Q. 1. This question contains Statement-1 and Statement -2. Of the four choices given after the statements, choose the one that best describes the two statements.

Statement - 1: Energy is released when heavy nuclei undergo fission or light nuclei undergo fusion. and

Statement - 2: For heavy nuclei, binding energy per nucleon increases with increasing Z while for light nuclei it decreases with increasing Z.

i. Statement - 1 is true, Statement- 2 is true; Statement -2 is not a correct explanation for Statement-1
ii. Statement - 1 is true, Statement- 2 is false
iii. Statement - 1 is false, Statement- 2 is true
iv. Statement - 1 is true, Statement- 2 is true; Statement -2 is a correct explanation for Statement-1

Sol: Correct answer is (2)

Q. 2. This question contains Statement-1 and Statement -2. Of the four choices given after the statements, choose the one that best describes the two statements.

Statement - 1: For a mass M kept at the centre of a cube of side „a" the flux of gravitational field passing through its sides is $4\pi GM$ and

Statement - 2: If the direction of a field due to a point source is radial and its dependence on the distance 'r' from the source is given as $\frac{1}{r^2}$, its flux through a closed surface depends only on the strength of the source enclosed by the surface and not on the size or shape of the surface.

i. Statement - 1 is true, Statement- 2 is true; Statement -2 is not a correct explanation for Statement-1
ii. Statement - 1 is true, Statement- 2 is false
iii. Statement - 1 is false, Statement- 2 is true
iv. Statement - 1 is true, Statement- 2 is true; Statement -2 is a correct explanation for Statement-1

Sol:

$$\oint \vec{E}_g \cdot d\vec{s} = -4\pi G\, M_{enclosed} = -4\pi GM$$

$\therefore$ Correct answer is (4)

Q. 3. Two full turns of the circular scale of a screw gauge cover a distance of 1 mm on its main scale. The total number of divisions on circular scale is 50. Further, it is found that screw gauge has a zero error of - 0.03mm. While measuring the diameter of a thin wire, a student notes the main scale reading of 3mm and the number of circular scale divisions in line with the main scale as 35. The diameter of wire is

i. 3.67 mm
ii. 3.38 mm
iii. 3.32 mm
iv. 3.73 mm

Sol:

$$\text{Least count} = \frac{0.5\ mm}{50} = 0.01\ mm$$

$$\text{Zero error} = -0.03\ mm$$

Diameter measured

$$= 3\ mm + 35 \times 0.01\ mm = 3.35\ mm$$

$$\text{Correct diameter} = 3.35\ mm - (-0.03\ mm) = 3.38\ mm$$

$\therefore$ Correct answer is (2)

Q. 4. An insulated container of gas has two chambers separated by an insulating partition. One of the chambers has volume V_1 and contains ideal gas at pressure P_1 and temperature T_1. The other chamber has volume V_2 and contains ideal gas at pressure P_2 and temperature T_2. If the partition is removed without doing any work on the gas, the final equilibrium temperature of the gas in the container will be

i. $\dfrac{P_1V_1T_2 + P_2V_2T_1}{P_1V_1 + P_2V_2}$

ii. $\dfrac{T_1T_2(P_1V_1 + P_2V_2)}{P_1V_1T_1 + P_2V_2T_2}$

iii. $\dfrac{T_1T_2(P_1V_1 + P_2V_2)}{P_1V_1T_2 + P_2V_2T_1}$

iv. $\dfrac{P_1V_1T_1 + P_2V_2T_2}{P_1V_1 + P_2V_2}$

Sol:

By Conservation of energy

$$(n_1 + n_2)CvT = n_1CvT_1 + n_2CvT_2$$

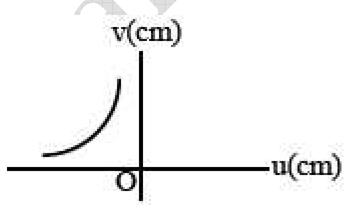
$$Or,\ \left(\frac{P_1V_1}{RT_1} + \frac{P_2V_2}{RT_2}\right)T = \frac{P_1V_1}{R} + \frac{P_2V_2}{R}$$

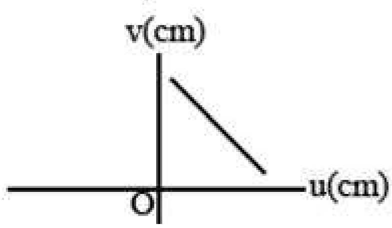
$$Or,\ \left(\frac{P_1V_1T_2 + P_2V_2T_1}{T_1T_2}\right)T = P_1V_1 + P_2V_2$$

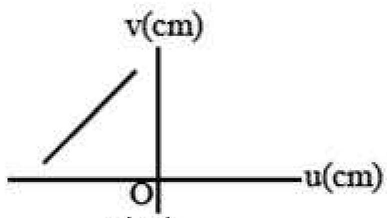
$$Or,\ T = \frac{T_1T_2(P_1V_1 + P_2V_2)}{P_1V_1T_2 + P_2V_2T_1}$$

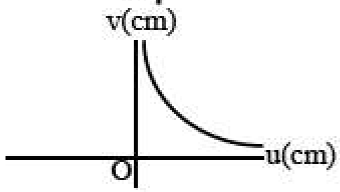
∴ Correct answer is (3)

Q. 5. A student measures the focal length of a convex lens by putting an object pin at a distance 'u' from the lens and measuring the distance'v' of the image pin. The graph between"u' and 'v' plotted by the student should look likes.

i. 

ii. 

iii. 

iv. 

Sol:

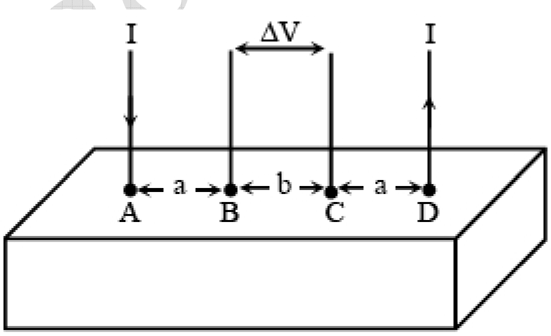
We know that in a lens $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\therefore$ *Correct answer is* (1)

Directions: Questions No. 76 and 77 are based on the following paragraph

Consider a block of conducting material of resistivity 'ρ' 'p' shown in the figure. Current 'I' enters at 'A' and leaves from 'D'. We apply superposition principal to find voltage 'ΔV' "developed between 'B' and 'C'. The calculation is done in the following steps:'

i. Take current 'I' entering from 'A' and assume it to spread over a hemispherical surface in the block.
ii. Calculate field E(r) at distance 'r' from A by using Ohm's law E = 'j' where 'j' $E = \rho j$ *where* j is the current per unit area at 'r'.
iii. From the-r' dependence of E(r), obtain the potential V(r) at 'r'.
iv. Repeat (i), (ii) and (iii) for current 'I' leaving 'D' and superpose results for'A' and 'D'.



Q. 76. 'ΔV' measured between B and C is

i. $\frac{\rho I}{2\pi a} - \frac{\rho I}{2\pi (a+b)}$

ii. $\frac{\rho I}{2\pi (a-b)}$

iii. $\frac{\rho I}{\pi a} - \frac{\rho I}{\pi (a+b)}$

iv. $\frac{\rho I}{a} - \frac{\rho I}{(a+b)}$

Sol:

$$E = \rho j = \rho \frac{I}{2\pi r^2}$$

$$V_B - V_c = -\int_c^B \vec{E} \cdot d\vec{e}$$

$$= -\int_{a+b}^{a} \rho \frac{I}{2\pi r^2} \cdot dr$$

$$\therefore \Delta V^1 = -\frac{\rho I}{2\pi}\left[-\frac{1}{r}\right]_{a+b}^{a}$$

$$= \frac{\rho I}{2\pi}\left(\frac{1}{a} - \frac{1}{a+b}\right)$$

$$\therefore \Delta V = 2\Delta V' = \frac{\rho I}{\pi}\left(\frac{1}{a} - \frac{1}{a+b}\right)$$

$\therefore$ *Correct answer is (3)*

Q. 7. For current entering at A, the electric field at a distance 'r' from A is

i. $\frac{\rho I}{2\pi r^2}$

ii. $\frac{\rho I}{4\pi r^2}$

iii. $\frac{\rho I}{8\pi r^2}$

iv. $\frac{\rho l}{r^2}$

Sol: Correct answer is (1)

Q. 8. 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

i. $\frac{7}{12}m^2$
ii. $\frac{2}{3}m^2$
iii. $\frac{5}{6}m^2$
iv. $\frac{1}{12}m^2$

Sol:

$$Moment\ of\ inertia = Icm + md^2$$
$$= \frac{ma^2}{6} + m\left(\frac{a}{\sqrt{2}}\right)^2$$
$$= \frac{2}{3}ma^2$$

$\therefore$ Correct answer is (2)

Q. 9. An experiment is performed to find the refractive index of glass using a travelling microscope. In this experiment distances are measured by

i. a meter scale provided on the microscope
ii. a screw gauge provided on the microscope
iii. a vernier scale provided on the microscope
iv. a standard laboratory scale.

Sol: Correct answer is (3)

Q. 10. A horizontal overhead powerline is at a height of 4m from the ground and carries a current of 100 A from east to west. The magnetic field directly below it on the ground is $\left(\mu_0 = 4\pi \times 10^{-7}\ T\ m\ A^{-1}\right)$

i. 5×10^{-6} T Southward
ii. 2.5×10^{-7} T northward
iii. 2.5×10^{-7} T southward
iv. 5×10^{-6} T northward

Sol:

$$\text{Magnetic field} = \frac{\mu_o}{4\pi}\cdot\frac{2i}{r}$$
$$= \frac{4\pi\times10^{-7}}{4\pi}\times\frac{2\times100}{4}$$
$$= 5\times10^{-6} \quad [T\ \text{southward}]$$

$\therefore$ Correct answer is (1)

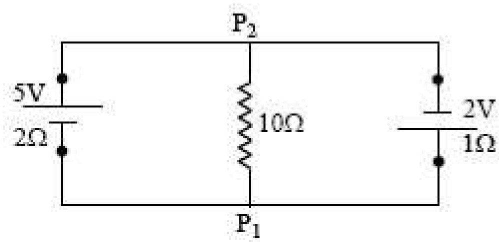
Q. 11. The speed of sound in oxygen (O_2) at a certain temperature is 460 ms^{-1}. The speed of sound in helium (He) at the same temperature will be (assume both gases to be ideal)

i. 650 ms^{-1}
ii. 330 ms^{-1}
iii. 460 ms^{-1}
iv. 500 ms^{-1}

Sol:

$$V = \frac{\gamma RT}{Mo}$$
$$V_o = 460 = \sqrt{\frac{7\ RT}{5\times32}} \quad (i)$$
$$V_{He} = \sqrt{\frac{5\ RT}{3\times4}} \quad (ii)$$
$$\frac{V_{He}}{V_o} = \frac{V_{He}}{460} = \sqrt{\frac{5\ RT}{3\times4}}\times\sqrt{\frac{7\ RT}{5\times32}}$$
$$= \sqrt{\frac{5\ RT}{3\times4}}\times\sqrt{\frac{5\times32}{7\ RT}}$$
$$V_{He} = 460\times3.08$$
$$= 1417ms^{-1}$$

Q. 12. A 5V battery with internal resistance 2Ω and a 2V battery with internal resistance 1Ω are connected to a 10Ω resistor as shown in the figure. The current in the 1Ω resistor is



i. 0.03 A P_2 to P1
ii. 0.27 A P_1 to P_2
iii. 0.27 A P_2 to P_1
iv. 0.03 A P_1 to P_2

Sol:

$$i = \frac{v_1 r_2 + v_2 r_1}{r_1 r_2 + R r_1 + R r_2}$$

$$= \frac{5 \times 1 + (-2) \times 2}{2 \times 1 + 10 \times 2 + 10 \times 1}$$

$$= \frac{1}{32} = 0.03\ A,\ P_2\ to\ P_1$$

$\therefore$ *Correct answer is* (1)

Q. 13. A body of mass m = 3.513 kg is moving along the x-axis with a speed of 5.00 ms^{-1}. The magnitude of its momentum is recorded as

i. 17.56 kg ms^{-1}
ii. 17.57 kg ms^{-1}
iii. 17. 6 kg ms^{-1}
iv. 17.565 kg ms^{-1}

Sol:

$Momentum = mV$

$= 3.513 \times 5.00$

$= 17.565\ Kgms^{-1}$

$= 17.6\ Kgms^{-1}$

(Results are given in 3 significant figures)

$\therefore$ Correct answer is (3)

Q. 14. A working transistor with its three legs marked P, Q and R is tested using a multimeter. No conduction is found between P and Q. By connecting the common (negative) terminal of the multimeter to R and the other (positive) terminal to P or Q, some resistance is seen on the multimeter. Which of the following is true for the transistor?

i. It is a pnp transistor with R as emitter
ii. It is an npn transistor with R as collector
iii. It is an npn transistor with R as base
iv. It is a pnp transistor with R as collector

Sol: Correct answer is (3)

Q. 15. A block of mass 0.50 kg is moving with a speed of 2.00 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

i. 0.67 J
ii. 0.34 J
iii. 0.16 J
iv. 1.00 J

Sol:

By the principle of conservation of momentum

$0.5 \times 2 = 1.5 \times V$

$\Rightarrow V = \frac{2}{3} ms^{-1}$

$Loss\ of\ energy = \frac{1}{2} \times 0.5 \times (2)^2 - \frac{1}{2} \times 1\ 5 \times \left(\frac{2}{3}\right)^2$

$= 1 - \frac{1}{3} = \frac{2}{3}$

$= 0.67\ J$

$\therefore$ *Correct answer is* (1)

Q. 16. A wave travelling along the x-axis is described by the equation $Y(x, t) = 0.005 \cos(ax - \beta t)$ If the wavelength and the time period of the wave are 0.08 m and 2.0 s, respectively, then $\alpha\ and\ \beta?$ in appropriate units are

i. $\alpha = \frac{0.04}{\pi}, \beta = \frac{1.0}{\pi}$
ii. $\alpha = 12\ 50\pi, \beta = \frac{\pi}{2.0}$
iii. $\alpha = 25\ 00\pi, \beta = \pi$
iv. $\alpha = \frac{0.08}{\pi}, \beta = \frac{2.0}{\pi}$

Sol:

$\alpha = \frac{2\pi}{\lambda} = \frac{2\pi}{0.08} = 25\pi$

$\beta = \frac{2\pi}{T} = \frac{2\pi}{2} = \pi$

$\therefore$ *Correct answer is* (3)

Q. 17. 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 solenoids has 300 turns and the other 400 turns, their mutual inductance is $(\mu_0 = 4\pi \times 10^{-7}\ T\ m\ A^{-1})$

i. $4.8\pi \times 10^{-5} H$
ii. $2.4\pi \times 10^{-4} H$

iii. $2.4\pi \times 10^{-5} H$

iv. $4.8\pi \times 10^{-4} H$

Sol:

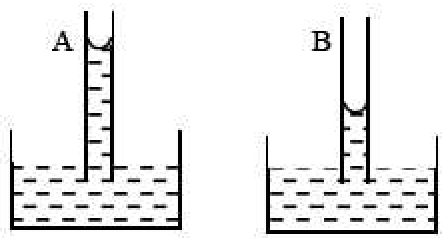
$$\text{Mutual Inductance} = \frac{\mu_0 N_1 N_2 A}{l}$$

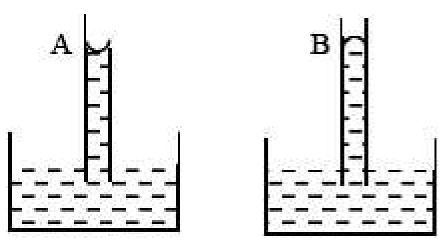
$$= \frac{4\pi \times 10^{-7} \times 300 \times 400 \times 10}{20}$$

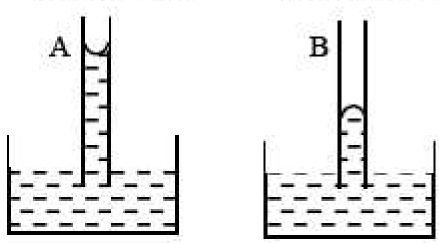
$$= 2.4 \times 10^{-4} \pi \ H$$

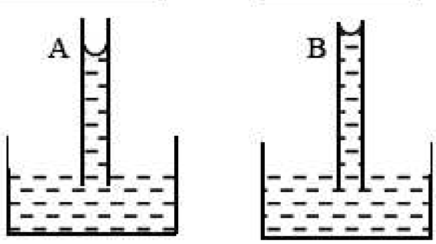
$\therefore$ *Correct answer is* (2)

Q. 18. A capillary tube (A) is dipped in water. Another identical tube (B) is dipped in a soap-water solution. Which of the following shows the relative nature of the liquid columns in the two tubes?

i. 

ii. 

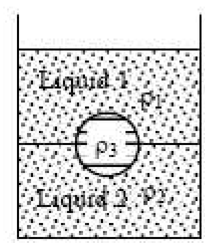
iii. 

iv. 

Sol: Surface tension of water is more than soap solution.

∴Correct choice: (1)

Q. 19. A jar is filled with two non-mixing liquids 1 and 2 having densities ρ_1 *and* ρ_2, respectively. A solid ball, made of a material of density ρ_3, is dropped in the jar. It comes to equilibrium in the position shown in the figure. Which of the following is true for ρ_1, ρ_2 *and* ρ_3?



i. $\rho_1 < \rho_2 < \rho_3$
ii. $\rho_1 < \rho_3 < \rho_2$
iii. $\rho_3 < \rho_1 < \rho_2$
iv. $\rho_1 < \rho_3 < \rho_2$

Sol:

As heavier liquid occupy lower level

$\therefore \rho_1 < \rho_2$

ball floats lower liquid and sin ks in upper one

$\therefore \rho_3 < \rho_2$ *and* $\rho_1 < \rho_3$

$\therefore \rho_1 < \rho_3 < \rho_2$

$\therefore$ *Correct answer is* (2)

Q. 20. Suppose an electron is attracted towards the origin by a force $\frac{k}{r}$ *where 'k'* where 'k' is a constant and 'r is the distance of the electron from the origin. By applying Bohr model to this system, the radius of the nth orbital of the electron is found to be 'rn' and the kinetic energy of the electron to be 'T_n'. Then which of the following is true?

i. $T_n \propto \frac{1}{n}, r_n \propto n$

ii. $T_n \propto \frac{1}{n}, r_n \propto n^2$

iii. $T_n \propto \frac{1}{n^2}, r_n \propto n^2$

iv. T_n independent of n, $r_n \propto n$

Sol:

$$Here, L = \frac{nh}{2\pi}$$

$$\Rightarrow mvr_n = \frac{nh}{2\pi} \qquad (i)$$

$$Also, \frac{mv^2}{r_n} = \frac{K}{r_n}$$

$$\Rightarrow mv^2 = K$$

$$\Rightarrow Tn = \frac{1}{2}mv^2 = \frac{1}{2}K,$$

Which is independent of n

From (i)

$$r_n = \frac{nh}{2\pi mv} = \frac{nh}{2\pi\sqrt{km}}$$

Hence, $r_n \propto_n$

$\therefore$ Correct answer is (4)

Directions : Questions No. 91, 92 and 93 are based on the following paragraph.

Wave property of electrons implies that they will show diffraction effects. Davisson and Germer demonstrated this by diffracting electrons from crystals. The law governing the diffraction from a crystal is obtained by requiring that electron waves reflected from the planes of atoms in a crystal interfere constructively (see figure).

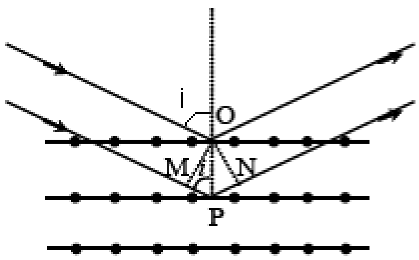
Q. 21. Electrons accelerated by potential V are diffracted from a crystal.

If $d = 1\overset{0}{A}$ and $i = 30^0$, V should be about

$(h = 6.6\times10^{-34}\ Js, m_e = 9.1\times10^{-31}\ kg, e = 1.6\times10^{-19}\ C)$

i. 500 V
ii. 1000 V
iii. 2000 V
iv. 50 V

Sol:



$$\text{Path difference} = MP + PN$$

or, $n\lambda = 2d\cos i$

or, $\lambda = \frac{2\cos 30^0}{n} \overset{0}{A}$

or, $\lambda = \frac{\sqrt{3}}{n} \overset{0}{A}$

Also, $\lambda = \sqrt{\frac{150}{V}} \overset{0}{A}$

$\therefore \sqrt{\frac{150}{V}} = \frac{\sqrt{3}}{n}$

or, $V = \frac{150\,n^2}{3} = 50n^2$

$\therefore$ for $n = 1$, $V = 50V$

$\therefore$ Correct answer is (4)

Q. 22. If a strong diffraction peak is observed when electrons are incident at an angle 'i' from the normal to the crystal planes with distance 'd' between them (see figure), de Broglie wavelength λ_{dB} of electrons can be calculated by the relationship (n is an integer)

i. $2d\sin i = n\lambda_{dB}$

ii. $d \cos i = n\lambda_{dB}$

iii. $d \sin i = n\lambda_{dB}$

iv. $2d \cos i = n\lambda_{dB}$

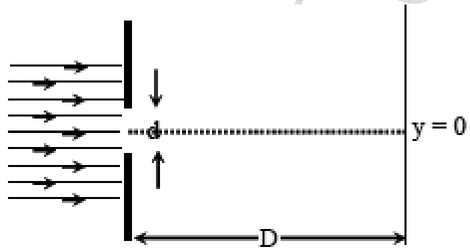
Sol:

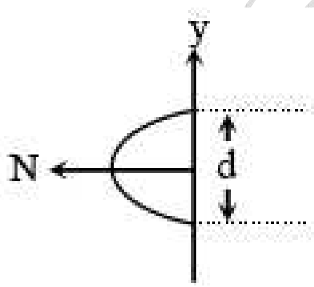
For the strong peak, path difference $= n\,\lambda_{dB}$

$\therefore\ 2d\cos_2 = n\,\lambda_{dB}$

$\therefore$ *Correct answer is* (4)

Q. 23. In an experiment, electrons are made to pass through a narrow slit of width 'd' comparable to their de Broglie wavelength. They are detected on a screen at a distance 'D' from the slit (see figure). Which of the following graphs can be expected to represent the number of electrons 'N' detected as a function of the detector position 'y' (y = 0 corresponds to the middle of the slit)?



i.


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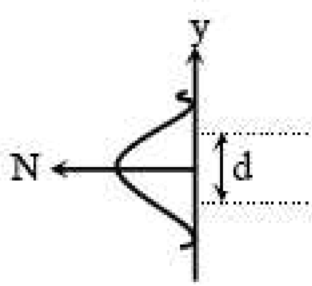
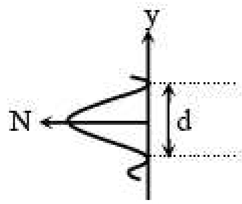
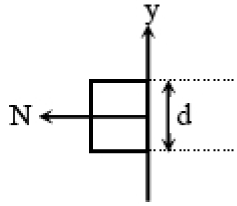


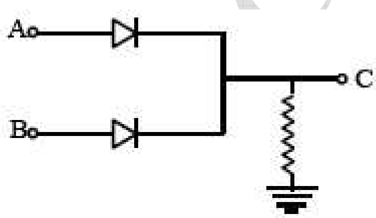
iii. 

iv. 

Sol: After diffraction the electron beam will spread.

Correct answer (2)

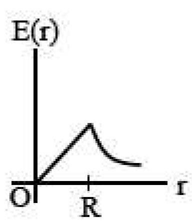
Q. 24. In the circuit shown, A and B represent two inputs and C represents the output. The circuit represents

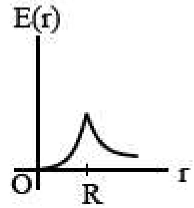


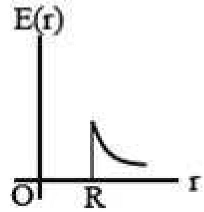
i. NAND gate
ii. OR gate
iii. NOR gate
iv. AND gate

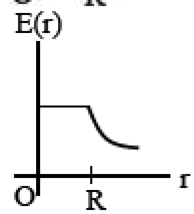
Sol: Correct answer (2)

Q. 25. A thin spherical shell of radius R has charge Q spread uniformly over its surface. Which of the following graphs most closely represents the electric field E(r) produced by the shell in the range $0 \le r < \infty$, where r is the distance from the centre of the shell?

i. 

ii. 

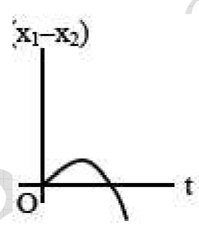
iii. 

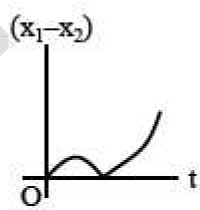
iv. 

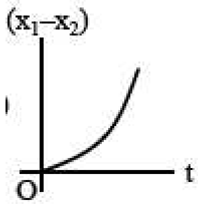
Sol: In this case, electric field inside the shell is zero and is inversely proportional to r^2, where r is the distance of a point outside the shell.

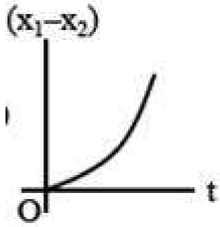
Correct answer (3)

Q. 26. A body is at rest at x = 0. At t = 0, it starts moving in the positive x-direction with a constant acceleration. At the same instant another body passes through x = 0 moving in the positive x direction with a constant speed. The position of the first body is given by $x_1(t)$ after time t and that of the second body by $x_2(t)$ after the same time interval. Which of the following graphs correctly describes $(x_1 - x_2)$ as a function of time t?

i. 

ii. 

iii. 

iv. 

Sol:

$x_1(t) = \frac{1}{2}at^2$ *and* $x_2(t) = Vt$

$\therefore (x_1 - x_2)(t) = \frac{1}{2}at^2 - Vt$

or, $x_{12} = \frac{1}{2}at^2 - Vt$

when $t = 0,\ x_{12} = 0$

$\frac{dx_{12}}{dt} = at - V$

and $\frac{d^2x_{12}}{dt^2} = a > 0$

$\therefore$ *Correct answer is* (4)

Q. 27. Relative permittivity and permeability of a material are ε_r *and* μ_r respectively. Which of the following values of these quantifies are allowed for a diamagnetic material?

i. $\varepsilon_r = 0.5,\ \mu_r = 0.5$
ii. $\varepsilon_r = 1.5,\ \mu_r = 1.5$
iii. $\varepsilon_r = 0.5,\ \mu_r = 1.5$
iv. $\varepsilon_r = 1.5,\ \mu_r = 0.5$

Sol: *For a diamagnetic material,* $o < \mu_r < i$ *and for any material* $\varepsilon r > 1$

$\therefore$ *Correct answer is* (4)

Q. 28. 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

i. 110 km s^{-1}
ii. 0.11 km s^{-1}
iii. 1.1 km s^{-1}
iv. 11 km s^{-1}

Sol :

Escape velocity from the surface earth,

$$V_e = \sqrt{\frac{Me}{\text{Re}}}$$

and that from the planet

$$Vp = \sqrt{\frac{M\rho}{R\rho}}$$

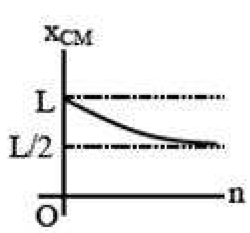
$$\therefore \frac{Vp}{Ve} = \sqrt{\frac{M\rho}{R\rho} \times \frac{\text{Re}}{Me}}$$

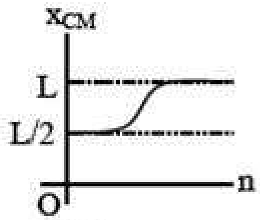
$$= 11 \times \sqrt{\frac{10Me}{R\rho} \times \frac{10R\rho}{Me}}$$

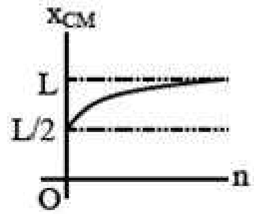
$$110\ km/s$$

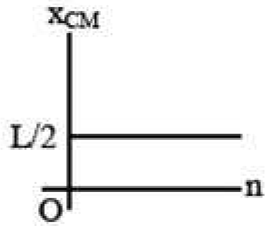
$\therefore$ *Correct answer is* (1)

Q. 29. A thin rod of length 'L' is lying along the x-axis with its ends at x = 0 and x = L. Its linear density (mass/length) varies with x $as\ k\left(\frac{x}{L}\right)^n$ where 'n' can be zero or any positive number. If the position $x_{CM}$of the centre of mass of the rod is plotted against 'n', which of the following graphs best approximates the dependence of xCM on n?

i. 

ii. 

iii. 

iv. 

Sol:

$$x\,cm = \frac{\int x\,dm}{\int dm} = \frac{\int_0^L x\,k\left(\frac{x}{L}\right)^n dx}{\int_0^L k\left(\frac{x}{L}\right)^n dx}$$

$$= \frac{\frac{k}{L^n}\int_o^L x^{n+1}\,dx}{\frac{k}{L^n}\int_o^L x^n\,dx} = \frac{\left[\frac{x^{n+2}}{n+2}\right]_o^L}{\left[\frac{x^{n+1}}{n+1}\right]_o^L}$$

$$= \left(\frac{n+1}{n+1}\right)L$$

When $n = 0$, $x\,cm = \frac{L}{2}$ and

When $n \to \infty$, $xcm = L$

$\therefore$ Correct answer is (3)

Q. 30. The dimension of magnetic field in M, L, T and C (Coulomb) is given as

i. $MT^{-1}C^{-1}$
ii. $MT^{-2}C^{-1}$
iii. $MLT^{-1}C^{-1}$
iv. $MT^{2}C^{-2}$

Sol:

$$As,\ F = iBl$$
$$[MLT^{-2}] = [i][B][l]$$
$$= \left[\frac{C}{T}\right][B][L]$$
$$\therefore [B] = [MLT^{-2}]\left[\frac{T}{C}\right]\left[\frac{1}{L}\right]$$
$$= [MT^{-1}\ C^{-1}]$$
$\therefore$ *Correct answer is* (1)

Q. 31. A parallel plate capacitor with air between the plates has a capacitance of 9 pF. The separation between its plates is 'd'. The space between the plates is now filled with two dielectrics. One of the dielectric has dielectric constant K1 = 3 and thickness $\frac{d}{3}$ while the other one has dielectric constant $k_2 = 6$ *and thickness* $\frac{2d}{3}$. Capacitance of the capacitor is now.

i. 40.5 pF
ii. 20.25 pF
iii. 1.8 pF
iv. 45 pF

Sol:

$$Co = 9pF = \frac{\varepsilon_0 A}{d}$$

$$\frac{1}{C} = \frac{d/3}{\varepsilon_0 AK_1} + \frac{2d/3}{\varepsilon_0 AK_2}$$

$$= \frac{d}{3\varepsilon_0 A \times 3} + \frac{2d}{3\varepsilon_0 A \times 6} = \frac{2d}{9\varepsilon_0 A}$$

$$\therefore C = \frac{9\varepsilon_0 A}{2d} = \frac{9}{2}(9pF)$$

$$= 40.5pF$$

$\therefore$ Correct answer is (1)

Q. 32. An athlete in the olympic games covers a distance of 100m in 10s. His kinetic energy can be estimated to be in the range.

i. 20,000 J - 50,000 J
ii. 2,000 J - 5,000 J
iii. 200 J - 500 J
iv. $2 \times 10^5 J - 3 \times 10^5 J$

Sol:

Let his average speed be v

$$\therefore v = \frac{100m}{10s} = 10ms^{-1}$$

$$\therefore K.E = \frac{1}{2}mv^2$$

Let mass of the athlete lie between 40 kg to 100 kg

$$\therefore \frac{1}{2} \times 40 \times 10^2 J < KE < \frac{1}{2} \times 100 \times 10^2 J$$

or, $2000J < KE < 5000J$

$\therefore$ Correct answer is (2)

Q. 33. A spherical solid ball of volume V is made of a material of density $\rho_2\ (\rho_2 < \rho_1)$. It is falling through a liquid of density. 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.

i. $\sqrt{\frac{Vg\ \rho_1}{k}}$

ii. $\frac{Vg\ (\rho_1 - \rho_2)}{k}$

iii. $\sqrt{\frac{Vg\ (\rho_1 - \rho_2)}{k}}$

iv. $\frac{Vg\ \rho_1}{k}$

Sol:

The ball will aquire terminal *speed in its equilibrium state*

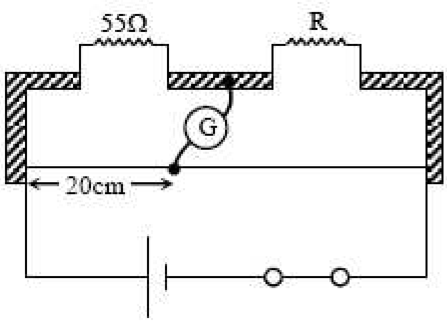
$i.e\ V\rho_2 g + K'v^2 - V\rho_1 g = 0$

$or,\ Kv^2 = vg\ (\rho_1 - \rho_2)$

$$\therefore v = \sqrt{\frac{Vg(\rho_1 - \rho_2)}{K}}$$

$\therefore$ *Corect answer is* (3)

Q. 34. Shown in the figure is a meter-bridge set up with null deflection in the galvanometer. The value of the unknown resistor R is



i. 110Ω
ii. 55Ω
iii. 13.75Ω
iv. 220Ω

Sol:

For the null deflection in the meter bridge

$$\frac{55}{R} = \frac{20}{100-20}$$

$or,\ 20\ R = 55 \times 80$

$\therefore\ R\ 220\Omega$

$\therefore$ *Correct answer is* (4)

Q. 35. While measuring the speed of sound by performing a resonance column experiment, a student gets the first resonance condition at a column length of 18 cm during winter. Repeating the same experiment during summer, she measures the column length to be x cm for the second resonance. Then

i. 54 > x > 36
ii. 36 > x > 18
iii. 18 > x
iv. x > 54

Sol:

$$\frac{Vw}{4l} = \frac{3V_s}{4x}$$

$$or,\ x = 3\left(\frac{Vs}{Vw}\right)l$$

$$or,\ x = 3\left(\frac{Vs}{Vw}\right) \times 18$$

$$or,\ x = 54\left(\frac{Vs}{Vw}\right)$$

As $Vs > Vw$

$\therefore\ x > 54cm$

$\therefore$ *Correct answer is* (4)