^2}{2m_2}$

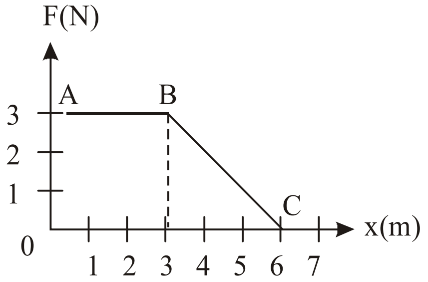
or, $m_1 = \frac{p_1^2}{2E_1}, m_2 = \frac{p_2^2}{2E_2}$

$m_1 > m_2 \Rightarrow \frac{m_1}{m_2} > 1$

$\therefore \frac{p_1^2 E_2}{E_1 P_2^2} > 1 \Rightarrow \frac{E_2}{E_1} > 1 \quad [\because p_1 = p_2]$

or, $E_2 > E_1$

17. (b)



Work done = area under F-x graph

= area of trapezium OABC

$= \frac{1}{2}(3+6)(3) = 13.5\text{ J}$

18. (b) Total kinetic energy of a rolling ball

K.E. = linear K.E. + rotational K.E.

$\text{K.E.} = \frac{1}{2}\text{mv}^2 + \frac{1}{2}\text{I}\omega^2$

$= \frac{1}{2}\text{mv}^2 + \frac{1}{2} \times \frac{2}{5}\text{mr}^2 . \frac{\text{v}^2}{\text{r}^2}$

$= \left(\frac{5+2}{10}\right)\text{mv}^2 = \frac{7}{10}\text{mv}^2$

Fraction of total energy associated with rotational kinetic energy $= \frac{\frac{1}{5}\text{mv}^2}{\frac{7}{10}\text{mv}^2}$

$= \frac{1}{5} \times \frac{10}{7} = \frac{2}{7}$

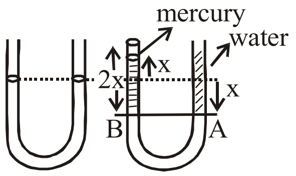
19. (d) Net charge inside the surface is zero. So, flux through the surface is zero.

20. (c) Microwave region wavelength $= 10^{-3}$ m to 1m

22. (c) $v_e = \sqrt{2gR}$

The escape velocity is independent of the angle at which the body is projected.

23. (c)



At point A and B pressure will be same. So pressure at A = P + $h_1\rho_1 g$

pressure at B = P + $h_2\rho_2 g$

$\text{P} + h_1\rho_1 g = \text{P} + h_2\rho_2 g$

or, $11.2 \times 1 \times g = 2x \times 13.6 \times g$

or, $x = \frac{11.2}{2 \times 13.6} = 0.41\text{ cm}$

24. (d) $F = YA\,\alpha\,t = (2.0 \times 10^{11})(10^{-6})(1.1 \times 10^{-5})(20) = 44$ newton

25. (c) Radiation is the fastest mode of transfer of heat.

26. (c) The loop (i) is for soft iron and the loop (ii) is for steel in fig.

27. (d) $P=\frac{1}{3}\rho\overline{v^2}=\frac{2}{3}\times\left(\frac{1}{2}\rho\overline{v^2}\right)=\frac{2}{3}E$

28. (b) Rate of cooling $\propto$ temperature difference between system and surrounding.

As the temperature difference is halved, so the rate of cooling will also be halved

29. (a) A is positive as electric lines are coming out of it. B is negative as electric lines are entering into it.

30. (a) $y=2\sin\pi\left\{200t-\frac{x}{15}\right\}$

$=2\sin\left\{200\pi t-\frac{x\pi}{15}\right\}$

Comparing it with the equation of a wave,

$y=a\sin(\omega t-kx)$

$\omega=200\pi;k=\frac{\pi}{15}$

$v=\frac{\omega}{k}=\frac{200\pi\times15}{\pi}=3000\text{ cm/sec}$

31. (c) $r=E/I=1.5/3=0.5$ ohm.

33. (a) The wheatstone bridge is balanced, when P/Q = R/S,

In this case $\frac{3}{4}=\frac{4}{8}$, so bridge is balanced & 7Ω resistance is not effective)

34. (d) For diffraction pattern to be observed, the dimension of slit should be comparable to the wavelength of light.

35. (c) By law of lepton numbers, mass number and atomic number is to be conserved on both sides.

36. (d) Since the magnetic field is uniform the flux *f* through the square loop at any time *t* is constant, because

$f=B\times A=B\times L^2=\text{constant}$

$\therefore\ \varepsilon=-\frac{d\phi}{dt}=\text{zero}$

37. (c) When the ray enters a glass slab from air, its frequency remains unchanged.

Since glass slab in an optically denser medium, the velocity of light decreases and therefore we can conclude that the wavelength decreases.

$(\because\ v=\nu\lambda)$

39. (b) As R $\propto$ $V^2$/P or R $\propto$ 1/P, so resistance of heater is less than that of fan.

40. (b) $F=Bil=2\times1.2\times0.5=1.2\,N$

41. (d) Since $p=nh\nu$

$\Rightarrow n=\frac{p}{h\nu}=\frac{2\times10^{-3}}{6.6\times10^{-34}\times6\times10^{14}}$

$=5\times10^{15}$

42. (a) The range of wavelengths of the lines of Lyman series varies from 912 A° to 1216 A°.

43. (c) P.E. = 2T.E.

$\Rightarrow$ P.E. = $2E_0$

In case of circular motion of satellite around the earth / planets revolving around sun/electrons revolving in circular orbit P.E. = 2 T.E. and |K.E.| = |T.E.|].

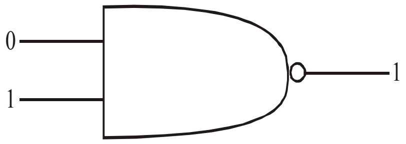
44. (d) Positive terminal is at lower potential (0V) and negative terminal is at higher potential 5V.

45. (d) (A) is a NAND gate so output is $\overline{1\times1}=\bar{1}=0$

(B) is a NOR gate so output is $\overline{0+1}=\bar{1}=0$

(C) is a NAND gate so output is $\overline{0\times1}=\bar{0}=1$

(D) is a XOR gate so output is $0\oplus0=0$

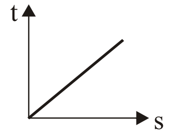


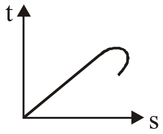
# Mock Test-4

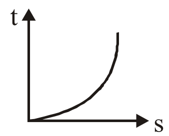
**Time : 1 hr** **Max. Marks -120**

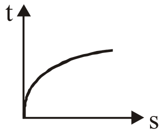
**1.** A force is given by F = at + bt$^2$, where t is time, the dimensions of a and b are respectively
(a) [M L T$^{-4}$] and [M L T$^{-1}$]
(b) [M L T$^{-1}$] and [M L T$^0$]
(c) [M L T$^{-3}$] and [M L T$^{-4}$]
(d) [M L T$^{-3}$] and [M L T$^0$]

**2.** Which of the following time-displacement graph is not possible in nature?

(a)


(b)


(c)


(d)


**3.** A particle undergoes simple harmonic motion having time period T. The time taken in 3/8th oscillation is
(a) $\frac{3}{8}T$ (b) $\frac{5}{8}T$
(c) $\frac{5}{12}T$ (d) $\frac{7}{12}T$

**4.** The angular velocity of a body changes from $\omega_1$ to $\omega_2$ without applying torque but by changing moment of inertia. The ratio of initial radius of gyration to the final radius of gyration is
(a) $\omega_2 : \omega_1$ (b) $\omega_2^2 : \omega_1^2$
(c) $\sqrt{\omega_2} : \sqrt{\omega_1}$ (d) $1/\omega_2 : 1/\omega_1$

**5.** The work function of aluminium is 4.2 eV. If two photons each of energy 3.5 eV strike an electron of aluminium, then emission of electron will
(a) depend upon the density of the surface
(b) possible
(c) not possible
(d) None of these

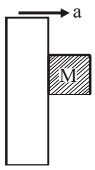
**6.** If a capacitor of capacitance 'C' is connected in series with an inductor of inductance L, then the angular frequency will be
(a) $\sqrt{\frac{1}{LC}}$ (b) $\sqrt{\frac{L}{C}}$
(c) LC (d) $\sqrt{LC}$

**7.** Two wires A and B of the same material, having radii in the ratio 1 : 2 and carry currents in the ratio 4 : 1. The ratio of drift speed of electrons in A and B is
(a) 16 : 1 (b) 1 : 16
(c) 1 : 4 (d) 4 : 1

**8.** If for a gas, $\frac{R}{C_V} = 0.67$, this gas is made up of molecules which are
(a) diatomic
(b) mixture of diatomic and polyatomic molecules
(c) monoatomic
(d) polyatomic

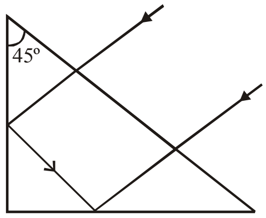
**9.** A metallic bar is heated from 0ºC to 100ºC. The coeficient of linear expansion is $10^{-5}$ K$^{-1}$. What will be the percentage increase in length?
(a) 0.01% (b) 0.1%
(c) 1% (d) 10%

**10.** A rough vertical board has an acceleration *a* along the horizontal so that a block of mass M pressing against it does not fall. The coefficient of friction between block and the board is



(a) $> \frac{a}{g}$ (b) $< \frac{g}{a}$
(c) $= \frac{a}{g}$ (d) $> \frac{g}{a}$

**11.** What should be the minimum value of refractive index of the material of the prism for the reflections to take place as shown in the figure?



(a) 1.7 (b) 1.4
(c) 1.2 (d) 2.7

**12.** Electric lines of force about a negative point charge are
(a) circular, anti-clockwise
(b) circular, clockwise
(c) radial, inwards
(d) radial, outwards

**13.** A gun fires two bullets at 60º and 30º with horizontal. The bullets strike at some horizontal distance. The ratio of maximum height for the two bullets is in the ratio of
(a) 2 : 1 (b) 3 : 1
(c) 4 : 1 (d) 1 : 1

**14.** A generator has an e.m.f. of 440 Volt and internal resistance of 400 Ohm. Its terminals are connected to a load of 4000 Ohm the voltage across the load is
(a) 220 volt (b) 440 volt (c) 200 volt (d) 400 volt

**15.** The radius vector, drawn from the sun to a planet, sweeps out equal areas in equal intervals of time. This is the statement of
(a) Kepler's first law (b) Kepler's second aw
(c) Newton's first law (d) Kepler's third law

**16.** The path difference between the two waves :

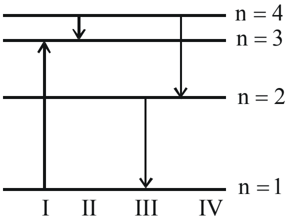
$$y_1 = a_1 \sin\left(\omega t - \frac{2\pi x}{\lambda}\right)$$

and $y_2 = a_2 \sin\left(\omega t - \frac{2\pi x}{\lambda} + \phi\right)$ will be

(a) $\frac{2\pi}{\lambda}\phi$ (b) $\frac{2\pi}{\lambda}\left(\phi - \frac{\pi}{2}\right)$

(c) $\frac{\lambda}{2\pi}\phi$ (d) $\frac{2\pi}{\lambda}\left(\phi + \frac{\pi}{2}\right)$

**17.** The diagram shows the energy levels for an electron in a certain atom. Which transition shown represents the emission of a photon with the most energy?



(a) IV (b) III (c) II (d) I

**18.** The direction of propagation of electromagnetic waves is given by the direction of
(a) Vector $\vec{E}$ (b) Vector $\vec{B}$
(c) Vector ( $\vec{E} \times \vec{B}$ ) (d) None of these

**19.** A body of mass 10 kg and velocity 10 m/s collides with a stationary body of mass 5 kg. After collision both bodies stick to each other, velocity of the bodies after collision will be

(a) $\frac{3}{10}$ m/s (b) $\frac{18}{3}$ m/s (b) $\frac{9}{20}$ m/s (d) $\frac{20}{3}$ m/s

**20.** Two particles of mass $m_1$ and $m_2$ ($m_1 > m_2$) attract each other with a force inversely proportional to the square of the distance between them. If the particles are initially held at rest and then released, the centre of mass will
(a) move towards $m_1$ (b) move towards $m_2$
(c) remain at rest (d) Nothing can be said

**21.** The r.m.s. velocity of oxygen molecule at 16ºC is 474 m/sec. The r.m.s. velocity in m/s of hydrogen molecule at 127ºC is
(a) 1603 (b) 1896 (c) 2230.59 (d) 2730

**22.** To demonstrate the phenomenon of interference, we require two sources which emit radiation
(a) of the same frequency
(b) of different wavelengths
(c) of the same frequency and having a definite phase relationship
(d) of nearly the same frequency

**23.** A galvanometer coil has a resistance of 15Ω and gives full scale deflection for a current of 4 mA. To convert it to an ammeter of range 0 to 6 A
(a) 10 mΩ resistance is to be conncected in parallel to the galvanometer
(b) 10 mΩ esistance is to be connected in series with the galvanometer
(c) 0.1 Ω resistance is to be connected in parallel to the galvanometer
(d) 0.1 Ω resistance is to be connected in series with the galvanometer

**24.** A uniform rod of mass m, length $\ell$, area of cross-section A has Young's modulus Y. If it is hanged vertically, elongation under its own weight will be

(a) $\frac{mg\ell}{2AY}$ (b) $\frac{2mg\ell}{AY}$ (c) $\frac{mg\ell}{AY}$ (d) $\frac{mgY}{A\ell}$

**25.** The magnifying power of a telescope is 9. When it is adjusted for parallel rays, the distance between the objective and the eye piece is found to be 20 cm. The focal length of lenses are
(a) 18 cm, 2 cm (b) 11 cm, 9 cm
(c) 10 cm, 10 cm (d) 15 cm, 5 cm

**26.** If two soap bubbles of different radii are connected by a tube. Then
(a) air flows from the smaller bubble to the bigger
(b) air flows from bigger bubble to the smaller bubble till the sizes are interchanged
(c) air flows from the bigger bubble to the smaller bubble till the sizes become equal
(d) there is no flow of air.

**27.** An object undergoing SHM takes 0.5 s to travel from one point of zero velocity to the next such point. The distance between those points is 50 cm. The period, frequency and amplitude of the motion is
(a) 1s, 1Hz, 25 cm (b) 2s, 1Hz, 50 cm
(c) 1s, 2Hz, 25 cm (d) 2s, 2Hz, 50 cm

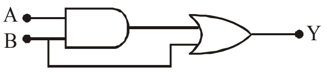
**28.** A plane wave of wavelength 6250 Å is incident normally on a slit of width $2 \times 10^{-2}$ cm. The width of the principal maximum on a screen distant 50 cm will be
(a) $312.5 \times 10^{-3}$ cm (b) $312.5 \times 10^{-3}$ m
(c) $312.5 \times 10^{-3}$ m (d) 312m

**29.** In a p-type semi-conductor germanium is doped with
(a) aluminium (b) boron
(c) gallium (d) all of these

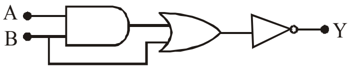
**30.** The table given below represents the truth table for which of the following combinations of logic gates?

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

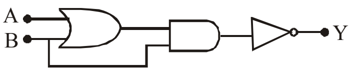
(a)



(b)



(c)



(d) None of these

## ANSWER KEY

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** (c) | **2.** (b) | **3.** (c) | **4.** (c) | **5.** (c) | **6.** (a) | **7.** (a) | **8.** (c) | **9.** (b) | **10.** (d) |
| **11.** (b) | **12.** (c) | **13.** (b) | **14.** (d) | **15.** (b) | **16.** (c) | **17**(b) | **18.** (c) | **19.** (d) | **20.** (c) |
| **21.** (c) | **22.** (c) | **23.** (a) | **24.** (c) | **25.** (a) | **26.** (a) | **27.** (a) | **28.** (a) | **29.** (d) | **30.** (a) |

## HINTS & SOLUTIONS

1. (c) $[at] = [F]$ amd $[bt^2] = [F]$

$\Rightarrow [a] = [MLT^{-3}]$ and $[b] = [MLT^{-4}]$

2. (b) At a particular time, two values of displacement are not possible.

3. (c) Time to complete 1/4th oscillation is $\frac{T}{4}$ s. Time to complete $\frac{1}{8}$ th vibration from extreme position is obtained from

$$y = \frac{a}{2} = a\cos\omega t = a\cos\frac{2\pi}{T}t \text{ or } t = \frac{T}{6}s$$

So time to complete 3/8th oscillation

$$= \frac{T}{4} + \frac{T}{6} = \frac{5T}{12}$$

4. (c) $I_1\,\omega_1 : I_2\,\omega_2$ or $MK_1^2\,\omega_1 : MK_2^2\,\omega_2$

$$\frac{K_1}{K_2} = \sqrt{\left(\frac{\omega_2}{\omega_1}\right)}$$

5. (c) Work function of aluminium is 4.2 eV. The energy of two photons can not be added at the moment photons collide with electron all its energy will be dissipated or wasted as this energy is not sufficient to knock it out.

Hence emmission of electron is not possible.

6. (a) In case of L-C circuit, angular frequency of oscillation

$$\omega = \sqrt{\frac{1}{LC}}$$

7. (a) Current flowing through the conductor,

I = n e v A. Hence

$$\frac{4}{1} = \frac{nev_{d_1}\pi(1)^2}{nev_{d_2}\pi(2)^2} \text{ or } \frac{v_{d_1}}{v_{d_2}} = \frac{4\times 4}{1} = \frac{16}{1}.$$

8. (c) Since $\frac{R}{C_V} = 6.7 \Rightarrow C_V = \frac{3}{2}R,$ hence gas is monoatomic.

9. (b) $\frac{\Delta\ell}{\ell} = \alpha\,\Delta T = 10^{-5}\times 100 = 10^3$

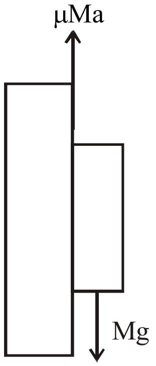
$$\frac{\Delta\ell}{\ell}\times 100\% = 10^{-3}\times 100$$

$$= 10^{-1} = 0.1\%$$

10. (d) Force on M = Mg

Reaction force = Ma

force of friction = $\mu R = \mu.Ma$



Force of friction will balance the weight. So

$$\mu Ma \geq Mg \;\;;\;\; \mu \geq \frac{g}{a.}$$

11. (b) From the figure, it is clear that angle of incidence on the reflecting surface is 45°. So, critical angle for glass air interface should be 45°.

Now, from the formula

$$\sin C = \frac{1}{\mu} \Rightarrow \sin 45° = \frac{1}{\mu}$$

$$\mu = \sqrt{2} = 1.4$$

12. (c) For a single negative point charge, electric lines of force are radial and inwards.

13. (b) The bullets are fired at the same initial speed

$$\frac{H}{H'} = \frac{u^2\sin^2 60^o}{2g}\times\frac{2g}{u^2\sin^2 30^o} = \frac{\sin^2 60^o}{\sin^2 30^o}$$

$$= \frac{(\sqrt{3}/2)^2}{(1/2)^3} = \frac{3}{1}$$

14. (d) Total resistance of the circuit

$= 4000 + 400 = 4400\,\Omega$

Current flowing $i = \frac{V}{R} = \frac{440}{4400} = 0.1$ *amp.*

Voltage across load = R i

$= 4000 \times 0.1 = 400$ volt.

16. (c) Phase difference = $\phi$

$$\text{Path diff} = \frac{\lambda}{2\pi}\times\text{phase diff.} = \frac{\lambda}{2\pi}\phi$$

17. (b) $E = Rhc\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

E will be maximum for the transition for which $\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ is maximum. Here $n_2$ is the higher energy level.

Clearly, $\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ is maximum for the third transition, i.e. $2 \to 1$. I transition represents the absorption of energy.

18. (c) Vector $(\vec{E} \times \vec{B})$

19. (d) Velocity after the collision

$$= \frac{10 \times 10 + 5 \times 0}{15} = \frac{100}{15} = \frac{20}{3} \text{m/sec}.$$

20. (c) The centre of mass remains at rest because force of attraction is mutual. No external force is acting.

21. (c) $v_{oxg.} = \sqrt{\frac{3R \times 289}{32}}$ $\left(v_{rms} = \sqrt{\frac{3RT}{M}}\right)$

$v_H = \sqrt{\frac{3R \times 400}{2}}$ so $v_H = 2230.59$ m/sec

22. (c) For the observation of interference phenomenon, the two source must be coherent & must have same frequency.

23. (a) $G = 15\Omega$, $i_g = 4$ mA, $i = 6$ A

Required shunt,

$$S = \left(\frac{i_g}{i - i_g}\right)G = \left(\frac{4 \times 10^{-3}}{6 - 4 \times 10^{-3}}\right) \times 15$$

$$= \frac{4 \times 10^{-3}}{5.996} \times 15 = 0.01\Omega$$

$= 10\text{m}\Omega$ (in parallel)

24. (c) $Y = \frac{F\ell}{A\Delta\ell} \Rightarrow \Delta\ell = \frac{F\ell}{YA} = \frac{mg\ell}{YA}$

25. (a) $\frac{f_0}{f_e} = 9$, $\therefore f_0 = 9f_e$

Also $f_0 + f_e = 20$ (∵ final image is at infinity)

$9f_e + f_e = 20$, $f_e = 2$ cm, $\therefore f_0 = 18$ cm

26. (a) Let pressure outside be $P_0$

$\therefore P_1$ ( in smaller bubble ) $= P_0 + \frac{2T}{r}$

$P_2$ ( in bigger bubble ) $= P_0 + \frac{2T}{R}$ $(R > r)$

$\therefore P_1 > P_2$

hence air moves from smaller bubble to bigger bubble.

27. (a) Given : $T/2 = 0.5$ s

$\therefore \quad T = 1$s

Frequency, $f = \frac{1}{T} = \frac{1}{1} = 1$Hz

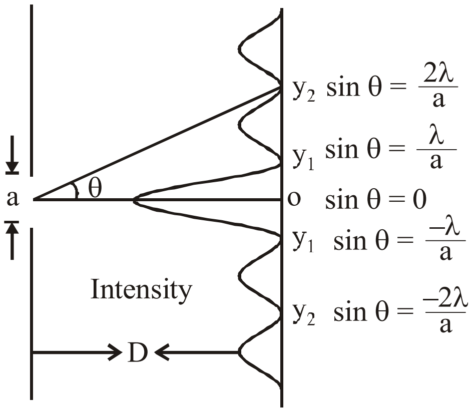
If A is the amplitude, then

$2A = 50$ cm $\quad \Rightarrow \quad A = 25$ cm.

28. (a) Width of central maximum

$$= \frac{2\lambda D}{a} = \frac{2 \times 6250 \times 10^{-10} \times 0.5}{2 \times 10^{-4}}$$

$$= 3125 \times 10^{-6} \text{m} = 312.5 \times 10^{-3} \text{ cm}.$$



Screen position of various minima for Fraunhoffer diffraction pattern of a single slit of width a.

29. (d) In a p-type semic-onductor germanium is doped with trivalent element. All the elements, like aluminium, boron & gallium are trivalent. So, the correct alternative is (d).

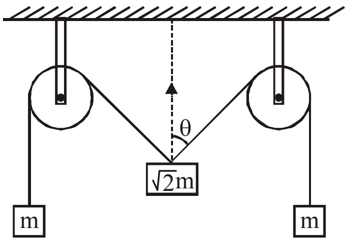
# Mock Test-5

**Time : 1 hr** **Max. Marks -120**

**1.** The respective number of significant figures for the numbers 23.023, 0.0003 and 2.1 × $10^{-3}$ are
(a) 5, 1, 2 (b) 5, 1, 5
(c) 5, 5, 2 (d) 4, 4, 2

**2.** If the kinetic energy of a particle is increased by 300%, the momentum of the particle will increase by
(a) 20% (b) 200%
(c) 100% (d) 50%

**3.** The pulleys and strings shown in the figure are smooth and of negligible mass. For the system to remain in equilibrium. The angle θ should be



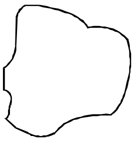
(a) 0° (b) 30°
(c) 45° (d) 60°

**4.** A particle starting from rest falls from a certain height. Assuming that the acceleration due to gravity remain the same throughout the motion, its displacements in three successive half second intervals are $S_1$, $S_2$ and $S_3$ then
(a) $S_1 : S_2 : S_3 = 1 : 5 : 9$
(b) $S_1 : S_2 : S_3 = 1 : 3 : 5$
(c) $S_1 : S_2 : S_3 = 9 : 2 : 3$
(d) $S_1 : S_2 : S_3 = 1 : 1 : 1$

**5.** The Bulk modulus for an incompressible liquid is
(a) zero (b) unity
(c) infinity (d) between 0 and 1

**6.** A transformer is employed to
(a) convert A.C. into D.C.
(b) convert D.C. into A.C.
(c) obtain a suitable A.C. voltage
(d) obtain a suitable D.C. voltage

**7.** As a result of change in the magnetic flux linked to the closed loop shown in the fig, an e.m.f. *V* volt is induced in the loop.

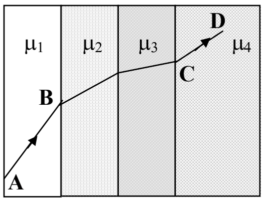


The work done (in joule) in taking a charge *Q* coulomb once along the loop is
(a) *QV* (b) 2*QV*
(c) *QV*/2 (d) zero

**8.** What is the acceleration of a projectile at its heighest point
(a) maximum (b) minimum
(c) zero (d) g

**9.** A sphere of radius *R* has uniform volume charge density. The electric potential at a point ($r < R$) is
(a) due to the charge inside a sphere of radius *r* only
(b) due to the entire charge of the sphere
(c) due to the charge in the spherical shell of inner and outer radii *r* and *R*, only
(d) independent of *r*

**10.** A ray of light passes through four transparent media with refractive indices $\mu_1$, $\mu_2$, $\mu_3$ and $\mu_4$ as shown in the figure. The surfaces of all media are parallel. If the emergent ray *CD* is parallel to the incident ray *AB*, we must have



(a) $\mu_1 = \mu_2$ (b) $\mu_2 = \mu_3$
(c) $\mu_3 = \mu_4$ (d) $\mu_4 = \mu_1$

**11.** The meniscus of a liquid contained in one of the limbs of a narrow U-tube is held in an electromagnet with the meniscus in line with the field. The liquid is seen to rise. This indicates that the liquid is
(a) ferromagnetic (b) paramagnetic
(c) diamagnetic (d) non-magnetic

**12.** Under a constant torque the angular momentum of a body changes from A to 4A in 4 second. The torque on the body will be
(a) 1A (b) $\frac{1}{4}$A (c) $\frac{4}{3}$A (d) $\frac{3}{4}$A

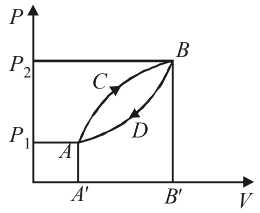
**13.** The kinetic theory of gases
(a) explains the behaviour of an ideal gas
(b) describes the motion of a single atom or molecule
(c) relates the temperature of the gas with K.E. of atoms of the gas
(d) all of the above

**14.** An electric bulb marked 40 W and 200V, is used in a circuit of supply voltage 100V. Now its power is
(a) 10 W (b) 20 W (c) 40 W (d) 100 W

**15.** The height at which the acceleration due to gravity becomes $\frac{g}{9}$ (where $g$ = the acceleration due to gravity on the surface of the earth) in terms of $R$, the radius of the earth, is

(a) $\frac{R}{\sqrt{2}}$ (b) $R/2$ (c) $\sqrt{2}R$ (d) $2R$

**16.** A thermodynamic system is taken from state $A$ to $B$ along $ACB$ and is brought back to $A$ along $BDA$ as shown in the $PV$ diagram. The net work done during the complete cycle is given by the area



(a) $P_1ACBP_2P_1$ (b) $ACBB'A'A$
(c) $ACBDA$ (d) $ADBB'A'A$

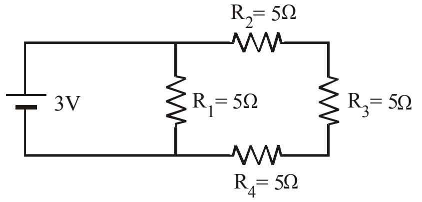
**17.** A man is watching two trains, one leaving and the other coming with equal speed of 4 m/s. If they sound their whistles each of frequency 240 Hz, the number of beats heard by man (velocity of sound in air = 320 m/s) will be equal to

(a) 12 (b) 0 (c) 3 (d) 6

**18.** When a wave travels in a medium the particles displacement is given by the equation $y = 0.03 \sin \pi(2t - 0.01x)$, where x and y are in seconds. The wavelength of the wave is

(a) 200 m (b) 100 m (c) 20 m (d) 10 m

**19.** The value of current I in the circuit shown in figure is



(a) 1.8 A (b) 0.8 A
(c) 0.2 A (d) 1.6 A

**20.** The oscillating electric and magnetic field vectors of electromagnetic wave are oriented along

(a) the same direction and in phase
(b) the same direction but have a phase difference of 90º
(c) mutually perpendicular directions and are in phase
(d) mutually perpendicular directions but has a phase difference of 90º

**21.** If the cold junction of a thermo-couple is kept at 0°C and the hot junction is kept at $T$°C then the relation between neutral temperature ($T_n$) and temperature of inversion ($T_i$) is

(a) $T_n = 2T_i$ (b) $T_n = T_i - T$
(c) $T_n = T_i + T$ (d) $T_n = T_i/2$

**22.** Let $E_a$ be the electric field due to a dipole in its axial plane distant $\ell$ and $E_q$ be the field in the equatorial plane distant $\ell'$, then the relation between $E_a$ and $E_q$ will be

(a) $E_a = 4E_q$ (b) $E_q = 2E_a$
(c) $E_a = 2E_q$ (d) $E_q = 3E_a$

**23.** Two coherent monochromatic light beams of intensities $I$ and 4 $I$ are superimposed. The maximum and minimum possible intensities in the resulting beam are

(a) $5I$ and $I$ (b) $5I$ and $3I$
(c) $9I$ and $I$ (d) $9I$ and $3I$

**24.** When an electron jumps from the fourth orbit to the second orbit, one gets the

(a) second line of Lyman series
(b) second line of Paschen series
(c) second line of Balmer series
(d) first line of Pfund series

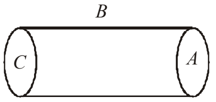
**25.** A uniform magnetic field acts at right angles to the direction of motion of electron. As a result, the electron moves in a circular path of radius 2 cm. If the speed of electron is doubled, then the radius of the circular path will be

(a) 2.0 cm (b) 0.5 cm (c) 4.0 cm (d) 1.0 cm

**26.** A photoelectric cell is illuminated by a point source of light 1 m away. When the source is shifted to 2 m, then

(a) number of electrons emitted is a quarter of the initial number
(b) each emitted electron carries one quarter of the initial energy
(c) number of electrons emitted is half the initial number
(d) each emitted electron carries half the initial energy

**27.** A hollow cylinder has $a$ charge $q$ coulomb within $i$. If $\phi$ is the electric flux in units of voltmeter associated with the curved surface $B$, the flux linked with the plane surface $A$ in units of voltmeter will be



(a) $\frac{q}{2\varepsilon_0}$ (b) $\frac{\phi}{3}$
(c) $\frac{q}{\varepsilon_0} - \phi$ (d) $\frac{1}{2}\left(\frac{q}{\varepsilon_0} - \phi\right)$

**28.** Two flat circular coils have a common center, but their planes are at right angles to each other. The inner coil has 150 turns and radius of π cm. The outer coil has 400 turns and a radius of 2π cm. The magnitude of the resultant magnetic induction at the common centers of the coils when a current of 200 mA is sent through each of them is

(a) $10^{-3}$ Wb/m$^2$ (b) $2 \times 10^{-3}$ Wb/m$^2$
(c) $5 \times 10^{-3}$ Wb/m$^2$ (d) $7 \times 10^{-3}$ Wb/m$^2$

**29.** Optical fibres transmit light along its axis, by the process of

(a) total internal reflection
(b) refraction
(c) interference
(d) diffraction

**30.** When a *p-n* junction diode is reverse biased the flow of current across the junction is mainly due to

(a) diffusion of charges
(b) drift of charges
(c) depends on the nature of material
(d) both drift and diffusion of charges

## ANSWER KEY

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** (a) | **2.** (c) | **3.** (c) | **4.** (b) | **5.** (c) | **6.** (c) | **7.** (a) | **8.** (d) | **9.** (a) | **10.** (d) |
| **11.** (b) | **12.** (d) | **13.** (d) | **14.** (a) | **15.** (d) | **16.** (c) | **17.** (d) | **18.** (a) | **19.** (b) | **20.** (c) |
| **21.** (d) | **22.** (c) | **23.** (c) | **24.** (c) | **25.** (c) | **26.** (a) | **27.** (d) | **28.** (a) | **29.** (a) | **30.** (b) |

# HINTS & SOLUTIONS

1. (a) Number of significant figures in 23.023= 5
Number of significant figures in 0.0003 = 1
Number of significant figures in $2.1 \times 10^{-3}$
$= 2$

2. (c) New K.E., E' = 4E

$$p = \sqrt{2mE} \text{ and } p' = \sqrt{2mE'}$$

$$\frac{p}{p} = \sqrt{\frac{2m \times 4E}{2mE}} = 2$$

$$\frac{p'}{p} - 1 = 2 - 1$$ [on substrating 1 in both sides.]

$$\frac{p-p}{p} \times 100 = (2-1) \times 100 = 100\%$$

3. (c) If $T$ is the tension in the string , Then
$T = mg$ (For outer masses)
$2T \cos\theta = \sqrt{2}\, mg$ (For inner mass)
Eliminating $T$, we get
$2(mg)\cos\theta = \sqrt{2}\, mg$
or $\cos\theta = 1/\sqrt{2} \Rightarrow \theta = 45°$

4. (b) $S_1 = \frac{1}{2} g \left(\frac{1}{2}\right)^2, S_1 + S_2 = g(1)^2$

$$\frac{1}{2} g \left(\frac{3}{2}\right)^2 = S + S_2 + S_3$$

5. (c) Bulk Modulus

$$= \frac{\text{Pressure}}{\text{Volume Strain}} = \frac{\text{Pressure}}{0}$$

Bulk Modulus = $\infty$
[As liquid is uncompressible, $\Delta V = 0$ ]

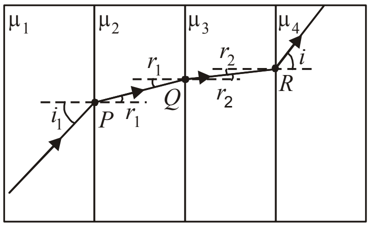
7. (a) $\xi = \frac{W}{Q} \Rightarrow V = \frac{W}{Q} \Rightarrow W = QV$

8. (d) Acceleration is the same everywhere equal to 'g'.

9. (a) Due to the charge inside a sphere of radius $r$ only.

10. (d) Applying Snell's law at $P$,

$${}^1\mu_2 = \frac{\sin i}{\sin r_1} = \frac{\mu_2}{\mu_1} \qquad ...(1)$$



Applying Snell's law at $Q$,

$${}^2\mu_3 = \frac{\sin r_1}{\sin r_2} = \frac{\mu_3}{\mu_2} \qquad ...(2)$$

Again applying Snell's law at $R$

$${}^3\mu_4 = \frac{\sin r_2}{\sin i} = \frac{\mu_4}{\mu_3} \qquad ...(3)$$

Multiplying (i), (ii) and (iii), we get
$\mu_4 = \mu_1$
If the emergent ray is parallel to incident ray after travelling a number of parallel interfaces then the refractive index of the first and the last medium is always same.

11. (b) Paramagnetic liquid tends to flow from region of weaker magnetic fields to stronger magnetic fields.

12. (d) Torque $= \frac{dL}{dt} = \frac{4A - A}{4} = \frac{3}{4}A$
[dL is change in angular momentum]

13. (d) All the given phenomena are explained by kinetic theory of gases.

14. (a) Resistance of bulb

$$= \frac{V^2}{P} = \frac{200 \times 200}{40} = 1000\Omega$$

New power $= \frac{V^2}{R} = \frac{100 \times 100}{1000} = 10W$ .

15. (d) We know that $\frac{g'}{g} = \frac{R^2}{(R+h)^2}$

$$\therefore \frac{g/9}{g} = \left[\frac{R}{R+h}\right]^2 \qquad \therefore \frac{R}{R+h} = \frac{1}{3}$$

$\therefore h = 2R$

16. (c) Work done = Area under curve $ACBDA$

17. (d) The apparent frquency of sound of both the trains will be changed.
The apparent frequency of sound of train coming in

$$= 240 \times \frac{320}{320-4}$$

$$= \frac{240 \times 320}{316} = 243$$

For apparent frequency of train going away

$$= 240 \times \frac{320}{320+4} = 237$$

When these sounds are heard simultaneously beat is listened.
No. of beats per sec = 243 – 237 = 6.

18. (a) $y = 0.03 \sin \pi(2t - 0.01x)$ is equation of a progressive wave.
Comparing it with the standard form of equation
$y = a \sin(\omega t - kx)$
$\omega = 2\pi$ ; $k = 0.01\pi$

$$k = \frac{2\pi}{\lambda} = 0.01\pi$$

$$\Rightarrow \lambda = \frac{2}{0.01} = 200 \text{ m.}$$

19. (b) Three 5Ω resistors are in series. Their total resistance = 15Ω. Now it is in parallel with 5Ω resistor, so total resistance,

$$\frac{1}{R} = \frac{1}{5} + \frac{1}{15} = \frac{3+1}{15} = \frac{4}{15}$$

$$R = \frac{15}{4}$$

$$\therefore\ I = \frac{V}{R} = \frac{3}{15/4} = \frac{3 \times 4}{15} = 0.8A$$

20. (c) The direction of oscillations of $E$ and $B$ fields are perpendicular to each other as well as to the direction of propagation. So, electromagnetic waves are transverse in nature.
The electric and magnetic fields oscillate in same phase.

21. (d) Since $T_n = \frac{T_i + T_c}{2}$ =Neutral temperature

$$T_n = \frac{T_i + 0}{2} = \frac{T_i}{2}$$

[$T_c = 0°C$ = temperature of cold junction]

22. (c) We know that for short dipole,

field at axial point, $E_a = \frac{2p}{d^3}$

and field at equatorial point, $E_q = \frac{p}{d^3}$

So, $E_a = 2E_q$

23. (c) Let $I_1 = I$ and $I_2 = 4I$

$$I_{\max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = \left(\sqrt{I} + \sqrt{4I}\right)^2 = \left(3\sqrt{I}\right)^2 = 9I$$

$$I_{\min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2 = \left(\sqrt{I} - \sqrt{4I}\right)^2 = I$$

24. (c) When the electron jumps from any orbit to second orbit, then wavelength of line obtained belongs to Balmer series.

25. (c) $r = \frac{mv}{qB}$ or $r \propto v$

As $v$ is doubled, the radius also becomes double. Hence radius = 2 × 2 = 4 cm

26. (a) Power ∝ no. of electrons emitted ($N$)

$$P \propto \frac{1}{r^2} \Rightarrow N \propto \frac{1}{r^2}$$

27. (d) Since $\phi_{\text{total}} = \phi_A + \phi_B + \phi_C = \frac{q}{\varepsilon_0}$

where $q$ is the total charge.
As shown in the figure, flux associated with the curved surface $B$ is $\phi = \phi_B$
Let us assume flux linked with the plane surfaces $A$ and $C$ be

$$\phi_A = \phi_C = \phi'$$

Therefore,

$$\frac{q}{\varepsilon_0} = 2\phi' + \phi_B = 2\phi' + \phi$$

$$\Rightarrow \phi' = \frac{1}{2}\left(\frac{q}{\varepsilon_0} - \phi\right)$$

28. (a) $B = \frac{\mu_0 In}{2\pi a}$ Add vectorially.

29. (a) The side-wall of optical fibre provides total internal reflection of beam of light incident on it.

30. (b) When $p$-$n$ junction is reverse biased, the flow of current is due to drifting of minority charge carriers across the junction.