-: Solution :-

1 Physical World and Measurement

(19) **Answer [C]**

Modulus of rigidity = $\dfrac{\text{tangential Stress}}{\text{Shearing Strain}}$

Unit of Modulus of rigidity = Nm^{-2}

(25) **Answer [C]**

From the formula of Electric field, $E = \dfrac{V}{d}$,

Unit is Vm^{-1}

(29) **Answer [D]**

$\dfrac{dyne}{g} = \dfrac{g\,cm\,s^{-2}}{g} = cm\ s^{-2}$

cm s^{-2} is a unit of acceleration

(31) **Answer [B]**

1N = 10^5 *dyne*

$\therefore$ 1 *dyne* = 10^{-5} N

$\therefore$ 1 *dyne* = 10^5 N is a wrong relation.

(33) **Answer [C]**

moment of Inertia

= mass × (perpendicular distance from rotation axis)^2

Unit of moment of Inertia = kg m^2

(34) **Answer [C]**

Ws, KWh and *e*V are unit of energy. While Js is Plank's constant and angular momentum.

(35) **Answer [C]**

Angular momentum $l = M^1\ L^2\ T^{-1}$

Angular momentum in new system is l'

$= [2M]^1\ [2L]^2\ [2T]^{-1}$

$= 4\ M^1\ L^2\ T^{-1}$

$\therefore\ l' = 4\ (l)$

$\therefore$ becomes four times.

(36) **Answer [A]**

$\dfrac{1ns}{1\mu s} = \dfrac{10^{-9}s}{10^{-6}s} = 10^{-3}$

(37) **Answer [C]**

Unit of velocity = ms^{-1}

Unit of angular momentum = Js

Unit of linear momentum = Ns

Unit of work = J

$\therefore$ Ns is a Unit of linear momentum

(38) **Answer [B]**

Assume that each length of cube is l.

Volume of cube = Area of surface of cube

$l^3 = 6l^2$

$\therefore\ l = 6$ Unit

Area of surface of cube $A = 6l^2$

$\therefore\ A = 6(6)^2$

A = 216 Unit

(39) **Answer [D]**

From the Formula of $P = \dfrac{F}{A}$, unit is Nm^{-2}

From the Formula of stress

$$\sigma = \frac{F\,(\text{Restoring force})}{A\ (\text{Area of cross-section})} \quad \text{unit is } Nm^{-2}$$

Formula of Bulk modulus is $B = \dfrac{-P}{\left(\dfrac{\Delta V}{V}\right)}$

unit is Nm^{-2}

$\therefore$ Strain is unitless. Nm^{-2} is not a unit of strain

(41) Answer [B]

Energy E = Force $\times$ distance

New value of Energy

$\therefore$ E' = 4 (force) $\times$ 4 (distance)

= 16 force $\times$ distance

E' = 16 (Energy E)

Unit of Energy 16 times increases.

(42) Answer [C]

$g = 9.8\ ms^{-2}$

$= 9.8 \times (10^{-3}\ km) \times (\frac{1}{3600}\ hr)^{-2}$

$= 9.8 \times 10^{-3} \times (3600)^2\ km\ hr^{-2}$

$= 127008\ km\ hr^{-2}$

$\therefore g = 127008\ km\ hr^{-2}$

(43) Answer [A]

$\theta = 1.6^0 = 1.6 \times \frac{\pi}{180}$ rad

$= 2.791 \times 10^{-2}$ rad

$D = \frac{b}{\theta} = \frac{1.276 \times 10^7}{2.791 \times 10^{-11}} = 4.57 \times 10^5$ km

(44) Answer [A]

$\alpha = \frac{d}{D} = \frac{1.393 \times 10^9}{1.496 \times 10^{11}}$

$= 0.93114 \times 10^{-2}$ rad, $\alpha = 1920''$

(45) Answer [A]

$\theta = 54' = 0.9^0$ $(\therefore 6' = 0.1^0)$

$\therefore \theta = 0.9 \times \frac{\pi}{180}$ rad

$\therefore b = 2(6.4 \times 10^6)$ m $= 12.8 \times 10^6$ m

Now $D = \frac{b}{\theta} = \frac{12.8 \times 10^6}{0.9 \times \left(\frac{\pi}{180}\right)}$

$= 8.153 \times 10^8$ m

(46) Answer [C]

$\text{Velocity} = \frac{\text{distance}}{\text{time}} = \frac{14 \pm 0.2}{4.0 \pm 0.3}$

$= \frac{14}{4} \pm \left(\frac{0.2}{14} + \frac{0.3}{4.0}\right) \times \frac{14}{4}$

$= (3.5 \pm 0.31)\ ms^{-1}$

(47) Answer [D]

For parallel connection of resistance $R_P = \frac{R_1 R_2}{R_1 + R_2}$

$\therefore \frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$

$R_P^{-1} = R_1^{-1} + R_2^{-1}$

$\therefore -\frac{\Delta R_P}{R_P^2} = -\frac{\Delta R_1}{R_1^2} - \frac{\Delta R_2}{R_2^2}$

$\therefore \frac{\Delta R_P}{R_P^2} = \frac{\Delta R_1}{R_1^2} + \frac{\Delta R_2}{R_2^2}$

(48) Answer [C]

For series connection of resistance $R = R_1 + R_2$

$= (3.0 \pm 0.1) + (6 \pm 0.3)$

$= (3.0 + 6.0) \pm (0.1 + 0.3)$

$\therefore R = (9 \pm 0.4)\ \Omega$

(49) Answer [A]

$\text{density } (\rho) = \frac{\text{mass (m)}}{\text{Volume (V)}} = \frac{m}{lbh}$

$= \frac{39.3}{5.12 \times 2.56 \times 0.37} = 8.10$

$$\rho = \frac{\text{mass (m)}}{\text{length } (l) \times \text{width } (b) \times \text{height } (h)}$$

$$\text{fractional error } \frac{\Delta s}{s} = \frac{\Delta m}{m} 2 + \frac{\Delta l}{l} + \frac{\Delta b}{b} + \frac{\Delta h}{h}$$

$$= \frac{0.1}{39.3} + \frac{0.01}{5.12} + \frac{0.01}{2.56} + \frac{0.01}{0.37}$$

$$\frac{\Delta\rho}{\rho} = 0.03541$$

$\therefore \Delta\rho = 0.03541 \times 8.10$

$\therefore \Delta\rho = 0.29 \text{ gcm}^{-3}$

Inaccuracy in measurement of density= 0.29 gcm^{-3}

(50) **Answer [D]**

$$\text{Density } (\rho) = \frac{\text{mass (m)}}{\text{volume (V)}} = \frac{m}{\pi r^2 l}$$

$$\therefore \frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + 2\frac{\Delta r}{r} + \frac{\Delta l}{l}$$

$$= \frac{0.003}{0.3} + 2\left(\frac{0.005}{0.5}\right) + \left(\frac{0.06}{6}\right)$$

$$\therefore \frac{\Delta\rho}{\rho} = 0.04 \;\therefore \frac{\Delta\rho}{\rho} \times 100\ \%$$

$$= 0.04 \times 100\ \% = 4\ \%$$

(51) **Answer [D]**

periodic time T = 2.0 s. In measurement of periodic time, average absolute error is = 0.01 s

$\therefore$ Periodic time = $T \pm \Delta T$

$= (2 \pm 0.01)$ s

(52) **Answer [C]**

$$\text{Resistance } R = \frac{V}{I}, \frac{\Delta R}{R} = \frac{\Delta V}{V} + \frac{\Delta I}{I}$$

$$= \frac{5}{100} + \frac{0.1}{10} = 0.05 + 0.01$$

$$\therefore \frac{\Delta R}{R} = 0.06 \;\therefore \frac{\Delta R}{R} \times 100\ \%$$

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

(53) **Answer [D]**

$H = I^2 Rt$

$$\frac{\Delta H}{H}\% = 2\frac{\Delta I}{I}\% + \frac{\Delta R}{R}\% + \frac{\Delta t}{t}\%$$

$$= 2\ (2\ \%) + 3\ \% + 1\ \%$$

$$\therefore \frac{\Delta H}{H}\% = 8\ \%$$

(54) **Answer [B]**

Volume of cube $V = l^3 = (1.5)^3 = 3.375 \text{ cm}^3$

$$\therefore \frac{\Delta V}{V} = 3\frac{\Delta l}{l}$$

$$= 3\left(\frac{0.02}{1.5}\right)$$

$$\therefore \frac{\Delta V}{V} = 0.04$$

$\therefore \Delta V = 0.04 \times 3.375$

$\therefore \Delta V = 0.135 \text{ cm}^3$

$\therefore$ volume of cube $V \pm \Delta V = (3.375 \pm 0.135) \text{ cm}^3$

(55) **Answer [B]**

$$Z = \frac{A^{\frac{1}{2}} B^2}{C D^3}, \frac{\Delta Z}{Z}\% = \frac{1}{2}\left(\frac{\Delta A}{A}\right)\%$$

$$+ 2\left(\frac{\Delta B}{B}\right)\% + \frac{\Delta C}{C}\% + 3\left(\frac{\Delta D}{D}\right)\%$$

$$= \frac{1}{2}\ (2\ \%) + 2\ (1\%) + 3\% + 3\left(\frac{1}{3}\%\right)$$

$$\therefore \frac{\Delta Z}{Z}\% = 7\ \%$$

(58) **Answer [B]**

1.875 + 2.41 = 4.285 After decimal point up to two digit, the answer of round off is 4.28

(59) Answer [A]

density of sphere $\rho = \dfrac{\text{mass (m)}}{\text{Volume (v)}} = \dfrac{m}{\frac{4}{3}\pi r^3}$

$= \dfrac{5.13}{\frac{4}{3} \times 3.14 \times (0.210)^3}$

$= 132.309 \text{ gcm}^{-3}$

From law of multiplication and divisions of significant digits, round off for first three digits the density $\rho = 132 \text{ gcm}^{-3}$.

(60) Answer [A]

$15.235 \times 3.315 \times 2 = 101.00805$ after round off up to first four digit the answer is 101.0.

($\because$ 2 has infinite significant digits.)

(65) Answer [C]

$g = 4\pi \dfrac{l}{T^2}$, $\therefore \dfrac{\Delta g}{g} = \dfrac{\Delta l}{l} + 2\dfrac{\Delta T}{T}$

But $t = n$T So $\dfrac{\Delta t}{t} = \dfrac{\Delta T}{T}$.

$\therefore \dfrac{\Delta g}{g} = \dfrac{\Delta l}{l} + 2\dfrac{\Delta t}{t} = \dfrac{0.1}{10} + 2\left(\dfrac{1}{90}\right)$

$= 0.01 + 0.022$, $\therefore \dfrac{\Delta g}{g} = 0.032$

$\therefore \Delta g = 0.032 \times 9.8 = 0.3136$

$\therefore \Delta g = 0.31 \text{ ms}^{-2}$

$\therefore g = (9.8 \pm 0.31) \text{ ms}^{-2}$

(68) Answer [B]

According to law of addition of significant digits $9.15 + 3.8 = 12.95$, in answer, one significant digit after decimal point, and remaining significant digit by round off summation becomes 13.0.

(69) Answer [B]

Average length

$\overline{l} = \dfrac{2.01 + 2.03 + 2.09 + 2.07 + 2.01}{5}$

$\therefore \overline{l} = 2.042$ m

$|\Delta l_1| = 2.01 - 2.042 = 0.032$ m

$|\Delta l_2| = 2.03 - 2.042 = 0.012$ m

$|\Delta l_3| = 2.09 - 2.042 = 0.048$ m

$|\Delta l_4| = 2.07 - 2.042 = 0.028$ m

$|\Delta l_5| = 2.01 - 2.042 = 0.032$ m

$\therefore \Delta\overline{l} = \dfrac{|\Delta l_1||\Delta l_2||\Delta l_3||\Delta l_4||\Delta l_5|}{5}$

$= \dfrac{0.032 + 0.012 + 0.048 + 0.028 + 0.032}{5}$

$\Delta\overline{l} = 0.030$ m

(71) Answer [A]

Volume of sphere $V = \frac{4}{3}\pi r^3$, $\therefore \dfrac{\Delta V}{V} = 3\dfrac{\Delta r}{r}$,

$\therefore 3\,\% = 3\dfrac{\Delta r}{r}$, $\therefore \dfrac{\Delta r}{r} = 1\,\%$

$\therefore$ The surface area of sphere, $A = 4\pi r^2$

$\therefore \dfrac{\Delta A}{A} = 2\dfrac{\Delta r}{r} = 2(1\,\%) = 2\,\%$

The percentage error in measurement of surface area = 2 %

(75) Answer [A]

$\dfrac{[E][L]^2}{[M]^5[G]^2} = \dfrac{\left[M^1 L^2 T^{-2}\right]^2}{[M^1]^5 [M^{-1} L^3 T^{-2}]^2}$

$= M^0 L^0 T^0$

plane angle is dimensionless. Its dimensional formula is $M^0 L^0 T^0$.

(76) Answer [C]

Dimensional formula of Force = $M^1 L^1 T^{-2}$

Dimensional formula of Work = $M^1 L^2 T^{-2}$

Dimensional formula of Energy = $M^1 L^2 T^{-2}$

Dimensional formula of torque = $M^1 L^2 T^{-2}$

Dimensional formula of power = $M^1 L^2 T^{-3}$

The dimensional formula for energy and torque are same.

(77) Answer [D]

$G \propto c^x g^y P^Z$, $[G] = [c]^x [g]^y [P]^z$

$\therefore M^{-1} L^3 T^{-2}$

$= [L^1 T^{-1}]^x [L^1 T^{-2}]^y [M^1 L^{-1} L^{-2}]^z$

$\therefore M^{-1} L^3 T^{-2}$

$= M^Z L^{x+y-z} T^{-x-2y-2z}$

Compare the exponent of M, L and T on both sides

$-1 = z$ $\quad\therefore z = -1$

$x + y - z = 3$ $\quad x = 0$

$-x + 2y - 2z = -2$ $\quad y = 2$

The dimensions of c, *g* and P are 0, 2 and –1.

(78) Answer [D]

$$\left(P + \frac{a}{V^2}\right)(V - b) = \mu RT$$

$\therefore [b] = [V] = L^3$, $\therefore \frac{a}{V^2} = [P]$

$\therefore [a] = [P][V]^2$, $\therefore [a] = M^1 L^{-1} T^{-2} \times (L^3)^2$

$\therefore [a] = M^1 L^5 T^{-2}$, $\therefore [ab] = M^1 L^5 T^{-2} \times L^3$

$\therefore [ab] = M^1 L^8 T^{-2}$

(80) Answer [D]

Addition and subtraction is possible for physical quantity having same dimension. Physical quantity having unequal dimension, multiplication and division is possible. Addition and subtraction is not possible. so,

Answer is $\frac{AB}{C}$.

(81) Answer [D]

Dimensional formula of Torque = $M^1 L^2 T^{-2}$

Dimensional formula of Work = $M^1 L^2 T^{-2}$

Dimensional formula of angular momentum $= M^1 L^2 T^{-1}$

Dimensional formula of Plank's constant $= M^1 L^2 T^{-1}$

Dimensional formula of impulse of force $= M^1 L^1 T^{-1}$

Dimensional formula of linear momentum $= M^1 L^1 T^{-1}$

Dimensional formula of tension force $= M^1 L^1 T^{-2}$

Dimensional formula of surface tension $= M^1 L^o T^{-2}$

Dimensional formula of tension force and surface tension are not equal.

(82) Answer [A]

exponential and trigenometry functions are dimensionless.

$\left[\frac{bt}{m}\right] = M^o L^o T^o$, $\therefore [b] = \frac{[m]}{[t]}$

$= \frac{M^1 L^o T^o}{M^o L^o T^1}$, $\therefore [b] = M^1 L^o T^{-1}$

(83) Answer [B]

$[\lambda t] = M^o L^o T^o$, $\therefore [\lambda][t] = M^o L^o T^o$

$\therefore [\lambda] T^1 = M^o L^o T^o$, $\therefore [\lambda] = M^o L^o T^{-1}$

(86) Answer [B]

Dimensional formula of

$R = [R] = M^1 L^2 T^{-3} A^{-2}$

Dimensional formula of

$L = [L] = M^1 L^2 T^{-2} A^{-2}$

$$\left[\frac{R}{L}\right] = \frac{M^1 L^2 T^{-3} A^{-2}}{M^1 L^2 T^{-2} A^{-2}} = T^{-1} = M^0 L^0 T^{-1}$$

$$\left[\frac{L}{R}\right] = \frac{M^1 L^2 T^{-2} A^{-2}}{M^1 L^2 T^{-3} A^{-2}} = T^1 = M^0 L^0 T^1$$

$[LR] = [M^1 L^2 T^{-2} A^{-2}][M^1 L^2 T^{-3} A^{-2}]$

$= M^2 L^4 T^{-5} A^{-4}$

$$\left[\frac{1}{LR}\right] = \frac{1}{[M^1 L^2 T^{-2} A^{-2}][M^1 L^2 T^{-3} A^{-2}]}$$

$= M^{-2} L^{-4} T^5 A^4$

(87) Answer [D]

Intensity of radiation $I = \dfrac{\text{Energy}}{\text{time} \times \text{Area}}$

$$[I] = \frac{[\text{Energy}]}{[\text{time}]\,[\text{area}]} = \frac{M^1 L^2 T^{-2}}{[T^1][L^2]}$$

$\therefore$ $[I] = M^1 L^0 T^{-3}$

(88) Answer [C]

$[Kt] = M^0 L^0 T^0$, $\therefore$ $[K]\,[t] = M^o L^o T^0$

$\therefore$ $[K]\, T^1 = M^o L^o T^0$, $\therefore$ $[K] = M^o L^o T^{-1}$

(89) Answer [A]

$\dfrac{dx}{dt} = v =$ Velocity, $\therefore$ $\left[\dfrac{dx}{dt}\right] = [a]$

$\therefore$ $[a] = M^0 L^1 T^{-1}$, $[bt] = M^0 L^0 T^0$

$\therefore$ $[b] = M^0 L^0 T^{-1}$

$$\therefore \left[\frac{a}{b}\right] = \left[\frac{M^0 L^1 T^{-1}}{M^0 L^0 T^{-1}}\right] = M^0 L^1 T^0$$

So dimension of $\dfrac{a}{b}$ is dimension of length.

(90) Answer [C]

$[P_i - P_0] = \dfrac{[T]}{[R]}$, $\therefore$ $[T] = [P_i - P_0]\,[R]$

$= M^1 L^{-1} T^{-2} \times L^1$, $\therefore$ $[T] = M^1 L^0 T^{-2}$

(91) Answer [B]

$n_1 u_1 = n_2 u_2$ Where n_1 = value in MKS system

n_2 = value in CGS system

$\therefore$ $n_2 = n_1 \dfrac{u_1}{u_2}$

$$= 2 \times 10^{11} \times \frac{\text{kg m}^{-1}\text{s}^{-2}}{(10^{-3}\text{kg})^1 (10^{-2}\text{m})^{-1} (1\text{s})^{-2}}$$

$n_2 = 2 \times 10^{12}$

$\therefore$ Young modulus for steel in CGS system.

$Y = 2 \times 10^{12}$ dyne cm^{-2}.

(92) Answer [A]

Dimensional formula of force $F^1 = M^1 L^1 T^{-2}$

$\therefore$ $M^1 = F^1 L^{-1} T^{-2}$

$\therefore$ value of mass in new unit system

$= (100\ \text{N})^1 (10\ \text{m})^{-1} (10\ \text{s})^2$

$= 10^2\ \text{N} \times 10^{-1}\ \text{m}^{-1} \times 10^2\ \text{s}^2 = 10^3$ kg

(94) Answer [C]

$F = 10\ \text{N} = M^1 L^1 T^{-2}$

Force in new unit system

$$F' = [2M]^1\,[2L]^1 \left[\frac{T}{2}\right]^{-2} = 16\, M^1 L^1 T^{-2}$$

$= 16\,F = 16\,(10)$ N, $\therefore$ $F' = 160$ N

(95) Answer [B]

Energy $E = 10\ \text{J} = M^1 L^2 T^{-2}$

The energy of particle in new system

$\therefore$ $E' = [M']^1\,[LT^{-2}]^1\,L^1$

$$\therefore E' = [4M^1]\,[2\,L^1 T^{-2}] \left[\frac{L^1}{2}\right]$$

$= 4\,M^1 L^2 T^{-2} = 4\,E = 4\,(10)$ J

$\therefore$ $E' = 40$ J

(96) Answer [C]

Power $P = M^1 L^2 T^{-3} = 100$ erg min^{-1}

$= \dfrac{100}{60}$ erg s^{-1} force $F = M^1 L^1 T^{-2} = 60$ dyne

time $t = T^1 = 1$ hr $= 3600$ s

$\therefore$ Power $P = M^1 L^2 T^{-3}$

$P^1 = [M^1 L^1 T^{-2}]\,[L^1]\,[T^{-1}]$

$\therefore$ $P^1 = F^1 L^1 T^{-1}$

$\therefore$ $L = P^1 F^{-1} T^1 = \dfrac{100}{60} \times (60)^{-1} \times 3600$

$L = 100$ cm

(97) Answer [D]

Dimensional formula of force = [F] = $M^1 L^1 T^{-2}$

= $M^a L^b T^c$, ∴ $a = 1$, $b = 1$ and $c = -2$

∴ $3a + 5b - 2c = 3(1) + 5(1) - 2(-2) = 12$

(98) Answer [B]

$[P] = M^1 L^2 T^{-3} A^0 = M^a L^b T^c A^d$

∴ $a = 1$, $b = 2$, $c = -3$ and $d = 0$

∴ $5a + 2b + c - d = 5(1) + 2(2) + (-3) + 0 = 6$

(99) Answer [A]

Dimensional formula of angular momentum

$= [l] = M^1 L^2 T^{-1} = M^a L^b T^c$

∴ $a = 1$, $b = 2$ and $c = -1$

Dimensional formula of Density

$[\rho] = M^1 L^{-3} T^0 = M^x L^y T^z$, ∴ $x = 1$,

$y = -3$ and $z = 0$, ∴ $ax + by - cz$

$= (1) + 2(-3) - (-1)(0) = -5$

(100) Answer [B]

Dimensional formula of Force $F = M^1 L^1 T^{-2}$

$= [M^1 L^1 T^{-1}] [T^{-1}]$, ∴ $F = pf$

∴ Frequency $f = \frac{F}{p}$, ∴ $f = \frac{10}{1} = 10$ Hz

(101) Answer [D]

$E \propto p^a A^b T^c$, ∴ $[E] = [p]^a [A]^b [T]^c$

$M^1 L^2 T^{-2} = [M^1 L^1 T^{-1}]^a [L^2]^b [T^1]^c$

∴ $M^1 L^2 T^{-2} = M^a L^{a+2b} T^{-a+c}$

∴ Compare the exponent of M, L and T on both sides,

∴ $a = 1$, ∴ $a + 2b = 2 \Rightarrow 2b$

$= 2 - a \Rightarrow b = 1 - \frac{a}{2} = 1 - \frac{1}{2} = \frac{1}{2}$

∴ $-a + c = -2 \Rightarrow c = -2 + a \Rightarrow c$

$= -2 + 1 = -1$, ∴ $E = p^1 A^{\frac{1}{2}} T^{-1}$

(102) Answer [A]

$$V_x(t) = \frac{A + Bt^2}{1 + Ct}$$

1 is dimensionless there fore Ct is also Dimensionless.

∴ $[C][t] = M^0 L^0 T^0$

∴ $[C] = M^0 L^0 T^{-1} = T^{-1}$

The denomitor $1 + Ct$ is dimensionless, So, the dimonsion of numerator $A + Bt^2$ is the dimension of velocity.

∴ [A] = Dimension of velocity = $L^1 T^{-1}$

∴ $[B] T^2 = L^1 T^{-1}$, ∴ $[B] = L^1 T^{-3}$

(103) Answer [C]

$p = \dfrac{mv}{\sqrt{1 - \frac{v^2}{c^2}}}$ Here 1 is dimensionless.

So $\frac{v^2}{c^2}$ is also becomes dimonsionless.

∴ Dimension becomes equal for c and v.

$[c] = [v] = M^0 L^1 T^{-1} = L^1 T^{-1}$

∴ $[p] = [m][v] = M^1 \times L^1 T^{-1}$

∴ $[p] = M^1 L^1 T^{-1}$, ∴ $L^1 T^{-1}$, $M^1 L^1 T^{-1}$

(104) Answer [A]

In $F = \dfrac{Dt + Et^2}{1 + A\sin^2 \omega t}$, $1 + A\sin^2\omega t$ is unitless

∴ $A\sin^2\omega t$ is unitless.

∴ A becomes unitless.

Unit of $Dt + Et^2$ is unit of force

∴ Unit of Dt = unit of force

∴ Unit of $D = Ns^{-1}$, ∴ unitless, Ns^{-1}

(105) **Answer [B]**

Work in new system

$= (100 \times 10^{-3}\ \text{kg})^1\ (10 \times 10^{-2}\ \text{m})^2\ (10^{-1}\ \text{s})^{-2}$

$= 10^{-1}\ \text{kg} \times 10^{-2}\ \text{m}^2 \times 10^2\ \text{s}^{-2}$

$= 0.1\ \text{kg m}^2\ \text{s}^{-2}$ $\therefore$ Work in new system is $= 0.1$ J

(106) **Answer [C]**

$E = G^x\, c^y\, h^z$, $[E] = [G]^x\ [c]^y\ [h]^z$

$M^1 L^2 T^{-2} = [M^{-1} L^3 T^{-2}]^x\ [L^1 T^{-1}]^y$

$[M^1 L^2 T^{-1}]^z$, $\therefore M^1 L^2 T^{-2}$

$= M^{-x+z}\ L^{3x+y+2c}\ T^{-2x-y-z}$

Compare the exponent of M, L and T on both sides

$-x + z = 1$ ...(1)

$3x + y + 2c = 2$ ...(2)

$-2x - y - z = -2$ ...(3)

Solving the equation (1), (2) and (3)

$x = -\frac{1}{2}, y = \frac{5}{2}, z = \frac{1}{2}$

(107) **Answer [A]**

Surface tension $S \propto E^a\, V^b\, T^c$

$\therefore [S] = [E]^a\ [V]^b\ [T]^c$

$\therefore M^1 L^0 T^{-2} = [M^1 L^2 T^{-2}]^a\ [L^1 T^{-1}]^b\ [T^1]^c$

$\therefore M^1 L^0 T^{-2} = M^a\ L^{2a+b}\ T^{-2a-b+c}$

Compare the exponents of M, L and T on both sides

$a = 1, 2a + b = 0, -2a - b + c = -2$

solving these equations $a = 1$, $b = -2$ and $c = -2$

$\therefore$ Answer $E^1\ V^{-2}\ T^{-2}$

(108) **Answer [A]**

If the electric charges q_1 and q_2 are separated by distance r to each other, then electric force between them is

$$F = \frac{1}{4\pi\varepsilon_0}\ \frac{q_1 q_2}{r^2},\ \therefore \varepsilon_0 = \frac{q_1 q_2}{4\pi F r^2}$$

$$[\varepsilon_0] = \frac{A^2 T^2}{M^1 L^1 T^{-2} \times L^2}$$

$\therefore [\varepsilon_0] = M^{-1}\ L^{-3}\ T^4\ A^2$

(109) **Answer [B]**

from Acceleration : $[a] = L^1 M^0 T^{-2} = L^a M^b T^c$

$\therefore a = 1, b = 0, c = -2$

from Pressure : $[P] = L^{-1} M^1 T^{-2} = L^a M^b T^c$

$\therefore a = -1, b = 1, c = -2$

from Force : $[F] = L^1 M^1 T^{-2} = L^a M^b T^c$

$\therefore a = 1, b = 1, c = -2$

from Velocity : $[v] = L^1 M^0 T^{-1} = L^a M^b T^c$

$\therefore a = 1, b = 0, c = -1$

(111) **Answer [B]**

In measurement of $Z = M^x\ L^y\ T^{-z}$, the maximum percentage error is $\frac{\Delta Z}{Z}\%$

$$= x\left(\frac{\Delta M}{M}\%\right) + y\left(\frac{\Delta L}{L}\%\right) + z\left(\frac{\Delta T}{T}\%\right)$$

$= xa + yb + cz$, $\therefore \frac{\Delta Z}{Z}\% = ax + by + cz$

(112) **Answer [A]**

Pressure $P = h\rho g$

where h = height of mercury column.

ρ = density of mercury and g = Acceleration of gravity. Pressure due to mercury column in CGS system

$P_1 = h\rho g = 76 \times 13.6 \times 980$

$= 1012928$ dyne cm^{-2}

Dimensional formula of pressure

$= M^1 L^{-1} T^{-2} = M^a L^b T^c$

$\therefore a = 1, b = -1$ and $c = -2$

Pressure of mercury column in MKS system

$$P_2 = P_1 \left[\frac{M_1}{M_2}\right]^a \left[\frac{L_1}{L_2}\right]^b \left[\frac{T_1}{T_2}\right]^c$$

$$= 1012928 \left[\frac{10^{-3}\ \text{kg}}{1\text{kg}}\right]^1 \left[\frac{10^{-2}\ \text{m}}{1\text{m}}\right]^{-1} \left[\frac{1\text{s}}{1\text{s}}\right]^{-2}$$

$1012928 \times 10^{-1}\ \text{Nm}^{-2}$

$= 1012928 \times 10^{-3} \times 10^{-2}\ \text{Nm}^{-2}$

$P_2 = 1.013 \times 10^5\ \text{Nm}^{-2}$

(113) Answer [D]

Least Count LC = $a - \frac{m}{n}\ a = a\left(1-\frac{m}{n}\right)$

using this formula $m = n - 1$ and taking $a = x$ cm

$$LC = \left(1-\frac{(n-1)}{n}\right) x\ ,\ LC = \frac{x}{n}\ \text{cm}$$

(114) Answer [C]

Least count measurement LC

$$= \frac{\text{distance between two divisions on main scale}}{\text{total number of divisions on circular scale}}$$

$$= \frac{0.05}{50} = 0.001\ \text{cm}$$

(115) Answer [A]

$LC = \left(1-\frac{m}{n}\right)a$, Here a = 0.5° = 30'

Take $m = 29$ and $n = 30$

$$= \left(1-\frac{29}{30}\right) \times 30' = \frac{30'}{30} = 1'$$

(116) Answer [B]

Diameter of wire = Reading of main scale + (Reading of circular scale × Least count)

= 0 + 48 × 0.01 = 0.48 mm = 0.048 cm

(118) Answer [A]

With the increase in the distance between earth and stars, parralex angle reduces resulting in an error in the measurement of parralex angle. Thus, parralex angle can't be measured accurately and hence distance of the stars situated at the distance more than 100 light years can't be measured accurately. So option 'a' is true.

(122) Answer [A]

(1) unit of work = J = kWh

(2) unit of power W = Js^{-1} = Nms^{-1}

(3) unit of momentum $kgms^{-1}$ = Ns

(4) unit of force = N = Jm^{-1}

(123) Answer [C]

(1) From Stephen's constant $\sigma = \frac{E}{A^2T^4}$

Unit = $\frac{J}{m^2K^2}$ = $Jm^{-2}\ K^{-4}$

(2) From universal gas constant $R = \frac{PV}{\mu T}$

unit is $Jmol^{-1}\ K^{-1}$

(3) electrical permittivity $\varepsilon_0 = \frac{Cd}{A}$ where

C = capacitance A = Area, d = distance between two plates

$\therefore$ unit of $\varepsilon_0 = \frac{Fm}{m^2} = F\ m^{-1}$

(4) Magnetic permeability $\mu o = \frac{Ll}{N^2A}$

where L = Self induction of coil

l = length of coil

A = cross sectional area of coil

N = number of turns in coil

$\therefore$ unit of $\mu o = \frac{Hm}{m^2} = H\ m^{-1}$

(124) Answer [B]

(1) In 33.015, there are 5 (3, 3, 0, 1, 5) significant digits.

(2) In 0.054, there are 2 (5, 4) significant digits.

(3) In 0.003530, there are 4 (3, 5, 3, 0) significant digits.

(4) In 1.75×10^{-4}, there are 3 (1, 7, 5) significant digits.

2 Kinematics

(1) Answer [C]

$|\vec{A}| = 10, |\vec{B}| = 20, \theta = 30°$

$|\vec{R}| = (?) \qquad \alpha = (?)$

$|\vec{R}| = \sqrt{A^2 + B^2 + 2AB\cos\theta}$

$= \sqrt{(10)^2 + (20)^2 + 2(10)(20)\cos 30°}$

$= \sqrt{840}$, $|\vec{R}| \approx 29$ unit

$\tan\alpha = \dfrac{B\sin\theta}{A + B\cos\theta} = \dfrac{20\sin 30°}{10 + 20\cos 30°}$

$\tan\alpha = 0.3670 \therefore \alpha = \tan^{-1}(0.3670)$

$\alpha = 20°\ 19'$

(2) Answer [B]

$\vec{F} = 5\hat{i} - 4\hat{j} + 2\hat{k}$ N, $\vec{x} = \hat{i}$

$\theta = \cos^{-1}\left(\dfrac{\vec{F} \cdot \vec{x}}{\sqrt{F_x^2 + F_y^2 + F_z^2}}\right)$

$= \cos^{-1}\left(\dfrac{5}{\sqrt{25 + 16 + 4}}\right)$

$\theta = \cos^{-1}\left(\dfrac{\sqrt{5}}{3}\right)$

(3) Answer [C]

$|\vec{A} \times \vec{B}|$ is 73% larger then $\vec{A} \cdot \vec{B}$ means 0.73 is larger.

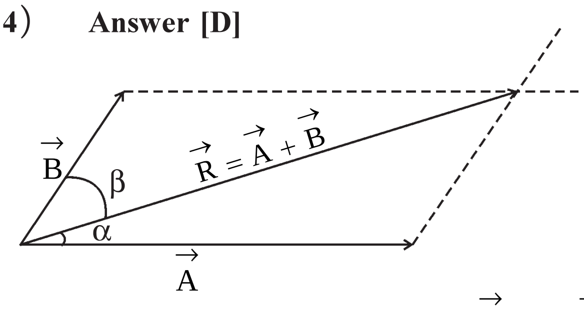
$\therefore |\vec{A} \times \vec{B}| = 1.73\ \vec{A} \cdot \vec{B}$

$\therefore$ AB $\sin\theta$ = 1.73 AB $\cos\theta$

$\therefore \tan\theta = 1.73 = \sqrt{3}$

$\therefore \theta = 60°$

(4) Answer [D]



From figure one can see that if $|\vec{A}| > |\vec{B}|$ then $\alpha < \beta$. Thus, the value of vector is large resultant vector angled towards that vector is small. So, angle with vector having large value is small.

(5) Answer [A]

$\vec{A} = 3\hat{i} - 4\hat{j} - 2\hat{k}$

$\vec{B} = 8\hat{i} + 3\hat{j} + 6\hat{k}$

$\therefore \vec{A} \cdot \vec{B} = A_x B_x + A_y B_y + A_z B_z$

$= (3)(8) + (-4)(3) + (-2)(6) = 0$

Here $\vec{A} \cdot \vec{B} = 0$, So $\vec{A} \perp \vec{B}$.

$\therefore \theta = 90°$

(6) Answer [B]

$\vec{A} = 5\hat{i} + 7\hat{j} - 3\hat{k}$

$\vec{B} = -2\hat{i} + m\hat{j} + 6\hat{k}$

For mutual perpendicular vector $\vec{A} \cdot \vec{B} = 0$

$\therefore A_x B_x + A_y B_y + A_z B_z = 0$

$(5)(-2) + (7)(+m) + (-3)(6) = 0$

$\therefore m = +4$

(7) Answer [D]

$\vec{A} = 2\hat{i} - \hat{j} + 3\hat{k}$

$\vec{B} = \hat{i} + 2\hat{j} - \hat{k}$

$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

$$= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -1 & 3 \\ 1 & 2 & -1 \end{vmatrix} = -5\hat{i} + 5\hat{j} + 5\hat{k}$$

$$|\vec{A} \times \vec{B}| = \sqrt{(-5)^2+(5)^2+(5)^2} = 5\sqrt{3}$$

$$\therefore \hat{u}_{\vec{A}\times\vec{B}} = \frac{\vec{A}\times\vec{B}}{|\vec{A}\times\vec{B}|} = \frac{5(-\hat{i}+\hat{j}+\hat{k})}{5\sqrt{3}}$$

$$\therefore \hat{u}_{\vec{A}\times\vec{B}} = \frac{1}{\sqrt{3}}\left(-\hat{i}+\hat{j}+\hat{k}\right)$$

(8) Answer [B]

$$\vec{A} = 4\hat{i} + 3\hat{j} - \hat{k}$$

$$\vec{B} = \hat{i} + 2\hat{j} + \hat{k}$$

$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

$$= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 4 & 3 & -1 \\ 1 & 2 & +1 \end{vmatrix}$$

$$= 5\hat{i} - 5\hat{j} + 5\hat{k}$$

Now area of $\Delta = \frac{1}{2} \; |\vec{A} \times \vec{B}|$

$$= \frac{1}{2}\left[\sqrt{(5)^2+(-5)^2+(5)^2}\right] = \frac{5\sqrt{3}}{2}$$

(9) Answer [D]

$|\vec{A}\times\vec{B}| = AB\sin\theta$, $\vec{A}\cdot\vec{B} = AB\cos\theta$

$|\vec{A}\times\vec{B}|^2 = A^2B^2\sin^2\theta$

$\vec{A}\cdot\vec{B} = A^2B^2\cos^2\theta$

Now $|\vec{A}\times\vec{B}|^2 + |\vec{A}\cdot\vec{B}|^2$

$= A^2B^2\sin^2\theta + A^2B^2\cos^2\theta = A^2B^2$

(10) Answer [D]

$|\vec{A}+\vec{B}| = |\vec{A}| = |\vec{B}|$, $\vec{R} = \vec{A} + \vec{B}$

$|\vec{R}| = \sqrt{A^2+B^2+2AB\cos\theta}$

$|\vec{A}+\vec{B}|^2 = |A|^2 + |B|^2 + 2AB\cos\theta$

$|\vec{A}+\vec{B}|^2 = 2|\vec{A}|^2 + 2|\vec{A}|^2\cos\theta$

$1 = 2(1+\cos\theta)$, $\frac{1}{2} = 1 + \cos\theta$,

$\cos\theta = -\frac{1}{2}$, $\therefore \theta = 120°$

(11) Answer [B]

Perpendicular vector of $\vec{A}$ and $\vec{B}$ $= \vec{A}\times\vec{B}$, So unit vector in direction of

$$\vec{A}\times\vec{B} = \frac{\vec{A}\times\vec{B}}{|\vec{A}\times\vec{B}|} = \frac{\vec{A}\times\vec{B}}{AB\sin\theta}$$

(12) Answer [A]

$\frac{2}{3}\hat{i} + \frac{1}{3}\hat{j} + m\hat{k}$ is unit vector so,

$\sqrt{\left(\frac{2}{3}\right)^2+\left(\frac{1}{3}\right)^2+m^2} = 1$, $\frac{4}{9} + \frac{1}{9} + m^2 = 1$

$\therefore m^2 = 1 - \frac{5}{9} = \frac{4}{9}$

$\therefore m = \pm\frac{2}{3}$, $\frac{2}{3}$ is given options.

(13) **Answer [A]**

$|\vec{A}| = 4, |\vec{B}| = 2.5, \vec{A}\cdot\vec{B} = 8$

$\vec{A}\cdot\vec{B} = |\vec{A}|\,|\vec{B}|\cos\theta,\ 8 = (4)\,(2.5)\cos\theta$

$\therefore \cos\theta = 0.8 \therefore \sin\theta = 0.6$

Now $|\vec{A}\times\vec{B}| = AB\sin\theta = (4)\,(2.5)\,(0.6)$

$|\vec{A}\times\vec{B}| = 6$

(14) **Answer [A]**

$\vec{A} = 2\hat{i} - 3\hat{j} - \hat{k},\ \vec{B} = 4\hat{i} + 3\hat{k}$

$$\vec{A}\times\vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -3 & -1 \\ 4 & 0 & 3 \end{vmatrix}$$

$= \hat{i}\ (-9 + 0) - \hat{j}\,(6+4) + \hat{k}\,(0+12)$

$= -9\hat{i} - 10\hat{j} + 12\hat{k}$

$|\vec{A}\times\vec{B}| = \sqrt{(81)+(100)+(144)} \approx 18$

Area of square $= |\vec{A}\times\vec{B}| = 18$ એકમ

(15) **Answer [C]**

$\vec{A} = 3\hat{i} - 2\hat{j} + \hat{k},\ \vec{B} = \hat{i} + \hat{j}$

Component of $\vec{A}$ on $\vec{B}$ $= A\cos\theta = \dfrac{\vec{A}\cdot\vec{B}}{|\vec{B}|}$

$$= \frac{A_xB_x + A_yB_y + A_zB_z}{\sqrt{B_x^2 + B_y^2 + B_z^2}}$$

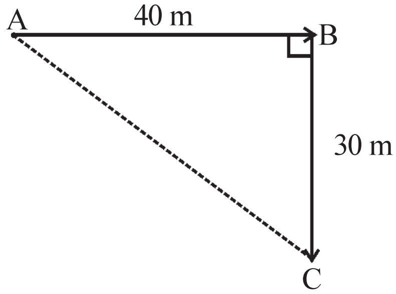
$$= \frac{(3)(1)+(-2)(1)+(1)(0)}{\sqrt{(1)^2+(1)^2}} = \frac{1}{\sqrt{2}}$$

(16) **Answer [A]**

$r = 30$ m, number of rotation = 2

Here initial position and final position are same so, displacement = 0 m. man completed two rotation of circle so, total travelled distance is $= 2 \times 2\pi r = 2 \times 2\pi \times 30 = 120\ \pi$ m. Thus, difference between total distance and displacement is $= 120\ \pi - 0 = 120\ \pi$ m

(17) **Answer [D]**



Here distance travel by person = AB + BC

= 40 m + 30 m = 70 m and distance = AC

$= \sqrt{(AB)^2+(BC)^2} = \sqrt{(40)^2+(30)^2} = 50\,m$

So, $\dfrac{\text{total traveled distance}}{\text{distance}} = \dfrac{70\,m}{50\,m} = 1.4$

(18) **Answer [B]**

Here, path of ant is circular. Radius of circle is 60 cm and displacement of ant (AB) is 60 cm. So, ΔOAB is equilateral triangle. So, $m\angle BOA = \dfrac{\pi}{3}$ rad. Now travelled total distance = length of arc AB = angle (in radian) $\times$ radius $= \dfrac{\pi}{3} \times 60$ $= 20\pi$ cm.

(19) **Answer [D]**

Suppose the speed of vehicle are v_1, v_2, v_3 ...... travells in one direction by distance d_1, d_2, d_3 ...... respectively.

$\therefore$ total distance travel by vehicle

$$D = d_1 + d_2 + d_3 + ...$$

for this total time taken is,

$$t = t_1 + t_2 + t_3 + ...$$

$$= \frac{d_1}{v_1} + \frac{d_2}{v_2} + \frac{d_3}{v_3} + ...$$

$$\left(\because \text{ speed} = \frac{\text{distance}}{\text{time}} \quad \therefore \text{ time} = \frac{\text{distance}}{\text{speed}}\right)$$

$$\text{Now, Average speed} = \frac{D}{t} = \frac{d_1 + d_2 + d_3 ......}{\frac{d_1}{v_1} + \frac{d_2}{v_2} + \frac{d_3}{v_3} + ...}$$

(20) Answer [D]

Suppose, cycle rider has to travel distance d. So, $\frac{d}{3}$ distance travelled by speed 12 kmh^{-1}. Time taken for travel this distance is

$$t_1 = \frac{\text{distance}}{\text{speed}} = \frac{\frac{d}{3}}{12}, \quad t_1 = \frac{d}{36} \text{ hr}$$

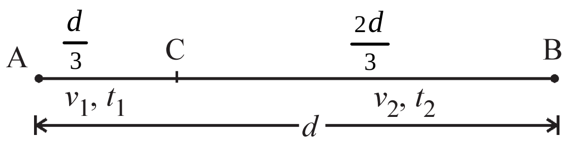
and remaining distance means $d - \frac{d}{3} = \frac{2d}{3}$ is travelled by speed 18 kmh^{-1}. Time taken to travel this distance is

$$t_2 = \frac{\text{distance}}{\text{speed}} = \frac{\frac{2d}{3}}{18}, \quad t_2 = \frac{d}{27} \text{ hr}$$

$$\text{Now Average speed} = \frac{\text{total distance}}{\text{total time period}}$$

$$= \frac{d}{\frac{d}{36} + \frac{d}{27}} = \frac{d}{\frac{3d + 4d}{108}} = 15.43 \text{ kmh}^{-1}$$

(21) Answer [B]



time for travel the initial $\frac{d}{3}$ distance

$$t_1 = \frac{\frac{d}{3}}{v_1} = \frac{d}{3v_1}$$

time for travel the remaining $\frac{2d}{3}$ distance

$$t_2 = \frac{\frac{2d}{3}}{v_2}, \quad t_2 = \frac{2d}{3v_2}$$

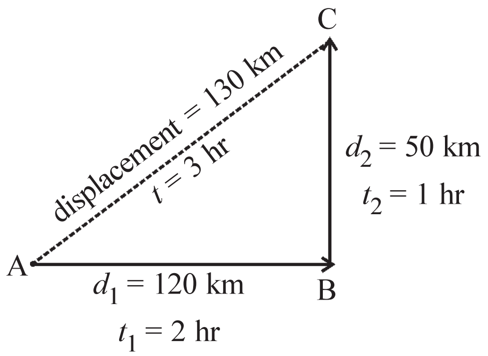
time for travel the d distance $t = t_1 + t_2$

$$= \frac{d}{3v_1} + \frac{2d}{3v_2}, \quad \frac{t}{d} = \frac{1}{3v_1} + \frac{2}{3v_2}$$

$$\text{But } \frac{d}{t} = v \text{ So, } \frac{1}{v} = \frac{1}{3v_1} + \frac{2}{3v_2}$$

$$\therefore v = \frac{3v_1 v_2}{2v_1 + v_2}$$

(22) Answer [B]



$AC^2 = AB^2 + BC^2 = (120)^2 + (50)^2$

$\therefore$ AC = 130 km

Here, travelled total distance $= d = d_1 + d_2$

$= 120 + 50 = 170$ km

for this, total time $t = t_1 + t_2$

$= 2 + 1 = 3$ hr

$$\text{So, Average speed} = \frac{d}{t} = \frac{170}{3}$$

$$= 56.67 \text{ kmh}^{-1}$$

Here displacement travelled by car

= AC = 130 km

$$\text{So, Average speed} = \frac{AC}{t} = \frac{130}{3}$$

$$= 43.33 \text{ kmh}^{-1}$$

(23) Answer [B]

Here length of second arm of watch is 10 cm. So, $r = 10$ cm and becomes semi circle by going digit 3 to 9.

So, travelled total distance = $\pi r = 3.14 \times 10$

$= 31.4$ cm

and travelled displacement = 2r = 20 cm

for this, time = 30 s

So, average speed = $\dfrac{\text{total displacement}}{\text{time}}$

$= \dfrac{31.4}{30} = 1.05\ \text{cms}^{-1}$

and average velocity = $\dfrac{\text{distance}}{\text{time}} = \dfrac{20}{30}$

$= 0.6666\ \text{cms}^{-1}$

(24) Answer [A]

$x(t) = 2t^2 - 3t + 4$, $x(0) = 0 - 0 + 4 = 4$ m

$x(3) = 2\,(3)^2 - 3\,(3) + 4 = 13$ m

$\therefore\ \Delta x = x(3) - x(0) = 13 - 4 = 9$ m

So, average velocity $\overline{v} = \dfrac{\Delta x}{\Delta t} = \dfrac{9}{3} = 3\ \text{ms}^{-1}$

For instantaneous velocity $v = \dfrac{dx}{dt} = \dfrac{d}{dt}\,(2t^2 - 3t + 4)$

$= 4t - 3 = 4(3) - 3$

$\therefore\ v_{t=3} = 9\ \text{ms}^{-1}$

(25) Answer [D]

$v = 2t + 3,\ \therefore\ \dfrac{dx}{dt} = 2t + 3,$

$\therefore\ dx = (2t + 3)dt$

$\therefore\ x = \int dx = \int_0^4 (2t+3)dt = [t^2 + 3t]_0^4$

$= 16 + 12 - 0, \quad x = 28$ m

(26) Answer [C]

Initial velocity of substance = $\vec{v}$

final velocity of substane = $-\vec{v}$

($\therefore$ Direction of motion becomes opposite after complete the half rotation.

So, change in velocity = final velocity - initial velocity = $-\vec{v} - \vec{v} = -2\vec{v}$

(27) Answer [C]

$x = 5t^2 - 6t + 2.2$, $v = \dfrac{dx}{dt} = 10t - 6$

Now for, $v = 0$, $10t - 6 = 0$

$t = \dfrac{6}{10} = \dfrac{3}{5}$ s $\quad x = 5t^2 - 6t + 2.2$

$= 5\left(\dfrac{3}{5}\right)^2 - 6\left(\dfrac{3}{5}\right) + 2.2 = \dfrac{9}{5} - \dfrac{18}{5} + 2.2,$

$= \dfrac{-9}{5} + 2.2, = -1.8 + 2.2,\ x = 0.4$ m

(28) Answer [B]

$x\,(t) = 4t^2 + 2t - 3$ m

$\therefore\ v = \dfrac{dx}{dt} = 8t + 2\ \text{ms}^{-1}$

$a = \dfrac{dv}{dt} = 8\ \text{ms}^{-2}$

(29) Answer [C]

$t = 4x^2 + 3x,\ \dfrac{dt}{dt} = 4\,\dfrac{d}{dt}\,(x^2) + 3\,\dfrac{dx}{dt}$

$\therefore\ 1 = 4\,(2x)\,\dfrac{dx}{dt} + 3\,\dfrac{dx}{dt}$

$1 = 8x\,v + 3v$ ...(1)

$\therefore\ 1 = (8x + 3)\,v$

$\therefore\ v = \dfrac{1}{8x+3}$ ...(2)

Differentiate equation (1) with respect to t.

$$\frac{d(1)}{dt} = 8\frac{d}{dt}(xv) + 3\frac{d}{dt}(v)$$

$$\therefore 0 = 8\left[x\frac{dv}{dt}+v\frac{dx}{dt}\right] + 3a$$

$$\therefore 0 = 8[xa + vv] + 3a$$

$$\therefore 0 = 8xa + 8v^2 + 3a$$

$$\therefore 0 = (8x + 3)a + 8v^2$$

$$\therefore a = -8v^2 \times \frac{1}{8x+3}$$

$\therefore a = -8v^3$ (from equation (2))

(30) Answer [A]

$x = At^2 + Bt + c$, $\therefore v = \frac{dx}{dt} = 2At + B$

acceleration $a = \frac{dv}{dt} = 2A$ = Constant (not depends on time)

[→ If equation of x is second order in t then this motion is constant acceleration motion.]

(31) Answer [A]

$$\vec{v}_0 = 4\hat{i} - 3\hat{j}\ ms^{-1}$$

$$\vec{v} = 9\hat{i} + 2\hat{j}\ ms^{-1},\ t = 5\ s,$$

$$\vec{a} = \frac{\vec{v} - \vec{v}_0}{t} = \frac{9\hat{i}+2\hat{j}-4\hat{i}+3\hat{j}}{5}$$

$$= \frac{5\hat{i}+5\hat{j}}{5},\ \vec{a} = \hat{i} + \hat{j}\ ms^{-2}$$

(32) Answer [B]

$a = 4t$, $\frac{dv}{dt} = 4t$, $\therefore dv = 4t\,dt$

$$\therefore v = \int_0^3 4t\,dt,\ = \left[2t^2\right]_0^3 = 18\ ms^{-1}$$

(33) Answer [D]

$v_0 = 0$, $a = 5\ ms^{-2}$, $v = (?)$, $d = (?)$, $t = 4s$

$v = v_0 + at$, $= 0 + (5)(4)$, $v = 20\ ms^{-1}$

$d = v_0 t + \frac{1}{2}at^2$, $= (0)(4) + \frac{1}{2}(5)(4)^2$

$= 40$ m

(34) Answer [B]

The distance travelled in n^{th} second by constant acceleration motion of object having initial velocity $v_0 = 0$, $a = 8\ ms^{-1}$, $t_1 = 5$ s, $t_2 = 3$ s,

$= v_0 + \frac{a}{2}(2n-1)$, $\therefore d(5) = 0 + \frac{8}{2}[2(5)-1]$

$d(5) = 4(9)$ ...(1)

and $d(3) = 0 + \frac{8}{2}[2(3)-1]$

$d(3) = 4(5)$ ...(2)

From equation (1) and (2), $\frac{d(5)}{d(3)} = \frac{9}{5}$

(35) Answer [C]

$v_0 = 1\ ms^{-1}$, $t_1 = 2$ s, $t_2 = 3$ s, $a = (?)$,

Assume that, object travel distance d in initial 2 second. So, according to equation

$$d = v_0 t + \frac{1}{2}at^2.$$

$$d = (1)(2) + \frac{1}{2}(a)(2)^2$$

$\therefore d = 2 + 2a$ ...(1)

Now, the distance travel by object in n^{th} second $= v_0 + \frac{a}{2}(2n-1)$ According to this equation,

$$d = (1) + \frac{a}{2}[2(3)-1]$$

$\therefore d = 1 + \frac{5a}{2}$ ...(2)

from equation (1) and (2),

$2 + 2a = 1 + \frac{5a}{2}$, $\therefore 1 = \frac{5a}{2} - 2a = \frac{a}{2}$

$\therefore a = 2\ ms^{-2}$

(36) **Answer [D]**

$t_1 = 10$ s, $t_2 = 12$ s, $t_3 = 15$ s

$v_1 = 45$ ms^{-1}, $v_2 = 53$ ms^{-1}, $d_3 = (?)$

$v_1 = v_0 + at_1$, $45 = v_0 + 10a$ ...(1)

$v_2 = v_0 + at_2$, $53 = v_0 + 12a$ ...(2)

from equation (1) and (2),

$a = 4$ ms^{-2} and $v_0 = 5$ ms^{-1}

Now $d_3 = v_0t + \frac{1}{2} at^2$

$= (5)(15) + \frac{1}{2}(4)(15)^2$, $d = 525$ m

(37) **Answer [D]**

$v_{0_1} = 0$, $a_1 = 4$ ms^{-2}, $t_1 = 10$ s, $d_1 = (?)$

$v = (?)$, $d_1 = v_{0_1}t_1 + \frac{1}{2} a_1 t_1^2$

$= 0 + \frac{1}{2} \times 4 \times (10)^2 = 200$ m

$v = v_0 + a_1 t_1 = 0 + (4)(10) = 40$ ms^{-1}

$d_2 = v\, t_2$ (motion with constant velocity)

$= (40)(50)$

$= 2000$ m

Now, $d_3 = \dfrac{v^2 - v_{0_3}^{\ 2}}{2a_3} = \dfrac{(0)^2 - (40)^2}{2(-2)}$

$= \dfrac{-1600}{-4} = 400$ m

So, total distance $d = d_1 + d_2 + d_3$

$= 200 + 2000 + 400 = 2600$ m

(38) **Answer [C]**

$t = 0 \Rightarrow v = v_0$, $t = t \Rightarrow v = v_0 - \frac{2}{3} v_0 = \frac{v_0}{3}$

$t' = (?) \Rightarrow v' = 0$, $a = \dfrac{v - v_0}{t} = \dfrac{\frac{v_0}{3} - v_0}{t}$

$= \dfrac{-2v_0}{3t}$ Now, $a = \dfrac{v' - v_0}{t'}$

$\therefore \dfrac{-2v_0}{3t} = \dfrac{0 - v_0}{t'}$, $\therefore t' = \dfrac{3t}{2}$

(39) **Answer [A]**

If speed is at center point of A and B

$2a\frac{d}{2} = v'^2 - u'^2$

$\therefore \dfrac{v^2 - u^2}{2} = v'^2 - u'^2$

$\therefore v'^2 = \dfrac{v^2}{2} - \dfrac{u^2}{2} + u^2 = \dfrac{v^2 - u^2}{2}$

$\therefore v' = \sqrt{\dfrac{v^2 + u^2}{2}}$

(40) **Answer [B]**

Here, $v_0 = 2$ ms^{-1}, $a = 6t^2 - 2t + 3$

$\therefore \dfrac{dv}{dt} = 6t^2 - 2t + 3$, $\therefore dv = (6t^2 - 2t + 3)dt$

taking integration $\displaystyle\int_{v_0=2}^{v} dv = \int_{t=0}^{t=3} (6t^2 - 2t + 3)dt$

$\therefore [v - 2] = [2t^3 - t^2 + 3t]_0^3$

$\therefore v - 2 = 54 - 9 + 9$, $\therefore v = 56$ ms^{-1}

(41) **Answer [B]**

$y_1 = -h_1$, $y_2 = -h_2$, $t_1 = t_1$, $\dfrac{t_1}{t_2} = ...$

for free falling substance

$y_1 = -\frac{1}{2} gt_1^2$, $\therefore -h_1 = -\frac{1}{2} gt_1^2$

and $-h_2 = -\frac{1}{2} gt_1^2$, $\therefore \dfrac{h_1}{h_2} = \dfrac{t_1^2}{t_2^2}$

$\therefore \dfrac{t_1}{t_2} = \sqrt{\dfrac{h_1}{h_2}}$

(42) **Answer [C]**

$h = 80$ m, $g = 10$ ms^{-2}

distance travel at n^{th} second = (?)

for free falling object, $h = \frac{1}{2} gt^2$

distance travel at n^{th} second $= v_0 + \frac{1}{2} a(2n-1)$

$\therefore 80 = \frac{1}{2} \times 10\, t^2$, $\therefore t = 4$ s

$d = 0 + \frac{1}{2} \times 10\,(7)$, distance = 35 m

(43) **Answer [D]**

Suppose, object is free falling from height h and time taken to reach land is n. So, $h = \frac{1}{2} gn^2$ (for free falling object). Now, distance travelled in last second is 25 m So, distance travelled in (n–1) second is (h–25) m.

$\therefore (h-25) = \frac{1}{2} g (n-1)^2$

$\therefore \frac{1}{2} gn^2 - 25 = \frac{1}{2} g (n^2-2n+1)$

$\therefore \frac{1}{2} g (2n-1) = 25$

$\therefore n = \dfrac{\frac{50}{10}+1}{2} = 3$

$\therefore h = \frac{1}{2} \times 10 \times (3)^2 = 5 \times 9 = 45$ m

(44) **Answer [B]**

For free falling object

$h = \frac{1}{2} gt^2 \Rightarrow h \propto t^2, \therefore h_1 \propto t_1^2$ and $\propto t_1^2$

$\therefore \frac{h_2}{h_1} = \left(\frac{t_2}{t_1}\right)^2 \Rightarrow \frac{t_2}{t_1} = \sqrt{\frac{h_2}{h_1}}$

(45) **Answer [D]**

Here, $d = -h$, $v_0 = v$, $a = -g$, $t = (?)$

$d = v_0 t + \frac{1}{2} at^2$, $\therefore -h = vt - \frac{1}{2} g t^2$

$\therefore g t^2 - 2vt - 2h = 0$

Here, $a = g$, $b = -2v$, $c = -2h$

$\Delta = b^2 - 4ac = (-2v)^2 - 4 (g) (-2h)$

$= 4v^2 + 8gh$, $t = \dfrac{-b \pm \sqrt{\Delta}}{2a}$

$= \dfrac{+2v \pm 2\sqrt{v^2+2gh}}{2g} = \dfrac{v \pm \sqrt{v^2+2gh}}{g}$

possible answer $t = \dfrac{v+\sqrt{v^2+2gh}}{g}$

(negative is not possible)

$= \dfrac{v+v\sqrt{1+\frac{2gh}{v^2}}}{g}$, $t = \dfrac{v}{g}\left[1+\sqrt{1+\frac{2gh}{v^2}}\right]$

(46) **Answer [B]**

$a = 4$ ms^{-2}, $t = 5$ s, $v_0 = 0$

speed of baloon after 5 second $v = v_0 + at$

$= 0 + (4)(5) = 20$ ms^{-1}

height acheived by balloon within this 5 s

$h = v_0 t + \frac{1}{2} at^2 = 0 + \frac{1}{2} (4) (5)^2 = 50$ m

maximum height acheived by stone which free fall from balloon. $H = h + \dfrac{v^2}{2g} = 50 + \dfrac{(20)^2}{2(10)}$

$= 50 + 20 = 70$ m

(47) **Answer [A]**

According to equations of constant acceleration motion $2ad = v^2 - v_0^2$

$2gH = (2v_0)^2 - (-v_0)^2$

$= 4v_0^2 - v_0^2$, $H = \dfrac{3V_0^2}{2g}$

(48) **Answer [C]**

Here, relative acceleration for both substance = 0

and relative velocity = 30 ms^{-1}

distance $d = 150$ m, So, $t = \dfrac{\text{distance}}{\text{relative velocity}}$

$= \dfrac{150}{30}$, $t = 5$ s

(49) **Answer [D]**

According to equation of constant accelaration motion

$v^2 - v_0^2 = 2ad$, $v_0^2 = 2g\, h_1$ and $v^2 = 2g\, h_2$

Now, acceleration $a = \dfrac{v-v_0}{t}$

$= \dfrac{\sqrt{2gh_2} - \left(-\sqrt{2gh_1}\right)}{t}$

($\because$ Motion of ball is mutually in opposite direction)

$$= \frac{\sqrt{2 \times 10 \times 5} + \sqrt{2 \times 10 \times 10}}{0.05}$$

$$= \frac{10 + 14.14}{0.05} = \frac{24.14}{0.05} = 482.8 \text{ ms}^{-2}$$

(50) Answer [A]

Here, taking traffic signal as a reference point (O), the velocity of truck (T) relative to traffic signal is v_{To} = 15 ms^{-1} = constant. The velocity of car (C) relative to traffic signal is v_{co} = (?)

Here for car, $v_o = 0$, $a = 4$ ms^{-2}, $t = 6$ s

$\therefore v_{co} = v_o + at = 0 + (4)(6) = 24$ ms^{-1}

Now, velocity of car relative to truck

$v_{CT} = v_C - v_T$

$= v_{CO} - v_{TO} = 24 - 15 = 9$ ms^{-1}

(51) Answer [B]

velocity of car A $= v_A = \frac{54 \times 1000}{3600} = 15$ ms^{-1}

velocity of car B $= v_B = \frac{72 \times 1000}{3600} = 20$ ms^{-1}

velocity of car C $= v_C = \frac{72 \times 1000}{3600} = 20$ ms^{-1}

Now, velocity of car C relative of car A $v_{CA} = v_C - v_A = 20 - (-15) = 35$ ms^{-1}

velocity of car B relative to car A $v_{BA} = v_B - v_A = 20 - 15 = 5$ ms^{-1}

1.4 km = 1400 m distance travel by car C

in time $t = \frac{d}{v_{CA}} = \frac{1400}{35}$, $t = 40$ s

Now, If acceleration of car B is a then

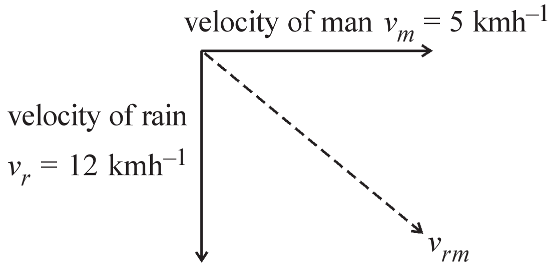
according to $d = v_o t + \frac{1}{2} at^2$, $d = v_{BA} t + \frac{1}{2} at^2$

$\therefore 1400 = (5)(40) + \frac{1}{2} a (40)^2$

$\therefore 1400 - 200 = 800 a \Rightarrow a = \frac{1200}{800}$

$= 1.5$ ms^{-2}

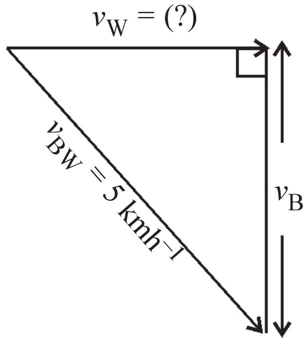
(52) Answer [B]



$v_{rm}^2 = v_r^2 + v_m^2 = (12)^2 + (5)^2$

$v_{rm} = 13$ kmh^{-1}

(53) Answer [C]



$d = 1.0$ km

$t = 20$ minute $= \frac{1}{3}$ hr

v_B = (?)

Here $v_B = \frac{d}{t} = \frac{1.0}{\frac{1}{3}}$ $v_B = 3$ kmh^{-1}

Now, from figure $v_{BW}^2 = v_B^2 + v_W^2$

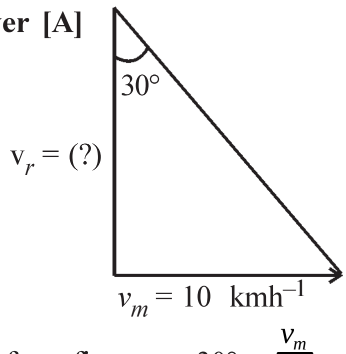
$v_W^2 = v_{BW}^2 - v_B^2$

$= (5)^2 - (3)^2$

$v_W^2 = 16$

$\therefore v_W = 4$ kmh^{-1}

(54) Answer [A]



Here, from figure, $\tan 30° = \frac{v_m}{v_r}$

$\therefore v_r = \frac{v_m}{\tan 30°} = \frac{10}{\frac{1}{\sqrt{3}}}$

$\therefore v_r = 10\sqrt{3}$ kmh^{-1}

(55) Answer [A]

Here $x_{AO} = 50$ m, $x_{BO} = 130$ m,
$v_A = 15$ ms^{-1}, $v_B = 7$ ms^{-1}
Here, both car are overtaking so,
$x_B - x_A = 0$.
$\therefore x_B - x_A = (x_{BO} - x_{AO}) + (v_B - v_A)t$

$0 = (130 - 50) + (7 - 15)t \therefore t = 10$ s
Now both car meet together at distance x from starting point. So,
$x = x_{AO} + v_At = 50 + (15)(10) = 200$ m

(56) Answer [A]

Assume that speed of particle A and B are v_A and v_B.
If particle travels in opposite then relative speed

$$v_A + v_B = \frac{16}{2} = 8 \quad ...(1)$$

and if travels in same diretion then relative speed

$$v_A - v_B = \frac{16}{8} = 2 \quad ...(2)$$

from equation (1) and (2),

$v_A = 5$ ms^{-1}
$v_B = 3$ ms^{-1}

(57) Answer [C]

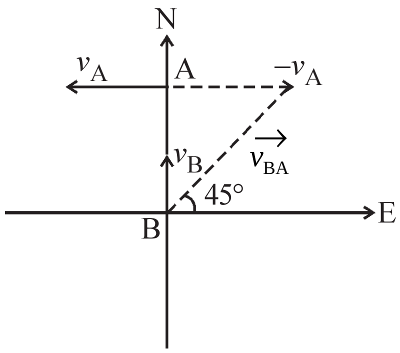
$$\vec{r} = \alpha t^2 \hat{i} + (\beta t - 3)\hat{j} \Rightarrow$$

$$\vec{v} = \frac{d\vec{r}}{dt} = 2\alpha t\hat{i} + \beta\hat{j}$$

$$\therefore |\vec{v}| = \sqrt{4\alpha^2 t^2 + \beta^2}$$

$$\vec{a} = \frac{d\vec{v}}{dt} = 2\alpha\hat{i}, \therefore |\vec{a}| = 2\alpha$$

(58) Answer [A]



Velocity of B relative to A $\vec{v}_{BA} = \vec{v}_B - \vec{v}_A$

$$\therefore |\vec{v}_{BA}| = \sqrt{v_B^2 + v_A^2}$$

$$\left(\because \vec{v}_B \perp \vec{v}_A\right)$$

$$= \sqrt{(10)^2 + (10)^2}, \; v_{BA} = 10\sqrt{2} \text{ kmh}^{-1}$$

minimum distance between A and B

$$= AC = AB \sin 45° = 20 \times \frac{1}{\sqrt{2}} = 10\sqrt{2} \text{ km}$$

distance travelled by plane B

$$= BC = AB \cos 45° = 20 \times \frac{1}{\sqrt{2}} = 10\sqrt{2} \text{ km}$$

time taken for travel this distance

$$t = \frac{BC}{v_{BA}} = \frac{10\sqrt{2}}{10\sqrt{2}} = 1 \text{ hr} = 60 \text{ min}$$

(59) Answer [C]

Here, $\vec{v}_o = 3\hat{j}$ ms^{-1}, $\vec{a} = 2\hat{i} + \hat{j}$ ms^{-2}

$v_{ox} = 0$ ms^{-1}, $v_{oy} = 3$ ms^{-1}

$a_x = 2$ ms^{-2}, $a_y = 1$ ms^{-2}

$x = 25$ m, $y = (?)$, for motion in x-direction

$$x = v_{ox}t + \frac{1}{2}a_x t^2, \; 25 = (0)t + \frac{1}{2}(2)t^2$$

$\therefore t^2 = 25$, $\boxed{\therefore t = 5 \text{ s}}$

for motion in y-direction, $y = v_{oy}t + \frac{1}{2}a_y t^2$

$$= (3)(5) + \frac{1}{2}(1)(5)^2 = 15 + 12.5$$

$\boxed{y = 27.5 \text{ m}}$

(60) Answer [C]

Here same range for two projection angle

So, $\theta_1 = \theta$, $\theta_2 = 90 - \theta$

Now time of flight $t_{F_1} = t_1 = \dfrac{2v_0 \sin\theta}{g}$

$$t_{F_2} = t_2 = \frac{2v_0 \sin(90-\theta)}{g} = \frac{2v_0 \cos\theta}{g}$$

Now $t_1 t_2 = \dfrac{2v_0 \sin\theta}{g} \times \dfrac{2v_0 \cos\theta}{g}$

$$\therefore t_1 t_2 = \frac{2v_0^2\, 2\sin\theta\cos\theta}{g \cdot g} = \frac{2v_0^2 \sin 2\theta}{g\ g}$$

$$t_1 t_2 = \frac{2R}{g}$$

(61) Answer [B]

Object have only horizontal velocity at maximum height. velocity in vertical direction is zero. Thus, the velocity of projectile object at maximum height is $v_0 \cos\theta_0$.

and kinetic energy at maximum height

$$K' = \frac{1}{2}\ m\ v_0^2 \cos^2 \theta_0 = K\cos^2 \theta_0$$

$$= K \cos^2 (30°) = \frac{3K}{4}$$

(62) Answer [D]

$$x\ (t) = 5t,\ v_x = \frac{dx}{dt} = 5\ ms^{-1}$$

$$y\ (t) = 12t - 5t^2,\ v_y = \frac{dy}{dt} = 12 - 10t\ ms^{-1}$$

at time t, $\vec{v} = v_x \hat{i} + v_y \hat{j}$

$= 5\hat{i} + (12 - 10t)\hat{j}\ ms^{-1}$

Initial velocity $\vec{v_0} = 5\hat{i} + 12\hat{j}\ ms^{-1}$

$$\therefore |\vec{v_0}| = \sqrt{(5)^2 + (12)^2} = \sqrt{25 + 144} = 13\ ms^{-1}$$

(63) Answer [C]

The projection angle of rifle with horizontal is θ. Distance travelled by fired bullet is its range. So, these bullets fired in circle of radius R. for maximum area Range is $R_{max} = \dfrac{v_0^2}{g}$

So, area of circle $= \pi R^2 = \pi\left(\dfrac{v_0^2}{g}\right)^2 = \dfrac{\pi v_0^4}{g^2}$

(64) Answer [C]

Here, $H = \dfrac{R}{4}$, Now $\tan\theta = \dfrac{4H}{R} = \dfrac{4R}{R4}$

$\therefore \tan\theta = 1$, $\therefore \theta = 45°$

(65) Answer [C]

In part B, Slope of graph $v \rightarrow t$ is zero. Thus, force on particle is zero.

(66) Answer [D]

Initially, $v_0 = \tan 30° = \dfrac{1}{\sqrt{3}}$

final $v = \tan 60° = \sqrt{3}$, $t = 2$ s

$$a = \frac{v - v_0}{t} = \frac{\sqrt{3} - \frac{1}{\sqrt{3}}}{2} = \frac{3-1}{2\sqrt{3}}$$

$a = \dfrac{1}{\sqrt{3}}$ unit

(67) Answer [B]

Here height of lift = distance travelled by lift = area enclosed by $v \rightarrow t$ graph on t axis = 32 m.

(73) Answer [A]

$$\text{Average Velocity} = \frac{\text{distance}}{\text{time}}$$

$$= \frac{\text{area of } v \rightarrow t \text{ graph}}{\text{time}}$$

$$= \frac{\frac{1}{2} v_m t_1}{t_1} = \frac{1}{2}\ v_m$$

So, assertion and reason both are true and complimetary to each other.

●

3 Laws of Motions

(2) **Answer [A]**

Stationary state and state of motion with constant velocity is equal. So, pen exactly drop on the head of sitting passenger.

(3) **Answer [B]**

When doing jerk on string, reactive force acting on QR part while jerk slowly tension on PQ is higher.

(6) **Answer [D]**

In absense of external force, a body in motion with constant speed. So graph of $v \to t$ is parallel to t-axis.

(8) **Answer [A]**

Resultant force on block $F = \sqrt{(12)^2 + (5)^2}$

$F = 13$ N

$\therefore$ acceleration $a = \frac{F}{m} = \frac{13}{1.5}$

$\therefore$ from $v = v_o + at$, $= 30 + \left(\frac{130}{15}\right) 3$

$= 56 \text{ ms}^{-1}$

(9) **Answer [D]**

$F = kt^2 = 15t^2$, $\therefore$ $ma = 15t^2$

$\therefore$ $a = 3t^2$, Now, $v = \int a dt = \int_0^2 3t^2 dt$

$v = 8 \text{ ms}^{-1}$

and from $d = \int_0^t v dt = \int_0^2 t^3 dt$, $d = 4$ m

(10) **Answer [B]**

at time $t = 3$ second, force $F_1 = \frac{dp}{dt} =$

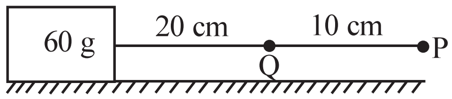
slope of graph $= \frac{20}{2} = 10$ N

force in first 3 second,

$$F_2 = \frac{\Delta P}{\Delta t} = \frac{P_2 - P_1}{t_2 - t_1} = \frac{20 - 0}{3 - 0} = \frac{20}{3} \text{N}$$

$$\frac{F_1}{F_2} = \frac{10 \times 3}{20} = 3 : 2$$

(11) **Answer [D]**



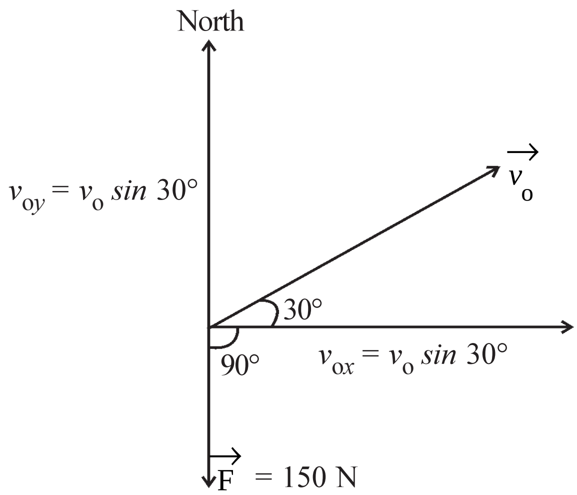
acceleration of system $a = \frac{F}{m_1 + m_2}$

$= \frac{1800}{60+30} = 20 \text{ cms}^{-2}$. tension force at Q

$T = (m_1 + \text{mass of string having length 20 cm}) \times a$

$= (60 + 20) \times 20 = 1600$ *dyne* $= 0.016$ N

(12) **Answer [C]**



acceleration $\vec{a} = \frac{\vec{F}}{m} = \frac{-150\hat{j}}{30} = -5\hat{j} \text{ ms}^{-2}$

$\vec{v} = \vec{v}_o + \vec{a} t$

$v_x = v_o \cos 30° + a_x t$

$= 20 \left(\frac{\sqrt{3}}{2}\right) + 0 = 17.3 \text{ ms}^{-1}$

$v_y = v_o \sin 30° + a_y t$

$= 20 \left(\frac{1}{2}\right) + (-5)5 = 10 - 25$

$= -15 \text{ ms}^{-1}$

$|\vec{v}| = \sqrt{v_x^2 + v_y^2} = 22.9\ ms^{-1}$

Angle of resultant velcity with east direction is α,

$\tan\alpha = \frac{v_y}{v_x} = \frac{-15}{17.3}$, $\alpha = \tan^{-1}(0.8670)$

$\alpha = 40°\ 56' \approx 41°$

(13) Answer [D]

(a) Observation by spring balance

$W_1 = mg$

(b) Observation by spring balance

$W_2 = mg \sin 45°$

$\therefore\ W_2 = \frac{mg}{\sqrt{2}}$

$\therefore\ \Delta W = W_1 - W_2 = mg - \frac{mg}{\sqrt{2}}$

$= mg\left(1 - \frac{1}{\sqrt{2}}\right)$

$\therefore\ \Delta W = 14.65\ N$

(14) Answer [C]

$P = \alpha + \beta t^2$, $\therefore\ F = \frac{dP}{dt} = 2\beta t$

taking $t = 3s$ and $\beta = 2$,

$F = 2 \times 2 \times 3 = 12\ N$ ...(1)

at $t = 0$ time $p_o = \alpha$

at $t = 3$ s time $p' = \alpha + 9\beta$

$\therefore$ Average force $< F > = \frac{p' - p_o}{t' - t}$

$= \frac{\alpha + 9\beta - \alpha}{3 - 0} = 3\beta$

$\therefore\ < F > = 3 \times 2 = 6\ N$ ...(2)

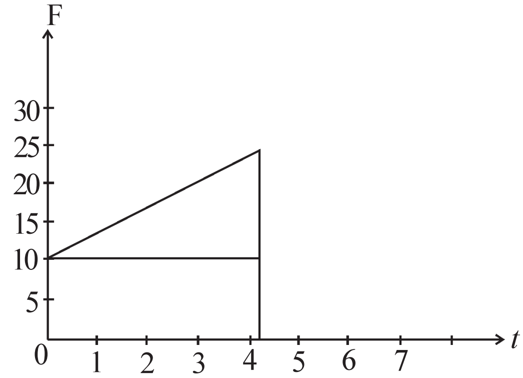
(15) Answer [D]

$F = \frac{\Delta p}{\Delta t} = \frac{m \cdot \Delta v}{\Delta t} = \frac{m(v_2 - v_1)}{\Delta t}$

$= \frac{m\left[\sqrt{2gh} - (-\sqrt{2gh})\right]}{\Delta t} = \frac{m2\sqrt{2gh}}{\Delta t}$

$= \frac{150 \times 10^{-3} \times 2 \times (2 \times 10 \times 20)^{\frac{1}{2}}}{0.1} = 60\ N$

(16) Answer [D]



$\Delta P = F \cdot \Delta t = (v - v_o)m$

$m = 1\ kg$

$\therefore\ v = v_o + F\Delta t$

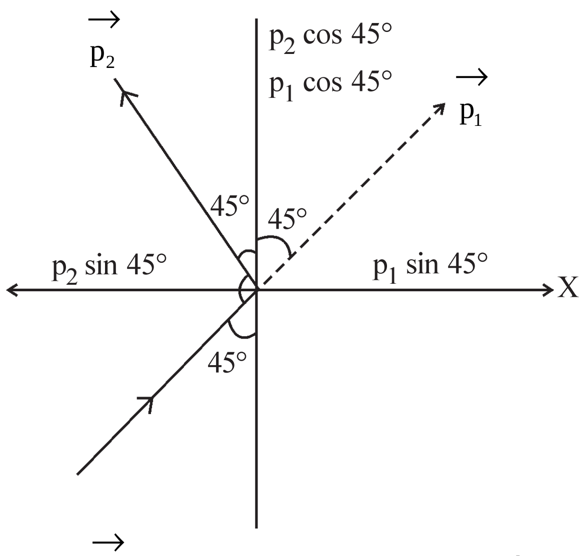
$= v_o + [\text{Area enclosed by graph}]$

$= 30 + \{(4 \times 10) + \frac{1}{2}(4)(15)\}$

$= 100\ m$

(17) Answer [A]

$v_2 = \frac{v_1}{2} = \frac{20}{2} = 10\ ms^{-1}$



$\vec{p}_1 = m(v_1 \sin 45° \hat{i} + v_1 \cos 45° \hat{j})$

$= m\left(\frac{v_1}{\sqrt{2}}\hat{i} + \frac{v_1}{\sqrt{2}}\hat{j}\right)$

$\vec{p}_1 = \frac{m}{\sqrt{2}}(v_1\hat{i} + v_1\hat{j})$ Ns

$\vec{P_2} = m(-v_2 \sin 45° \hat{i} + v_2 \cos 45° \hat{j})$

$= m(-\frac{v_2}{\sqrt{2}}\hat{i} + \frac{v_2}{\sqrt{2}}\hat{j})$

$\vec{P_2} = \frac{m}{\sqrt{2}}(-v_2\hat{i} + v_2\hat{j})$ Ns

$\therefore$ From $\Delta\vec{p} = \vec{p_2} - \vec{p_1}$ $|\Delta p| = \sqrt{5}$ Ns

(18) Answer [C]

$F = \frac{\Delta p}{\Delta t} = \frac{m\Delta v}{\Delta t} = \frac{2(16-4)}{4} = \frac{2\times 12}{4} = 6$ N

(19) Answer [B]

$v^2 - v_o^2 = 2ad$

$\therefore v = \sqrt{2ad} = \sqrt{2\times 10\times 5} = 10$ ms^{-1}

$F = \frac{m\cdot\Delta v}{\Delta t} = \frac{60(10-0)}{0.4} = \frac{600}{0.4} = 1500$ N

(20) Answer [C]

Resultant force on trolly bag $F_R = F\cos 60°$

$= (50)\left(\frac{1}{2}\right)$, $F_R = 25$ N

$\therefore$ acceleration $a = \frac{F_R}{m} = \frac{25}{40} = 0.625$ ms^{-2}

(21) Answer [C]

Force on object up to it gets constant velocity F = 0

$\therefore 1200 - 4\times 10^5 t = 0$, $\therefore t = 0.003$ s

$\therefore$ Impact of force $= \int_0^{0.003} F\,dt$

$= 1.8$ Ns

(22) Answer [D]

Rate of flow of water = 30 cm^3 s^{-1}

$= 30\times 10^{-6}$ m^{3}s^{-1}

$\therefore$ Reaction force $= v\frac{dm}{dt} = \frac{Av}{t}$

(23) Answer [C]

From, $F = v\frac{dm}{dt}$, F = 20 N

(24) Answer [C]

Resultant force on Rocket $F_R = F - M_R g$

$\therefore M_R a_R = v\frac{dm}{dt} - M_R g$

$\therefore a_R = \frac{v}{M_R}\frac{dm}{dt} - g$

$\therefore a_R = 15$ ms^{-2}

(25) Answer [A]

Force on conveyor belt = Force of car

$v\frac{dm}{dt} = Ma$, $\therefore \frac{dm}{dt} = \frac{Ma}{v} = 5$ kgs^{-1}

(27) Answer [C]

Mo = 2000 + 18000 = 20000 kg

Ma = 2000 kg

$v = v_G - v_R = 7\times 10^3 - 6\times 10^3 = 10^3$ ms^{-1}

Maximum speed of Rocket $v_b = v\ln\left(\frac{Mo}{Ma}\right) = 2.3$ kms^{-1}

(28) Answer [D]

$F_R = F - Mg = v\frac{dm}{dt} - Mg = 1\times 10^4$ N

(29) Answer [B]

From $F = v\frac{dm}{dt}$, $v = 100$ ms^{-1}

(33) Answer [C]

Observation of spring balance = (main observation) + (reaction force by bird)

= 25 + (0.4) (2.5) = 25 + 1 = 26 N

(35) Answer [B]

Here, force on one end of spring provide support. So, tension in spring is force generated on second end.

$\therefore$ tension force = 8 N

(38) Answer [B]

Force on disc = The rate of change in momentum of bullet.

$\therefore$ From $Mg = nmv$, $v = 50\ \text{ms}^{-1}$

(43) Answer [C]

Slope of distance (d) $\rightarrow$ time (t) graph = Velocity

$$\therefore \text{ momentum } p = m \times \text{Slope} = 12 \times \left(\frac{4}{3}\right) = 16\ \text{Ns}$$

(44) Answer [D]

distance travelled by person w. r. t. bank

$$= \frac{m_R v_{PR}}{m_P + m_R} t = \frac{60 \times 7}{140} \times 2 = 6\ \text{m}$$

$\therefore$ total distance due to moving away from bank $= 20 + 6 = 26$ m

(45) Answer [B]

$$\vec{v}_3 = -\left[\frac{m_1\vec{v}_1 + m_2\vec{v}_2}{m_3}\right]$$

$$= -\left[\frac{m9\hat{i} + 2m6\hat{j}}{3m}\right] \text{ substituting values } v = 5\ \text{ms}^{-1}$$

(47) Answer [B]

$$R = \left[9F^2 + 4F^2 + 12F^2\cos\theta\right]^{\frac{1}{2}} \qquad ...(1)$$

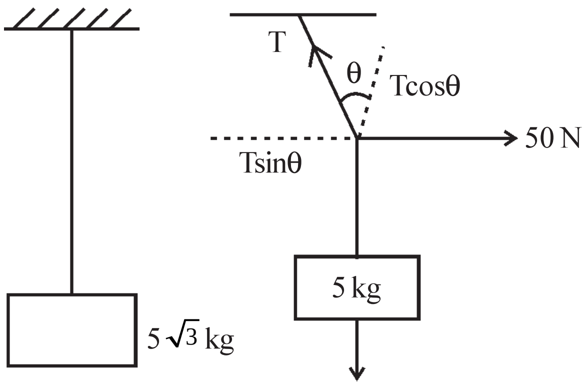
and

$$2R = \left[36F^2 + 4F^2 + 24F^2\cos\theta\right]^{\frac{1}{2}} \qquad ...(2)$$

from (1) and (2), $\theta = 120°$

(48) Answer [A]

From figure, $T\sin\theta = 50$ ...(1)



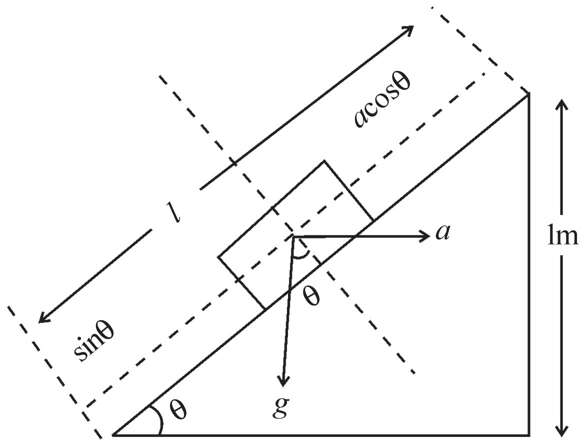
$T\cos\theta = Mg = 5\sqrt{3} \times 10$

$\therefore T\cos\theta = 50\sqrt{3}$ ...(2)

From (1) and (2), $\tan\theta = \dfrac{50}{50\sqrt{3}} \Rightarrow \theta = 30°$

(49) Answer [C]

from figure, acceleration of substance



$$a = g\tan\theta = g\left(\frac{1}{d}\right) \qquad \left[\because \tan\theta = \frac{1}{d}\right]$$

But from figure, $d = \sqrt{l^2 - 1^2} = \sqrt{l^2 - 1}$

$$\therefore a = \frac{g}{\sqrt{l^2-1}} = \sqrt{\frac{g^2}{l^2-1}} = \sqrt{\frac{100}{16-1}} = \sqrt{\frac{20}{3}}\ \text{ms}^{-2}$$

(50) Answer [D]

friction force on block $F = \mu m g$,

$\therefore a = \mu g$ ...(1)

$v^2 - v_o^2 = 2ad$

$\therefore 0 - v_o^2 = -2\mu g d$

$$\therefore d = \frac{v_o^2}{2\mu g} = \frac{m^2 v_o^2}{2\mu g m^2} = \frac{p^2}{2\mu g m^2}$$

$$\therefore d \propto \frac{1}{m^2}, \therefore \frac{d_2}{d_1} = \left(\frac{m_1}{m_2}\right)^2$$

(52) Answer [C]

For steady box, $\mu(m_A + m)g = m_B g$

$$\therefore m + m_A = \frac{m_B}{\mu}, \therefore m + 5 = \frac{10}{0.2}$$

$\therefore$ m + 5 = 50, $\therefore$ m = 45 kg

time taken for 0.2 kg sand fill in the box = 1 s

time taken for 45 kg = (?) Sand fill in the box

(53) Answer [C]

friction force $f' = f_{AB} + f_{BC}$

$$= \mu_{AB}\, m_A g + \mu_{BC}\, (m_A + m_B)g$$

and $f' = F \cos 60° = \frac{F}{2}$, $\therefore$ F = $2f'$

(54) Answer [C]

$$(f_s)_{max} = \mu mg = 0.25 \times 8 \times 10$$

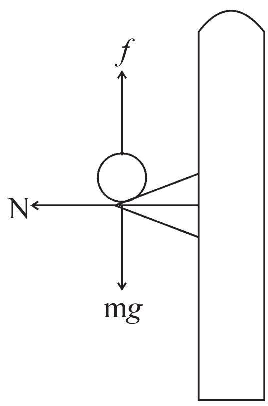
$$(f_s)_{max} = 20\ N$$

$F_1 = 5$ N force is applied $f_1 = 5$ N

$F_2 = 25$ N force is applied $f_2 = 20$ N

$\therefore f_1 \times f_2 = 20 \times 5 = 100\ N^2$

(55) Answer [D]



Friction force $f = \mu N = mg$

$\therefore N = \frac{mg}{\mu}$, N = 1500 N

(56) Answer [C]

$v^2 - v_o^2 = 2ad$, $(64)^2 - 0 = 2a\,(2000)$

$\therefore a = \frac{(64)^2}{4000}$ and $F - F_k = ma$

$\therefore F - \mu_k mg = ma$, $\therefore \mu_k = \frac{F}{mg} - \frac{a}{g}$

From above relation, $\mu_k = 0.1176$

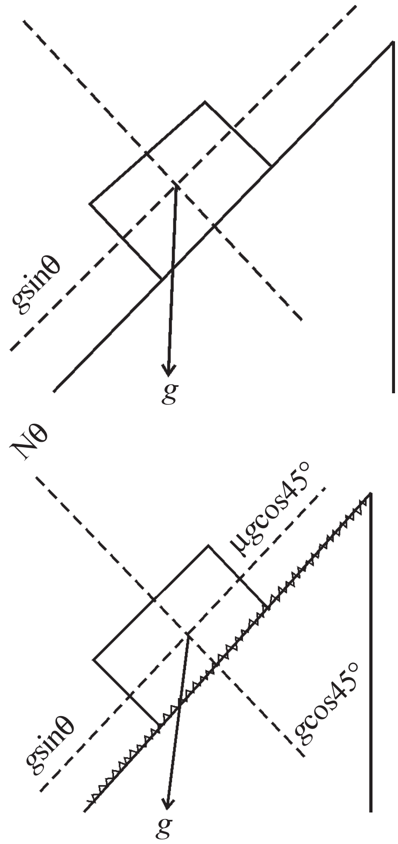
(57) Answer [A]

From $d = \frac{v^2}{2a}$, $d = 50$ m

(58) Answer [D]

From $a = \mu g$ and $v^2 = v_o^2 + 2ad$, $d = 0.4$ m

(59) Answer [A]



From $d = v_o t + \frac{1}{2} at^2$,

$$t^2 = \frac{2d}{a} \Rightarrow t^2 \propto \frac{1}{a} \quad ...(1)$$

For smooth surface, $a_1 = g\sin 45° = \frac{g}{\sqrt{2}}$ ...(2)

For rough surface, $a_2 = g \sin 45° - \mu\, g \cos 45°$

$$a_2 = \frac{+g}{\sqrt{2}}(1 - \mu) = a_1 (1 - \mu) \quad ...(3)$$

Now, $t_2 = nt_1$, $\therefore t_2^2 = n^2 t_1^2$

$\therefore \frac{1}{a_2} = \frac{n^2}{a_1}$ [$\because$ from eq^n. (1)]

$$\therefore \frac{1}{a_1(1-\mu)} = \frac{n^2}{a_1}$$

$$\therefore 1-\mu = \frac{1}{n^2}$$

$$\therefore \mu = 1-\frac{1}{n^2}$$

(60) Answer [B]

Force required for upward motion of block on slope is, $F_1 = \mu mg\cos\theta + mg\sin\theta$ ...(1)

Force required for downward motion of block on slope is, $F_2 = mg\sin\theta - \mu mg\cos\theta$ ...(2)

from $2F_2 = F_1$, $\theta = \tan^{-1}(0.9)$

(61) Answer [C]

maximum friction force on block

$(f_s)_{max} = \mu mg\cos\theta = 353.328$ N.

Here applied force $F > (f_s)_{max}$ so object is in motion and thus, friction force is less than 353.328 N but not zero.

(62) Answer [B]

acceleration of body on slope,

$a = g\sin 30° = \frac{10}{2} = 5\ ms^{-2}$

If velocity v at bottom of slope then, $v^2 - v_0^2 = 2ad$

$\therefore v^2 - 0 = 2 \times 5 \times 3 = 30\ m^2$

Force on body on slope $F = \mu mg$

$\therefore ma' = \mu mg \therefore a' = \mu g = 0.25 \times 10 = 2.5\ ms^{-2}$

If body travel d' distance before stationary,

$v'^2 - v_0'^2 = 2a'd'$ from, $d' = 6$ m

(63) Answer [D]

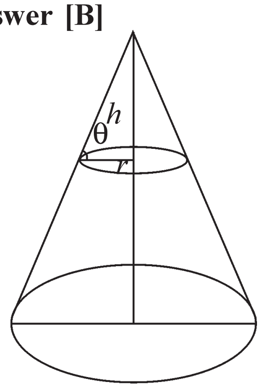
centripetal force $F_c = \frac{mv^2}{r}$, $F_c = 80$ N

(64) Answer [C]

$$\frac{v_1}{v_2} = \frac{5}{10} = \frac{1}{2}$$

$$\frac{F_1}{F_2} = \frac{m_1 v_1^2}{m_2 v_2^2} = \frac{m_1\, 1}{m_2\, 4} = \frac{m_1}{4m_2}$$

(67) Answer [B]



from figure $\tan\theta = \frac{v^2}{rg} = \frac{h}{r}$

$\therefore h = \frac{v^2}{g}$, $\therefore$ height from ground $= 10 - 0.4 = 9.6$ m

(69) Answer [B]

From $v = \sqrt{2gh}$ and $F_c = \frac{mv^2}{r}$, $F_c = 0.4$ N

(70) Answer [C]

$$F_c = \frac{mv^2}{r} = \frac{m^2v^2}{mr} = \frac{p^2}{mr}$$

(71) Answer [C]

$$F = \frac{mv^2}{r} = \frac{mr^2\omega^2}{r} = m\, r\omega^2$$

$\therefore F_A : F_B : F_C = m_A r_A : m_B r_B : m_C r_C$

$\therefore F_A : F_B : F_C = 1 : 4 : 9$

(72) Answer [B]

for substance A, $d = v_0 t + \frac{1}{2} gt^2$

$$\therefore t = \sqrt{\frac{2d}{g}} = \sqrt{\frac{2 \times 20}{10}} = 2\ s$$

For substance B, $v = \frac{\text{distance}}{\text{time}} = \frac{10 \times 2\pi \times 7}{2}$

and from $a_c = \frac{v^2}{r}$, $a_c = 7 \times 10^3\ ms^{-2}$

(73) Answer [B]

$v_{max} = \sqrt{r\mu_s g} = [20 \times 0.18 \times 100]^{\frac{1}{2}} = 6\ ms^{-1}$

$\therefore$ Reducing Speed $= 10 - 6 = 4\ ms^{-1}$

(74) **Answer [C]**

From $tan\theta = \dfrac{v^2}{rg}$, $\theta = \tan^{-1}\left(\dfrac{2}{5}\right)$

(75) **Answer [B]**

$\omega = \dfrac{5\times 2\pi}{60} = \dfrac{\pi}{6}\ \dfrac{rad}{s}$

$\therefore\ v = r\omega = 4 \times \dfrac{\pi}{6} = \dfrac{2\pi}{3}\ \text{ms}^{-1}$

Tension force $\therefore\ T = \dfrac{mv^2}{r} = \dfrac{0.1\times 4\pi^2}{9\times 4} = \dfrac{1}{9}$ N

(76) **Answer [A]**

$\dfrac{v_1}{v_2} = \sqrt{r\mu g}$, $v_2 = \sqrt{rg\left(\dfrac{\mu+\tan\theta}{1-\mu\tan\theta}\right)}$

$\therefore\ \dfrac{v_1}{v_2} = \sqrt{\dfrac{\mu(1-\mu\tan\theta)}{\mu+\tan\theta}} = 1:\sqrt{6}$

(77) **Answer [C]**

$\therefore\ v_{max} = \sqrt{\mu g\left[\dfrac{tan\theta + \mu}{1-\mu\, tan\theta}\right]}$

optimum speed, from the eq^n.

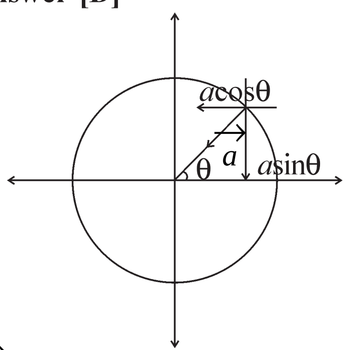
$v_0 = \sqrt{rg\tan\theta} = 1.77\ \text{ms}^{-1}$

(79) **Answer [D]**

$\tan\theta = \dfrac{v^2}{rg}$, $\therefore\ \theta = \tan^{-1}\left(\dfrac{v^2}{rg}\right)$

from above relation $\theta = \tan^{-1}(4)$

(80) **Answer [D]**



$\vec{a} = -a\cos\theta\,\hat{i} - a\sin\theta\,\hat{j}$

$= -\dfrac{v^2}{r}\cos\theta\,\hat{i} - \dfrac{v^2}{r}\sin\theta\,\hat{j}$

(81) **Answer [A]**

$\dfrac{v_1}{v_2} = \dfrac{\sqrt{gl}}{\sqrt{5gl}} = \dfrac{1}{\sqrt{5}}$

(82) **Answer [B]**

centrifugal acceleration on water $\dfrac{v^2}{R} = g$

$\therefore\ v = \sqrt{Rg}$, $\therefore\ \dfrac{2\pi R}{T} = \sqrt{Rg}$

$\therefore$ from $T = 2\pi\sqrt{\dfrac{R}{g}}$, $T = 4s$

(83) **Answer [A]**

For object rotates in verticle plane

$v = \sqrt{2gl(1-\cos\theta)}$, taking $\theta = 60°$

$v = \sqrt{2gl(1-\cos 60°)} = \sqrt{2gl\left(1-\dfrac{1}{2}\right)}$

$\therefore\ v = \sqrt{gl}$, $\therefore$ tension in string

From $T = mg + \dfrac{mv^2}{l} = mg + \dfrac{mgl}{l} = 2mg$,

$T = 60$ N

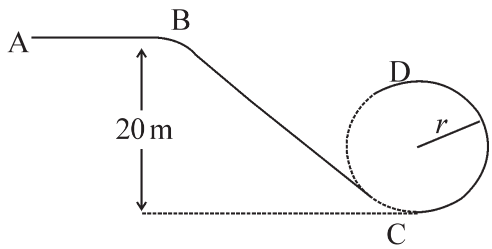
(84) **Answer [D]**

acceleration of sphere $a = \dfrac{10}{2} = 5\ \text{ms}^{-2}$

$\therefore\ v^2 - v_0^2 = 2ad$

$\therefore\ v = \sqrt{2ad} = \sqrt{2\times 5\times 10} = 10\ \text{ms}^{-1}$

Velocity of sphere at point C



$v_1 = v + \sqrt{2gh} = 10 + \sqrt{2\times 10\times 20}$

$\therefore\ v_1 = 30\ \text{ms}^{-1}$

Sphere reached at point D. (to complete one semi-circle.)

Required velocity $v = v' = \sqrt{5gr}$ $\therefore\ 30 = \sqrt{5\times 10\times r}$

$\therefore\ 900 = 50\,r$, $\therefore\ r = 18$ m

(85) **Answer [B]**

The particle on sphere leave the surface of sphere by distance $h = \dfrac{2r}{3}$ from upper point.

$h = \dfrac{2r}{3} = \dfrac{2\times 24}{3} = 16$ m

$\therefore$ height of sphere from surface

$H = h + r = 16 + 24 = 40$ m

(86) Answer [D]

maximum tension force generated in string

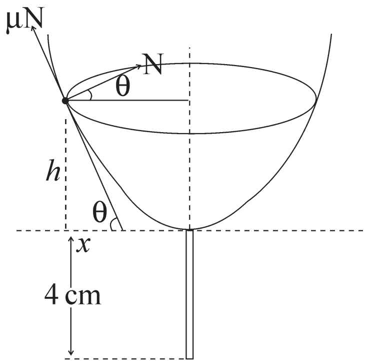
$$T_{max} = \frac{mv^2}{r} + mg$$

and minimum tension force $T_{min} = \frac{mv^2}{r} - mg$

$$\therefore \frac{T_{max}}{T_{min}} = \frac{\frac{mv^2}{r} + mg}{\frac{mv^2}{r} - mg} = \frac{5}{3}$$

$\therefore$ Now, $\frac{v^2 + rg}{v^2 - rg} = \frac{5}{3}$, $v = 4\sqrt{5}$ ms^{-1}

(88) Answer [A]



Here, $x^2 = 20y$, $\therefore 2x = 20\frac{dy}{dx}$

$\therefore \frac{dy}{dx} = \frac{x}{10}$ ...(1)

from figure $\tan\theta = \mu = \frac{h}{x} = \frac{x}{10}$, $\therefore x = 5$ cm

$\therefore y = \frac{x^2}{20} = \frac{25}{20} = 1.25$ cm

$\therefore$ height from table surface = 4 + 1.25 = 5.25 cm

(89) Answer [B]

tension force up to 3 m $T = \frac{50 \times (10-3)}{10} = 35$ N

(90) Answer [C]

$T_1 = \frac{2 \times 4 \times 6}{10} \times 10 = 48$ N

$T_2 = \frac{2 \times 4 \times 2}{10} \times 10 = 16$ N

$\therefore \frac{T_1}{T_2} = \frac{48}{16} = 3$

(91) Answer [D]

$$a = \frac{(m_1 + m_2) - m_3}{m_1 + m_2 + m_3} \times g$$

$$= \frac{(4+5)-7}{4+5+7} \times 10 = \frac{5}{4} = 1.25 \text{ ms}^{-2}$$

$T = 7g + 7a = 70 + 8.75 = 78.75$ N

(92) Answer [B]

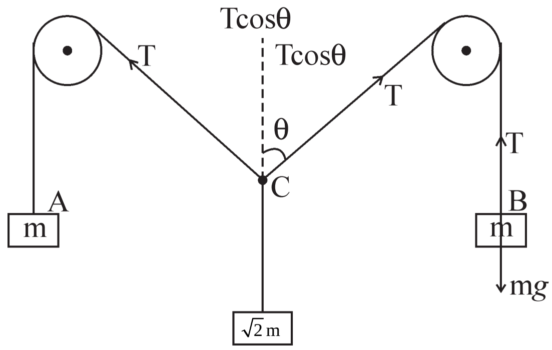
acceleration $a = \frac{m_1 - m_2}{m_1 + m_2} g = \frac{12-8}{12+8} \times 10 = 2$ ms^{-2}

$T = m_1 g - m_1 a$

$= m_1 (g - a)$

$= 12(10\text{-}2) = 96$ N

(94) Answer [B]



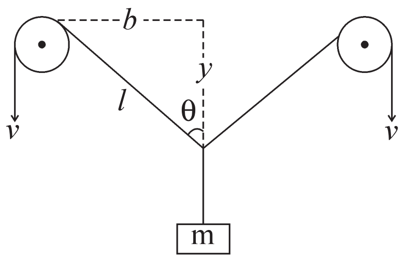
From figure, at point B, $T = mg$ ...(1)

and at C, $2T\cos\theta = \sqrt{2}\, mg$

$\therefore 2(mg)\cos\theta = \sqrt{2}\, mg$ [$\because$ From eq^n–1]

$\therefore \cos\theta = \frac{\sqrt{2}}{2} = \frac{1}{\sqrt{2}}$, $\therefore \theta = 45°$

(95) Answer [C]



The rate of decrease in length of string due to pulling the string by labour $\frac{dl}{dt}$ = velocity of string, v ...(1)

From diagram shown in figure, $l^2 = b^2 + y^2$

$\therefore 2l\frac{dl}{dt} = 2b\frac{db}{dt} + 2y\frac{dy}{dt}$, but $\frac{db}{dt} = 0$

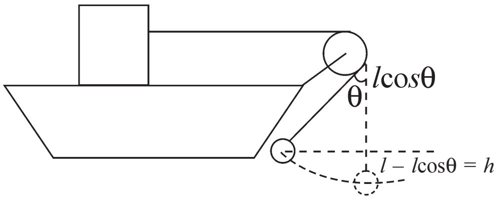
$\therefore 2l \frac{dl}{dt} = 2y \frac{dy}{dt}$

$\therefore \frac{l}{y} v = \frac{dy}{dt}$ ...[$\because$ θ]

From figure, $\sec\theta = \frac{1}{\cos\theta} = \frac{l}{y}$

$\therefore \frac{dy}{dt} = v\sec\theta$

(96) Answer [D]



Velocity of sphere $v = \sqrt{2gh} = [2gl(1-\cos\theta)]^{\frac{1}{2}}$

$T_{max} = mg + \frac{mv^2}{l}$

$= mg + \frac{m}{l}[2gl(1-\cos\theta)]$

$\therefore T_{max} = mg(3-2\cos\theta)$

But, Here $T_{max} \le \mu 4mg$

$\therefore \mu \ge \frac{T_{max}}{4mg}$, $\therefore \mu \ge \frac{(3-2\cos\theta)}{4}$

(97) Answer [B]

Maximum acceleration in block $= \frac{f_{max}}{m_B} = \frac{\mu m_A g}{m_B}$

$\therefore$ Maximum force on block,

From $F_{max} = (m_A + m_B)\, a_{max}$, $F_{max} = 60$ N

(98) Answer [A]

Here $T_6 = 2T_3 = 2T_4$ ...(1)

$T_5 = 2T_1 = 2T_2$ ...(2)

$T_7 = T_5 + T_6$ ...(3)

to solve this $T_1 = 10$ N

(99) Answer [C]

tension in string $T = 5(2a_A) = 20$ N

$\therefore a_A = 2$ ms^{-2} ...(1)

Resultant force on block B, $8a_B = 8g - 2T$,

$\therefore a_B = g - \frac{2T}{8} = 10 - \frac{20}{4}$

$a_B = 5$ ms^{-2} ...(2)

$\therefore \frac{a_A}{a_B} = \frac{2}{5}$

(100) Answer [D]

acceleration of system, $a = \frac{m_A g}{m_A + m_B}$

and resultant force on block A

$m_A a = m_A g - T$, $\therefore$ From $T = m_A \cdot g - m_A \cdot a$

$T = 48$ N

(101) Answer [C]

For block A, $mg\sin\theta - T = ma$ ...(1)

For block B, $T = ma$ ...(2)

from (1) and (2),

$mg\sin\theta - T = T$, $\therefore T = \frac{1}{2} mg\sin\theta$

(102) Answer [B]

$T_2 = 5a$ ...(1)

$T_1 = (5+10)a$ ...(2)

$\therefore \frac{T_2}{T_1} = \frac{5a}{(5+10)a} = \frac{1}{3}$

(103) Answer [C]

acceleration of system $a = \frac{80}{8} = 10$ ms^{-2}

$F_1 = (m_2 + m_3 + m_4)a = (2+3+2)a = 7a = 70$ N

$F_2 = (m_3 + m_4)a = (3+2) \times 10 = 50$ N

(104) Answer [B]

Contact force applied near P, $F_R = (m_2 + m_3)a$

$= (24+8) \times 2$, $F_R = 64$ N

If force at Q generated acceleration a' then,

$v = v_0 + a't$, $\therefore 12 = 0 + 3a'$, $\therefore a' = 4$ ms^{-2}

$\therefore F_S = (m_1 + m_2)a' = (12+24) \times 4 = 36 \times 4$ N

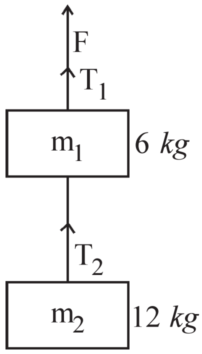
$\therefore \frac{F_R}{F_S} = \frac{64}{36 \times 4} = \frac{4}{9}$

(105) **Answer [D]**

acceleration parallel to slope, $a = g\sin 60° - g\sin 30°$

$= g(0.866 - 0.5) = 10 \times 0.366 = 3.66$ ms^{-2}

(107) Answer [A]



resultant force on m_2, $m_2 a = T_2 - m_2 g$ ...(±)

$\therefore\ T_2 = m_2(a+g) = 12\,(3+10)$

$= 12 \times 13$ N ...(1)

resultant force on m_1

$m_1 a = T_1 - T_2 - m_1 g,\ \therefore\ T_1 = m_1 a + T_2 - m_1 g$

$= T_2 + m_1(a+g) = (12 \times 13) + 6\,(13)$

$T_1 = 18 \times 13$ N ...(2)

$$\therefore\ \frac{T_1}{T_2} = \frac{18 \times 13}{12 \times 13} = \frac{3}{2}$$

(108) Answer [D]

$$\vec{v} = 5t\hat{i} + 2t\hat{j},\ \vec{a} = \frac{d\vec{v}}{dt} = 5\hat{i} + 2\hat{j} \text{ and,}$$

Reactive acceleration generated by sphere $\vec{g} = 10\hat{j}$

$\therefore$ Force due to sphere $\vec{F} = m(\vec{a} + \vec{g})$

$= 2\,[5\hat{i} + 2\hat{j} + 10\hat{j}] = 2\,[5\hat{i} + 12\hat{j}]$

$= [10\hat{i} + 24\hat{j}],\ \therefore\ F = \sqrt{100 + (24)^2} = 26$ N

(109) Answer [B]

Acceleration $a = g\sin 30° \cdot \sin 30° = (10)\left(\frac{1}{2}\right)\left(\frac{1}{2}\right)$

$= 2.5\ \text{ms}^{-2},\ \ \therefore\ d = v_o t + \frac{1}{2}at^2$

$\therefore\ d = \frac{1}{2}at^2$ $[\therefore\ v_o = 0]$

$$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2 \times 5}{2.5}} = 2 \text{ s}$$

Practical Work

(110) Answer [B]

co-efficient of friction of surface, slope of $P \rightarrow N$ graph

$$= \tan 30° = \frac{1}{\sqrt{3}} = 0.58$$

(111) Answer [B]

The slope of graph of action force $\rightarrow$ normal reaction force gives coefficience of friction μ.
Here $\mu_A < \mu_B$. $(f_A) < f_B$ [$\because$ *m* is equal]
so $W_A < W_B$

(112) Answer [B]

$$\text{friction co-efficient } \mu = \frac{P}{W} = \frac{P_o + P'}{W + W_o}$$

Here W is same for surface,

$\mu \propto P_o + P'$ and $P'_A < P'_B$ So, $\mu_A < \mu_B$.

(125) Answer [C]

Tension near R, $T_1 = \frac{F}{2} = 50$ N = Tension near S

Tension near P, $T_2 = \frac{T_1}{2} = \frac{50}{2} = 25$ N

Resultant force on block with 2kg mass $2a = 2g - T_2$

$\therefore\ a = g - \frac{T_2}{2},\ a = 10 - \frac{25}{2} = 10 - 12.5$

$a = -2.5\ \text{ms}^{-2}$

= Resultant force of block of 4 kg

$4a = 4g - T_2$

$\therefore\ a = g - \frac{T_2}{4} = 10 - \frac{25}{4} = 10 - 6.25$

$= 3.75\ \text{ms}^{-2}$

(126) Answer [A]

(i) acceleration of block having mass1 kg
= acceleration of system

$$= \frac{60 - 18 - (m_1 + m_2 + m_3)\,g\sin 30°}{m_1 + m_2 + m_3}$$

$$= \frac{42 - (6)(10)\frac{1}{2}}{6} = \frac{12}{6} = 2\ \text{ms}^{-2}$$

(ii) Resultant force on block of 2kg mass
$= F = 2a = 2 \times 2 = 4$ N

(iii) Perpendicular force on block of 3 kg mass,

$N = 3g\cos 30° = 3 \times 10 \times \frac{\sqrt{3}}{2} = 15\sqrt{3}$ N

(iv) Assuming FBD of mass of 1kg block,
$N_{12} - (1)\,g\sin 30° - 18 = (1)(a)$

$\therefore\ N_{12} - (10)\left(\frac{1}{2}\right) - 18 = 1 \times 2$

$\therefore\ N_{12} = 2 + 5 + 18 = 25$ N

4 Work, Energy and power

(1) **Answer [B]**

$F d\cos\theta = W$, $\therefore \cos\theta = \dfrac{W}{Fd} = \dfrac{120}{24 \times 10}$

$\therefore \cos\theta = \frac{1}{2}$, $\therefore \theta = 60°$

$\therefore$ angle with horizontal = 60°

$\therefore$ angle with vertical = 90 – 60 = 30°

(3) **Answer [B]**

$v_o = \dfrac{108 \times 1000}{3600} = 30 \text{ ms}^{-1}$

$\therefore v^2 - v_o^2 = 2ad$, $\therefore 0 - (30)^2 = 2a(15)$

$\therefore a = -30 \text{ ms}^{-2}$

$\therefore$ Work, $W = +Fd = +mad$

$= +2000 \times (-30) \times (15) = -90 \times 10^4$

$= -900$ kJ

(4) **Answer [D]**

The work due to gravitationa force on ball with horizontal motion is zero because $\vec{F} \perp \vec{d}$

(5) **Answer [B]**

Here, resulting displacement is h for both substance having mass m_1 and m_2.

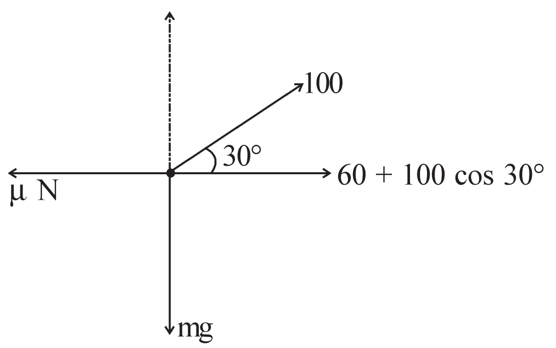
$\dfrac{W_1}{W_2} = \dfrac{m_1 gh}{m_2 gh} = \dfrac{2}{3}$

(6) **Answer [D]**

The displacement of stone is perpendicular to both gravitatinal force and tension force. So, work on stone is zero.

(7) **Answer [C]**

Assuming FBD of block



from FBD, N + 100 sin30° = mg

$\therefore N + (100)\left(\frac{1}{2}\right) = (10)(10)$

$\therefore N + 50 = 100$, $\therefore N = 50$ N ...(1)

Resulting force $F = 70 + 100\cos 30° - \mu N$

$= 70 + (100)(0.866) - (50 \times 0.2)$

$= 70 + 86.6 - 10 = 146.6$ N

$\therefore$ acceleration $a = \dfrac{F}{m} = \dfrac{146.6}{10} = 14.66 \text{ ms}^{-2}$

$\therefore$ distance travelled by block,

$d = \dfrac{v^2}{2a} = \dfrac{14.66}{2 \times 14.66} = \dfrac{1}{2}$

$\therefore$ Work $W = Fd = 146.6 \times \frac{1}{2} = 73.3$ J

(10) **Answer [D]**

Solution : $W_1 = \int_0^2 kx^2 dx = k\left[\dfrac{x^3}{3}\right]_0^2 = \dfrac{8k}{3}$

$W_2 = \int_3^{-2} kx^2 dx = k\left[\dfrac{x^3}{3}\right]_3^{-2} = \dfrac{19k}{3}$

$\therefore \dfrac{W_1}{W_2} = \dfrac{8}{19}$

(11) **Answer [D]**

Solution : displacement $s = \dfrac{t^3}{3} + \dfrac{t^2}{2} + 5$ ...(1)

$\therefore$ Velocity $v = \dfrac{ds}{dt} = \dfrac{3t^2}{3} + \dfrac{2t}{2} \Rightarrow t^2 + t$ ...(2)

$\therefore ds = t^2\,dt + t\,dt$ ...(3)

and from (2), acceleration $a = \frac{dv}{dt} = 2t + 1$ ...(3)

$\therefore$ Work, $W = m\int_0^2 a\,ds$

$= m\int_0^2 (2t+1)\,(t^2dt + tdt)$

(12) Answer [D]

Work $W = \frac{ml^2g}{2L} = \frac{9 \times 1 \times 10}{3 \times 2} = 15$ J

(14) Answer [B]

Work = Area enclosed by graph

= (Area of $\square$ OABC) – (Area enclosed of curve CDE) + (Area enclosed of curve EFG) – (Area of Δ GHI) + (Area of $\square$ IJKL)

$\therefore$ W = (2) (6) – $\left(\frac{1}{2}\right)$ (2) (8) + (2) (10)

= 24 J

(15) Answer [C]

For first substance $U_1 = mgh_1 = \frac{1}{2}mv^2$ ...(1)

For second substance,

$H = \frac{{v_o}^2 \sin^2 30^\circ}{2g} = \frac{v^2 \times 1}{4 \times 2g} = \frac{v^2}{8g}$

$\therefore$ For second substance,

$U_2 = mgH = \frac{mgv^2}{8g} = \frac{mv^2}{8}$ ...(2)

From (1) and (2), $\frac{U_1}{U_2} = \frac{mv^2}{2}\,\frac{8}{mv^2} = \frac{4}{1}$

(16) Answer [A]

$K_1 = K_2$, $\therefore \frac{1}{2} m_1{v_1}^2 = \frac{1}{2} m_2{v_2}^2$

$\therefore \frac{v_1}{v_2} = \sqrt{\frac{m_2}{m_1}} = \sqrt{\frac{4}{16}} = \frac{1}{2}$

$\Rightarrow \frac{F_1\,\Delta t_1}{F_2\,\Delta t_2} = \frac{m_1v_1}{m_2v_2}$

$\therefore \frac{\Delta t_1}{\Delta t_2} = \frac{m_1v_1\,F_2}{m_2v_2\,F_1} = \frac{m_1v_1\,m_2a_2}{m_2v_2\,m_1a_1} = \frac{1 \times 8}{2 \times 2} = \frac{2}{1}$

(17) Answer [B]

Velocity of sphere of mass m_1 reaches to the sphere of mass m_2,

$v_1 = \sqrt{2gh}$ ...(1)

According to conservation of momentum,

$m_2v_2 = m_1v_1$, $\therefore v_2 = \frac{m_1}{m_2}\,v_1 = \frac{m_1}{2m_1}\sqrt{2gh}$

$\therefore v_2 = \sqrt{\frac{gh}{2}}$,

$\therefore$ Kinetic energy $K = \frac{1}{2}\,m_2{v_2}^2$

$= \frac{1}{2}\,m_2\,\frac{gh}{2} = \frac{1}{4}\,m_2gh$

$\therefore m_2 = \frac{4K}{gh} = \frac{4 \times 2 \times 4}{10 \times 1} = 3.2$ kg

(18) Answer [B]

(Potential energy near A) – (loss of energy on AC) – (loss of energy on CB) = potential energy near B

$\therefore mgh_1$ – R (length of AC) – R (length of BC) = U_B

$\therefore (1)\,(10)\,(7) - \frac{(0{\cdot}5)(7)}{\sin 30^\circ} - \frac{(0{\cdot}5)(4)}{\sin 30^\circ} = U_B$

$\therefore 70 - \frac{(0{\cdot}5)(7)\,(2) \times 2}{1} - \frac{(0{\cdot}5)(4)\,(2) \times 2}{1} = U_B$

$\therefore 70 - 14 - 8 = U_B$

$\therefore U_B = 19$ J

(19) Answer [C]

According to conservation of momentum in of blast.

$p_1 = p_2$, $\therefore \sqrt{2K_1m_1} = \sqrt{2K_2m_2}$

$\therefore K_2 = \frac{K_1\,m_1}{m_2} = \frac{360 \times 1}{4}$, $\therefore K_2 = 90$ J

(21) **Answer [B]**

Final kinetic energy (K) = 2 (Initial kinetic energy)

$\therefore \frac{1}{2}$ m$(v + 2)^2 = 2 \frac{1}{2}$ mv^2

$\therefore (v + 2)^2 = 2v^2, \therefore v^2 + 2v + 4 = 2v^2$

$\therefore v^2 - 2v - 4 = 0, \therefore v = \left(2 \pm \sqrt{8}\right)$ ms^{-1}

(22) **Answer [D]**

When pulling the object from the bottom of well, used energy = 15 × 0.6 = 9J

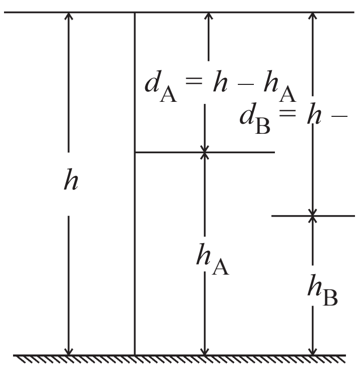
When object reached at the bottom of well, the kinetic energy = $\frac{1}{2}$ mv^2 = 9

$\therefore$ m $= \frac{9 \times 2}{v^2} = \frac{9 \times 2}{9} = 2$ kg

$\therefore$ U = mgh = 9, $\therefore$ 2 × 10 × h = 9

$h = \frac{9}{2 \times 10} = 0.45$ m

(23) **Answer [B]**



Here $U_A = 3U_B$, $\therefore \frac{U_A}{U_B} = 3$

$\therefore \frac{m_A g d_A}{m_B g d_B} = 3$, $\therefore \frac{1(h - h_A)}{4(h - h_B)} = 3$

$\therefore \frac{h - h_A}{h - h_B} = \frac{12}{1}$

(24) **Answer [A]**

$$\frac{\Delta U}{U} = \frac{U - U'}{U} = \frac{mg(h - h')}{mgh} = \frac{60 - 40}{60} = \frac{1}{3}$$

(25) **Answer [C]**

$$U = \frac{a}{x^{12}} - \frac{b}{x^6} \qquad ...(1)$$

$\therefore U = ax^{-12} - bx^{-6}$

$$\therefore \frac{dU}{dx} = \frac{(a)(-12)}{x^{13}} - \frac{b(-6)}{x^7}$$

at equilibrium, U = minimum $\Rightarrow \frac{dU}{dx} = 0$

$$\therefore \frac{(a)(-12)}{x^{13}} - \frac{b(-6)}{x^7} = 0$$

$$\therefore \frac{(a)(-12)}{x^{13}} = \frac{(b)(-6)}{x^7}$$

$$\left.\begin{aligned} \therefore x^6 &= \frac{2a}{b} \\ x^{12} &= \frac{4a^2}{b^2} \end{aligned}\right\} \qquad ...(2)$$

From (1) and (2), $U(x) = \frac{a \cdot b^2}{2a^2} - \frac{b \cdot b}{2a}$

$$U(x) = -\frac{b^2}{4a} \qquad ...(3)$$

and, $U(v) = 0$

$\therefore$ required energy to dissociate two atoms = ΔU

$= U(v) - U(x) = \frac{b^2}{4a}$

(26) **Answer [B]**

Suppose balloon displaced downward by distance d, when man is climbing up a rope by distance L.

$\therefore$ man's resulting displacement h = L – d

$$\therefore \frac{\text{increase in man's potential energy}}{\text{decrease in balloon polential energy}}$$

$$= \frac{mg(L - d)}{Mg\,d} = \frac{L - d}{d} \times \frac{m}{M}$$

(28) Answer [A]

$U = \frac{1}{2} kx^2 = \frac{F^2}{2k}$ ...(1)

If x is same then, $U \propto k$

$\therefore b = \frac{U_1}{U_2} = \frac{k_1}{k_2} = \frac{1200}{600} = \frac{1}{2}$ ...(2)

If F is same then, $U \propto \frac{1}{k}$

$\therefore a = \frac{U_1}{U_2} = \frac{k_2}{k_1} = \frac{1200}{600} = 2$ ...(3)

$\therefore a\, b = \left(\frac{1}{2}\right)(2) = 1$

(29) Answer [A]

generated acceleration on sphere due to friction force

$a = \mu g = 0.2 \times 10 = 2\ ms^{-2}$ ...(1)

$v^2 = v_0^2 - 2ad$

$= 100 - (2)(2)(10) \Rightarrow v^2 = 60$ ...(2)

$\therefore \frac{1}{2} mv^2 = \frac{1}{2} kx^2$

$\therefore x^2 = \frac{mv^2}{k} = \frac{0.1 \times 60}{6} = 1, \therefore x = 1m$

(30) Answer [D]

$x_1 = 2\ mm,\ x_2 = 2 + 2 = 4\ mm$

$\Rightarrow U \propto x^2, \therefore \frac{U_2}{U_1} = \frac{x_2^2}{x_1^2} = \frac{16}{4} = 4$

$\therefore U_2 = 4U_1 = 4 \times 36 = 144$ J

(32) Answer [C]

Suppose, the compression of spring is x.

$\therefore$ Kinetic energy of block – loss of energy in oppose of friction = potential energy stored in spring

$\therefore \frac{1}{2} mv^2 - f_k x = \frac{1}{2} kx^2$

$\therefore \frac{1}{2}(2)(16) - 15x = \frac{1}{2}(10000)x^2$

$\therefore 16 - 15x = 5000x^2, \therefore x = 5.5$ cm

(33) Answer [C]

From $F = -\frac{dU}{dx}$, Slope of plot near OP is constent So, F = constant.

Ahead of P, slope of plot is zero, So, F = 0. This is given in option C.

(34) Answer [B]

Work $W = \frac{1}{2} kx^2 = Fx$

= (Area enclosed by $F \rightarrow x$ plot.)

$= \left(\frac{1}{2} \times 40 \times 4\right) = 80$ J

(35) Answer [A]

Here, if maximum increase in length of spring is x then sphere comes down of maximum height x.

$\therefore$ loss of potential energy by sphere A = stored potential energy in spring =

$\therefore mgx = \frac{1}{2} kx^2,$

$\therefore kx = 2mg$ ...(1)

$\Rightarrow$ Assuming FBD of block B,

$F = Mg, kx = Mg, \therefore 2mg = Mg, \therefore m = \frac{M}{2}$

(36) Answer [D]

Power for engine $P = Fv = m\left(\frac{dv}{dt}\right) v$

$\therefore \frac{P}{m} = v\frac{dv}{dt}, \therefore \frac{P}{m} v = v^2 \frac{dv}{dt}$

$\therefore v^2 dv = \frac{P}{m} vdt, \therefore \int_{v_1}^{v_2} v^2 dv = \frac{P}{m} \int vdt$

$$\therefore \left[\frac{v^3}{3}\right]_{v_1}^{v_2} = \frac{P}{m} d, \therefore v_2{}^3 - v_1{}^3 = \frac{3P}{m} d$$

$$\therefore v_2{}^3 = v_1{}^3 + \frac{3Pd}{m}$$

$$\therefore v_2 = \left[v_1^3 + \frac{3Pd}{m}\right]^{\frac{1}{3}}$$

(37) Answer [A]

$$P = \frac{20\,\%\,\text{potential energy}}{t} = \frac{0.2 \times mgh}{t}$$

$$= 0.2 \times 20 \times 10 \times 80$$

$$= 3200 \text{ W} = 3.2 \text{ kW}$$

(38) Answer [B]

power of motor = 10 kW

Used power to fill the water into tank

$$= 40\ \% \times 10 \text{ kW} = \frac{40}{100}\ 10 \times 10^3$$

$$P = 40 \times 10^2, \therefore P = \frac{mgh}{t}$$

$$\therefore t = \frac{mgh}{P} = \frac{9 \times 10 \times 10 \times 10^3}{40 \times 10^2}$$

$t = 3.75$ min

(39) Answer [A]

$$\text{maximum height } H = \frac{v_0^2 \sin^2 30^\circ}{2g}$$

$$= \frac{v_0^2}{4 \times 2g} = 20 \text{ m} \qquad ...(1)$$

$$\text{and time } t_m = \frac{v_0 \sin 30^\circ}{g} = \frac{40 \times 1}{2 \times 10} = 2$$

$$\text{Power, } P = \frac{mgH}{t_m} = \frac{3 \times 10 \times 20}{2} = 300 \text{ W}$$

(40) Answer [D]

$$\text{Power } P = \frac{W}{t} = \frac{\Delta K}{t} = \frac{\frac{1}{2} m\left(v_2^2 - v_1^2\right)}{t}$$

$$= \frac{12 \times 10^6 (25 - 9)}{2 \times 2 \times 60} = 800 \text{ kW}$$

(41) Answer [A]

$$\text{Power of engine } P = \frac{mgh}{t}, \therefore P \propto \frac{m}{t}$$

$$\therefore \frac{P_1}{P_2} = \frac{m_1\ t_2}{m_2\ t_1} = \frac{2000 \times 6}{3000 \times 8} = \frac{1}{2}$$

(42) Answer [B]

$$\vec{F} = \left(2\hat{i} - 3\hat{j} + 4\hat{k}\right) \text{N}$$

$$\vec{r} = \left(3t^2\hat{i} + 4t\hat{j} + 6t^3\hat{k}\right) \text{m}$$

$$\therefore \vec{v} = \frac{d\vec{r}}{dt} = \left(6t\hat{i} + 4\hat{j} + 18t^2\hat{k}\right) \text{m}$$

taking, $t = 2$s

$$\vec{v} = (6 \times 2)\,\hat{i} + 4\hat{j} + (18 \times 4)\,\hat{k}$$

$$\vec{v} = \left(12\hat{i} + 4\hat{j} + 72\hat{k}\right) \text{ms}^{-1}$$

$$\therefore \text{Power, } P = \vec{F} \cdot \vec{v}$$

$$= \left(2\hat{i} - 3\hat{j} + 4\hat{k}\right) \cdot \left(12\hat{i} + 4\hat{j} + 72\hat{k}\right)$$

$$= 24 - 12 + 288 = 300 \text{ W}$$

(44) Answer [C]

$$P = \frac{\text{Work done by heart}}{\text{time}} = \frac{F \cdot d}{t}$$

$$= \frac{\text{Pressure} \times d \times \text{area}}{t} = \frac{23000 \times 1 \times 10^{-6}}{1}$$

$$= 0.023 \text{ W}$$

(45) Answer [D]

frequency of motor

$$f = 600 \frac{\text{revolution}}{\text{minute}} = \frac{600}{60} = 10 \frac{\text{revolution}}{\text{second}}$$

$\therefore$ time required for 1 revolution $= \frac{1}{f} = \frac{1}{10}$ s

$\therefore$ Energy required for 1 revolution = power $\times$ time

$= 0.5 \times 746 \times \frac{1}{10}$ time, $E = 37.3$ J

work done by motor

$= 70\ \%\ E = \frac{70}{100} \times 37.3 = 2.611$ J

(46) Answer [B]

Speed of sphere B after impact

$$v_B = \frac{2m_A v_A}{m_A + m_B} = \frac{2 \times 3 \times 9}{3+6} = 6\ ms^{-1}$$

For impact between B and C,

$m_B v_B + m_C v_C = (m_B + m_C)\ v$

$\therefore$ (6) (6) + (3) (0) = (6 + 3) v

$\frac{36}{9} = v, \quad \therefore v = v_C = 4\ ms^{-1}$

(47) Answer [C]

Here, $m_1 v_1 - m_2 v_2 = 0,\ \therefore m_2 v_2 = m_1 v_1$

$$\therefore \quad v_2 = \frac{m_1 v_1}{m_2} = \frac{m_1 \times 12}{2m_1} = 6\ ms^{-1}$$

(48) Answer [D]

mass of each fragment $m = \frac{3}{3} = 1$ kg

Initial horizontal velocity of bomb before blast

$\vec{v} = v_0 \cos 60° \hat{i}$

$= 200 \times \frac{1}{2}\ \hat{i}\ ,\ \vec{v} = 100\hat{i}\ ms^{-1}$

According to conservation of momentum

$$m_1 \vec{v_1} + m_2 \vec{v_2} + m_3 \vec{v_3} = M \vec{v}$$

$$\therefore \quad 1 \times 100\,\hat{j} - 1 \times 100\,\hat{j} + (1)\ \vec{v_3} = 3 \times 100\,\hat{i}$$

$$\therefore \quad \vec{v_3} = 300\,\hat{i}\ ms^{-1}$$

$\therefore$ Kinetic energy of third fragment

$K_3 = \frac{1}{2} m_3 v_3^2 = \frac{1}{2} \times 1 \times 90000$

$= 45000$ J $= 45$ kJ

(49) Answer [B]

Suppose, mass of one nucleon is m.

$\therefore$ According to law of conservation of momentum.

$238\ m \cdot v \ = 4m\ (3v) + 234m\ v'$

$\therefore 234\ m\ v' \ = 238\ mv - 12\ mv$

$234\ m\ v' \ = 226mv$

$\therefore\ v' \ = \frac{226}{234}\ v = \frac{113}{117}\ v$

(50) Answer [A]

Here, mass of sphere is very small compare to mass of wall. So, final velocity $v' = -v = -8\ ms^{-1}$

and kinetic energy $K = \frac{1}{2} mv' = \frac{1}{2} \times 8 \times 64$

$= 256$ J

(51) Answer [B]

Velocity of P and Q after impact, respectively,

$v_P = 5\ ms^{-1}$ and $v_Q = 3\ ms^{-1}$

$$\therefore \frac{p_P}{p_Q} = \frac{mv_P}{mv_Q} = \frac{5}{3}$$

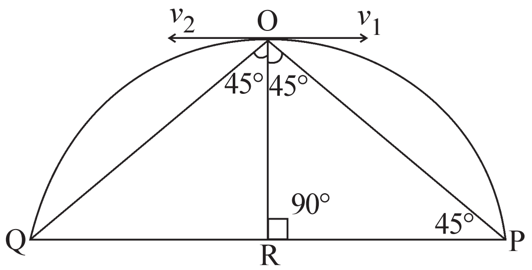
(52) Answer [C]

elastic constant, $e = \frac{v_2}{v_1} = \sqrt{\frac{h_2}{h_1}}$

$$\therefore e = \sqrt{\frac{4 \cdot 2}{16 \cdot 8}} = \frac{1}{2},\ \therefore v_2 = \frac{v_1}{2}$$

$$\therefore \frac{\Delta v}{v_1} = \frac{v_1 - v_2}{v_1} = \frac{v_1 - \frac{v_1}{2}}{v_1} = \frac{1}{2} \times 100 = 50\ \%$$

(53) Answer [D]



Here both fragments blast at O then its motion is as shown in figure. Suppose, both fragments reached at pond Q then their radius vector is perpendicular to eachother.

$\therefore$ From geometry of figure, OR = RP

$\therefore$ distance travel in vertical direction by fragments = distance travel in horizontal direction of fragments

$(v_{0_y} t + \frac{1}{2} a_y t^2) = v_{0_x} t,$

$\therefore\ 0 + \frac{1}{2}(10)t^2 = 15t$

$\therefore\ 5t^2 = 15t, \quad \therefore\ t = 3$

(55) Answer [C]

velocity of object at time $t = 4$ s

$v = v_0 - gt = 200 - (10)(4)$

$\therefore v = 160\ \text{ms}^{-1}$.

$\therefore$ According to conservation of momentum

$m_1 v_1 + m_2 v_2 = mv$

$(400)\frac{m}{4} + \frac{3m}{4} v_2 = m \times 160$

$400 + 3v_2 = 640$

$v_2 = \frac{240}{3} = 80\ \text{ms}^{-1}$

(56) Answer [D]

50 % of initial energy = final energy

$\therefore \frac{50}{100}\left(mgh_1 + \frac{1}{2}mv^2\right) = mgh_2$

$\therefore \frac{1}{2}\left(gh_1 + \frac{v^2}{2}\right) = gh_2$

$\therefore v^2 = 2\,[2gh_2 - gh_1] = 2 \times 10\,[(2)(15) - 10]$

$= 20\,(20), \therefore\ v = 20\ \text{ms}^{-1}$

(57) Answer [A]

height achieved by ball after m collisions $h_n = he^{2n}$

$\therefore$ distance travelled by ball during n collisions,

$$H = h + 2h_1 + 2h_2 + 2h_3 + \ldots$$

$$= h + 2he^2 + 2he^4 + 2he^8 + \ldots$$

$$= h + 2h\,[e^2 + e^4 + e^8 + \ldots]$$

$$= h + 2h\left[\frac{e^2}{1-e^2}\right] = h\left[1 + \frac{2e^2}{1-e^2}\right]$$

$$= h\left[\frac{1-e^2+2e^2}{1-e^2}\right] \quad \therefore \quad H = h\left[\frac{1+e^2}{1-e^2}\right]$$

(58) Answer [C]

decrease in kinetic energy

$$\frac{m_1 m_2 (v_1 - v_2)^2}{2(m_1 + m_2)}$$

$$= \frac{4 \times 6}{2(4+6)}(12-0)^2 = \frac{24 \times (12)^2}{2 \times 10} = 172.8\ \text{J}$$

(71) Answer [B]

Velocity of object at time $t = 5$ s,

$v = v_0 + at = 0 + g(t) = (10)(5) = 50\ \text{ms}^{-1}$

$\therefore$ Kinetic energy of object

$K = \frac{1}{2}mv^2 = \frac{1}{2} \times 2 \times 50 \times 50 = 2500$ J

(72) Answer [A]

momentum $p = mv = 2 \times 50 = 100$ N·S

(73) Answer [B]

E = U + K

$\therefore$ U = E – K = 5000 – 2500 = 2500 J

(74) Answer [D]

$\Delta E = 0$

5 Rotational motion

(1) **Answer [B]**

$$\vec{r}_{cm} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2 + m_3\vec{r}_3}{m_1 + m_2 + m_3}$$

$$= \frac{3(0,0) + 3(2,0) + 3(2,1.5)}{9}$$

$$= \frac{(12, 4.5)}{9} = (1.33, 0.5) \text{ cm}$$

(2) **Answer [A]**

$$\vec{r}_{cm} = \frac{50(3\hat{i} + 4\hat{j} + 5\hat{k}) + 100(-6\hat{i} + 4\hat{j} - 2\hat{k})}{150}$$

$$= -3\hat{i} + 4\hat{j} + \tfrac{1}{3}\hat{k} \text{ cm}$$

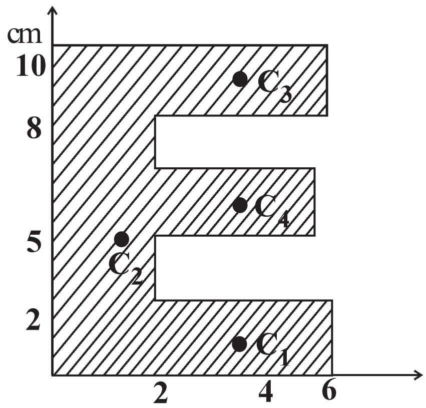
$$|\vec{r}_{cm}| = \sqrt{9 + 16 + \tfrac{1}{9}} = \sqrt{226} = 15.03 \text{ cm}$$

(3) **Answer [C]**

Area of rectangular part = $2 \times 6 = 12$ cm^2

Area of square = $2 \times 2 = 4$ cm^2

If mass m for unit area of E,



C_1 For $\vec{r}_1 = (3, 1)$ cm $\quad m_1 = 12$ m

C_2 For $\vec{r}_2 = (1, 5)$ cm $\quad m_2 = 12$ m

C_3 For $\vec{r}_3 = (3, 9)$ cm $\quad m_3 = 12$ m

C_4 For $\vec{r}_4 = (3, 5)$ cm $\quad m_4 = 4$ m

$$\vec{r}_{cm} = \frac{12m(3,1) + 12m(1,5) + 12m(3,9) + 4m(3,5)}{40m}$$

$$= \frac{(96, 104)}{40} = (2.4, 5) \text{ cm}$$

(4) **Answer [D]**

$m_1 = 1$ g, $\vec{r}_1 = (0, 0)$, $m_2 = 2$ g

$$\vec{r}_2 = (a\cos 60°, a\sin 60°) = \left(\frac{a}{2}, \frac{\sqrt{3}a}{2}\right) \text{cm}$$

$$m_3 = 3\text{g}, \ \vec{r}_3 = (a + a\cos 60°, a\sin 60°)$$

$$= \left(\frac{3a}{2}, \frac{\sqrt{3}a}{2}\right)\text{cm}, \ m_4 = 4\text{g}$$

$$\vec{r}_4 = (a, 0) \text{ cm}, \ \vec{r}_{cm} = \frac{\sum m_i r_i}{\sum m_i}$$

$$\vec{r}_{cm} = \frac{1(0,0) + 2\left(\frac{a}{2}, \frac{\sqrt{3}a}{2}\right) + 3\left(\frac{3a}{2}, \frac{\sqrt{3}a}{2}\right) + 4(a, 0)}{10}$$

$$= \frac{\left(9.5a, \frac{5\sqrt{3}a}{2}\right)}{10} = \left(0.95a, \frac{\sqrt{3}a}{4}\right) \text{cm}$$

(5) **Answer [C]**

Here $y_1 = l$ $\quad m_1 = 2m$

(taking surface as a reference point)

Here $y_2 = 2l$ $\quad m_2 = m$

$$y_{cm} = \frac{m_1 y_1 + m_2 y_2}{m_1 + m_2} = \frac{2ml + 2lm}{3m} = \frac{4}{3}l$$

(6) **Answer [B]**

$m_1 = m \quad x_1 = \frac{L}{2}$

$m_2 = m \quad x_2 = L$

$m_3 = m \quad x_3 = \frac{L}{2} + \frac{L}{4} = \frac{3L}{4}$

$m_4 = m \quad x_4 = L + \frac{L}{4} = \frac{5L}{4}$

$$x_{cm} = \frac{\sum m_i x_i}{\sum m_i}$$

$$x_{cm} = \frac{m\left[\frac{L}{2} + L + \frac{3L}{4} + \frac{5L}{4}\right]}{4m}$$

$$= \frac{14}{16}L = \frac{7}{8}L$$

(7) Answer [C]

mass of unit area of disc

$$\lambda = \frac{M}{\pi R^2} = \frac{M}{900\pi}$$

mass of small disc $m_1 = \pi \cdot 400 \cdot \lambda = \frac{4}{9}M$

position of center of mass $y_1 = 10$ cm

mass of remaining disc $m_2 = M - \frac{4}{9}M = \frac{5}{9}M$

position of center of mass $y_2 = y$

$My_{cm} = m_1y_1 + m_2y_2$

$O = \frac{4}{9}M\,(10) + \frac{5}{9}M(y)$

$y = -8$ cm

(8) Answer [D]

$m_1 = 10$g

$\vec{r_1} = (4\cos 30°, 4\sin 30°) = \left(2\sqrt{3}, 2\right)$cm

$m_2 = 20$ g, $\vec{r_2} = (0, -4)$ cm, $m_3 = 30$ g

$\vec{r_3} = \left(-2\sqrt{3}, -2\right)$cm, $m_4 = 40$ g

$\vec{r_4} = (-4\cos 60°, 4\sin 60°)$

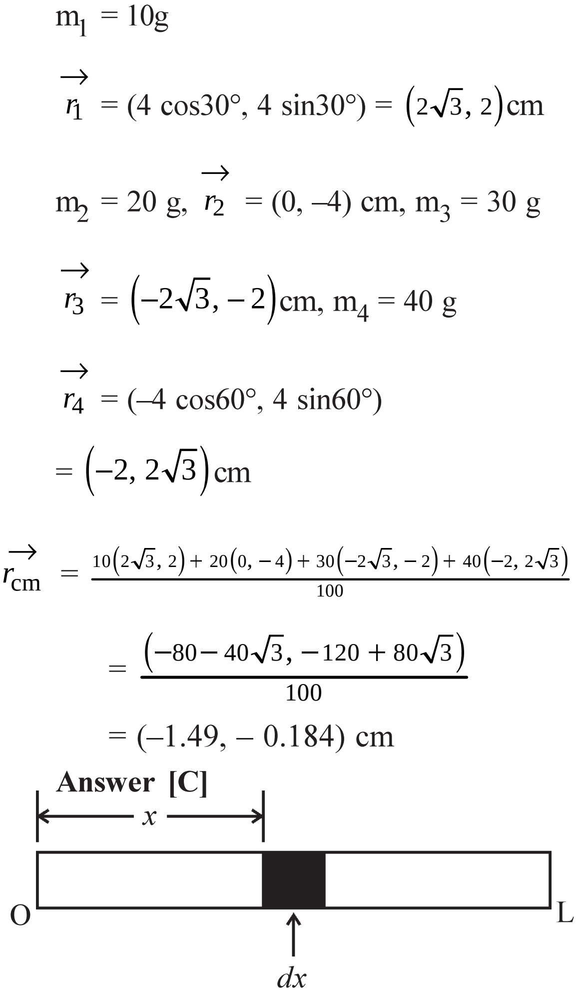
$= \left(-2, 2\sqrt{3}\right)$cm

$$\vec{r}_{cm} = \frac{10\left(2\sqrt{3}, 2\right) + 20\left(0, -4\right) + 30\left(-2\sqrt{3}, -2\right) + 40\left(-2, 2\sqrt{3}\right)}{100}$$

$$= \frac{\left(-80 - 40\sqrt{3}, -120 + 80\sqrt{3}\right)}{100}$$

$= (-1.49, -0.184)$ cm

(9) Answer [C]



$$x_{cm} = \frac{1}{M}\int_0^L x\, dm$$

Where $dm = \lambda dx$ = mass of rod with dx thickness

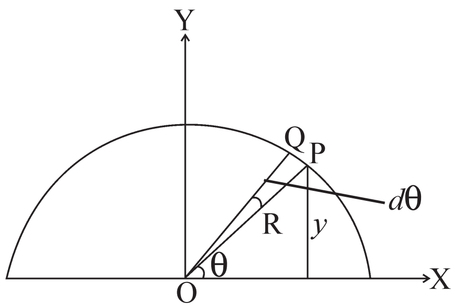
$$x_{cm} = \frac{1}{M}\int_0^L x\, \beta x\, dx$$

$$= \frac{\beta}{M}\int_0^L x^2\, dx = \frac{\beta}{M}\left[\frac{L^3}{3}\right] \quad ...(1)$$

$$\text{Now, } M = \int_0^L dm = \beta\int_0^L x dx = \frac{\beta L^2}{2} \quad ...(2)$$

$$\therefore\ x_{cm} = \frac{2\beta}{\beta L^2}\left[\frac{L^3}{3}\right] = \frac{2}{3}L$$

(10) Answer [A]



Here, centre of mass is on Y-axis because ring follows symmetry on X-axis.

$$\therefore\ y_{cm} = \frac{1}{M}\int y\, dm \quad ...(1)$$

For point P at height $y = R\sin\theta$ ...(2)

length of PQ is $Rd\theta$ So, its mass

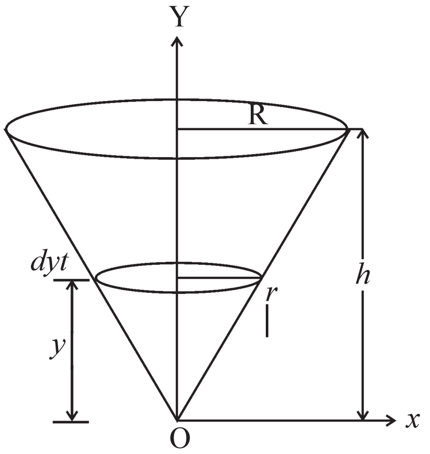
$$dm = \lambda R d\theta = \frac{M}{\pi}d\theta \quad ...(3) \quad \left(\because \lambda = \frac{M}{\pi R}\right)$$

$$y_{cm} = \frac{1}{M}\int_0^\pi R\sin\theta\, \frac{M}{\pi}d\theta$$

$$= \frac{R}{\pi}\int_0^\pi \sin\theta\, d\theta = \frac{R}{\pi}\left[-\cos\pi + \cos 0\right]$$

$$= \frac{2R}{\pi}$$

(11) **Answer [C]**



Here according to symmetry, center of mass is on Y-axis $y_{cm} = \frac{1}{M}\int y\, dm$ ...(1)

Considening cone distributed into cylindrical having subtle thickness. As in figure, the mass of cylindrical having thickness dy and radius r is $dm = \rho\, dV = \rho \cdot \pi r^2 dy$ ...(2)

total mass $M = \rho V = \rho \frac{\pi R^2 h}{3}$ ...(3)

$$\therefore y_{cm} = \frac{3}{\pi R^2 h}\int y \rho \pi r^2 dy$$

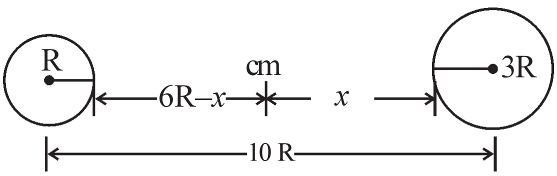
$$= \frac{3}{R^2 h}\int y r^2 dy \quad ...(4)$$

From figure $\frac{r}{y} = \frac{R}{h} \therefore r = \frac{Ry}{h}$ ...(5)

$$\therefore y_{cm} = \frac{3}{R^2 h}\int_0^h y \frac{R^2 y^2}{h^2} dy$$

$$= \frac{3}{h^3}\int_0^h y^3 dy = \frac{3}{h^3}\left[\frac{h^4}{4}\right] = \frac{3}{4}h$$

(12) **Answer [D]**



Taking centre of mass as starting point in absensence of external force it will remain sationary.

$m_1 \Delta x_1 = m_2 \Delta x_2$, M (6R – x) = 4M x

6MR – Mx = 4Mx ⇒ x = 1.2R

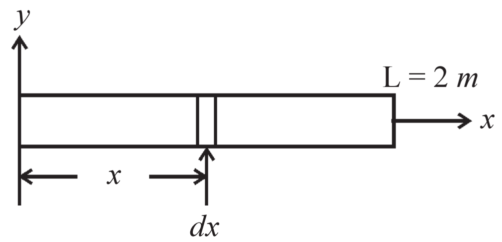
(13) **Answer [B]**

Here, assume that due to same density, three particles having same mass at the vertex of the triagle

$$\vec{r}_{cm} = \frac{m(0, 0) + m(x, 0) + m(0, y)}{3m}$$

$$= \left(\frac{x}{3}, \frac{y}{3}\right)$$

(14) **Answer [A]**



Here, According to symmetry

$x_{cm} = \frac{1}{M}\int x\, dm$ ...(1)

$dm = \lambda dx = (3 + x)dx$ ...(2)

$$M = \int_0^2 dm = \int_0^2 (3 + x)dx = \left(3x + \frac{x^2}{2}\right)_0^2$$

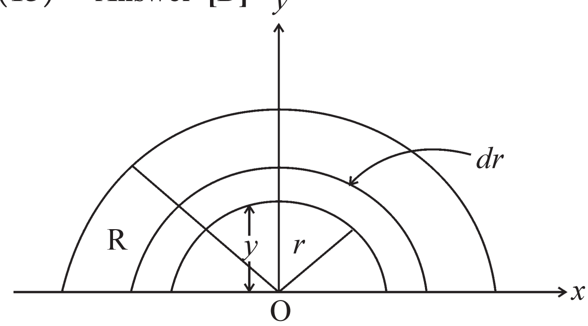
= 8 unit ...(3)

$$\therefore x_{cm} = \frac{1}{8}\int_0^2 x(3 + x)dx$$

$$= \frac{1}{8}\int_0^2 \left(3x + x^2\right)dx$$

$$= \frac{1}{8}\left(\frac{3x^2}{2} + \frac{x^3}{3}\right)_0^2 = \frac{26}{8 \times 3} = \frac{13}{12}\text{ m}$$

(15) **Answer [D]**



According to symmetry, center of mass is on Y-axis.

$y_{cm} = \frac{1}{M}\int y\, dm$ ...(1)

mass of unit area of disc $\sigma = \dfrac{M}{\frac{\pi R^2}{2}} = \dfrac{2M}{\pi R^2}$

From figure if center of mass at distance y for ring having radius r and thickness dr

then, $y = \dfrac{2r}{\pi}$ ...(2)

mass of ring having r radius and dr thickness

$dr = \dfrac{2Mr\,dr}{R^2}$ ...(3)

$dm = \sigma\, \pi r\, dr = \dfrac{2M}{\pi R^2}\, \pi r\, dr$

$$y_{cm} = \frac{1}{M}\int_0^R \frac{(2r)}{\pi}\frac{(2Mr)\,dr}{R^2}$$

$$= \frac{4}{\pi R^2}\int_0^R r^2\, dr = \frac{4}{\pi R^2}\left[\frac{R^3}{3}\right] = \frac{4R}{3\pi}$$

(16) Answer [C]

$m_1 = 2$ kg $m_2 = 4$ kg

$v_1 = 2\hat{i}\,\text{ms}^{-1}$ $v_2 = -\,3\hat{i}\,\text{ms}^{-1}$

$$\vec{v}_{cm} = \frac{m_1\vec{v}_1 + m_2\vec{v}_2}{m_1 + m_2}$$

$$= \frac{2(2\hat{i}) + 4(-3\hat{i})}{6} = \frac{4\hat{i} - 12\hat{i}}{6} = -\frac{4}{3}\hat{i}\,\text{ms}^{-1}$$

(17) Answer [D]

$$F = \frac{Gm_1m_2}{(r_1+r_2)^2} \quad a_2 = \frac{F}{m_2} = \frac{Gm_1}{(r_1+r_2)^2}$$

(18) Answer [C]

In absense of external force, center of mass remains stationary

$M\Delta r_{cm} = m_1\Delta r_1 + m_2\Delta r_2$

$0 = M\Delta r_1 + mx \Rightarrow \Delta r_1 = -\left(\dfrac{m}{M}\right)\cdot x$

(19) Answer [B]

$M\Delta r_{cm} = m_1\Delta r_1 + m_2\Delta r_2$

$0 = 90x + 60\,(10 - x)$

$90x = -\,(600 - 60x)$

$x = -\,4$m, 4m far away from rock

(21) Answer [B]

$m_1 = M$ $\Delta r_1 = 12$ cm

$m_2 = 4M$ $\Delta r_2 = ?$

$$\Delta r_2 = -\frac{m_1}{m_2}\,\Delta r_1 = -\frac{M}{4M}\times 12 = -\,3 \text{ cm}$$

(22) Answer [B]

$F_x = 4\cos 30° + 6\cos 60° + 0 + 2\cos 60°$

$= 4\times\dfrac{\sqrt{3}}{2} + 3 + 1 = 7.46$ N

$F_y = 4\sin 30° - 6\sin 60° + 7 - 2\sin 60°$

$= 4\times\dfrac{1}{2} - 6\times\dfrac{\sqrt{3}}{2} + 7 - 2\times\dfrac{\sqrt{3}}{2}$

$= 2.08$ N

$F = \sqrt{55.65 + 4.32} = 7.74$ N

$a_{cm} = \dfrac{F}{m} = \dfrac{7.74}{2.6} = 3\ \text{ms}^{-2}$

(23) Answer [C]

$$x_{cm} = \frac{mx + 2m\cdot 2x + 3m\cdot 3x + \ldots}{m + 2m + 3m + \ldots}$$

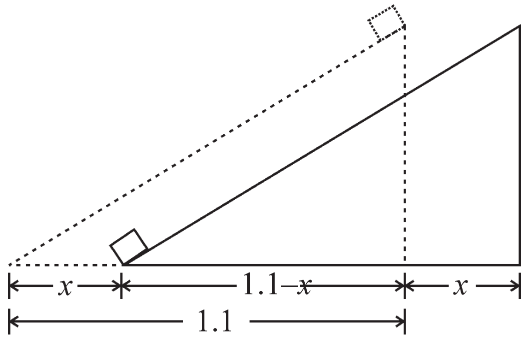
$$= \frac{mx\left[1 + 4 + 9 + \ldots + n^2\right]}{m\left[1 + 2 + 3 + \ldots + n\right]}$$

$$= \frac{x\left[(1)^2 + (2)^2 + (3)^2 + \ldots + n^2\right]}{1 + 2 + 3 + \ldots + n}$$

$$= \frac{x\left(n(n+1)(2n+1)\right)}{6\times\frac{n(n+1)}{2}} = \left(\frac{2n+1}{3}\right)x$$

(24) Answer [A]

Suppose, slope shifted by x in backside, means small block travel distance $1.1 - x$ in forward. Here there are no external force so,



$\Delta r_2 = \frac{m_1}{m_2} \cdot \Delta r_1$, m_1 = mass of small block = m

Δr_1 = displacement of small block = $1.1 - x$

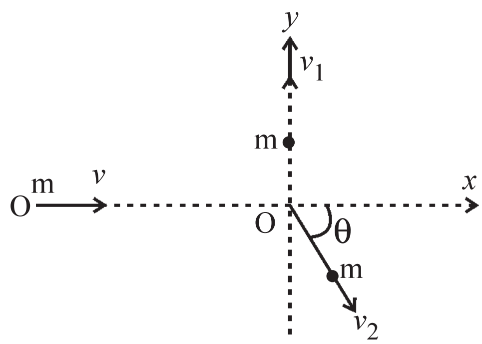
m_2 = mass of big block (slope) = 10m

Δr_2 = displacemont of big block (slope) = x

$$x = \frac{m}{10m}(1.1 - x)$$

$10x = 1.1 - x \Rightarrow 11x = 1.1 \therefore x = 0.1m$

(25) Answer [C]



According to conservation of momentum

Initial velocity = final velocity

on X-axis $mv = mv_2 \cos\theta$ ...(1)

$\therefore v_2 \cos\theta = v = 5 \text{ ms}^{-1}$

on Y-axis $0 = -mv_2 \sin\theta + mv_1$

$mv_1 = mv_2 \sin\theta$ ...(2)

$\therefore v_2 \sin\theta = v_1 = 3 \text{ ms}^{-1}$

$\therefore v_2 = \sqrt{25+9} = \sqrt{34} \text{ ms}^{-1}$

(26) Answer [C]

According to conservation of momentum

$mv = (M + m) v'$

v' = velocity of (block + bullet)

$$v' = \frac{mv}{M+m} = \frac{5 \times 10^{-2} \times v}{0.5 + 0.05}$$

$$= \frac{5 \times 10^{-2} v}{55 \times 10^{-2}} = \frac{v}{11} \quad ...(3)$$

Now, if system of (block + bullet) becomes steady after traveling the distance d then $2ad = v^2 - v_0^2$

$$2 \times 10 \times 1.1 = 0 - \frac{v^2}{121}$$

$\therefore v^2 = 2662, \therefore v = 51.6 \text{ ms}^{-1}$

(27) Answer [C]

If mass is m for unit area of plate then

mass of circular disc = $\frac{\pi d^2}{4}$m

mass of square disc = d^2m

Here $x_1 = 0$ = Taking center of mass for first square disc

$x_2 = d$ (for circular disc)

$x_3 = 2d$ (for second square disc)

$$x_{cm} = \frac{md^2(0) + \frac{\pi d^2}{4}md + d^2m2d}{2d^2m + \frac{\pi d^2}{4}m}$$

$$= \frac{\frac{\pi d^3}{4} + 2d^3}{d^2\left(2 + \frac{\pi}{4}\right)} = d$$

(28) Answer [D]

$$\Delta x_{cm} = \frac{m_1\Delta x_1 + m_2\Delta x_2}{m_1 + m_2}$$

$$1 = \frac{(5 \times 8) + 10\Delta x_2}{15}$$

$10\Delta x_2 = 15 - 40 \Rightarrow \Delta x_2 = -2.5$ cm

(29) Answer [B]

$m_1 = 40$ kg, $r_1 = 0$, $m_2 = 60$ kg, $r_2 = 5$ m

$m_3 = 50$ kg, $r_3 = 2.5$ m

Taking A end as a reference point, the initial position of center of mass for system is

$$r_{cm} = \frac{0 + 300 + 125}{150} = \frac{425}{150} = 2.8 \text{ m}$$

Now both person comes to centre of boat, the last position of centre of mass for system is 2.5 cm from A end. (center point of boat)

thus, $\Delta r_{cm} = 2.8 - 2.5 = 0.3$ A

(30) Answer [D]

$m_1 = m, \Delta r_1 = \frac{L}{2}, m_2 = M + m, \Delta r_2 = ?$

displacement of centre of mass of sphere having mass m is $\frac{L}{2}$.

$\therefore$ From $\Delta r_{cm} = \frac{m_1\Delta r_1 + m_2\Delta r_2}{m_1 + m_2}$

$$\Delta r_2 = -\frac{m_1}{m_2}\,\Delta r = -\,\frac{m}{M+m}\,\frac{L}{2}$$

(31) Answer [A]

mass of human $m_1 = 50$ kg, velocity of human v_1

mass of bag $m_2 = 20$ kg, velocity of bag v_2

According to conservation of momentum in horizontal direction

$$m_1v_1 = m_2v_2 \Rightarrow v_2 = \frac{m_1v_1}{m_2} \quad ...(1)$$

time required for human to come 100 m downward from top

$$d = v_o t + \frac{1}{2}at^2,\ t = \sqrt{\frac{2d}{a}}$$

$$t_1 = \sqrt{\frac{2\times 100}{10}} = 4.47 \text{ s}$$

time required for human to come 20 m distance downward from top

$$t_2 = \sqrt{\frac{2\times 20}{10}} = 2 \text{ s}$$

time required for human to travel remaining 80 m distance

$t = 4.47 - 2 = 2.47$ s ...(2)

0.5 m distance travelled by human with velocily v_1 in time t in the horizontal direction So,

$$0.5 = v_1 t,\ \therefore\ v_1 = \frac{0.5}{2.47} = 0.202 \text{ ms}^{-1} \quad ...(3)$$

from equation (1),

$$v_2 = \frac{50}{20}\times 0.202 = 0.5 \text{ ms}^{-1}$$

(33) Answer [A]

$$\omega_0 = 0,\quad \omega = \frac{v}{r} = \frac{50\pi}{10} = 5\pi \text{ rad s}^{-1}$$

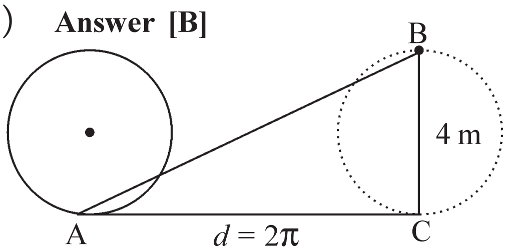
$$\theta = 2\pi\times 2.5 = 5\pi \text{ rad}$$

$$\text{From } \theta = \frac{\omega^2 - \omega_0^2}{2\alpha},$$

$$\alpha = \frac{25\pi^2}{10\pi} = 2.5\pi \text{ rad s}^{-2}$$

$$a_T = \alpha r = 2.5\pi\times\frac{10}{\pi} = 25 \text{ ms}^{-2}$$

(34) Answer [B]



$r = 2$m, $d = r\theta = 2\pi$ m, $\theta = \pi$ rad

$$\therefore\ AB = \sqrt{4\pi^2 + 16} = 2\sqrt{\pi^2 + 4}$$

(35) Answer [B]

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2 = 8 + \frac{1}{2}\times 3\times(4)^2$$

$= 32$ rad

(36) Answer [C]

Velocity of contact point is zero and ω of the three points equal so, relative to contact point.

$r_A < r_B < r_C \Rightarrow v_A < v_B < v_C$

(37) Answer [C]

$\omega_0 = 0,$

$$\omega = 500\ rpm = \frac{500\times 2\pi}{60} = \frac{50\pi}{3} \text{ rad s}^{-1}$$

$$\alpha = \frac{\omega - \omega_0}{t} = \frac{\frac{50\pi}{3} - 0}{4} = \frac{50\pi}{12} \text{ rad s}^{-2}$$

$$\omega' = 250\ rpm = \frac{25\pi}{3} \text{ rad s}^{-1}$$

from $\omega' = \omega_0 + \alpha t$,

$$t = \frac{\omega'}{\alpha} = \frac{25\pi}{3}\times\frac{12}{50\pi} = 2 \text{ s}$$

or

$\omega_0 = 0$ and if α = constant then,

$$\omega \propto t \qquad \frac{\omega_2}{\omega_1} = \frac{t_2}{t_1}$$

$$t_2 = \frac{\omega_2}{\omega_1}t_1 = \frac{250}{500}\times 4 = 2\text{s}$$

(38) Answer [C]

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2,\ 3 = 0 + \frac{1}{2}\alpha(1)^2$$

$\therefore\ \alpha = 6$ rad s^{-1}, for $t = 2$ s,

$$\theta = 0 + \frac{1}{2}\times 6\times(2)^2 = 12 \text{ rad}$$

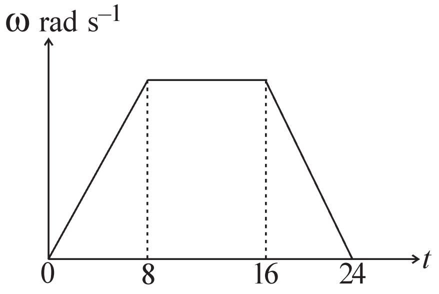
displacement in 2nd second = 12–3=9 rad.

(39) Answer [B]

$$\theta = \left(\frac{\omega + \omega_0}{2}\right)t$$

$$\omega = \frac{2\theta}{t} = \frac{2 \times 50 \times 2\pi}{4} = 50\pi \text{ rad s}^{-1}$$

(40) Answer [A]



θ = Area enclosed by $\omega \rightarrow t$ graph

$$= 2\left(\frac{1}{2} \times 8 \times 24\right) + (8 \times 24) = 384 \text{ rad}$$

(41) Answer [D]

$$a_r = \omega v = \frac{\omega^2}{r} = \frac{100}{2} = 50 \text{ cms}^{-2}$$

$$a_T = r\,\alpha = 5 \times 2 = = 10 \text{ cms}^{-2}$$

$(\because\ \omega = \omega_0 + \alpha t = 0 + 10 = 10 \text{ rad s}^{-1})$

(42) Answer [B]

$$I = 3(OA)^2 + 5(OB)^2 + 6(OC)^2 + 2(OD)^2$$

$$= \frac{1}{2}\ [3 + 5 + 6 + 2]$$

$$= 8 \text{ kg m}^2\ (\because\ OA = OB = OC = OD = \frac{1}{\sqrt{2}})$$

(43) Answer [A]

$$I = 3(0) + 5(AB)^2 + 6(DC)^2 + 2(0)$$
$$= 5(1)^2 + 6(1)^2 = 11 \text{ kg m}^2$$

(44) Answer [C]

$$I = 3\ (OA)^2 + 5(0) + 6(OC)^2 + 2(0)$$

$$= \frac{1}{2}\ (3 + 6\ ) = 4.5 \text{ kg m}^2$$

(45) Answer [D]

$$I = \frac{1}{2}\ MR^2 = \frac{1}{2} \times 10 \times 4 \times 10^{-2} = 0.2 \text{ kg m}^2$$

$$\alpha = \frac{\omega - \omega_0}{t} = \frac{\frac{200 \times 2\pi}{60} - 0}{15} = 0.44\pi \text{ rad s}^{-2}$$

$\tau = I\alpha,\ \therefore\ FR = I\alpha$

$$\therefore\ F = \frac{I\alpha}{R} = \frac{0.2 \times 0.44\pi}{0.2} = 0.44\pi \text{ N}$$

(46) Answer [D]

$$I = \frac{1}{2}\ MR^2 = \frac{1}{2} \times 5 \times 16 \times 10^{-2} = 0.4 \text{ kg m}^2$$

$$L = I\omega = 0.4 \times \frac{30 \times 2\pi}{60} = 0.4\pi \text{ Js}$$

$$\tau = \frac{dL}{dt} \text{ where } dL = 20\ \% \text{ of } L$$

$$= \frac{0.08\pi}{5} = 0.016\pi \text{ Nm}$$

(47) Answer [A]

$$K_R = \frac{1}{2}\ I\left(\omega_2^2 - \omega_1^2\right)$$

$$\therefore\ I = \frac{2K_R}{\left(\omega_2^2 - \omega_1^2\right)}$$

$$= \frac{2 \times 1500 \times 3600}{\left(625 - 100\right) \times 10^4 \times 4\pi^2} = 0.052 \text{ kg m}^2$$

(48) Answer [C]

For large disc, $I_1 = \frac{1}{2}\ M_1R_1^{\,2} = 0.04 \text{ kg m}^2$

For small disc, $I_2 = \frac{1}{2}\ M_2R_2^{\,2} = 0.045 \text{ kg m}^2$

total angular momentum of two disc

$L = I_1\omega_1 + I_2\omega_2 = (0.04 \times 50) + (0.045 \times 250)$

$= 2 + 11.25 = 13.25$ Js

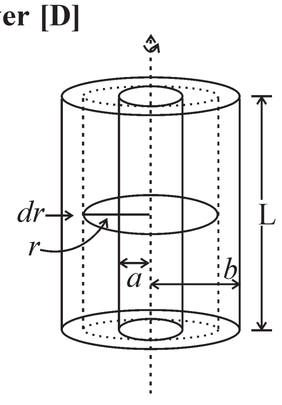
For joint system $I' = I_1 + I_2 = 0.085 \text{ kg m}^2$

According to conservation of angular momentum final angular momentum L' = L

$I'\omega' = 13.25$

$$\omega' = \frac{13.25}{0.085} = 153 \text{ rad s}^{-1}$$

(50) Answer [D]



mass of cylinder of radius r with thickness dr and length L, as shown in figure.

$dm = 2\pi\, r\, dr\, L\, \rho$ ...(1)

moment of inertia with respect to its axis

$dI = 2\pi\, r\, dr\, L\, \rho\, r^2$

$= 2\pi\, L\, \rho\, r^3 dr$ ...(2)

$\therefore$ moment of inertia for cylinder

$$I = 2\pi L \rho \int_a^b r^3\, dr = 2\pi L \rho \left[\frac{b^4 - a^4}{4}\right]$$

(51) Answer [A]

For main disc $I = \frac{1}{2} MR^2$

According to symmetry $\frac{1}{6}^{th}$ part of moment of inertia

$I' = \frac{1}{6} \times \frac{1}{2} MR^2 = \frac{1}{12} MR^2$

(52) Answer [C]

$l = 2\pi R \qquad I = I_C + Md^2$

$\therefore R = \frac{l}{2\pi} \qquad = \frac{1}{2} MR^2 + MR^2 = \frac{3}{2} MR^2$

$M = \lambda l \qquad = \frac{3}{2} \times \lambda l \times \frac{l^2}{4\pi^2} = \frac{3\lambda l^3}{8\pi^2}$

(54) Answer [A]

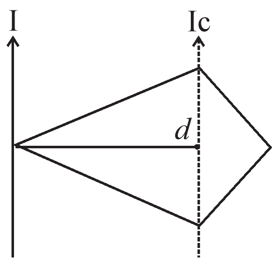
$$I = 4[I_C + md^2] = 4\left[\frac{ml^2}{12} + m\left(\frac{l}{2}\right)^2\right]$$

$$= 4\left[\frac{ml^2}{12} + \frac{ml^2}{4}\right]$$

$\therefore I = \frac{4}{3} ml^2$

(55) Answer [D]

$I = I_C + Md^2$



$= \frac{ml^2}{6} + \frac{ml^2}{2} \qquad (\because d = \frac{l}{\sqrt{2}})$

$= \frac{4}{6} ml^2 = \frac{2}{3} ml^2$

(57) Answer [D]

moment of inertia with respect to axis passing through O point of main disc

$I = \frac{1}{2}(4M)R^2 = 2\, MR^2$ ...(1)

radius of small disc $= \frac{R}{4}$

mass of small disc $= \frac{4M}{16} = \frac{M}{4} \quad (\because M \propto R^2)$

moment of inertia with respect to axis passing through center of small disc

$I_C = \frac{1}{2}\left(\frac{M}{4}\right)\left(\frac{R^2}{16}\right) = \frac{MR^2}{128}$ ...(2)

moment of inertia with respect to axis passing through O of small disc

$I_o = I_C + Md^2 = \frac{MR^2}{128} + M\frac{9R^2}{16}$

$= \frac{73}{128} MR^2$ ...(3)

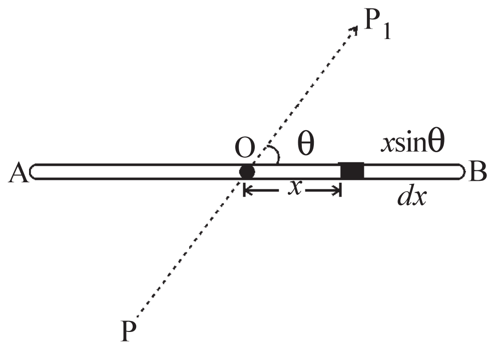
$I_{total} = I_{small\ disc} + I_{remaining\ part}$

$I_{remaining\ part} = I_{total} - I_{small\ disc}$

$= 2MR^2 - \frac{73}{128} MR^2$

$= \frac{183}{128} MR^2 = 1.43\, MR^2$

(58) Answer [B]



mass of element of thickness dx as shown in figure, $dm = \frac{m}{l} dx$

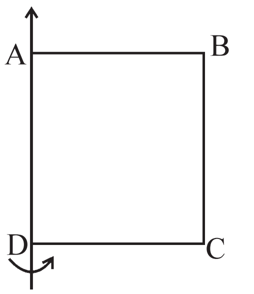
Perpendicular distance from axis $= x \sin\theta$

$\therefore$ moment of inertia $= dI = \frac{m}{l} dx\, x^2 \sin^2\theta$

$$I = \int_{-l/2}^{l/2} dI = \frac{m}{l} \sin^2\theta \int_{-l/2}^{l/2} x^2\, dx$$

$$= \frac{m}{l} \sin^2\theta \left[\frac{l^3}{24} + \frac{l^3}{24}\right] = \frac{ml^2 \sin^2\theta}{12}$$

(59) Answer [A]



Assume that length of AB is x. So, length of BC becomes $4x$ Here, circumference $2x + 8x = 4l$

$$x = 0.4l \qquad ...(1)$$

$$I = 2I_{AB} + I_{BC} = 2\left[\tfrac{1}{3}m_1x^2\right] + 4m_2x^2$$

$$= \tfrac{2}{3} \times 0.4\text{m} \times (0.4l)^2 + 1.6\text{m}(0.4l)^2$$

$$= 0.042\text{m}l^2 + 0.256\text{m}l^2 = 0.298\text{m}l^2 \approx 0.3\text{m}l^2$$

(60) Answer [C]

$$V = \tfrac{4}{3}\pi R^3, \frac{\Delta V}{V} = 3\frac{\Delta R}{R}, \frac{\Delta R}{R} = \frac{1}{3}\left(\frac{\Delta V}{V}\right)$$

$$\therefore \frac{\Delta R}{R} \times 100\,\% = \text{increse of } 2\,\%$$

Now $I = \tfrac{2}{5}MR^2$

$$I \propto R^2, \therefore \frac{\Delta I}{I} \times 100\,\% = 2\frac{\Delta R}{R} \times 100\,\%$$

$= 2\ (2\ \%) =$ increase of 4%

Now according to $L = I\omega =$ constant, increase of 4% in I

So, decrease of 4 % in ω.

(61) Answer [D]

According to conservation of angular momentum

$L_1 = L_2$, $0 = mvr + I\omega$

$$\omega = -\frac{mvr}{I} = -\frac{60 \times 2 \times 1.5}{150} = 1.2$$

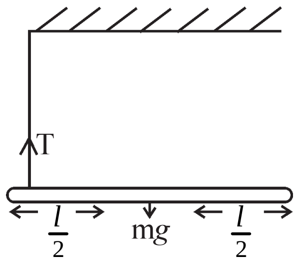
(62) Answer [B]

In pure rotational motion P is consider as stationary. So, rotational motion of sphere with respect to axis which passing throught point P and parallel to surface.

$$\text{Thus, } I = \tfrac{2}{3}MR^2 + MR^2 = \tfrac{5}{3}MR^2 \qquad ...(1)$$

$$\tau = 2RF, I\alpha = 2RF, \ \alpha = \frac{2RF}{\frac{5}{3}MR^2} = \frac{6}{5}\ \frac{F}{MR}$$

(63) Answer [A]



For linear motion $mg - T = ma$

$$T = mg - ma \qquad ...(1)$$

For rotational motion, $\tau = I\alpha$

$$\alpha = \frac{\tau}{I} = \frac{\frac{l}{2}mg}{\frac{1}{3}ml^2} = \frac{3}{2}\ \frac{g}{l} \qquad ...(2)$$

From contact acceleration $a_T = \alpha r$,

$$a = \frac{l}{2}\ \frac{3}{2}\ \frac{g}{l} = \frac{3}{4}g \qquad ...(3)$$

$$\therefore \text{ from equation (1), } T = mg - \tfrac{3}{4}mg = \tfrac{1}{4}mg$$

(64) Answer [B]

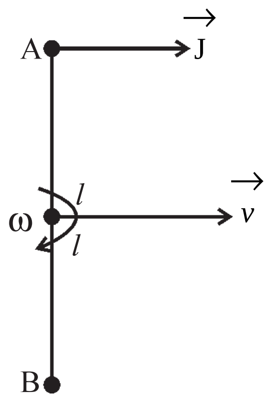
The rate of change in momentum of ball having mass m.

$\Delta p = mv_0 = p$ $\qquad (\because P_0 = 0)$

Now, $L = I\omega$, $h \cdot p = \frac{2}{5}mr^2\omega$

$$h\cancel{m}v_0 = \frac{2}{5}\cancel{m}r^2\omega \Rightarrow \omega = \frac{5}{2}\ \frac{hv_0}{r^2}$$

(65) Answer [A]



If the velocity of center of mass is v then,

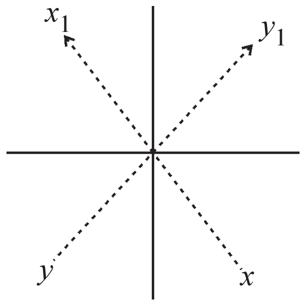
$$J = 2mv, \ v = \frac{J}{2m} \qquad ...(1)$$

from $L = I\omega$,

$$\omega = \frac{L}{I} = \frac{l \cdot 2mv}{2ml^2} = \frac{lJ}{2ml^2} = \frac{J}{2ml} \qquad ...(2)$$

$v_A = v + I\omega = \frac{J}{2m} + \frac{lJ}{2ml} = \frac{J}{2m} + \frac{J}{2m} = \frac{J}{m}$

(66) Answer [C]



Moment of inertia with respect to axis which passing through intersection point of both rod and perpendicular to surface is $I_C = I_1 + I_2$

$= \frac{1}{12} ml^2 + \frac{1}{12} ml^2 = \frac{ml^2}{6}$ ...(1)

According the theorem of perpendicular axis

$I_C = I_{xx'} + I_{yy'}$

$= 2 I_{xx'}, \therefore\ I_{xx'} = \frac{I_C}{2} = \frac{1}{12} ml^2$

(67) Answer [D]

moment of inertia with respect to axis of square disc

$I_{square} = \frac{M}{12}\ [16R^2 + 16R^2] = \frac{8}{3} MR^2$ ...(1)

mass of one small circular dics $= m = \frac{M}{16R^2}\ \pi R^2$

$= \frac{M\pi}{16}$ ...(2)

From moment of inertia with respect to axis of small circular disc. $I_{disc} = I_C + md^2$,

$I_{disc} = \frac{1}{2}\ mR^2 + m\left(\sqrt{2}\,R\right)^2$

$= \frac{5}{2} mR^2$ ...(3)

total moment of inertia for all of four discs

$4I_{disc} = 10mR^2$ ...(4)

moment of inertia for remaining part

$I_{remaining} = I_{square} - 4I_{disc}$

$= \frac{8}{3} MR^2 - 10\, mR^2$

$= \frac{8}{3} MR^2 - 10\left(\frac{M\pi}{16}\right) R^2 = \left(\frac{8}{3} - \frac{5\pi}{8}\right) MR^2$

(68) Answer [B]

Here, both spheres are in contact with rod. So, its velocity in horizontal direction are same.

$\therefore\ 8\cos 60° = v\cos 30°,\ v = \frac{8}{\sqrt{3}}\ ms^{-1}$

Speed of B relative to A, $v_{BA} = v_B - v_A$

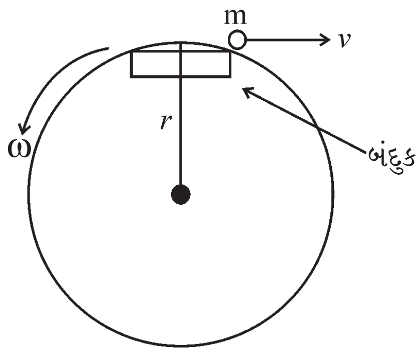
$= v\sin 30° - 8\,sin 60°$

$= \frac{8}{\sqrt{3}} \times \frac{1}{2} - 8 \times \frac{\sqrt{3}}{2}$

$= \frac{4}{\sqrt{3}} - 4\sqrt{3} = \frac{-8}{\sqrt{3}}\ ms^{-1}$

$\omega = \frac{v_{BA}}{r} = \frac{8}{\sqrt{3} \times 1} = \frac{8}{\sqrt{3}}\ rad\ s^{-2}$

(69) Answer [A]



Initial angular momentum of system

$L_i = (I_0 + mr^2)\,\omega_0$ ...(1)

final angular momentum of system

$L_f = I_0\omega - m\,(v - \omega r)r$

$= I_0\omega - mvr + m\omega r^2$

$= \omega(I_0 + mr^2) - mvr$ ...(2)

$L_i = L_f$

$(I_0 + mr^2)\omega_0 = (I_0 + mr^2)\omega - mvr$

$(\omega - \omega_0)\,(I_0 + mr^2) = mvr$

$\omega - \omega_0 = \frac{mvr}{I_0 + mr^2}$

(70) Answer [C]

Suppose velocity of rod is v after impact then accarding to conservation of momentum,

$mv_0 = Mv$ ...(1)

According to conservation of angular momentum,

$mv_0 x = \frac{ML^2}{12}\,\omega$ ...(2)

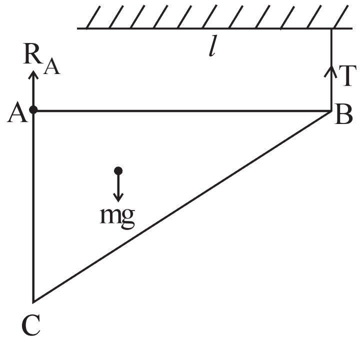
Steady point A, Velocity v should mantain in backward direction. So,

$v = \frac{L}{2}\,\omega$ ...(3)

$M v x = \frac{ML^2}{12}\omega$ putting values in equation (2))

$\frac{L}{2}\omega x = \frac{L^2}{12}\omega \Rightarrow x = \frac{L}{6}$

(71) Answer [B]



If tension force T generated in string then torque near Bend with respect to point A = Tl ...(1)

$I_{AB} = I_{AC} = \frac{Ml^2}{6}$,

$I_A = 2I_{AC}$ (Theorem of perpendicular axis = $\frac{Ml^2}{3}$

Also, $\tau = I_A\alpha = I_A \frac{a}{r}$

$= \frac{Ml^2}{3}\frac{g}{l} = \frac{Mgl}{3}$ ...(2)

From (1) and (2), $Tl = \frac{Mgl}{3}$

$\therefore T = \frac{Mg}{3}$ ...(3)

For vertical equilibrium $R_A + T = Mg$

$R_A = Mg - \frac{Mg}{3} = \frac{2}{3}Mg$

(72) Answer [D]

$\frac{2}{5}MR^2 = \frac{3}{2}Mr^2 \Rightarrow r = \frac{2}{\sqrt{15}}R$

(73) Answer [B]

$\alpha = \frac{\omega - \omega_0}{t} = \frac{\frac{90 \times 2\pi}{60} - 0}{30} = \frac{\pi}{10}$ rad s^{-2}

$\tau = I\alpha = 2.5 \times \frac{\pi}{10} = \frac{\pi}{4}$ Nm

(74) Answer [C]

If I_z is the moment of inertia with respect to perpendicular to surface of plate and axis passing through center then, axis $I_z = I_x + I_y$

$= 2I_x$ $\quad (\because I_x = I_y)$

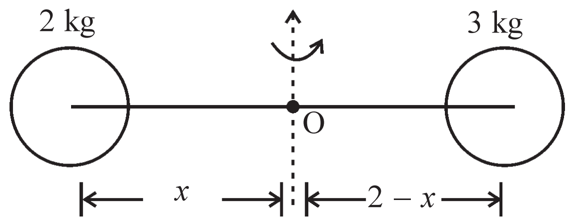
Also, $I_z = I_{PP'} + I_{QQ'}$

$= 2\,I_{PP'}$ ...(2)

From (1) and (2)

$2I_x = 2\,I_{PP'} \Rightarrow I_{PP'} = I_x = I$

(75) Answer [A]



moment of inertia with respect to axis passing through O point. $I = 2x^2 + 3\,(2 - x)^2$

$\frac{dI}{dx} = 4x + [3 \times 2\,(2 - x)(-1)] = 4x - 12 + 6x.$

Now for minimum work, $\frac{dI}{dx} = 0$

$\therefore 4x - 12 + 6x = 0$

$x = 1.2$ m (with 2 kg mass)

(76) Answer [D]

$I_1 = I_2 = I_3 = I_4 = \frac{I_0}{2}$

I_0 = moment of inertia with respect to axis perpendicular to surface and passing through O point.

(77) Answer [B]

$MR^2\omega = [MR^2 + mR^2)\omega'$

$\omega' = \frac{M}{M + m}\omega$

(78) Answer [C]

$L = L_{linear} + L_{rotational\ motion}$

$= MvR + I\omega = M\omega R^2 + MR^2\omega = 2MR^2\omega$

(79) Answer [D]

An axis parallel to Z-axis and at 2R distance on X-axis. So, according to theorem of parallel axis,

$I_1 = I_Z + Md^2 = \frac{1}{2}MR^2 + M(2R)^2$

$= \frac{9}{2}MR^2$ ...(1)

Also, $I_Z = 2I_x$ (theorem of perpendicular axis),

$\frac{1}{2}MR^2 = 2I_x$

$\therefore I_x = \frac{1}{4}MR^2$ ...(2)

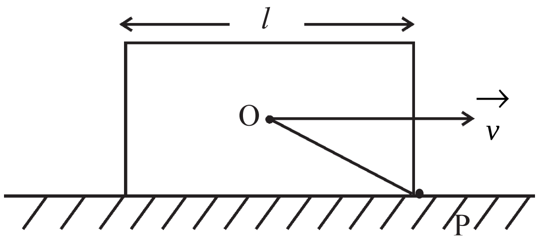
Now, axis passing through $(y, 0)$ is parallel to x-axis. So,

$$I_2 = I_x + Md^2 = \frac{1}{4} MR^2 + My^2 \quad ...(3)$$

$$I_1 = I_2, \frac{9}{2} MR^2 = \frac{1}{4} MR^2 + My^2$$

$$My^2 = \frac{17}{4} MR^2 \Rightarrow y = \frac{\sqrt{17}}{2} R$$

(80) Answer [A]



$$OP = r = \frac{\sqrt{2}l}{2} = \frac{l}{\sqrt{2}}$$

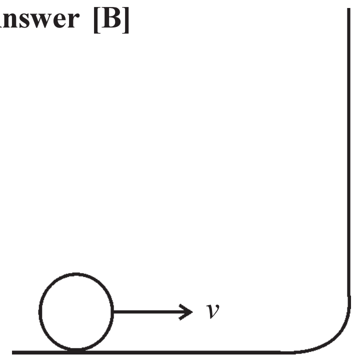
Here, torque is zero with respect to P point. So, according to conservation of angular momentum

$$mv\frac{l}{2} = I_P\omega = (I_0 + md^2)\omega$$

$$mv\frac{l}{2} = \left(\frac{ml^2}{6} + \frac{ml^2}{2}\right)\omega \quad (\because d = r)$$

$$\omega = \frac{3}{4}\frac{v}{l}$$

(82) Answer [B]



According to law of energy conservation,

$$\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mgh$$

$$\frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{3}mR^2\frac{v^2}{R^2}\right) = mgh$$

$$\frac{1}{2}mv^2\left(1 + \frac{2}{3}\right) = mgh \Rightarrow h = \frac{5}{6}\frac{v^2}{g}$$

(83) Answer [C]

$$\frac{1}{2}mv^2 + \frac{1}{2}I\left(\frac{v^2}{R^2}\right) = mg\left(\frac{3}{4}\frac{v^2}{g}\right)$$

$$\frac{Iv^2}{R^2} = m\left(\frac{3}{2} - 1\right)v^2 \Rightarrow I = \frac{1}{2}mR^2 \therefore \text{disc}$$

(85) Answer [D]

The velocity of small sphere becomes v when reached at bottom of large sphere.

Then, total kinetic energy $= \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

$$= \frac{1}{2}mv^2 + \frac{1}{2} \times \frac{2}{5}mv^2$$

$$= \frac{7}{10}mv^2 \quad ...(1)$$

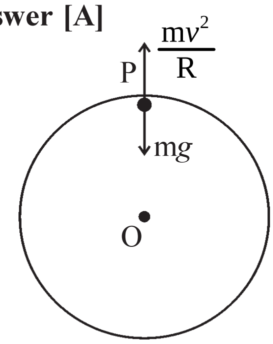
Now, according to energy conservation,

$$\frac{7}{10}mv^2 = mg(R - r)$$

$$v = \left(\frac{10}{7}g(R - r)\right)^{\frac{1}{2}}$$

$$\text{Now, } \omega = \frac{v}{R - r} = \left(\frac{10g}{7(R - r)}\right)^{\frac{1}{2}}$$

(86) Answer [A]



As depicted in figure, the acting weitage mg and pseudo centrifugal force $\frac{mv^2}{R}$ at the top point of loop.

If minimum velocity of sphere is v then at point P

$$\frac{mv^2}{R} = mg \Rightarrow v = \sqrt{gR} \quad ...(1)$$

Now, total kinetic energy of sphere at point P is

$$= \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = \frac{7}{10}mv^2 \quad ...(2)$$

$$\therefore K_{net} = \frac{7}{10}mgR \quad ...(3) \text{ (from equation (2))}$$

Now when sphere reached at point P then decrease in its height is $h-2R$. So, according to energy conservation.

$$\frac{7}{10}mgR = mg(h-2R) \Rightarrow h = 2R + \frac{7}{10}R = 2.7R$$

(87) Answer [A]

In (i), initially due to rough surface it rolls. So, no used energy, to oppose friction. In (ii), little rolling over rough surface. So, loss of its energy.

(88) Answer [C]

For solid sphere $v^2 = \frac{2gh_1}{1+\frac{2}{5}} = \frac{10}{7}\ gh_1$

For solid cylinder $v'^2 = \frac{2gh_2}{1+\frac{1}{2}} = \frac{4}{3}\ gh_2$

Here $v = v'$ So, $\frac{10}{7}\ gh_1 = \frac{4}{3}\ gh_2$

$$\frac{h_1}{h_2} = \frac{14}{15}$$

(89) Answer [B]

velocity of sphere when it reaches at B point.

$$v = \sqrt{\frac{2gh}{1+\frac{k^2}{R^2}}} = \sqrt{\frac{10gh}{7}} \qquad ...(1)$$

Rotational energy at B point

$$K_R = \frac{1}{2}I\omega^2 = \frac{k^2}{R^2}\left(\frac{1}{2}mv^2\right)$$

$$= \frac{2}{5} \times \frac{1}{2}m \times \frac{10gh}{7} = \frac{2}{7}mgh \qquad ...(2)$$

Now, no increment in Rotational energy during B to C. So, at point C, $K_R = \frac{2}{7}mgh$ ...(3)

But, linear kinetic energy increases. So, linear kinetic energy at point C is $K_T = K_{AB} + K_{BC}$

$$= \frac{1}{2}m\left(\frac{2gh}{1+\frac{k^2}{R^2}}\right) + mgh$$

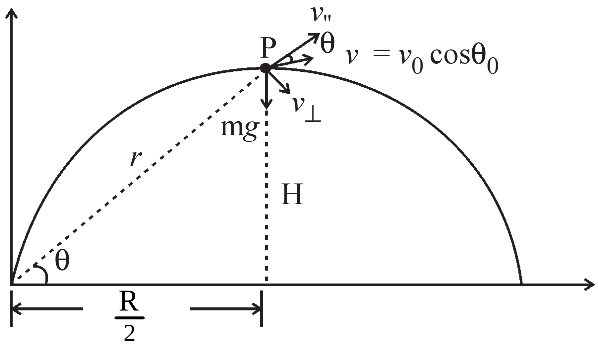
$$= \frac{5}{7}mgh + mgh = \frac{12}{7}\ mgh \qquad ...(4)$$

$$\frac{K_T}{K_R} = 6$$

(90) Answer [D]

$$m\omega^2 r \le \mu mg,\ r \le \frac{\mu g}{\omega^2}$$

(103) Answer [C]



$$\theta_0 = 45°,\ v_0 = 10\sqrt{2}\ ms^{-1},\ H = \frac{v_0^2\sin^2\theta_0}{2g}$$

$$= \frac{100 \times 2}{2 \times 2 \times 10} = 5\ m$$

$$R = \frac{v_0^2\sin 2\theta_0}{g} = \frac{100 \times 2}{10} = 20\ m$$

If position vector of P point with respect to starting point is r then torque with respect to starting point is $\tau = rF$

$$= \frac{R}{2}mg = 10 \times 0.5 \times 10 = 50\ SI$$

angular momentum L = linear momentum × perpendicular distance of applicable line of linear momentum from the junction point.

$$= mvH$$

$$= mv_0\cos\theta_0 H$$

$$= 0.5 \times 10\sqrt{2} \times \frac{1}{\sqrt{2}} \times 5 = 25\ SI$$

$$\omega = \frac{v_{\perp}}{r} = \frac{v\sin\theta}{r} = \frac{vH}{r \cdot r} \qquad \left(\because \sin\theta = \frac{H}{r}\right)$$

$$= \frac{vH}{\frac{R^2}{4}+H^2} = \frac{10 \times 5}{100+25} = 0.4\ SI$$

●

6 Gravitation

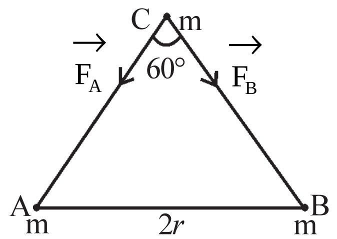
(1) Answer [A]

(A) Here $m_1 = m_2 = 2\text{kg}$, $r = 20 \text{ cm} = 0.2 \text{ m}$

$$\therefore F = \frac{Gm_1 m_2}{r^2} = \frac{(6.67 \times 10^{-11})(2)(2)}{(0.2)^2}$$

$$= 6.67 \times 10^{-9} \text{ N}$$

(2) Answer [D]



Three equal mass of m kg are placed at the three vertices of equilateral triangle having length $2r$.

Here, $F_A = F_B = \frac{Gm^2}{(2r)^2} = \frac{Gm^2}{4r^2}$

$\therefore$ The resultant force on particle having mass m on vertex point C.

$$F = \sqrt{F_A^2 + F_B^2 + 2F_A F_B \cos 60°}$$

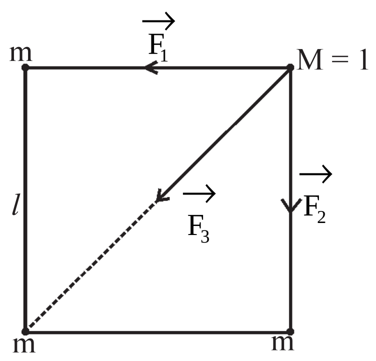
($\because$ angle between $\vec{F_A}$ and $\vec{F_B}$ is 60°)

$$= \sqrt{F_A^2 + F_A^2 + 2F_A^2\left(\frac{1}{2}\right)}$$

($\because F_A = F_B$, $\cos 60° = \frac{1}{2}$)

$$= \sqrt{3}\ F_A = \sqrt{3}\ \frac{Gm^2}{4r^2}$$

(3) Answer [C]



Here, $F_1 = F_2 = \frac{Gm}{l^2}$

Value of resulting force of $\vec{F_1}$ and $\vec{F_2}$

$$F' = \sqrt{2}\ \frac{Gm}{l^2}, \ (\because F' = \sqrt{F_1^2 + F_2^2 + 2F_1F_2 \cos 90°})$$

$$F_3 = \frac{Gm}{(\sqrt{2}\,l)^2} = \frac{Gm}{2l^2}$$

Here F_3 and F' are in same direction.

$\therefore$ their resulting force (value)

$$F = \sqrt{2}\ \frac{Gm}{l^2} + \frac{Gm}{2l^2} = \frac{Gm}{l^2}\left(\sqrt{2} + \frac{1}{2}\right)$$

(4) Answer [D]

Suppose mass of each sphere of brass is M and density is ρ.

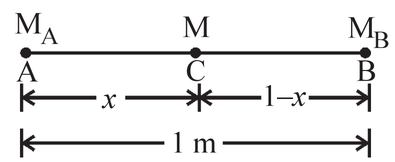
$\therefore M = \frac{4}{3}\pi R^3 \rho$ ($\because$ mass = volume × density)

Now, gravitational force acting between both spheres

$$F = \frac{GMM}{(2R)^2} = \frac{GM^2}{4R^2} = \frac{G\left(\frac{4}{3}\pi R^3\right)^2}{4R^2}$$

$$= \frac{4}{9}\pi^2 G \rho^2 R^4$$

$\therefore F \propto R^4$ ($\because$ G, ρ constant)



(5) Answer [A]

Suppose particle C is placed at a distance x m from particle A.

gravitational force acting between A and C,

$$F_{AC} = \frac{G M_A M}{x^2}$$

gravitational acting force between B and C,

$$F_{BC} = \frac{G M_B M}{(1-x)^2}, \text{ But } F_{AC} = \frac{1}{5} F_{BC}$$

$$\therefore \frac{G M_A M}{x^2} = \frac{1}{5} \frac{G M_B M}{(1-x)^2}$$

$$\therefore \frac{M_A}{M_B} = \frac{1}{5} \frac{x^2}{(1-x)^2}$$

$$\therefore \frac{4}{5} = \frac{1}{5} \frac{x^2}{(1-x)^2} \quad (\because M_A : M_B = 4 : 5)$$

$$\therefore 2(1-x) = x \Rightarrow 2 - 2x = x$$

$$\Rightarrow 3x = 2 \ \therefore x = \frac{2}{3} \text{ m}$$

(6) **Answer [A]**

$$F = \frac{G M_1 M_2}{r^2} \text{ and } F' = \frac{G M_1 M_2}{r'^2}$$

$$\therefore \frac{F'}{F} = \frac{r^2}{r'^2} \Rightarrow \frac{F'}{F} = \frac{r^2}{r'^2} \quad (\therefore F' = 2F)$$

$$\therefore 2 = \frac{r^2}{r'^2} \Rightarrow r' = \frac{r}{\sqrt{2}} = 0.707\, r$$

$$\therefore r' = (1 - 0.293)\, r = r - 0.293\, r$$
$$= r - 29.3\%\, r$$

$\therefore$ distance should reduced by 29.3 %

(7) **Answer [B]**

Gravitational force acting on the object having mass m at height h from earth's surface is $F' = \frac{GMm}{(R+h)^2}$ Where M = mass of earth and gravitational force acting on the object at sea level (surface of earth) is

$$F = \frac{GMm}{R^2} \text{ but } F' = \frac{1}{3} F$$

$$\therefore \frac{GmM}{(R+h)^2} = \frac{1}{3} \frac{GmM}{R^2}$$

$$\therefore \sqrt{3}\, R = R + h$$

$$\therefore (\sqrt{3} - 1)\, R = h \Rightarrow \frac{h}{R} = \sqrt{3} - 1$$

$= 1.732 - 1 = 0.732$

(8) **Answer [A]**

Suppose resultant gravitational force on the object having mass m at a distance x from the center of earth is zero.

$$\therefore \frac{G M_e m}{x^2} = \frac{G M_m m}{(r-x)^2}$$

(M_e and M_m are mass of earth and moon, respectively.)

$$\therefore \frac{M_e}{x^2} = \frac{M_m}{(r-x)^2}$$

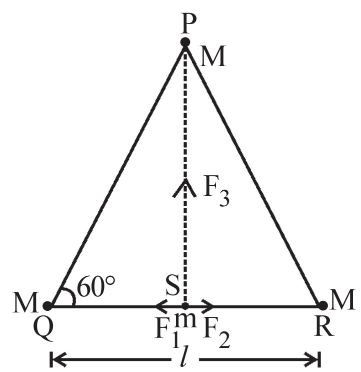
$$\frac{81 M_m}{x^2} = \frac{M_m}{(r-x)^2}$$

$$\therefore \frac{9}{x} = \frac{1}{r-x} \Rightarrow 9(r-x) = x \Rightarrow 9r = 10\,x$$

$$\therefore x = \frac{9}{10} r = 0.9\, r$$

(9) **Answer [B]**

Forices acting on the particle of mass m due to particles at Q and R are eqnal and opposite.



$\therefore$ Resultant force of F_1 and F_2 will be zero.

$\therefore$ The resultant force acting on particle having mass m is equal to force acting by particle putting on P.

Resultant force,

$$\therefore F = \frac{GMm}{(PS)^2}, \text{ Here } PS = l \sin 60^\circ = l\left(\frac{\sqrt{3}}{2}\right)$$

$$\therefore F = \frac{GMm}{(\frac{\sqrt{3}}{2} l)^2} = \frac{4GMm}{3l^2}$$

(10) **Answer [A]**

gravitational force between two pieces having mass m and (M – m) separated by distance r is

$$F = \frac{Gm(M-m)}{r^2} \Rightarrow F \propto (m)(M-m)$$

$\therefore$ For the force to be maximum,

$$\frac{dF}{dm} = \frac{d}{dm}(mM - m^2) = 0$$

$$\therefore M - 2m = 0 \Rightarrow \frac{m}{M} = \frac{1}{2}$$

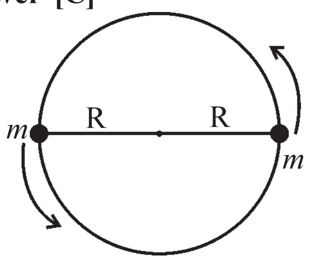
(12) **Answer [A]**

$F = \frac{GM(1)}{R^2} = 10$, Force acting on satellite,

$$F' = \frac{GM(100)}{\left(\frac{3}{2}R\right)^2} = \frac{4}{9}\left(\frac{GM}{R^2}\right)100$$

$$= \frac{4}{9}(10)(100) = 4.44 \times 10^2 \text{ N}$$

(14) **Answer [C]**



Suppose mass of both particle is m. Here required centripetal force is provided by the gravitational force between them.

$$\therefore \frac{Mv^2}{R} = \frac{GmM}{(2R)^2} \Rightarrow v = \frac{1}{2}\sqrt{\frac{Gm}{R}}$$

(16) **Answer [B]**

gravitational acceleration on surface of earth, $g = \frac{GM}{R^2}$

gravitational acceleration on surface of moon $g' = \frac{GM'}{R'^2}$

$$\therefore \frac{g'}{g} = \left(\frac{M'}{R'^2}\right)\left(\frac{R^2}{M}\right) = \left(\frac{M'}{M}\right)\left(\frac{R}{R'}\right)^2 = \left(\frac{1}{9}\right)\left(\frac{2}{1}\right)^2$$

$$= \frac{4}{9}, \therefore g' = \frac{4}{9}(g)$$

$\therefore$ Weight on surface of moon

$$W' = mg' = m\,\frac{4}{9}(g)$$

$= \frac{4}{9}$ W ($\because$ W = mg = Weight on surface of earth)

$$= \frac{4}{9}(81) = 36\ kgf$$

Note : Multiplication of mass of object in kg and gravitational acceleration is known as kilogram-force-kgf.)

(17) **Answer [A]**

density of earth

ρ = (relative density of lead) $\times$ (density of water)

($\because$ relative density = $\frac{\text{density of substance}}{\text{density of water}}$)

$= 11.3 \times 10^3$ kgm^{-3}

$\therefore$ gravitational acceleration on earth's surface

$$g' = \frac{GM^1}{R^2} = \frac{G\left(\frac{4}{3}\pi R^3\rho\right)}{R^2} = \frac{4}{3}\pi GR\rho$$

$\therefore g' = \frac{4}{3}(3.14)(6.67 \times 10^{-11})$

$(6.4 \times 10^6)(11.3 \times 10^3) = 20.2$ ms^{-2}

(18) **Answer [D]**

$$g_1 = \frac{GM_1}{R_1^2},\ g_2 = \frac{GM_2}{R_2^2}$$

$$\therefore \frac{g_1}{g_2} = \left(\frac{GM_1}{R_1^2}\right)\left(\frac{R_2^2}{GM_2}\right)$$

$$= \left(\frac{M_1}{M_2}\right)\left(\frac{R_2}{R_1}\right)^2 = \left(\frac{1}{2}\right)\left(\frac{3}{1}\right)^2 = \frac{9}{2}$$

[$\because$ Ratio of diameter = ratio of radius $= \frac{R_1}{R_2} = \frac{1}{3}$]

(19) **Answer [A]**

gravitational acceleration on surface of earth,

$$g = \frac{GM}{R^2} = \frac{G\left(\frac{4}{3}\pi R^3\rho\right)}{R^2} = \frac{4}{3}\pi GR\rho$$

Here, $\frac{4}{3}$, π and G are constants.

The value of 'G' remains constant for that

$R\rho$ = Should remain constant $\therefore R \propto \frac{1}{\rho}$

$\therefore$ If radius is 3R then density is $\frac{\rho}{3}$
i.e. value of density is approximately 33 % means required decrease in value of density is approximately 67 %.

(20) **Answer [B]**

$H = \frac{V_0^2}{2g}$ From $H \propto \frac{1}{g}$

(putting $v = 0$ in $H = \frac{v^2 - v_0^2}{2g}$)

$\therefore \frac{H_A}{H_B} = \frac{g_B}{g_A} = \frac{\rho_B R_B}{\rho_A R_A}$ $(\because g \propto R\rho)$

$\therefore H_B = H_A \left(\frac{\rho_A}{\rho_B}\right)\left(\frac{R_A}{R_B}\right)$

= (2) (4) (3) = 24 m

Second method : According to law of conservation of energy

$mg_A H_A = mg_B H_B$

$\therefore \frac{H_A}{H_B} = \frac{g_B}{g_A}$ (then same as previous method)

(21) **Answer [D]**

gravitational acceleration at height h from surface of earth,

$$g' = g\left(\frac{R_e}{R_e + h}\right)^2 = g\left(\frac{R_e}{R_e + \frac{R_e}{2}}\right)^2$$

$= \frac{4}{9}(g)$ $(\because h = \frac{R_e}{2})$

$\therefore W' = mg' = m\frac{4}{9}(g) = \frac{4}{9}$ (W)

$= \left(\frac{4}{9}\right)$ (54) = 24 N

(22) **Answer [A]**

Suppose, value of gravitational acceleration at height h from earth's surface becomes half than that of gravitational acceleration at earth surface.

$g' = \frac{g}{2}$ but $g' = g\left(\frac{R}{R+h}\right)^2$

$\therefore \frac{g}{2} = g\left(\frac{R}{R+h}\right)^2 \Rightarrow \frac{R}{R+h} = \frac{1}{\sqrt{2}}$

$\therefore \sqrt{2}\,R = R + h$, $\therefore h = \sqrt{2}\,R - R$

= 1.414 R – R = 0.414 R = (0.414) (6400)

= 2649.6 km ≈ 2650 km

(23) **Answer [B]**

In equilibrium condition, Weight of hanging object = Restoring force generated in spring. On earth's surface, $mg = kx$ and at height h from earth's surface, $mg' = kx'$ where k is force-constant of spring.

$$\therefore \frac{g'}{g} = \frac{x'}{x} = \frac{R^2}{(R+h)^2} = \left(\frac{6400}{6400+1600}\right)^2$$

$$= \left(\frac{6400}{8000}\right)^2 = \left(\frac{8}{10}\right)^2 = \frac{64}{100} = 0.64 \therefore \frac{x'}{x} = 0.64$$

$\therefore x' = (0.64)(1)$ $(\because x = 1$ cm)

= 0.64 cm

(24) **Answer [B]**

$g' = \frac{g}{(1+\frac{h}{R})^2}$; $g' = \frac{g}{16}$

$\therefore \frac{g}{16} = \frac{g}{(1+\frac{h}{R})^2}$

$\therefore 1 + \frac{h}{R} = 4 \Rightarrow \frac{h}{R} = 3$, $\therefore h = 3R$

$\therefore$ distance from centre of earth = R + 3R = 4R

(25) **Answer [A]**

Suppose, value of gravitational acceleration at height h from earth's surface is equal to the value of gravitational acceleration at depth d from earth's surface.

$\therefore g_h = g_d$ $\therefore g\left(1 - \frac{2h}{R}\right) = g\left(1 - \frac{d}{R}\right)$

$\therefore \frac{2h}{R} = \frac{d}{R} \Rightarrow h = \frac{d}{2} = \frac{100}{2} = 50$ km

(26) Answer [C]

gravitational acceleration on earth surface is g and at depth d from earth surface is g'.

$\therefore g' = 10\ \%\ g$ and $g' = g\left(1 - \frac{d}{R}\right)$

$\therefore \frac{10}{100}\ g = g\left(1 - \frac{d}{R}\right)$

$\therefore \frac{1}{10} = \frac{R - d}{R} \Rightarrow \frac{6400 - d}{6400} = \frac{1}{10}$

$\therefore 6400 - d = 640$

$\therefore d = 6400 - 640 = 5760$ km

(27) Answer [D]

Suppose, gravitational acceleration g_1 and g_2 and weight of object are W_1 and W_2 for height h and depth d from earth's surface respectively.

$g_1 = g\left(1 - \frac{2h}{R}\right)$, $g_2 = g\left(1 - \frac{d}{R}\right)$

$\therefore \frac{g_1}{g_2} = \frac{1 - \frac{2h}{R}}{1 - \frac{d}{R}} = \frac{R - 2h}{R - d}$

$\therefore$ Ratio of weight $\frac{W_1}{W_2} = \frac{mg_1}{mg_2}$

$= \frac{R - 2h}{R - d} = \frac{6400 - 2(30)}{6400 - 30} = \frac{6340}{6370} = 0.995$

(28) Answer [B]

Effective gravitational acceleration at place having lattitude of 45°, $g' = g - R\omega^2\cos^2\lambda$.

$= g - R\omega^2\cos^2 45°$

$= g - R\omega^2\left(\frac{1}{\sqrt{2}}\right)^2 = g - \frac{R\omega^2}{2}$

If an effective gravitational acceleration is g'' at the equator then,

$g'' = g - R\omega^2\cos^2\lambda$

$= g - R\omega^2\cos^2 0° = g - R\omega^2$

$\therefore g' - g'' = \left(g - \frac{R\omega^2}{2}\right) - (g - R\omega^2)$

$= \frac{R\omega^2}{2}$

(29) Answer [A]

$g' = g - R\omega^2\cos^2 60°$

$\therefore 0 = g - R\omega^2\left(\frac{1}{2}\right)^2 \qquad (\because g' = 0)$

$\therefore g = \frac{R\omega^2}{4} \Rightarrow \omega = \sqrt{\frac{4(g)}{R}} = \sqrt{\frac{(4)(10)}{6400 \times 10^3}}$

$= 2.5 \times 10^{-3}$ rad s^{-1}

(30) Answer [B]

$mg' = mg - mR\omega^2 \qquad (\because \cos\lambda = 1)$

$\therefore \frac{mg}{3} = mg - mR\omega^2$

$\therefore R\omega^2 = g\left(1 - \frac{1}{3}\right) = \frac{(2)(g)}{3}$

$\therefore \omega = \sqrt{\frac{(2)(9.8)}{3 \times 6.4 \times 10^6}} = 10 \times 10^{-4}$ rad s^{-1}

(31) Answer [A]

Weight of object at depth d from earth's surface,

$mg' = mg\left(1 - \frac{d}{R}\right)$

$W' = W\left(1 - \frac{\frac{R}{2}}{R}\right) = W\left(1 - \frac{1}{2}\right) = \frac{W}{2}$

(32) Answer [B]

$g = \frac{4}{3}\pi G \rho R$ From $g \propto \rho R$

For planet $g' \propto \rho' R'$, For earth $g \propto \rho R$

$\frac{g'}{g} = \frac{\rho' R'}{\rho R} = \left(\frac{2\rho}{\rho}\right)\left(\frac{3R}{2R}\right) = 3$

(34) Answer [A]

gravitational acceleration at depth of x

$g' = g\left(1 - \frac{x}{R}\right)$ Where R = radius of earth,

g = value of gravitational acceleration on surface

$g' = g - \frac{xg}{R}$

$\therefore \frac{d}{dx}(g') = \frac{d}{dx}\left(g - \frac{gx}{R}\right) = 0 - \frac{g}{R}(1)$

$\therefore$ The rate of change in gravitational acceleration at depth of x,

$$\frac{dg'}{dx} = \frac{-g}{R} = -\left(\frac{GM}{R^2}\right)\left(\frac{1}{R}\right) = -\frac{GM}{R^3}$$

$$= -\frac{G\frac{4}{3}\pi R^3\rho}{R^3}$$

(Where ρ = uniform density of earth)

$$= -\frac{4}{3}\pi G\rho$$

(35) Answer [C]

gravitational acceleration at height h,

$$g' = \frac{g}{\left(1+\frac{h}{R}\right)^2} = \frac{9.8}{\left(1+\frac{1600}{6400}\right)^2}$$

$$= \frac{9.8}{\left(1+\frac{1}{4}\right)^2} = \frac{(16)(9.8)}{25} = 6.27 \text{ ms}^{-2}$$

(36) Answer [B]

The rate of change in value of gravitational acceleration at a place having lattitude of 45°, $g' = g - R\,\omega^2\cos^2\lambda$

$\therefore g - g' = R\,\omega^2\cos^2\lambda$

$$\Delta g = (6.4 \times 10^6)\left(\frac{2 \times 3.14}{24 \times 60 \times 60}\right)^2 \cos^2(45°)$$

$$(\because \omega = \frac{2\pi}{T} \text{ અને } T = 24\ hr.)$$

$$= (6.4 \times 10^6)\left(\frac{2 \times 3.14}{24 \times 60 \times 60}\right)^2 \left(\frac{1}{2}\right)$$

$= 1.68 \times 10^{-2}$ ms^{-2} = 1.68 cms^{-2}

(36) Answer [ ]

$$g = \frac{GM}{R^2} \Rightarrow \frac{g}{G} = MR^2$$

(38) Answer [B]

$g' = g - R\,\omega^2\cos^2\lambda$

Here, $g_{30} = g - R\,\omega^2(\cos^2 30°)$

$$\therefore g_{30} - g = R\,\omega^2\left(\frac{\sqrt{3}}{2}\right)^2$$

$$= R\,\omega^2\left(\frac{3}{4}\right) = \frac{3}{4}R\,\omega^2$$

(39) Answer [D]

Range of the projectile, $R = \frac{v_0^2 \sin 2\theta}{g}$

$\theta = 45°$ For $R = R_{max} \Rightarrow R_{max} = \frac{v_0^2}{g}$

$\Rightarrow R_{max} \propto \frac{1}{g}$ $\quad(\because v_0$ and θ are constants)

$$\therefore \frac{R_m}{R_e} = \frac{g_e}{g_m} = \frac{g_e}{0.2\,g_e} = \frac{1}{0.2}$$

$$\therefore R_m = \frac{R_e}{0.2} \Rightarrow R_m = 5\text{ Re}$$

(40) Answer [A]

From the formula $I = \frac{F}{m}$, $I = \frac{2}{50 \times 10^{-3}} = 40$ N/kg

(41) Answer [A]

Magnitude of gravitational field due to ring at distance x on axis of ring from center of ring.

$$I = \frac{GMx}{(R^2 + x^2)^{\frac{3}{2}}} \quad ...(1)$$

For the intensity to be maximum $\frac{dI}{dx} = 0$

$$\therefore \frac{d}{dx}I = \frac{d}{dx}\left(\frac{GMx}{(R^2+x^2)^{\frac{3}{2}}}\right) = 0$$

$$\therefore \frac{d}{dx}\left(GM\,(x)\,(R^2+x^2)^{\frac{-3}{2}}\right) = 0$$

$$\therefore \frac{d}{dx}\left((x)\,(R^2+x^2)^{\frac{-3}{2}}\right) = 0 \; (\therefore G, M \text{ are constants})$$

$$\therefore (x)\left(\frac{-3}{2}\right)(R^2+x^2)^{\frac{-3}{2}-1}(2x) + (1)(R^2+x^2)^{\frac{-3}{2}} = 0$$

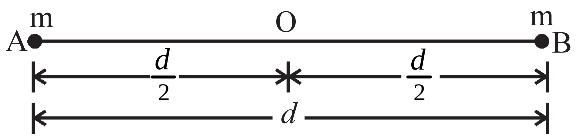
$$\therefore -3x^2(R^2+x^2)^{\frac{-3}{2}}(R^2+x^2)^{-1} + (R^2+x^2)^{\frac{-3}{2}} = 0$$

$$\therefore 3x^2(R^2+x^2)^{-1} = 1, \therefore 3x^2 = R^2 + x^2$$

$$\therefore 2x^2 = R^2$$

$\therefore x = \frac{R}{\sqrt{2}}$ (Note : If value of maximum intensity is asked then put $x = \frac{R}{\sqrt{2}}$ in equation (1).

(43) Answer [C]

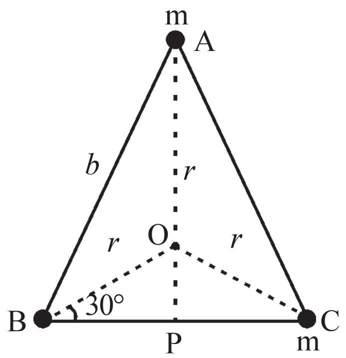


total gravitational potential at point 'O'

$\phi = \phi_A + \phi_B$

$$= -\frac{Gm}{\frac{d}{2}} + \left(\frac{-Gm}{\frac{d}{2}}\right) = \frac{-4Gm}{d}$$

(44) Answer [A]



total gravitational potential at point 'O',

$\phi = \phi_A + \phi_B + \phi_C$

$$= -\frac{Gm}{r} + \left(\frac{-Gm}{r}\right) + \left(\frac{-Gm}{r}\right) = -\frac{3Gm}{r}$$

Where r = AO = BO = CO

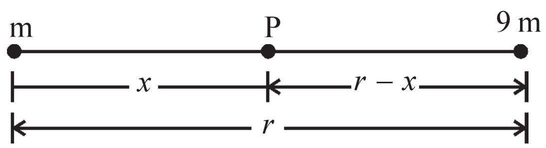
distance from vertex to centroid.

From the geometry of the figure,

$$r = \frac{PB}{\cos 30°} = \frac{\frac{b}{2}}{\frac{\sqrt{3}}{2}} = \frac{b}{\sqrt{3}}$$

$$\therefore\ \phi = -\frac{3Gm}{\frac{b}{\sqrt{3}}} = -3\frac{\sqrt{3}Gm}{b}$$

(45) Answer [D]



The magnitude of resultant gravitational field at point P is zero as seen in figure.

$$\therefore\ \frac{Gm}{x^2} = \frac{G(9m)}{(r-x)^2} \Rightarrow \frac{r-x}{x} = 3$$

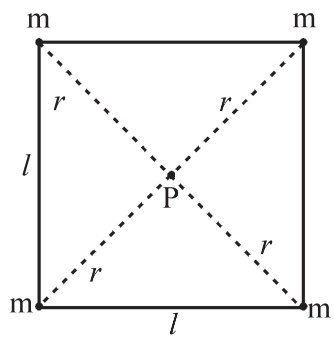
$$\therefore\ r - x = 3x \Rightarrow 4x = r,\ x = \frac{r}{4}$$

∴ Resultant gravitational potential at point P,

$$\phi = -\frac{Gm}{\frac{r}{4}} + \left(\frac{-G(9m)}{\frac{3r}{4}}\right)$$

$$\therefore\ \phi = -\frac{4Gm}{r} - \frac{12Gm}{r} = -\frac{16Gm}{r}$$

(46) Answer [B]



total gravitational potential at point 'P', shown in figure,

$$\phi = -4\frac{Gm}{r},\ \text{but } r = \frac{l}{\sqrt{2}}$$

$$\therefore\ \phi = -4\left(\frac{Gm}{\frac{l}{\sqrt{2}}}\right) = \frac{-4\sqrt{2}Gm}{l}$$

(47) Answer [B]

Increase in gravitational potential energy,

$$= \left(-\frac{GMm}{R + \frac{R}{5}}\right) - \left(-\frac{GMm}{R}\right)$$

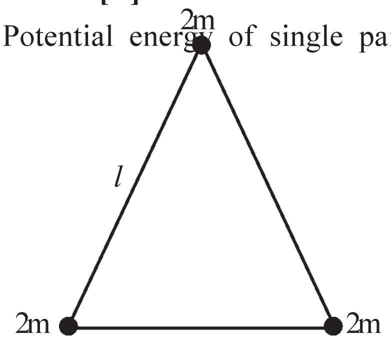
$$= \frac{GMm}{R} - \frac{GMm(5)}{6R} \qquad (\because\ gR^2 = GM)$$

$$= mgR\left(1 - \frac{5}{6}\right) \qquad (\because\ R = 5h)$$

$$= \frac{mgR}{6} = \frac{mg(5h)}{6} = \frac{5}{6}\ mgh$$

(48) **Answer [C]**

Potential energy of single pair = $-\ G\dfrac{(2m)^2}{l}$



$= -\dfrac{4Gm^2}{l}$

There are total three pairs.

$\therefore$ total gravitational potential energy of system is

$$= 3\left(\frac{-4Gm^2}{l}\right) = \frac{-12Gm^2}{l}$$

(49) **Answer [B]**

gravitational potential energy at height h from earth surface,

$$U = -\frac{GMm}{R+h}$$

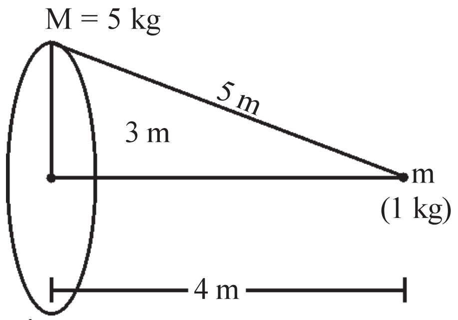
Here, $U_i = \dfrac{GMm}{R+3R} = -\dfrac{GMm}{4R}$ $(\therefore h = 3R)$

and $U_f = -\dfrac{GMm}{R+R} = -\dfrac{GMm}{2R}$

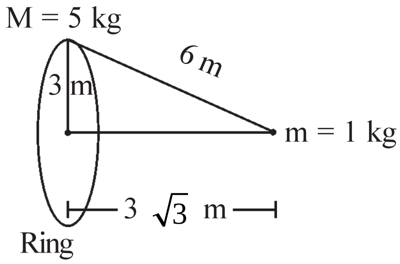
$\therefore$ decrease in potential energy = increase in kinetic energy

$$= \frac{GMm}{2R} - \frac{GMm}{4R} = \frac{GMm}{4R}$$

(50) **Answer [A]**



(A)



(B)

potential energy of object having mass m in gravitational field generated by uniform ring.

$$U = -\frac{GMm}{r}$$

For event A, $U_1 = -\dfrac{G(5)(1)}{5} = -G$

For event B, $U_2 = -\dfrac{G(5)(1)}{6} = -\dfrac{5G}{6}$

$\therefore$ Work done = Change in potential energy = ΔU

$\therefore \Delta U = U_2 - U_1$

$$= -\frac{5G}{6} - (-G) = G - \frac{5G}{6} = \frac{G}{6}$$

(52) **Answer [C]**

For earth $v_e = \sqrt{\dfrac{2GM}{R}}$ and for planet

$$v_P = \sqrt{\frac{2GM'}{R'}} = \sqrt{\frac{2G(3M)}{3R}}$$

$$= \sqrt{\frac{2GM}{R}} = v_e$$

(53) **Answer [B]**

$v_e = \sqrt{\dfrac{2GM}{R}}$ and $v_e' = \sqrt{\dfrac{2GM}{R'}} = 10\ v_e$

$$\therefore \frac{Ve'}{Ve} = 10 = \sqrt{\frac{R}{R'}} \Rightarrow \frac{R}{R'} = 100$$

$$\therefore R' = \frac{R}{100} = \frac{6400}{100} = 64\ \text{km}$$

(54) **Answer [C]**

Orbital speed of satellite $v_0 = \sqrt{\dfrac{GM}{r}}$

Kinetic energy of satellite

$$K = \frac{1}{2}\, m\, v_0^2 = \frac{1}{2}\, m \left(\frac{GM}{r}\right) = \frac{GMm}{2r}$$

kinetic energy to make free from gravitational field,

$$K' = \frac{1}{2} m v_e^2$$

$$= \frac{1}{2} m \left(\sqrt{\frac{2GM}{r}}\right)^2 = \frac{GMm}{r} = 2K$$

$\therefore$ Required additional kinetic energy

$= K' - K = 2K - K = K$

(55) **Answer [B]**

Orbital velocity of satellite $= \sqrt{\frac{GM}{r}} = \sqrt{gR}$

$= \sqrt{9.8 \times 6.4 \times 10^6} = 7.92\ \text{kms}^{-1}$

escape velocity $= 11.20\ \text{kms}^{-1}$

$\therefore$ Required additional velocity to free from earth's attraction.

$= 11.2 - 7.92 = 3.28 \approx 3.25\ \text{kms}^{-1}$

(56) **Answer [A]**

Escape velocity $v_e = \sqrt{\frac{2GM}{R}}$, $v_e \propto \sqrt{\frac{M}{R}}$

and $v_e' \propto \sqrt{\frac{M'}{R'}} \Rightarrow v_e' \propto \sqrt{\frac{2M}{\frac{R}{2}}}$

$$\therefore \frac{v_e'}{v_e} = \sqrt{\left(\frac{2M}{\frac{R}{2}}\right)\left(\frac{R}{M}\right)} = 2 \Rightarrow v_e' = 2v_e$$

(57) **Answer [B]**

$$v_e = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2G\frac{4}{3}\pi R^3\rho}{R}}$$

$$= 2\sqrt{\frac{8}{3}\pi G\rho},\ \therefore v_e \propto R\sqrt{\rho}$$

$$\frac{v_1}{v_2} = \frac{R_1\sqrt{\rho_1}}{R_2\sqrt{\rho_2}} = \frac{R}{4R}\sqrt{\frac{\rho}{9\rho}} = \frac{1}{12}$$

(58) **Answer [B]**

$T \propto r^{\frac{3}{2}}$ so, $T_1 \propto R^{\frac{3}{2}}$ and

$T_2 \propto (4R)^{\frac{3}{2}}$ ($\because h = 3R \Rightarrow r = R + h = 4R$)

$$\therefore \frac{T_2}{T_1} = \left(\frac{4R}{R}\right)^{\frac{3}{2}} = 8$$

$\therefore T_2 = 8\, T_1 = 8(50) = 400$ min

(59) **Answer [B]**

$T \propto r^{\frac{3}{2}}\ \therefore \frac{2\pi}{\omega} \propto r^{\frac{3}{2}}$ ($\because T = \frac{2\pi}{\omega}$)

$$\therefore \omega \propto \frac{1}{r^{\frac{3}{2}}} \Rightarrow r \propto \frac{1}{\omega^{\frac{2}{3}}}$$

$$\therefore \frac{r_1}{r_2} = \left(\frac{\omega_2}{\omega_1}\right)^{\frac{2}{3}} = \left(\frac{1}{8}\right)^{\frac{2}{3}}\ (\because \omega_1 = 8\omega_2)$$

$$\therefore \frac{r_1}{r_2} = \frac{1}{4}$$

(62) **Answer** [B]

$T^2 \propto r^3 \Rightarrow r \propto T^{\frac{2}{3}}$

$$\frac{r_A}{r_B} = \left(\frac{T_A}{T_B}\right)^{\frac{2}{3}} = (27)^{\frac{2}{3}} = 9$$

$$\therefore \frac{r_A}{r_B} = 9 \Rightarrow r_A = 9\, r_B$$

$\therefore r_A - r_B = 9\, r_B - r_B = 8\, r_B$

$\therefore$ Distance of planet A is 8 times larger than planet B.

(63) **Answer [C]**

$$\frac{T_2}{T_1} = \left(\frac{r_2}{r_1}\right)^{\frac{3}{2}} = \left(\frac{1.01r}{r}\right)^{\frac{3}{2}} = (1.01)^{\frac{3}{2}}$$

Now, $(1.01)^{\frac{3}{2}} = (1+0.01)^{\frac{3}{2}} = \left(1+\frac{3}{2}(0.01)\right)$

($\because$ From binomial theorem)

$= 1 + \frac{3}{200}, \frac{T_2}{T_1} = 1 + \frac{3}{200}$

$\therefore \frac{T_2}{T_1} - 1 = \frac{T_2 - T_1}{T_1} = \frac{3}{200}$

$\therefore$ Percentage change in value of periodic time (increament)

$\frac{T_2 - T_1}{T_1} \times 100\,\% = \frac{3}{200} \times 100\,\% = 1.5\,\%$

(64) Answer [B]

$$T = \frac{2\pi(R+R)}{v_0} = \frac{4\pi R}{\sqrt{\frac{GM}{R+R}}} = \frac{4\pi R}{\sqrt{\frac{GM}{2R}}}$$

$$= \frac{4\pi R}{\sqrt{\frac{gR^2}{2R}}} \qquad (\because GM = gR^2)$$

$$= 4\sqrt{2}\pi\sqrt{\frac{R}{g}}$$

(65) Answer [A]

$r_1 = 6R + R = 7R$, $T_1 = 24\ h$

$r_2 = 2.5\ R + R = 3.5\ R$

Now, $\frac{T_2}{T_1} = \left(\frac{3.5R}{7R}\right)^{\frac{3}{2}} = \left(\frac{1}{2}\right)^{\frac{3}{2}}$

$T_2 = \frac{T_1}{2\sqrt{2}} = \frac{24}{2\sqrt{2}} = 6\sqrt{2}\ h$

(67) Answer [C]

$$T = 2\pi\sqrt{\frac{r^3}{GM_e}} = 2\pi\sqrt{\frac{(R_e+h)^3}{GM_e}}$$

$$= 2\pi\sqrt{\frac{R_e^{\,3}}{GM_e}} \qquad (\because 4 = 0)$$

$$= 2\pi\sqrt{\frac{R_e^{\,3}}{gR_e^{\,2}}} \qquad \left(\because g = \sqrt{\frac{GM_e}{R_e^{\,2}}}\right)$$

$$= 2\pi\sqrt{\frac{R_e}{g}} = (2)\,(3.14)\sqrt{\frac{6400\times10^3}{9.8}}$$

$= 84.6$ min

(68) Answer [A]

$$T = 2\pi\sqrt{\frac{R_e^{\,3}}{GM_e}}$$

$$= \sqrt{\frac{4\pi^2 R_e^3}{G\frac{4}{3}\pi R_e^3\,\rho}}$$

$$= \sqrt{\frac{3\pi}{G\rho}}$$

(69) Answer [A]

From the formula of orbital speed

$$v_0 = \sqrt{\frac{GM}{r}}$$

For A, $3v = \sqrt{\frac{GM}{4R}}$,

For B, $v' = \sqrt{\frac{GM}{R}}$

$\therefore \frac{v'}{3v} = 2 \Rightarrow v' = 6v$

(70) Answer [B]

From orbital speed $v_0 = \sqrt{\frac{GM}{r}}$,

For first satellite, $v_0 = \sqrt{\frac{GM}{R}}$

For second satellite,

$$v_0' = \sqrt{\frac{GM}{R+h}} = \sqrt{\frac{GM}{R+\frac{R}{2}}} = \sqrt{\frac{2GM}{3R}}$$

$$\therefore \frac{v_0'}{v_0} = \sqrt{\frac{2GM}{3R}} \sqrt{\frac{R}{(GM)}}$$

$$\frac{v_0'}{v_0} = \sqrt{\frac{2}{3}} \Rightarrow v_0' = \sqrt{\frac{2}{3}}\ v_0$$

(71) Answer [C]

From $T^2 \propto r^3$, $\frac{T_2^2}{T_1^2} = \frac{r_2^3}{r_1^3} = \left(\frac{2r}{r}\right)^3 = 8$

$\therefore T_2 = \sqrt{8}\ T_1 = \sqrt{8}\ T = 2.82\ T \approx 2.8\ T$

(72) Answer [D]

Orbital speed $v_0 = \sqrt{\frac{GM}{r}}$

$\Rightarrow$ kinetic energy $\propto v^2 \propto \frac{1}{r}$

and $T^2 \propto r^3 \Rightarrow r \propto T^{\frac{2}{3}}$

$\therefore$ kinetic energy $\propto \frac{1}{T^{\frac{2}{3}}} \propto T^{\frac{-2}{3}}$

(73) Answer [C]

Angular momentum $= mvr =$

$\sqrt{2mK} \cdot r = \sqrt{2mKr^2}$

$(\because \frac{p^2}{2m} = K \Rightarrow p = \sqrt{2mK} = mv)$

(76) Answer [A]

Planets are revolving in an elliptical path around the sun. Thus their linear speed is different on various position of orbit. Thus, angular speed and kinetic energy reason also changes with time.

There is no external torque on planet thus angular momentum remains constant. Here, statement and reason both are ture and cause gives true explanation of statement.

(78) Answer [A]

According to Kepler's third law,

$T^2 \propto r^3 \propto (R + h)^3$

Means, as the height from the surface of satellite is more then periodic time is more. Here statement and reason are true, and gives correct explanation of statement.

(80) Answer [A]

Escape velocity $v_e = \sqrt{\frac{2GM}{R}}$ depends on mass and radius of planet. Two planets with same mass and speed then only their escape velocities will be same. Statement and reason both are ture and reason gives correct explanation of statement.

(82) Answer [B]

gravitational force $F = \frac{Gm_1 m_2}{r^2}$

($\because$ Newton's universal law of gravitation) For small particles like electrons, the gravitational force for two electrons separated by distance r is,

$$F_G = \frac{(6.67 \times 10^{-11})\,(9.1 \times 10^{-31})^2}{r^2} = \frac{5 \times 10^{-71}}{r^2}$$

and electric force between two electrons (from coulomb's law)

$$F_e = k\,\frac{q_1 q_2}{r^2} = \frac{(9 \times 10^9)\,(1.6 \times 10^{-19})^2}{r^2} = \frac{2 \times 10^{-28}}{r^2}$$

$$\therefore \frac{F_G}{F_e} = \frac{10^{-71}}{10^{-28}} \approx 10^{-43}$$

$\therefore$ Statement and reason both are true but reason does not give the explanation of statement.

(83) Answer [C]

Substituting $d = R$ in $g' = g(1 - \frac{d}{R})$ at the centre of the earth. $\therefore$ mass of object becomes zero for $g' = 0$ (by from $\omega' = mg'$). statement is ture but cause is wrong.

(84) **Answer [C]**

gravitational potential energy U = mϕ = (m) (gravitational potential), $\therefore$ For spherical shell graph of U $\rightarrow r$ is same as that of graph of $\phi \rightarrow r$.

(85) **Answer [C]**

$$U = \frac{-GMm}{r},\ K = \frac{GMm}{2r},\ E = \frac{-GMm}{2r}$$

Here, for satellite, potential energy and total energy is negative while, kinetic energy is positive.

(86) **Answer [C]**

$$\phi_{inside} = \frac{-GM}{2R}\left(3-\left(\frac{r}{R}\right)^2\right)$$

In interior part,

$\phi_{surface} = \frac{-GM}{R}$ on surface,

$\phi_{outside} = \frac{-GM}{r}$ In exterior part

(like $\phi \rightarrow r$ graph for uniform solid sphere)

(87) **Answer [A]**

$$\vec{F} = \vec{I}\ m$$

$$|\vec{I}| = \sqrt{(5)^2 + (12)^2} = 13\ \text{Nkg}^{-1}$$

F = I m = (13) (2) = 26 N

(88) **Answer [C]**

$$V(P) - V(O) = -\int_O^P \vec{I} \cdot \vec{dr}$$

Now, $\vec{I} \cdot \vec{dr} = (5\hat{i} + 12\hat{j}) \cdot (dx\hat{i} + dy\hat{j})$
$= 5\ dx + 12\ dy$

$$\therefore V(P) - V(O) = -\int_{(0,0)}^{(12,0)} (5dx + 12dy)$$

$$\therefore V(P) = -5\int_0^{12} dx \quad (\because V(O) = 0 \text{ given})$$

$$\therefore -5\left[x\right]_0^{12} = -5\ [12 - 0] = -60\ \text{Jkg}^{-1}$$

Similarlay for Q (0.5 m),

$$V(Q) - V(O) = -\int_{(0,0)}^{(0,5)} 5dx + 12dy$$

$$= -12\int_0^5 dy = -12\left[y\right]_0^5 = -12\ (5)$$

$= -60\ \text{Jkg}^{-1}$

(89) **Answer [B]**

P(12, 5), O(0, 0)

$$U(P) - U(0) = -m\int_O^P \vec{I} \cdot \vec{dr}$$

$$= -2\int_{(0,0)}^{(12,5)} (5dx + 12dy)$$

$$= -2\left\{5\int_0^{12} dx + 12\int_0^5 dy\right\}$$

$$= -2\left\{5\left[x\right]_0^{12} + 12\left[y\right]_0^5\right\}$$

$= -2\ \{5(12 - 0) + 12\ (5 - 0)\} = -240$ J

(90) **Answer [B]**

$$\Delta U = -2\int_{(12,0)}^{(0,5)} (5dx + 12dy)$$

$$= -2\left\{5\int_{12}^{0} dx + 12\int_0^5 dy\right\}$$

$$= -2\left\{5\left[x\right]_{12}^{0} + 12\left[y\right]_0^5\right\}$$

$= -2\ \{5(0 - 12) + 12\ (5 - 0)\}$
$= -2\{-60 + 60\} = 0$ J

(91) **Answer [D]**

From $T^2 \propto R^3$,

$T_e^2 = k\ R_e^3,\ T_m^2 = k\ R_m^3,\ T^2 = k\ R^3$ (For satellite)

$$\therefore\ R_e = \frac{T_e^{\frac{2}{3}}}{k^{\frac{1}{3}}} \text{ and } R_m = \frac{T_m^{\frac{2}{3}}}{k^{\frac{1}{3}}}$$

$$\text{Now, } R = \frac{R_e + R_m}{2}$$

$$\Rightarrow T^2 = k\left[\frac{R_e + R_m}{2}\right]^3$$

$$= k\left[\left(\frac{1}{2}\right)\left(\frac{T_e^{\frac{2}{3}}}{k^{\frac{1}{3}}} + \frac{T_m^{\frac{2}{3}}}{k^{\frac{1}{3}}}\right)\right]^3$$

$$= k\left(\frac{T_e^{\frac{2}{3}} + T_m^{\frac{2}{3}}}{2k^{\frac{1}{3}}}\right)^3$$

$$\therefore\ T = \left(\frac{T_e^{\frac{2}{3}} + T_m^{\frac{2}{3}}}{2}\right)^{\frac{3}{2}}$$

(92) Answer [A]

$$\text{Here, for earth, } E_e = -\frac{GM_s M_e}{2R_e}$$

$$\Rightarrow GM_s = -\frac{2 R_e E_e}{M_e}$$

$$\text{For planet, } E = -\frac{GM_s M}{2R} = -\frac{M}{2R}\left(\frac{-2R_e E_e}{M_e}\right)$$

$$= \frac{M}{2\left(\frac{R_e + E_e}{2}\right)}\left(\frac{2R_e E_e}{M_e}\right) = \frac{2M}{M_e}\left(\frac{R_e E_e}{R_e + R_m}\right)$$

(93) Answer [D]

$$\left(\frac{dA}{dt}\right)_{\text{Satellite}} > \left(\frac{dA}{dt}\right)_{\text{earth}}$$

(94) Answer [A]

Here orbital acceleraltion for planet

$v_0 = \sqrt{gR}$

$= \sqrt{(4.9)\ (3.2 \times 10^6)} = 3.95\ \text{kms}^{-1} \approx 4\ \text{kms}^{-1}$

escape velocity $v_0 = \sqrt{2gR}$

$= \sqrt{2 \times 4.9 \times 3.2 \times 10^6} = 5.6\ \text{kms}^{-1}$

If $v = 4\ \text{kms}^{-1} = v_0 \Rightarrow$ circular

$v = 5\ \text{kms}^{-1} \Rightarrow v_0 < v < v_e \Rightarrow$ elliptical

$v = 5.6\ \text{kms}^{-1} \Rightarrow v = v_e \Rightarrow$ parabola

$v = 6.6\ \text{kms}^{-1} \Rightarrow v > v_e \Rightarrow$ hyperbolic

(95) Answer [A]

Force acted by planet or satellite is central force.

$\therefore$ torque = 0 $\Rightarrow$ consenvation of angular momenturm.

$\Rightarrow$ For kepler's second law, Areal velocity is constant.

$\Rightarrow$ In an elliptical orbit as distance from centre changes, speed also changes.

Kinetic energy changes $\Rightarrow$ When speed at any point is constant in circular orbit so kinetic energy is constant.

$\Rightarrow$ escape velocity $= \sqrt{\frac{2GM_e}{R_e}}$

Which is independent to mass of object

$\Rightarrow$ orbital speed $v_o = \sqrt{\frac{GM}{R}}$

Which is independent to mass of satellite

●

7 Properties of Solid and liquid

(1) Answer [C]

Suppose, length of rubber string is l. So, force on its unit increment is K.

$T_1 = K(l_1 - l)$ and $T_2 = K(l_2 - l)$

$\therefore T_2 - T_1 = K(l_2 - l_1)$

$$K = \frac{T_2 - T_1}{l_2 - l_1} = \frac{4-3}{l_2 - l_1} = \frac{1}{l_2 - l_1} \text{ and}$$

$$Y = \frac{T_1}{A} \times \frac{l}{l_1 - l} = \frac{T_2}{A}\ \frac{l}{l_2 - l}$$

$$\therefore \frac{T_1}{l_1 - l} = \frac{T_2}{l_2 - l}$$

$$l = \frac{T_2 l_1 - T_1 l_2}{T_2 - T_1} = \frac{4l_1 - 3l_2}{4-3},\ l = 4l_1 - 3l_2$$

When pulling force is 7 N then new length is l_3.

$\therefore T_3 = K(l_3 - l)$

$$\therefore 7 = \frac{1}{l_2 - l_1}[l_3 - 4l_1 + 3l_2] \text{ or}$$

$l_3 = 4l_2 - 3l_1$

(2) Answer [C]

Certrifugal force due to the rotation of rod is at contre of gravity. i.e. acted at distance $\frac{l}{2}$, center of the rod is fixed both ends.

Thus, maximum centrifugal force

$$F_{max} = M\omega^2\left(\frac{l}{2}\right)$$

$$= Al\rho \times 4\pi^2 f^2 \times \frac{l}{2} = 2Al^2\pi^2\rho f^2$$

F_{max} = Breaking stress × Area of cross-section

$= 3 \times 10^9 \times A$

$\therefore 2Al^2\pi^2\rho f^2 = 3 \times 10^9 \times A$

$$f = \sqrt{\frac{3\times10^9}{2l^2\pi^2\rho}} = \sqrt{\frac{3\times10^9}{2\times1^2\times(3.14)^2\times6000}}$$

$= 159\ rps$

(3) Answer [D]

Given rod is regular. So, half of its weight is at centre point.

$\therefore$ stress generated on center point

$$\sigma = \frac{\text{Weight of hanging object} + \text{Weight of half part of rod}}{\text{area of cross - section}}$$

$$= \frac{Mg + M\frac{g}{2}}{A} = \frac{3Mg}{2A}$$

$$= \frac{3\times1\times10}{2\times10^{-4}} = 15\times10^4\ Nm^{-2}$$

(4) Answer [B]

The value of stress generated in wire higher then the stress value of elastic limit, it breaks the wire.

$$\text{Tangential stress} = \frac{F_n}{A} = \frac{Mg}{\pi r^2}$$

Where g, π are constants.

$$\therefore \sigma_n \propto \frac{M}{r^2},\ \therefore \frac{\sigma_n}{\sigma_{n'}} = \frac{M}{M'} \times \frac{(r')^2}{r^2}$$

But stress equal to breaking stress the wire

$$\therefore 1 = \frac{M}{M'} \times \frac{\left(\frac{r}{3}\right)^2}{r^2}$$

$$1 = \frac{27}{M'} \times \frac{1}{9}$$

$\therefore M' = 3$ kg

(5) Answer [C]

$$\left(L - \frac{L}{4}\right) = \frac{3L}{4}$$

the mass of rod having length L is m.

$\therefore$ mass of rod having length $\frac{3L}{4} = \frac{3m}{4}$.

$\therefore$ weight of rod having length $\frac{3L}{4} = \frac{3mg}{4}$

and weight of hanging mass $M = Mg$

$\therefore$ total weight near required cross-section

$$= Mg + \frac{3mg}{4}$$

$\therefore$ Stress near the cross-section $= \dfrac{\text{total weight}}{\text{area}}$

$$= \frac{Mg + \frac{3mg}{4}}{A} = \left(M + \frac{3m}{4}\right)\frac{g}{A}$$

(6) **Answer [A]**

For equal tension force in both wire

$$\frac{T_1}{A_1} = \frac{T_2}{A_2}$$

$$\therefore \frac{T_1}{T_2} = \frac{A_1}{A_2} = \frac{0.2}{0.4} \quad ...(1)$$

Now for linear balance

$$T_1 + T_2 = W \quad ...(2)$$

From equation (1) and (2)

$T_1 = \dfrac{W}{3}$ and $T_2 = \dfrac{2W}{3}$

For balance condition of rod, weight W at distance x from steel wire,

$$T_1 x = T_2 (1 - x)$$

$$\therefore \frac{W}{3}x = \frac{2W}{3}(1 - x)$$

$$\therefore x = \frac{2}{3} \text{ m}$$

(7) **Answer [D]**

Bulk modulus $B = -\dfrac{\Delta P}{\left(\frac{\Delta V}{V}\right)}$

When we go upwards where, pressure $\propto \rho_a$ let change in volume is ΔV, then

$$B = \frac{V\Delta P}{\Delta V} = \frac{V(\alpha\rho_a - \rho_a)}{\Delta V} = \frac{V(\alpha - 1)\rho_a}{\Delta V}$$

or $\Delta V = \dfrac{V(\alpha - 1)\rho_a}{B}$

$$V' = V - \Delta V = V\left[1 - \frac{(\alpha - 1)\rho_a}{B}\right]$$

density at given depth, $\rho' = \dfrac{\rho V}{V'}$

where ρ is a density of surface.

$$\rho' = \frac{\rho B}{B - (\alpha - 1)P_a}$$

(8) **Answer [A]**

When mass m applied on the piston then change in pressure is,

$$\Delta P = \frac{Mg}{A}$$

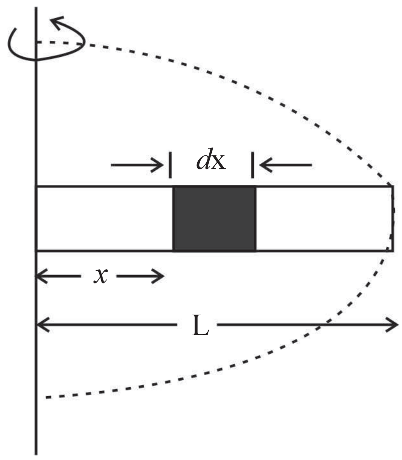
Now, $B = \dfrac{\Delta P}{\left(\frac{\Delta V}{V}\right)}$ or $\dfrac{\Delta V}{V} = \dfrac{\Delta P}{B} = \dfrac{Mg}{AB}$

So, $V = \frac{4}{3}\pi R^3$ hence, $\dfrac{dV}{V} = \dfrac{3dR}{R}$

or $\dfrac{dR}{R} = \dfrac{1}{3}\dfrac{dV}{V} = \dfrac{1}{3}\dfrac{Mg}{AB}$

Change in radius $= \dfrac{dR}{R} = \dfrac{1}{3}\dfrac{Mg}{AB}$

(9) **Answer [B]**



Small element of wire at distance x from axial as shown in figure, Centrifugal force is $dF = dM\, x\, \omega^2 = \rho A dx \cdot x\omega^2$

Thus, total centrifugal force at end of one revolution is

$$F = \rho A\omega^2 \int_x^L x\,dx = \frac{1}{2}\rho A\omega^2 (L^2 - x^2)$$

If increase in length of element is dy then

$$\text{tension} = \frac{dy}{dx} = \frac{F}{AY}$$

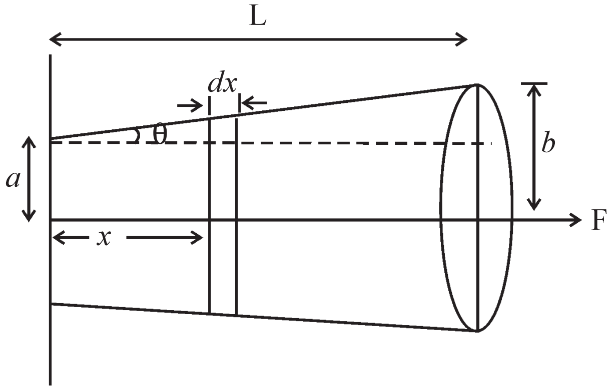
or $dy = \frac{F}{AY} dx = \frac{1}{2} \frac{\rho A \omega^2 (L^2 - x^2)}{AY} dx$

total increase in the length of rod

$$\Delta l = \int_0^L dy = \frac{\rho\omega^2}{2Y} \int_0^L (L^2 - x^2)\, dx = \frac{\rho\omega^2 L^3}{3Y}$$

$$= \frac{10^4 \times 400^2 \times \left(\frac{1}{2}\right)^3}{3 \times 2 \times 10^{11}} = \frac{1}{3} \times 10^{-3} \text{ m} = \frac{1}{3} \text{ mm}$$

(10) Answer [D]



linear increase in length of wire gives linear decrement radius. So, $\frac{dr}{dx}$ is constant

$$\therefore \frac{dr}{dx} = \frac{b-a}{L} = k \qquad \text{...(1)}$$

Suppose, small element at the initial part of wire having length dx and radius r. Suppose, the increase in the length of subtle element is dl when force F acting on it.

$$Y = \frac{Mg\, dx}{\pi r^2\, dl}$$

$$\therefore dl = \frac{Mg dx}{\pi r^2 Y} = \frac{Mg}{\pi r^2 Y}\left(\frac{dr}{k}\right)$$

So, total increase in length of wire,

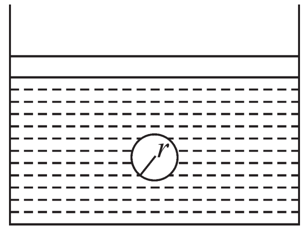
$$l = \frac{Mg}{\pi Y k} \int_a^b \frac{dr}{r^2} = \frac{Mg}{\pi Y k}\left[\frac{-1}{r}\right]_a^b$$

$$= \frac{Mg}{\pi Y k}\left[\frac{1}{a} - \frac{1}{b}\right]$$

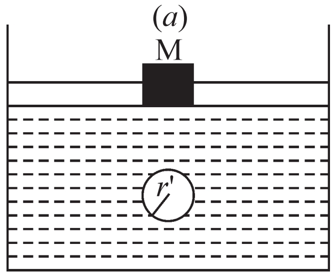
$$= \frac{Mg}{\pi Y k}\left[\frac{b-a}{ab}\right] = \frac{Mg}{\pi Y k}\,\frac{kL}{ab} = \frac{MgL}{\pi Y ab}$$

$$\therefore \frac{l}{L} = \frac{Mg}{\pi Y ab} = \frac{F}{\pi Y ab}$$

(11) Answer [C]



(*a*)



(*b*)

Volume of liquid sphere shown as in figure

$= V = \frac{4}{3}\pi r^3$ When mass m is kept on the piston, the increase in pressure is $P = \frac{Mg}{a}$.

Hence, increased pressure acts at all the sides of sphere so, radius of sphere decreases and finally volume of sphere decrease.

change in volume $dV = \frac{4}{3}\pi \times 3r^2 dr = 4\pi r^2 dr$

$$\therefore \frac{dV}{V} = \frac{4\pi r^2 dr}{\left(\frac{4}{3}\right)\pi r^3} = \frac{3dr}{r}$$

$$B = \frac{P}{\frac{dV}{V}} = \frac{mg}{a} \times \frac{r}{3dr} \text{ now}$$

$$\frac{dr}{r} = \frac{mg}{3Ba}$$

(12) Answer [B]

Twist produced in the solid cylinder per unit length by virtue of coupled force,

$$\tau_1 = \frac{\pi\eta r^4}{2l}$$, for the hollow cylindrical

$$\tau_2 = \frac{\pi\eta\left(r_2^4 - r_1^4\right)}{2l}, \tau_2 = \tau_1 \frac{\left(r_2^4 - r_1^4\right)}{r^4}$$

$$= \frac{0.1 \times \left(5^4 - 4^4\right)}{3^4} = \frac{36.9}{81} = 0.455 \text{ N}m$$

(13) **Answer [B]**

Assume that length of rod is l. When the length of the middle rod is not increased even if its temperature increases upto T, we can say that the increase in the length of the middle rod is equal to the decrease in the length $\frac{Fl}{AY_2}$ due to the force on the remaing two rods.

$$\therefore l\alpha_2 T = \frac{Fl}{AY_2} \text{ or } T = \frac{F}{AY_2\alpha_2}$$

All three rods are fitted between two wall. So, with increasing temperetuee T, increase in first and third rod = decrease in second rod due to pressure, Assume that pressure acting on rod is F, then

$$\therefore l_1\alpha_1 T + l_2\alpha_3 T = \frac{Fl_1}{AY_1} + \frac{Fl_2}{AY_3}$$

$$l_1\alpha_1\left(\frac{F}{AY_2\alpha_2}\right) + l_2\alpha_3\left(\frac{F}{AY_2\alpha_2}\right)$$

$$= \frac{F}{A}\left[\frac{l_1}{Y_1} + \frac{l_2}{Y_3}\right]$$

$$\therefore l_1\left[\frac{\alpha_1}{\alpha_2 Y_2} - \frac{1}{Y_1}\right] = l_2\left[\frac{1}{Y_3} - \frac{\alpha_3}{Y_2\alpha_2}\right]$$

$$\therefore l_1\left[\frac{\alpha_1 Y_1 - \alpha_2 Y_2}{\alpha_2 Y_1 Y_2}\right] = l_2\left[\frac{Y_2\alpha_2 - Y_3\alpha_3}{\alpha_2 Y_2 Y_3}\right]$$

$$\therefore \frac{l_1}{l_2} = \left[\frac{\alpha_3 Y_3 - \alpha_2 Y_2}{Y_2\alpha_2 - Y_1\alpha_1}\right]\frac{Y_1}{Y_3}$$

(14) **Answer [C]**

Suppose, force acting at distence x from front end of wooden is F.

$$\therefore \frac{F}{x} = \frac{F_0}{L} \text{ or } F = \frac{F_0 x}{L}$$

Increase in length of wooden under the force is, $dl = \frac{F_0}{LAY}\, x\, dx$

$$\therefore \text{total increase in length } \Delta L = \frac{F_0}{LAY}\int_0^L x dx = \frac{F_0 L}{2AY}$$

$$\therefore \text{tensile strain } \frac{\Delta L}{L} = \frac{F_0}{2AY}$$

(15) **Answer [B]**

Young modulus $Y = \frac{F}{A} \times \frac{l}{\Delta l}$ ...(1)

Accepting wire as a elastic spring, formula for force constant of the spring $k = \frac{F}{\Delta l}$

$\therefore k = \frac{YA}{l}$ (Substituting value of equation (1))

For parallel connection of springs $k = k_1 + k_2 + k_3$

$$\therefore k = \frac{Y_1 A}{l} + \frac{Y_2 A}{l} + \frac{Y_3 A}{l}$$

$$\therefore \frac{3YA}{l} = \frac{Y_1 A}{l} + \frac{Y_2 A}{l} + \frac{Y_3 A}{l}$$

$$\therefore 3Y = Y_1 + Y_2 + Y_3$$

$\therefore Y = \frac{Y_1 + Y_2 + Y_3}{3}$ ...(2)

$Y_1 = 2 \times 10^{11}$ Nm^{-2},

$Y_2 = 0.7 \times 10^{11}$ Nm^{-2},

$Y_3 = 3.6 \times 10^{11}$ Nm^{-2},

Substituting in equation (2) $Y = 2.1 \times 10^{11}$ Nm^{-2}

(16) **Answer [D]**

$r_0 = 3.2 \times 10^{-10}$ m, $K = 6$ Nm^{-1}

Now, $K = Yr_0$, $\therefore Y = \frac{K}{r_0} = \frac{6}{3.2 \times 10^{-10}}$

Young modulus $Y = 1.875 \times 10^{10}$ Nm^{-2}

(17) **Answer [C]**

Suppose increase in temperature of both rod is equal to ΔT.

$\therefore \Delta L_1 = \alpha_1 L_1 \Delta T$

(increase in the length of rod having length L_1)

$\Delta L_2 = \alpha_2 L_2 \Delta T$

(increase in the length of rod having longth L_2)

$$\therefore \frac{\Delta L_1}{L_1} = \alpha_1 \Delta T \text{ and } \frac{\Delta L_2}{L_2} = \alpha_2 \Delta T \quad ...(1)$$

But young modulus, $Y = \frac{\text{thermal stress}}{\text{strain}}$

$$\therefore Y = \frac{\text{thermal stress}}{\Delta L} \times L$$

thermal stress in rod having length $L_1 = \frac{Y_1 \Delta L_1}{L_1}$

thermal stress in rod having length $L_2 = \frac{Y_2 \Delta L_2}{L_2}$

thermal stress are equal in both rod,

$$\therefore \frac{Y_1 \Delta L_1}{L_1} = \frac{Y_2 \Delta L_2}{L_2} \quad ...(2)$$

from result (1) and (2)

$Y_1 \alpha_1 \Delta T = Y_2 \alpha_2 \Delta T$

$$\therefore \frac{Y_1}{Y_2} = \frac{\alpha_2}{\alpha_1} = \frac{4}{3}, \ \therefore Y_1 : Y_2 = 4 : 3$$

(18) **Answer [B]**

$$\text{Strain} = \frac{\Delta l}{l} = \frac{2\pi R - 2\pi r}{2\pi r} = \frac{R - r}{r}$$

Stress = Y × strain

$$\therefore \frac{F}{A} = Y \times \left[\frac{R - r}{r}\right]$$

$$\therefore F = AY \left[\frac{R - r}{r}\right]$$

But, $r = \frac{R}{2}$ and $A = 100\ cm^2$,

$Y = 2 \times 10^{11} Pa, \ \therefore \ F = 2 \times 10^9$ N

(19) **Answer [D]**

From graph

$$\frac{Y_A}{Y_B} = \frac{\tan\theta_A}{\tan\theta_B} = \frac{\tan 36^\circ}{\tan 180^\circ} = \frac{0.75}{0.3} = 2.5$$

$$\therefore \frac{Y_A}{Y_B} = \frac{5}{2}$$

(20) **Answer [A]**

$$Y = \frac{FL}{A \Delta L}$$

$\therefore \Delta L = \frac{FL}{AY} = \frac{FL}{\pi r^2 Y}$ in this F, L, π and Y are same.

$$\therefore \Delta L \propto \frac{1}{r^2}$$

i.e., the increase in length is minimum for same mass hanging in thick wire.

$$\text{elongation} \propto \left(\frac{1}{\text{increase in length}}\right)$$

So, wire OD has highest thickness.

(21) **Answer [C]**

$U = \frac{M}{r^6} - \frac{N}{r^{12}}$ in equilibrium condition $-\frac{dU}{dr} = F = 0$

$$F = \frac{-dU}{dr} = \frac{-d}{dr}\left(\frac{M}{r^6} - \frac{N}{r^{12}}\right) = 0$$

$$\text{or } \frac{6M}{r^7} - \frac{12}{r^{13}} N = 0 \text{ or } r^6 = \frac{2N}{M}$$

$$\therefore U = \frac{M}{\left(\frac{2N}{M}\right)} - \frac{N}{\left(\frac{2N}{M}\right)^2}$$

$$= \frac{M^2}{2N} - \frac{M^2}{4N} = \frac{M^2}{4N}$$

(22) **Answer [B]**

$$\text{Poisson Ratio } \mu = \frac{\frac{dr}{r}}{\frac{dl}{l}}$$

$$\therefore \frac{dr}{r} = -(\mu)\frac{dl}{l}$$

$= (0.1)(10^{-3}) = 10^{-4}$

$$\therefore \frac{r_1 - r_2}{r_1} = 10^{-4} = 1 - \frac{r_2}{r_1}$$

$$\therefore \frac{r_2}{r_1} = 1 - 10^{-4} = 0.9999$$

$\therefore$ percentage increase in volume $\left(\frac{V_2 - V_1}{V_1}\right) \times 100$

$$= \left(\frac{\pi r_2^2 l_2 - \pi r_1^2 l_1}{\pi r_1^2 l_1}\right) \times 100$$

$$= \left[\left(\frac{r_2^2 l_2}{r_1^2 l_1}\right) - 1\right] \times 100$$

$= [(0.9999)^2 \times 1.001 - 1] \times 100 = 0.08$ %

(23) Answer [D]

$V = \pi r^2 l$

$$\therefore \frac{dV}{V} = 2\frac{dr}{r} + \frac{dl}{l} \quad ...(1)$$

$$\text{Now, } \mu = \left(\frac{\frac{dr}{r}}{\frac{dl}{l}}\right), \therefore \frac{dr}{r} = -\mu \frac{dl}{l}$$

$= -(0.5) \times (2 \times 10^{-3})$

$= -1 \times 10^{-3}$

substituting values in equation (1)

$$\frac{dV}{V} = 2 \times 10^{-3} + 2(-1 \times 10^{-3}) = 0$$

(24) Answer [B]

potential energy of wire per unit volume

$$\rho = \frac{1}{2}\frac{(\text{tension stress})^2}{\text{Young modulus}}$$

$$\therefore \rho = \frac{1}{2}\frac{S^2}{Y}$$

Where tensile stress $= \frac{\text{force}}{\text{Area}}$

$$\therefore \frac{S_1}{S_2} = \left(\frac{F_1}{F_2}\right)\left(\frac{A_2}{A_1}\right)$$

Here $F_1 = F_2$ is given $\therefore \frac{S_1}{S_2} = \frac{A_2}{A_1}$

Also, mass of both wire is same. So, $Y_1 = Y_2$

$$\therefore \frac{\rho_1}{\rho_2} = \left(\frac{S_1}{S_2}\right)^2 = \left(\frac{A_2}{A_1}\right)^2$$

$$= \left[\left(\frac{d_2}{d_1}\right)^2\right]^2 = \left(\frac{d_2}{d_1}\right)^4 = \left(\frac{3}{2}\right)^4 = \frac{81}{16}$$

(25) Answer [C]

Energy per unit volume $= \frac{1}{2} \times$ stress $\times$ strain

$$= \frac{1}{2} \times \text{stress} \times \frac{\text{stress}}{\text{Young modulus}}$$

$$\left[\because \text{strain} = \frac{\text{stress}}{\text{Young modulus}}\right]$$

$$= \frac{1}{2} \times \frac{(\text{Stress})^2}{\text{Young modulus}} = \frac{S^2}{2Y} \quad ...(1)$$

$S = 20\ Nm^{-2}$ and $Y = 2 \times 10^{11}\ Pa$

taking in equation (1).

$$\text{Energy per unit volume} = \frac{20 \times 20}{2 \times 2 \times 10^{11}} = 10^{-9}\ Jm^{-3}$$

(26) Answer [C]

$$\text{Apparent Weight} = V(\rho - \sigma)g = \frac{m}{\rho}(\rho - \sigma)g$$

m = mass of object

ρ = density of object

σ = density of water

Since weighting scale having both object is in equilibrium, their apparent weight are equal.

$$\therefore \frac{m_1}{\rho_1}(\rho_1 - \sigma) = \frac{m_2}{\rho_2}(\rho_2 - \sigma)$$

Where $m_1 = 36\ g$, $\rho_1 = 9\ g\ cm^{-1}$

$m_1 = 72\ g$, $\rho_2 = (?)$

$$\frac{36}{9}(9 - 1) = \frac{72}{\rho_2}(\rho_2 - 1)$$

$$\frac{36 \times 8}{9} = \frac{72}{\rho_2}(\rho_2 - 1)$$

$\rho_2 = 1.8\ gcm^{-3}$

(27) **Answer [D]**

Apparent weight of object in air medium = true weight – Normal force by displacement of air due to object

$\therefore$ For object having density d_1, $M_0 g - \left(\frac{M_0}{d_1}\right) dg$

For object having density d_2, $Mg - \left(\frac{M}{d_2}\right) dg$

$$\therefore \quad M_0 g - \left(\frac{M_0}{d_1}\right) dg = Mg - \left(\frac{M}{d_2}\right) dg$$

$$\therefore \; M_0 = \frac{M\left(1 - \frac{d}{d_2}\right)}{\left(1 - \frac{d}{d_1}\right)}, \text{ Where } d = 1 \text{ kgm}^{-3}$$

$d_1 = 4$ kgm^{-3}, $d_2 = 8$ kgm^{-3}, M = 1 kg

$$\therefore \quad M_0 = \frac{1\left(1 - \frac{1}{8}\right)}{\left(1 - \frac{1}{4}\right)} = \frac{\frac{7}{8}}{\frac{3}{4}}, \; \therefore \; M_0 = \frac{7}{6} \text{ kg}$$

(29) **Answer [D]**

Drawing the horizontal line from bottom of glycerine (Pressure at point A) = (Pressure at point B)

$P_A = P_B$

$h_1 \rho_{Ge} g = h\rho_w g + (20 - h)\, \rho_{Hg} \times g$

$\rho_{Ge} = 1.3$ gcm^{-3}, $\rho_w = 0.8$ gcm^{-3}

$\rho_{Hg} = 13.6$ gcm^{-1}, $h_1 = 20$ cm

$26g = 0.8\, gh + 272g - 13.6\, gh$

$\therefore 12.8\, gh = 246g, \; \therefore \; h = \frac{246}{12.8}$

$\therefore \; h \approx 19.2$ cm

(30) **Answer [A]**

$$\text{Volume of wood V} = \frac{\text{mass}}{\text{density}} = \frac{120}{600} = 0.2 \text{ m}^3$$

Suppose, mass x is kept on raft of wood then total weight is

$= (120 + x) \times 10$ N ...(1)

Now, weight of displace water by it

$= V\rho g = 0.2 \times 10^3 \times 10$ N ...(2)

When total weight of raft with weight x is equal to the weight of water displaced by it then raft of weight x is sink on the brink.

Comparison of equation (1) and (2),

$(120 + x) \times 10 = 0.2 \times 10^3 \times 10$

$\therefore \quad 120 + x = 200, \; \therefore \; x = 80$ kg

(31) **Answer [C]**

The diameter of outer surface of bowl is D and diameter of inner surface of bowl is d.

If density of material of bowl is ρ, then weight of hemispherical bowl = mg = Vρg

$$= \frac{2}{3}\pi \left[\left(\frac{D}{2}\right)^3 - \left(\frac{d}{2}\right)^3\right] \rho g \qquad ...(1)$$

($\because$ Volume of hemispherical shield bowl)

$= \frac{1}{2} \times$ volume of sphere $= \frac{1}{2} \times \frac{4}{3}\pi r^3$

$= \frac{2}{3}\pi r^3$.)

Weight of liquid displaced by bowl

$$= V\rho' g = \frac{2}{3}\pi\left(\frac{D}{2}\right)^3 \rho' g \qquad ...(2)$$

(ρ' density of liquid)

For floating bowl in liquid and comparing of equation (1) and (2),

$$\frac{2}{3}\pi\left(\frac{D}{2}\right)^3 \rho' g = \frac{2}{3}\pi\left[\left(\frac{D}{2}\right)^3 - \left(\frac{d}{2}\right)^3\right]\rho g$$

$$\therefore \left(\frac{1}{2}\right)^3 \times 1.8 \times 10^3 = \left[\left(\frac{1}{2}\right)^3 - \left(\frac{d}{2}\right)^3\right] 3 \times 10^4$$

By simplyfing, $d = 0.98$ m

(32) **Answer [B]**

density of concrete is ρ_1, density of waste of unknown object is ρ_2, density of water is = σ = 1,According to law of floatation.

(weight of concrete sphere filled with waste of unknown object) = (weight of water displaced by sphere)

$\therefore \frac{4}{3}\pi (R^3 - r^3) \rho_1 g + \frac{4}{3}\pi r^3 \rho_2 g$

$= \frac{4}{3}\pi R^3 \sigma g$

$\therefore \frac{4}{3}\pi (R^3 - r^3) \rho_1 g + \frac{4}{3}\pi r^3 \rho_2 g$

$= \frac{4}{3}\pi R^3 g \quad (\because \sigma = 1)$

$\therefore R^3\rho_1 - r^3\rho_1 + r^3\rho_2 = R^3$

$\therefore R^3 (\rho_1 - 1) = r^3 (\rho_1 - \rho_2),$

$$\therefore \frac{R^3}{r^3} = \frac{\rho_1 - \rho_2}{\rho_1 - 1}$$

$$\therefore \frac{R^3 - r^3}{r^3} = \frac{\rho_1 - \rho_2 - \rho_1 + 1}{\rho_1 - 1}$$

$$\therefore \frac{(R^3 - r^3)\rho_1}{r^3\rho_2} = \left(\frac{1-\rho_2}{\rho_1 - 1}\right)\frac{\rho_1}{\rho_2}$$

$$\therefore \frac{\text{mass of concrete}}{\text{mass of waste of unknown object}}$$

$$= \left(\frac{1 - 0.5}{2.5 - 1}\right) \frac{2.5}{0.5} = \frac{5}{3}$$

(33) Answer [A]

Volume of cube drawn into a liquid is $V' = \left(\frac{\rho}{\rho'}\right)$ shows that density of cube depends on density of liquid. Thus, whole system consisting of a floating cube moves upward or downward with constant velocity or acceleration with having no change in it, only half part of cube is drawn into $\left(\frac{1}{2}\right)$ part of liquid

(34) Answer [A]

Weight of solid cylinder =

Normal force due to both liquids

$$\therefore VDg = \left(\frac{A}{5} \times \frac{3}{4} L\right) \times d \times g$$

$$+ \left(\frac{A}{5} \times \frac{L}{4}\right) \times 2d \times g$$

$$\therefore \left(\frac{A}{5} \times L\right) \times D \times g = \frac{A \times L \times d \times g}{4}$$

$$\therefore \frac{D}{5} = \frac{d}{4}, \therefore D = \frac{5}{4}d$$

(35) Answer [D]

Cube moves upwards when frog falls down into the water and hence decreases in l. In addition due to the decrease in volume of cube which is drawn in liquld makes decrease in displaced liquid and hence level of water decreases so h is also decreases. (But, some level of water increases due to the displaced water equal to volume of frog when frog fell into the water but it is negligible. Because volume of cube >> volume of frog.

(36) Answer [C]

Weight of sphere having density ρ is

$= \frac{4}{3}\pi R^3 \rho g$ ...(1)

Normal force on sphere due to oil is

$= \frac{2}{3}\pi R^3 \sigma_{oil}\, g$ ...(2)

Normal force on sphere due to Mercury ($_{Hg}$) is $= \frac{2}{3}\pi R^3 \sigma_{Hg}\, g$ ...(3)

Weight for a floating sphere is

= (Normal force due to oil) + (Normal force due to mercury)

From equation (1), (2) and (3),

$$\frac{4}{3}\pi R^3 \rho g = \frac{2}{3}\pi R^3 \sigma_{oil}\, g + \frac{2}{3}\pi R^3 \sigma_{Hg}\, g$$

$$\therefore \frac{4}{3}\pi R^3 \rho g = \frac{2}{3}\pi R^3 (\sigma_{oil} + \sigma_{Hg}) g$$

$\therefore 2\rho = \sigma_{oil} + \sigma_{Hg}$

$\therefore 2\rho = 0.8 + 13.6$

$\therefore 2\rho = 14.4$

$\therefore \rho = 7.2\ gcm^{-3}$

(37) Answer [A]

Suppose, length of rod PQ is = L

$\therefore$ SP = SQ = $\frac{L}{2}$, Weight of rod W = ALρg which acts on point S in downward direction. Buoyant force acts on rod $F_B = Al\rho_0 g$ which acts on the center point of PR in vertical direction.

l = length of PR.

According to the condition of rotational equilibrium

$F_B = W$

$\therefore A l \rho_0 g \times \frac{l}{2} \cos\theta = AL\rho g \times \frac{L}{2} \cos\theta$

$\therefore \frac{l^2}{L^2} = \frac{\rho}{\rho_0}, \therefore \frac{l}{L} = \sqrt{\frac{\rho}{\rho_0}}$

From figure $\sin\theta = \frac{h}{l} = \frac{L}{2l}$

$\therefore \sin\theta = \frac{1}{2}\sqrt{\frac{\rho_0}{\rho}}$

(38) Answer [C]

decrease in weight of metal piece in liquid
$= 250 - 200 = 50\ g$
decrease in weight of metal piece in water
$= 250 - 150 = 100\ g$
$\therefore$ Speitic density of liquid

$= \frac{\text{decrease of weight in liquid}}{\text{decrease of weight in water}}$

$= \frac{100}{50}, \therefore \frac{\text{density of liquid}}{\text{densily of water}} = 2$

$\therefore$ density of liquid $= 2 \times$ density of water
$= 2 \times 1 = 2\ \text{gcm}^{-3}$
Specific densily of metal piece

$= \frac{\text{Weight of piece in air}}{\text{decrease of weight in water}} = \frac{250}{50}$

$\therefore \frac{\text{density of metal}}{\text{density of water}} = 5$

$\therefore$ density of metal $= 5 \times$ density of water
$= 5 \times 1 = 5\ \text{gcm}^{-3}$

(39) Answer [A]

Suppose, displacement given to object is x from its equilibrium condition. So, here generated excess Buoyant force $x\rho Ag$ is applied to object.
If generated acceleration is a then,

$x\rho Ag = ma, \therefore a = \left(\frac{Agx}{m}\right)\rho$

Here acceleration is $\propto x$, So, this is the equation of simple harmonic motion.

$\left[\text{equation of simple harmonic motion } \frac{d^2y}{dt^2} = -\omega^2 y\right]$

$\therefore \omega^2 = \frac{\rho Ag}{m} \Rightarrow T = 2\pi\sqrt{\frac{m}{\rho Ag}}$

$\therefore T \propto \frac{1}{\sqrt{A}}$

(40) Answer [C]

Liquid flowing in pipe is unpressurized so, as mass of liquid enters in left side of pipe same mass of liquid exits from right side of pipe.
Suppose, mass of liquid which is entering = M mass of liquid which is exiting is m_1 and m_2 then
$M = m_1 + m_2 \Rightarrow Av_1 = Av_2 + 2.5Av$
$A \times 6 = A \times 2.5 + 2.5Av$
$3.5\ A = 2.5Av$

$\frac{3.5}{2.5} = v = \frac{7}{5}\ \text{ms}^{-1}$

(41) Answer [D]

$\frac{1}{2} mv_2^2 = mgy \Rightarrow v_1 = \sqrt{2gy}$ and area $A_1 = L^2$ and

$\frac{1}{2} mv_2^2 = mg \times 4y \Rightarrow v_2 = \sqrt{2g \times 4y}$ and area $A_2 = \pi R^2$

From continuity equation $A_1v_1 = A_2v_2$

$\therefore L^2 \times \sqrt{2gy} = \pi R^2 \times \sqrt{8gy}$

$\therefore \frac{L^2}{\pi} \times \frac{1}{\sqrt{4}} = R^2, \therefore R^2 = \frac{L^2}{2\pi}$

$\therefore R = \frac{L}{\sqrt{2\pi}}$

(42) Answer [D]

the velocity is v_2 when water comes down from height h then, $v_2^2 - v_1^2 = 2gh$

$v_2^2 = v_1^2 + 2gh \Rightarrow v_2^2 = (0.6)^2 + 2 \times 10 \times 0.2$

$v_2 = 2.1\ \text{ms}^{-1}$

Now from equation of continuity $A_1v_1 = A_2v_2$

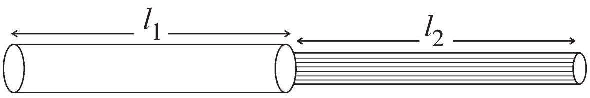
$$\therefore \pi\left(\frac{D_1}{2}\right)^2 v_1 = \pi\left(\frac{D_2}{2}\right)^2 \times 2.1$$

$$\therefore \left(\frac{12\times10^{-3}}{2}\right)^2 \times 0.6 = \left(\frac{D_2}{2}\right)^2 \times 2.1$$

$$\therefore \frac{144\times10^{-6}\times0.6}{4} = \frac{D_2^{\,2}}{4} \times 2.1$$

$D_2 = 6.4 \times 10^{-3}$ m

(43) **Answer [B]**



flow rate of liquid $V = \dfrac{P}{R}$ ...(1)

Where resistance of liquid $R = \dfrac{8\eta l}{\pi r^4}$ ...(2)

$R' = \dfrac{8\eta l}{\pi\left(\frac{r}{2}\right)^4} = \dfrac{8\eta l}{\pi r^4} \times 16 = 16R$ ...(3)

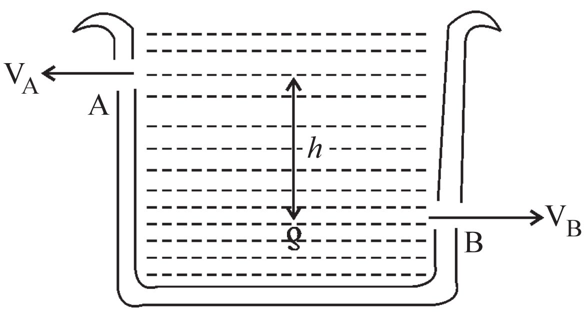
For small pipe and series connection of both pipe,

$$V_{Series} = \frac{P}{R + R'}$$

$$\therefore V_{Series} = \frac{P}{R+16R} = \frac{P}{17R} = \frac{V}{17}$$

$$\therefore V_{Series} = \frac{V}{17}$$

(45) **Answer [C]**



Here from figure, it is clear that $v_B > v_A$

$\therefore$ Resulting force

$$F = F_B - F_A = \frac{dp_B}{dt} - \frac{dp_A}{dt}$$

$= av_B\rho \times v_B - av_A\rho \times v_A$

$\therefore F = a\rho\,(v_B^2 - v_A^2)$

Now, According to Bernoulli's equation

$P_A + \frac{1}{2}\rho v_A^2 + \rho gh = P_B + \frac{1}{2}\rho v_B^2 + 0$ .....

(taking hole A near surface)

$\therefore \frac{1}{2}\rho\,(v_B^2 - v_A^2) = \rho gh$

$\therefore v_B^2 - v_A^2 = 2gh,$

substituting this value in equation (1),

$\therefore F = 2a\rho gh$

Now put the values.

(46) **Answer [B]**

According to Bernoulli's equation

$$P_A + \frac{1}{2}\rho v_A^2 + \rho g h_A = P_B + \frac{1}{2}\rho v_B^2 + \rho g h_B$$

Here $h_A = h_B$

$\therefore P_A + \frac{1}{2}\rho v_A^2 = P_B + \frac{1}{2}\rho v_B^2$

$\therefore P_A - P_B = \frac{1}{2}\rho\,[v_B^2 - v_A^2]$

Now $v_A = 0$, $v_B = r\omega$ and $P_A - P_B = h\rho g$

Where $\omega = 2\pi\ rad\ s^{-1}$

$\therefore h\rho g = \frac{1}{2}\rho r^2\omega^2$ or $h = \dfrac{r^2\omega^2}{2g}$

putting values in equation

$$h = \frac{25(4\pi^2)}{2(1000)} = \frac{\pi^2}{20} = 0.05\pi^2 \text{ cm}$$

(47) **Answer** [B]

According to Bernoulli's equation $\frac{1}{2}\rho v^2 = \rho gh$

means $h = \dfrac{v^2}{2g}$

$v = r\omega$, $h = \dfrac{r^2\omega^2}{2g}$, $h = 0.0128$ m, $h = 1.3$ cm

$h < 2$ cm $\therefore$ liquid will not overflow.

(48) Answer [A]

length of combined pipe is double then previous and rate of liquid flow inversely proportional to length x. ($\because$ According to Poiseiulle's rule)

$\therefore$ Rate of liquid flow $\propto \dfrac{1}{\text{length}}$

$\therefore$ Rate of liquid flow $= \dfrac{x}{2}$

(49) Answer [D]

Area of plate A = $(0.1)^2 = 0.01$ m^2

$\eta = 0.01$ poise

$\eta = 0.001$ deca poise taking (MKS unit)

$dv = 0.1$ ms^{-1}

Viscous force F = 0.002 N

$\therefore$ F $= \eta A \dfrac{dv}{dx}$, $\therefore dx = \eta A \dfrac{dv}{F}$

$= \dfrac{0.001 \times 0.01 \times 0.1}{0.002}$, $\therefore$ $dx = 0.0005$ m

(50) Answer [C]

When sphere falls on the surface after travelling distance h then its velocity

$v = \sqrt{2gh}$ ...(1)

final velocity when sphere moves in liquid

$v = \dfrac{2}{9}\dfrac{r^2}{\eta} \cdot (\rho - \sigma) \cdot g$ (σ, density of air = 1)

$\therefore$ $v = \dfrac{2r^2(\rho - 1)g}{9\eta}$ ...(2)

Compare the equation (1) and (2),

$$\sqrt{2gh} = \frac{2r^2(\rho - 1)g}{9\eta}$$

$\therefore$ $h = \dfrac{2}{81} \cdot r^4 \left(\dfrac{\rho - 1}{\eta}\right)^2 g$, $h \propto r^4$

$\dfrac{h_2}{h_1} = \left(\dfrac{r_2}{r_1}\right)^4$, $h_2 = 16\, h_1$, $h_2 = 16 \times 10$

$h_2 = 160$ cm

(52) Answer [C]

Here from stoke's law

$6\pi\eta r v_r = mg$, $\therefore v_r = \dfrac{mg}{6\pi\eta r}$

$[v_r] = \dfrac{[mg]}{[\eta r]}$ (6π constant)

$= \dfrac{M^1L^1T^{-2}}{M^1L^{-1}T^{-1} \times L^1} = M^0L^1T^{-1}$

This is dimonsion of Velocity.

$\therefore$ true relation is $v_r \propto \dfrac{mg}{r\eta}$.

(53) Answer [B]

(total volume of n small drops) = Volume of one big drop)

$n \times \dfrac{4}{3}\pi r^3 = \dfrac{4}{3}\pi R^3$, $\therefore n = \dfrac{R^3}{r^3}$

Generated heat $= \dfrac{\text{Work done}}{J}$

$= \dfrac{\text{Surface tension} \times \text{decrease in area}}{J}$

$\therefore$ ms$d\theta = \dfrac{T \times \left(n \times 4\pi r^2 - 4\pi R^2\right)}{J}$

$\therefore$ $\dfrac{4}{3}\pi R^3 \times 1 \times 1 \times d\theta = \dfrac{T}{J}$

$\left(n \times 4\pi r^2 - 4\pi R^2\right)$

$\therefore$ $d\theta = \dfrac{3T \times 4\pi}{J \times 4\pi R^3}[nr^2 - R^2]$

$= \dfrac{3T}{JR^3}\left[\dfrac{R^3}{r^3}r^2 - R^2\right] = \dfrac{3TR^3}{JR^3}\left[\dfrac{1}{r} - \dfrac{1}{R}\right]$

$= \dfrac{3T}{J}\left[\dfrac{1}{r} - \dfrac{1}{R}\right]$

(54) Answer [A]

Accrding to capillary action,

$h_1 = \dfrac{2T\cos\theta}{r_1\rho g}$, $h_2 = \dfrac{2T\cos\theta}{r_2\rho g}$, $\therefore h = h_1 - h_2$

$= \dfrac{2T\cos\theta}{r_1\rho g} - \dfrac{2T\cos\theta}{r_2\rho g} = \dfrac{2T}{\rho g}\left[\dfrac{1}{r_1} - \dfrac{1}{r_2}\right]$

$\therefore h = \dfrac{2T(r_2 - r_1)}{\rho g r_1 r_2}$, $\therefore$ T $= \dfrac{h\rho g r_1 r_2}{2(r_2 - r_1)}$

(55) Answer [B]

Surface energy $u = T \times 4\pi R^2$

liquid drop of R radius dissociates in 512 drops of radius r.

$\therefore$ (Volume of drop having radius R)

= (Volume of 512 drop having radius r)

$\therefore \frac{4}{3}\pi R^3 = 512 \times \frac{4}{3}\pi r^3$, $\therefore r = \frac{R}{8}$

Now total surface energy of 512 drops

$= T \times 512 \times 4\pi r^2 = T \times 512 \times 4\pi\left(\frac{R^2}{64}\right)$

$= 8\,(4\pi TR^2) = 8\,u$

(56) Answer [A]

Suppose, the radius of bubbles are a and b and the radius of combined large drop is c then,

$P_a = P_0 + \frac{4T}{a}$, $P_b = P_0 + \frac{4T}{b}$, $P_c = P_0 + \frac{4T}{c}$

However, $V_a = \frac{4}{3}\pi a^3$, $V_b = \frac{4}{3}\pi b^3$, $V_c = \frac{4}{3}\pi c^3$

Now due to the conservation of mass of air inside bubble, in mole $n_a + n_b = n_c$

According to equation of ideal gas

$$\frac{P_aV_a}{RT_a} + \frac{P_bV_b}{RT_b} = \frac{P_cV_c}{RT_c}$$

Assuming temperature T constant

$P_aV_a + P_bV_b = P_cV_c$

$$\left(P_0 + \frac{4T}{a}\right)\left(\frac{4}{3}\pi a^3\right) + \left(P_0 + \frac{4T}{b}\right)\left(\frac{4}{3}\pi b^3\right)$$

$$= \left(P_0 + \frac{4T}{c}\right)\left(\frac{4}{3}\pi c^3\right)$$

$\therefore\ 4T\,(a^2 + b^2 - c^2) = P_0\,(c^3 - a^3 - b^3)$

$\therefore\ \frac{4}{3}T4\pi\,(a^2 + b^2 - c^2) = P_0\,\frac{4}{3}\pi\,(c^3 - a^3 - b^3)$

But, $4\pi\,(a^2 + b^2 - c^2) = S$ Difference in area of surface

$\frac{4}{3}\pi\,(c^3 - a^3 - b^3) = -V$

Difference in volume of bubble formed in air

$\therefore\ \frac{4T}{3}S = -P_0V$, $\therefore\ 4ST = -3P_0V$

$\therefore\ 3P_0V + 4ST = 0$

(57) Answer [D]

Work done to spread bubble from radius r_1 to r_2,

$W = 8\pi T\left(r_2^2 - r_1^2\right)$

($\because$ bubble has two free surface)

Here, putting $r_2 = \frac{D}{2}$ and $r_1 = \frac{d}{2}$

$$W = 8\pi T\left[\left(\frac{D}{2}\right)^2 - \left(\frac{d}{2}\right)^2\right]$$

$W = 8\pi T\left[\frac{D^2}{4} - \frac{d^2}{4}\right]$, $W = 2\pi T\,[D^2 - d^2]$

Where $D = 2d$, $T = 30$ *dyne* cm^{-1}

$\therefore\ W = 2\pi\,(30)\,(3)$

$W = 180\,\pi$ erg

(58) Answer [B]

When n small drops together and forms large drop having radius R then, total volume of n small drops = volume of large drop.

Radius of each drop is r then,

$n\,\frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$

$\therefore\ R = n^{\frac{1}{3}}r$ (Here, $n = 1000$)

$\therefore\ R = (1000)^{\frac{1}{3}}r$, $R = 10r$

Ratio of surface energy of small drop to large drop

$$\frac{E_i}{E_f} = \frac{1000\left(4\pi r^2T\right)}{4\pi R^2T} = \frac{1000\ r^2}{R^2} = \frac{1000\ r^2}{100r^2}$$

$= 10$, $E_i : E_f = 10 : 1$

(59) Answer [C]

Here bubbles are togethered in vaccum and no change in temperature. So, no change surface energy also mean no change in surface area

$d_1 = 1$ cm $\Rightarrow$ $r_1 = 0.5$ cm

$d_2 = 2$ cm $\Rightarrow$ $r_2 = 1$ cm

So, $4\pi r_1^2 + 4\pi r_2^2 = 4\pi R^2$

$R = \sqrt{r_1^2 + r_2^2}$, $R = 1.1$ cm

(60) Answer [D]

The water surface becomes concave in test tube for this,

$P_i - P_0 = \frac{2T}{R}$, $\therefore P_i = P_0 + \frac{2T}{R}$

$= 10^5 + \frac{2 \times 0.07}{0.1 \times 10^{-3}} = 10^5 + 0.14 \times 10^4$

$= 101.4 \times 10^3 \text{ Nm}^{-2}$

(61) Answer [C]

At bottom of lake, volume of bubble is V_1 and pressure on it is P_1.

On surface of lake, volume of bubble is V_2 and pressure on it is P_2.

$\therefore$ (For bubble at bottom of lake P_1V_1)

= (for bubble on surface of lake P_2V_2)

$\therefore (P_0 + h\rho g)\, V_1 = P_0V_2$, where $V_1 = V$

$V_2 = 4V$

$(P_0 + h\rho g)\, V = P_0\,(4V)$, $h\rho g = 3\,P_0$

$h = \frac{3P_0}{\rho g}$, where $P_0 = H \times \rho_{Hg} \times g$

$P_0 = 75 \times 13.6 \times g$, ρ Water $= \frac{\rho_{Hg}}{10}$

$= 3\left(\frac{75 \times 13.6 \times g}{\left(\frac{13.6}{10}\right)g}\right)$, $h = 22.5$ m

(62) Answer [B]

Suppose density of water $\rho = 1$ and required height is h.

density of gas bubble is σ unit.

$\therefore \quad (h\sigma g + H\rho g)\, \frac{4}{3}\pi r^3 = h\sigma g \times \frac{4}{3}\pi(3r)^3$

$27\, h\sigma g = h\sigma g + H\rho g$, $26\, h\sigma g = H\rho g$

$26\, h\sigma = H$, $h = \frac{H}{26\sigma}$

(63) Answer [B]

For rod $A_1 = \pi r^2$

For cylindrical shield $A_2 = \pi\left((2r)^2 - r^2\right)$

$= 3\pi r^2$, thermal conductivity $\frac{Q}{t} = \frac{Q_1}{t} + \frac{Q_2}{t}$

$= \frac{k_1A_1(T_1 - T_2)}{L} + \frac{k_2A_2(T_1 - T_2)}{L}$

$$\frac{Q}{t} = \frac{k_1(\pi r^2)(T_1 - T_2)}{L} + \frac{k_2(3\pi r^2)(T_1 - T_2)}{L} \quad ...(1)$$

Here, cross-section of combine rod, $A = \pi(2r)^2 = 4\pi r^2$

$\therefore$ If taking equivalent thermal conductivity k_{eq}

$$\frac{Q}{t} = \frac{k_{eq}(4\pi r^2)(T_1 - T_2)}{L} \quad ...(2)$$

$\therefore$ Compare the equation (1) and (2)

$4k_{eq} = k_1 + 3k_2$, $\therefore k_{eq} = \frac{2k + 3k}{4} = \frac{5k}{4}$

(64) Answer [C]

Choose one subtle element of thickness dr at distance r from axis as shown in figure. The difference in temperature between inside and outside of this element is dT.

$\therefore$ thermal conductivity $H = kA\frac{dT}{dr}$, $H = \frac{k(2\pi rL)}{dr}\, dT$

$\frac{dr}{r} = k\,\frac{2\pi L}{H}\, dT$, By integration

$$\int_{r_1}^{r_2} \frac{1}{r}\, dr = \frac{2\pi kL}{H} \int_{T_1}^{T_2} dT$$

$$ln\left(\frac{r_2}{r_1}\right) = \frac{2\pi kL}{H} \times (T_2 - T_1)$$

$$ln\left(\frac{4}{2}\right) = \frac{2 \times 3.14 \times 69.3 \times 0.5(200 - 0)}{H}$$

$H = 6.28 \times 10^4 \text{ Js}^{-1}$

(65) Answer [A]

Slab-2 and slab-3 are in series connection

$\therefore$ equivalent thermal conductivity $k_{23} = \frac{2k_2k_3}{k_2 + k_3}$

Now compound slab of 2 and 3 and slab 1 and slab 4, are in parallel connection.

$\therefore$ equivalent thermal conductivity of parallel connection is

$$k = \frac{k_1A_1 + k_{23}A_{23} + k_4A_4}{A_1 + A_{23} + A_4}$$

$$= \frac{k_1(x^2) + k_{23}(2x^2) + k_4(x^2)}{x^2 + 2x^2 + x^2}$$

$$= \frac{k_1 + 2k_{23} + k_4}{4} = \frac{k_1 + \frac{4k_2k_3}{k_2 + k_3} + k_4}{4}$$

$$k = \frac{(k_1 + k_4)(k_2 + k_3) + 4k_2k_3}{4(k_2 + k_3)}$$

(66) Answer [C]

Slab (1) and (2) are in parallel connection.

$\therefore$ equivalent thermal conductivity

$$k_{12} = \frac{k_1A_1 + k_2A_2}{A_1 + A_2} = \frac{k(2x^2) + 2k(x^2)}{2x^2 + x^2}$$

$$k_{12} = \frac{4kx^2}{3x^2} = \frac{4}{3}k \quad ...(1)$$

Simullarly cube (3) and (4) are parallel equaivolent ther mal conductivity

$$k_{34} = \frac{k_3A_3 + k_4A_4}{A_3 + A_4} = \frac{2k(2x^2) + k(x^2)}{2x^2 + x^2}$$

$$= \frac{5kx^2}{3x^2}, k_{34} = \frac{5k}{3} \quad ...(2)$$

Now, for compound slab of slab 1 and slab 2 and mixture of 3 and 4 are in series connection to each other.

$\therefore$ equilibrium thermal conductivity

$$k = \frac{2k_{12}k_{34}}{k_{12} + k_{34}} = \frac{2\left[\frac{4k}{3} \times \frac{5k}{3}\right]}{\frac{4k}{3} + \frac{5k}{3}}$$

$$= \frac{40k^2}{9\left[\frac{9k}{3}\right]} = \frac{40k}{27}$$

(67) Answer [D]

335 kJ heat require to melt 1 kg Ice.

$\therefore$ Heat require to melt 5 kg Ice is

$Q = 5 \times 335 = 1675$ kJ

Now, for circular vessel

$$\frac{Q}{t} = \frac{4\pi k r_1 r_2}{(r_1 - r_2)}(T_1 - T_2)$$

Where r_1 is outer radius and r_2 is inner radius

$$\therefore t = \frac{Q(r_1 - r_2)}{4\pi r_1 r_2 (T_1 - T_2)k}$$

$$= \frac{1675 \times 10^3 (5 \times 10^{-2})}{12.56 \times 25 \times 30 \times 10^{-4} \times 45 \times 0.028}$$

$= 70560.7$ s $= 19.6$ h ≈ 20 h

(68) Answer [A]

thermal conductivity $H = \frac{Q}{t} = \frac{T_1 - T_2}{R}$

Here three layers are in series connection

$\therefore$ its equivalent resistance

$$R = R_1 + R_2 + R_3 = \frac{L_1}{k_1A} + \frac{L_2}{k_2A} + \frac{L_3}{k_3A}$$

$$= \frac{1}{A}\left[\frac{L_1}{k_1} + \frac{L_2}{k_2} + \frac{L_3}{k_3}\right]$$

$$= \frac{1}{25}\left[\frac{0.1}{1.26} + \frac{0.05}{0.0275} + \frac{0.075}{0.65}\right] = \frac{1}{25}(1.936)$$

$$R = 0.077 \text{ KsJ}^{-1}, \therefore H = \frac{12}{0.077} = 155.84 \text{ W}$$

(69) Answer [C]

$$\frac{k_1}{k_2} = \frac{k_3}{k_4}, \therefore k_3 = \frac{k_1k_4}{k_2}$$

$$= \frac{370 \times 16}{320} = 18.5 \text{ Wm}^{-1}\text{K}^{-1}$$

(70) Answer [B]

$$t = \frac{1}{2}\frac{\rho L}{kT}\left(x_2^2 - x_1^2\right)$$

$$= \frac{1}{2} \times \frac{0.92 \times 80}{0.004 \times 12}[225 - 64]$$

$= 123433$ s $= 34.3$ h

(71) Answer [B]

According to Newton's law $-\frac{dT}{dt} = k'(T - T_S)$

during first 4 minute,

$$\frac{-(74 - 90)}{4} = k'\left(\frac{90 + 74}{2} - T_S\right)$$

$$4 = k'(82 - T_S) \quad ...(1)$$

during second 4 minute,

$$\frac{-(62 - 74)}{4} = k'\left(\frac{62 + 74}{2} - T_S\right)$$

$$3 = k'(68 - T_S) \quad ...(2)$$

Ratio of equation (1) and (2)

$$\frac{4}{3} = \frac{82 - T_S}{68 - T_S}, 272 - 4T_S = 246 - 3T_S$$

$T_S = 26$ °C, substituting in equation (1)

$4 = k'(82 - 26) = k'(56) \Rightarrow k' = 1/14$

during last 12 minute

Suppose T_x is the temperature after total 20 minute.

$$-\left(\frac{T_x - 62}{12}\right) = \frac{1}{14}\left(\frac{62 + T_x}{2} - 26\right)$$

$62 - T_x = \frac{3}{7}(T_x + 10) \Rightarrow 434 - 7T_x = 3T_x + 30$

$404 = 10T_x \therefore T_x = 40.4\,°C$

(72) Answer [C]

Acconding to Lorent-Langmuir law,

$$\frac{-dT}{dt} = k'\left(T - T_S\right)^{\frac{5}{4}}$$

$$-\left[\frac{82 - 100}{t}\right] = 0.01234567\left[\frac{82 + 100}{2} - 10\right]^{\frac{5}{4}}$$

$$\frac{18}{t} = \frac{1}{81}\left(91 - 10\right)^{\frac{5}{4}} = \frac{1}{81}\left(81\right)^{\frac{5}{4}}$$

$$\frac{18}{t} = 81^{\frac{1}{4}} \Rightarrow \frac{18}{t} = 3 \;\therefore\; t = 6 \text{ minute}$$

(73) Answer [C]

According to Wien's displacement law

$\lambda_m T = \text{constant}$

$\therefore$ From $\lambda_m \propto \frac{1}{T}$ decrease of 30%

(74) Answer [A]

According to wien's displacement law $\therefore \lambda_m \propto \frac{1}{T}$

Accouding to Stephen Boltzman's law $W \propto T^4$

$$W \propto \frac{1}{\lambda_m{}^4}, \therefore \frac{W_2}{W_1} = \left(\frac{\lambda_{m_1}}{\lambda_{m_2}}\right)^4$$

$$\therefore \frac{W_2}{W_1} = \left(\frac{\lambda_{m_1}}{0.7\lambda_{m_1}}\right) = \left(\frac{1}{0.7}\right)^4$$

Increase of emission power $= W_2 - W_1$

$= (4.16 - 1)\, W_1 = 3.16\, W_1$

$\therefore$ Percentage increase in emission power = 316 %

(75) Answer [B]

According to Stephen-Boltzman's law

$$W \propto T^4, \quad \therefore \frac{W_2}{W_1} = \left(\frac{T_2}{T_1}\right)^4$$

$$\therefore \frac{T_2}{T_1} = \left(\frac{W_2}{W_1}\right)^{\frac{1}{4}}, \quad \therefore \frac{T_2}{T_1} = \left(\frac{0.75W_1}{W_1}\right)^{\frac{5}{4}}$$

$\therefore \; T_2 = 0.9305\, T_1$

$\therefore$ Decrease in temperature $= (1 - 0.9305)T_1$

$= (0.0695)T_1$

$\therefore$ Percentage decrease in temperature $= 6.95\,\% \approx 7\,\%$

(76) Answer [D]

law of Stephen - Boltzman, $W \propto T^4$

$$\frac{W_2}{W_1} = \left(\frac{T_2}{T_1}\right)^4 = \left(\frac{3T_1}{T_1}\right)^4, \; W_2 = 81W_1$$

$\therefore$ Power is 81 times higher.

$\therefore$ Percentage increment = 8000 %

(77) Answer [D]

From Stephen-Boltzman law,

$$\frac{dQ}{dt} = e\sigma A\left(T^4 - T_S{}^4\right)$$

$$\therefore \frac{\left(\frac{dQ}{dt}\right)_1}{\left(\frac{dQ}{dt}\right)_2} = \frac{T_1{}^4 - T_S{}^4}{T_2{}^4 - T_S{}^4}$$

$$\therefore 3.65 = \frac{(360)^4 - T_S{}^4}{(320)^4 - T_S{}^4}$$

$\therefore 3.65\,[(320)^4 - (T_S)^4] = (360)^4 - T_S{}^4$

$\therefore T_S = 300\,K$

(78) Answer [D]

If original length is L then increase in length due to tension force is, $l = \frac{FL}{\pi r^2 Y}$, However $a = L + l$

$$= L + \frac{5L}{\pi r^2 Y} = L + 5C \text{ and}$$

$$b = L + \frac{6L}{\pi r^2 Y} = L + 6C, \text{ Where } C = \frac{L}{\pi r^2 Y}$$

From equation (1) and (2), $L = 6a - 5b$

$C = b - a$, For F = 9 N

$$x = L + \frac{9L}{\pi r^2 Y} = L + 9C$$

$= (6a - 5b) + 9\,(b - a)$, $x = 4b - 3a$

(79) Answer [C]

Area of Hysterisis loop A is very low compare to B. That means rubber A losses less heat energy than B. Result is tyre made from rubber is not heated fill high temperature.

(80) Answer [A]

$$\Delta L = \frac{FL}{AY}$$

Here Y is same due to matter is same for both wires. F and A are also same. $\therefore \Delta L \propto L$

(81) Answer [A]

Area of cross-section $A = \frac{\pi d^2}{4}$, Where d=diameter

$$\therefore \Delta L = \frac{4F}{\pi d^2} \frac{L}{Y}, \quad \therefore \Delta L \propto \frac{1}{d^2}$$

(83) Answer [A]

Blowing air on the piece of paper, speed of upper most air molecules of paper is more than the lowermost molecules.

Now, from the theorem of energy conservation of floatation, pressure of the upper surface of paper is less than the lower surface. Thus, lowest air, gives upward thrust to the page.

(84) Answer [C]

Water flows outwards from the hole posseses momentum. According to the law of conservation of momentum applied force is in opposite direction to the vessel. Thus, momentum and force acts in the opposite direction.

(86) Answer [C]

Rotating balls attracts air with them. Hence Velocity of air increases at the lower surface. Thus, pressure is low at the upper surface and high at the lower surface. Due to the difference of pressure, ball swings upward.

(88) Answer [C]

mass of object is balanced by two forces, buoyant force and viscous force in upward direction.

(89) Answer [A]

$\Delta L_1 = L\,\alpha_1\,T$

$\Delta L_2 = L\,\alpha_2\,T$

$\therefore \Delta L_1 + \Delta L_2 = LT\,(\alpha_1 + \alpha_2)$ ...(1)

Here, length of wall does not increases due to rigidity. Hence, length of rod decreases due to force F.

$$\Delta L_1' = \frac{FL}{Y_1 A}, \quad \Delta L_2' = \frac{FL}{Y_2 A}$$

$$\Delta L_1' + \Delta L_2' = \frac{FL}{A}\left[\frac{1}{Y_1} + \frac{1}{Y_2}\right] \quad ...(2)$$

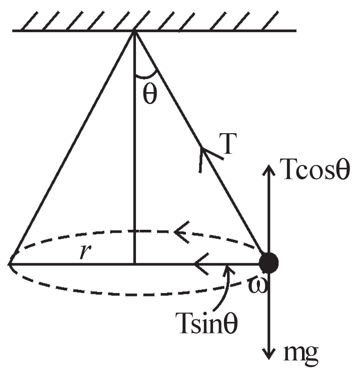
Here total length remains constant. Increase in total length due to heating = decrease in total length due to pressure. taking values from equation (1) and (2).

(90) Answer [C]

New length of rod P = (original length + increase in length due to heating - decrease in length due to pressure)

$$\therefore L_1 = L + L\alpha_1\,T - \frac{FL}{AY_1}$$

(92) Answer [C]



$T\cos\theta = mg$ ...(1)

$T\sin\theta = mr\omega^2$ ...(2)

divide equation (1) by (2)

$$\tan\theta = \frac{r\omega^2}{g}, \therefore \omega = \sqrt{\frac{g\tan\theta}{r}}$$

$$= \sqrt{\frac{10 \times \tan 30}{0.2}} = 5.37 \text{ rad s}^{-1}$$

(93) Answer [A]

$T\cos\theta = mg$

$$\therefore T = \frac{mg}{\cos\theta} = \frac{2 \times 10}{\cos 30} = 23.12 \text{ N}$$

(94) Answer [B]

$$\text{Stress} = \frac{T}{A} \quad ...(1)$$

$$\text{Also strain } \frac{\Delta L}{L} = \frac{T}{AY}, \therefore \Delta L = \frac{TL}{AY}$$

$$= \frac{mgL}{AY\cos\theta} = \frac{2 \times 10 \times 1}{10^{-6} \times 2 \times 10^{11} \times \cos 30}$$

$= 1.156 \times 10^{-4}$ m

(95) Answer [A]

$$\text{Stress} = \frac{mg}{A} = \frac{2 \times 10}{10^{-6}} = 20 \times 10^6 \text{ Nm}^{-2}$$

(96) Answer [B]

$Mg - T = Ma$ ...(1)

$T - mg = ma$ ...(2)

Compare the equation (1) and (2)

$$a = \frac{(M - m)}{(M + m)} g \text{ , Here, } M = 2m$$

$$a = \frac{(2m - m)}{(2m + m)} g, \quad a = \frac{g}{3}$$

(97) Answer [D]

Compare the equation (1) and (2)

$$T = m(g + a) = m\left(g + \frac{g}{3}\right) = \frac{4mg}{3}$$

$$\text{Stress} = \frac{T}{A} = \frac{4mg}{3A}$$

(98) Answer [D]

A maximum Stress can supported by wire is known as Breaking stress.

Compare the equation (1) and (2)

$$M = m\left[\frac{g + a}{g - a}\right] = 20 \text{ kg}$$

(99) Answer [A] and [C]

For one solid object sliding on another solid object, the frictional force is independent on area of contact surface and relative velocity between cube surfaces. This fact is not true for viscocity between liquid layers.

(101) Answer [C]

The velocity of water which is contact with bottom of river is zero.

$$\frac{|F|}{A} = n\frac{dv}{dx} = 10^{-3} \times \frac{2}{5} = 4 \times 10^{-4} \text{ Nm}^{-2}$$

(102) Answer [D]

$$Av_1 = av_2 \quad \text{or} \quad v_1 = \left(\frac{a}{A}\right) v_2$$

$a << A$, $v_2 \approx 0$, According Bernoulli's equation

$$P_0 + \frac{1}{2} dv_1^2 + dg\left(\frac{H}{2}\right) + (2d)\, g\left(\frac{H}{2}\right)$$

$$= P_0 + \frac{1}{2}(2d)v_2^2 + 2d(gh), \text{ Here, } v_1 = 0$$

$$v_2 = \left[\left(\frac{3}{2}H - 2h\right)g\right]^{\frac{1}{2}}, h = \frac{H}{4}, v_2 = \sqrt{gH}$$

(103) Answer [B]

$$t = \sqrt{\frac{2h}{g}} \text{ , Horizontal range } x = v_2 t$$

$$= \left[\left(\frac{3}{2}H - 2h\right)g\right]^{\frac{1}{2}} \times \sqrt{\frac{2h}{g}}$$

$$= \left[h(3H - 4h)\right]^{\frac{1}{2}}, \; h = \frac{H}{4}, \; x = \frac{H}{\sqrt{2}}$$

(104) Answer [C]

$$\frac{dx}{dh} = 0, \; \frac{d}{dh}\left[3Hh - 4h^2\right]^{\frac{1}{2}} = 0$$

$$\frac{1}{2}\left[3Hh - 4h^2\right]^{\frac{1}{2}} \times (3H - 8h) = 0$$

$$\text{Here, } 3H - 8h = 0 \Rightarrow h = \frac{3}{8} H$$

$$\left[\therefore \left(3Hh - 4h^2\right)^{\frac{-1}{2}} \neq 0\right]$$

Substitaing values in equation of x

$$x_m = \left[\frac{3}{8}H\left(3H - \frac{12}{8}H\right)\right]^{\frac{1}{2}} = \frac{3}{4} H$$

(105) Answer [D]

$$a_1 v_1 = a_2 v_2, v_1 = \left(\frac{a_2}{a_1}\right) v_2 = \frac{v_2}{3} \quad ...(1)$$

$$P_0 + \rho gh + \frac{1}{2}\rho v_1^2 = P_0 + \frac{1}{2}\rho v_2^2$$

$$v_1^2 = v_2^2 - 2gh$$

Substitaing values of equation (1) into (2), $v_1 = \frac{1}{2}\sqrt{gh}$

(106) Answer [C]

$$v_2 = 3v_1 = \frac{3}{2}\sqrt{gh}$$

(107) Answer [B]

$$v_1 = \frac{-dh}{dt}, \; dt = -\frac{dh}{v_1} = -\frac{2}{\sqrt{g}} \times h^{-\frac{1}{2}}\, dh$$

time require to empty of tank

$$h = h \text{ to } h = 0, \; t = -\frac{2}{\sqrt{g}} \int_h^0 h^{-\frac{1}{2}}\, dh$$

$$= -\frac{2}{\sqrt{g}}\left(0 - 2\sqrt{h}\right), \; t = 4\sqrt{\frac{h}{g}}$$

8 Thermodynamics

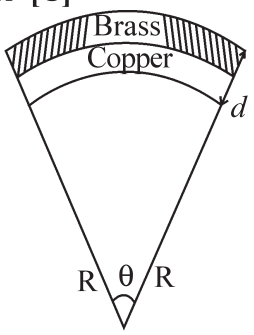
(1) Answer [D]

gas–thermometer has constant volume

$$\therefore \frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow T_2 = \frac{3.5 \times 10^4}{3 \times 10^4} \times 273.16$$

$= 318.6$ K $= 45.6°$ C

(2) Answer [C]



(Brass) ...B $\alpha_B > \alpha_C$ is given.

(Copper) ...C

For Brass

$L_B = L_0 (1 + \alpha_B \Delta T)$

$(R + d)\theta = L_0 (1 + \alpha_B \Delta T)$ ...(1)

For Copper $L_C = L_0 (1 + \alpha_C \Delta T)$

$R\,\theta = L_0 (1 + \alpha_C \Delta T)$ ...(2)

equation (1) ÷ (2)

$$\frac{(R + d)\theta}{R\theta} = \frac{1 + \alpha_B \Delta T}{1 + \alpha_C \Delta T}$$

$$\frac{R + d}{R} = (1 + \alpha_B \Delta T) \cdot (1 + \alpha_C \Delta T)^{-1}$$

According to binomial theorem

$$1 + \frac{d}{R} = (1 + \alpha_B \Delta T) \cdot (1 - \alpha_c \Delta T)$$

$$1 + \frac{d}{R} = 1 + (\alpha_B - \alpha_C)\,\Delta T$$

neglecting higher order terms

$$R = \frac{d}{(\alpha_B - \alpha_C)\Delta T}$$

(3) Answer [B]

Suppose m gram steam is required.

Heat loss by steam = Heat gain by water

$mL + mS\Delta T_1 = MS\Delta T_2$

$m \times 540 + m \times 1 \times (100 - 90)$

$= 100 \times 1 \times (90 - 24)$,

$550m = 6600$

$\therefore m = 12$ g

(4) Answer [A]

Suppose, temperature on "A" scale relative to kelvin scale is T_A.

$$\frac{T_A - (-160)}{50 - (-160)} = \frac{T_K - 273}{373 - 273}$$

$$\frac{T_A + 160}{50 + 160} = \frac{340 - 273}{100}$$

$$\Rightarrow \frac{T_A + 160}{210} = \frac{67}{100} \Rightarrow T_A = -86.3 \text{ A}$$

(5) Answer [A]

$$\frac{100 - 50}{50 - 0} = \frac{150 - x}{x - 20}, \quad \frac{50}{50} = \frac{150 - x}{x - 20}$$

$x - 20 = 150 - x$, $2x = 170$, $x = 85$°C

(6) Answer [B]

Suppose mass of steam is m.

Heat loss by steam = $mL' + ms\Delta\theta$

$= m(540) + m \times 1 \times (100° - 0°)$

$= 540m + 100m = 640m$

Heat gain by Ice $= m_{ice} \times S \times \Delta\theta'$

$= 1200 \times 0.5 \times [0 - (-20)]$

$= 1200 \times 0.5 \times 20 = 12000$

$\therefore$ Heat loss by steam = Heat gain by Ice

$640m = 12000$, $m = 18.75$ g

(7) Answer [A]

Suppose, x kg Ice is melting.

$\therefore$ Heat loss by copper sphere = Heat gain by piece of Ice.

$\therefore$ $ms\,\Delta\theta' = xL'$

$\therefore$ $1 \times 400 \times (500 - 0) = x\,(3.5 \times 10^5)$

$\therefore$ $400 \times 500 = 3.5 \times 10^5 x$ $\therefore$ $x = 0.57$ kg

(8) Answer [A]

$\Delta V = V_0 \gamma \Delta T$

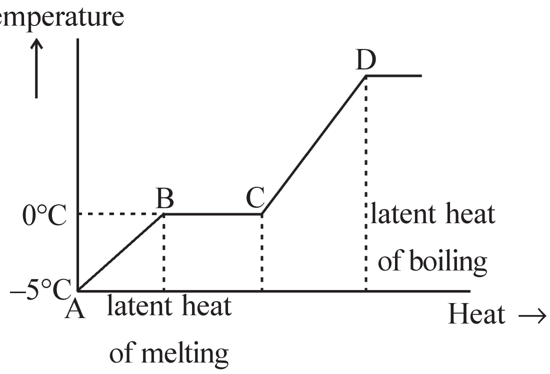
$\Delta V = V_0 (3\alpha) \Delta T \qquad \gamma = 3\alpha$

$\frac{\Delta V}{V} = 3\alpha \Delta T, \alpha = \frac{\Delta V}{V} \times \frac{1}{3} \times \frac{1}{\Delta T}$

$= \frac{0.12}{100} \times \frac{1}{3} \times \frac{1}{60} = 0.00666 \times 10^{-3}$

$= 6.66 \times 10^{-6} \quad °C^{-1}$

(15) Answer [A]



First temperature of ice increases from –5 °C to 0 °C (AB curve). Bc curve indicate that ice convert from solid state to liquid state. CD curve indicate that water convert from liquid state to gases state.

(16) Answer [D]

Moment of Inertia of sphere $I = \frac{2}{5} MR^2$

Now, angular speed $\omega = 2\pi f$

$\therefore$ Kinetic energy $K = \frac{1}{2} I \omega^2$

$= \frac{1}{2}\left(\frac{2}{5}MR^2\right)(2\pi f)^2, K = \frac{4}{5}M\pi^2R^2f^2$

50 % of this kinetic energy transfer into heat

$\therefore \Delta Q = \frac{1}{2} \times$ Kinetic energy

$\Delta Q = \frac{1}{2} \times \frac{4}{5} M\pi^2R^2f^2$

$\Delta Q = \frac{2}{5} M\pi^2R^2f^2$, But $\Delta Q = MS\,\Delta T$

$\Delta T = \frac{\Delta Q}{MS} = \frac{\frac{2}{5}M\pi^2R^2f^2}{MS} = \frac{2}{5}\frac{\pi^2R^2f^2}{S}$

(17) Answer [D]

Heat capacity of Aluminum = ms

$= 100 \times 0.2 = 20 \text{cal } °C^{-1}$

$= 20 \times 4.2 \text{ J } °C^{-1} = 44 \text{ J } °C^{-1}$

(20) Answer [C]

$T_C = -273.15 \text{ °C}, T_F = \frac{9}{5} T_C + 32$

$= \frac{9}{5}(-273.15°) + 32° = -459.67 \text{ °F}$

(21) Answer [C]

$T_C = T_F, T_C = \frac{9}{5} T_C + 32$

$T_C = \frac{9}{5} T_C = 32, T_C = -40°C = -40°F$

(22) Answer [B]

density of water is maximum at 4 °C

$T_F = \frac{9}{5} T_C + 32 = \frac{9}{5}(4°) + 32$

$T_F = 39.2 \text{ °F}$

(24) Answer [D]

Required heat to increase 1 K temperature of sphere having radius R_1

$(\Delta Q)_1 = m_1 S_{cu} \Delta T = \rho_{cu}(V)_{cu} S_{cu} \Delta T$

$= \rho_{cu}\left(\frac{4}{3}\pi R_1^3\right) S_{cu}(1) \qquad ...(1)$

Required heat to increase 1 K temperature of sphere having radius R_2.

$(\Delta Q)_2 = m_2 S_{cu} \Delta T$

$= \rho_{cu}\left(\frac{4}{3}\pi R_2^3\right) S_{cu} \qquad ...(2)$

But $R_1 = 2R_2 \Rightarrow R_2 = \frac{R_1}{2}$

$\therefore (\Delta Q)_2 = \rho_{cu}\left(\frac{4}{3}\pi\frac{R_1^3}{8}\right) S_{cu}$

$= \frac{\rho_{cu}\left(\frac{4}{3}\pi R_1^3\right) S_{cu}}{8}$

$(\Delta Q)_2 = \frac{(\Delta Q)_1}{8}, \quad \frac{(\Delta Q)_2}{(\Delta Q)_1} = \frac{1}{8}$

(25) Answer [B]

(i) $P_1 \rightarrow 2P_1$

$V \rightarrow V \Rightarrow$ constant volume $\Delta V = 0$, $W = P\Delta V = 0$

(ii) $P \rightarrow$ constant. $V_1 \rightarrow 2V_1$

$W = P\Delta V = P(2V_1 - V_1)$, $W = PV_1$

(26) Answer [D]

$\Delta Q = mS\,\Delta T$

$= 100 \times 10^{-3} \times 4184 \times (50 - 25) = 10460$ J

According to first law of thermodynamics,

$\Delta U = \Delta Q - \Delta W$

$$\Delta U = 10460 \text{ J} \quad \left(\begin{aligned} \because \Delta W &= P \cdot \Delta W \\ &= P(0) \\ &= 0 \end{aligned}\right)$$

(27) Answer [B]

According to Boyle's law for isothermal process.

PV = constant. By differentiating

$PdV + VdP = 0$, $PdV = -VdP$

$$-\frac{dV}{V} = \frac{dP}{P}$$

(28) Answer [A]

For adiabatic process, PV^{γ} = constant

$P(\gamma V^{\gamma - 1}\, dV) + V^{\gamma}\, dP = 0$

$P\gamma V^{\gamma - 1}\, dV = -V^{\gamma}\, dP$, V^{γ} વડે ભાગતા

$$P\gamma V^{-1}\, dV = -dP, \; -\gamma \frac{dV}{V} = \frac{dP}{P}$$

(31) Answer [B]

$\Delta l = \alpha\, l\, \Delta T = 1.1 \times 10^{-5} \times 50 \times 100$

$= 1.1 \times 5 \times 10^{-2} = 5.5 \times 10^{-2}$ cm

(32) Answer [A]

$\Delta A = (2\alpha)\, A\, \Delta T$ temperature increases and its area increases.

(33) Answer [A]

$P_1 = 1$ *atm*, $\mu = 5$ *mol*, $T_1 = 293$ K

$$V_2 = \frac{V_1}{10}, \; T_1 V_1^{\gamma - 1} = T_2 V_2^{\gamma - 1}$$

$$T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma - 1} = 293\,(10)^{1.4 - 1} = 736 \text{ K}$$

(34) Answer [B]

$$W = 2.303\,(\mu RT)\, log_{10}\left(\frac{V_2}{V_1}\right)$$

$$= 2.303\,(P_1V_1)\, log\left(\frac{V_2}{V_1}\right)$$

$$= 2.303 \times 20 \times 1.01 \times 10^5 \times 3 \times 10^{-2}\, log\left(\frac{24}{3}\right)$$

$= 2.303 \times 60 \times log\,(8) = 1.26 \times 10^4$

$= 12600$ J

(35) Answer [C]

Volume of crystal $V = l \times b \times h$

$V = l \times A$ ...(1)

By differntiate

$dV = A\, dl + l dA$ ...(2)

equation (2) ÷ (1)

$$\frac{dV}{V} = \frac{dl}{l} + \frac{dA}{A}$$

$$= \frac{dl}{l} + [b + b], \; \frac{dV}{V} = a + 2b$$

(37) Answer [D]

$\gamma = \dfrac{C_P}{C_V}$ because of ratio, it is dimension less.

(38) Answer [B]

$$V_1 = V, \; V_2 = \frac{V}{2}$$

$P_1 = 0.76$ *m* – H*g*, P_2 = ?,

$$P_1V_1^{\gamma} = P_2V_2^{\gamma} \Rightarrow P_2 = P_1\left(\frac{V_1}{V_2}\right)^{\gamma}$$

$= 0.76 \times (2)^{1.4}$ m–Hg

(39) Answer [C]

$$\frac{T_F - 32}{9} = \frac{T_C}{5} \Rightarrow \frac{T_F - 32}{9} = \frac{T_K - 273}{5}$$

$$\frac{T - 32}{9} = \frac{T - 273}{5} \Rightarrow 5T - 160 = 9T - 2457$$

$2457 - 160 = 4T \Rightarrow 2297 = 4T$, $T = 574.25$

(40) Answer [A]

For adiabatic process,

$$P_1^{1-\gamma}\, T_1^{\gamma} = P_2^{1-\gamma}\, T_2^{\gamma}$$

$\therefore\ T_2 = T_1\left(\frac{P_1}{P_2}\right)^{\frac{1-\gamma}{\gamma}} = 300\ \left(\frac{4}{1}\right)^{\frac{1-\frac{7}{5}}{\frac{7}{5}}}$

$= 300\ (4)^{\frac{-2}{7}}$

(41) Answer [A]

$T_F = \frac{9}{5}\ T_C + 32 = \frac{9}{5}\ [T - 273.15] + 32$

$= \frac{9}{5}\ [95 - 273.15] + 32 = \frac{9}{5}\ [-178.15] + 32$

$= -320.67 + 32 = -288.67\ °F$

(42) Answer [D]

$\Delta l = \alpha\ l\ \Delta T,\ \Delta A = (2\alpha)\ A\ \Delta T$

$\frac{\Delta l}{l} = \alpha\ \Delta T$ ...(1)

$\frac{\Delta A}{A} = 2\ (\alpha\Delta T) = 2\left(\frac{\Delta l}{l}\right)$

$= 2\ (2\ \%) = 4\ \%$

(44) Answer [A]

$\Delta L_A = \Delta L_B = \Delta L_C,$ જ્યાં $\underset{\substack{\uparrow \\ \text{Combine}}}{L_C} = L_A + L_B$

$\Delta L_A = \Delta L_C \leftarrow$ Combine length

$L_A\alpha_A T = (L_A + L_B)\ \alpha_C T$

$L_A\alpha_A = (L_A + L_B)\ \alpha_C$

$\frac{L_A}{L_A + L_B} = \frac{\alpha_C}{\alpha_A}$

(45) Answer [A]

$\frac{(\Delta T)^{\circ}F}{9} = \frac{(\Delta T)^{\circ}C}{5}$

$\frac{(212 - 140)}{9} = \frac{(\Delta T)^{\circ}C}{5} \Rightarrow \frac{72 \times 5}{9} = (\Delta T)°C$

$\therefore\ \Delta T = 40\ °C$

(46) Answer [B]

$l = l_0\ [1 + \alpha\ \Delta T]$

$= 30\ [1 + 11 \times 10^{-6}\ (10° - 30°)]$

$= 30\ [1 - 11 \times 10^{-6} \times 20]$

$= 30\ [1 - 22 \times 10^{-5}] = 30\ [1 - 0.00022]$

$= 30\ (0.9998) = 29.99$ cm

(48) Answer [C]

$\frac{\Delta V}{V} = \gamma\,\Delta T \Rightarrow \frac{0.30}{100} = \gamma\ (30)$

$\gamma = \frac{0.30}{100 \times 30} = 0.0001\ \ °C^{-1}$

(49) Answer [C]

$1\alpha : 2\alpha : 3\alpha \Rightarrow \begin{matrix}\alpha : \beta : \gamma \\ 1 : 2 : 3\end{matrix}$

(52) Answer [A]

$\Delta U = \Delta Q - \Delta W = (-1000) - (-100)$

$= -1000 + 100 = -900$ J

(53) Answer [D]

$\Delta U\ = \Delta Q - \Delta W = -200 - (-100)$

$= -200 + 100,\ \Delta U = -100$ J

$U_2 - U_1 = -100,\ U_2 - 10\ = -100$

$U_2 = -90$ J

(54) Answer [B]

Here work done on system so internal energy increases.

$\Delta U = \frac{\Delta Q}{J} = \frac{420}{4.2} = +100$ J

(55) Answer [C]

$\Delta U = \Delta Q - \Delta W \Rightarrow (\Delta W)_P = (\Delta Q)_P - (\Delta U)_V$

$= mC_P\Delta T - mC_V\Delta T = m[C_P - C_V]\ \Delta T$

$= 10\ [3400 - 2400]\ [40 - 30]$

$= 10 \times 1000 \times 10 = 10^5$ cal

(56) Answer [A]

$T_1^{\gamma}\,P_1^{1-\gamma} = T_2^{\gamma}\,P_2^{1-\gamma}$

$P_2 = P_1\left(\frac{T_2}{\pi}\right)^{\frac{\gamma}{\gamma-1}} = 1\ atm \times \left(\frac{900}{300}\right)^{\frac{1.5}{1.5-1}}$

$= 1\ atm \times (3)^3,\ \therefore\ P_2 = 27\ atm$

(57) Answer [C]

$\Delta U\ = \Delta Q - \Delta W,\ \Delta W = (\Delta Q)_P - (\Delta U)$

$= (\Delta Q)_P - (\Delta U)_V = (\Delta Q)_P \left[1 - \frac{(\Delta Q)_V}{(\Delta Q)_P}\right]$

$= Q\left[1 - \frac{\mu C_V\Delta T}{\mu C_P\Delta T}\right] = Q\left[1 - \frac{C_V}{C_P}\right]$

$= Q\left[1 - \frac{5\,R/2}{7\,R/2}\right] = Q\left[1 - \frac{5}{7}\right],\ \Delta W = \frac{2}{7}Q$

(58) Answer [C]

$(\Delta U)_{iaf} = (\Delta U)_{ibf}$

$(\Delta Q - \Delta W)_{iaf} = (\Delta Q - \Delta W)_{ibf}$

$(500 - 100) = 2000 - \Delta W,\ 400 = 2000 - \Delta W$

$\Delta W = 2000 - 400, = 1600\ cal$

(59) Answer [B]

$C_P - C_V = R$ But $C_P = \frac{7}{2}R$ is given.

$\frac{7}{2}R - R = C_V \Rightarrow \frac{5}{2}R = C_V$

$$\gamma = \frac{C_P}{C_V} = \frac{\frac{7}{2}R}{\frac{5}{2}R} = \frac{7}{5}$$

(60) Answer [D]

Volume of 1 mole at STP $= 22.4$ Litre, $\mu = \frac{5.6}{22.4} = \frac{1}{4}$

For ideal gas $\gamma = \frac{5}{3}$; $V_1 = 5.6$ L ;

$$T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma - 1} = T_1\left(\frac{5.6}{0.7}\right)^{\frac{5}{3}-1}$$

$= T_1\,(8)^{\frac{2}{3}} = T_1\,(2)^2,\ \therefore\ T_2 = 4T_1$

Work done in adiabatic process

$$W = \frac{\mu R}{\gamma - 1}[T_2 - T_1] = \frac{\frac{1}{4}\times R[4T_1 - T_1]}{\frac{5}{3}-1}$$

$$= \frac{\frac{3}{4}RT_1}{\frac{2}{3}} = \frac{9}{8}RT_1$$

(61) Answer [B]

$P^3\ \alpha\ \frac{1}{V^4},\ P^3 = \frac{K}{V^4}$

$PV^{\frac{4}{3}} = K =$ constant, compare with $PV^{\gamma} = K$

$\gamma = \frac{4}{3} = 1.33$

(62) Answer [A]

$$Q = W = 2.303\ \mu RT log\left(\frac{V_2}{V_1}\right)$$

$$= 2.303 \times 10 \times 8.314 \times 100\ log\left(\frac{20}{10}\right)$$

$= 2.303 \times 8314 \times 0.3010 = 5763$ J

(63) Answer [B]

$\Delta U = \Delta Q - \Delta W,\ \Delta Q = 0 \leftarrow$ Adiabatic process

$\Delta U = -\Delta W,\ \frac{f}{2}\mu RT = -\Delta W$

$\frac{f}{2} \times 1000 \times 8.3 \times 7 = -(-146 \times 1000)$

$\frac{f}{2} \times 58.1 = 146,\ f = \frac{146 \times 2}{58.1} = 5.02$

$f \approx 5$ is diatomic rigid rotor.

(64) Answer [B]

$$\frac{d\rho}{\rho} = -\gamma\, dT = -49 \times 10^{-5} \times 20$$

$$= -980 \times 10^{-5},\ \therefore \frac{d\rho}{\rho} = -0.00980$$

$$\frac{d\rho}{\rho} \times 100\,\% = -0.980\,\% = -0.98\,\%$$

(65) Answer [C]

$$C_P - C_V = R,\ C_P - \frac{C_P}{\gamma} = R$$

$$\frac{C_P}{C_V} = \gamma \Rightarrow \frac{C_P}{\gamma} = C_V,\ C_P\left[1 - \frac{1}{\gamma}\right] = R$$

$$C_P\left[\frac{\gamma - 1}{\gamma}\right] = R \Rightarrow C_P = \frac{\gamma R}{\gamma - 1}$$

(66) Answer [D]

$C_P - C_V = R,$

$$\frac{C_P}{C_V} = \gamma \Rightarrow C_P = \gamma C_V,\ \gamma C_V - C_V = R$$

$C_V\,[\gamma - 1] = R$

$$C_V = \frac{R}{\gamma - 1}$$

(67) Answer [A]

$P \propto T^3$ (is given), $P \propto (PV)^3$

$$\begin{bmatrix} PV = \mu RT \\ PV \propto T \end{bmatrix} \mu R = \text{constant},\ P = KP^3V^3$$

constant $= K^{-1} = P^2V^3,\ P^2V^3 =$ constant

Compare $PV^{\frac{3}{2}} =$ constant with $PV^{\gamma} =$ constant

$\gamma = \frac{3}{2}$

(68) Answer [B]

$W = \dfrac{\mu R(T_1 - T_2)}{\gamma - 1}$, $6R = \dfrac{1 \times R(T_1 - T_2)}{\frac{5}{3} - 1}$

$6 = \frac{3}{2}(T_1 - T_2)$, $4 = T_1 - T_2$

$T_2 = (T_1 - 4)$ K

(69) Answer [C]

$\Delta U = \Delta Q - \Delta W = mL - \Delta W$

$= (1 \times 2240) - 168 = 2072$ J

(70) Answer [B]

radius of close loop $r = 1$ unit

For cyclic process $Q = W = \pi r^2$, $W = \pi$ unit

(71) Answer [A]

$\Delta Q - \Delta W = (\Delta U)_{int}$

ΔU is not depends on path of process. but depends on initlal (i) and final (f) condition. So,

$\therefore (\Delta U_{int})_1 = (\Delta U_{int})_2$

(72) Answer [C]

Here in $P \rightarrow V$ graph

23 and 14	=	isothermal
34	=	isochoric
12	=	isobaric process

(73) Answer [C]

Work W = enclosed area by $P \rightarrow V$ graph

$= (4P - P)(4V - V) = (3P)(3V) = 9$ PV

(74) Answer [C]

Heat loss by He gas. $W = -1000$ J

(i) AB (For isobaric process) :

$W_{AB} = P\Delta V = \mu R \Delta T = \mu R(T_B - T_A)$

$= 1 \times 8.3(600 - 300) = 2490$ J

(ii) BC (isothermal process $\rightarrow$ want to find out

(iii) CA (Isochoric process) :

$W_{CA} = P\Delta V = P(0)$ Volume is constant

$W_{CA} = 0$

$\therefore$ total work $W = W_{AB} + W_{BC} + W_{CA}$

$-1000 = 2490 + W_{BC} + 0$, $W_{BC} = -3490$ J

(75) Answer [C]

At point A, $P_1 V_1 = \mu RT_2$

$(10)(1) = \mu RT_2$, $T_2 = \dfrac{10}{\mu R}$

At point B, $P_2 V_2 = \mu RT_1$, $(10)(2) = \mu RT_1$

$T_1 = \dfrac{20}{\mu R} = 2\left(\dfrac{10}{\mu R}\right)$, $T_1 = 2T_2$

efficiency $\eta = 1 - \dfrac{T_2}{T_1} = 1 - \dfrac{T_2}{2T_2}$

$= 1 - \frac{1}{2} = \frac{1}{2} = 50\ \%$

(77) Answer [D]

At 50 K temperature, O_2 is liquid and initially its temperature increases (AB part). Then liquid O_2 transforms in gas so, its temperature remains constant (BC part). Then liquid O_2 in gas phase and its temperature will increases (CD part)

(78) Answer [D]

First using isothermal expansion on 1 mol of ideal gas increases volume V to 3V. So graph is hyperbola. Then at constant pressure, volume decreases by compression 3V to V. So graph is parallel to X-axis.

$\therefore$ graph (D) is answer.

(79) Answer [B]

In clockwise direction cyclic process W = positive

In anti-clockwise direction cyclic process W = negative

Area of closed path large, its W is large.

$\therefore$ 1c2e1 path.

(80) Answer [C]

Initial condition of system = final condition of system

$U_i = U_f$, $\therefore \Delta U = 0$

$\Delta U = \Delta Q - \Delta W$, $0 = \Delta Q - \Delta W$

$\Delta Q = \Delta W$

In cyclic process, work done on the system. So, it becomes negative

ΔQ = negative

(81) Answer [A]

For cyclic process, Q = W = area enclosed by $P \rightarrow V$ graph = area of ΔABC

$= \frac{1}{2} \times (300 - 100)(30 - 10) \times 10^4$

$= \frac{1}{2} \times 200 \times 20 \times 10^4 = 20 \times 10^6$ J

(82) Answer [D]

$\eta = \dfrac{Q_1 - Q_2}{Q_1}$, $0.30 = \dfrac{60}{Q_1}$

$Q_1 = \frac{60}{0.30} = 200$ J, $Q_1 - Q_2 = 60$

$200 - Q_2 = 60$, $Q_2 = 140$ J

(83) Answer [A]

$$\eta = 1 - \frac{Q_2}{Q_1}, \; 0.30 = 1 - \frac{Q_2}{50 \times 10^3}$$

$$\frac{Q_2}{50 \times 10^3} = 0.70, \; Q_2 = 35 \text{ kJ}$$

(84) Answer [B]

$$\eta = 1 - \frac{Q_2}{Q_1} = 1 - \frac{1.5}{2} \times \frac{10^3}{10^3} = 1 - 0.75$$

$= 25\ \%$

(85) Answer [C]

$$\frac{Q_2}{Q_1} = \frac{T_2}{T_1} \Rightarrow Q_2 = Q_1\left(\frac{T_2}{T_1}\right)$$

$$= 3 \times 10^6 \left(\frac{300}{900}\right), \; Q_2 = 1 \times 10^6 \text{ cal}$$

Now work $W = Q_1 - Q_2 = 3 \times 10^6 - 1 \times 10^6$

$= 2 \times 10^6$ cal $= 2 \times 10^6 \times 4.2 = 8.4 \times 10^6$ J

(86) Answer [D]

$$\eta = 1 - \frac{T_2}{T_1}, \; 0.40 = 1 - \frac{400}{T_1}, \; \frac{400}{T_1} = 0.60$$

$$T_1 = 666.66 \text{ K} = 667 \text{ K}, \; \eta' = 1 - \frac{T_2'}{T_1}$$

$$0.80 = 1 - \frac{T_2'}{667} \Rightarrow \frac{T_2^1}{667} = 0.20$$

$T_2' = 133.4$ K, $\therefore$ $T_2' = 133$ K

(87) Answer [A]

$$\frac{Q_2}{Q_1} = \frac{T_2}{T_1}, \; Q_2 = 6 \times 10^3 \times \frac{400}{500}$$

$Q_2 = 4.8 \times 10^3$ J, $Q = W = Q_1 - Q_2$

$= 6 \times 10^3 - 4.8 \times 10^3 = 1.2 \times 10^3$ J

(88) Answer [A]

$$\eta = 1 - \frac{T_2}{T_1}, \; 0.40 = 1 - \frac{300}{T_1}, \; \frac{300}{T_1} = 0.60$$

$T_1 = 500$ K

Now $T_2 = 300$ K, sink temperature remain contant.

$$\eta' = 1 - \frac{T_2}{T_1^1}$$

$$0.90 = 1 - \frac{300}{T_1^1} \qquad 40\ \% + 50\ \% = 90\ \%$$

$$\frac{300}{T_1^1} = 0.10, \; T_1' = 3000 \text{ K}$$

$\therefore$ Increase in temperature of heat source.
$= 3000$ K-500 K $= 2500$ K

(89) Answer [B]

$$\eta = 1 - \frac{T_2}{T_1}$$

$$\frac{1}{6} = 1 - \frac{T_2}{T_1} \qquad ...(1)$$

$$\eta' = 1 - \frac{T_2'}{T_1}, \; 2\left(\frac{1}{6}\right) = 1 - \frac{(T_2 - 62)}{T_1}$$

$$\frac{2}{6} = \left(1 - \frac{T_2}{T_1}\right) + \frac{62}{T_1}, \; \frac{2}{6} = \frac{1}{6} + \frac{62}{T_1}$$

$$\frac{1}{6} = \frac{62}{T_1}, \; T_1 = 372 \text{ K} = 99\ ^\circ\text{C}$$

(90) Answer [C]

$$\alpha = \frac{Q_2}{Q_1 - Q_2} = \frac{Q_2}{W} = \frac{Q_2/Q_1}{1 - \frac{Q_2}{Q_1}}$$

$$\alpha = \frac{1-\eta}{\eta} = \frac{Q_2}{W} \; \therefore \; \frac{1 - 0.20}{0.20} = \frac{Q_2}{50}$$

$$\therefore \frac{0.80}{0.20} = \frac{Q_2}{50}, \; Q_2 = 200 \text{ J}$$

(91) Answer [D]

$$\alpha = \frac{Q_2}{W}, \; W = \frac{120}{5}, \; W = 24 \text{ J}$$

$Q_1 - Q_2 = W$, $Q_1 = Q_2 + W = 120 + 24$

$= 144$ J

(103) Answer [A]

(i) Work done to take over A $\rightarrow$ B.

$W = \mu R\Delta T = 1 \times 8.314 \times (300 - 100)$

$= 8.314 \times 200 = 16628$ joule

(104) Answer [D]

(ii) Work done to take over B $\rightarrow$ C

$$W = 2.303\ \mu RT\ log\left(\frac{V_2}{V_1}\right)$$

$$= 2.303\ \mu RT\ log\left(\frac{P_1}{P_2}\right)$$

$$= 2.303 \times 1 \times 8.314 \times 300\ log\left(\frac{4 \times 10^5}{2 \times 10^5}\right)$$

$= 2.303 \times 8.314 \times 300\ log\,(2)$

$= 2.303 \times 8.314 \times 300 \times 0.3010 = 1729$ J

(105) Answer [A]

(i) Volume for A $\rightarrow$ B path = 100 cm^3 is constant

$W = P\Delta V = P\,(0)$, $W = 0$ J

(106) Answer [D]

(ii) Volume for B $\rightarrow$ C path V_1= 100 cm^3 to V_2= 400 cm^3 constant temperature is 400 K.

$$W = 2.303\ \mu RT\ log\left(\frac{V_2}{V_1}\right)$$

$$= 2.303 \times 1 \times 8.314 \times 400\ log\left(\frac{400 \times 10^{-6}}{100 \times 10^{-6}}\right)$$

$= 7658.85\ log\,4 = 7658.85 \times 0.6021$

$= 4611.40$ J

(107) Answer [D]

(iii) $W = \mu R\,(\Delta T) = \mu R\,(400 - 100)$

$= 1 \times 8.314 \times 300 = 2494.2$ J

(108) Answer [B]

Here, suddenly cycle's tyre breaks. So, process is very fast. $\therefore$ adiabatic

(109) Answer [A]

Here, Abrupt compression of gas is happened.

$\therefore \Delta Q = 0$ (Adiabatic process)

$\therefore \Delta U = \Delta Q - \Delta W$

$\Delta U = -\Delta W$, But work done on gas is negative.

$= -(-\Delta W) = +\Delta W$ $\therefore$ ΔU increases.

(110) Answer [A]

Abrupt compression of gas is happen. So, process is adiabatic. $\Delta U = +$ positive

(111) Answer [A]

$$\Delta Q = mC\Delta T \quad \Rightarrow \quad C = \frac{\Delta Q}{m \cdot \Delta T} = \frac{0}{m \cdot \Delta T}$$

$(\because \Delta Q = 0)$, $\therefore C = 0$

(112) Answer [B]

Formulae of work in thermodynamic processes

$$\text{Adiabatic process } W = \frac{\mu R(T_1 - T_2)}{\gamma - 1}$$

$$\text{isothermal process } W = 2.303\ \mu RT\ log\left(\frac{V_2}{V_1}\right)$$

isobaric process $W = P\Delta V$

isochoric process $W = 0$

(113) Answer [C]

For thermodynamic process, adiabatic process $\Delta Q = 0$, isothermal process $\Delta U = 0$

isocharic process $\Delta W = 0$

isobaric process $\Delta Q \neq 0$; $\Delta U \neq 0$; $\Delta W \neq 0$

(114) Answer [D]

1. AB graph – pressure (isobaric) is constant so, parallel to X-axis.

4. CD graph – isochoric process, parallel to Y-axis.

2. GH graph – isothermal process, temperature constant (Boyle's law)

4. EH graph – adiabatic process, difference in Heat $(\Delta Q) = 0$

•

9 Kinetic Theory of Gases

(1) Answer [B]

$$V_s = \sqrt{\frac{\gamma P}{\rho}} \text{ and } V_{rms} = \sqrt{\frac{3P}{\rho}}$$

$$\frac{V_s}{V_{rms}} = \sqrt{\frac{\gamma}{3}} \Rightarrow V_s = V_{rms}\left(\frac{\gamma}{3}\right)^{\frac{1}{2}}$$

(2) Answer [C]

$$P_1 = P, \quad P_2 = P + \frac{0.4}{100} P = 1.004\ P$$

$$T_1 = T, \quad T_2 = T + 1, \frac{P_2}{P_1} = \frac{T_2}{T_1}$$

$$\frac{1.004P}{P} = \frac{T+1}{T}, T = \frac{1}{0.004} = 250\ K$$

(3) Answer [B]

$$V_1 = \frac{PV}{T} \times \frac{T_1}{P_1} = \frac{1 \times 100 \times 746.3}{373.15 \times 2} = 100\ cc$$

(7) Answer [B]

$$C_V = \frac{\mu_1 C_{V_1} + \mu_2 C_{V2}}{\mu_1 + \mu_2} = \frac{2\left(\frac{3}{2}R\right) + 3\left(\frac{5}{2}R\right)}{2+3}$$

$$= \frac{3R + 7.5R}{5} = \frac{10.5R}{5} = 2.1\ R$$

(8) Answer [C]

$$P \propto T, \frac{P_1}{P_2} = \frac{T_1}{T_2}, \therefore \frac{P_2 - P_1}{P_1} = \frac{T_2 - T_1}{T_1}$$

$$\therefore \left(\frac{\Delta P}{P}\right)\% = \left(\frac{251 - 250}{250}\right) \times 100\ \%$$

$$= 0.4\ \%$$

(10) Answer [C]

At constant pressure, $V \propto T, \frac{V_2}{V_1} = \frac{T_2}{T_1}$

$$T_2 = \left(\frac{V_2}{V_1}\right) T_1 = \left(\frac{3V}{V}\right) \times 273$$

$$= 819\ K, T_2 = 546\ °C$$

(11) Answer [D]

$PV = \mu RT$, Now V and R are constants. $P \propto \mu\ T$

$$\frac{P_2}{P_1} = \frac{\mu_2}{\mu_1} \times \frac{T_2}{T_1}, \frac{P_{He}}{P} = \frac{1}{1} \times \frac{2T}{T}$$

$$\frac{P_{He}}{P} = 2, P_{He} = 2P$$

(12) Answer [C]

$$V \propto T \Rightarrow \frac{V_1}{V_2} = \frac{T_1}{T_2}, \frac{V}{V_2} = \frac{300}{600}$$

$$\frac{V}{V_2} = \frac{1}{2}, \therefore V_2 = 2V$$

(13) Answer [D]

$$PV = \mu RT, PV = \frac{mRT}{M}$$

P, V and R are constant. So, $\frac{T}{M}$ = constant

$$\frac{T_{N_2}}{T_{O_2}} = \frac{M_{N_2}}{M_{O_2}} \Rightarrow \frac{T_{N_2}}{288} = \frac{28}{32} \Rightarrow T_{N_2} = 252\ K$$

$$T_{N_2} = -21\ °C$$

(15) Answer [D]

According to Boyle's law at constant temperature

$$PV = \text{constant}, \frac{P_1}{P_2} = \frac{V_2}{V_1}, \frac{70}{120} = \frac{V_2}{1200ml}$$

$V_2 = \frac{70 \times 1200\text{ml}}{120}$, $V_2 = 700$ ml

(16) Answer [A]

$$R = \frac{PV}{T} = \frac{(h\rho g)V}{T}$$

$$= \frac{76 \times 13.6 \times 980 \times 22400}{273}$$

$= 83112041.0256$ erg K^{-1}

$= 83112041.0256 \times 10^{-7}$ JK^{-1}

$= 8.31$ $JK^{-1} = \frac{8.31}{4.2}$ cal $K^{-1} = 2$ cal K^{-1}

(17) Answer [D]

$PV = \mu RT$, $PV = \frac{m}{M}$ RT

$PV = \frac{m}{M}$ R (300) ...(1)

Now, air having half mass is going out

$PV = \frac{m/2}{M}$ RT' ...(2)

Compare the equation (1) and (2)

$\frac{T'}{2} = 300 \Rightarrow T' = 600$ K

$(273 + t) = 600$, $\therefore$ $t = 327$ °C

(18) Answer [A]

$\frac{PV}{T}$ = constant, Closed gas chamber V (volume) = constant

$\frac{P}{T}$ = constant, $\frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow T_2 = \frac{P_2}{T_1} \times T_1$

$T_1 + 1 = \frac{100.4}{100} \times T_1$ (Change in temperature 1 °C or 1 K, both are same.)

$T_1 + 1 = 1.004\ T_1$, $1 = 0.004\ T_1$

$T_1 = \frac{1}{0.004} = \frac{1000}{4} = 250$ K

(19) Answer [C]

$\frac{PV}{T}$ = constant, Volume of gas chamber V = constant

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$, $\frac{2}{300} = \frac{P_2}{327} \Rightarrow P_2 = \frac{2 \times 327}{300}$

$P_2 = 2.18$ *atm*

(20) Answer [A]

$PV = \mu RT$, $V = \frac{\mu RT}{P}$

$V_1 = \frac{\mu RT_1}{P_1}$ and $V_2 = \frac{\mu RT_2}{P_2}$

$\frac{V_1}{V_2} = \frac{T_1}{T_2}$, $P_1 = P_2$ = constant pressure

$\frac{1\text{ L}}{V_2} = \frac{300}{370}$, $V_2 = \frac{370}{300}$ L

= 1.23 L

(21) Answer [D]

$\frac{PV}{T} = \frac{P' \times \frac{90}{100} V}{T}$, $\frac{P'}{P} = \frac{100}{90}$

$= \frac{90 + 10}{90}$, $\frac{P'}{P} = 1 + \frac{10}{90} \Rightarrow \frac{P'}{P} - 1 = \frac{10}{90}$

$\left(\frac{P' - P}{P}\right)\% = \frac{10}{90} \times 100\ \%$

$\left(\frac{P_1 - P}{P}\right)\% = 11.1\ \%$

(22) Answer [D]

$P = P_1 + P_2 + P_3$

$= \frac{\mu_1 RT}{V} + \mu_2 \frac{RT}{V} + \mu_3 \frac{RT}{V}$

$= \left(\frac{8}{32} + \frac{14}{28} + \frac{22}{44}\right)\frac{RT}{V}$

$$= \frac{(0.25 + 0.5 + 0.5) \times 8.31 \times 300}{4 \times 10^{-3}}$$

$= 7.79 \times 10^5\ Nm^{-2}$

(23) Answer [C]

$P = P_1 + P_2 + P_3$

$$= \left(\frac{8}{32} + \frac{14}{28} + \frac{22}{44}\right) \times \frac{0.082 \times 300}{10}$$

$= 3.075 = 3.075\ atm$

(24) Answer [C]

For first gas $P_1V = \mu_1RT_1 \Rightarrow \mu_1 = \frac{P_1V}{RT_1}$

For second gas $P_2V = \mu_2RT_2 \Rightarrow \mu_2 = \frac{P_2V}{RT_2}$

For mix gas $P(2V) = (\mu_1 + \mu_2)\ RT$

$$\frac{P}{T} = \left(\frac{\mu_1 + \mu_2}{2}\right)\frac{R}{V}$$

$$\frac{P}{T} = \frac{1}{2}\left[\frac{P_1V}{RT_1} + \frac{P_2V}{RT_2}\right]\frac{R}{V}$$

$$= \frac{1}{2}\left[\frac{P_1}{T_1} + \frac{P_2}{T_2}\right] \times \frac{V}{R} \times \frac{R}{V}$$

$$\frac{P}{T} = \frac{1}{2}\left[\frac{P_1T_2 + P_2T_1}{T_1T_2}\right]$$

(26) Answer [C]

$PV = \mu_1RT \Rightarrow \mu_1 = \frac{PV}{RT}$ (For gas-1)

$PV = \mu_2RT \Rightarrow \mu_2 = \frac{PV}{RT}$ (For gas-2)

$P'V = (\mu_1 + \mu_2)RT \Rightarrow \mu_1 + \mu_2 = \frac{P'V}{RT}$

(For mixture) $\frac{2PV}{RT} = \frac{P'V}{RT}$, $2P = P'$

(29) Answer [D]

$$(v_{rms})_{O_2} = (v_{rms})_{H_2}$$

$$\sqrt{\frac{3RT_1}{M_{O_2}}} = \sqrt{\frac{3RT_2}{M_{H_2}}},\ \frac{T_1}{M_{O_2}} = \frac{T_2}{M_{H_2}}$$

$\frac{T_1}{32} = \frac{1000}{2}$, $\therefore T_1 = 16000$ K

(30) Answer [A]

$$(v_{rms})_{H_2} = \sqrt{\frac{3RT}{M_{H_2}}}$$

$$= \sqrt{\frac{3R \times 300}{2}} = 1000\ ms^{-1} \qquad ...(1)$$

$$(v_{rms})_{O_2} = \sqrt{\frac{3RT}{M_{O_2}}} = \sqrt{\frac{3R \times 1200}{32}}$$

$$= \sqrt{\frac{3R \times 300}{8}} = \frac{1}{2}\sqrt{\frac{3R \times 300}{2}}$$

$= \frac{1}{2}$ (1000) $= 500\ ms^{-1}$

(32) Answer [B]

$P = \frac{\rho RT}{M_O}$, $P \propto \rho\, T$, $\therefore \frac{\rho_2}{\rho_1} = \frac{1}{2}$

(33) Answer [D]

$v_{rms} = \sqrt{\frac{3k_BT}{m}}$ $\qquad T = 27 + 273 = 300$

$$= \sqrt{\frac{3 \times 1.38 \times 10^{-23} \times 300}{1.38 \times 10^{-10}}} = \sqrt{900 \times 10^{-13}}$$

$= 9.49 \times 10^{-6}\ ms^{-1}$

(34) Answer [A]

$E \propto T, E_2 = E_1 \times \frac{T_2}{T_1} = 6.21 \times 10^{-21} \times \frac{600}{400}$

$= 9.315 \times 10^{-21}$ J

(35) Answer [A]

$PV = \mu RT = \frac{m}{M_O}RT = \frac{5}{32}RT$

(37) Answer [B]

$$v_{rms} \propto \frac{1}{\sqrt{M}} \Rightarrow \frac{(V_{rms})_{H_2}}{(V_{rms})_{H_e}} = \sqrt{2} : 1$$

(40) Answer [B]

$$C_P = \left(1+\frac{f}{2}\right)R = \left(1+\frac{3}{2}\right)R = \frac{5}{2}\ R$$

(41) Answer [C]

$$C_v = \frac{R}{0.672} = 1.488\ R = = 1.5\ R = \frac{3}{2}R$$

$\therefore f = 3$ monoatomic

(42) Answer [C]

$$v_{rms} \propto \sqrt{T},\ \frac{(v_{rms})_2}{(v_{rms})_1} = \sqrt{\frac{9T_1}{T_1}} = 3$$

(45) Answer [B]

$$v_{rms} = \sqrt{\frac{3P}{\rho}} \Rightarrow v_{ms} \propto \frac{1}{\sqrt{\rho}} \Rightarrow \frac{8}{1}$$

(46) Answer [C]

$$\overline{l} = \frac{1}{\sqrt{2}\, n \pi d^2}$$

$$= \frac{1}{1.41 \times 2.5 \times 10^{25} \times 3.14 \times (3.4 \times 10^{-10})^2}$$

$$= \frac{1}{127.95 \times 10^5} = 7.8 \times 10^{-8}\ \text{m}$$

(47) Answer [D]

$$\overline{l} = \frac{k_B T}{\sqrt{2}\, \pi P d^2}$$

$$= \frac{1.38 \times 10^{-23} \times 300}{1.41 \times 3.14 \times 1.01 \times 10^5 \times \left(3.56 \times 10^{-10}\right)^2}$$

$= 7.3 \times 10^{-8}$ m

(48) Answer [A]

$$\overline{l} = \frac{k_B T}{\sqrt{2}\, P \pi p d^2} = d \qquad ...(1)$$

$$\overline{l}' = \frac{k_B (4T)}{\sqrt{2}\left(\frac{P}{4}\right) \pi d^2} \qquad ...(2)$$

$\overline{l}' = 16\ \overline{l},\ \overline{l}' = 16\ d$

(50) Answer [C]

$$\gamma = \frac{7}{5} = 1 + \frac{2}{f} \Rightarrow f = 5$$

So ans is H_2 (rigid rotater)

(53) Answer [B]

According to Boyle's law PV = constant

and $v_{rms} = \sqrt{\frac{3RT}{M}}$

(54) Answer [C]

$$v_{rms} = \sqrt{\frac{3P}{\rho}} = \sqrt{\frac{3P}{M/V}} = \sqrt{\frac{3PV}{M}}$$

v_{rms} = constant, But according to Boyle's law PV = constant

(56) Answer [A]

$$\overline{l} = \frac{k_B T}{\sqrt{2}\, \pi d^2 P} \text{ and } \overline{l} = \frac{M}{\sqrt{2}\, \pi d^2 \rho}$$

$$\overline{l} \propto \frac{T}{P} \text{ and } \overline{l} = \frac{1}{\rho}$$

(57) Answer [D]

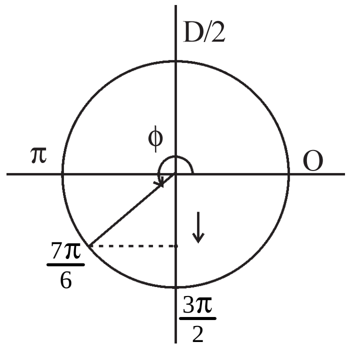
$$v_{rms} = \sqrt{\frac{v_1^2 + v_2^2 + v_3^2}{3}}$$

$$= \sqrt{\frac{(1v)^2 + (2v)^2 + (3v)^2}{3}}$$

$$= \sqrt{\frac{(1 + 4 + 9)\, v^2}{3}} = \sqrt{\frac{14}{3}}\ v$$

10 Oscillations and Waves

(1) Answer [B]



Here SHO exactly at center of mean point and negative end and motion starts towards negative end.

$\therefore \phi = \pi + \frac{\pi}{6}$, $\therefore \phi = \frac{7\pi}{6}$ rad

T = 0.5 s, t = 10 s, θ = ?

$\theta = \frac{2\pi}{T} t + \phi = \frac{2\pi}{0.5}(10) + \frac{7\pi}{6}$

$\theta = 247\frac{\pi}{6}$ rad

(2) Answer [C]

Compare with $y = a \sin \omega t + b \cos \omega t$

$a = \sqrt{2}$, $b = \sqrt{7}$, $\omega = 10\pi$

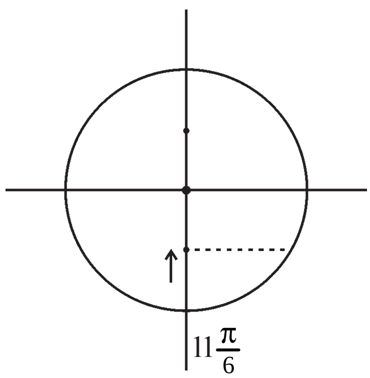
$\therefore$ Amplitude $A = \sqrt{a^2 + b^2} = \sqrt{2+7} = 3$ cm

Periodic time $T = \frac{2\pi}{\omega} = \frac{2\pi}{10\pi} = 0.20$

Initial phase $\phi = \tan^{-1}\left(\frac{b}{a}\right)$

$= \tan^{-1}\left(\frac{\sqrt{7}}{\sqrt{2}}\right) = \tan^{-1}(1.8709)$, $\phi = 48° 52'$

(3) Answer [C]



SHO exactly at center between negative end and equilibrium point when it completed $\frac{7}{8}$ oscillations and travels towards mean point.

$\therefore \omega t = 11\frac{\pi}{6}$, $\frac{2\pi}{T} t = 11\frac{\pi}{6}$ $\therefore t = 11\frac{T}{12}$

(4) Answer [D]

Here, initial phase $\phi = \frac{3\pi}{4}$ rad, $n = 10\frac{1}{2}$

Now, phase $\theta = n\,2\pi + \phi$

$= \left(10\frac{1}{2}\right)2\pi + \frac{3\pi}{4} = 21\pi + \frac{3\pi}{4}$

$= \frac{84\pi + 3\pi}{4} = 87\frac{\pi}{4}$ rad

(5) Answer [A]

$y_1 = 1$ cm, $v_1 = 2$ cms^{-1}

$y_2 = 2$ cm, $v_2 = 1$ cms^{-1}

Amplitude $A = \left[\frac{v_1^2 y_2^2 - v_2^2 y_1^2}{v_1^2 - v_2^2}\right]^{\frac{1}{2}}$

$= \left[\frac{16-1}{4-1}\right]^{\frac{1}{2}} = \sqrt{5}$ cm

Periodic time $T = 2\pi\left[\frac{y_2^2 - y_1^2}{v_1^2 - v_2^2}\right]^{\frac{1}{2}}$

$= 2\pi\left[\frac{4-1}{4-1}\right]^{\frac{1}{2}}$

$= 2\pi = 6.28$ s

(6) Answer [D]

Displacement, $y = 10 \sin(2\pi t + \frac{\pi}{6})$

$t = 0$, $y_o = 10 \sin\frac{\pi}{6} = 5$ cm

Velocity, $v = 20\pi \cos(2\pi t + \frac{\pi}{6})$

$t = 0$, $v_o = 20\pi \cos\frac{\pi}{6} = 17.32\pi$ cm s^{-1}

Acceleration $a = -40\pi^2 \sin(2\pi t + \frac{\pi}{6})$

$t = 0$, $a_o = -40\pi^2 \sin\frac{\pi}{6} = -20\pi^2$ cm s^{-2}

(7) Answer [C]

A = 0.05 m, y = 0.03 m, $a = -3 = -\omega^2 y$

$\therefore \quad -3 = -\omega^2 (.03), \omega^2 = 10^2$

$\omega = 10$ rad s^{-1}

from now velocity $v = \omega \sqrt{A^2 - y^2}$, $v = 0.4$ ms^{-1}

maximum velocity $v_{max} = \omega A = 0.5$ ms^{-1}

maximum acceleration $a_{max} = \omega^2 A = 5$ ms^{-2}

(8) Answer [B]

$y = A \sin (\omega t + \frac{\pi}{2})$

$\therefore \frac{A}{2} = A \cos \omega t \therefore \omega t = \frac{\pi}{3}$

$\Rightarrow t = \frac{T}{6} = \frac{3}{6} = \frac{1}{2} = 0.5, \therefore t = 0.5$ s

(9) Answer [C]

$y = A \sin (\omega t + \phi)$, $\frac{\sqrt{3}}{2} A = A \sin (\omega t)$

$\therefore \omega t = \frac{\pi}{3} \Rightarrow t = \frac{T}{6}$

(10) Answer [B]

$x^2 + y^2 = A^2$, $\therefore$ Path of particle is circular.

(11) Answer [A]

$y_1 = A \sin (\omega t + \phi_1)$,

$y_2 = A \sin (\omega t + \phi_2)$, $y_1 - y_2 =$

$$2A \sin \left[\omega t + \frac{\phi_1 + \phi_2}{2}\right] \sin \left(\frac{\phi_1 - \phi_2}{2}\right)$$

$$\therefore A = 2A \sin \left(\frac{\phi_1 - \phi_2}{2}\right)$$

$$\therefore \frac{\phi_1 - \phi_2}{2} = \frac{\pi}{6} \qquad \because \phi_1 - \phi_2 = \frac{\pi}{3} \text{ rad}$$

(12) Answer [B]

$T = 16 \Rightarrow \omega = \frac{\pi}{8}$, $t = 2$, $y = 0$ $\phi = 0$

$t_1 = 4$, $v = \sqrt{2}$ ms^{-1}

In 4 – 2 = 2 s, $y_1 = A \sin (\omega t)$

$= A \sin (\frac{\pi}{8} \times 2) = \frac{A}{\sqrt{2}}$

Now, $v = \omega \sqrt{A^2 - y^2}$

$\therefore \sqrt{2} = \frac{\pi}{8} \sqrt{A^2 - \frac{A^2}{2}} \Rightarrow A = \frac{16}{\pi}$

(13) Answer [B]

$v = \omega \sqrt{A^2 - y^2}$, $v^2 = \omega^2 (A^2 - y^2)$

$9v^2 = \omega^2 (A_1^2 - y^2)$

Solving the equations $A_1 = \sqrt{7}$ m

(14) Answer [D]

$v_{max} = 2$ ms^{-1}, $a_{max} = 1$ ms^{-2}

$\therefore A = \frac{v_{max}^2}{a_{max}} = 4$ m, $T = 2\pi \frac{v_{max}}{a_{max}} = 4\pi$ s

(15) Answer [D]

$2A = 20 \Rightarrow A = 10$ cm

$y = 6$ cm $v = 16$ cms^{-1} $\Rightarrow \omega = 2$ rads^{-1}

$a = \omega^2 y$ Here $y = 7$ cm $= (2)^2 \times 7 = 28$ ms^{-2}

(16) Answer [C]

A = 10 cm, $a = 8$ cms^{-2}

T = 2π s, $\therefore$ ω = 1π rads^{-1},

$8 = \omega^2 y \therefore y = 8$ cm

Velocity $v = \omega \sqrt{A^2 - y^2}$

$= 1\sqrt{100 - 64} = 6$ cms^{-1}

(17) Answer [A]

For first oscillator; $A_x = 20$ cm, $\omega_x = 5\pi$, $\phi_1 = \frac{\pi}{6}$

For second oscillator $A_y = 10$ cm, $\omega_y = 10\pi$

$\therefore \frac{A_x}{A_y} = 2$, $\frac{T_x}{T_y} = \frac{10}{5} = 2$

(18) Answer [D]

$t = 0$, $y = 100 \therefore \frac{1}{2} = \sin\alpha$

$\therefore \alpha = \frac{\pi}{6}$, $\omega = \frac{3\pi}{5} \therefore T = \frac{10}{3}$ s

$t = 10$ s $\theta = \frac{2\pi}{T} t + \phi$ or $\theta = \omega t + \alpha$

$\therefore \theta = 37 \frac{\pi}{6}$ rad

(19) Answer [A]

$T = \frac{2\pi}{5}$ s, if $y = 0$ then $v = 10\sqrt{5}$ cms^{-1}

$y = ?$ If $v = 10 \ \text{cms}^{-1}$

$v = \omega \sqrt{A^2 - y^2}$, $A^2 = \frac{100}{5} = 20$

$\therefore \ 10 = 5 \sqrt{20 - y^2}$, $\therefore y = 4$ cm

(20) Answer [C]

Length is constant so, T and ω is also constant.

$v_{max} = \pm \omega A$

A is double so, v_{max} also becomes doubled

$v_{max} = 0.04 \ \text{ms}^{-1}$

(21) Answer [B]

$A = 4$ cm, $T = 4$ s, $\phi = 0$, $\omega = \frac{\pi}{2}$ rad^{-1}

$y = A \sin (\omega t) \ \therefore y = \frac{4}{\sqrt{2}}$ cm

Now, $a = -\omega^2 y \ \therefore a = -\frac{\pi^2}{\sqrt{2}}$ cm

(22) Answer [D]

$\theta = \frac{2\pi}{T_1} t = 2\pi$ rad, $\theta_2 = \frac{2\pi}{T_2} t = \frac{8\pi}{3}$ rad

$\therefore \theta_2 - \theta_1 = \frac{2\pi}{3} = 120°$

(23) Answer [B]

$A = 12$ cm, $f = \frac{\sqrt{3}}{2\pi}$ s^{-1}, $\omega = \sqrt{3}$ rads^{-1}

From $\omega^2 y = \omega \sqrt{A^2 - y^2}$, $y = 6$ cm

(24) Answer [B]

$\omega = 2\sqrt{3}$ rads^{-1}, $t = \frac{T}{12}$, $y = 2$ cm

$y = A \sin \omega t$ From, $A = 2y$

$v = \omega \sqrt{A^2 - y^2}$, $\therefore v = 12$ cms^{-1}

(25) Answer [C]

$v = \alpha$, $a = \beta$, $v^2 = \omega^2 (A^2 - y^2)$ $a = \omega^2 y$

Solving both equations $A^2 = \frac{\alpha^2 y - \beta y^2}{\beta}$

(26) Answer [A]

equivalent force constant for series $k_s = \frac{k}{N}$

equivalent force-constant for paralled $k_P = kN$

(27) Answer [B]

If equivalent force-constant is K' then,

$\frac{1}{k'} = \frac{1}{2k} + \frac{1}{2k} + \frac{1}{k}$, $\therefore k' = \frac{k}{2}$

$T = 2\pi \sqrt{\frac{m}{k'}}$, $\therefore T = 2\sqrt{2} \ \pi \sqrt{\frac{m}{k}}$

(28) Answer [C]

$k' = k_1 + k_2$, $T_1 = 2\pi \sqrt{\frac{m}{k'}}$

Now, $k'' = 4(k_1 + k_2) = 4k'$, $T_2 = \frac{T_1}{2}$

(29) Answer [B]

From $k \propto \frac{1}{l}$, $k_1 = \frac{4}{3}$ k and $k_2 = 4k$

equivalent force constant $k' = \frac{16k}{3}$

$\Rightarrow T = \frac{\pi}{2} \sqrt{\frac{3m}{k}}$

(31) Answer [A]

from $mg = k\Delta l$, $k = 100$ Nm^{-1}, $m = 1$ kg

$\therefore T = 0.2\pi$ s

(32) Answer [C]

According to law of momentum conservation,

$M v_{max} = (M + m) v_{new}$

$\therefore v_{new} = \frac{M v_{max}}{(M + m)}$

$v_{new} = \frac{M}{(M + m)}$ $A_1 \omega_1 = A_2 \omega_2$

$\therefore \frac{M}{(M + m)} A_1 \sqrt{\frac{k}{M}} = A_2 \sqrt{\frac{k}{M + m}}$

$\therefore \frac{A_1}{A_2} = \left(\frac{M + M}{(M)}\right)^{\frac{1}{2}} = \left(\frac{100 + 21}{100}\right)^{\frac{1}{2}} = \frac{11}{10}$

(33) Answer [B]

$T_1 = T$, $m_1 = m$, $k_1 = k$

$T_2 = ?$, $m_2 = m$, $k_2 = 4k$

$$\frac{T_1}{T_2} = \sqrt{\frac{k_2}{k_1}}, \therefore T_2 = \frac{T_1}{2}$$

(34) Answer [D]

k = 4000 Nm^{-1}, m = 10 kg

$$T = 2\pi\sqrt{\frac{m}{k}} = \frac{\pi}{10} = 0.314 \text{ s}$$

(35) Answer [B]

friction force, $f = m\omega^2 A = m\,\frac{k}{2m}\,A = \frac{kA}{2}$

(36) Answer [C]

$f = \frac{1}{2\pi}\sqrt{\frac{g}{y}}$, substituting values in $f = \frac{25}{\pi}$

(37) Answer [A]

$$k = \frac{2}{0{\cdot}01} = 200 \text{ Nm}^{-1}$$

k Δl = mg, from $\Delta l = y = 0.025$ m

$T = 2\pi\sqrt{\frac{m}{k}}$ from $T = \frac{\pi}{10}$ s

(38) Answer [B]

Here $k_1 x_1 = k_2 x_2$ and $A = x_1 + x_2$

Solving equations, $x_1 = \frac{k_2 A}{k_1 + k_2}$

(39) Answer [C]

$$K = U \Rightarrow y = \pm \frac{A}{\sqrt{2}}$$

$$\therefore v = \frac{\omega A}{\sqrt{2}} \quad a = \frac{\omega^2 A}{\sqrt{2}}$$

(40) Answer [A]

total mechanical energy E = 43 + 58 = 101 J

Now K = 61 $\therefore$ U = 40 J

K = 20 Nm^{-1} $\therefore$ y = 2m

(41) Answer [D]

$T = 2\pi$ s $\Rightarrow \omega = 1$ $rads^{-1}$, A = 10 cm

y = 6 cm, from $v = \omega\sqrt{A^2 - y^2}$, $v = 8$ cms^{-1}

$\therefore$ K= 6.4×10^{-5} J

from $E = \frac{1}{2} KA^2 = \frac{1}{2} m\omega^2 A^2$ $\therefore$ $E = 10^{-4}$ J

$\therefore$ U = 3.6×10^{-5} J

(42) Answer [A]

m = 20 kg, $v = 2$ ms^{-1}, T = 6 $\Rightarrow \omega = \frac{\pi}{3}$ rad s^{-1}

t = 1 s, ϕ = 0

from $K = \frac{1}{2} mv^2$, K = 40 J

from $v = A\omega \cos(\omega t + \phi)$, $A\omega = 4$

from $E = \frac{1}{2} m\omega^2 A^2$, E = 160 J

$\therefore$ U = 120 J

(43) Answer [B]

Mechanical energy $E = \frac{F^2}{2k}$ substituting values = 2 J

(44) Answer [B]

from $E = \frac{1}{2} m\omega^2 A^2$, $\omega^2 = 10^6$, $\omega = 10^3$ rad s^{-1}

$k = m\omega^2$ $\therefore$ $K = 2 \times 10^6$ Nm^{-1}

(45) Answer [A]

m = 0.1 kg, from $E = \frac{1}{2} m\omega^2 A^2$, $\omega^2 = 16$

$\therefore$ $\omega = 4$ $rads^{-1}$, $A = 10^{-1}$ m, $k = m\omega^2$

$\therefore$ k = 0.1 × 16, k = 1.6 Nm^{-1}

(46) Answer [D]

$y = \frac{A}{2}$; $K = \frac{1}{2} mv^2 = \frac{1}{2} m\omega^2 (A^2 - y^2)$

$$= \frac{1}{2} k\left(A^2 - \frac{A^2}{4}\right) = \frac{1}{2} k\left(\frac{3A^2}{4}\right) = \frac{3E}{4}$$

(47) Answer [B]

Here $U = \frac{1}{4} U_{max}$

$$\frac{1}{2} ky^2 = \frac{1}{4}\,\frac{1}{2} kA^2 \Rightarrow y = \frac{A}{2}$$

(48) Answer [C]

$$\frac{U}{E} = \frac{\frac{1}{2} k y^2}{\frac{1}{2} k A^2} = \left(\frac{y}{A}\right)^2$$

(49) Answer [B]

When amplitude reduced by 25 % it will remain 75 %

$A_2 = 0.75\, A_1$

$$\frac{E_2}{E_1} = \left(\frac{A_2}{A_1}\right)^2 = (0.75)^2 = 0.5625$$

$\therefore$ Mechanical energy is 56.25 %

$\therefore$ decrease of 43.75 %

(50) Answer [A]

$$E_1 = \frac{1}{2} ky_1^2 \therefore y_1 = \sqrt{\frac{2E_1}{k}} \text{ and } y_2 = \sqrt{\frac{2E_2}{k}}$$

Now, if displacement is $y_1 + y_2$ then

$$E = \frac{1}{2} k (y_1 + y_2)^2$$

$$\therefore y_1 + y_2 = \sqrt{\frac{2E}{k}} \Rightarrow \sqrt{E_1} + \sqrt{E_2} = \sqrt{E}$$

(51) Answer [A]

$$E = \frac{1}{2} ky^2 + \frac{1}{2} Mv^2 + \frac{1}{2} I\omega^2$$

When $y = 0$, $\omega = 0$, $\therefore K = \frac{1}{2} Mv^2 = \frac{1}{3}$ J

$$\therefore \quad E = \frac{1}{2} ky^2 + \frac{3}{4} Mv^2 \Rightarrow E = \frac{3}{4} Mv^2$$

$Kv = \frac{1}{4} Mv^2 = \frac{1}{6}$ J, Now $E = \frac{1}{2} kA^2$

$0.5 = \frac{3}{4} Mv^2, \frac{1}{2}(4)(0.5)^2$ J

$\therefore Mv^2 = \frac{2}{3} = 0.5$ J

Now, $E = \frac{1}{2} ky^2 + \frac{3}{4} Mv^2$

$$\frac{dE}{dt} = \frac{1}{2} k\, 2y \frac{dy}{dt} + \frac{3}{4} m\, 2v \frac{dv}{dt}$$

$$0 = ky(v) + \frac{3}{2} mv \frac{d^2v}{dt^2}$$

$$\therefore \frac{d^2v}{dt^2} = -\frac{2K}{3m} y$$

$$\omega^2 = \frac{2K}{3M} \Rightarrow T = 2\pi \sqrt{\frac{3m}{2K}}$$

(52) Answer [D]

Kinetic energy $= \frac{1}{4}$ Potential energy $(K_1 = \frac{1}{4} U)$

$$\therefore A^2 - y^2 = \frac{1}{4} y^2 \Rightarrow y = 0.8944 A$$

$y = 89.44$ % of A

(53) Answer [A]

$$\phi = 0, \frac{1}{2} mv^2 = \frac{25}{100} \frac{1}{2} kA^2, T = 12 \text{ s}$$

$$m\omega^2 A^2 \cos^2\theta = \frac{1}{4} kA^2 \Rightarrow \theta = \frac{\pi}{3}$$

$$t = ?, \therefore \frac{2\pi}{T} t = \frac{\pi}{3}, t = \frac{T}{6} \Rightarrow t = 2 \text{ s}$$

(54) Answer [D]

$\phi = \frac{\pi}{3}$ $t = 0$, $v = A\omega \cos\phi$

potential energy $= E - \frac{E}{4}$, $v = \frac{1}{2} A\omega$

$\therefore U = \frac{3E}{4}$, kinetic energy

$$K = \frac{1}{2} mv^2 = \frac{1}{2} m \frac{1}{4} A^2\omega^2 = \frac{E}{4}$$

(55) Answer [C]

For simple pendulum,

$$\text{from } \frac{T_2}{T_1} = \sqrt{\frac{l_2}{l_1}}, 2 = \sqrt{\frac{l + 7.5}{l}} \Rightarrow l = 2.5 \text{ m}$$

(56) Answer [A]

l is constant, g is variable.

$$\frac{T_2}{T_1} = \sqrt{\frac{g_1}{g_2}} \cdot g_2 = 75 \text{ \% decreases.}$$

$$\therefore g_2 = 25 \text{ \% } g_1 \Rightarrow \frac{g_1}{g_2} = 4$$

$\therefore T_2 = 2T_1$, $\therefore$ 100 % increases.

(57) Answer [A]

$M_p = 4 M_e$, $R_p = 2R_e$

$$g \propto \frac{M}{R^2} \Rightarrow \frac{g_e}{g_P} = \frac{M_e}{M_P} \frac{R_P^2}{R_e^2} = 1$$

$\therefore T_P = T_e$

(58) Answer [D]

When mercury liquidate, then its center of mass comes down. length l incrcases. T increases. $\therefore$ Oscillations become slow.

(59) Answer [C]

Periodic time for upward motion $= T_1$,

$$g_e = g + \frac{g}{4} \; \frac{T_1}{T} = \sqrt{\frac{g}{\frac{5g}{4}}} \Rightarrow T_1 = \frac{2}{\sqrt{5}} T$$

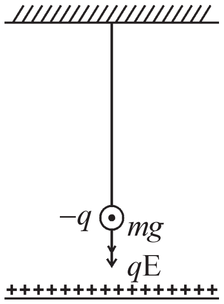
periodic time for downward direction = T_2

$g_e = g - \frac{g}{4}$

$\frac{T_2}{T} = \sqrt{\frac{g}{\frac{3g}{4}}} \Rightarrow T_2 = \frac{2}{\sqrt{3}}\ T$

$\frac{T_1}{T_2} = \frac{\sqrt{3}}{\sqrt{5}} = \sqrt{\frac{3}{5}}$

(60) Answer [B]



– q charge on sphere

A positive charge on horizontal surface

$\therefore$ electric force F = qE is in downward direction.

Effective weight

$mg' = mg + qE,\ \therefore\ g' = g + \frac{qE}{m}$

$T = 2\pi\sqrt{\frac{m}{g'}}$

(61) Answer [A]

For simple pendulum, $T = 2\pi\sqrt{\frac{l}{g}}$

$\therefore\ g = 4\pi^2\frac{l}{T^2}$ substituting values $g = \pi^2$

(62) Answer [C]

from $f \propto \frac{1}{\sqrt{l}}$, $l \propto \frac{1}{f^2}$; $f_1 : f_2 = 5:4$

$\therefore$ from $\frac{l_1}{l_2} = \left(\frac{f_2}{f_1}\right)^2$, $\frac{l_1}{l_2} = \frac{16}{25}$

(63) Answer [A]

periodic time $T \propto \sqrt{l}\ \ \therefore\ l \propto T^2\ \ \therefore\ l_2 = 4l$

(64) Answer [B]

For simple pendulum hanged from roof of plane,

$T = 2\pi\ \frac{\sqrt{l}}{\left[g^2 + a_0^{\ 2}\right]^{\frac{1}{4}}}$ substituting values

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

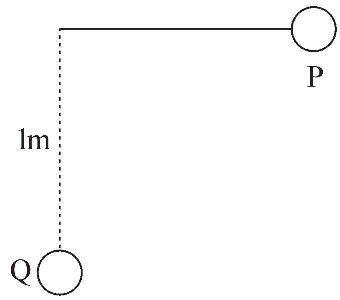
(65) Answer [C]

Center of mass shifted upward when child stand up on swing.

So, length l decreases and periodic time decreases.

$\therefore\ T' < T$

(66) Answer [A]

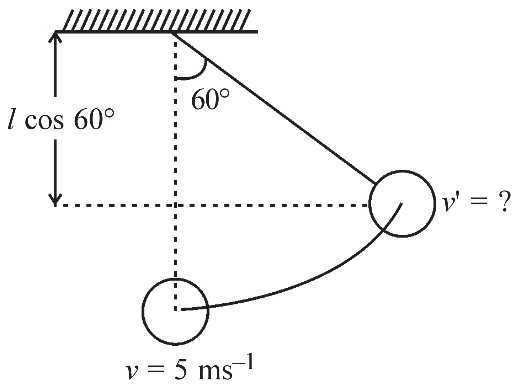


{loss of potential energy} = {gain in kinetic energy}

from 0.8 mgh = $\frac{1}{2}$ mv^2, $v^2 = 16$

$v = 4\ ms^{-1}$

(68) Answer [A]



$\frac{1}{2}\ mv^2 = \frac{1}{2}mv'^2 + mg\ (l - l\cos 60°)$

$v^2 = v'^2 + 2g\left(\frac{l}{2}\right),\ v^2 = v'^2 + gl$

$25 = v'^2 + 10\ (0{\cdot}9),\ v' = 4\ ms^{-1}$

(69) **Answer [B]**

$l_1 = 25$ m, $l_2 = 9$ m, $T_1 = T_2 = T$

$$R = \frac{h\sqrt{l_2}}{\sqrt{l_1} - \sqrt{l_2}} = \frac{2000 \times \sqrt{9}}{5-3} = 3000 \text{ km}$$

(70) **Answer [B]**

$$y = kt^2 \therefore v = \frac{dy}{dt} = 2k\,t$$

$$\therefore v = \frac{dv}{dt} = 2k$$

but k = 1 so, $a = 2\ ms^{-2}$

so, a rigid support is shifting upward by 2 ms^{-2}

thus, effective acceleration

$g' = g + a = 10 + 2 = 12\ ms^{-2}$

Now $T \alpha \frac{1}{\sqrt{g}}$ so, $\frac{T_1^2}{T_2^2} = \frac{g'}{9} = \frac{12}{10} = \frac{6}{5}$

upward by $a = 2\ ms^{-2}$.

Effective acceleration $g' = g + a = 10 + 2 = 12$

$$\frac{d^2y}{dt^2} = 2k,\ \frac{T_1}{T_2} = \sqrt{\frac{g'}{g}} = \sqrt{\frac{12}{10}} = \sqrt{\frac{6}{5}}$$

$\therefore\ a = 2 \times 1, a = 2\ ms^{-2}$

(71) **Answer [C]**

For damped oscillations $A' = Ae^{-\frac{bt}{2m}}$

$Ae^{-1} = Ae^{-\frac{bt}{2m}} \Rightarrow t = \frac{2m}{b}$

(72) **Answer [B]**

m = 100 g, $A' = Ae^{-\frac{bt}{2m}}$

b = 0.805 CGS,

A' = decreases 80 % of A

$= 20$ % of A, $A' = \frac{20}{100}$ A, $\frac{A'}{A} = 5$

$t = \frac{2m}{b}$ 2.303 *log* (5), substituting values $t = 400$ s.

(73) **Answer [B]**

$$A_t = A_0\ e^{-\frac{bt}{2m}} \Rightarrow \frac{A_t}{A_0} = e^{-\frac{bt}{2m}}$$

$$\therefore \frac{bt}{2m} = ln\left(\frac{A_0}{A_t}\right) \therefore b = \frac{2m}{t\ ln\left(\frac{A_0}{A_t}\right)}$$

(74) **Answer [B]**

m = 500 g, $A' = Ae^{-\frac{bt}{2m}}$, T = 2 s $A' = \frac{A}{2}$

$b = \frac{2m}{t}\ ln\left(\frac{A}{A'}\right)$, $t = 50 \times 2 = 100$ s

substituting values $b = 6.930$ CGS,

(75) **Answer [C]**

$A' = A_0\ e^{-\frac{bt}{2m}}$,

$0.8\ A_0 = A_0 e^{-\frac{bt}{2m}}$

$e^{-\frac{5b}{2m}} = 0.8$ ...(1)

$t = 5 + 10 = 15$ s, A'' = NA,

$N = e^{-\frac{15b}{2m}} \therefore N\left(e^{-\frac{5b}{2m}}\right)^3$, $= (0.8)^3 = 0.512$

(76) **Answer [D]**

In air, $T_0 = 2\pi\sqrt{\frac{l}{g}}$ Effective weight in liquid

$mg' = mg\left(1 - \frac{\rho_l}{\rho}\right)$ where ρ_l = density of liquid

ρ = density of sphere, $\therefore g' = g\left(1 - \frac{1}{4}\right)$

$g' = \frac{3g}{4}$ periodic time in liquid $T = 2\pi\sqrt{\frac{m}{g'}}$

$T = \frac{2}{\sqrt{3}}\ T_0$

(77) **Answer [B]**

$t = 100$ T,

A = 20 % of $A_0 \Rightarrow \frac{A}{A_0} = \frac{1}{5}$

$A = A_0\ e^{-\frac{100Tb}{2m}}$

$e^{-\frac{100Tb}{2m}} = \frac{1}{5}$

Now, $t = 200$ T then,

$A' = A_0\ e^{-\frac{200Tb}{2m}}$, $A' = A_0\left(e^{-\frac{100Tb}{2m}}\right)^2$

$A' = A_0\left(\frac{1}{5}\right)^2$

$A' = \frac{A_0}{25}$ or $A' = 0.04\ A_0 = 4$ % of A_0

(78) Answer [D]

angular frequency for damped oscillator

$$\omega = \sqrt{\left(\frac{k}{m}\right) - \left(\frac{b}{2m}\right)^2}$$

$$\therefore f = \frac{1}{2\pi}\sqrt{\left(\frac{k}{m}\right) - \left(\frac{b}{2m}\right)^2}$$

(79) Answer [A]

Significant amplitude = $\frac{A}{e}$ $\therefore t = \frac{2m}{b}$

(80) Answer [C]

Amplitude at time of resonance $A = \frac{F}{b\omega} = \frac{ma_o}{b\omega}$

(81) Answer [C]

Natural frequency of the building having height more than the frequency of the seismic wave is too high ($f \neq f$o). Likewise natural frequency of the heighted building is considerable less ($f \neq f$o). So probability of resonance is too less. On the contrary probability of resonance for the building having medium height is maximum.

(82) Answer [D]

Curve of resonance shows that if b is low then sharpness is high.

(83) Answer [C]

At time of resonance $f = f_0$, $\therefore 2\pi f = 2\pi f_o$

$\therefore \omega = \omega_0 \Rightarrow \frac{\omega}{\omega_0} = 1$

(84) Answer [A]

$A_1 = A_0\, e^{-\frac{bt_1}{2m}}$, $A_2 = A_0\, e^{-\frac{bt_2}{2m}}$

$\therefore \frac{A_2}{A_1} = e^{-\frac{bt_2}{2m}} \cdot e^{+\frac{bt_1}{2m}}$

$\therefore A_2 = A_1\, e^{\frac{b}{2m}(t_1 - t_2)}$

(85) Answer [D]

$t = t_1$, $t_2 = t$ (same) $b_2 = 2b$

$A_1 = A_0\, e^{-\frac{bt}{2m}}$, $A_2 = A_0\, e^{-2\frac{bt}{2m}}$

$\frac{1}{10} = e^{-\frac{bt}{2m}}$ ...(1)

$\frac{A_2}{A_0} = \left(\frac{1}{10}\right)^2$, $\therefore A_2 = 0.01\, A_0$

$\therefore A_2 = 0.01\, A_0 = 1$ % of A_0.

(86) Answer [A]

Phase difference $\delta = kx$.

$\therefore \frac{17\pi}{2} = 2\pi \times 10^8\, x$

$\therefore x = \frac{17}{2} \times 10^{-8}$ cm $= 4.25$ Å

(87) Answer [D]

wave vector $k = 10\pi$ rad cm^{-1}, $x = 3.6$ cm

$\therefore \delta = kx = 10\pi \times 3.6 = 36\pi$ rad

(88) Answer [B]

wave equation $y = 10 \sin (4\pi t - \pi x)$

compare with $y = A \sin (\omega t - kx)$

$\omega = 4\pi$, $k = \pi$ Velocity of wave $= \frac{\omega}{k} = 4$ cms^{-1},

Velocity of particle $v = 40\pi \cos (4\pi t - \pi x)$

$t = 10$ s, $x = 38$ cm, $v = 40\pi$ cms^{-1}

$\therefore \frac{\text{Velocity of particle}}{\text{Velocity of wave}} = \frac{40\pi}{4} = 10\pi$

(89) Answer [B]

$A = 5$ cm, $x = 4$ cm, $t = 2$ s, $y = \frac{5}{\sqrt{2}}$ cm,

$\therefore \frac{5}{\sqrt{2}} = 5 \sin (2\omega - 4k)$

$x = 16$, $t = 4$, $y = 2.5$ cm, $\therefore 2\omega - 4k = \frac{\pi}{4}$

$2.5 = 5 \sin (4\omega - 16k)$, $4\omega - 16k = \frac{\pi}{6}$

Solving equations $\omega = \frac{5\pi}{24}$ rad s^{-1}

$k = \frac{\pi}{24}$ rad cm^{-1}

(90) Answer [C]

$f = \frac{10}{\pi}$ Hz, A = 0.4 cm $v_{max} = \omega A$,

$= 2\pi f A$, $v_{max} = 8$ cms^{-1}

(91) Answer [A]

wave equation $y = 10 \sin (\pi t - \pi x)$ cm

$x = 2$ cm $t = \frac{13}{6}$ s $\therefore y = 5$ cm velocity $v = 10\pi \cos(\pi t - \pi x)$

substituting values $v = 5\sqrt{3}\,\pi$ cms^{-1}

acceleration $a = -10\pi^2 \sin(\pi t - \pi x)$

$a = -5\pi^2$ cms^{-2}

(92) Answer [A]

$f = 15 \times 10^7$ Hz, wave vector

$$k = \frac{2\pi}{\lambda} = \frac{2\pi f}{v} = \frac{2\pi \times 15 \times 10^7}{3 \times 10^8}$$

$k = \pi$ rad m^{-1}

(93) Answer [C]

Here $k = 0.02\pi$ rad m^{-1}, phase diff $= \frac{\pi}{4}$

$\therefore kx = \frac{\pi}{4} \therefore 0.02\pi x = \frac{\pi}{4} \Rightarrow x = 12.5$ cm.

(94) Answer [B]

$\lambda = \frac{v}{f} = \frac{330}{10^3} = 33 \times 10^{-2}$ m, $\delta = \frac{2\pi}{\lambda} x$

$\delta = 60° = \frac{\pi}{3}, x = ?$

$\therefore x = \frac{\delta\lambda}{2\pi} = 5.5 \times 10^{-2}$ m

(95) Answer [C]

Difference in initial phase $= \phi_2 - \phi_1$

$= \frac{\pi}{3} - \frac{\pi}{2} = \frac{-\pi}{6}$

[**Note :** difference in initial phase for displacement of particle 2 relative to perticle 1 is $\phi_1 - \phi_2 = \frac{\pi}{6}$.]

(96) Answer [A]

$y = 0.008 \cos(\alpha x - \beta t)$

$\lambda = 0.08$ m $\Rightarrow k = \frac{2\pi}{\lambda} \therefore \alpha = 25\pi$

$T = 0.5$ s $\Rightarrow \beta = \frac{2\pi}{T} \therefore \beta = 4\pi$

(97) Answer [C]

A = yo, $v_{max} = 4$ Velocity of wave

$\omega A = 4\frac{\omega}{k} \therefore \text{yo} = 4\frac{\lambda}{2\pi} \Rightarrow \lambda = \frac{\pi \text{Yo}}{2}$

(98) Answer [D]

$A = 0.01$ m, $T = 0.05$ s, $\therefore \omega = \frac{2\pi}{T} = 40\pi$

$v_{max} = \omega A = 40\pi \times .01 = 0.4\pi$ ms^{-1}

$a_{max} = \omega^2 A = 1600\pi^2 \times .01 = 16\pi^2$ ms^{-2}

(99) Answer [A]

$\omega = 100$ rad s^{-1}, $k = 20$ rad m^{-1}

Speed of wave $v = \frac{\omega}{k} = 5$ ms^{-1}

(100) Answer [B]

$y = 10 \sin(20\pi t - \frac{\pi x}{8})$ m

Slope of wave $\frac{dy}{dx} = 10\left(-\frac{\pi}{8}\right)\cos(20\pi t - \frac{\pi x}{8})$

taking $x = 320$ m and $t = 2$ s

$\frac{dy}{dx} = -\frac{10\pi}{8}\cos(40\pi - 40\pi) = -\frac{5\pi}{4}$

(101) Answer [A]

$f = 400$ Hz, minimum time between two consecutive condensation and rarefaction

$= \frac{T}{2}$, $T = \frac{1}{400}$ s $= \frac{1}{800}$ s

(102) Answer [C]

Velocity in mixture $= v_{mix}$

Velocity in $H_2 = v_{H_2} = 1225$ ms^{-1}

Now, $\rho_{mix} = \frac{2V\rho_{H_2} + 16V\rho_{H_2}}{3V} = \frac{18}{3}\delta_{H_2}$

$\therefore \rho_{mix} = 6\,\delta_{H_2}, \frac{1}{6} = \frac{\delta_{H_2}}{\rho_{mix}}$

Now, $\frac{v_{mix}}{v_{H_2}} = \sqrt{\frac{\delta_{H_2}}{\rho_{mix}}} = \sqrt{\frac{1}{6}}$

$v_{mix} = \frac{v_{H_2}}{\sqrt{6}} = \frac{1225}{2.45} = 500$ ms^{-1}

(103) Answer [B]

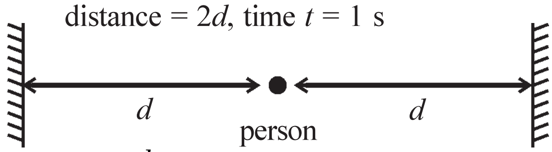
Temperature of NTP, $T_1 = 300$ K, Velocity $= v_1$

$T_2 = ?$, Velocity $v_2 = 2v_1$

$\frac{v_2}{v_1} = \sqrt{\frac{T_2}{T_1}} \Rightarrow T_2 = 1200$ K

(104) Answer [A]

distance $= 2d$, time $t = 1$ s



$v = \frac{2d}{1} \Rightarrow d = \frac{v}{2} = 116$ m

Velocity $= v \therefore$ distance between two walls $= 2 \times 116$

$= 332$ m

(105) Answer [A]

$h = 20$ m, g = 10 ms^{-2}, $t = 2.06$ s

For freely falling stone $d = v_0 t + \frac{1}{2} g t^2$

from $h = \frac{1}{2} g t^2$, $t_1^2 = \frac{2h}{g}$

$\therefore t_1 = \sqrt{\frac{2h}{g}}$

Velocity of sound after collision = v

time = t_2, distance = h, $t_2 = \frac{h}{v}$

$\therefore \sqrt{\frac{2h}{g}} + \frac{h}{v} = t$, $\sqrt{\frac{2 \times 20}{10}} + \frac{20}{v} = 2.06$

$2 + \frac{20}{v} = 2.06 \Rightarrow v = 333$ ms^{-1}

(106) Answer [D]

$I_o = 10^2$ W m^{-2}, Level of intensity

$I = 10^7$ W m^{-2}, L = 10 log $\left(\frac{I}{I_o}\right)$

= 10 log (10^5) = 50 dB

(107) Answer [D]

$L_1 = 10 \log\left(\frac{I_1}{I_o}\right)$, simillarly

$20 = 10 \log\left(\frac{I_1}{I_o}\right)$, $50 = 10 \log\left(\frac{I_2}{I_o}\right)$

$\frac{I_1}{I_o} = 10^2$, $\frac{I_2}{I_o} = 10^5 \Rightarrow \frac{I_2}{I_1} = 10^3$

(108) Answer [B]

One person can hear 5 echo in 1 sec.

$\therefore$ time of pronunciation = $\frac{1}{5}$

$\therefore \frac{1}{5} = \frac{2d}{v} \Rightarrow d = \frac{v}{10} = \frac{330}{10} = 33$ m

$d = 33$ m

(109) Answer [B]

Suppose original intensity = I

10 % decreases when passing through first slab.

$\therefore$ intensity becomes 90% $\therefore I_1 = \frac{90}{100} I = \frac{9}{10} I$

When passing through adjacent second slab, the emerging intensity is

$I_2 = \frac{9}{10} I_1$, $I_2 = \frac{81}{100} I$

$\therefore I_2$ is 81 % of original intensity.

$\therefore$ The decrease in intensity is 19 %

(110) Answer [C]

Velocity of longitudinal waves

$v = \sqrt{\frac{Y}{\rho}} = \sqrt{\frac{13.2 \times 10^{10}}{3.3 \times 10^4}} = 2 \times 10^3$ ms^{-1}

(111) Answer [A]

$\alpha = \frac{v_t - v_o}{t}$, $\alpha = \frac{v_o}{546}$, $v_o = 273$ ms^{-1}

$\alpha = \frac{273}{546} = \frac{1}{2} = 0.5$ ms^{-1} K^{-1}

(112) Answer [B]

$\frac{\text{PQ wire}}{\text{L = 2m}}$, m = 0.025 kg, $\mu_1 = \frac{m}{L}$

$\mu_1 = 0.0125$ kg m^{-1}, Velocity $v_1 = \sqrt{\frac{T}{\mu_1}}$

= 80 ms^{-1}

$\frac{\text{QR wire}}{\text{L = 1m}}$, m = 0.05 kg, $\mu_2 = 0.05$ kg m^{-1}

Velocity, $v_2 = \sqrt{\frac{T}{\mu_2}} = 40$ ms^{-1}

Time taken by wave to reach R end from P end.

$t = t_1 + t_2$, $t = \frac{2}{80} + \frac{1}{40}$

$\therefore t = \frac{1}{20} = 0.05$ s

(113) Answer [D]

possible maximum wavelength for stationary wave

$\lambda = 2L = 200$ cm

(114) Answer [B]

Here $\frac{\lambda}{4} = 0.01$ m $\Rightarrow \lambda = 0.04$ m

$f = \frac{v}{\lambda} = \frac{320}{0.04} = 8 \times 10^3$ H$_z$ = 8 kHz

(115) Answer [A]

f closed pipe = $\frac{1}{2}$ f open pipe

$\Rightarrow f$ closed = 256 Hz

(116) Answer [B]

f_1 = 160 Hz, v = 320 ms^{-1}, L = ?

$L = \frac{v}{4f_1} = \frac{320}{4 \times 160} = 0.5$ m = 50 cm

(117) Answer [C]

Closed pipe $f_1 = \frac{v}{4L}$, For open pipe $f_1 = \frac{v}{2L'}$

$\therefore$ 4L = 2L' $\Rightarrow \frac{L}{L'} = \frac{1}{2}$ = 1:2

(118) Answer [D]

f = 160 H_z, v = 320 ms^{-1}, L = ?

for open pipe, $f = \frac{v}{2L} \Rightarrow$ L = 1 m = 100 cm

(119) Answer [B]

f_1 = 325 – 285 = 40 Hz

(120) Answer [A]

For closed pipe, third overtone n = 7

$\lambda = \frac{4L}{(2n-1)}$ substituting values λ = 40 cm

(121) Answer [B]

For closed pipe, first overtone $f_2 = \frac{3v}{4L_1}$

For Open pipe, first overtone $f_2 = \frac{v}{L_2}$

$\therefore \frac{L_1}{L_2} = \frac{3}{4}$ = 3:4

(122) Answer [A]

For Tenth harmonic n = 10

Nodal points $(n - 1)$ = 9, antinode points n = 10

(123) Answer [C]

f = 320 Hz, v = 320 ms^{-1}

$f = \frac{v}{4L} \Rightarrow$ 4L = 1 $\Rightarrow$ L = 0.25 m = 25 cm

For resonance h = L' – L = 125 – 25 = 100 cm

(124) Answer [A]

minimum resonance frequency = 415 – 295 = 120 Hz

(125) Answer [B]

$k = \frac{2\pi}{7}$, $\omega = 70\pi$, $\frac{2\pi}{\lambda} = \frac{2\pi}{7} \Rightarrow \lambda$ = 7 cm

Distance between two consecutive N points $\frac{\lambda}{2}$ = 3.5 cm

(127) Answer [A]

$k = \frac{\pi}{4}$, $\frac{2\pi}{\lambda} = \frac{\pi}{4}$, λ = 8 cm

position of antinode points, $\frac{\lambda}{4}$, $3\frac{\lambda}{4}$, $5\frac{\lambda}{4}$, ...

2, 6, 10, 14...

(128) Answer [B]

specific density of liquid = $\frac{f_1^2 - f_3^2}{f_1^2 - f_2^2}$

$= \frac{5^2 - 1^2}{5^2 - 3^2} = \frac{24}{16} = 1.5$

(129) Answer [C]

L = 35 × 10^{-2} m, v = 350 ms^{-1}

fundamental frequency

$f_1 = \frac{v}{2L} = \frac{350}{2 \times 35 \times 10^{-2}}$ = 500 Hz

Now, f_n = 3000 Hz, $f_n = n f_1$

3000 = n × 500 $\Rightarrow$ n = 6 (close loop)

(131) Answer [D]

$\frac{I_2}{I_1} = \left(\frac{A_2}{A_1}\right)^2$, $0.81 = \left(\frac{A_2}{A_1}\right)^2$

$0.9 = \frac{A_2}{A_1}$, $A_2 = 0.9\, A_1$, $= 0.9 \times 10$, $A_2 = 9$

$y_r = -9 \sin(4\pi t + \frac{2\pi}{5}x)$

(132) Answer [C]

f_1 = 320 Hz, f_2 = 480 Hz, $\lambda_1 - \lambda_2 = \frac{17}{48}$

$f_1 \lambda_1 = f_2 \lambda_2$, substituting values $\lambda_1 = \frac{17}{16}$ m

Velocity of sound $v = f_1 \lambda_1 = 320 \times \frac{17}{16}$ = 340 ms^{-1}

(133) Answer [A]

λ_1 = 50, λ_2 = 50.5, $f_1 - f_2$ = 6

$f_1 \lambda_1 = f_2 \lambda_2$, substituting volues $\lambda_1 = \frac{17}{16}$ m

substituting values $f_1 = 606$ Hz

velocity of sound $v = f_1 \lambda_1$

$= 606 \times 50 \times 10^{-2} = 303$ ms^{-1}

(134) Answer [D]

$\lambda_1 = \frac{90}{175}$ m, $\lambda_2 = \frac{90}{173}$ m, $f_1 - f_3 = 4$

$f_1 = f_3 + 4, f_3 - f_2 = 4, f_2 = f_3 - 4$

$f_1 \lambda_1 = f_2 \lambda_2, (f_3 + 4) \frac{90}{175} = (f_3 - 4) \frac{90}{173}$

by solving $f_3 = 696$ Hz

(135) Answer [B]

$316 - 312 = 4$ or $320 - 316 = 4$

(136) Answer [A]

$f_Q = 384 \therefore f_P = 380$ or $f_P = 388$ Hz

After polishing wings $f_P = 381$ or $f_P = 387$ Hz. Now frequency increases after polishing the wings. So, decrease from 388 to 387 Hz is not possible.

$\therefore$ Before polish $f_P = 380$ Hz

(137) Answer [B]

$f_N = 588$ $f_M = 583$ Hz or $f_M = 593$ H_2

After applying the wax $f_M = 585$ Hz or $f_M = 591$ Hz

Frequency must be reduced after applying the wax $\therefore f_M = 593$ Hz

(138) Answer [B]

$f_1 - f_2 = 3, f_{51} = 3 f_1$

$f_n = a + (n-1)d$

$\therefore 3 f_1 = f_1 + (51 - 1)3, \therefore f_1 = 75$ Hz

Now, $f_{26} = f_1 + (n-1)d = 150$ Hz

(139) Answer [A]

$d = x, f_{21} = 1.4 f_1, 1.4 f_1 = f_1 + (21 - 1)\, x$

$f_1 = 50x, f_{11} = f_1 + (11 - 1)x$

$120 = 50\,x + 10\,x, x = 2$

(140) Answer [B]

$f_1 - f_2 = 355 - 350$

$\therefore$ T $= \frac{1}{5}$ minimum time between maxima and minima $= \frac{T}{2} = \frac{1}{10}$ s

(141) Answer [B]

$l_1 = 80$ cm, $l_2 = 60$ cm, $f_1 l_1 = f_2 l_2$

$f_1 = \frac{6}{8} f_2, f_1 = \frac{3}{4} f_2$

Now, $f - f_1 = 2, f_2 - f = 2, f_2 - f_1 = 4$

$f_2 - \frac{3}{4} f_2 = 4, f_2 = 16$ Hz, $f_2 - f = 2$,

$f = f_2 - 2 = 16 - 2, f = 14$ Hz

(142) Answer [B]

$L_1 = 50$ cm, $L_2 = 48$ cm

$f_1 L_1 = f_2 L_2$, (f – 5) 50 = (f + 5) 48

$\therefore f = 245$ Hz

(143) Answer [A]

unknown frequecy $= f$

$350 \pm 4 = 346$ Hz or 354 Hz

$360 \pm 6 = 354$ Hz or 366 Hz

$\therefore f = 354$ Hz

(145) Answer [B]

Here, $f_2 - f_1 = N, \frac{f_2}{f_1} = 1.5$

$1.5 f_1 - f_1 = N, 0.5 f_1 = N, f_1 = 2N$

(146) Answer [A]

$200 \pm 4 = 196$ Hz or 204 Hz

After applying strip

$200 \pm 6 = 194$ Hz or 206 Hz

Frequency decreases after applying strip (Never increases)

$\therefore f = 196$ Hz

(147) Answer [D]

For clear hearing of pulse in case of noise

$f_1 - f_2 \le 6, 2\pi f_1 - 2\pi f_2 \le 12\pi$

$\omega_1 - \omega_2 \le 12\pi$

(148) Answer [D]

Due to beats, two wave having same amplitude (A) and sligtly different frequency (f_1 and f_2) or different angular frequency (ω_1 and ω_2)

(149) Answer [C]

According to the principle of superposition

$y = y_1 + y_2$ resultant amplitude

$= 2A \cos 2\pi \left(\frac{f_1 - f_2}{2}\right) t$.

(151) Answer [A]

$v = 340\ ms^{-1}$

$\frac{v + v_S}{v - v_S} = 1.5$ by simplifying $v_s = 68\ \ ms^{-1}$

(152) Answer [C]

$v_L = 0, f_L = 5\%$ more than f_S

$\therefore f_L = 1.05 f_S, v = 325\ ms^{-1}, v_s = ?$

Car moving towards listner $f_L = \left(\frac{v}{v - v_S}\right) f_s$

substituting values $v_s = 15\ ms^{-1}$

(153) Answer [A]

$v_s = 20\ ms^{-1}, f_S = 10^3$ Hz, $v_L = 0$

$f_{L_1} - f_{L_2} = ?$

$$f_{L_1} - f_{L_2} = \left[\left(\frac{v}{v - v_S}\right) - \left(\frac{v}{v + v_S}\right)\right] f_S$$

substituting values $f_{L_1} - f_{L_2} = 124.8$ Hz

(154) Answer [C]

$v_{S_1} = 20\ ms^{-1}, v_{S_2} = 10\ ms^{-1}, v_L = 0$

$f_s = 200$ Hz, $v = 320\ ms^{-1}$

Beats hear by listner

$$f_{L_1} - f_{L_2} = \left[\left(\frac{v}{v - v_{S_2}}\right) - \left(\frac{v}{v - v_{S_1}}\right)\right] f_s$$

substituting values $f_{L_1} - f_{L_2} = 7.04$

(155) Answer [A]

$v_S = v_L = 20\ ms^{-1}$, Consider v_L is positive and v_S negative. $v = 320\ ms^{-1}, f_S = 600$ Hz frequency hear by listner (Train driver)

$f_L = \left(\frac{v + v_L}{v - v_S}\right) f_s$, substituting values

$f_L = 680$ Hz

(156) Answer [B]

$v_s = 0, f_s = 700$ Hz, $v_L = 10\ ms^{-1}, f_L = ?$

$f_L = \left(\frac{v + v_L}{v}\right) f_s$, substituting values $f_L = 720$ Hz

(157) Answer[C]

$v_s = 20\ ms^{-1}, v_L = 10\ ms^{-1}, f_s = 990$ Hz

$v = 350\ ms^{-1}$

Here v_s and v_L both are consider as a negative.

$f_L = \left(\frac{v - v_L}{v - v_S}\right) f_s$, substituting values $f_L = 1020$ Hz

(158) Answer [D]

$v_s = 10\ ms^{-1}, v_L = 30\ ms^{-1}, v = 330\ ms^{-1}$

$\frac{f_L}{f_S} = ?$, Here $f_L = \left(\frac{v + v_L}{v + v_S}\right) f_s$

substituting values $\frac{f_L}{f_S} = \frac{18}{17}$

(159) Answer [C]

$f_s = 1000$ M Hz, $f_L = 1000.005$ M H_z

$v_s = 0$ (stationary radar), $v_L = ?\ v = 3 \times 10^8\ ms^{-1}$

Here, $f_L = \left(\frac{v + v_L}{v}\right) f_s$

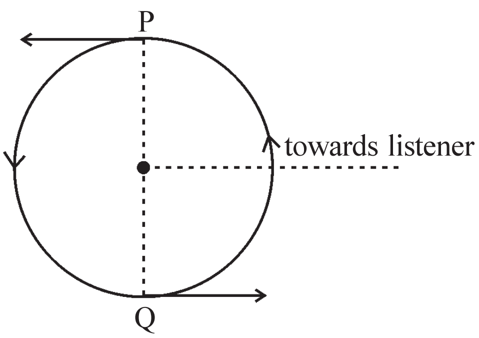
$\therefore\ v_L = \left(\frac{f_L}{f_S} - 1\right) v$

substituting values $v_L = 1500\ ms^{-1}$

(160) Answer [A]

$v_L = 0, r = 0.5$ m, $\omega = 20\ rads^{-1}$

$v_s = r\omega = 10\ ms^{-1}, f_s = 500$ Hz, $v = 340\ ms^{-1}$



When sound is at point P, the frequency hear by listener is minimum.

$f_L = \left(\frac{v}{v + V_L}\right) f_s$, substituting values $f_L = 486$ Hz

When sound is at point Q, the frequency hear by listener is maximum.

$f_L = \left(\frac{v}{v - v_S}\right) f_s$, putting values $f_L = 515$ Hz

(161) Answer [C]

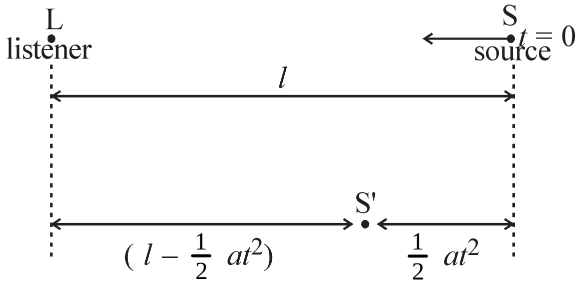
$v_L = 0$, $v_s = 2\ ms^{-1}$, $v = 332\ ms^{-1}$

$f_{L_1} - f_{L_2} = 4$, Here

$$f_{L_1} - f_{L_2} = \left[\frac{v}{v - v_S} - \frac{v}{v + v_S}\right] f_S$$

substituting values $f_s = 330.5$ Hz

(162) Answer [A]



Suppose at time $t = 0$, the distance between listener and source is l and at this time sound wave transmitted from source S.

If velocity of wave is v then time required to reach this wave to listener is

$$t_1 = \frac{l}{v} \quad ...(1)$$

Now, at time $t = T$, source transmitted second wave. During this time, the distance travelled by source towards listner is $d = 0 + \frac{1}{2}at^2 \Rightarrow \frac{1}{2}aT^2$ $(t = T)$

$\therefore$ distance between listener and source $= (l - \frac{1}{2}aT^2)$

Thus, time taken to reach at listener for second wave is

$$t_2 = T + \frac{l - \frac{1}{2}aT^2}{v}$$

$\therefore$ time difference experienced by listener is $T' = t_2 - t_1$

$$\therefore T' = T + \frac{l}{v} - \frac{aT^2}{2v} - \frac{l}{v}$$

putting $T' = \frac{1}{f'}$, and $T = \frac{1}{f}$, $f' = \frac{2vf^2}{2vf - a}$

(163) Answer [C]

$v_L = 0$, $f_L = f_S + 10\ \%\ f_S$, $\therefore \frac{f_L}{f_S} = 1.1$

$v = 330\ ms^{-1}$, $v_s = ?$

$\frac{f_L}{f_S} = \left(\frac{v}{v - v_S}\right)$, substituting values

$v_s = 30\ ms^{-1}$

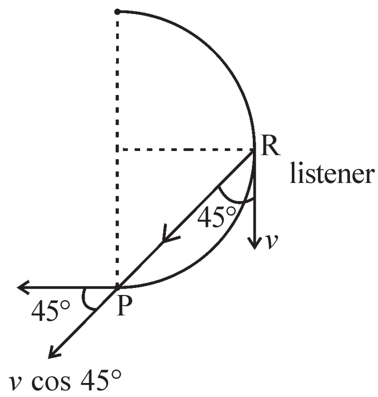
(164) Answer [D]

$v_S = 30\ ms^{-1}$, $v_L = 0$, $v = 330\ ms^{-1}$

$$\frac{f_{L_1}}{f_{L_2}} = ?, \quad \frac{f_{L_1}}{f_{L_2}} = \left(\frac{v + v_S}{v - v_S}\right)$$

substituting values $\frac{f_{L_1}}{f_{L_2}} = \frac{6}{5}$

(165) Answer [A]



The direction of motion for source and listener is mutually perpendicular as shown in figure.

component of velocity of listener in direction of source is $= v \cos 45°$

Simillarly, velocity of in direction of line joining source and listener is $= v \cos 45°$

$\therefore$ There is no relative motion so, frequency hear by listener is $f_L = 160$ Hz.

(166) Answer [D]

$m = 100$ g, $\Delta l = 0.1$ cm, $g = 10^3\ cms^{-1}$

$$k = \frac{mg}{\Delta L} = 10^6 \text{ dyne cm}^{-1}$$

$$T = 2\pi\sqrt{\frac{m}{k}}, = 2\pi\sqrt{10^{-4}} = 0.02\pi \text{ s}$$

(167) Answer [B]

$R = \frac{1.98}{2} = 0.99$, $\therefore l = 50.99$ cm, $g = 980$ cms^{-2}

from $T = 2\pi\sqrt{\frac{l}{g}}$, T = 1.433S

$\therefore t = 25 \times 1.433 = 35.8$ s

(168) Answer [B]

m = 250 g, T = 0.5, $k = 4\pi^2 \frac{m}{T^2}$

$= 4 \times 10^4$ dyne cm^{-1}, $mg = k\,\Delta l$

from $\Delta l = \frac{mg}{k}$, $\Delta l = 6.25$ cm

(173) Answer [C]

T = 2 sec, $T^2 = 4\ s^2$

Slope $= \frac{l}{T^2} = \frac{99.4}{4} = 24.85$

(174) Answer [A]

When frequency increases,

length decreases $\therefore fl$ = constant

(176) Answer [C]

$v_t = 4fl = 4\,(82.55) = 330.2$ ms^{-1}

(208) Answer [C]

2A = 20 $\Rightarrow$ A = 10 cm

$\Rightarrow$ In second quadrant $\phi = \pi - \frac{\pi}{6} = \frac{5\pi}{6}$

$\Rightarrow \theta = n\,(2\pi) + \phi = 5\pi + \frac{5\pi}{6} = \frac{35\pi}{6}$

$\Rightarrow T = \frac{8}{2.5} = 3.2$

(209) Answer [B]

A = 10 cm, $T = \frac{2\pi}{3}$, $\therefore \omega = 3$

Velocity at equilibrium point $v = \pm\,\omega A = 30$ cms^{-1}

acceleration at equilibrium point $a = 0$

Velocity at positive end $v = 0$

acceleration at negative end $a = (3)^2\,(10) = 90$ cms^{-2}

(210) Answer [D]

E = 2K, $\therefore K_1 = U = \frac{E}{2}$, $U = \frac{E}{2}$

displacement $y = \pm \frac{A}{\sqrt{2}}$

Velocity $v = \pm\,\omega\sqrt{A^2 - \frac{A^2}{2}} = \frac{v_{max}}{\sqrt{2}}$

acceleration $a = \omega^2 Y = \frac{a_{max}}{\sqrt{2}}$

(211) Answer [D]

A = 10 cm, $\omega = 4\pi$, $K = \frac{\pi}{5}$, $\frac{2\pi}{\lambda} = \frac{\pi}{5}$

$\lambda = 10$ cm, $f = \frac{4\pi}{2\pi}$, $f = 2$ Hz, wave velocity

$v = \frac{\omega}{K} = \frac{4\pi}{\frac{\pi}{5}} = 20$ cms^{-1}

(212) Answer [D]

$y = 10$ cm, $\omega = 2\pi$ rad s^{-1}, $K = \frac{\pi}{8}$ rad m^{-1}

$\frac{2\pi}{\lambda} = \frac{\pi}{8}$, $\lambda = 16$ cm, velocity of wave $v = \frac{\omega}{K}$

$v = 16$ cms^{-1}

$x = 4$, $t = 1$, $y = -10$ cm

$x = 16$ $t = 1$, $v = ?$, $v = 20\pi$ cms^{-1}

$x = 16$, $t = 1$ s, $a = ?$, $a = 0$

(213) Answer [A]

$K = \frac{\pi}{4}$, $\omega = 80\pi$, $\therefore \frac{2\pi}{\lambda} = \frac{\pi}{4}$, $\therefore \lambda = 8$ cm

Velocity of wave $v = \frac{\omega}{K}$, $v = 320$ cms^{-1}

Positions of node point $\frac{\lambda}{2}$, λ ..

4, 8, 12, 16... cm

Positions of antinode points $\frac{\lambda}{4}$, $\frac{3\lambda}{4}$...

2, 6, 10, 14, 18,...... cm

●

11 Electrostatics

(1) Answer [D]

Number of electrons removed from sphere

$$n = \frac{Q}{e} = \frac{2 \times 10^{-6}}{1.6 \times 10^{-19}} = 1.25 \times 10^{13}$$

Total number of electrons on sphere

$N_o = 29 \times 2 \times 10^{22} = 5.8 \times 10^{23}$

$\therefore$ Fraction of electrons removed

$$= \frac{n}{N_o} = \frac{1.25 \times 10^{13}}{5.8 \times 10^{23}} = 2.16 \times 10^{-11}$$

(2) Answer [A]

Total electric charge on object

$$Q = \frac{\% ne}{100} = \frac{0.01 \times 5 \times 10^{21} \times 1.6 \times 10^{-19}}{100}$$

$= 8 \times 10^{-2} = + 0.08$ Coulomb

(3) Answer [C]

Mass $M = m_e n$

$$n = \frac{M}{m_e} = \frac{75}{9 \times 10^{-31}} = \frac{25}{3} \times 10^{31}$$

Now, $Q = -ne = -\frac{25}{3} \times 10^{31} \times 1.6 \times 10^{-19}$

$= -1.33 \times 10^{13}$ C

(4) Answer [B]

Atomic number of water (H_2O) = 18 g

Now, number of molecules in 18 g water is $= 6.02 \times 10^{23}$

$\therefore$ Number of molecules in 100 g water is

$$n = \frac{100 \times 6.02 \times 10^{23}}{18} \quad \therefore \; n = 3.34 \times 10^{24}$$

In each atom of water there is 2 + 8 = 10 electron and 10 proton.

$\therefore$ Total electron in 100 g water

$= 10\, n = 3.34 \times 10^{25}$

$\Rightarrow$ Total negative charge in 100 g water $Q = 10\, ne$, $Q = 3.34 \times 10^{25} \times 1.6 \times 10^{-19}$

$= 5.34 \times 10^{6}$ C

(5) Answer [B]

Suppose total charge on object in time t is 1 C.

Now, number of electrons coming on object in 1 second is $= 10^{10}$

$\therefore$ Number of electrons coming on object in t second is $n = 10^{10} t$.

Charge of 1 electron = e

$\therefore$ Charge of n electron $Q = ne = 10^{10} te$

$$\therefore \; t = \frac{Q}{10^{10} e} = \frac{1}{10^{10} \times 1.6 \times 10^{-19}}$$

$t = 0.625 \times 10^{9} = 625 \times 10^{6}$ sec

$$= \frac{625 \times 10^{6}}{365 \times 24 \times 3600} \text{ year} = 19.81 \text{ year} \approx 20 \text{ year}$$

(7) Answer [C]

Total electric charge on both spheres.

$Q = 40 + 20 = 60\ \mu C$

Electric charge on both after conneted by wire.

$$Q_1 = \frac{QR_1}{R_1 + R_2} = \frac{60 \times 2}{5} = 24\ \mu C$$

$$Q_2 = \frac{QR_2}{R_1 + R_2} = \frac{60 \times 3}{5} = 36\ \mu C$$

$\therefore$ Electric charge goes from sphere of radius 2 cm to sphere of radius 3 cm is $40 - 24 = 16\ \mu C$

(8) Answer [A]

Suppose number of electrons removed

$q_1 = q_2 = n \times 1.6 \times 10^{-19}$ C

$$F = 3.7 \times 10^{-9} \text{ N}, \; F = \frac{k q_1 q_2}{r^2}$$

$r = 5\,\mathring{A} = 5 \times 10^{-10}$ m

$$3.7 \times 10^{-9} = \frac{9 \times 10^{9} \times \left(n \times 1.6 \times 10^{-19}\right)^2}{\left(5 \times 10^{-10}\right)^2}$$

$\therefore \quad n = 2$

(9) Answer [C]

gravitational force = electric force

$$\frac{GM_e m_m}{r^2} = \frac{kq^2}{r^2}$$

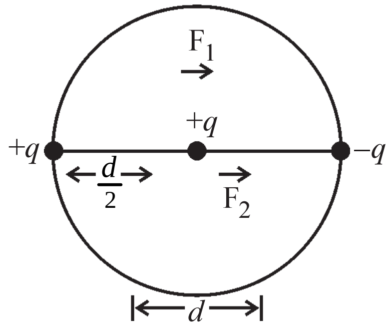
$$\therefore q^2 = \frac{GM_e m_m}{k} = 32.72 \times 10^{26}$$

$$\therefore q = 5.7 \times 10^{13} \text{ C}$$

(10) Answer [A]

Electric force on $+q$ electric charge

$F = F_1 + F_2$ (in values)



$$F = \frac{kq^2}{\frac{d^2}{4}} + \frac{kq^2}{\frac{d^2}{4}},\ F = \frac{8kq^2}{d^2}$$

(11) Answer [D]

Suppose $q_1 = q$ and $q_2 = -q$, $F = \frac{Kq^2}{r^2}$

Now, 25 % electric charge goes from one to second, $q_1' = q - 25\ \%\ q = 0.75q$

$q_2' = q + 25\ \%\ q = -0.75q$

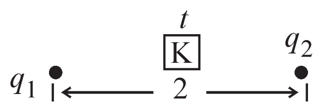
$\therefore$ New attractive force

$$F' = \frac{k(0.75q)(0.75q)}{r^2} = 0.5625\ F = \frac{9}{16} F$$

(12) Answer [B]

Force on electric charges in air

$$F = \frac{kq_1q_2}{r^2} \qquad ...(1)$$



When putting a slab of t thickness and K dielectric constant between two electric charges, the force is

$$F' = \frac{kq_1q_2}{\left(r - t + t\sqrt{K}\right)^2},\ \text{But } F' = \frac{F}{2}$$

$$\therefore \frac{F}{2} = \frac{kq_1q_2}{\left(r - t + t\sqrt{K}\right)^2} \qquad ...(2)$$

Taking ratio of equation (1) and (2),

$$\frac{F}{\frac{F}{2}} = \frac{\left(r - t + t\sqrt{K}\right)^2}{r^2}$$

$$\therefore 2r^2 = \left(r - t + t\sqrt{K}\right)^2$$

$$2 \times (0.2)^2 = \left(0.2 - 0.08 + 0.08\sqrt{K}\right)^2$$

$$\therefore \sqrt{0.08} = 0.12 + 0.08\sqrt{K}$$

$$\therefore \sqrt{K} = \frac{0.16}{0.08},\ K = 4$$

(13) Answer [C]

Electric force = Friction force

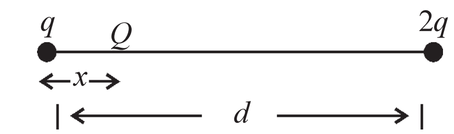
$$\frac{kq^2}{r^2} = \mu_s mg,\ \therefore \mu_s = \frac{kq^2}{r^2 mg}$$

$$\mu_s = \frac{9 \times 10^9 \times 10^{-14}}{10^{-2} \times 5 \times 10^{-3} \times 9.8}$$

$$\mu_s = 0.1836 = 0.18$$

(14) Answer [B]

Suppose, Q electric charge are placed from q to x distance.



$$\therefore x = \frac{d}{\sqrt{\frac{2q}{q}} + 1} = \frac{d}{\sqrt{2} + 1}$$

$$x = \frac{\left(\sqrt{2} - 1\right)d}{\left(\sqrt{2} - 1\right)\left(\sqrt{2} + 1\right)} = \left(\sqrt{2} - 1\right)d$$

(15) Answer [D]

$$F = \frac{kq_1q_2}{r^2} \Rightarrow q_1q_2 = \frac{Fr^2}{k} = \frac{0.075 \times 9}{9 \times 10^9}$$

$\therefore\ q_1q_2 = 7.5 \times 10^{-11}$

and $q_1 + q_2 = 20 \times 10^{-6}\,\text{C} = 2 \times 10^{-5}\,\text{C}$ ...(1)

Now, $(q_1 - q_2)^2 = (q_1 - q_2)^2 - 4q_1 - q_2$

$= (2 \times 10^{-5})^2 - 4 \times 7.5 \times 10^{-11} = 10^{-10}$

$\therefore\ q_1 - q_2 = 10^{-5}\,\text{C}$ ...(2)

From equation (1) and (2),

$q_1 = 15 \times 10^{-6}\,\text{C} = 15\,\mu\text{C}$

$q_2 = 5 \times 10^{-6}\,\text{C} = 5\,\mu\text{C}$

(16) **Answer [B]**

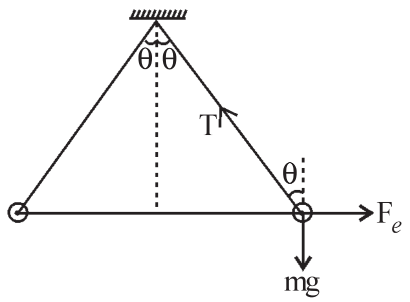
Force between q_1 and q_2 electric charge before collistion $F = \dfrac{kq_1q_2}{r^2}$

After collision of both spheres separated each electric charge $= \dfrac{q_1q_2}{2}$

$$\therefore\ F' = \frac{k\left(\frac{q_1+q_2}{2}\right)^2}{r^2}$$

$$\Rightarrow \left(\frac{q_1+q_2}{2}\right)\left(\frac{q_1+q_2}{2}\right) > q_1q_2 \ \therefore\ F' > F$$

(17) **Answer [C]**



$$x = \left(\frac{2q^2l}{4\pi\epsilon_0 mg}\right)^{\frac{1}{3}},\ x^3 = \frac{2q^2l}{4\pi\epsilon_0 mg}$$

Put value in $x^2 = \dfrac{x^3\ 4\pi\epsilon_0\ \text{mg}}{2l}$

(18) **Answer [B]**

Initially, distance between two ball

$$x = \left[\frac{\left(\frac{q}{2}\right)^2 l}{2\pi\epsilon_0\ \text{mg}}\right]^{\frac{1}{3}} \quad ...(1)$$

When electric charge of ball reduced by halved from its initial electric charge, then new distance is

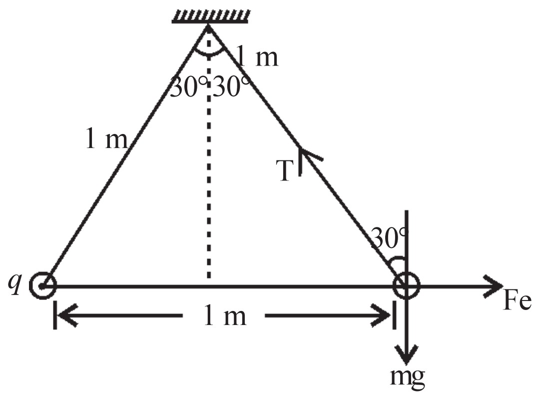
$$x' = \left[\frac{\left(\frac{q}{2}\right)^2 l}{2\pi\epsilon_0\ \text{mg}}\right]^{\frac{1}{3}} \quad ...(2)$$

from equation (1) and (2),

$$x' = \frac{x}{(2)^{\frac{1}{3}}} = \frac{8}{2^{\frac{1}{3}}} = 6.35 = 6.4\ \text{cm}$$

(19) **Answer [D]**

$q = 10\,\mu\text{C} = 10^{-5}\,\text{C}$ According to Lami's theorem,



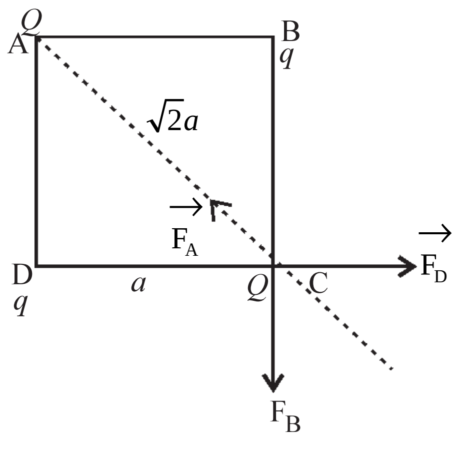
$$\frac{T}{\sin 90^\circ} = \frac{Fe}{\sin 150^\circ}$$

$$\therefore\ T = \frac{Kq^2}{r^2 \sin 30^\circ} = \frac{9 \times 10^9 \times 10^{-10}}{11^2 \times \frac{1}{2}}$$

$T = 18 \times 10^{-1} = 1.8\ \text{N}$

(20) **Answer [C]**

Suppose, the resultant electric force on Q electric charge near C is zero.

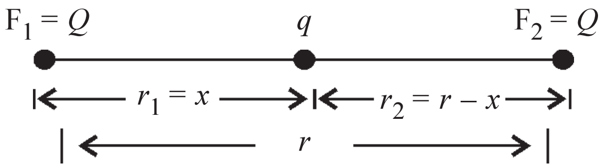


$$\therefore \overrightarrow{F_A} + \overrightarrow{F_B} + \overrightarrow{F_D} = 0 \Rightarrow \overrightarrow{F_B} + \overrightarrow{F_D} = -\overrightarrow{F_A}$$

$$\therefore \frac{\sqrt{2}\,kQq}{a^2} = \frac{kQ^2}{2a^2} \quad \therefore \frac{Q}{q} = -2\sqrt{2}$$

(21) Answer [B]

According to equilibrium condition for three electric charge,



$$\frac{q_1}{q_2} = \frac{r_1^2}{r_2^2} \;\therefore\; \frac{Q}{Q} = \frac{x^2}{(r-x)^2} \;\Rightarrow\; (r-x)^2 = x^2$$

$$\therefore 2x = r \quad \therefore x = \frac{r}{2}$$

Now, in equilibrium condition, repulsive force between electric charge Q and Q = Attractive force between = Q and q.

$$\therefore \frac{kQ^2}{r^2} = \frac{kQq}{\left(\frac{r}{2}\right)^2} \quad \therefore Q = 4q$$

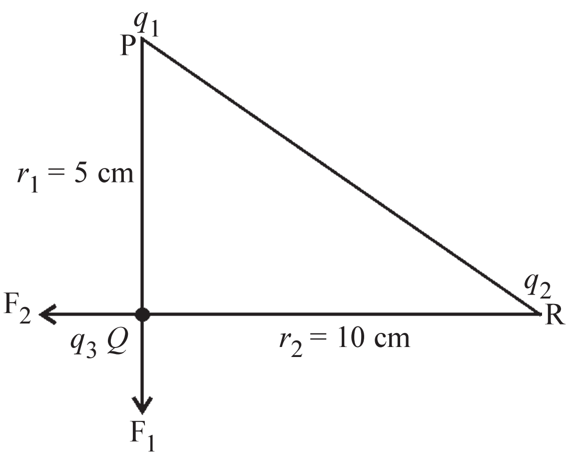
$\therefore q = -\frac{Q}{4}$ ($\because$ Should feel the force of attraction)

(22) Answer [D]

$q_2 = 20$ nC $= 2 \times 10^{-8}$ C

$q_1 = 10$ nC $= 10^{-8}$ C, $q_3 = 1\ \mu$C $= 10^{-6}$ C

$r_1 = 5 \times 10^{-2}$ m, $r_2 = 10^{-1}$ m



$$F_1 = \frac{kq_1q_3}{r_1^2} = \frac{9 \times 10^9 \times 1 \times 10^{-8} \times 10^{-6}}{25 \times 10^{-4}}$$

$F_1 = 0.36 \times 10^{-1} = 36 \times 10^{-3}$ N

$$F_2 = \frac{kq_2q_3}{r_2^2} = \frac{9 \times 10^9 \times 2 \times 10^{-8} \times 10^{-6}}{10^{-2}}$$

$= 18 \times 10^{-3}$ N, $\therefore$ resultant force

$$F = \sqrt{F_1^2 + F_2^2 + 2F_1F_2 \cos\frac{\pi}{2}}$$

$$F = \sqrt{(36)^2 + (18)^2} \times 10^{-3}$$

$$F = \sqrt{(18 \times 2)^2 + (18)^2} \times 10^{-3}$$

$F = \sqrt{4+1}\ 18 \times 10^{-3}$, $F = 18\sqrt{5}$ mN

Compare with $F = 18\sqrt{x}$ with mN, $x = 5$

(23) Answer [D]

$$\vec{r} = \vec{r_2} - \vec{r_1} = (2, 3, 1) - (1, 1, -1) = (1, 2, 2)$$

$$\therefore r = \sqrt{1+4+4} = \sqrt{9} = 3$$

$\therefore$ Force between two electric charge

$$F = \frac{kq^2}{r^2} = \frac{9 \times 10^9 \times \left(10^{-9}\right)^2}{9} = 10^{-9}\ \text{N}$$

(24) Answer [A]

Specific electric charge of stationary electron

$$\frac{q}{m_0} = 1.76 \times 10^{11}\ \text{Ckg}^{-1}$$

Now, electron travels with velocity $v = c/2$ then its charge doesn't changes.

But, mass $m = \frac{m_0}{\sqrt{1 - \frac{v^2}{C^2}}} = \frac{m_0}{\sqrt{1 - \frac{C^2}{4C^2}}} = \frac{m_0}{\sqrt{3/4}}$

$\therefore$ Specific electric charge of moving electroy is

$$\frac{q}{m} = \frac{q}{\frac{m_0}{\sqrt{\frac{3}{4}}}} = \frac{1.76 \times 10^{11}}{0.866}$$

$= 2.03 \times 10^{11}$ Cm^{-2} $= 2 \times 10^{11}$ Cm^{-2}

(25) Answer [D]

length of subtle line segment on circle = $ad\theta$

$\therefore$ electric charge on this line segment $dq = \lambda a d\theta$

$= \lambda_0 cos\theta a d\theta$, $\therefore$ total electric charge $Q = \oint dq$

$= a\lambda_0 \oint cos^2\theta\, d\theta = a\lambda_0\pi$

(26) Answer [B]

length of arc $dl = ad\theta$

$\therefore$ total electric charge on arc $dq = a\alpha\theta d\theta$

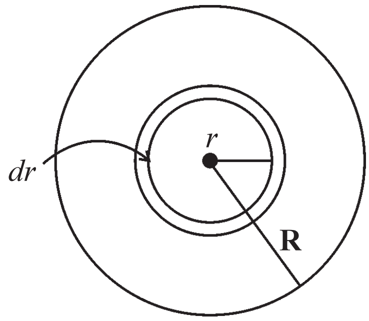
$\therefore$ total electric charge on semicircle

$$Q = \int_0^{\pi} a\alpha\theta d\theta$$

$$= a\alpha\int_0^{\pi}\theta d\theta = a\alpha\left[\frac{\theta^2}{2}\right]_0^{\pi} = \frac{a\alpha\pi^2}{2}$$

(27) Answer [C]

As depicted in figure, the electric charge on circular shield having radius r and thickness dr is $dq = 4\pi r^2 dr \times \rho(r) = 4\pi\beta r^2 dr$



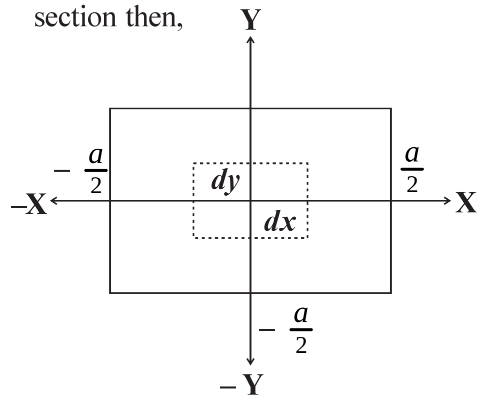
$\therefore$ total electric charge on whole shield $Q = \int_0^{R} dq$

$$\therefore Q = 4\pi\beta\int_0^{R} r^4 dr = 4\pi\beta\left[\frac{r^5}{5}\right]_0^{R}$$

$$\Rightarrow Q = \frac{4\pi R^5\beta}{5}$$

(28) Answer [D]

If dq is the electric charge on subtle $dxdy$ section then,



$dq = \sigma_0 dxdy = \sigma_0 xydxdy$

$\therefore$ total electric charge on whole section

$$Q = \int dq,\ \therefore\ Q = \sigma_0\int_{\frac{-a}{2}}^{\frac{a}{2}} xd_x \int_{\frac{-a}{2}}^{\frac{a}{2}} yd_y$$

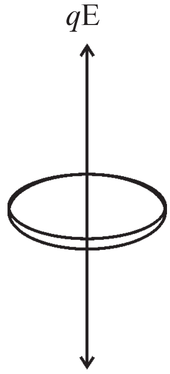
$$\therefore\ Q = \sigma_0\left[\frac{x^2}{2}\right]_{\frac{-a}{2}}^{\frac{a}{2}}\left[\frac{y^2}{2}\right]_{\frac{-a}{2}}^{\frac{a}{2}}$$

$$Q = \frac{\sigma_0}{2}\left[\frac{a^2}{2} - \frac{a^2}{2}\right]\left[\frac{a^2}{2} - \frac{a^2}{2}\right] = 0$$

(29) Answer [A]

Suppose, n electrons are removed.

In balance condition electric force = Weight force



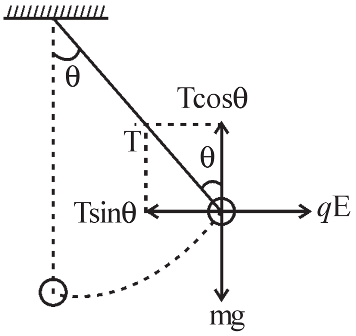
$\therefore\quad qE = mg$, $\therefore\ neE = mg$

$$\therefore\ n = \frac{mg}{eE},\ \therefore\ n = \frac{1.6\times10^{-3}\times9.8}{1.6\times10^{-19}\times10^{9}}$$

$n = 9.8 \times 10^7$

(30) **Answer [C]**

m = 80 mg = 8×10^{-5} kg



q = 20nC = 2×10^{-8} C

E = 2×10^4 NC^{-1}, in equilibrium condition

Tsinθ = qE and T(cos)θ = mg

$$\therefore \quad \frac{T\sin\theta}{T\cos\theta} = \frac{qE}{mg} = \frac{2 \times 10^{-8} \times 2 \times 10^{4}}{8 \times 10^{-5} \times 9.8}$$

$\therefore$ tanθ = 0.5102, $\therefore$ θ = 27°

Now, Tsinθ = qE $\Rightarrow$ T = $\dfrac{qE}{\sin\theta}$

$$= \frac{2 \times 10^{-8} \times 2 \times 10^{4}}{\sin 27^\circ} = 8.8 \times 10^{-4} \text{ N}$$

(31) **Answer [D]**

F = qE = $5 \times 10^{-6} \times 2 \times 10^5$ = 1N

particle moving in opposite direction of electric field, So, $a = \dfrac{-F}{m} = -\dfrac{1}{10^{-3}} = -10^3$ ms^{-2}

Now according to formula of constant accelerated motion

$v^2 - v_0^2 = 2ad$

$\therefore$ 0 – 400 = $-2 \times 10^3 \times d$, $\therefore$ d = 0.2 m

(32) **Answer [B]**

Electric force in upward direction for electrons in electric field between two plates F = eE = $\dfrac{eV}{d}$

$\therefore$ પ્રવેગ $a = \dfrac{F}{m} = \dfrac{eV}{md}$

$$= \frac{1.8 \times 10^{11} \times 2400}{0.02} = 2.16 \times 10^{16} \text{ ms}^{-2}$$

Now according to formula of constant accelerated motion

$d = v_0 t + \frac{1}{2}at^2$, $d = 0 + \frac{1}{2}at^2$

$$\therefore\ t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2 \times 0.0.2}{2.16 \times 10^{16}}}$$

$t = 1.4 \times 10^{-9}$ = 1.4 ns

(33) **Answer [B]**

In equilibrium condition,

$$QE = mg \Rightarrow Q\frac{V}{d} = \frac{4}{3}\pi r^3 \rho g \Rightarrow Q \propto \frac{r^3}{V}$$

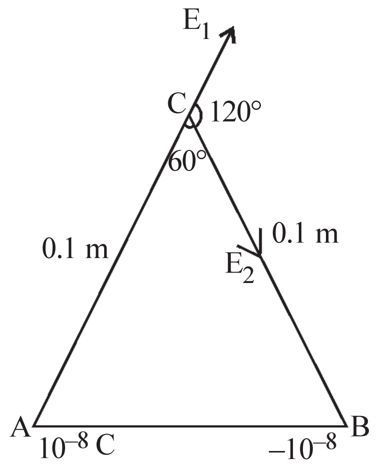
$$\therefore \quad \frac{Q'}{Q} = \left(\frac{r^1}{r}\right)^3 \times \frac{V}{V^1} = \left(\frac{r}{2r}\right)^3 \times \frac{2400}{600}$$

$Q' = 4 \times \frac{1}{8}Q$, $Q' = \dfrac{Q}{2}$

(34) **Answer [C]**

$E_1 = E_2 = E' \dfrac{kq}{r^2}$

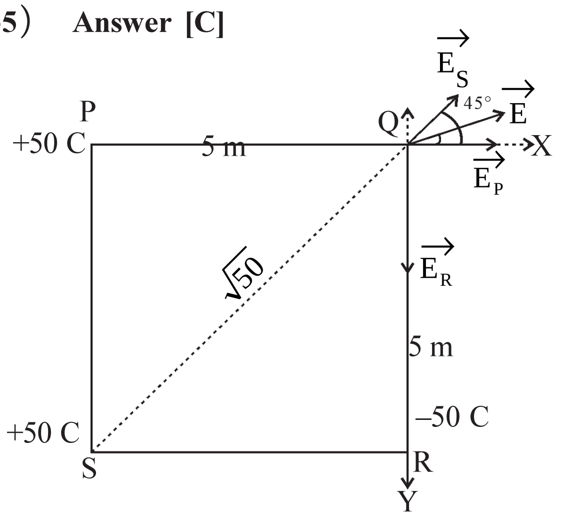
Resultant electric field E = $E_1 = E_2$ = E'



E = E' (∵ angle is 120°)

$$E = \frac{9 \times 10^{9} \times 10^{-8}}{10^{-2}}, \ E = 9 \times 10^3 \text{ NC}^{-1}$$

(35) Answer [C]



From figure $E_P = \dfrac{kq}{r^2} = \dfrac{k \times 50}{25} = 2\text{ K}$

$E_R = \dfrac{kq}{r^2} = 2K$, $E_D = \dfrac{kq}{r^2} = \dfrac{k \times 50}{50} = K$

x component of $E_P = 2K\hat{i}$, x component of $E_R = 0$

x component of $E_S = E_S \cos 45° = \dfrac{k}{\sqrt{2}}\hat{i}$

y component of $E_P = 0$, E_R, $y = 2k\hat{j}$

y component of $E_S = E_S \sin 45° = \dfrac{k}{\sqrt{2}}\hat{j}$

$\therefore$ Resultant eletric field $\vec{E} = \vec{E}_P + \vec{E}_S + \vec{E}_R$

$$\vec{E} = \left(2k + 0 + \frac{k}{\sqrt{2}}\right)\hat{i} + \left(-2k + \frac{k}{\sqrt{2}}\right)\hat{j}$$

$$\vec{E} = k\left(2 + \frac{1}{\sqrt{2}}\right)\hat{i} - k\left(2 - \frac{1}{\sqrt{2}}\right)\hat{j}$$

$$\therefore E = \sqrt{\left(2 + \frac{1}{\sqrt{2}}\right)^2 + \left(2 - \frac{1}{\sqrt{2}}\right)^2}\, k$$

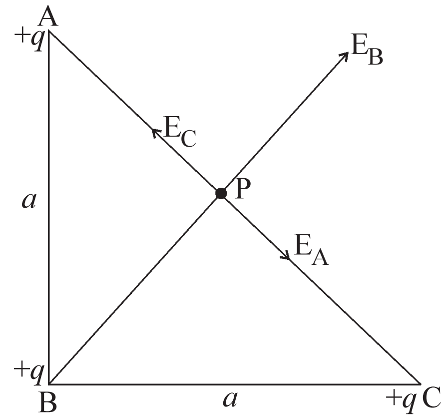
$$= \sqrt{9}\,k = 3k$$

$$\tan\theta = \frac{E y}{E x}$$

$$\tan\theta = \frac{\left(2 - \frac{1}{\sqrt{2}}\right)k}{\left(2 + \frac{1}{\sqrt{2}}\right)k} = 0.4776,\ \theta = 25.5°$$

(36) Answer [A]

E_A and E_C have same values and in opposite directions. So, they eliminate effect of one another.



$\therefore$ Resultant electric field at point P

$$E = E_B = \frac{kq}{(BP)^2}$$

Now, $BP = a \cos 45° = \dfrac{a}{\sqrt{2}}$, $\therefore\ E = 2\dfrac{kq}{a^2}$

(40) Answer [A]

Electric field at y distance on equinoctial line of electric dipole

$$\vec{E}(y) = \frac{-k\vec{P}}{\left(y^2 + a^2\right)^{\frac{3}{2}}}, \text{ At center point } y = 0$$

$$\therefore\ \vec{E}(y) = \frac{-k\vec{P}}{a^3}$$

(41) Answer [B]

$p_1 = p_2 = p = 6.2 \times 10^{-3}$ Cm

$$F = \frac{6kp_1p_2}{r^4} = \frac{6 \times 9 \times 10^9 \times (6.2)^2 \times 10^{-10}}{10^{-32}}$$

$= 2075.76 \times 10^{31}$

$= 2.08 \times 10^{34} = 2.1 \times 10^{34}$ N

(42) Answer [C]

Electric field on axis of dipole is $E = \dfrac{2kpZ}{\left(Z^2 - a^2\right)^2}$

in first case Z = 0.1 m

$$\therefore\ 0.025 = \frac{2kp \times 0.1}{\left[(0.1)^2 - a^2\right]^2} \qquad ...(1)$$

In second case Z = 0.2 m

$$\therefore\ 0.002 = \frac{2kp \times 0.2}{\left[(0.2)^2 - a^2\right]^2} \qquad ...(2)$$

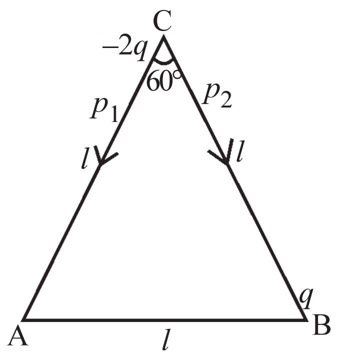
taking ratio, $\frac{0.025}{0.002} = \frac{0.1}{0.2}\,\frac{\left[(0.2)^2 - a^2\right]^2}{\left[(0.1)^2 - a^2\right]^2}$

$$\therefore\ \frac{25}{2} = \frac{1}{2}\,\frac{\left[(0.2)^2 - a^2\right]^2}{\left[(0.1)^2 - a^2\right]^2}$$

$$\therefore\ 5 = \frac{0.04 - a^2}{0.01 - a^2},\ \therefore\ a = 0.05 \text{ m}$$

$\therefore$ length of dipole = $2a$ = 0.1 m

(43) Answer [C]



Here $p_1 = p_2 = p' = ql$

$\therefore$ Resultant dipole moment

From $P = \sqrt{p_1^2 + p_2^2 + 2p_1p_2\cos\theta}$,

$P = \sqrt{3}\,p'$, $P = \sqrt{3}\,ql$

(44) Answer [D]

from $\tan\beta = \frac{1}{2}\tan\theta$,

$$\tan\left(\theta - \frac{\pi}{3}\right) = \frac{1}{2}\tan\frac{\pi}{3} = \sqrt{\frac{3}{2}}$$

$$\therefore\ \theta - \frac{\pi}{3} = \tan^{-1}\sqrt{\frac{3}{2}}$$

$$\therefore\ \theta = \frac{\pi}{3} + \tan^{-1}\frac{\sqrt{3}}{2}$$

(45) Answer [A]

$$\vec{\tau} = \vec{p} \times \vec{E} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 5 & 1 & -2 \\ 1 & 1 & 1 \end{vmatrix}$$

$$= \hat{i}\,(1 + 2) + \hat{j}\ (5 + 2) + \hat{k}\,(5 - 1)$$

$$= 3\hat{i} + 7\hat{j} + 4\hat{k}$$

$$\therefore\ |\vec{\tau}| = \sqrt{(3)^2 + (7)^2 + (4)^2} = 8.6 \text{ Nm}$$

(46) Answer [B]

From $\tau = pE\sin\theta$,

$\tau = q2aE\sin\theta$, $2a$ = 4 cm = 4×10^{-2} m

$$\therefore\ q = \frac{\tau}{2aE\sin\theta} = \frac{8\sqrt{3}}{4 \times 10^{-2} \times 4 \times 10^{5} \times \sin 60^\circ}$$

$= 10^{-3}$ C = 1 mC

(47) Answer [B]

$$E = \frac{kp}{r^3}\sqrt{3\cos^2\theta + 1}$$

$$= \frac{9 \times 10^9 \times 2 \times 10^{-8}}{(1)^3}\sqrt{3\cos^2 60 + 1}$$

$$= 180\sqrt{3 \times \frac{1}{4} + 1} = 180\sqrt{\frac{7}{4}} = 238.1 \text{ NC}^{-1}$$

(48) Answer [A]

$W = PE\ (\cos\theta_1 - \cos\theta_2)$

$W = PE\ (\cos 0 - \cos 180^\circ)$

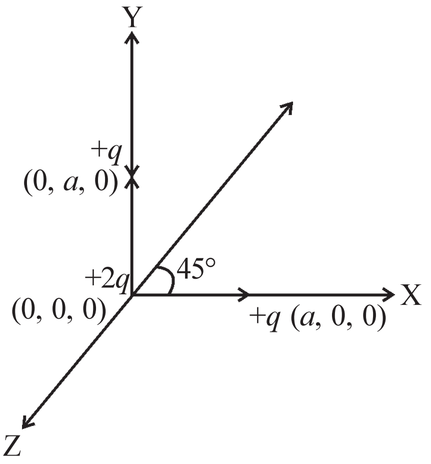
$= 2PE = 2(q2a)E$

$= 2 \times 10^{-6} \times 2 \times 10^{-2} \times 10^{5} = 4 \times 10^{-3}$ J

(49) Answer [B]

From figure resultant electrical dipole moment

$p_{net} = \sqrt{2}\,p = \sqrt{2}\,qa$



Its direction is in line liking the points (0, 0, 0) and $(a, a, 0)$

(50) Answer [A]

Electric field on axis of dipole

$p = q2a = 10^{-5} \times 5 \times 10^{-3} = 5 \times 10^{-8}$ Cm

$$E_Z = \frac{2kp}{Z^3} \quad \because 2 >> a$$

$$= \frac{2 \times 9 \times 10^9 \times 5 \times 10^{-8}}{(0.15)^3}$$

$E_Z = 2.66 \times 10^5$ N|C

Electric field on equinoctial line

$$E(y) = \frac{E(z)}{2} = 1.33 \times 10^5 \text{ NC}^{-1}$$

(51) Answer [B]

$$\sigma = \frac{q}{4\pi r^2} \text{ In first case, } 0.7 = \frac{q}{4\pi r^2} \quad ...(1)$$

$$\text{In second case, } 0.7 + 0.14 = \frac{q + 0.44}{4\pi r^2}$$

$$0.84 = \frac{q + 0.44}{4\pi r^2} \quad ...(2)$$

taking ratio of equation (2) and (1)

$$\frac{0.84}{0.7} = \frac{q + 0.44}{q} \Rightarrow \frac{6}{5} = 1 + \frac{0.44}{q}$$

$\therefore q = 2.2$ C

from equation (1), $r = \sqrt{\dfrac{q}{4\pi \times 0.7}} = 0.5$ m

(52) Answer [C]

If big drop's radius is R then,

Volume of big drop = 64 × Volume of small drop.

$\frac{4}{3}\pi R^3 = 64 \times \frac{4}{3}\pi R^3$, $\therefore R^3 = 64 \times r^3$

$R = 4r = 4 \times 0.02$, $R = 0.08$ m

Electric charge on small drop

$q = 5\ \mu C = 5 \times 10^{-6}$ C

$\therefore$ Electric charge on large drop

$Q = 64\,q = 64 \times 5 \times 10^{-6}$ C

Now, surface density of small drop

$$\sigma_1 = \frac{q}{4\pi r^2} = \frac{5 \times 10^{-6}}{4\pi \times (0.02)^2} \text{ Cm}^{-2}$$

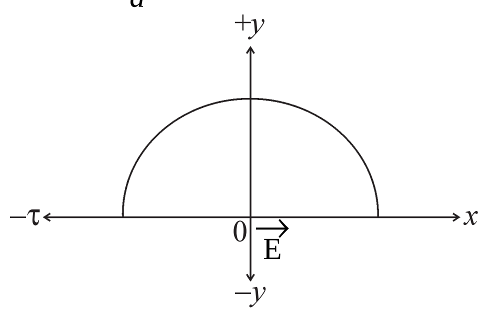
Surface density of big drop

$$\sigma_1 = \frac{Q}{4\pi R^2} = \frac{5 \times 64 \times 10^{-6}}{4\pi \times (0.08)^2} \text{ Cm}^{-2}$$

$$\therefore \frac{\sigma_1}{\sigma_2} = \frac{5 \times 10^{-6}}{4\pi \times (0.02)^2} = \frac{4\pi \times (0.08)^2}{5 \times 64 \times 10^{-6}} = \frac{1}{4} = 1:4$$

(53) Answer [A]

$$\vec{E} = \frac{K\lambda}{a}[-\sin\theta\,\hat{i} + (\cos\theta - 1)\,\hat{j}] = 180°$$



$$\vec{E} = \frac{k\lambda}{a}[-\sin 180\,\hat{i} + (\cos 180 - 1)\,\hat{j}]$$

$$\vec{E} = -\frac{k\lambda}{a}[0\,\hat{i} - 2\,\hat{j}],$$

$$\therefore \vec{E} = -\frac{2k\lambda}{a}$$

$$\therefore |\vec{E}| = \frac{2\lambda}{4\pi \in_0 a} = \frac{\lambda}{2\pi \in_0 a}$$

(54) Answer [D]

$dq = \rho(r)V = \rho(r)\, 4\pi r^2 dr$

$(\because\ V = A dr = 4\pi r^2 dr)$

$\therefore\ q(r) = \int_0^r dq$

$\therefore\ q(r) = 4\pi\rho_0 \int_0^r \frac{5}{4}r^2 - \frac{r}{R}r^2\ dr$

$= 4\pi\rho_0 \left[\frac{5}{4}\frac{r^3}{3} - \frac{r^4}{4R}\right]_0^r$

$= 4\pi\rho_0 \left[\frac{5r^3}{12} - \frac{r^4}{4R}\right] = \pi\rho_0 \left[\frac{5r^3}{12} - \frac{r^4}{R}\right]$

$= \pi\rho_0 r^3 \left[\frac{5}{4} - \frac{r}{R}\right]$ $\therefore$ Electric field $E_r = \frac{Kq(r)}{r^2}$

$= \frac{1}{4\pi\epsilon_0} \frac{\pi\rho_0 r^3\left[\frac{5}{3} - \frac{r}{R}\right]}{r^2}$

$= \frac{\rho_0 r}{4\epsilon_0}\left[\frac{5}{3} - \frac{r}{R}\right]$

(55) Answer [B]

length of small arc $= r d\theta$

$\therefore$ Electric charge on small arc $= r d\theta\, q_0 \cos\theta$

$\therefore$ Electric field near center

$dE = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_0 r\cos\theta d\theta}{r^2}$

X component of Electric field

$dE_x = -\frac{1}{4\pi\epsilon_0}\frac{q_0\cos\theta d\theta}{r}\cos\theta$

$= -\frac{1}{4\pi\epsilon_0}\frac{q_0\cos^2\theta d\theta}{r}$

Y component $dE_y = -\frac{1}{4\pi\epsilon_0}\frac{q_0\cos\theta\sin\theta d\theta}{r}$

$\therefore\ E_x = \frac{1}{4\pi\epsilon_0}\frac{q_0}{r}\int_0^{2\pi}\cos^2\theta d\theta = \frac{q_0}{4\epsilon_0 r}$

$E_y = -\frac{1}{4\pi\epsilon_0}\frac{q_0}{r}\int_0^{2\pi}\sin\theta\cos\theta d\theta = 0$

$\therefore\ E = \sqrt{E_x^2 + E_y^2} = \frac{q_0}{4\epsilon_0 r}$

(56) Answer [A]

$\vec{E} = \frac{K\lambda}{r}\left[-\sin\theta\,\hat{i} + (\cos\theta - 1)\,\hat{j}\right]$

$\theta = 180^\circ,\ \therefore\ \vec{E} = -\frac{2K\lambda}{r}\hat{j}$

$\therefore\ |\vec{E}| = \frac{2Kq}{r\pi r}\left(\because \lambda = \frac{q}{l} = \frac{q}{\pi r}\right)$

$= \frac{2Kq}{\pi r^2} = \frac{2\times 9\times 10^9\times 0.7\times 10^{-9}}{3.14\times 4\times 10^{-2}}$

$|\vec{E}| = 10\ NC^{-1}$

(57) Answer [B]

Electric field on ring axis

from $E = \frac{1}{4\pi\epsilon_0}\frac{Qx}{(a^2 + x^2)^{\frac{3}{2}}}$, $E = \frac{Qx}{4\pi\epsilon_0 a^3}$

force on electron in center.

$F = -eE = -\frac{Qx}{4\pi\epsilon_0 a^3}e$

$\therefore\ m\frac{d^2x}{dt^2} = -\frac{1}{4\pi\epsilon_0}\frac{Qex}{a^3}$

$\therefore\ \frac{d^2x}{dt^2} = -\frac{1}{4\pi\epsilon_0}\frac{Qex}{ma^3}$

Compare with $\frac{d^2y}{dt^2} = -\omega^2 y$

$\omega^2 = \frac{1}{4\pi\epsilon_0}\frac{Qex}{ma^3}$ $\therefore\ \omega = \sqrt{\frac{Qe}{4\pi\epsilon_0 ma^3}}$

$\therefore\ f = \frac{1}{2\pi}\sqrt{\frac{eQ}{4\pi\epsilon_0 ma^3}}$

(58) Answer [A]

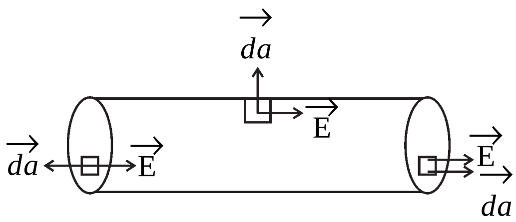
Making semi-spherical ring from wire of length l.

$l = \pi r \Rightarrow r = \frac{l}{\pi}$, and $\lambda = \frac{Q}{l}$

Now, Electric field on center $E = \frac{2K\lambda}{r}$

$$\therefore\ E = \frac{2Q}{4\pi \in_0 \left(\frac{l}{\pi}\right)\cdot l}\ ,\ E = \frac{Q}{2 \in_0 l^2}$$

(59) Answer [D]



total flux associated with whole cylindrical

$$\phi = \underset{\substack{\text{Surface}\\ \text{of leftside}}}{\int \vec{E}\cdot\vec{da}} + \underset{\substack{\text{Surface}\\ \text{of right side}}}{\int \vec{\varepsilon}\cdot\vec{da}} + \underset{\substack{\text{Circular}\\ \text{surface}}}{\int \vec{E}\cdot\vec{da}}$$

$$\therefore \phi = \int E da\cos 180° + \int \varepsilon da \cos 10 + \int E da \cos 90°$$

$$\phi = -E\int da + E\int da + 0$$

$$\phi = -E\pi r^2 + E\pi r^2 = 0$$

(60) Answer [A]

$$\vec{E} = \left(\frac{3}{5}\hat{i} + \frac{4}{5}\hat{j}\right) \times 2 \times 10^3\ NC^{-1}$$

$$\vec{A} = 0.2\ m^2\ \hat{i}$$

$$\therefore \phi = \vec{E}\cdot\vec{A} = \frac{3}{5} \times 2 \times 10^3 \times 10.2$$
$$= 240\ Nm^2C^{-1}$$

(61) Answer [D]

For maximum flux, the maximum length of wire enclosed in cube which is on diagonal axis of cube.

$\therefore$ maximum length $= \sqrt{3}a$

$\therefore$ maximum enclosed electric charge $\varepsilon q = \sqrt{3}a\,\lambda$

$$\therefore \phi_0 = \frac{\sqrt{3}a\lambda}{\in_0}$$

(62) Answer [A]

$$\phi = \frac{\Sigma q}{\in_0}$$

$$\therefore (-5 \times 10^5 + 4 \times 10^5) \times 8.85 \times 10^{-12} = \Sigma q$$

$$\therefore \Sigma q = -8.85 \times 10^{-7}\ C$$

(63) Answer [C]

Electric field associated with surface distanced by 0.1 m from starting point is

$$E_1 = 600\, x^{\frac{1}{2}} = 189.73\ NC^{-1}$$

Electric field associated with surface distanced by 0.2 m from starting point is

$$E_2 = 600\sqrt{0.2} = 268.32\ NC^{-1}$$

Now, According to gauss's theorem,

$$\int \vec{E}\cdot\vec{da} = \frac{\Sigma q}{\in_0}\ \text{from}\ \Sigma q = (E_2 - E_1)A\in_0$$

$$\therefore Q = 78.59 \times 0.1 \times 0.1 \times 8.85 \times 10^{-12}$$
$$= 6.95 \times 10^{-12}\ C,\ Q = 7\ \mu\mu C$$

(64) Answer [A]

(i) According to Gauss's theorem, flux associated with sphere A, $\phi_1 = \dfrac{Q}{\in_0}$

flux associated with sphere B $\phi_2 = \dfrac{Q}{\in_0}$

$\therefore \phi_1 : \phi_2 = 1:3$

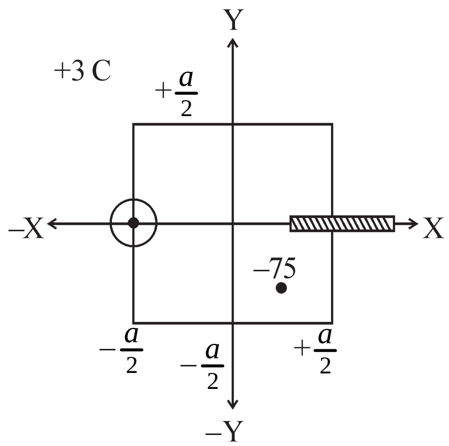
(ii) Electric field in medium of dielectric constant K $E_m = \dfrac{Ea}{K}$

$$\therefore \text{flux}\ \phi = \oint \vec{E}_m\cdot\vec{da} = \oint \frac{\vec{E}_a}{K}\cdot\vec{da}$$

$$= \frac{1}{K}\oint \vec{E}_a\,\vec{da} = \frac{Q}{5\in_0}$$

(65) Answer [A]

Half part of disc is enclosed in cube so, electric charge in cube $q_1 = 3C$.



$\frac{1}{4}$ part of rod enclosed in cube So, Electric charge $q_2 = 2$ C

Electric charge 7C is inside the cube so $q_3 = 7$ C

$\therefore$ total electric charge enclosed in cube

$\Sigma q = 3 + 2 - 7 = -2$ C

$\therefore$ flux associated with cube

$$\phi = \frac{\Sigma q}{\epsilon_0} = \frac{-2\,\text{C}}{\epsilon_0}$$

(66) Answer [D]

For enclosing the charge situated at corner of a cube seven more cubes are require.

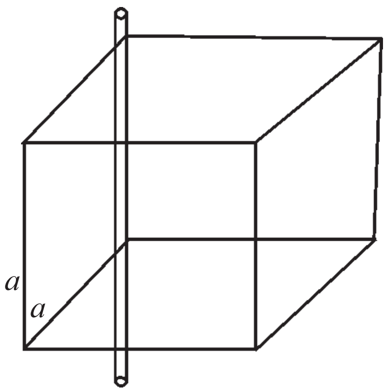
$\therefore$ flux associated with 8 cube $\phi = \frac{8q}{\epsilon_0}$

$\therefore$ flux associated with 1 cube $\phi = \frac{8q}{\epsilon_0} \times \frac{1}{8}$

$$\phi = \frac{q}{\epsilon_0}$$

(67) Answer [C]

Linear electric charge density of a given wire is λ. $\Sigma q = \lambda a$ is an electric charge of wire with having length to cube of a.



this electric charge enclosed by other three cube.

Now, flux associated with 4 cube $= \frac{\lambda q}{\epsilon_0}$

$\therefore$ flux associated with 1 cube $= \frac{\lambda q}{4\epsilon_0}$

(68) Answer [A]

Electric field generated by first wire at second wire.

$$E = \frac{2K\lambda_1}{r}$$

Due to this field, the force per unit length of second wire is F = (electric charge per unit length) $\times$ E ($\because$ F = qE)

$\therefore$ F = λ_2E,

$$F = \frac{2K\lambda_1\lambda_2}{r} = \frac{2 \times 9 \times 10^9 \times 2 \times 10^{-4} \times 4 \times 10^{-4}}{0.2}$$

F = 72×10^2 N

(69) Answer [B]

Elecrtic force F = eE = $\frac{e\lambda}{2\pi\epsilon_0 r}$ on an electron through electric field of a wire is F = $\frac{\lambda}{2\pi\epsilon_0 r}$, Which gives centripetal force to an electron for circular motion.

$\therefore$ Centripetal force = electric force $\Rightarrow \frac{mv^2}{r} = \frac{e\lambda}{2\pi\epsilon_0 r}$

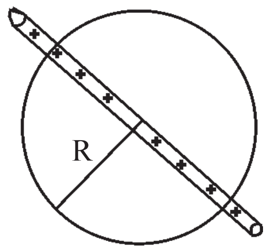
$$\therefore v^2 = \frac{e\lambda}{2\pi\epsilon_0 m}$$

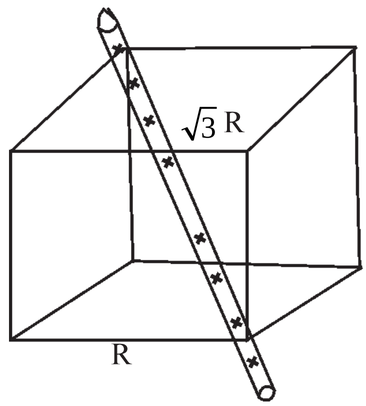
Now, kinetic energy K = $\frac{1}{2}mv^2 = \frac{e\lambda}{2\pi\epsilon_0}$

(70) Answer [C]

The following figure shows the alignment of wire gives maximum flux :

flux associated with sheilding,





$$\phi_1 = \frac{q}{\epsilon_0} = \frac{\lambda L_1}{\epsilon_0} = \frac{2R\lambda}{\epsilon_0} \quad ...(1)$$

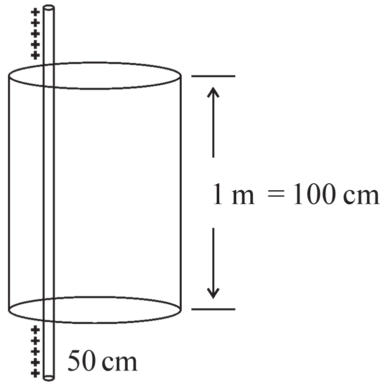
flux associated with cube

$$\phi_2 = \frac{\lambda L_2}{\epsilon_0} = \frac{\sqrt{3}R\lambda}{\epsilon_0} \quad ...(2)$$

$$\therefore \frac{\phi_1}{\phi_2} = \frac{2}{\sqrt{3}}$$

(71) Answer [B]

length of cylinder $= 1m = 100$ cm



Now, electric charge on wire having length 1 cm $= Q$C

$\therefore$ electric charge on wire having length of 100 cm $= 100Q$C

$\therefore$ Electric charge associated with cylindrical $\Sigma q = 100\,Q$

$$\therefore \text{According to Gauss's law } \phi = \frac{\Sigma q}{\epsilon_0}$$

$$\phi = \frac{100Q}{\epsilon_0}$$

(72) Answer [C]

linear electric charge density $\lambda = \frac{1}{3}\ \text{Cm}^{-1}$

$$\text{According to Gauss's theorem } \int \vec{E} \cdot \vec{da} = \frac{\Sigma q}{\epsilon_0}$$

$$\therefore E \cdot 2\pi r l = \frac{\Sigma q}{\epsilon_0}, \therefore E = \frac{\Sigma q}{2\pi\epsilon_0 rl}$$

$$E = \frac{2\lambda}{2\pi\epsilon_0 r} \quad \left(\because \frac{\Sigma q}{l} = \lambda\right)$$

$$E = \frac{2K\lambda}{r} = \frac{2 \times \overset{3}{\cancel{9}} \times \overset{9}{10} \times 1}{18 \times 10^{-2} \times \cancel{3}} = \frac{1}{3} \times 10^{11}$$

$= 0.33 \times 10^{11}\ \text{NC}^{-1}$

(73) Answer [B]

Electric field between two conducting plate $E = \frac{2\sigma}{\epsilon_0}$

$$\therefore \text{Electric force on electron } F = eE = \frac{2e\sigma}{\epsilon_0}$$

$$\therefore \text{acceleration of electron } a = \frac{F}{m} = \frac{2e\sigma}{\epsilon_0}$$

Acconding to formula of constant accelerated motion

$d = v_0 t + \frac{1}{2} at^2$

But, $v_0 = 0$

$$\therefore d = \frac{1}{2}\left(\frac{2e\sigma}{m\epsilon_0}\right)t^2 \quad d = 2\text{ cm} = 2 \times 10^{-2}\text{ m}$$

$t = 2\ \mu\text{s} = 2 \times 10^{-6}$ s

$$\therefore \sigma = \frac{md\epsilon_0}{et^2}$$

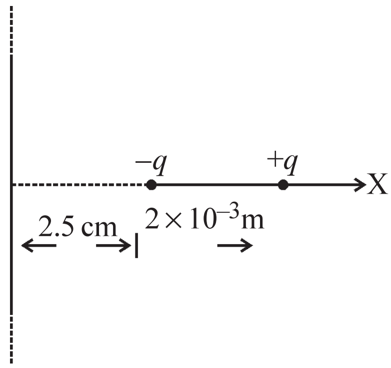
$$= \frac{2 \times 10^{-31} \times 2 \times 10^{-2} \times 8.85 \times 10^{-12}}{1.6 \times 10^{-19} \times 4 \times 10^{-12}}$$

$\sigma = 2.52 \times 10^{-13}\ \text{Cm}^{-2}$

(74) Answer [A]

Force on $-q$ electric charge

$$\vec{F}_- = -q\vec{E} = \frac{-2kq\lambda}{r_-}$$



$$\text{Force on } +q \text{ electric charge } \vec{F}_+ = \frac{2kq\lambda}{r_+}$$

$$\therefore \text{Resultant force } \vec{F} = \vec{F}_+ + \vec{F}_-$$

$r_- = 2.5 \times 10^{-2}\text{ m} = 25 \times 10^{-3}$ m

$r_+ = 27 \times 10^{-3}$ m, $q = 5 \times 10^{-9}$ C

$\lambda = 4.5 \times 10^{-4}\ \text{Cm}^{-1}$

$$\vec{F} = 2Kq\lambda\left[\frac{1}{r_+} - \frac{1}{r_-}\right]\hat{i}$$

$$\vec{F} = 2Kq\lambda\left[\frac{r_- - r_+}{r_+ \cdot r_-}\right]\hat{i}$$

$$\vec{F} = 2 \times 9 \times 10^9 \times 5 \times 10^{-9} \times 4.5 \times 10^{-4} \left[\frac{(25-27)\times 10^{-3}}{25 \times 27 \times 10^{-6}}\right]$$

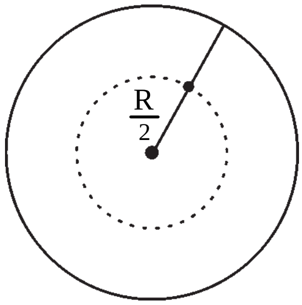
$$\vec{F} = 18 \times 5 \times 4.5 \times 10^{-9}\left[\frac{-2}{675}\right]\hat{i}$$

$$\vec{F} = 0.12\,\hat{i}\text{ N} \therefore F = 0.12\text{ N}$$

(75) Answer [D]

$Q = ne = Ze = 79 \times 1.6 \times 10^{-19}$ C, $R = 7 \times 10^{-15}$ m

Consider Gaussian surface having radius R_2 to calculate electric field at center point of nuclear radius.



Electric charge associated by this surface $q = \rho V'$

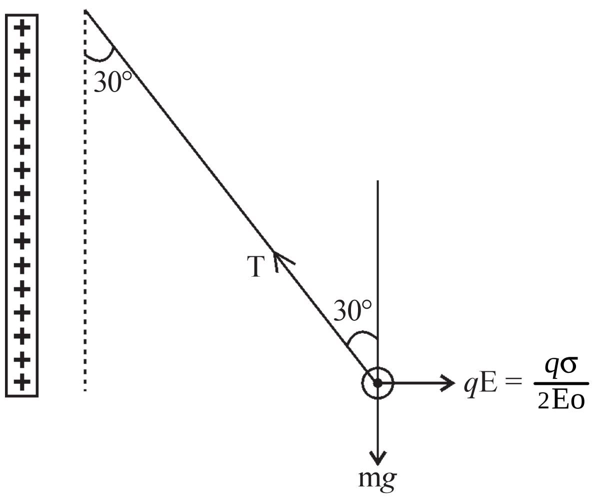
$$q = \rho \frac{4}{3}\pi\left(\frac{R}{2}\right)^3, \therefore q = \frac{Q}{8}$$

∴ Electric field at center point,

$$E' = \frac{Kq}{\left(\frac{R}{2}\right)^2} = \frac{KQ}{8\frac{R^2}{4}} = \frac{E}{2}$$

(76) Answer [A]

$m = 1\,mg = 10^{-6}$ kg, $q = 2 \times 10^{-8}$ C



According to Lami's theorem,

$$\frac{mg}{\sin 120°} = \frac{q\sigma}{2\epsilon_0 \sin 150°}$$

$$\therefore \frac{mg}{\sin 60°} = \frac{q\sigma}{2\epsilon_0 \sin 30°}$$

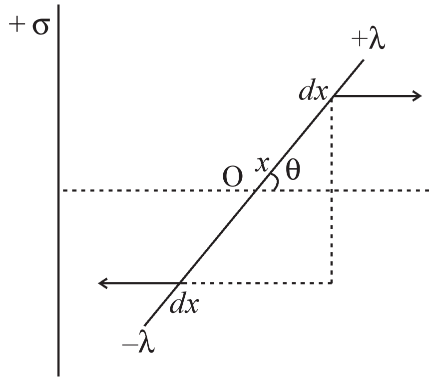
$$\therefore \frac{2mg}{\sqrt{3}} = \frac{q\sigma}{\epsilon_0}, \therefore \sigma = \frac{2mg\epsilon_0}{\sqrt{3}q}$$

$$= \frac{2 \times 10^{-6} \times 9.8 \times 8.85 \times 10^{-12}}{1.73 \times 2 \times 10^{-8}}$$

$$= 2.506 \times 10^{-9}\text{ Cm}^{-2}$$

(77) Answer [C]

Consider two pair of subtle section having length dx Which is at distance from 0 to x. Electric charge of dx section $dq = \lambda dx$.



∴ From force $dF = qE$, $dF = \lambda dx E$

$$= \lambda dx\left(\frac{\sigma}{2\epsilon_0}\right)$$

perpendicular distance between two forces $= 2x\sin\theta$

$$\therefore \text{torque } d\tau = \lambda dx\left(\frac{\sigma}{2\epsilon_0}\right) 2x\sin\theta$$

$$\therefore \text{total torque } \tau = \int_0^l d\tau = \int_0^l \frac{\sigma\lambda\sin\theta}{\epsilon_0}x\,dx$$

$$\tau = \frac{\sigma\lambda\sin\theta}{2\epsilon_0}\cdot l^2$$

(78) Answer [D]

Electric field $E = \frac{\sigma}{2\epsilon_0}$ and time $t = \frac{l}{u}$

In direction of Y-axis (downward direction), intial velocity $v_0 = 0$.

$$a = \frac{F}{m} = \frac{eE}{m} = \frac{e\sigma}{2\epsilon_0 m}$$

∴ According to formula of constant

accelerated motion $d = \frac{1}{2}at^2$

$$d = \frac{1}{2}\left(\frac{e\sigma}{2\epsilon_0 m}\right)\cdot\frac{l^2}{u^2},\ \therefore \sigma = \frac{4d\epsilon_0 mu^2}{el^2}$$

(79) Answer [B]

turning the frame in circular its radius is

$$r = \frac{2(25+15)}{2\pi} = \frac{40}{\pi}\ \text{cm} = \frac{40}{\pi}\times 10^{-2}\ \text{m}^2$$

$\therefore$ flux $\phi = \text{EA}\cos 0 = \text{E}\pi r^2$

$$= \text{E}\pi\frac{(40)^2}{\pi^2}\times 10^{-4} = \frac{1600\times 2\times 10^4\times 10^{-4}}{3.14}$$

$= 1019.1\ \text{Nm}^2\text{C}^{-1}$

(80) Answer [B]

$$q\text{E} = \text{m}g \ \Rightarrow \frac{q\sigma}{\epsilon_0} = \text{m}g$$

$$\therefore q = \frac{\text{m}g\,\epsilon_0}{\sigma}$$

$$= \frac{9\times 10^{-8}\times 9.8\times 8.854\times 10^{-12}}{5\times 10^{-5}}$$

$= 1.56\times 10^{-13}\ \text{C}$

(81) Answer [A]

Here direction of electric field is downward direction.

If electric charge of particle is q then force is $\text{F} = q\text{E}$

$\therefore$ accelaration $a = \frac{q\text{E}}{\text{m}}$

If time required by particle to cross the plate is t then,

$$d = \frac{1}{2}at^2\ (\because v_0 = 0),\ \therefore\ d = \frac{q\text{E}t^2}{2\text{m}}$$

$$\therefore \frac{q}{\text{m}} \propto d$$

$\Rightarrow$ Because of large $\frac{q}{\text{m}}$ for particle B, its deviation is more.

(84) Answer [B]

mass of electron and moton is different. Thus, their acceleration is different as equation $a = \frac{\text{F}}{m}$. Electric force is not depends on mass as per equation $\text{F} = q\text{E}$.

(85) Answer [A]

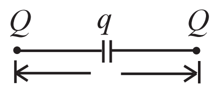
total flux associated with surface.

$\phi = 8k\text{V}m - 3k\text{V}m = 5k\text{V}m = 5\times 10^3\ \text{V}m$

$\therefore Q = \phi\varepsilon_0 = 5\times 10^3\times 8.85\times 10^{-12}$

$44.2\times 10^{-9} = 0.044\times 10^{-16} = 0.044\ \mu\text{C}$

(88) Answer [B]

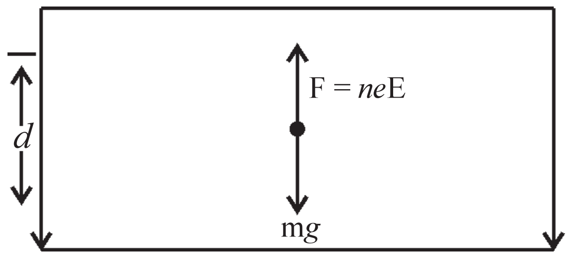


$$\frac{\text{K}Q^2}{r^2} = \frac{4\text{K}Qq}{r^2}$$

$\therefore Q = 4\text{q},\ \therefore \text{q} = \frac{Q}{4}$

(91) Answer [B]

Suppose, n is the number of additional electrons on drops. $\Rightarrow q = ne$



In equilibrium condition $q\text{E} = \text{m}g \Rightarrow ne\text{E} = \text{m}g$

$$\therefore n = \frac{\text{m}g}{e\text{E}} = \frac{4.9\times 10^{-15}\times 9.8}{1.6\times 10^{-19}\times 10^5}\quad n = 3$$

(92) Answer [C]

total flux by reversing the electric field. $\text{F} = ne\text{E} + \text{m}g$

But $ne\text{E} = \text{m}g$, $\therefore \text{F} = 2\text{m}g$

$$\therefore a = \frac{2\text{m}g}{\text{m}} = 2g = 19.6\ \text{ms}^{-1}$$

(93) Answer [D]

According to stoke's theorem, $6\pi\eta r V_t = 2mg$

$$V_t = \frac{mg}{3\pi\eta r}$$

$$= \frac{4.9\times10^{-15}\times9.8}{3\times3.14\times1.8\times10^{-5}\times5\times10^{-6}}$$

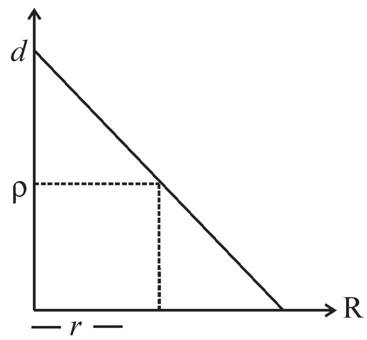
$= 5.7\times10^{-5}\ ms^{-1}$

(94) Answer [A]

Electric field at $r = R$ is $E = \frac{KQ}{R^2} = \frac{K(Ze)}{R^2}$

So, E is independent of a.

(95) Answer [B]



$$\frac{d}{R} = \frac{\rho}{R-r} \ \therefore\ \rho = \frac{d}{R}(R-r)$$

$$\text{Now, } Q = \int_0^R \rho\cdot4\pi r^2 dr = \int_0^R \frac{d}{R}(R-r)\times4\pi r^2 dr$$

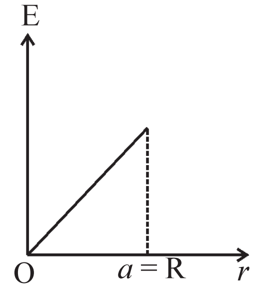
$$= \frac{4\pi d}{R}\left[R\int_0^R r^2 dr - \int_0^R r^3 dr\right]$$

$$= \frac{4\pi d}{R}\left[\frac{R^3}{3}-\frac{R^4}{4}\right]\ Ze = \frac{4\pi d}{R}\times\frac{R^4}{R}$$

$$\therefore d = \frac{3Ze}{\pi R^3}$$

(96) Answer [C]

The electric field generated by a regular distribution of electric charge on a solid



sphere is $E = \frac{r}{3\epsilon_0}$

$\therefore \in \propto r$. density ρ is constant on volume of nucleus. For this if $a = R$ then it is possible.

(97) Answer [B]

τ = force × perpendicular distance = $qE\times l\sin\theta$

$\tau = qEl\sin\theta$

(98) Answer [B]

Restorative torque $\tau = -qEl\theta$

($\because$ θ is small So, $\sin\theta\approx\theta$)

$I\alpha = -qEl\theta$ ...(1)

But moment of inertia

$$I = mr^2 + mr^2 = m\left(\frac{l}{2}\right)^2 + m\left(\frac{l}{2}\right)^2$$

$$= \frac{2ml^2}{4} = \frac{ml^2}{2} \text{ Now, } \tau = I\alpha$$

$$\therefore\ \tau = \frac{ml^2\alpha}{2} \text{ From result (1) } I\alpha = -qEl\theta$$

$$\therefore\ \alpha = \frac{-qEl\theta}{I},\ \therefore\ \alpha = \frac{-2qEl\theta}{ml^2}$$

$$\alpha = -\omega^2\theta \text{ Compare with } \omega^2 = \frac{2qE}{ml}$$

$$\omega = \left(\frac{2qE}{ml}\right)^{\frac{1}{2}}$$

(99) Answer [A]

Time required by making free rod and arrange it parallel to electric field is $t_{min} = \frac{T}{4} = \frac{2\pi}{4\omega}$

$$t_{min} = \frac{\pi}{2}\times\left(\frac{ml}{2qE}\right)^{\frac{1}{2}}$$

●

(105) Answer [B]

$W = q\,\Delta V$, $\therefore$ $W = q\,[V - (-10)]$

$\therefore$ $100 = 4\,[V + 10]$, $V = 25 - 10 = 15$ V

(106) Answer [C]

$r = 14$ cm $= 14 \times 10^{-2}$m

$\sigma = 1\ \mu Cm^{-2} = 10^{-6}\ Cm^{-2}$

Now, Electric potential

$$V = \frac{1}{4\pi\epsilon_0}\ \frac{q}{r} = \frac{1}{4\pi\epsilon_0}\ \frac{4\pi r^2\sigma}{r} = \frac{\sigma r}{\epsilon_0}$$

$$V = \frac{10^{-6} \times 14 \times 10^{-2}}{8.85 \times 10^{-12}},\ V = 15819.2 = 15820\ V$$

(107) Answer [A]

total electric charge $Q = 200\ \mu C = 2 \times 10^{-4}$ C

$r = 10$ cm $= 0.1$ m

Consider full circle in dr sections. Electric potential of center by the underlaying dq electric charge is

$dV = \frac{kdq}{r}$ $\therefore$ total electric potential

$$V = \int dV = \frac{k}{r}\int dq,\ V = \frac{kQ}{r}$$

$$V = \frac{9 \times 10^9 \times 2 \times 10^{-4}}{0.1},\ V = 18 \times 10^6\ V$$

(108) Answer [D]

For middle point $q_1 > q_2$ So,

$$d = \frac{r}{\frac{q_2}{q_1} + 1} = \frac{0.15}{\frac{2}{3} + 1} = \frac{0.15}{1.66} = 0.09\ m = 9\ cm$$

For point which is outside

$$d = \frac{r}{\frac{q_2}{q_1} - 1} = \frac{0.15}{-0.33} = 0.45\ m = 45\ cm$$

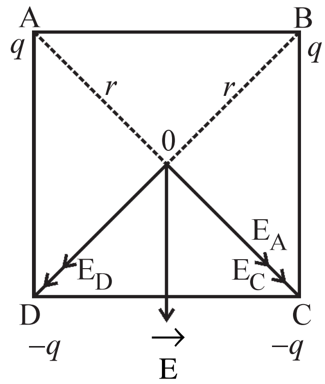
(109) Answer [A]

$W\ (V_Q - V_P)q$ $\therefore$ $W = (V_Q - V_P)\ (-N_e)$

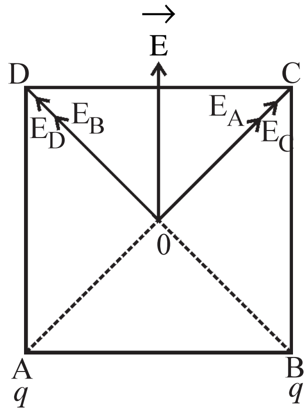
$= (-4 - 10) \times 100 \times (-1.6 \times 10^{-19})$

$= +\ 2.24 \times 10^{-16}$ J

(110) Answer [D]



Initial condition



Final condition

total electric potential in initial condition

$$V = \frac{kq}{r} + \frac{kq}{r} - \frac{kq}{r} - \frac{kq}{r} = 0$$

$\therefore$ final electric potential

$V = 0$

But electric field is $\vec{E'} = -\vec{E}$

Thus, electric field $\vec{E}$ changing but electric potential does not change.

(111) Answer [B]

$W = QV$, $\therefore$ $\Delta K = eV$

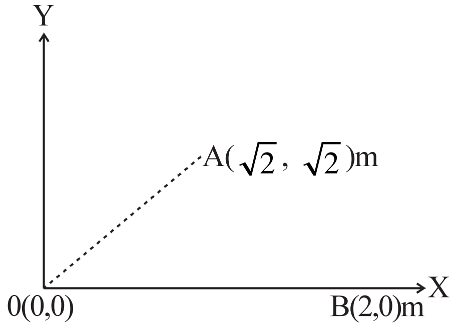
$\therefore$ $\frac{1}{2}\ mv^2 = eV$

$\therefore\ v^2 = \frac{2eV}{m}$, $v = \sqrt{\frac{2eV}{m}}$

$\therefore\ v = \sqrt{\frac{2\times1.6\times10^{-10}\times20}{9.11\times10^{-31}}}$

$v = 2.65 \times 10^6\ ms^{-1}$
$= 2.66 \times 10^6\ ms^{-1}$

(112) Answer [D]



$q = 10^{-3}\ \mu C = 10^{-9}\ C$

$OA = r_A = \sqrt{(\sqrt{2}-O)^2 + (\sqrt{2}-O)^2} = 2m$

$OB = r_B = 2m \Rightarrow r_A = r_B = r$

$V_A - V_B = \frac{kq}{r_A} - \frac{kq}{r_B} = 0$

(113) Answer [B]

$V_A - V_0 = -\int_0^A \vec{E}\cdot\vec{dr}$

$= -\int_O^2 30x^2\, dx\, \hat{i}\cdot\hat{i} = -30\int_O^2 x^2\, dx$

$\therefore\ V_A - V_0 = -30\left[\frac{x^3}{3}\right]_0^2 = -80\ V$

(114) Answer [C]

$V_B - V_A = W/Q$, $\therefore\ V_B - 10 = 20/5 = 4$

$\therefore\ V_B = 14\ V$

(115) Answer [A]

Electric potential at point Y

$V_y = k\left[\frac{Q}{a+r} + \frac{(-Q)}{a}\right]$

electric potential at point X

$V_x = k\left[\frac{Q}{a} + \frac{(-Q)}{a+r}\right]$ Now, $W = q\,(V_y - V_x)$

$= 2kqQ\left[\frac{1}{a+r} - \frac{1}{a}\right] = \frac{2kqQr}{a(a+r)}$

(116) Answer [D]

Suppose, radius of large drop = R and radius of small drop = r.

$\therefore$ Volume of large drop = $n \times$ Volume of small drop

$\frac{4}{3}\pi R^3 = n \times \frac{4}{3}\pi r^3$, $\therefore\ R = n^{\frac{1}{3}} r$

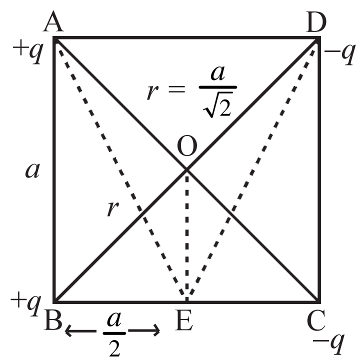
If q is the electric charge on small drop then, electric charge on large drop is = nq

$\therefore$ Potential diflrent on lange drop

$V' = \frac{k(nq)}{n^{\frac{1}{3}}\cdot r} = \frac{kq}{r}\ n^{\frac{2}{3}}$ $V' = n^{\frac{2}{3}} V$

(117) Answer [A]

$E = \frac{kQ}{r^2}$ and $V = \frac{kQ}{r}$



$\therefore\ \frac{V}{E} = r\ \therefore\ r = \frac{600}{150} = 4$ m

(118) Answer [B]

Assume that OA = OB = OC = OD = r

$\therefore$ Electric potential at point O,

$V_O = k\left[\frac{q}{r} + \frac{q}{r} - \frac{q}{r} - \frac{q}{r}\right]$, $\therefore\ V_O = 0$

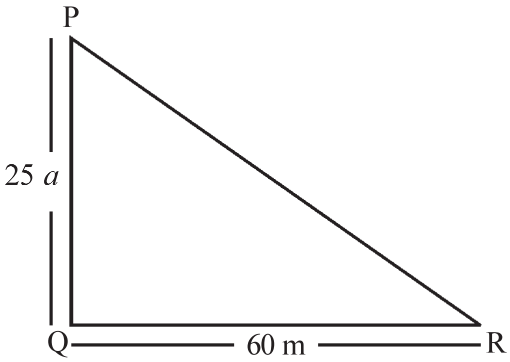
Electric potential at point E,

$V_E = k\left[\frac{q}{AE} + \frac{q}{BE} - \frac{q}{CE} - \frac{q}{DE}\right]$

$V_E = 0 \qquad [\because\ AE = DE$ તથા $BE = CE]$

$\therefore$ Work done to bring electric charge e from O to E is $W = e(V_E - V_O)$ $W = 0$

(119) Answer [C]



Electric potential of sphere $V = \frac{kQ}{r}$

$\therefore 9 \times 10^5 = \frac{9 \times 10^9 \times Q}{0.02}$

$\therefore Q = \frac{0.02}{10^4} = 2 \times 10^{-6}$ C

Now, Electric potential at point P through electric charge Q. $V_P = \frac{kQ}{r_1} = \frac{9 \times 10^9 \times 2 \times 10^{-6}}{0.25}$ V

Electric potential at point R through electric charge Q

$$V_R = \frac{kQ}{r_2} = \frac{9 \times 10^9 \times 2 \times 10^{-6}}{0.6} \text{ V}$$

$\therefore$ Work done to bring +1 C electric charge from R to P. $W = 1(V_P - V_R)$

$= 18 \times 10^3 \left[\frac{1}{0.25} - \frac{1}{0.6}\right] = 42.12$ kJ

(120) Answer [A]

$W = \Delta K \therefore q\Delta V = \Delta K$

$\therefore e(V_f - V_i) = \frac{1}{2} mv^2 - 0$

$$\therefore e\left(\frac{kQ}{R} - \frac{kQ}{\sqrt{R^2 + x^2}}\right) = \frac{1}{2} mv^2$$

So, $x >> R$

$$\frac{keQ}{R} = \frac{1}{2} mv^2 \therefore v = \sqrt{\frac{2keQ}{mR}}$$

(121) Answer [B]

total electric potential at point P

$$V_P = \frac{1}{4\pi\epsilon_0}\left[\frac{q}{r-a} - \frac{2q}{r} + \frac{q}{r+a}\right]$$

$$V_P = \frac{2qa^2}{4\pi\epsilon_0 r(r^2 - a^2)}$$

(122) Answer [C]

Electric potential of sphere $V = \frac{KQ}{2R^3}(3R^2 - r^2)$

taking $r = 0$ at center, $V_C = \frac{3KQ}{2R}$ ...(1)

For the point at which Electric potential is halved from the center. $V_r = \frac{V_c}{2} = \frac{3KQ}{4R}$ ...(2)

and $Vr = \frac{KQ}{r}$ ...(3)

$\therefore \frac{KQ}{r} = \frac{3KQ}{4R}, \therefore r = \frac{4}{3}R$

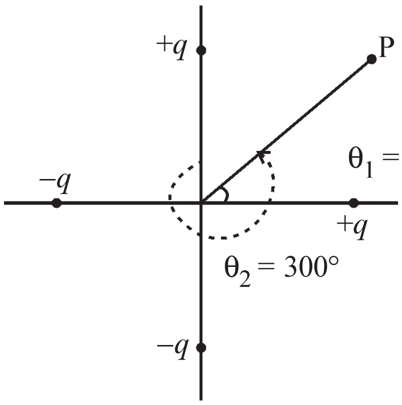
$\therefore$ distance of point from surface $= \frac{4}{3}R - R = \frac{R}{3}$

(123) Answer [D]

Electric charge on semi circular ring $q = \pi RA$

$\therefore$ Electric potential $V = k\frac{\pi R\lambda}{R} = k\pi\lambda$

(124) Answer [A]



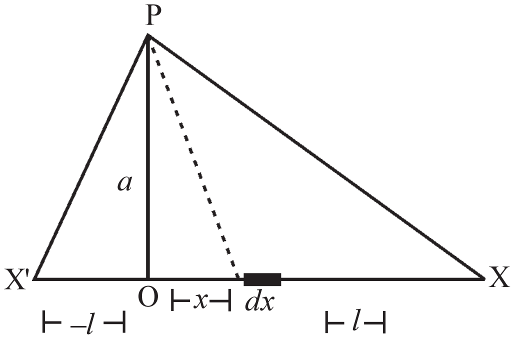
from $V = \frac{1}{4\pi\epsilon_0}\frac{p\cos\theta}{r^2}$,

$$V_1 = \frac{1}{4\pi\epsilon_0}\frac{p\cos 30°}{(0.2)^2} = 0.974 \text{ V}$$

$$V_2 = \frac{1}{4\pi\epsilon_0}\frac{p\cos 300°}{(0.2)^2} = 0.562 \text{ V}$$

$\therefore$ V = $V_1 + V_2$ = 1.536V

(125) Answer [B]



Electric charge on dx section is $dq = \lambda dx$

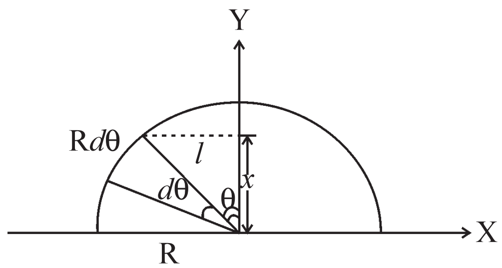
$$\therefore dV = \frac{k\,dq}{\sqrt{a^2 + x^2}} = \frac{k\lambda\,dx}{\sqrt{a^2 + x^2}}$$

$$\therefore V = k\lambda \int_{-l}^{+l} \frac{dx}{\sqrt{a^2 + x^2}}$$

$$\therefore V = \frac{\lambda}{4\pi\epsilon_0}\left[ln\frac{x + \sqrt{a^2 + x^2}}{a}\right]_{-l}^{+l}$$

$$\therefore V = \frac{\lambda}{4\pi\epsilon_0}\, ln\left(\frac{\sqrt{l^2 + a^2} + l}{\sqrt{l^2 + a^2} - l}\right)$$

(126) Answer [D]



Electric charge on section is $dq = 2\pi r\, Rd\theta\sigma$

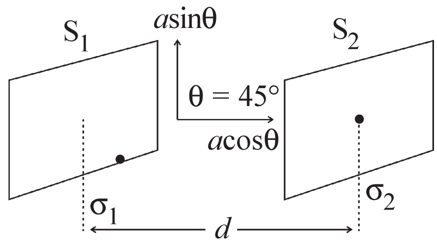
$= 2\pi R \sin\theta\, Rd\theta\sigma = 2\pi R^2 \sin\theta\, \sigma d\theta$

$$\therefore dV = \frac{1}{4\pi\epsilon_0}\cdot\frac{dq}{R} = \frac{\sigma R}{2\epsilon_0}\sin\theta\, d\theta$$

$$\therefore V = \int_0^{\pi/2} dV = \frac{\sigma R}{2\epsilon_0}\int_0^{\pi/2}\sin\theta\, d\theta$$

$$V = \frac{\sigma R}{2\epsilon_0}$$

(127) Answer [D]



Electric field at q is $E = E_1 - E_2$

$$E = \frac{\sigma_1 - \sigma_2}{E_o}$$

$\therefore$ displacement on connecting

perpendicular line = $a\cos\theta = \frac{a}{\sqrt{2}}$,

$\therefore$ Work $W = qE \times \frac{a}{\sqrt{2}}$

$$W = \frac{q(\sigma_1 - \sigma_2)a}{\sqrt{2}\epsilon_0}$$

(128) Answer [B]

$\int_{l=\infty}^{l=0} -\vec{E}\cdot\vec{dl}$ = According to defination of electric potential, electric potential at $l = 0$ is

$$= \frac{kq}{r} = \frac{9\times 10^9 \times 1.11 \times 10^{-10}}{0.5} = +2 \text{ V}$$

(129) Answer [D]

Electric charge on shell A is $q_A = 4\pi a^2\sigma$

Electric charge on shell B is $q_B = -4\pi b^2\sigma$

Electric charge on shell C is $q_C = 4\pi c^2\sigma$

Shell A is inside the shell B and C. So,

$$V_A = \frac{1}{4\pi\epsilon_0}\left[\frac{q_A}{a} + \frac{q_B}{b} + \frac{q_C}{c}\right]$$

$$= \frac{1}{4\pi\epsilon_0}\left[\frac{4\pi a^2\sigma}{a} - \frac{4\pi b^2\sigma}{b} + \frac{4\pi c^2\sigma}{c}\right]$$

$$= \frac{\sigma}{\epsilon_0}[a - b + c]$$

(130) Answer [C]

Due to the shell having radius R_1, the electric potential at center is

$$V_1 = \frac{1}{4\pi\epsilon_0}\frac{Q_1}{R_1} = \frac{1}{4\pi\epsilon_0}\frac{\sigma(4\pi R_1^2)}{R_1} = \frac{\sigma R_1}{\epsilon_0}$$

Similarly $V_2 = \frac{\sigma R_2}{\epsilon_0}$

$\therefore$ Resultant electric potential on center is

$$V = V_1 + V_2,\ V = \frac{\sigma}{\epsilon_0}(R_1 + R_2)$$

(131) Answer [A]

The total electric charge of shell is considered as focused on its center.

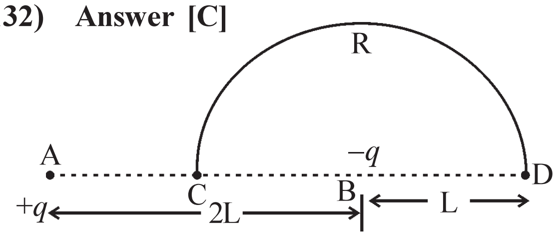
$$\therefore\ V = V_a - V_{3a} = \frac{kQ}{a} - \frac{kQ}{3a}$$

$$V = \frac{2}{3}\frac{kQ}{a},\ \therefore\ kQ = \frac{3}{2}Va$$

Now, electric field at distance $3a$ is

$$E = \frac{kQ}{(3a)^2} = \frac{\frac{3}{2}Va}{9a^2} = \frac{V}{6a}$$

(132) Answer [C]



From figure AD = 2L + L = 3L

Electrical potential at point C.

$$V_C = \frac{1}{4\pi\epsilon_0}\left[\frac{q}{AC} + \frac{(-q)}{BC}\right]$$

$$= \frac{1}{4\pi\epsilon_0}\left[\frac{q}{L} - \frac{q}{L}\right] = 0$$

Electrical potential at point D.

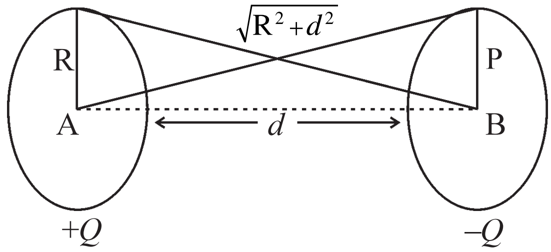
$$V_D = \frac{1}{4\pi\epsilon_0}\left[\frac{q}{AD} - \frac{q}{BD}\right]$$

$$= \frac{1}{4\pi\epsilon_0}\left[\frac{q}{3L} - \frac{q}{L}\right],\ V_D = -\frac{q}{6\pi\epsilon_0 L}$$

$\therefore$ Work done to bring $+Q$ electric charge from C to D is $W = Q(V_D - V_C)$

$$W = Q\left(\frac{-q}{6\pi\epsilon_0 L} - 0\right),\ W = -q\frac{Q}{6\pi\epsilon_0 L}$$

(133) Answer [D]



Electric potential on center of ring A is

$$V_A = \frac{1}{4\pi\epsilon_o}\frac{Q}{R} - \frac{1}{4\pi\epsilon_o}\frac{Q}{\sqrt{R^2+d^2}}$$

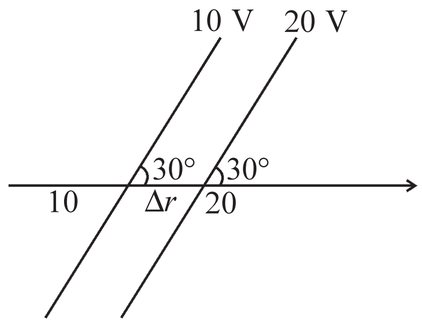
Electric potential on center of ring B is

$$V_B = \frac{1}{4\pi\epsilon_o}\frac{(-Q)}{R} + \frac{1}{4\pi\epsilon_o}\frac{Q}{\sqrt{R^2+d^2}}$$

$$\therefore\ V_A - V_B = \frac{Q}{4\pi\epsilon_0}\left[\frac{2}{R} - \frac{2}{\sqrt{R^2+d^2}}\right]$$

$$= \frac{Q}{2\pi\epsilon_0}\left[\frac{1}{R} - \frac{1}{\sqrt{R^2+d^2}}\right]$$

(134) Answer [A]



According to formula, $dV = -\vec{E}\cdot\vec{dr}$

$$\Delta V = -E\,\Delta r\cos\theta,\ \therefore\ E = -\frac{\Delta V}{\Delta r\cos\theta}$$

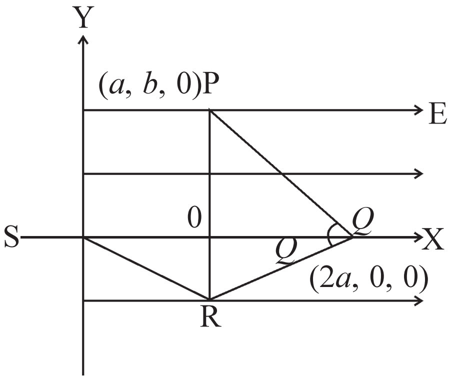
$$E = -\frac{(20-10)}{10\times 10^{-2}\times\cos 120^\circ}$$

$[\because\ \theta = 30 + 90 = 120^\circ]$

$$E = -\frac{-10}{10 \times 10^{-2} \times (-\sin 30°)} = \frac{-100}{-\frac{1}{2}}$$

= 200 Vm^{-1}, Angle of 120° with X-axis

(137) Answer [B]



$W_{PQRS} = W_{POS} = W_{PO} + W_{OS}$
= Fb cos 90° + Fa cos 180°
= 0 – qEa = –qEa

(139) Answer [A]

$$dV = -\vec{E} \cdot \vec{dr}$$

$= -(y\hat{i} + x\hat{j}) \cdot (dx\hat{i} + dy\hat{j} + dz\hat{k})$

$= -ydx - xdy = -d(xy)$

$\therefore \int dV = \int -d(xy)$, $\therefore V = -xy + C$

(140) Answer [D]

$V = -x^2y - xz^3 + 4$

$$E_x = -\frac{dV}{dx} = -(-2xy - z^3) = 2xy + z^3$$

$$E_y = -\frac{dV}{dy} = -(-x^2) = x^2$$

$$F_z = -\frac{dV}{dz} = -(-3xz^2) = 3xz^2$$

$$\therefore \vec{E} = E_x\hat{i} + E_y\hat{j} + E_z\hat{k}$$

$$\therefore \vec{E} = (2xy + z^3)\hat{i} + x^2\hat{j} + 3xz^2\hat{k}$$

(141) Answer [C]

$$\vec{E} = -\left(\frac{dV}{dx}\hat{i} + \frac{dV}{dy}\hat{j} + \frac{dV}{dz}\hat{k}\right)$$

$$\vec{E} = -\left[\frac{d}{dx}(4x^2)\hat{i} + \frac{d}{dy}(4x^2)\hat{j} + \frac{d}{dz}(4x^2)\hat{k}\right]$$

$$\vec{E} = -8x\hat{i}$$

Intensity of electric field $\vec{E}$ at point (1, 0, 2) is

$= -8(1)\hat{i} = -8\hat{i}$

$\therefore$ 8 Vm^{-1} in –X direction

(142) Answer [A]

$$E = -\frac{dV}{dx} = -\frac{d}{dx}\left(\frac{20}{x^2-4}\right)$$

$$= -\frac{20}{(x^2-4)^2}(-1)(2x) = \frac{40x}{(x^2-4)^2}$$

Electric field at point x = 4 μm is,

$$E = \frac{40 \times 4}{\left[(4)^2-4\right]^2} = \frac{160}{144} = +\frac{10}{9}\ V\mu m$$

In + X direction

(144) Answer [C]

$V = -Kx\,z$

$$\therefore E_x = -\frac{dV}{dx} = -Kz, \therefore E_z = -\frac{dV}{dz} = -Kx$$

$$\therefore \quad E = \sqrt{(Kx)^2 + (Kz)^2}$$

$$E = K\sqrt{x^2 + z^2}, E = K\sqrt{r^2}$$

$E = Kr \Rightarrow E \propto r$

(145) Answer [D]

$$E = -\frac{dV}{dy} = -\frac{d}{dy}(5 + 4y^2), E = -8y$$

$\therefore$ Electric field at distance y = 0.5 m

$E = -8 \times 0.5 = -4\ NC^{-1}$

$\therefore F = qE = -2 \times 10^{-6} \times -4 = 8 \times 10^{-6}$ N

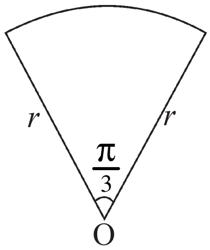
(146) Answer [B]

For surface having equal potential of 60 V is

$$V = \frac{Kq}{r} \quad \therefore 60 = \frac{Kq}{0.1}, \therefore Kq = 6\ Vm$$

$$\therefore E = \frac{Kq}{r^2} = \frac{6}{r^2}\ Vm^{-1}$$

(147) Answer [C]



length of arc is $= r\theta = \dfrac{\pi r}{3}$

$\therefore$ Electric charge on arc is $= \dfrac{\pi r}{3}\lambda$

$\therefore$ Electric potential $V = \dfrac{kq}{r}$

$$V = \frac{1}{4\pi\epsilon_0}\ \frac{\pi r\lambda}{3}\ \frac{1}{r},\ V = \frac{\lambda}{12\epsilon_0}$$

(148) Answer [B]

Electric potential energy of whole system is

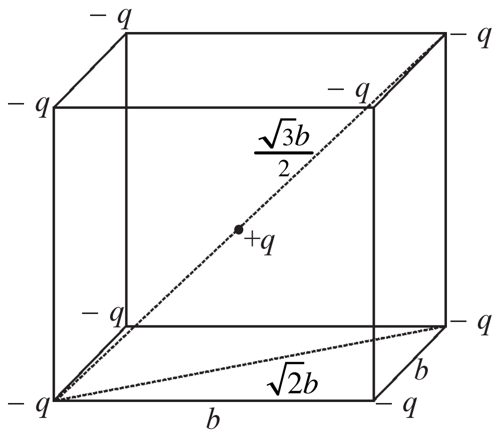
$$U = \frac{kQq}{a} + \frac{kqq}{a} + \frac{kQq}{\sqrt{2}a} = 0$$

$$\therefore Qq + q^2 + \frac{Qq}{\sqrt{2}} = 0,\ \therefore Q + q + \frac{Q}{\sqrt{2}} = 0$$

$$\therefore Q + \frac{Q}{\sqrt{2}} = -q,\ \therefore Q\left(\frac{\sqrt{2}+1}{\sqrt{2}}\right) = -q$$

$$\therefore Q\left(\frac{2+\sqrt{2}}{2}\right) = -q,\ \therefore Q = \frac{-2q}{2+\sqrt{2}}$$

(149) Answer [D]



the distance of $+q$ electric charge from each $-q$ electric charge is $r = \dfrac{\sqrt{3}b}{2}$

Electric potential energy of $+q$ due to any one $-q$ electric charge of vertices is

$$U = \frac{1}{4\pi\epsilon_0}\ \frac{(q)(-q)}{r}$$

$$= -\frac{q^2}{2\pi\epsilon_0(\sqrt{3}b)}$$

Total potential energy of these 8 electric charge is

$$U = -\frac{8q^2}{2\pi\epsilon_0(\sqrt{3}b)} = \frac{-4q^2}{\sqrt{3}\pi\epsilon_0 b}$$

(150) Answer [C]

If q_3 electric charge is on point C then, the potential energy of system is,

$$U_1 = \frac{1}{4\pi\epsilon_0}\left[\frac{q_1 q_3}{0.4} + \frac{q_2 q_3}{\sqrt{(0.4)^2 + (0.3)^2}}\right]$$

If q_3 electric charge is at point D then, the potential energy of system is

$$U_2 = \frac{1}{4\pi\epsilon_0}\left[\frac{q_1 q_3}{0.4} + \frac{q_2 q_3}{0.1}\right]$$

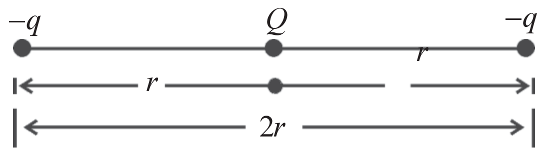
Change in potential energy $= U = U_2 - U_1$

$$\Delta U = \frac{Kq_3}{4\pi\epsilon_0}$$

$$= \frac{1}{4\pi\epsilon_0}\left[\frac{q_1 q_3}{0.4} + \frac{q_2 q_3}{0.1} - \frac{q_1 q_3}{0.4} - \frac{q_2 q_3}{0.5}\right]$$

$$\therefore K = \frac{5q_2 - q_2}{0.5} = \frac{4q_2}{0.5} = 8q_2$$

(151) Answer [A]



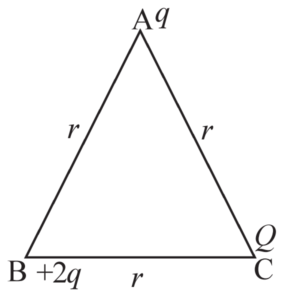
total energy of system

$$U = \frac{kQ(-q)}{r} + \frac{k(Q)(-q)}{r} + \frac{k(-q)(-q)}{2r}$$

$$U = -\frac{2kQq}{r} + \frac{kq^2}{2r},\ \therefore 0 = -2Q + \frac{q}{2}$$

$$\therefore 2Q = \frac{q}{2},\ \frac{q}{Q} = \frac{4}{1} = 4 : 1$$

(152) Answer [B]



$$\frac{1}{4\pi\epsilon_o}\left[\frac{q\times 2q}{r}+\frac{qQ}{r}+\frac{2q\times Q}{r}\right]=0$$

$\therefore\ 2q + Q + 2Q = 0,\ \therefore\ Q = -\dfrac{2q}{3}$

(153) Answer [A]

For minimum potential energy of system of given charges, more charges to be put away as far as possible and the third charge should put near less charge on the line connecting the two charges.

potential energy of whole system is

$$U = k\left[\frac{(2q)(q)}{r}+\frac{q(8q)}{0.09-r}+\frac{(2q)(8q)}{0.09}\right]$$

$$= 2kq^2\left[\frac{1}{r}+\frac{4}{0.09-r}+\frac{8}{0.09}\right] = 2kq^2\cdot x$$

Where $x = \dfrac{1}{r}+\dfrac{4}{0.09-r}+\dfrac{8}{0.09}$

Now if potential energy is minimum then, $\dfrac{dU}{dr} = 0$

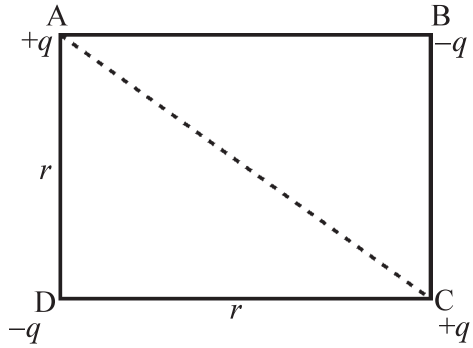
$$\frac{d}{dr}\left[\frac{1}{r}+\frac{4}{0.09-r}+\frac{8}{0.09}\right]=0$$

$$\therefore\ \frac{1}{r^2}-\frac{4}{(0.09-r)^2}+0=0$$

$$\therefore\ \frac{1}{r^2}=\frac{4}{(0.09-r)^2},\ \therefore\ r = 0.03\text{ m}$$

$r - x \Rightarrow$ distance from $8q = 0.06$ m

(154) Answer [B]



The four pair is found like AB, $U_1 = -\dfrac{4kq^2}{r}$,

for pair AC, $U_2 = +\dfrac{kq^2}{\sqrt{2}r}$

for pair BD, $U_3 = +\dfrac{kq^2}{\sqrt{2}r}$

$U = U_1 + U_2 + U_3$

$U = -\dfrac{4kq^2}{r}+\dfrac{2kq^2}{\sqrt{2}r}$

$U = \dfrac{kq^2}{r}\,[\sqrt{2}-4]$

(155) Answer [C]

$U = \dfrac{kq_1q_2}{r}$

$\therefore\ \dfrac{9\times10^9\times5\times10^{-9}\times(-2)\times10^{-9}}{(x-2)\times10^{-2}} = -05\times10^{-6}$

$\therefore\ x = 20$ cm

(156) Answer [A]

potential energy $U = -pE\,cos\theta$

$U = -q2aE\cos\theta$

$U = -8\times10^{-9}\times4\times10^{-2}\times2.5\times10^{10}\times\frac{1}{2}$

$\because\ U = -4J,\ [\cos60^\circ = \frac{1}{2}]$

(157) Answer [D]

$W = pE(\cos\theta_1 - \cos\theta_2)$

$= q2aE\,(\cos0 - \cos180^\circ)$

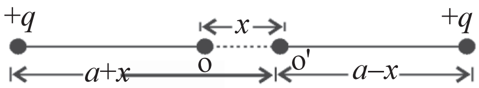
$= 1\times10^{-6}\times2\times10^{-2}\times10^5\,(1+1)$

$= 4\times10^{-3}$ J

(158) Answer [B]

$$U_1 = \frac{kqQ}{a} + \frac{kqQ}{a} = \frac{2kqQ}{a}$$

Thus, taking Q from O to O',



$$U_2 = \frac{kqQ}{a+x} + \frac{kqQ}{a-x} = \frac{2kQq}{a}\ (1 + x^2 / a^2)$$

$$\therefore\ \Delta U = U_2 - U_1 = \frac{2kQq}{a3}\ x^2,\ \therefore\ \Delta U \propto x^2$$

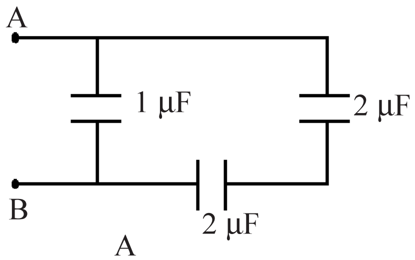
(160) Answer [D]

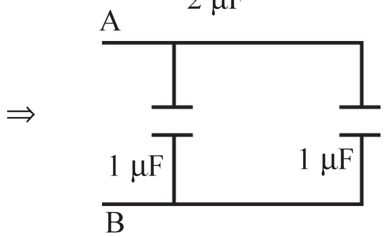
Electric charge should be such that $Q_1 = Q_3$, $Q_2 = Q_4$ and $Q_2 = -Q_3$.

$$\therefore\ C = \frac{Q_4}{V} = \frac{Q_2}{V}\ \therefore\ V = \frac{Q_2}{C} = -\frac{Q_3}{C}$$

$$V = \frac{\frac{Q_2}{C} - \frac{Q_3}{C}}{2} = \frac{Q_2 - Q_3}{2C}$$

(161) Answer [A]

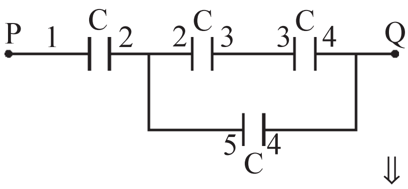


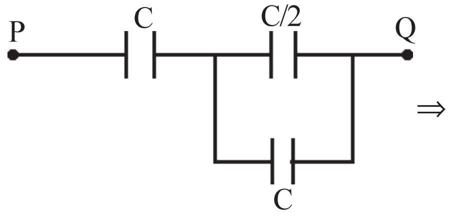


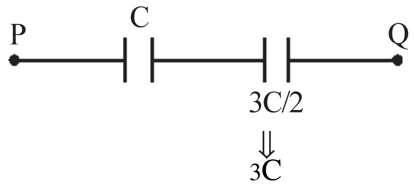
$\therefore$ By equivalent capacitance between A and B = 2μF

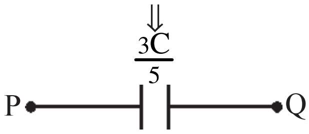
(162) Answer [A]

equivalent circuit :



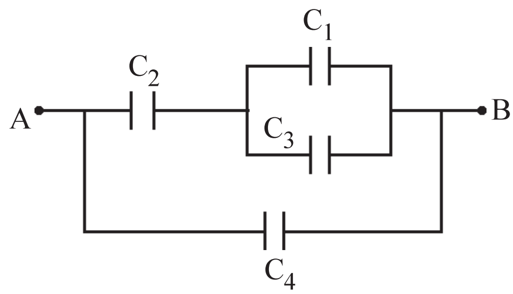






$$C_{PQ} = \frac{3}{5}\ \frac{A \in_0}{d}$$

(163) Answer [C]

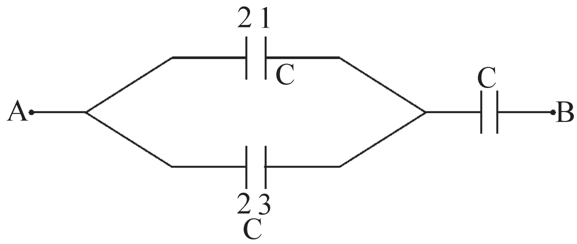


$C_{13} = 18\ \mu F$, $C_{213} = 6\ \mu F$

$\therefore\ C_{AB} = C_{213} + C_4 = 6 + 9 = 15\ \mu F$

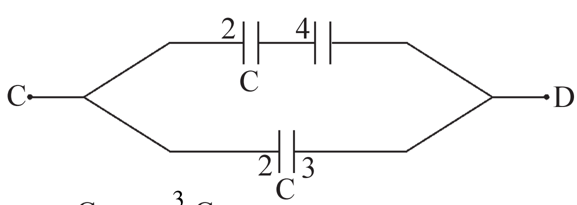
(164) Answer [C]

For first circuit :



$$C_{AB} = \frac{2C}{3}$$

For second circuit :

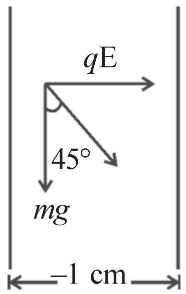


$$C_{CD} = \frac{3}{2}C$$

$$C_{AB} \times C_{CD} = \frac{2}{3}\ C \times \frac{3}{2}\ C = C^2$$

(167) Answer [D]

For stationary proton, qE = mg



$\therefore \frac{qV}{d} = mg, \frac{qX}{d} = mg, X = \frac{mgd}{q}$

$X = \frac{1.67 \times 10^{-27} \times 10 \times 0.01}{1.6 \times 10^{-19}}$

$X = 1 \times 10^{-9}$ V

(168) Answer [D]

$U_i = \frac{1}{2} CV^2 = \frac{1}{2} \times 2 \times V^2 = V^2$

$q_i = 2V$, When switch S connect at point 2

then, $\frac{2V-q}{2} = \frac{q}{8} \Rightarrow q = \frac{8V}{5}$

$\therefore$ energy l costs =

$V^2 - \left(\frac{64V^2}{2 \times 25 \times 8} + \frac{4V^2}{2 \times 25 \times 2}\right) = \frac{4V^2}{5}$

$= 0.8\ V^2 = 80\ \%\ V^2 = 80\ \%.\ V^2$

(169) Answer [A]

$C = \frac{Q}{V}$. The capacitance of capacitor–B is 3 times larger than the capacitance of capacitor–A. So, potential difference between two plate of B is $\frac{1}{3}^{rd}$ of potential difference between two plates of A.

$\therefore$ for capacitor – A, 7.5 V

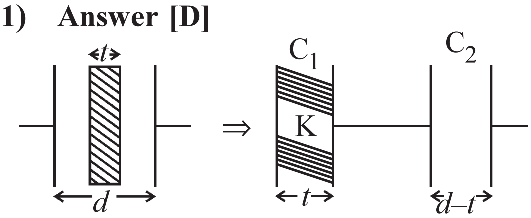
for capacitor – B, 2.5 V

(170) Answer [B]

The capacitance of parallel plate capacitor is $C = \frac{A\epsilon_0}{d} = \frac{A\epsilon_0}{t}$. When metal foil having thickness $\frac{t}{3}$ inserted between two plates then effective thickness $d = t - \frac{t}{3} = \frac{2t}{3}$, The capacitance in new condition $C' = \frac{A\epsilon_0}{\frac{2}{3}t} = \frac{3}{2} C$

$\therefore C' = \frac{3}{2} \times 100\ pF,\ C' = 150\ pF$

(171) Answer [D]



$C_1 = \frac{KA\epsilon_0}{t}, C_2 = \frac{A\epsilon_0}{d-t}$

$\therefore \frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{t}{KA\epsilon_0} + \frac{d-t}{A\epsilon_0}$

$= \frac{1}{A\epsilon_0}\left[\frac{t}{K} + d - t\right] = \frac{1}{A\epsilon_0}\left[\frac{t + K(d-t)}{K}\right]$

$\therefore C = \frac{KA\epsilon_0}{K(d-t)+t} = \frac{KA\epsilon_0}{K[d-t+t/K]}$

$C = \frac{A\epsilon_0}{d - t\left(1 - \frac{1}{K}\right)}$

(172) Answer [C]

$C_{ACP} = \frac{3 \times 3}{3+3} = \frac{3}{2}\ \mu F$, C_{ACP} and C_{ADP} are parallel to each other So,

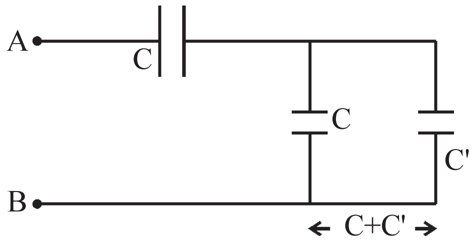
$C_{ADP} = \frac{3+3}{3+3} = \frac{3}{2}\ \mu F$

$C_{AP} = \frac{3}{2}\ \mu F + \frac{3}{2}\ \mu F = 3\mu F$

Similarly, $C_{PQ} = 3\mu F$ and $C_{QB} = 3\mu F$

$\therefore \frac{1}{C} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = \frac{3}{3} = 1\mu F$

(173) Answer [A]



$$C_{AB} = \frac{C(C+C')}{C+(C+C')} = C'$$

$\therefore C^2 + CC' = CC' + CC' + C'^2$

$\therefore C'^2 + CC' - C^2 = 0$

$$C' = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$ substituting values $a = 1, b = C$

$C = -C^2$

$$C' = \frac{-C \pm \sqrt{C^2 - 4(1)(-C^2)}}{2(1)}$$

$$C' = \left(\sqrt{5} - 1\right)\frac{C}{2}$$

(174) Answer [D]

The equivalent capacitance for series connection of n_1 capacitors is $C_S = \frac{C_1}{n_1}$

Energy of this series connection

$$U_S = \frac{1}{2} C_S (4)^2 = \frac{8C_1}{n_1}$$

The equivalent capacitantce for parallel connection of n_2 capacitors is $C_P = n_2C_2$

Energy stored in parallel connection

$U_P = \frac{1}{2} C_P V^2 = \frac{1}{2} (n_2C_2)V^2$

$U_P = U_S$

$\therefore \frac{1}{2} n_2C_2 = \frac{8C_1}{n_1}, C_2 = \frac{16C_1}{n_1n_2}$

(175) Answer [A]

Capacitance of small drop $C = 4\pi\epsilon_0 r$

If radius of big drop is R then,

$\frac{4}{3}\pi R^3 = n \times \frac{4}{3}\pi r^3$

$R = n^{\frac{1}{3}} r$, Capacitance of big drop $C' = 4\pi\epsilon_0 R$

$= 4\pi\epsilon_0 (n^{\frac{1}{3}} r)$, $C' = n^{\frac{1}{3}} C$

(176) Answer [C]

$$C' = \frac{A\epsilon_0}{d - t + \frac{t}{K}}$$ by taking $t = d/2$,

$$C' = \frac{A\epsilon_0}{\left(d - \frac{d}{2}\right) + \frac{\frac{d}{2}}{K}} = \frac{2A\epsilon_0}{d}\left(\frac{1}{\frac{K+1}{K}}\right)$$

$\therefore C' = 2C\frac{K}{K+1}$, Now, $C' = \frac{4}{3}C$

$\therefore \frac{4}{3}C = 2C\left(\frac{K}{K+1}\right)$, $2K = 4$, $K = 2$

(178) Answer [C]

In absence of dielectric $C_o = \frac{A\epsilon_0}{d}$

In presence of dielectric $C_1 = \frac{K_1\epsilon_0 A/2}{d} = \frac{K_1C_o}{2}$

$$C_2 = \frac{K_2 \in_0 A/2}{d} = \frac{K_2 C_o}{2}$$

both capacitors are parallel, so

$$C = C_1 + C_2 = \left(\frac{K_1 + K_2}{2}\right) C_o$$

$$\frac{C}{C_o} = \frac{K_1 + K_2}{2}$$

(179) Answer [D]

Here $V_B = 0$. Capacitance are equal on both sides of point – B. So,

$V_A - V_B = V_B - V_C$, $\therefore V_A + V_C = 2V_B = 0$

But $V_A - V_C = 10V$, $\therefore V_A = +5V$, and $V_C = -5V$

(181) Answer [B]

Given arrangement shows series connection of three capacitors.

$$C_1 = \frac{2A\in_0}{\frac{d}{3}} = \frac{6A\in_0}{d}$$

$$C_2 = \frac{KA\in_0}{\frac{d}{3}} = \frac{3K\in_0}{d}$$

$$C_3 = \frac{A\in_0}{\frac{d}{3}} = \frac{3A\in_0}{d}$$

$$\therefore \frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\therefore \frac{1}{C} = \frac{d}{6\in_0 A} + \frac{d}{3KA\in_0} + \frac{d}{3\in_0 A}$$

But for cupper $K = \infty$

$$\therefore \frac{1}{C} = \frac{d}{6\in_0 A} + O + \frac{d}{3\in_0 A}$$

$$\therefore C = \frac{2A\in_0}{d}$$

(182) Answer [D]

$$\frac{1}{C'} = \frac{1}{C_2} + \frac{1}{C_3} \text{ But,}$$

$$C_2 = \frac{K_2\in_0 \frac{A}{2}}{\frac{d}{3}} = \frac{3K_2\in_0 A}{2d}$$

$$C_3 = \frac{K_3\in_0 \frac{A}{2}}{2\frac{d}{3}} = \frac{3K_3\in_0 A}{4d}$$

$$\therefore \frac{1}{C^1} = \frac{2d}{3K_2\in_0 A} + \frac{4d}{3K_3\in_0 A}$$

$$= \frac{2d}{3AEo}\left(\frac{1}{K_2} + \frac{2}{K_3}\right)$$

$$C' = \frac{3A\in_0 K_2 K_3}{2d(K_3 + 2K_2)}$$

$$\text{Now } C = C' + C_1 = \frac{3A\in_0 K_2 K_3}{2d(K_3 + 2K_2)} + \frac{\in_0 K_1 A}{2d}$$

$$= \frac{A\in_0}{2d}\left[\frac{3K_2K_3}{K_3 + 2K_2} + K_1\right]$$

$$C = \frac{A\in_0}{2d}\left[\frac{3K_2K_3 + K_3K_1 + 2K_2K_1}{K_3 + 2K_2}\right]$$

(189) Answer [D]

$W = q(V_B - V_A)$

$2 = 10{,}000 \times 10^{-6} (250 - V_A)$

$200 = 250 - V_A \Rightarrow V_A = 50$ V

(191) Answer [A]

total kinetic energy = Initial potential energy

$$2 \times \frac{1}{2} mv^2 = \frac{Ke^2}{1}$$

$$V = \sqrt{\frac{Ke^2}{m}} = e\sqrt{\frac{K}{m}}$$

●

12 Current Electricity

(1) Answer [C]

Electric current $I = \frac{Q}{t} = \frac{e}{T} = \frac{ev}{2\pi r}$

$$\left(\because v = r\omega = r \times 2\pi f = \frac{2\pi r}{T}\right)$$

$\therefore\ v = \frac{I \times 2\pi r}{e}$

$= \frac{1.06 \times 10^{-3} \times 2 \times 3.14 \times 5.3 \times 10^{-11}}{1.6 \times 10^{-19}}$

$= 2.2 \times 10^{6}\ ms^{-1}$

(2) Answer [D]

Electric current $I = \frac{Q}{t} = \frac{ne}{t}$

$\Rightarrow$ number of electrons, $n = \frac{It}{e}$

$= \frac{9 \times 10^{-3} \times 3 \times 60}{1.6 \times 10^{-19}} = 1.01 \times 10^{19}$ electron

(3) Answer [B]

Electric current $I = \frac{dQ}{dt} = I_0 + \alpha t$

$\therefore\ dQ = (I_0 + \alpha t)dt$

by integration $\int dQ = \int (I_0 + \alpha t)dt$

$\therefore\quad Q = \left[I_0 t + \frac{\alpha t^2}{2}\right]$

$= \left[100 \times 20 + \frac{8 \times (20)^2}{2}\right] = 2000 + 1600 = 3600$ C

(4) Answer [C]

Electric current $I = \frac{Q}{t} = \frac{ev}{2\pi r}$

$= \frac{e}{2\pi} \times \frac{4\pi e^2}{h} \times \frac{16\pi^2 me^2}{h^2} = \frac{32\pi^2 me^5}{h^3}$

(5) Answer [C]

Electric current $I = \frac{dQ}{dt} \Rightarrow dQ = Idt,\ Q = \int Idt$

$= \int_0^4 (3 + 2t)dt = \left[3t + t^2\right]_0^4 = (12 + 16) = 28$ C

(6) Answer [A]

Drift velocity of electron

$= \frac{\text{effective displacement of electron}}{\text{time period}}$

$= \frac{4 \times 10^{-4} - 10^{-4}}{10} = 3 \times 10^{-5}\ ms^{-1}$

(7) Answer [C]

Number density of electron

$n = \frac{\rho}{V} = \frac{\rho \times N_A}{M} = \frac{8920 \times 6.02 \times 10^{26}}{63.5}$

$= 8.5 \times 10^{28}$ electron m^{-3}

Electric current $I = neAv_d \Rightarrow v_d = \frac{1}{n}\left(\frac{I}{eA}\right)$

putting values $v_d = 1.2 \times 10^{-4}\ ms^{-1}$

(8) Answer [A]

$J = \sigma E \Rightarrow J = \frac{1}{\rho}$ E,

Resistivity $\rho = \frac{E}{J} = \frac{8 \times 10^{-8}}{5} = 1.6 \times 10^{-8}\ \Omega m$

(9) Answer [B]

Electric current $I = Av_d ne$

$= 4 \times 10^{-4} \times 8 \times 10^{10} \times 6 \times 10^{12} \times 1.6 \times 10^{-19}$

$= 307.2 \times 10^{-1} = 30.72$ A

(10) Answer [C]

From $I = Av_d ne,\ v_d \propto \frac{1}{A},\ \therefore\ v_d \propto \frac{1}{\pi r^2}$

$\therefore\ \frac{v_{d_2}}{v_{d_1}} = \frac{r_1^2}{r_2^2} = \left(\frac{r_1}{r_2}\right)^2 = \left(\frac{1}{4}\right)^2 = \frac{1}{16}$

Thus, drift velocity in thin wire is $v_{d_1} = 16\ v_d$

(11) Answer [D]

From $\mu = \frac{\sigma}{ne}$ and $\sigma = \frac{ne^2\tau}{m}$

Mobility of conductor $\mu = \frac{\sigma}{ne} = \frac{ne^2\tau}{mne} = \frac{e\tau}{m}$

$= \frac{1.6 \times 10^{-19} \times 18.2 \times 10^{-12}}{9.1 \times 10^{-31}} = 3.2\ Cs\ kg^{-1}$

(12) Answer [B]

Resistivity of wire $\rho = \dfrac{m}{ne^2\tau}$

$$= \frac{2.56 \times 10^{-27}}{8 \times 10^{12} \times \left(1.6 \times 10^{-19}\right)^2 \times 4 \times 10^{-12}}$$

$= 0.03125 \times 10^{11} = 0.31 \times 10^{10}\ \Omega\text{m}$

(13) Answer [C]

Electric current density (J) $= \dfrac{\Delta I}{\Delta a \cos\theta}$

$$= \frac{4}{2 \times 10^{-4} \times \cos 60^\circ} = \frac{4}{2 \times 10^{-4} \times \frac{1}{2}}$$

[angle between $\Delta \vec{a}$ and I is 60°.]

$= 4 \times 10^4\ \text{A m}^{-2}$

(14) Answer [A]

Resistance of first conductor $R_1 = \dfrac{\rho_1 l_1}{A}$

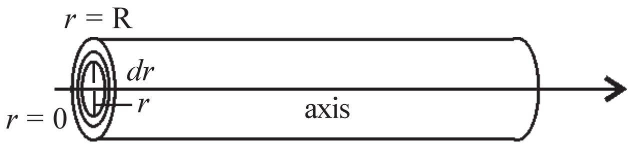
Resistance of second conductor $R_2 = \dfrac{\rho_2 l_2}{A}$

equivalent resistance $R = R_1 + R_2$

$$\frac{\rho(l_1 + l_2)}{A} = \frac{\rho_1 l_1}{A} = \frac{\rho_2 l_2}{A}$$

$$\rho(l_1 + l_2) = \rho_1 l_1 + \rho_2 l_2 \Rightarrow \rho = \frac{\rho_1 l_1 + \rho_2 l_2}{l_1 + l_2}$$

(15) Answer [B]



Consider ring of thickness dr at distance r from axis of cross-section perpendicular to cylinder axis.

Current flow from this ring $dI = da$

[$\because \cos\theta = 1$], $dI = J_0 \dfrac{r^3}{R^4}\ 2\pi r dr$

Flow of electric current in the direction of length of conductor parallal to axis of conducting cylinder is

$$I = \int dI \int_{r=0}^{r=R} J_0 \frac{r^3}{R^4} 2\pi r dr = \frac{2\pi J_0}{R^4} \int_0^R r^4\, dr$$

$$= \frac{2\pi J_0}{R^4} \left[\frac{r^5}{5}\right]_0^R = \frac{2\pi J_0}{5R^4} R^5 = \frac{2\pi J_0}{5} R$$

(16) Answer [A]

Current density in ion wire

$$J_2 = \frac{I_2}{A_2} = \frac{I_2}{\pi r_2^2} = \frac{4 \times 10^{-3}}{3.14 \times \left(10^{-3}\right)^2}$$

$= 1.27 \times 10^3\ \text{Am}^{-2}$

(17) Answer [B]

Initial resistance of wire $R_1 = \dfrac{\rho l_1}{\pi r_1^2}$

Final resistance of wire

$$R_2 = \frac{\rho l_2}{\pi r_2^2} = \frac{\rho n l_1}{\pi \times \frac{r_1^2}{n}} = n^2 \frac{\rho l_1}{\pi r_1^2} = n^2 R_1$$

(18) Answer [B]

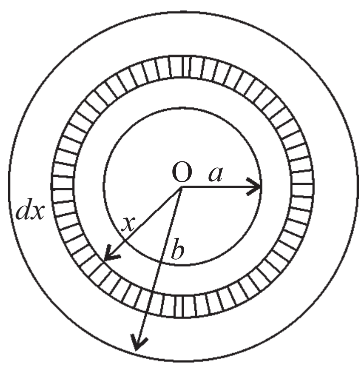
In parallel connection, ρd is equal between both wire.

$V_1 = V_2$, $I_1 R_1 = I_2 R_2$

$$I_1\left[\rho \frac{l_1}{\pi r_1^2}\right] = I_2\left[\frac{\rho l_2}{\pi r_2^2}\right], \frac{I_1}{I_2} = \left(\frac{l_2}{l_1}\right)\left(\frac{r_2}{r_1}\right)^2$$

$$\therefore \frac{I_1}{I_2} = \left(\frac{6}{8}\right)\left(\frac{4}{6}\right)^2 = \frac{2}{6} = \frac{1}{3}$$

(19) Answer [D]



Consider shell of dx thickness at distance x from center of sphere as shown in figure. Resistance of this shell

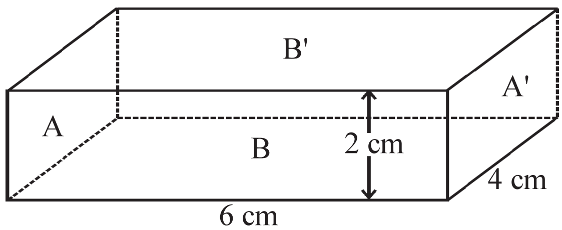
$$dR = \rho \frac{dx}{A} = \rho \frac{dx}{4\pi x^2}$$

Total resistance of inner space between circular shell $R = \int dR = \int_a^b \frac{\rho}{4\pi x^2}\,dx$

$$= \frac{\rho}{4\pi}\int_a^b \frac{1}{x^2}\,dx = \frac{\rho}{4\pi}\left[-\frac{1}{x}\right]_a^b$$

$$\therefore\ R = \frac{\rho}{4\pi}\left[\frac{1}{a} - \frac{1}{b}\right]$$

(20) Answer [A]



Maximum resistance found between AA' side of block

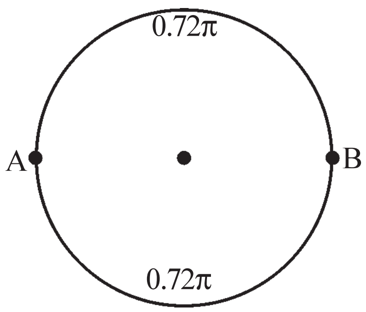
$$R_{max} = \rho\frac{l}{A} = \rho\ \frac{6}{4\times 4} = \frac{3}{4}$$

minimum resistance found between BB' sides of block

$$R_{min} = \rho\frac{l'}{A'} = \frac{\rho\times 2}{6\times 4} = \frac{\rho}{12}$$

$$\therefore\ \frac{R_{max}}{R_{min}} = \frac{3\rho}{4}\times\frac{12}{\rho} = 9$$

(21) Answer [B]



length of wire $l = 2\pi r = 2\pi\,(0.12) = 0.24\pi$

Resistance of circular wire, $R = 6\times 0.24\pi = 1.44\pi$

As shown in figure, the resistance of upper half of the circle from two end points A and B of diameter is $= \frac{R}{2} = 0.72\pi\ \Omega$.

and the resistance of lower half $= \frac{R}{2} = 0.72\pi\ \Omega$

Both resistance arein parallel conection so equivalent resistance,

$$R_{AB} = \frac{0.72\pi\times 0.72\pi}{0.72\pi + 0.72\pi} = 0.36\pi\ \Omega$$

(22) Answer [A]

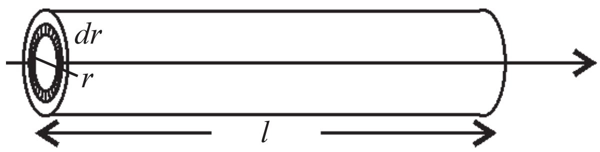
Electric charge $Q = \alpha t - \beta t^2$, Now, electric current

$$I = \frac{dQ}{dt} = \frac{d}{dt}\left[\alpha t - \beta t^2\right] = \alpha - 2\beta t$$

For maximum electric current $\frac{dQ}{dt} = 0$.

Thus, $\alpha - 2\beta t = 0 \Rightarrow$ time $t = \frac{\alpha}{2\beta}$

(23) Answer [C]



As shown in figure, taking cylindrical shell having dr thickness and l length at distance r from center of cylindre. The resistance of section is

$$dR = \rho\frac{l}{A} = \frac{\rho}{2\pi r l}\,dr.$$

Now, the resistance between outer wall and inner wall of whole cylindrical.

$$R = \int dr = \int_{r_1}^{r_2}\frac{\rho}{2\pi r l}\,dr = \frac{\rho}{2\pi l}\int_{r_1}^{r_2}\frac{1}{r}\,dr$$

$$= \frac{\rho}{2\pi l}\left[ln\ r\right]_{r_1}^{r_2}$$

$$\therefore\ R = \frac{\rho}{2\pi l}\left[ln\ r_2 - ln\ r_1\right]$$

$$= \frac{\rho}{2\pi l}\left[ln\left(\frac{r_2}{r_1}\right)\right]$$

(24) Answer [B]

Initial resistance of wire $R_0 = \frac{\rho_l}{A} = 8\ \Omega$

Fold a wire by 180° degree, and twist both ends, its length become half and thickness doubled.

Thus new resistance of wire is

$$R = \frac{\rho\left(\frac{1}{2}\right)}{2A} = \frac{l}{A}\frac{1}{4} = 8 \times \frac{1}{4} = 2\ \Omega$$

(25) Answer [C]

Initial resistance of wire $R = \rho\frac{l}{A} \times \frac{l}{l} = \rho\frac{l^2}{V}$

$$\frac{dR}{dl} = 2\frac{\rho l}{V} \Rightarrow dR = 2\frac{\rho l}{V}\ dl$$

$$\therefore \frac{dR}{R} = 2\frac{dl}{l}$$

$$\Rightarrow \frac{dR}{R} \times 100 = 2\frac{dl}{l} \times 100$$

$$= 2 \times 0.1\ \% = 0.2\ \%$$

(26) Answer [B]

number density of electron depends on atomic structure of metal. So, it remains constant.

Now, $I = \frac{V}{R} = neAV_d$

Thus, with increasing V, I increases. Resultant V_d also increases.

(27) Answer [D]

Resistance $R = \rho\frac{l}{A} \times \frac{l}{l}$

$$\Rightarrow R = \rho\frac{l^2}{V} = \frac{\rho l^2 d}{m} \quad \left[\because \text{density } d = \frac{m}{V}\right]$$

$\therefore$ from $R \propto \frac{l^2}{m}$

$$R_1 : R_2 : R_3 = \frac{l_1^2}{m_1} : \frac{l_2^2}{m_2} : \frac{l_3^2}{m_3}$$

$$\therefore R_1 : R_2 : R_3 = \frac{9}{2} : \frac{25}{2} : \frac{49}{5}$$

$$\therefore R_1 : R_2 : R_3 = 135 : 250 : 294$$

(28) Answer [D]

Temperature co-efficient of resistivity

$$\alpha = \frac{R_t - R_0}{R_0 t} = \frac{6-5}{5(50)} = \frac{1}{250}\ °C^{-1}$$

Now, $\alpha = \frac{R_{100} - R_0}{5 \times 100} \Rightarrow \frac{1}{250} = \frac{6 - R_0}{500}$

$$\therefore R_0 = 6 - 2 = 4\ \Omega$$

(29) Answer [B]

Here $R_\theta = R_{\theta_0}\left[1 + \alpha\left(\theta - \theta_0\right)\right]$,

$$R_1 = R_{\theta_0}\left[1 + \alpha\left(\theta_1 - 20\right)\right] \quad ...(1)$$

and $R_2 = R_{\theta_0}\left[1 + \alpha\left(\theta_2 - 20\right)\right] \quad ...(2)$

Taking ratio of equation (2) and (1)

$$\frac{R_2}{R_1} = \frac{R_{\theta_0}}{R_{\theta_0}}\frac{\left[1 + \alpha\left(\theta_2 - 20\right)\right]}{\left[1 + \alpha\left(\theta_1 - 20\right)\right]} \Rightarrow \frac{4R_1}{R_1}$$

$$= \frac{\left[1 + \alpha\left(\theta_2 - 20\right)\right]}{\left[1 + \alpha\left(\theta_1 - 20\right)\right]} \Rightarrow 4 = \frac{1 + \alpha\theta_2 - 20\alpha}{1 + 7\alpha}$$

$\therefore 4(1 + 7\alpha) = 1 + \theta_2\alpha + 20\alpha$

$4 + 28\alpha = 1 + \theta_2\alpha + 20\alpha$, $\theta_2\alpha = 3 + 8\alpha$

$$\therefore \theta_2 = \frac{3 + 8\alpha}{\alpha} = \frac{3 + 8\left(4 \times 10^{-3}\right)}{4 \times 10^{-3}}$$

$$= \frac{3 + 0.032}{4 \times 10^{-3}} = 758\ °C$$

(30) Answer [D]

From $R_\theta = R_0\ [1 + \alpha\theta]$

$3.1 = R_0\ (1 + 30\alpha) \quad ...(1)$

$4.5 = R_0\ (1 + 100\alpha) \quad ...(2)$

Taking ratio of equation (2) and (1),

$$\frac{4.5}{3.1} = \frac{R_0\left(1 + 100\alpha\right)}{R_0\left(1 + 30\alpha\right)}$$

$\Rightarrow \quad 4.5\ (1 + 30\alpha) = 3.1\ (1 + 100\alpha)$

$4.5 + 135\alpha = 3.1 + 310\alpha$

$$\alpha = \frac{1.4}{175} = 0.008\ °C^{-1}$$

(31) Answer [B]

Resistance of Nichrome wire $R_2 = \frac{230}{2.68} = 85.5\ \Omega$

Now, $R_2 = R_1\left[1 + \alpha\left(T_2 - T_1\right)\right]$

$$85.5 = 75.3\left[1 + 1.7 \times 10^{-4}\left(T_2 - 27\right)\right]$$

$$\frac{85.5}{75.3} - 1 = 1.7 \times 10^{-4}\ (T_2 - 27)$$

$$T_2 = \frac{85.5 - 75.3}{75.3 \times 1.7 \times 10^{-4}} + 27$$

$\therefore\ T_2 = 820 + 27 = 847\ °C$

(32) Answer [B]

Temperature of heat bath $t = \left[\frac{R_t - R_0}{R_{100} - R_0}\right] \times 100$

$$= \frac{5.795 - 5}{5.23 - 5} \times 100 = 345.65 = 346\ °C$$

(33) Answer [D]

$R_{\theta_0} = 18\ \Omega,\ \theta_0 = 27 + 273 = 300\ K$

Resistance of bulb $R_\theta = \frac{V}{I} = \frac{45}{0.25} = 180\ \Omega$

Now, $R_\theta = R_{\theta_0}\ [1 + \alpha\ (\theta - \theta_0)]$

$180 = 18\ [1 + 4.5 \times 10^{-3}\ (\theta - 300)]$

$10 - 1 = 4.5 \times 10^{-3}\ (\theta - 300)$

$$\frac{9}{4.5 \times 10^{-3}} = \theta - 300 \Rightarrow \theta = 2000 + 300 = 2300\ K$$

(34) Answer [D]

$\rho_\theta = \rho_{20}\ [1 + \alpha\ (\theta - 20)]$

$$\therefore\ \frac{d\rho_\theta}{d\theta} = \rho_{20}\ \alpha$$

for first matter $\left(\frac{d\rho_\theta}{d\theta}\right)_1 = (\rho_{20})_1\ \alpha_1$

for second matter $\left(\frac{d\rho_\theta}{d\theta}\right)_2 = (\rho_{20})_2\ \alpha_2$

Resistivity of mixture does not change with temperature. So,

$$\frac{d\rho}{d\theta} = \left(\frac{d\rho_\theta}{d\theta}\right)_1 + \left(\frac{d\rho_\theta}{d\theta}\right)_2 = 0.$$

$(\rho_{20})_1\ \alpha_1 + (\rho_{20})_2\ \alpha_2 = 0$

$$(\rho_{20})_2 = -\frac{(\rho_{20})_1\alpha_1}{\alpha_2}$$

$$= \frac{-2.4 \times 10^{-8} \times 5 \times 10^{-4}}{-3.8 \times 10^{-4}} = 3.158 \times 10^{-8}\ \Omega m$$

(35) Answer [A]

First band in national flag of india is Orange $\rightarrow 3$

Second band in national flag is white $\rightarrow 9$

Third band in national flag is green $\rightarrow 10^5$

There is no fourth band. So, tolerence $\rightarrow \pm\ 20\ \%$

So Resistance is $R = 39 \times 10^5 \pm 20\ \%\ \Omega$

(36) Answer [D]

$R + \Delta R = 2640\ \Omega,\ R - \Delta R = 1760\ \Omega$

$2R = 4400\ \Omega,\ \therefore\ R = 2200\ \Omega$ અને $\Delta R = 440\ \Omega$

$\therefore\ R \pm \Delta R = (2200 \pm 440)\ \Omega$

$= (22 \times 10^2 \pm 20)\ \Omega$

Thus, colour code of resistance $\rightarrow$ red, red, red, no colour

(37) Answer [A]

Terminal voltage of battery

$$V = \varepsilon - Ir \text{ But } V = Ir \Rightarrow I = \frac{V}{R}$$

$$\therefore\ V = \varepsilon - \frac{Vr}{R}$$

$$V + \frac{Vr}{R} = \varepsilon \Rightarrow V\left[1 + \frac{r}{R}\right] = \varepsilon$$

$$1 + \frac{r}{R} = \frac{\varepsilon}{V} \Rightarrow \frac{r}{R} = \frac{\varepsilon}{V} - 1 \Rightarrow r = \frac{\varepsilon R}{V} - R$$

(38) Answer [D]

The generated heat energy by passing electric current for time t through resistance R_1 with electric cell is

$$W_1 = I_1^2 R_1 t = \left[\frac{\varepsilon}{R_1 + r}\right]^2 R_1 t$$

Similarly $W_2 = I_2^2 R_3 t = \left[\frac{\varepsilon}{R_2 + r}\right]^2 R_2 t$

But $W_1 = W_2$,

$$\frac{\varepsilon^2 R_1 t}{(R_1 + r)^2} = \frac{\varepsilon^2 R_2 t}{(R_2 + r)^2}$$

$$R_2\left(R_2^2 + 2R_2 r + r^2\right)$$

$$= R_2\left(R_1^2 + 2R_1 r + r^2\right)$$

$r^2 \ (R_1 - R_2) = R_1 \cdot R_2 \ (R_1 - R_2)$

$\therefore \ r = \sqrt{R_1 R_2}$

(41) Answer [D]

Both batteries are in series connection so,

total *emf* $\varepsilon = 2 + 2 = 4$ V

total internal resistance $r = 1 + 1 = 2 \ \Omega$

Power in outer resistans R is $P = \left[\dfrac{\varepsilon}{R + r}\right]^2 R$

For maximum power, taking $r = R$.

$$P_{max} = \left[\frac{4}{2+2}\right]^2 \times 2 = 2 \text{ W}$$

(42) Answer [A]

Cell *emf*, $\varepsilon = V + Ir$

$$\text{Internal Resistance, } r = \frac{\varepsilon - V}{I} = \frac{2.2 - 1.8}{0.36} = \frac{10}{9}\Omega$$

$$\left[\because I = \frac{V}{R} = \frac{1.8}{5} = 0.36\text{A}\right]$$

(43) Answer [B]

Current, $I = \dfrac{\varepsilon}{R + r}$, $0.75 = \dfrac{3.75}{4 + r}$

$4 + r = \dfrac{3.75}{0.75} = 5$, $r = 1 \ \Omega$

$$\text{Now } I' = \frac{\varepsilon}{R + r} = \frac{3.75}{10 + 1} = \frac{3.75}{11} = 0.34 \text{ A}$$

(44) Answer [B]

Electromotive force of battery

$\varepsilon = I_1 \ (R_1 + r)$ and $\varepsilon = I_2 \ (R_2 + r)$

$\therefore \ I_1 \ (R_1 + r) = I_2 \ (R_2 + r)$

$0.9 \ (2 + r) = 0.3 \ (7 + r)$

$3 \ (2 + r) = 7 + r, \ 6 + 3r = 7 + r$

$2r = 1 \Rightarrow r = 0.5 \ \Omega$

(45) Answer [C]

Due to the series connection of both batteries in circuit, the flow of equal electric current is $I = \dfrac{2\varepsilon}{R + r_1 + r_2}$

the P.*d.* between both ends of the first battery is $V_1 = \varepsilon - Ir_1$

$$= \varepsilon - \frac{2\varepsilon r_1}{R + r_1 + r_2}$$

$$\therefore \ V_1 = \frac{\varepsilon R + \varepsilon r_1 + \varepsilon r_2 - 2\varepsilon r_1}{R + r_1 + r_2} = 0$$

$\therefore$ for $\varepsilon \ (R + r_2 - r_1) = 0$, $R = r_1 - r_2$

(46) Answer [C]

The effective resistance between S and T of three resistances froms triangle.

$$R_1 = \frac{10 \times 20}{10 + 20} = \frac{20}{3} \ \Omega$$

Now, effective resistance between PSTR,

$$R_2 = 10 + \frac{20}{3} + 10 = \frac{80}{3} \ \Omega$$

Now, effective resistance between point P and R of circuit

$$\frac{1}{R} = \frac{1}{10} + \frac{1}{\frac{80}{3}} = \frac{1}{10} + \frac{3}{80} = \frac{11}{80}$$

$$\therefore \ R = \frac{80}{11} \ \Omega$$

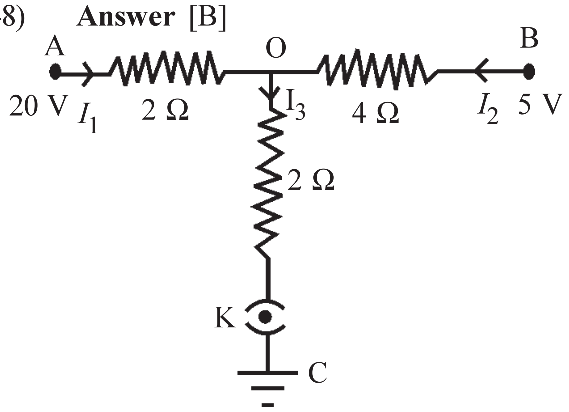
(47) Answer [C]

$$R_{PQ} = 3 + \frac{(3 + R) \times 10}{(3 + R) + 10}, \ R = 3 + \frac{30 + 10R}{13 + R}$$

$\therefore \ 13R + R^2 = 39 + 3R + 30 + 10 \ R$

$\therefore \ R^2 = 69 \Rightarrow R = \sqrt{69}$.

(48) **Answer** [B]



According to Kirchhoff's law for junction O,

$I_1 + I_2 = I_3$, $\frac{20 - V}{2} + \frac{5 - V}{4} = \frac{V - 0}{2}$

$2(20 - V) + (5 - V) = 2(V - 0)$

$40 - 2V + 5 - V = 2V$

$45 = 5V, \therefore V = 9V$

Thus, electric current flow from switch is

$I = \frac{V - 0}{2} = \frac{9}{2} = 4.5$ A

(49) Answer [B]

Given circuit forms wheastone bridge which is balanced so no current flows in BD branch. If current flows in path ABC and path ADC are respectively I_1 and I_2 then according to kirchhoff's first law,

$I_1 + I_2 = 7 \Rightarrow I_2 = 7 - I_1$

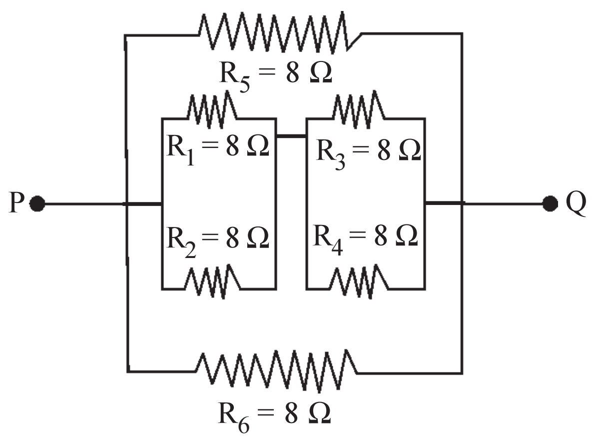
$I_1 \times (4 + 2) = I_2 \times (10 + 5)$

$6I_1 = 15I_2$, $2I_1 = 5(7 - I_2)$

$2I_1 = 35 - 5I_1 \Rightarrow I_1 = 5$ A

Now, P.*d.* between B and C $= 2 \times I_1 = 2 \times 5 = 10$ V

(50) Answer [B]



Simplifying the given circuit,

Resistance R_1 and R_2 are parallel connected in circuit so, their equivalent resistance is

$$R' = \frac{R_1 R_2}{R_1 + R_2} = \frac{8 \times 8}{8 + 8} = \frac{64}{16} = 4\ \Omega$$

Similarly,

$$R'' = \frac{R_3 R_4}{R_3 + R_4} = \frac{8 \times 8}{8 + 8} = \frac{64}{16} = 4\ \Omega$$

Resistance R' and R'' are in sereis connection so, their equivalent resistance is

$R''' = R' + R'' \Rightarrow R''' = 4 + 4 = 8\ \Omega$

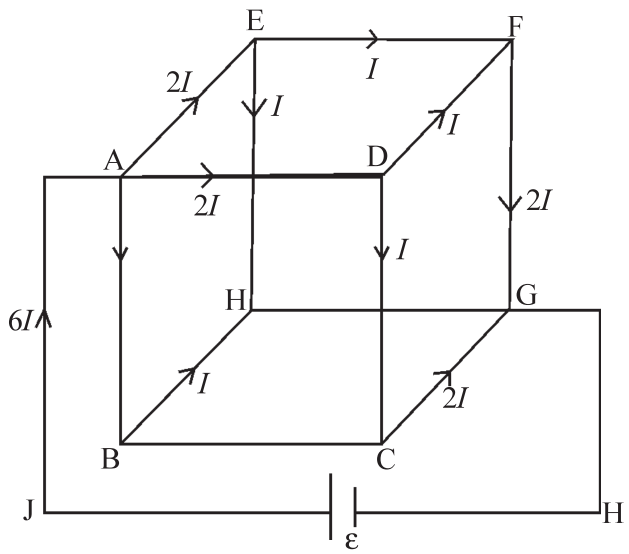
Resistance R_5, R'' and R_6 are in parallel connection so, their equivalent resistance is

$$\frac{1}{R} = \frac{1}{R_5} + \frac{1}{R'''} + \frac{1}{R_6} \Rightarrow \frac{1}{R}$$

$$= \frac{1}{8} + \frac{1}{8} + \frac{1}{8} \Rightarrow \frac{1}{R} = \frac{3}{8} \Rightarrow R = \frac{8}{3}\ \Omega$$

(51) Answer [C]

As shown in figure, the resistance of AB, AD and AE is same so the current flow from each is $\frac{6I}{3} = 2I$. Now, current at junction B, D and E equally distributed in two branches. These current together at junction C, F and H. So, same current $2I$ flows in CG, FG and HG branch. All three current combined at juction G, total current 6I is returned.



Applying kinchhoff's second law to closed loop ABCGHJA,

$-12(2I) - 12(I) - 12(2I) = -\varepsilon$

$60I = \varepsilon$ ...(1)

Taking equivalent resistance R between end points A and G of diagonal AG of cube, from Ohm's law,

$6IR = \varepsilon$ ...(2)

Comparison of equation (1) and (2)

$6IR = 60I \Rightarrow R = 10\ \Omega$

(52) Answer [C]

The equivalent resistance between A and B before the connection of resistance is, $R_{AB} = 2 + 2 + 2 + 2 + 2 = 10\ \Omega$. Connecting the resistance of 2 Ω at dashed line, it forms wheastone bridge. The resistance between point C and D of this bridge is also 2 Ω. So,

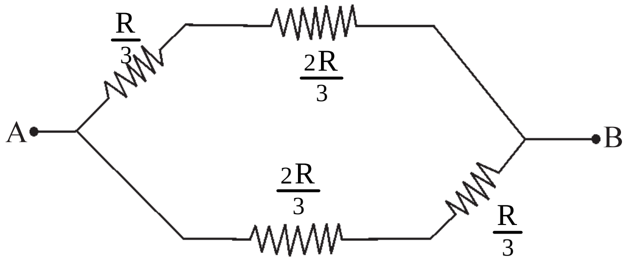
$R'_{AB} = 2 + 2 + 2 = 6\ \Omega$

$\therefore \dfrac{R_{AB}}{R'_{AB}} = \dfrac{10}{6} = \dfrac{5}{3}$

(53) Answer [C]

Here, resistance didn't complete the circuit. are neglected. Thus, the equivalent resistance for parallel connected three resistance connected in triangle is

$R_1 = \dfrac{R}{3}$ and the resultant resistance for triangle having three resistance (R) at side is



$R_2 = \dfrac{2R \times R}{2R + R} = \dfrac{2R^2}{3R} = \dfrac{2}{3}R$

Now, the equivalent resistance for series connection of $\dfrac{R}{3}$ and $\dfrac{2R}{3}$,

$R' = R_1 + R_2 = \dfrac{R}{3} = \dfrac{2R}{3} = R$

Thus, the equivalent resistance between point A and B is

$R_{AB} = \dfrac{R \times R}{R + R} = \dfrac{R}{2}.$

(54) Answer [C]

length of wire $l = 2\pi r = 2\pi \times 8 = 16\pi$ m

now total resistance $R = l\rho = 16\pi \times \dfrac{1}{\pi} = 16\ \Omega$

Resistance of minor arc $R_1 = \dfrac{6 \times 90}{360} = 4\ \Omega$

Resistance of major arc $R_1 = 16 - 4 = 12\ \Omega$

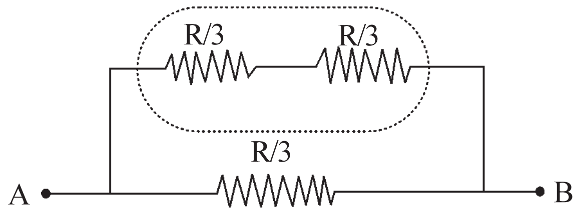
$\therefore$ The equivalent resistance between A and B is

$R_{AB} = \dfrac{4 \times 12}{4 + 12} = \dfrac{48}{16} = 3\ \Omega$

$\therefore$ Current flow in circuit is $I = \dfrac{10}{3} = 3.33$ A

(55) Answer [D]

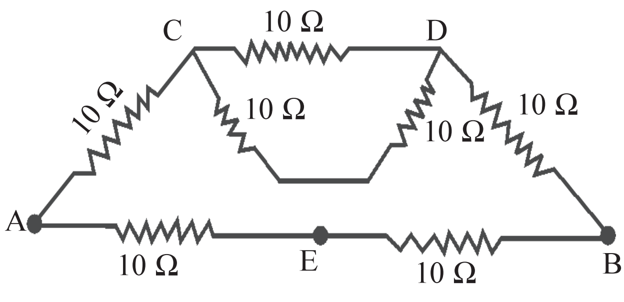
The parallel connection of resistance in all three path of given network So, the equivalent resistance is R/3 Ω. Now, the equivalent resistance between A and B points of triangle is as following :



$$R = \frac{\left(\frac{2R}{3}\right)\left(\frac{R}{3}\right)}{\frac{2R}{3} + \frac{R}{3}} = \frac{\frac{2R^2}{9}}{\frac{3R}{3}} = \frac{2}{9}\ R\ \Omega$$

(56) Answer [C]

The equivalent circuit of given circuit is as following.



Resultant Resistance in branch

$\text{A-C-D-B} = R_1 = \dfrac{80}{3}\ \Omega$

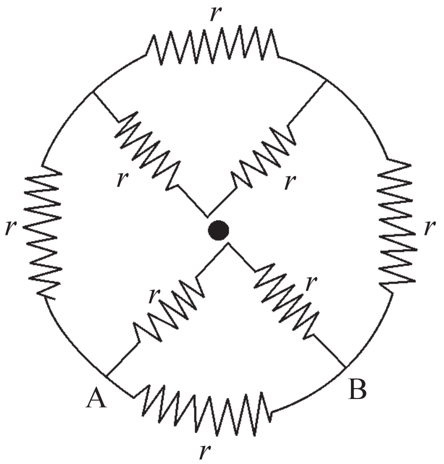
Resultant Resistance in branch A-E-B $= R_2 = 20\ \Omega$

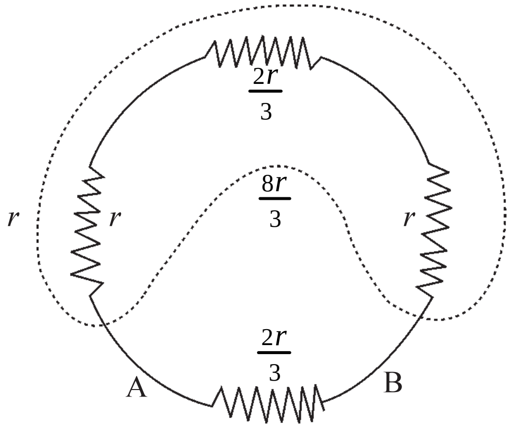
Now, R_1 and R_2 are parallel,

$$R_{AB} = \frac{R_1 R_2}{R_1 + R_2} = \frac{\frac{80}{3} \times 20}{\frac{80}{3} + 20} = \frac{80}{7}\ \Omega$$

(57) **Answer [C]**

Given circuit can draw as shown in following figure. So, the equivalent resistance between point A and B is

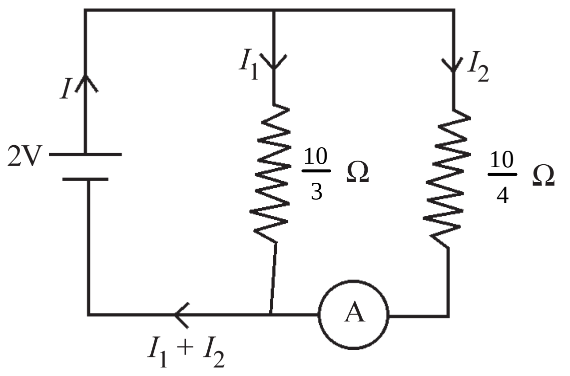




$$R_{AB} = \frac{\left(\frac{8r}{3}\right)\left(\frac{2r}{3}\right)}{\frac{8r}{3} + \frac{2r}{3}} = \frac{\frac{16r^2}{9}}{\frac{10r}{3}} = \frac{8}{15}r$$

(58) **Answer [D]**

Given circuit can be drawn as shown in following figure.

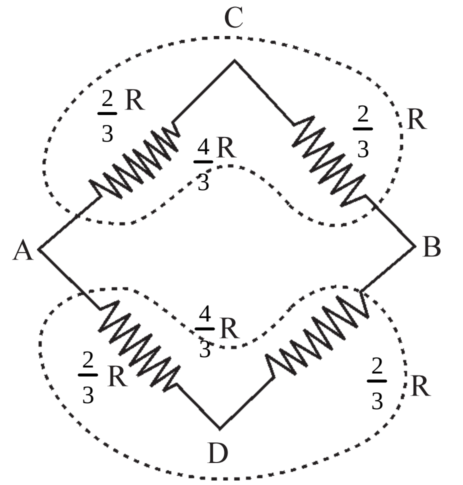


Electrical current flowing in Ameter is

$$I_2 = \frac{V}{R} + \frac{2}{\frac{10}{4}} + \frac{8}{10} = 0.8\text{ A}$$

(59) **Answer [C]**

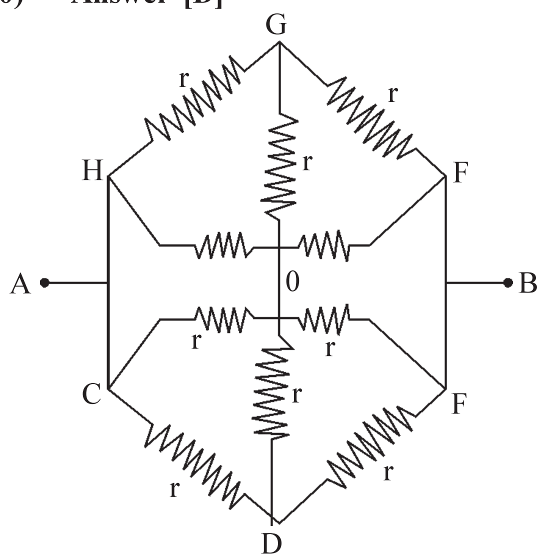
Given circuit can be drawn as shown in following figure.



the equivalent resistance between points A and B.

$$R_{AB} = \frac{\frac{4}{3}R\,\frac{4}{3}R}{\frac{4}{3}R + \frac{4}{3}R} = \frac{4}{6}R = \frac{2}{3}R$$

(60) **Answer [D]**



The simplified circuit of given circuit can drawn as shown in figure.

In equilibrium condition of wheastone bridge, the equivalent resistance of GHOFG close circuit is,

$$\frac{1}{R'} = \frac{1}{2r} + \frac{1}{2r} \Rightarrow \frac{1}{R'} = \frac{2}{2r} \qquad \therefore R' = r$$

Now, the equivalent resistance of COEDC circuit is

$$\frac{1}{R''} = \frac{1}{2r} + \frac{1}{2r} \Rightarrow \frac{1}{R''} = \frac{2}{2r} \quad \therefore R'' = r$$

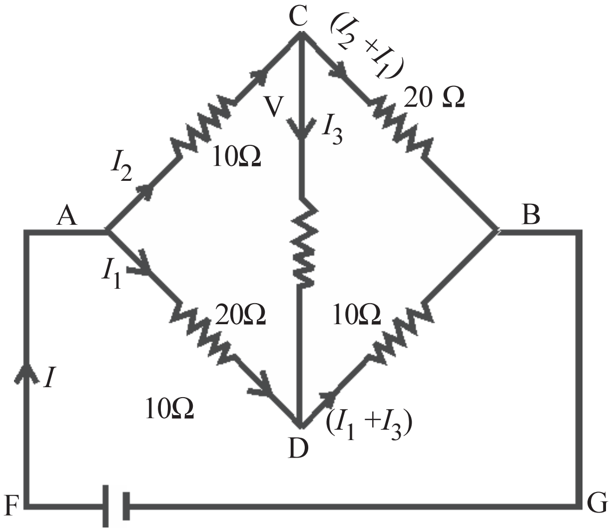
Thus, the equivalent resistance between points A and B

$$R = \frac{R'R''}{R' + R''} = \frac{r\,r}{r + r} = \frac{r^2}{2r} = \frac{r}{2}$$

$$\therefore R = \frac{r}{2}\,\Omega$$

(61) Answer [D]

The simplification of given circuit is wheastone bridge circuit. But this Wheastone bridge is not in balanced condition.



According to Kirchhoff's second law to ACDA close circuit,

$-10I_2 - 10I_3 + 20\,I_1 = 0$

$2I_1 - I_2 - I_3 = 0$ ...(1)

According to kirchhoff's second law to CBDC close - circuit,

$-20(I_2 - I_3) + 10(I_1 + I_3) + 10I_3 = 0$

$I_1 - 2I_2 + 4I_3 = 0$ ...(2)

According to Kirrchhoff's second law to ACBDA close circuit,

$-10I_2 - 20\,(I_2 - I_3) + 10(I_1 + I_3) + 20I_1 = 0$

$I_1 - I_2 + I_3 = 0$ ...(3)

from equation (1) and (2) $I_3 = \frac{1}{2}I_1$ ...(4)

from equation (1) and (3) $I_2 = \frac{3}{2}I_1$ ...(5)

Now, according to Kirchhoff's second law to ADBGFA close - circuit,

$-20I_1 - 10\,(I_1 + I_3) - \varepsilon = 0$

$3I_1 + I_3 - \frac{\varepsilon}{10} = 0$ ...(6)

Putting values of equation (4) in equation (6)

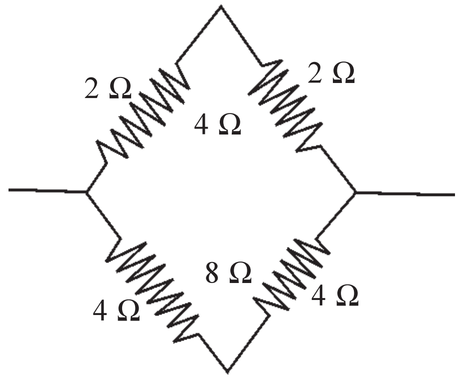
$$3I_1 + \frac{1}{2}I_1 - \frac{\varepsilon}{10} = 0 \Rightarrow \frac{7}{2}I_1 - \frac{\varepsilon}{10} = 0 \Rightarrow$$

$$\varepsilon = \frac{70}{2}I_1 = 35I_1$$

If effective resistance R between A and B then,

$$R = \frac{\varepsilon}{I_1 + I_2} = \frac{\varepsilon}{I_1 + \frac{3}{2}I_1} = \frac{2\varepsilon}{5I_1} = \frac{2}{5I_1} \times 35\,I_1 = 14\,\Omega$$

(62) Answer [C]



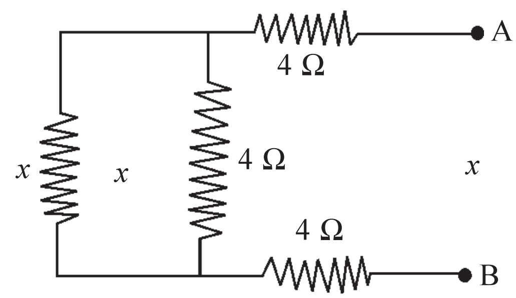
Due to the parallel connection of 4 Ω and 8 Ω resistance

$$R_1 = \frac{4 \times 8}{4 + 8} = \frac{32}{12} = \frac{8}{3}\,\Omega$$

The equivalent resistance between points A and B of circuit having four resistance in series connection is

$$R = \frac{8}{3} + \frac{8}{3} + \frac{8}{3} + \frac{8}{3} = \frac{32}{3}\,\Omega$$

(63) Answer [A]



The resistance between point A at infinite length and point B is x.

$$\frac{4x}{4+x} + 8 = x, \quad \therefore\ 4x + 8x + 32 = 4x + x^2$$

$$x^2 - 8x - 32 = 0$$

Compare with $ax^2 + bx + c$

$a = 1$, $b = -8$, $c = -32$

Now, $\Delta = b^2 - 4ac = 64 + 128 = 192$

Now, putting values in $\frac{-b \pm \sqrt{\Delta}}{2a}$

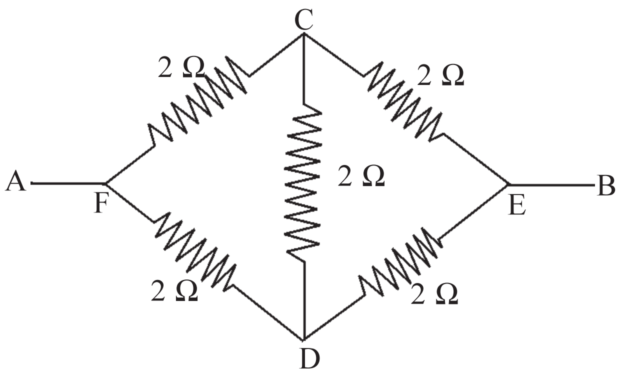
$x = 10.92$ or $x = -2.92$ which is not possible

$\therefore\ x = 10.92\ \Omega$

$\therefore$ Current flow from battery $I = \frac{10}{10.92 + 0.5}$

$$I = 0.88\ \text{A}$$

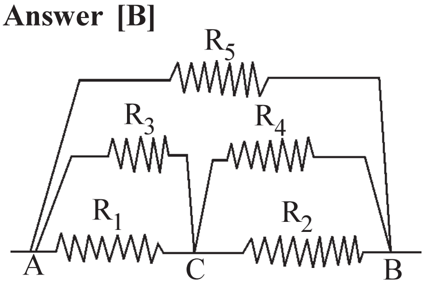
(64) Answer [A]



In balanced condition of wheastone bridge, the equivalent resistance between point A and B is

$$\frac{1}{R} = \frac{1}{4} + \frac{1}{4} = \frac{2}{4} = \frac{1}{2} \qquad \therefore\ R = 2\ \Omega$$

(65) Answer [B]



The circuit can draw as following for equal electric potential at points.

$R_1 = R_2 = R_3 = R_4 = R_5 = 4\ \Omega$

The equivalent resistance between points A and C is

$$\frac{1}{R_{AC}} = \frac{1}{R_1} + \frac{1}{R_3} \Rightarrow \frac{1}{R_{AC}} = \frac{1}{4} + \frac{1}{4} + \frac{2}{4}$$

$\Rightarrow R_{AC} = 2\ \Omega$, Similarly

$$\frac{1}{R_{CB}} = \frac{1}{R_2} + \frac{1}{R_4} \Rightarrow \frac{1}{R_{CB}} = \frac{1}{4} + \frac{1}{4} + \frac{2}{4}$$

$\Rightarrow R_{CB} = 2\ \Omega$

Now, $\frac{1}{R_{AB}} = \frac{1}{R_{AC} + R_{CB}} + \frac{1}{R_5}$

$$\Rightarrow \frac{1}{R_{AB}} = \frac{1}{2+2} + \frac{1}{4} \Rightarrow \frac{1}{R_{AB}} = \frac{2}{4} = \frac{1}{2}$$

$\therefore\ R_{AB} = 2\ \Omega$

(66) Answer [A]

In $R = \rho \frac{l}{A}$ ρl is equal so, $R \propto \frac{1}{A}$

$$\frac{R_2}{R_1} = \frac{A_1}{A_2} = \frac{3}{1} \Rightarrow R_2 = 10 \times 3 = 30\ \Omega$$

Series connection of both resistances their equivalent resistance is

$R = R_1 + R_2 \Rightarrow R = 10 + 30 = 40\ \Omega$

(67) Answer [A]

Resistance of each side of polygon is $\frac{R}{n}$. Taking resistance R_1 and R_2 of two part form by the opposite vertices of polygon, $R_1 = R_2 = \frac{n}{2} \times \frac{R}{n} = \frac{R}{2}$

Now, the equilibrium resistance for parallel connection of R_1 and R_2 is.

$$R' = \frac{R_1 R_2}{R_1 + R_2} = \frac{\frac{R}{2}\frac{R}{2}}{\frac{R}{2} + \frac{R}{2}} = \frac{R}{4} \qquad \text{...(1)}$$

Now, the resistance between vertex points one side of polygon is $R_3 = \frac{R}{n}$ and the resistance of remaining part is

$$R_4 = R - \frac{R}{n} = R\left[\frac{n-1}{n}\right]$$

Now, R_3 and R_4 are parallel connected so its equivalent resistance is

$$R'' = \frac{R_3 \times R_4}{R_3 + R_4} = \frac{\frac{R}{n} \times R\left(\frac{n-1}{n}\right)}{\frac{R}{n} + R\left(\frac{n-1}{n}\right)}$$

$$= \frac{R^2\left[\frac{n-1}{n^2}\right]}{\frac{R + Rn - R}{n}} = \frac{R^2\left[\frac{n-1}{n^2}\right]}{\frac{nR}{n}}$$

$$= \frac{R(n-1)}{n^2} \qquad ...(2)$$

Taking ratio of equation (2) and (1),

$$\frac{R(n-1)}{n^2} \times \frac{4}{R} = \frac{4(n-1)}{n^2}$$

(68) Answer [C]

The equivalent resistance for parallel connection of three resistances.

$$\frac{1}{R'} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\therefore \frac{1}{6} = \frac{1}{R} + \frac{1}{2R} + \frac{1}{3R} \Rightarrow \frac{1}{6} = \frac{11}{6R}$$

$\therefore$ R = 11 Ω

$\therefore$ $R_1 = R = 11\ \Omega$, $R_2 = 2R = 2 \times 11$
$= 22\ \Omega$, $R_3 = 3R = 3 \times 11 = 33\ \Omega$

Thus, the equavalent resistance for series connection of three resistances is

$R = R_1 + R_2 + R_3 = 11 + 22 + 33 = 66\ \Omega$.

(69) Answer [A]

The equivalent resistance for series connection of R_1 and R_2.

$R_1 + R_2 = 50\ \Omega$ ...(1)

The equivalent resistance for parallel connection of R_1 and R_2.

$$\frac{R_1 R_2}{R_1 + R_2} = 12\ \Omega \qquad ...(2)$$

Putting values of equation (1) in equation (2)

$$\frac{R_1 R_2}{50} = 12 \Rightarrow R_1 R_2 = 600 \Rightarrow R_1 = \frac{600}{R_2}$$

Putting values of R_1 in equation (1)

$$\frac{600}{R_2} + R_2 = 50 \Rightarrow 600 + R_2^2 = 50 R_2$$

$\therefore$ $R_2^2 - 50 R_2 + 600 = 0$

$\therefore$ $R_2 = 30\ \Omega$ or $R_2 = 20\ \Omega$

$R_1 = 20\ \Omega$ or $R_1 = 30\ \Omega$

(70) Answer [C]

The equivalent resistance of series connection of R_1 and R_2

$R_1 + R_2 = R_S$

The equivalent resistance for parallel connection of R_1 and R_2

$$\frac{R_1 R_2}{R_1 + R_2} = R_P$$

$\therefore$ $R_1 R_2 = R_P (R_1 + R_2) = R_P R_S = 16$ ...(1)

Now, $\frac{R_1}{R_2} = 4 \Rightarrow R_1 = 4R_2$ ...(2)

putting values in equation ...(1)

$4R_2 R_2 = 16 \Rightarrow R_2^2 = 4 \Rightarrow R_2 = 2\ \Omega$

Now, from equation (2) $R_1 = 4(2) = 8\ \Omega$

(71) Answer [B]

For series connection $S = R_1 + R_2$

For parallel connection $P = \frac{R_1 R_2}{R_1 + R_2}$

Now, $S = nP$, $R_1 + R_2 = n\left[\frac{R_1 R_2}{R_1 + R_2}\right]$

$(R_1 + R_2)^2 = n R_1 R_2$

for minimum value of n $R_1 = R_2 = R$

$(R + R)^2 = n (R R)$, $4R^2 = nR^2 \Rightarrow n = 4$.

(72) Answer [D]

According to kirchhoff's second law for PQST closed loop.

$I = \frac{12}{500 + R}$, potential between two ends of R.

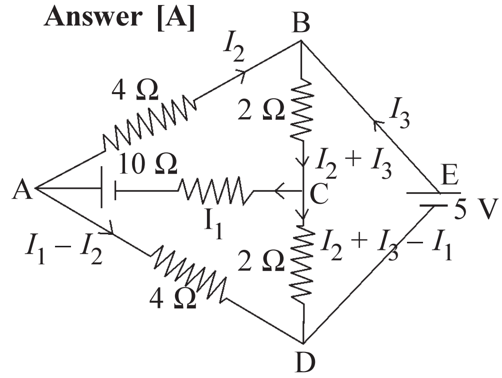
$$V = IR = \left[\frac{12}{500 + R}\right] R$$

When V = 2 V, the galvanometer shows zero deflection.

$$\therefore 2 = \frac{12}{500 + R} R$$

$1000 + 2R = 12 R \Rightarrow R = 100\Omega$

(73) Answer [A]



Kirchhoff's second law for ADCA closed - loop,

$-4(I_1 - I_2) + 2(I_2 + I_3 - I_1) - I_1 = -10$

$7I_1 - 6I_2 - 2I_3 = 10$ ...(1)

Similary, for ABCA closed loop,

$-4I_2 - 2(I_2 + I_3) - I_1 = -10$

$I_1 + 6I_2 + 2I_3 = 10$ ...(2)

Similary, for closed loop BCDEB,

$-2(I_2 + I_3) - 2(I_2 + I_3 - I_1) = -5$

$-2I_1 + 4I_2 + 4I_3 = 5$ ...(3)

Summation of equation (1) and (2),

$7I_1 - 6I_2 - 2I_3 = 10$

$I_1 + 6I_2 + 2I_3 = 10$

$8I_1 = 20$

$\therefore\ I_1 = \frac{5}{2}$ A. Multiply equation (2) by 2 and Substract from equation (3)

$-2I_1 \pm 12I_2 \pm 4I_3 = 20$

$-2I_1 + 4I_2 + 4I_3 = 5$

$-4I_1 - 8I_2 + 0I_3 = -15$

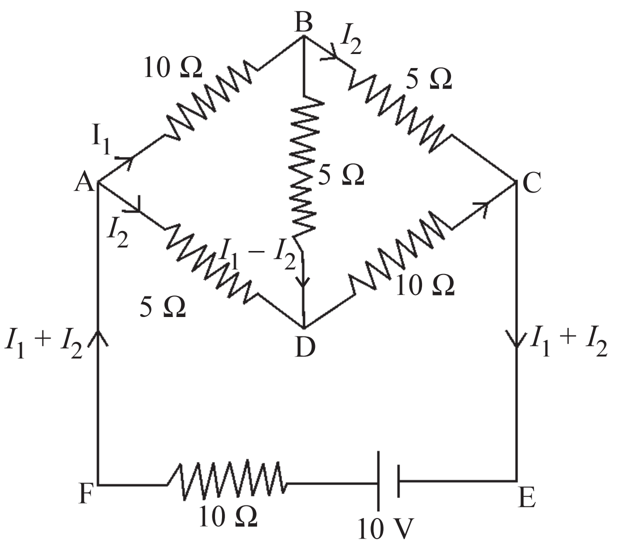
$4\left(\frac{5}{2}\right) + 8I_2 = +15, 8I_2 = +5,\ I_2 = \frac{5}{8}$ A

Putting values of I_1 and I_2 in equation (2),

$\left(\frac{5}{2}\right) + 6\left(\frac{5}{8}\right) + 2I_3 = 10$

$\frac{5}{2} + \frac{15}{4} + 2I_3 = 10\ 2I_3 = \frac{15}{4} \Rightarrow I_3 = \frac{15}{8}$ A

(74) Answer [B]



According to Kirchhoff's second law for ABDA closed loop,

$-10I_1 - 5(I_1 - I_2) + 5I_2 = 0$

$15I_1 = 10I_2$ ...(1)

For closed loop ABCEFA,

$-10I_2 - 5I_2 + 10 - 10(I_1 + I_2) = 0$

$20I_1 + 15I_2 = 10$ ...(2)

putting values of equation (1) into equation (2)

$20\left(\frac{10}{15} I_2\right) + 15I_2 = 0$

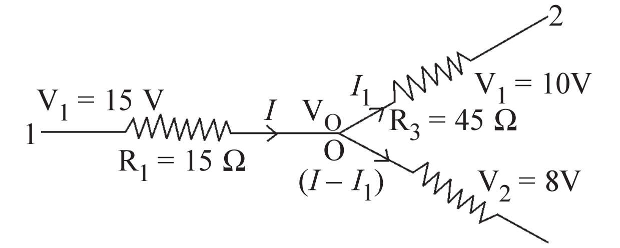
$I_2 = \frac{10 \times 15}{200 + 225} = \frac{150}{425} = \frac{6}{17}$ A

Now, $I_1 = \frac{10}{15} I_2 = \frac{10}{15} \times \frac{6}{17} = \frac{4}{17}$ A

Electrical current flowing from Galvanometer $= \left| I_1 - I_2 \right|$

$= \left| \frac{4}{17} - \frac{6}{17} \right| = \frac{2}{17}$ A

(75) Answer [C]



According to Kirchhoff's second law for 102 path,

$V_1 - IR_1 - I_1R_2 = V_2$, $15 - 15I - 30I_1 = 10$

$\therefore\ 3I - 6I_1 = 1$ ...(1)

According to Kirchhoff's second law for103 path,

$V_1 - IR_1 - (I - I_1)R_2 = V_3$

$15 - 15I - (I - I_1)45 = 8$

$-60I + 45I_1 = -7$ ...(2)

Solving equation (1) and (2), $I = 0.175$ A

If electric potential at junction is V_0 then,

$15 - V_0 = IR_1, V_0 = 15 - (0.175)(15) = 12.375$ V

(76) Answer [C]

emf of battery in initial condition $\varepsilon = I_1(R + r)$

emf of battery in final condition $\varepsilon = I_2(R. + R' + r)$

Now, $I_1(R + r) = I_2(R + R' + r)$

$8(0.02 + r) = 2(0.02 + 3 + r)$

[Final current $I_2 = 8 - 6 = 2$]

$0.16 + 8r = 6.04 + 2r$

$6r = 5.88 \Rightarrow r = 0.98\ \Omega$, now, $\varepsilon = I_1 (R + r)$

$= 8 (0.02 + 0.98) = 8$ V

(77) Answer [A]

Here $(n - 1)$ cells are connected in supporting positions and one cell connected in opposing position

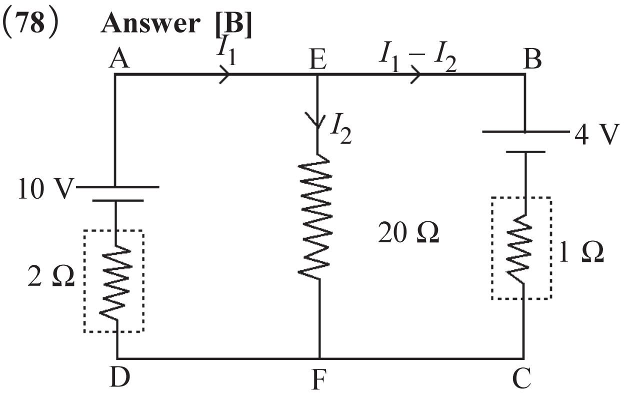
Electric current flowing in circuit $I = \dfrac{(n-1)\varepsilon - \varepsilon}{nr}$

$= \dfrac{(n-2)\varepsilon}{nr}$

Now, difference in electric potential $V = \varepsilon - Ir$

$= \varepsilon - \left[\dfrac{(n-2)\varepsilon}{nr}\right] r = \dfrac{n\varepsilon - n\varepsilon + 2\varepsilon}{n} = \dfrac{2\varepsilon}{n}$

(78) Answer [B]



According to Kirchhoff's second law for AEFDA closed loop,

$-20I_2 - 2I_1 = -10, I_1 + 10I_2 = 5$ ...(1)

According to Kirchhoff's second law for EBCFE closed loop,

$+20I_2 - 1(I_1 - I_2) = -4, I_1 - 21I_2 = 4$ ...(2)

Substracting equation (2) from (1),

$31I_2 = 1 \Rightarrow I_2 = \frac{1}{31} = 0.03$ A

(79) Answer [C]

The equivalent resistance of circuit

$r = \dfrac{r_1 r_2}{r_1 + r_2} = \dfrac{2 \times 2}{2 + 2} = 1\ \Omega$

The equivalent *emf* of circuit $\varepsilon = 4$ V

Electric current flowing in circuit

$I = \dfrac{\varepsilon}{R + r} = \dfrac{4}{1+1} = 2$ A

(80) Answer [B]

In equilibrium condition of Wheastone bridge,

$\dfrac{R_1}{R_2} = \dfrac{l_1}{l_2}$

For first condition $\dfrac{5}{R} = \dfrac{l_1}{100 - l_1}$ ...(1)

for second condition $\dfrac{5}{\frac{R}{2}} = \dfrac{1.6l_1}{100 - 1.6l_1}$

Taking ratio of equation (1) and (2)

$\dfrac{5}{R} \times \dfrac{R}{10} = \dfrac{l_1}{100 - l_1} \times \dfrac{100 - 1.6l_1}{1.6l_1}$

$\Rightarrow \dfrac{1}{2} = \dfrac{100 - 1.6l_1}{160 - 1.6l_1}$

$160 - 1.6l_1 = 200 - 3.2l_1$

$1.6l_1 = 40 \Rightarrow l_1 = 25$ cm

From equation (1),

$\dfrac{5}{R} = \dfrac{25}{75} \Rightarrow R = 15\ \Omega$

(81) Answer [B]

Due to the parallel connection of resistance 4 Ω and 3 Ω, P.*d*. between their two ends are equal.

$\therefore 4 \times 1 = 3 \times I_1$ Thus, electric current passing through resistance 3 Ω is $I_1 = \frac{4}{3}$ A

So, total current for POQ is $I = 1 + \frac{4}{3} = \frac{7}{3}$ A

P.*d*. between P and Q is $V = IR = \frac{7}{3} \times \left[\frac{4 \times 3}{4 + 3}\right] = 4$ V

So, electric current flowing in QNP path is,

$I' = \dfrac{V}{R'} = \dfrac{4}{1 + \frac{0.5 \times 0.5}{0.5 + 0.5}} = \dfrac{4}{1.25} = \dfrac{16}{5}$ A

Thus, P.*d*. between two ends of 1 Ω resistance

$V' = I'R = \frac{16}{5} \times 1 = 3.2$ V

(82) Answer [C]

When potentiometer is in equilibrium then voltage of potentiometer wire and *emf* of battery becomes same. $\varepsilon' = V$

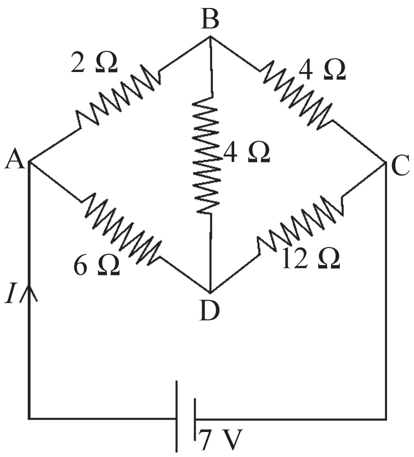
Electrostatic potential perunit length of potentiometer wire $= \dfrac{\varepsilon}{L}$

Thus, potential of wire at length l_1 is $V = \dfrac{\varepsilon}{L} l_1$

$$= \frac{\varepsilon}{200} = 40 = \frac{\varepsilon}{5}$$

(83) Answer [A]

Given circuit is equivalent circuit of Wheastone bridge. Thus, current flows from BD branch is zero.



Now, the resistance of branch AB and BC are in series connection so the equivalent resistance is $R_1 = 2 + 4 = 6\ \Omega$

The resistance of branch AD and DC is also series connection so the equivalent resistance is

$R_2 = 6 + 12 = 18\ \Omega$

Now, the equivalent resistance for parallel connection of resistance R_1 and R_2 is

$$R = \frac{R_1 R_2}{R_1 + R_2} = \frac{6 \times 18}{6 + 18} = 4.5\ \Omega$$

Current flows from battery $I = \frac{V}{R} = \frac{7}{4.5} = 1.55\ A$

(84) Answer [B]

In balanced condition of wheastone bridge

$$\frac{x}{l} = \frac{y}{(100 - l)},\ x = \frac{yl}{(100 - l)} = \frac{12.5 \times 39.5}{(100 - 39.5)}$$

$$= \frac{12.5 \times 39.5}{60.5} = 8.2\ \Omega$$

(85) Answer [C]

$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{l_3 + l_4}{l_3 - l_4} = \frac{6+2}{6-2} = \frac{8}{4} = \frac{2}{1}$$

(86) Answer [C]

Internal resistance of battery

$$r = \left[\frac{l_1 - l_2}{l_2}\right] R = \left[\frac{76.3 - 64.8}{64.8}\right](9.5) = 1.7\ \Omega$$

(87) Answer [C]

helping connection of ε_1 and ε_2, $(\varepsilon_1 + \varepsilon_2) \propto l_3$

Oppositing connection of ε_1 and ε_2, $(\varepsilon_1 - \varepsilon_2) \propto l_4$

$$\therefore\ \frac{\varepsilon_1 + \varepsilon_2}{\varepsilon_1 - \varepsilon_2} = \frac{l_3}{l_4} = \frac{64}{32} = 2$$

$$\therefore\ \varepsilon_1 + \varepsilon_2 = 2(\varepsilon_1 - \varepsilon_2)$$

$$\therefore\ 3\varepsilon_2 = \varepsilon \Rightarrow \frac{\varepsilon_1}{\varepsilon_2} = \frac{3}{1} = 3 : 1$$

(88) Answer [D]

In initial condition $\frac{20}{60} = \frac{l}{100 - l}$

$100 - l = 3l \Rightarrow l = 25$ cm

Now, ulternate the resistance

$\frac{60}{20} = \frac{l'}{100 - l'}$, $300 - 3l' = l' \Rightarrow l' = 75$ cm

So, netural point dispaced by $l' - l = 75 - 25 = 50$ cm.

(89) Answer [B]

Resistance per unit length of wire, $R = \frac{\rho}{A}$ [$\because l = 1$ m]

Multiply with I both sides,

potential gradient $\sigma = IR = \frac{I\rho}{A}$

$$= \frac{0.5 \times 10^{-12}}{10^{-6}} = 5 \times 10^{-7} = V\ m^{-1}$$

(90) Answer [B]

For potentiometer $V_l = \left[\frac{\varepsilon\rho}{R + L\rho + r}\right] l$

Here, $L\rho = 40\ \Omega$ and $L = 10$ m

So, $\rho = \frac{40}{L} = \frac{40}{10} = 4\ \Omega m^{-1}$

potential gradient

$$\sigma = \frac{V_l}{l} = \left[\frac{\varepsilon\rho}{R + L \quad + 0}\right],\ \therefore R = \frac{\varepsilon\rho}{\sigma} - L$$

$$= \frac{2 \times 4}{10^{-2}} - 40 = 800 - 40 = 760\ \Omega$$

(91) Answer [B]

total resistance of circuit $R = \frac{3 \times 6}{3+6} + 1 = 2 + 1 = 3\,\Omega$

Thus, total current pass in circuit

$I = \frac{V}{R} = \frac{12}{3} = 4$ A

Voltage in 1 Ω = IR = $1 \times 4 = 4$ V

Remaining voltage = 12 – 4 = 8 V, is across the combination of 3 Ω and 6 Ω.

Heat generated in 3 Ω resistance. is,

$H = \frac{V^2 t}{R} = \frac{(8)^2 \times 60}{3} = 1280$ J

(92) Answer [A]

total power $VI = (40\times15)+(100\times5)+(80\times5)+1000$
$= 600 + 500 + 400 + 1000 = 2500$ W

Current flow in fuse $I = \frac{2500}{220} = 11.36 \approx 12$ A

(93) Answer [C]

Electric power of electric motor

$P_1 = VI = 200 \times 5 = 1000$ W

Mechanical efficiency of electric motor

$= \frac{\text{Mechanical power}}{\text{electrical power}}$

$\therefore$ Mechanical power = electrical power $\times$ mechanical efficiency

$P_2 = 60 \times \frac{1}{100} \times 1000 = 600$ W

power dissipated as heat energy = Electric power – Mechanical power

$I^2 r = 1000 - 600 = 400$ W

$\therefore$ Resistance of winding wire of motor

$r = \frac{400}{I^2} = \frac{400}{25} = 16\,\Omega$

(94) Answer [C]

Resistance of each bulb $R = \frac{V^2}{P}$

Total resistance for series connection of n bulb.

$R' = nR = n\frac{V^2}{P}$

total power $P' = \frac{V^2}{R'} = \frac{V^2 P}{nV^2} = \frac{P}{n}$

(95) Answer [B]

Here length of both filament are same so its resistance will be same.

Suppose, Current flows from source is I.

Power loss in series connection of filament is

$P_S = I^2R + I^2R = 2I^2R$.

Due to the parallel connection of filament, the current flows from each filament will be $\left(\frac{I}{2}\right)$.

Power loss in parallel connection of filament is

$P_P = \left(\frac{I}{2}\right)^2 R + \left(\frac{I}{2}\right)^2 R = \frac{I^2 R}{2}$

$\therefore \frac{P_S}{P_P} = \frac{2I^2R}{\frac{I^2R}{2}} = \frac{4}{1} \Rightarrow 4:1$

(96) Answer [C]

The equivalent power for series connection of both resistance

$P_S = \frac{V^2}{R_S} = \frac{V^2}{R_1 + R_2}$

The equivalent power for paralled connection of both resistance.

$P_P = \frac{V^2}{R_P} = \frac{V^2}{\frac{R_1 R_2}{R_1 + R_2}}$, Now, $P_P = 5\,P_s$

$\frac{V^2}{\frac{R_1 R_2}{R_1+R_2}} = 5\,\frac{V^2}{R_1 + R_2}$

$(R_1 + R_2)^2 = 5\,R_1R_2$

$R_1^2 = 2R_1R_2 + R_2^2 = 5\,R_1R_2$

$R_1^2 - 3R_1R_2 + R_2^2 = 0$

$1000 - 300R_2 + R_2^2 = 0$, Compare with

$ax^2 + bx + c = 0$, a = 1000, b = –300, c = 1

$\Delta = b^2 - 4ac = (-300)^2 - 4(1000)(1)$
$= 50{,}000$

$R_2 = \frac{-b + \sqrt{\Delta}}{2a}$ or $R_2 = \frac{-b - \sqrt{\Delta}}{2a}$

$= \frac{-(-300) + \sqrt{50{,}000}}{2(1)}$

or $= \frac{-(-300) - \sqrt{50{,}000}}{2(1)}$

$R_2 = 262\,\Omega$ or $R_2 = 38\,\Omega$

(97) Answer [A]

Joule constant $J = \frac{W}{H} = \frac{V^2 t}{RH} \Rightarrow H = \frac{V^2 t}{RJ}$

But H = Q = mL Where L = Latent heat of melting of Ice = 80 Cal g^{-1}, $\therefore$ mL $= \frac{V^2 t}{RJ}$

$\therefore$ Melting rate of Ice

$$\frac{m}{t} = \frac{V^2}{RJL} = \frac{(-210)^2}{20 \times 4.2 \times 80} = 6.56 \text{ gs}^{-1}$$

(98) Answer [D]

Resistance of B_1 buld $R_1 = \frac{V^2}{P_1} = \frac{(250)^2}{100} = 625\,\Omega$

Resistance of B_2 buld $R_2 = \frac{V^2}{P_2} = \frac{(250)^2}{60} = 1042\,\Omega$

Resistance of B_3 buld $R_3 = \frac{V^2}{P_3} = \frac{(250)^2}{60} = 1042\,\Omega$

The equal electric current passing through series connection of Bulb B_1 and B_2

$$I_1 = \frac{V}{R_1 + R_2} = \frac{250}{625 + 1042} = \frac{250}{1667} = 0.149\text{A}$$

Output power of B_1 buld

$W_1 = I_1^2 R_1 = (0.149)^2 (625) = 14$ W

Output power of B_2 buld

$W_2 = I_2^2 R_2 = (0.149)^2 (1042) = 23.1$ W

Output power of B_3 buld

$$W_3 = \frac{V^2}{R_3} = \frac{(250)^2}{1042} = 60 \text{ W}$$

So, $W_1 < W_2 < W_3$

(99) Answer [B]

Heat energy $H = \frac{V^2 t}{RJ} = \frac{V^2 t}{\frac{\rho l}{A} J} = \frac{V^2 A t}{\rho l J}$

In first case, $H_1 = \frac{V^2 A t_1}{l_1 J}$, In second case,

$H_2 = \frac{V^2 A t_2}{l_2 J}$, But $H_1 = H_2$

$$\frac{V^2 A t_1}{l_1 J} = \frac{V^2 A t_2}{l_2 J} = \frac{V^2 A t_2}{\left(\frac{2}{3} l_2\right) J}$$

$$t_2 = \frac{2}{3} t_1 = \frac{2}{3} \times 15 = 10 \text{ minute}$$

(100) Answer [D]

If equal resistance of each n resistor is r then maximum resistance for series connection is $R_{max} = nr$

minimum resistance for parallel connection of resistance $R_{min} = \frac{r}{n}$

Now, power $P \propto \frac{1}{R}$

$\therefore P_P \propto \frac{1}{R_{min}}$ and $P_\rho \propto \frac{1}{R_{max}}$

$\therefore \frac{P_P}{P_S} = \frac{R_{max}}{R_{min}} = \frac{nr}{\frac{n}{r}} = n^2$, $\therefore P_P = n^2 P_s$

$= (4)^2 \times 20 = 16 \times 20 = 320$ W

(101) Answer [A]

In circuit A, Connection of ameter in series with resistance and voltmeter in parallel with resistance so, it is appropniate cricuit.

(102) Answer [A]

Resistance of wire $R = \frac{l}{A}$

Area of cross - section in AB direction is ac and length b. So, resistance of wire is $R = \frac{\rho b}{ac}$.

(103) Answer [B]

Resistance of wire, $R = R_0 (1 + \alpha \Delta T)$

$4 = 2 (1 + 1.25 \times 10^{-3} \Delta T)$

$2 = 1 + 1.25 \times 10^{-3} \Delta T$, $\frac{1}{1.25 \times 10^{-3}} = \Delta T$

$\therefore \Delta T = 800$ K, $T_F = T_0 + \Delta T$

$= 300 + 800 = 1100$ K

$= 1100 - 273 = 827°$ C

(104) Answer [B]

The equivalent resistance for parallel connection of n resistances.

$$\frac{1}{R_1} + \frac{1}{R_2} + ... + \frac{1}{R_{n-1}} + \frac{1}{R_n} = \frac{1}{x} \quad ...(1)$$

If removing the one resistance, the equivalent resistance.

$$\frac{1}{R_1} + \frac{1}{R_2} + ... + \frac{1}{R_{n-1}} = \frac{1}{y} \quad ...(2)$$

Substracting equation (2) and (1)

$$\frac{1}{R_n} = \frac{1}{x} - \frac{1}{y} \Rightarrow \frac{1}{R_n} = \frac{y - x}{xy}$$

$$\therefore R_n = \frac{xy}{y - x}$$

(105) Answer [C]

The slope of V $\rightarrow$ I graph shows resistance

$\therefore\ R_1 = R_0\,[1 + \alpha\, T_1]$

$\tan\theta = R_0\,[1 + \alpha\, T_1]$

...(1) Slope $R_1 = \tan\theta$

Now, $R_2 \quad = R_0\,[1 + \alpha\, T_2]$

$\cot\theta = R_0\,[1 + \alpha\, T_2]$

...(2) Slope $R_2 = \cot\theta$

$\therefore\ \cot\theta - \tan\theta = R_0\,[1 + \alpha\, T_2] - R_0\,[1 + \alpha\, T_2]$

$= R_0\,[\alpha\,(T_2 - T_1)]$

$$\therefore\ T_2 - T_1 = \frac{1}{R_{0\alpha}}(\cot\theta - \tan\theta)$$

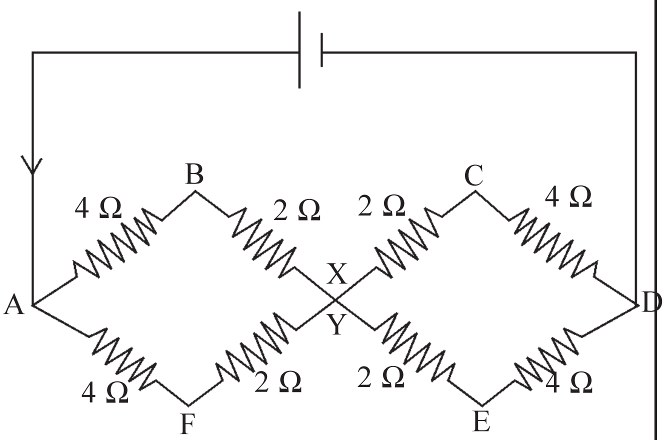
$$\therefore\ T_2 - T_1 \quad = \frac{1}{R_{0\alpha}}\left[\frac{\cos\theta}{\sin\theta} - \frac{\sin\theta}{\cos\theta}\right]$$

$$= \frac{1}{R_{0\alpha}}\left[\frac{\cos\theta}{\sin\theta} - \frac{\sin\theta}{\cos\theta}\right]$$

$$= \frac{1}{R_{0\alpha}}\left[\frac{\cos 2\theta}{\frac{1}{2}\sin 2\theta}\right] = \frac{1}{R_{0\alpha}}\ 2\cot 2\theta$$

$$\therefore\ T_2 - T_1 \propto \cot 2\theta \left[\because \frac{2}{R_{0\alpha}} \text{is constant}\right]$$

(106) Answer [D]



Potential is equal at XY point. due to symetrical circuit. As shown in circuit. Wheatstane bridge ABXF and XCDE are balanced. So resistance between BF and CE are not effective.

$$\therefore\ R_{AX} = \frac{(4+2)(4+2)}{(4+2)+(4+2)} = 3\ \Omega$$

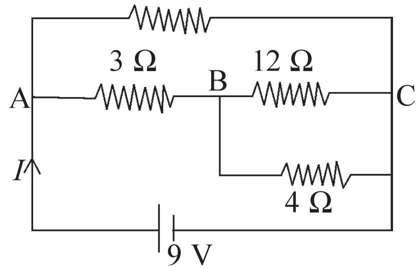
Similarly $R_{XD} = 3\ \Omega$

So, $R_{AD} = R_{AX} + R_{XD} = 3 + 3 = 6\ \Omega$

thus, electric current $I = \dfrac{V}{R_{AD}} + \dfrac{6}{6} = 1$ A

(107) Answer [B]

Given circuit can describe as following figure :



In figure, the parallel connection of 12 Ω and 4 Ω So, their equivalent resistance is

$$R_1 = \frac{12 \times 4}{12 + 4} = \frac{48}{16} = 3\ \Omega$$

Which is in series connection with 3 Ω between A and B.

$R_2 = 3 + 3 = 6\ \Omega$

This 6 Ω and other 6 Ω are in parallel connection,

$$\therefore \text{Equivalent resistance } R = \frac{6 \times 6}{6 + 6} = \frac{36}{12} = 3\ \Omega$$

Electric current flowing in battery $I = \dfrac{V}{R} = \dfrac{9}{3} = 3$ A

(108) Answer [A]

Resistance of wire

$$R = \rho\frac{l}{A} \Rightarrow R = \frac{\rho l A}{A A} = \frac{\rho V}{A^2} = \frac{\rho V}{\left(\pi r^2\right)^2}$$

$$\therefore\ R \propto \frac{1}{r^4},\ \therefore\ \frac{R_2}{R_1} = \left[\frac{r_1}{r_2}\right]^4 = \left[\frac{r}{nr}\right]^4$$

$$\therefore\ R_2 = \frac{R}{n^4}$$

(109) Answer [D]

Suppose, resistance of each resistor is R.

total resistance for series connection $R_1 = 3$ R

So, loss of power $P_1 \propto \frac{1}{R_1} \alpha \frac{1}{3R}$

total resistance for parallel connection $R_2 = \frac{R}{3}$

So, loss of power $P_2 \propto \frac{1}{R_2} \alpha \frac{3}{R}$

$$\therefore \frac{P_2}{P_1} = \frac{R_1}{R_2} = \frac{3R}{\frac{R}{3}} = 9$$

$$\therefore P_2 = 9 \times P_1 = 9 \times 100 = 900 \text{ W}$$

(110) Answer [A]

The equivalent resistance for series connection of two same resistance is double and for parallel connection it is halved. Thus, resistance is less for parallel connection. The slope of line OA in graph is less so, required graph is *a*.

(111) Answer [B]

For wheastone bridge $\frac{R_1}{R_2} = \frac{l_1}{(100 - l_1)}$

$$\frac{x}{12} = \frac{40}{(100 - 40)} \Rightarrow x = \frac{12 \times 4}{6} = 8\ \Omega$$

(112) Answer [A]

for first case

$$\frac{P}{40} = \frac{P}{60} \Rightarrow P = \frac{Q \times 40}{60} \qquad ...(1)$$

connecting 60 Ω parallel to Q, the resistance decreases of that branch of according, for maintain same ratio, length of according with branch is finally decreases.

So, for second case $\frac{P}{40+20} = \frac{\left[\frac{60Q}{60+Q}\right]}{(60-20)}$

$$\Rightarrow P = \frac{60 \times 60Q}{40(60 + Q)} \qquad ...(2)$$

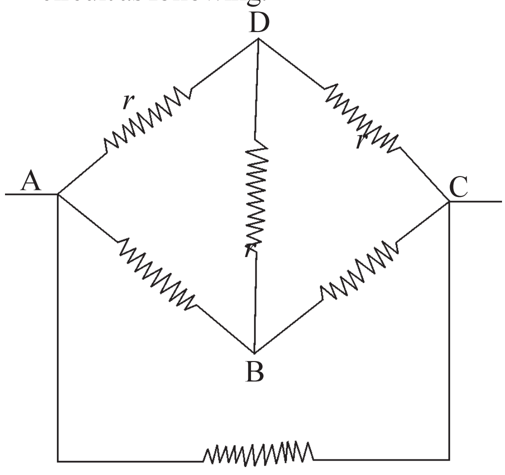
Comparison of equation (1) and (2),

$$\frac{40Q}{60} = \frac{60 \times 60Q}{40(60 + Q)}$$

$Q = 75\ \Omega$ and $P = 50\ \Omega$

(113) Answer [D]

Given circuit can draw as its equivalent circuit as following.



Here Wheastone bridge is in equilibrium condition So, the effective resistance between point B and D is zero

$$R_1 = \frac{2r \times 2r}{2r + 2r} = r$$

Now, Resistance R_1 and r are in parallel cnnection So,

$$R_{AB} = \frac{R_1 r}{R_1 + r} = \frac{r\,r}{r + r} = \frac{r^2}{2r} = \frac{r}{2}$$

(114) Answer [A]

Slope of $V \rightarrow I$ graph shows resistance. with increasing temperature, the value of resistance increases. For temperature T_1 $\frac{\Delta V}{\Delta I}$ is lowest means resistance is lowest and for temperature T_3, $\frac{\Delta V}{\Delta I}$ is highest means resistance is highest.

(115) Answer [A]

In experiment of meterbridge, $\frac{R_1}{R_2} = \frac{l_1}{l_2} = \frac{l_1}{(100 - l_1)}$

For first case, $\frac{P}{Q} = \frac{20}{100 - 20} = \frac{20}{80} = \frac{1}{4}$

For second case, $\frac{4P}{Q} = \frac{l_2}{(100 - l_2)}$

$$\therefore 4 \times \frac{1}{4} = \frac{l_2}{100 - l_2}, 100 - l_2 = l_2 \Rightarrow l_2 = 50 \text{ cm}$$

(116) Answer [D]

Here no current pass from Galvanometer due to the balanced condition of wheatstone bridge So, equivalent resistance of meterbridge

$$R = \frac{(10+30)(20+60)}{(10+30)+(20+60)} = 26.7\ \Omega$$

Electric current flowing from ballery

$$I = \frac{5}{26.7+2} = 0.174\ A$$

(117) Answer [D]

In equilibrium condition of Wheatstone bridge, $\frac{R_1}{R_2} = \frac{R_3}{R_4}$

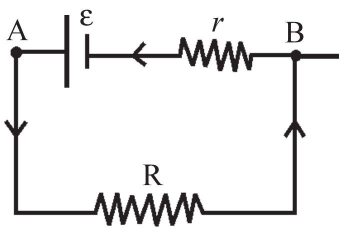
Changing the position of resistance R_1, R_2, R_3 and R_4, Wheastonbridge is not in balanced condition so, current flows from galvanometer thus its deflection is not zero. While in remaining condition, Wheatstone bridge is in balanced condition so no current flows from galvanometer thus its deflection remain zero.

(118) Answer [C]

$\varepsilon_1 \propto l_1 \Rightarrow \varepsilon_1 = \phi\, l_1$ and $\varepsilon_2 = \phi\, l_2$

$\therefore \frac{\varepsilon_2}{\varepsilon_1} = \frac{l_2}{l_1}, \therefore \varepsilon_2 = \left[\frac{63}{35}\right] \times 1.25 = 2.25\ V$

(119) Answer [A]



Potential gradient of wire = K

E = 250 K Now, $V_{AB} = \varepsilon - Ir = IR = 125\ K$

$\therefore I = \frac{125\,K}{R} = \frac{125}{2} K$

Now, $\varepsilon - Ir = 125\ K \Rightarrow 250\ K - \frac{125}{2} K(r) = 125\ K$

$\therefore r = 2\ \Omega$

(120) Answer [C]

Internal resistance of primary cell

$$r = R\left[\frac{l_1 - l_2}{l_2}\right] = 10\left[\frac{7.8-7}{7.0}\right] = 1.14\ \Omega$$

(121) Answer [C]

According the theory of potentiometer

$L\rho = 10\ \Omega$, L = 1 m, $\therefore \rho = 10\ \Omega m^{-1}$

$$V_l = \left[\frac{\varepsilon}{R + L\ \ + r}\right] l$$

$$\frac{10 \times 10^{-3}}{0.4} = \frac{2 \times 10}{R + 10 + 0}$$

$$R + 10 = \frac{2 \times 10 \times 0.4}{10 + 10^{-3}} = 800$$

$\therefore R = 800 - 10 = 790\ \Omega$

(122) Answer [A]

$V_l = \left[\frac{\varepsilon}{R + L\ \ + r}\right] l$, Potential gradient

$$\sigma = \frac{Vl}{l} = \frac{\varepsilon}{R + L + r} = \frac{2 \times 2 \times 10^{-2}}{4 + 1 + 0}$$

$= 8 \times 10^{-3}\ V\ cm^{-1}$

(123) Answer [A]

emf of battery = Potential potential gradient × length of potentiometer wire at neutral point.

$$\frac{V_0}{4} \times 1 = \frac{V_0}{5} \times l, l = \frac{5}{4} = 1.25\ m$$

(124) Answer [C]

For potentiometer $V_l = \left[\frac{\varepsilon}{R + L\ \ + 0}\right] l$

$$= \frac{5 \times 2 \times 0.4}{20 + 30 + 0} = \frac{5 \times 2 \times 0.4}{50} = 0.08\ V$$

(125) Answer [B]

For battery, $V = \varepsilon - Ir \Rightarrow \varepsilon = V + Ir$

r = internal resistance battery

for frist condition $\varepsilon = V_1 + I_1 r \Rightarrow \varepsilon = 1.2 + 0.04\,r$

for second condition $\varepsilon = V_2 + I_2 r \Rightarrow \varepsilon = 0.8 + 0.12\,r$

So, $1.2 + 0.04\,r = 0.8 + 0.12\,r$

$0.4 = 0.08\,r, \therefore r = \frac{0.4}{0.08} = 5\ \Omega$

electromotive force of battery $\varepsilon = V_1 + I_1 r$

$= 1.2 + 0.04 \times 5 = 1.2 + 0.20 = 1.4\ V$

(126) Answer [B]

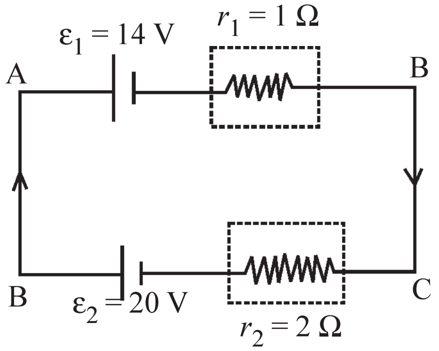
maximum current pass thorugh battery

$$I = \frac{\varepsilon}{r} = \frac{1.4}{5} = 0.28\ A$$

(127) Answer [B]

maximum power $P_{max} = \dfrac{\varepsilon^2}{4r}$

$= \dfrac{(1.4)^2}{4 \times 5} = \dfrac{1.96}{20} = 0.098 \text{ W} = 98\, m\text{W}$



(128) Answer [C]

Here $\varepsilon_2 > \varepsilon_1$ so, current flows from ε_2 to ε_1. Applying kirchhoff's second law to closed loop ABCDR, $-I - 2I = 14 - 20$

$3I = 6 \Rightarrow I = 2\text{A}$

(129) Answer [D]

Electric power in ε_1 battery

$= \varepsilon_1 I = 14 \times 2 = 28 \text{ W}$

Electric power in ε_2 battery

$= \varepsilon_2 I = 20 \times 2 = 40 \text{ W}$

(130) Answer [A]

terminal vollage in ε_1 battery (charging condition)

$V_1 = \varepsilon_1 - I_1 r_1 \Rightarrow V_1 = 14 - (2 \times 1)$

$\Rightarrow V_1 = 14 - 2 \Rightarrow V_1 = 12 \text{ V}$

terminal vollage in ε_1 battery (discharging condition)

$V_2 = \varepsilon_2 + [r_2 \Rightarrow V_2 = 20 + (2 \times 2) \Rightarrow V_2 = 20 + 4 \Rightarrow V_2 = 24 \text{ V}$

(131) Answer [B]

loss of electric power in ε_1 battery

$P_1 = I^2 r_1 \Rightarrow P_1 = (2)^2 \times 1 = 4 \text{ W}$

loss of electric power in ε_2 battery

$P_2 = I^2 r_2 \Rightarrow P_2 = (2)^2 \times 2 \Rightarrow P_2 = 8 \text{ W}$

(132) Answer [B]

Resistance of Bulb A

$$R_A = \frac{V_A^{\ 2}}{P_A} = \frac{110 \times 110}{40} = 302.5\ \Omega$$

Resistance of Bulb B

$$R_B = \frac{V_B^{\ 2}}{P_B} = \frac{110 \times 110}{100} = 121\ \Omega$$

When Bulb A and B connected in series, the equal electric current pass through each Bulb.

(133) Answer [A]

$$I = \frac{V}{R_A + R_B} = \frac{220}{302.5 + 121} = 0.515 \text{ A}$$

current capacity of bulb A is $I_A = \dfrac{P_A}{V_A} = \dfrac{40}{110} = 0.3636 \text{A}$

current capacity of bulb B is $I_B = \dfrac{P_B}{V_B} = \dfrac{100}{110} = 0.9090 \text{A}$

Here $I > I_A$ and $I < I_B$ so, Bulb A will fused

(134) Answer [B]

In $V_d = a\,\tau$, τ is a relaxation time and a is acceleration. With increasing temperature τ decreases so V_d is also decreases. Thus, sentence is true. conductivity of metal is $\sigma = \dfrac{l}{RA}$. With increasing temperature R increases and σ decreases so, reason is also true. But cause is not true explonation of statement.

(136) Answer [A]

$P = I^2 R$. Thus in series connection $P \propto R$, So bulb of 60 W will more bright and in parallel connection, $P = \dfrac{V^2}{R}$

$\therefore P \propto \dfrac{1}{R}$ So, bulb of 200 W will more bright.

Thus, statement and cause both are ture and cause is true explanation of statement.

(137) Answer [B]

$R_S = R + R = 2R, R_P = \dfrac{R \times R}{R + R} = \dfrac{R}{2} \therefore \dfrac{R_S}{R_P} = \dfrac{4}{1}$

Statement and cause both are true but cause is not a true explanation of the statement.

(139) Answer [A]

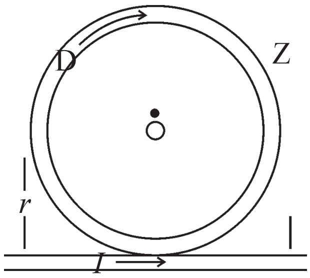
Here statement and cause both are true, Because according to formula $V = \varepsilon - Ir$, to make $V = \varepsilon$ requires $I = 0$ and after connection of battery with voltmeter $I \neq O$.

●

13 Magnetic effect of Electric current and Magnetism

(2) Answer [B]

The equivalent figure for given figure is mentioned below. The magnetic field produced by linear wire at point O is



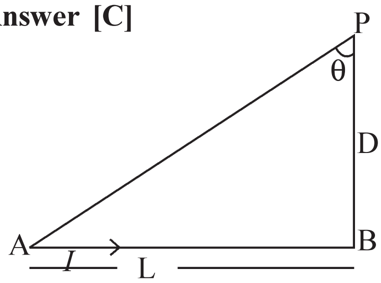
$B_1 = \frac{\mu_0}{4\pi}\frac{2I}{r}$. The magnetic field produced at point O due to the circular loop $B_2 = \frac{\mu_0}{4\pi}\frac{2\pi I}{r}$

Both are in opposite direction to each other

∴ The resultant magnetic field at point O is

$$B = B_1 - B_2 = \frac{\mu_0}{4\pi}\frac{2I}{r}(\pi - 1)$$

(3) Answer [C]



From Biot - Savart law,

$$B = \frac{\mu_0 IL}{4\pi D}(\sin\theta + \sin 0)$$

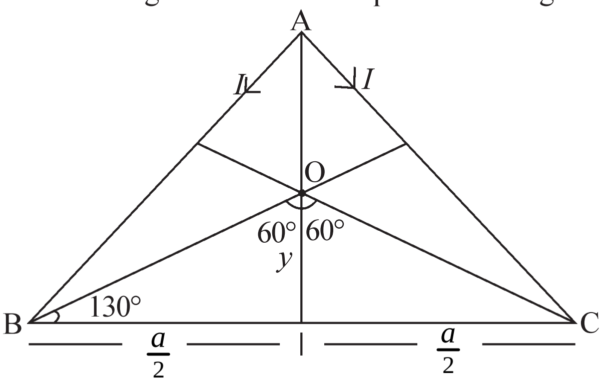
From figure $AP = \sqrt{L^2 + D^2}$ and

$$\sin\theta = \frac{L}{\sqrt{L^2 + D^2}}$$

$$\therefore \quad B = \frac{\mu_0 I}{4\pi D}\frac{L^2}{\sqrt{L^2 + D^2}}$$

(4) Answer [A]

The equal magnetic field B is produced at center due to the electric current passing through three sides of equilateral triangle.



Resultant magnetic field at center is B' = 3B

$$= \frac{3\mu_0 I}{4\pi y}(\sin 60° + \sin 60°)$$

$$= \frac{3\mu_0 I}{4\pi y}\left[2 \times \frac{\sqrt{3}}{2}\right] \text{ But } \tan 30° = \frac{y}{\frac{a}{2}}$$

$$\text{But } \tan 30° = \frac{y}{\frac{a}{2}} \quad \therefore y = \frac{a}{2\sqrt{3}}$$

$$= \frac{3\mu_0 I}{4\pi y} \times 2\sqrt{3} \times \sqrt{3} = \frac{9}{2\pi}\frac{\mu_0 I}{a}$$

(5) Answer [C]

Electric current $I = \frac{dq}{dt}$ and the distance travelled in time dt for charge dq is vdt

∴ Electric current $Idl = \frac{dq}{dt}(vdt) = vdq$

From Biot - Savart law,

$$dB = \frac{\mu_0}{4\pi}\frac{Idl\sin\theta}{r^2} = 10^{-7}\frac{vdq\sin\theta}{r^2}$$

$$= \frac{10^{-7} \times 2 \times 10^6 \times 35 \times 10^{-6} \times \sin 60°}{(50 \times 10^{-3})^2}$$

$= 2425\ \mu T$

(6) Answer [B]

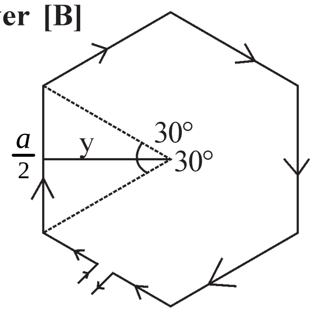
Magnetic field lines comes out from surface in second quadrant and enters in surface in fourth quadrant. Magenetic field lines comes out from north pole and enters in south pole.

(7) Answer [B]

$$B = \frac{\mu o I}{4\pi Q}(2\pi - \theta)$$

$$= \frac{4\pi \times 10^{-7} \times 6}{4\pi \times 0.2}\left(\frac{3\pi}{2}\right) = 1.41 \times 10^{-5}\ \text{T}$$

(8) Answer [B]



Each side of $\frac{\sqrt{3}\mu_0 I}{\pi a}$ hexagon make angle of 60° with center. So, $\theta_1 = \theta_2 = 30°$

Magnetic field generated at point O is,

B = 6 × magnetic field produced by each side.

$$= 6 \times \frac{\mu_0 I}{4\pi Y}[\sin\theta_1 + \sin\theta_2]$$

$$\text{But, } y = \frac{\frac{a}{2}}{\tan 30°} = \frac{\frac{a}{2}}{\frac{1}{\sqrt{3}}} = \frac{\sqrt{3}}{2}a$$

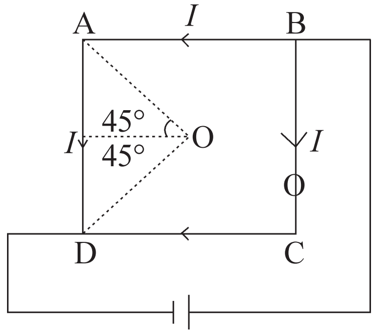
$$= 6 \times \frac{\mu_0 I}{4\pi y}(\sin 30° + \sin 30°)$$

$$= \frac{6\mu_0 I}{4\pi y},\ \therefore\ B = \frac{6\mu_0 I}{4\pi \frac{\sqrt{3}}{2}}$$

$$\therefore\ B = \frac{\sqrt{3}\mu_0 I}{\pi a}$$

(9) Answer [A]

From figure, the current flowing in conducting wire which are opposite to each other. Thus the magnetic field $B = \frac{\mu_0 I}{4\pi y}$ produced at point O is equal in magnitude and opposite in direction to each other $\therefore\ \vec{B_1} + \vec{B_2} + \vec{B_3} + \vec{B_4} = 0$



(10) Answer [A]

For very long wire $B = \frac{\mu_0 I}{4\pi y}$ $\therefore\ B \propto \frac{1}{y}$

$$\therefore\ \frac{B_2}{B_1} = \frac{y_1}{y_2}\ \therefore\ B_2 = B_1\frac{y_1}{y_2}$$

$$= 10^{-8} \times \frac{4}{3} = 1.33 \times 10^{-8}$$

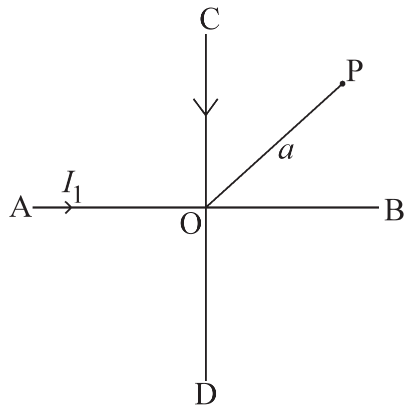
(11) Answer [C]

$$B = \frac{\mu_0}{4\pi}\ \frac{2\pi q v}{r}$$

$$= \frac{10^{-7} \times 2 \times 3.14 \times 1.6 \times 10^{-19} \times 6.6 \times 10^{15}}{0.53 \times 10^{-10}}$$

$$= 12.5\ \text{T}$$

(12) Answer [C]



Due to the electric current passing through AOB and COD wire, the magnetic fields produced at point P at distance a from O is.

$B_1 = \frac{\mu_0 I_1}{2\pi a}$ and $B_2 = \frac{\mu_0 I_2}{2\pi a}$

and $\vec{B_1} \perp \vec{B_2}$. So, resultant magnetic field

$B = \sqrt{B_1^2 + B_2^2} = \frac{\mu_0}{2\pi a} (I_1^2 + I_2^2)^{\frac{1}{2}}$

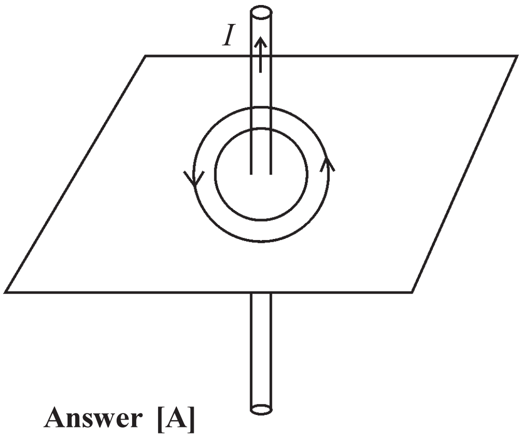
(13) Answer [B]

$B = \frac{\mu_0 I}{4\pi y} (\cos\alpha_1 + \cos\alpha_2)$, $\alpha_1 = \alpha_2 = 60°$

$= \frac{\mu_0 I}{4\pi \times 0.1} 2\cos 60° = \frac{\mu_0 5}{4\pi \times 0.1} = 3.98\,\mu_0$

(15) Answer [B]

$B = \frac{\mu_0 I}{4\pi r} \therefore B \propto \frac{1}{r}$



(16) Answer [A]

For static electric charged wire, inside

$B \propto r$ and outside $B \propto \frac{1}{r}$

(17) Answer [C]

$B = \frac{\mu_0 n}{2}\left[\frac{I_1}{r_1} - \frac{I_2}{r_2}\right]$

$= \frac{20\mu_0}{2}\left[\frac{0.4}{0.4} - \frac{0.6}{0.8}\right]$

$= \frac{20\mu_0}{2}\left[1 - \frac{3}{4}\right] = \frac{10\mu_0}{4}$

(18) Answer [B]

If current I is passing in circular ring having radius A then the magnetic field produced at center is

$B = \frac{\mu_0 I}{2R}$ ...(1)

Making loop having n turns and r radius from this wire, $l = 2\pi R = 2\pi rn$

$\therefore$ R = nr ...(2)

Magnetic field at center of loop having radius r is

$B' = \frac{\mu_0 n I}{2r}$ ...(3)

Taking ratio of equation (3) and (1)

$\frac{B'}{B} = \frac{\mu_0 n I}{2r} \times \frac{2R}{\mu_0 I} = \frac{nR}{r} = \frac{n^2 r}{r} = n^2$

$\therefore B' = n^2 B$

(19) Answer [A]

$\frac{B\text{centre}}{B(x)} = \frac{\mu_0 I}{2R} \times \frac{2(R^2 + x^2)^{\frac{3}{2}}}{\mu_0 I\ R^2}$

$\therefore \frac{8}{1} = \frac{(R^2 + x^2)^{\frac{3}{2}}}{R^3} \therefore 2 = \frac{(R^2 + x^2)^{\frac{1}{2}}}{R}$

$\therefore 4R^2 = R^2 + x^2 \therefore 3R^2 = x^2 \therefore x = \sqrt{3}R$

(20) Answer [C]

Magnetic field near center of the ring

$B_1 = \frac{\mu_0 I}{2a}$. Magnetic field at distance a from center of the ring.

$B_2 = \frac{\mu_0 I a^2}{2(a^2 + a^2)^{\frac{3}{2}}} = \frac{\mu_0 I a^2}{2(2a^2)^{\frac{3}{2}}}$

$\therefore \frac{B_1}{B_2} = \frac{\mu_0 I}{2a} \cdot \frac{2(2a^2)^{\frac{3}{2}}}{\mu_0 I\ a^2} = \frac{2\sqrt{2}}{1}$

(21) Answer [B]

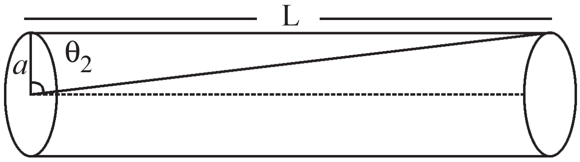
For ring carrying electric current I_1 is, $B_1 = \frac{\mu_0 I_1}{2r_1}$

For ring carrying electric current I_2 is, $B_2 = \frac{\mu_0 I_2}{2r_2}$

$\therefore \frac{B_1}{B_2} = \frac{I_1}{r_1} \cdot \frac{r_2}{I_2}$

$\therefore \frac{I_1}{I_2} = \frac{B_1}{B_2} \times \frac{r_1}{r_2} = \frac{1}{3} \times \frac{1}{2} = \frac{1}{6}$

(22) Answer [C]



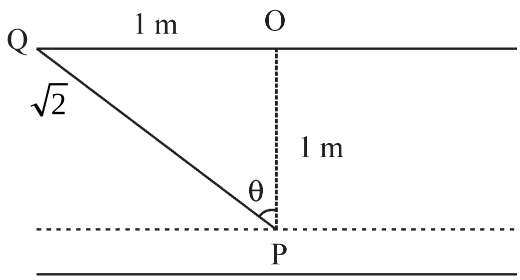
For solenoid having length L,

$$B = \frac{\mu_0 nI}{2}(\sin\theta_1 + \sin\theta_2)$$

$$\theta_1 = 0 \text{ and } \sin\theta_2 = \frac{L}{\sqrt{L^2 + a^2}}$$

$$\therefore B = \frac{\mu_0 nIL}{2(L^2 + a^2)^{\frac{1}{2}}}$$

(23) Answer [D]



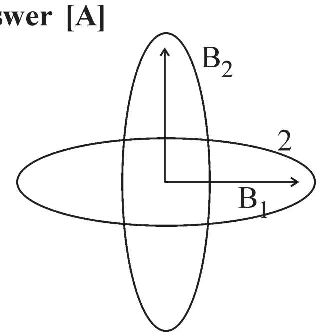
For solenoid having finite length

$$B = \frac{\mu_0 nI}{2}(\sin\theta_1 + \sin\theta_2),\ \theta_1 = \theta_2 = \theta$$

$$PQ = \sqrt{PO^2 + OQ^2} = \sqrt{1+1} = \sqrt{2}$$

$$\sin\theta = \frac{OQ}{PQ} = \frac{1}{\sqrt{2}},\ B = \mu_0 nI\sin\theta = \frac{\mu_0 nI}{\sqrt{2}}$$

(24) Answer [A]



The magnitude of produced magnetic field at center of both ring having radius r is, $B_1 = B_2 = B = \frac{\mu_0 I}{2r}$

Here $\vec{B}_{net} = \vec{B}_1 + \vec{B}_2,\ \vec{B}_1 \perp \vec{B}_2$

$$B_{net} = \sqrt{B_1^2 + B_2^2},\ B_1 = B_2 = B = \sqrt{2}B$$

$$\therefore \frac{B}{B_{net}} = \frac{B}{\sqrt{2}B} = \frac{1}{\sqrt{2}}$$

(25) Answer [C]

$$B = \mu_0 nI = \mu_0 \frac{N}{l} I$$

$$0.2 = \frac{4\pi \times 10^{-7} \times N \times 10}{0.8} \Rightarrow N = \frac{4 \times 10^4}{\pi}$$

Total length of wire $L = 2\pi r N$

$$= \frac{2\pi \times 3 \times 10^{-2} \times 4 \times 10^4}{\pi} = 2.4 \times 10^3 m$$

(27) Answer [B]

$F = BIl \sin\theta$

$$\therefore B = \frac{F}{Il\sin\theta} = \frac{M^1 L^1 T^{-2}}{A^1 L^1} = M^1 T^{-2} A^{-1}$$

(28) Answer [A]

Magnetic field is maximum on axis of solenoid carrying electric current and magnetic field is its half on its end.

$$B_{end} = \frac{1}{2} B_{center}$$

(29) Answer [A]

Here $\frac{1}{2} mv^2 = qV$

and $\frac{mv^2}{R} = Bqv \therefore v = \frac{BqR}{m}$

$$\therefore \frac{1}{2} m\left(\frac{BqR}{m}\right)^2 = qv,\ \therefore \frac{q}{m} = \frac{2v}{B^2R^2}$$

(30) Answer [A]

For electrically charged particle having same kinetic energy

$$r = \frac{\sqrt{2mk}}{Bq} \quad \therefore r \propto \frac{\sqrt{m}}{q}$$

$$\therefore r_\alpha : r_p : r_d = \frac{\sqrt{4}}{2} : \frac{\sqrt{1}}{1} : \frac{\sqrt{2}}{1}$$

$$= 1 : 1 : \sqrt{2},\ \therefore r_\alpha = r_p < r_d$$

(31) Answer [B]

$F = Bqv \sin\theta,\ \theta = 90°,\ \sin 90° = 1$

$\therefore\ F_{maximum} = Bqv$

$= 5 \times 10^{-5} \times 1.6 \times 10^{-19} \times 4 \times 10^4$

$= 3.2 \times 10^{-19}$ N

(32) Answer [C]

$$\vec{F} = q[\vec{E} + \vec{v} \times \vec{B}]$$

$$0 = \vec{E} + \vec{v} \times \vec{B},\ \therefore\ \vec{B} \times \vec{v} = \vec{E}$$

$$\therefore\ |\vec{B} \times \vec{v}| = |\vec{E}| = 5$$

(33) Answer [C]

$$\vec{F} = q(\vec{v} \times \vec{B})$$

$$= 1.6 \times 10^{-19}(10\hat{i} \times 5\hat{j}) = 8 \times 10^{-18}\ \hat{k}$$

(34) Answer [D]

$F = Bqv \quad \because \sin\theta = \sin 90° = 1$

$$K = \frac{1}{2}mv^2 \therefore v = \sqrt{\frac{2K}{m}} \quad \therefore F = Bq\sqrt{\frac{2K}{m}}$$

$$= 5 \times 1.6 \times 10^{-19}\sqrt{\frac{2 \times 2 \times 10^6 \times 1.6 \times 10^{-19}}{1.6 \times 10^{-27}}}$$

$= 16 \times 10^{-12}$ N

(35) Answer [C]

$$\vec{F} = q(\vec{v} \times \vec{B})$$

$$= q\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 3 & 0 \\ 2 & 3 & 0 \end{vmatrix} = q(0) = 0 \text{ N}$$

(36) Answer [C]

Lorentz force $\vec{F} = q[\vec{E} + (\vec{v} \times \vec{B})]$

$$= 400\hat{i} = \left[\vec{E} + (25\hat{j} \times 4\hat{k})\right]$$

$$= 200\hat{i} = \vec{E} + 100\hat{i}$$

$\vec{E} = 100\hat{i}\ \text{Vm}^{-1}$

(37) Answer [A]

$F = Bqv \sin 90° \Rightarrow ma = Bqv$

$$a = \frac{Bqv}{m} = \frac{2 \times 1.6 \times 10^{-19} \times 3.4 \times 10^7}{1.67 \times 10^{-27}}$$

$= 6.5 \times 10^{15}\ \text{ms}^{-2}$

(38) Answer [C]

radius of charged particle $r = \sqrt{\frac{2mK}{Bq}}$

$$K = \frac{B^2q^2r^2}{2m},\ \therefore\ k \propto \frac{q^2}{m}$$

$$\therefore\ \frac{K_p}{K_d} = \left(\frac{q_p}{q_d}\right) \times \frac{m_d}{m_p} \qquad q_p = q_d,\quad m_d = 2m_p$$

$\therefore\ K_p = 2 \times K_d = 2 \times 50 = 100$ KeV

(39) Answer [C]

Electric force $F_e = \frac{1}{4\pi\epsilon_0}\frac{e^2}{r^2}$

magnetic force $F_m = \frac{\mu_0}{4\pi}\frac{e^2v^2}{r^2}$

$$\therefore\ \frac{F_m}{F_e} = \mu_0\epsilon_0 v^2,\ \mu_0\epsilon_0 = \frac{1}{c^2} = \frac{v^2}{c^2}$$

(42) Answer [C]

Direction towards wire. Force on wire is

$$F = BIl = \frac{\mu_0 I^2 l}{2\pi r}\ \therefore\ F \propto \frac{1}{r}$$

The resultant force on left side of rectangular loop.

(44) Answer [B]

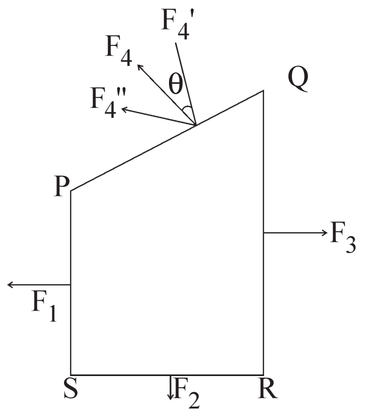
$M = NIA = NI\pi r^2$

$= 20 \times 3 \times \frac{22}{7} \times (4 \times 10^{-2})^2 = 0.3\ \text{Am}^2$

(45) **Answer [B]**

$$\frac{F}{l} = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{r} = \frac{\mu_0}{2\pi}\frac{I^2}{b} \quad (\because r = b)$$

(46) **Answer [D]**



The loop is in equilibrium for same magnetic field.

$F_4^{'} = F_4 \cos\theta = F_2$

$F_4^{''} = F_4 \sin\theta = F_3 - F_1$, $F_4' \perp F_4'$

$\therefore F_4 = \sqrt{F_2^2 + (F_3 - F_1)^2}$

(47) **Answer [A]**

According to equation $F = \frac{\mu_0 I_1 I_2 l}{2\pi y}$

current is halved then force becomes F/4 and flowing in same direction so there is attractive force between them.

(48) **Answer [A]**

Left side $F \propto I_1 I_2$ and current flow from P and Q are equal. $\therefore$ attractive force produced.

$\therefore F_{QR} > F_{PQ}$ Current passing thnough R and Q are in opp Q sit.

$\therefore$ Force acting on Q is left side.

(49) **Answer [B]**

$$|\vec{F}| = \frac{\mu_0 I_1 I_2 l}{2\pi y} = \frac{4\pi \times 10^{-7} \times 4 \times 4 \times 2}{2\pi \times 4}$$

$= 16 \times 10^{-7}$ N

(50) **Answer [D]**

$$l = 2\pi r \;\therefore\; r = \frac{l}{2\pi} = \frac{4}{2\pi} = \frac{2}{\pi}$$

$$M = IA = I\pi r^2 = I\pi\left(\frac{2}{\pi}\right)^2 = \frac{4}{\pi}\ \text{Am}^2$$

(51) **Answer [B]**

$$\vec{\tau} = \vec{M} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 3 & 5 \\ 0 & 0 & 3 \end{vmatrix}$$

$$\vec{\tau} = 9\hat{i} - 6\hat{j} + 0\hat{k}$$

$$|\vec{\tau}| = \sqrt{81 + 36} = \sqrt{117}$$

(52) **Answer [B]**

$$\mu = IA,\ I = \frac{e}{t} = \frac{e}{2\pi r / v} = \frac{ev}{2\pi r}$$

$$A = \pi r^2,\ \mu = \frac{ev}{2\pi r} \times \pi r^2 = \frac{evr}{2}$$

(53) **Answer [C]**

$$L = 2\pi RN \;\therefore\; R = \frac{L}{2\pi N}$$

$$\therefore A = \pi R^2 = \frac{\pi L^2}{2\pi^2 N^2} = \frac{L^2}{4\pi N}$$

maximum torque due to current passing through coil is, $\tau = NIAB$

$$= \frac{NIB \cdot L^2}{4\pi N^2} = \frac{BIL^2}{4\pi N}$$

(54) **Answer [B]**

Magnetic moment of 0.25 Nm loop is $M = NIA$

$= (1)(1) \times \pi(0.2)^2 = 0.04\pi$

$\tau = MB \sin\theta = 0.04 \times (3.14) \times 2 \times \sin 90°$

$= 0.2512$ Nm $= 0.25$Nm

(55) **Answer [C]**

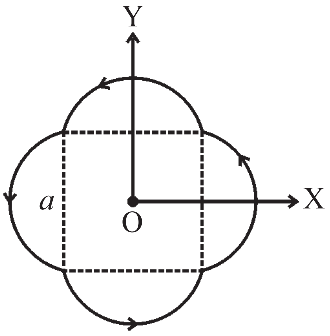
$$\vec{A} = l\hat{j} \times b\hat{k} = 0.04 \times 0.08\hat{i} = 0.0032\hat{i}$$

$$\vec{M} = NIA\,\hat{i} = (1)(0.5)(0.0032)\,\hat{i} = 0.0016\hat{i}$$

$$\vec{\tau} = \vec{M} \times \vec{B} = 0.0016\hat{i} \times \frac{0.05}{\sqrt{2}}\hat{j}$$

$= 4\sqrt{2} \times 10^{-5}\ \hat{k} = 5.64 \times 10^{-5}\ \hat{k}$

(56) Answer [B]



Area of part shown in figure = Area of Square + area of four semicircle

$$A = a^2 + 4\frac{1}{2}\pi\frac{a^2}{4} = a^2 + \frac{\pi a^2}{2} = a^2(1 + \frac{\pi}{2})$$

$$\vec{M} = I\ \vec{A} = Ia^2(1 + \frac{\pi}{2})\hat{k}$$

(57) Answer [B]

$F = BIl \sin 90° = 2 \times 1.2 \times 0.5 = 1.2$ N

(58) Answer [A]

Attractive $\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi y}$

$$= \frac{4\pi \times 10^{-7} \times 10 \times 10}{2\pi \times 0.1} = 2 \times 10^{-4}\ \text{N}$$

(59) Answer [B]

$W = MB(\cos\theta_2 - \cos\theta_1)$

$= NIAB(\cos 0 - \cos 180°) = NIAB[1 - (-1)]$

$= 2NIAB$

(60) Answer [B]

$J = NIAB \sin\theta$

$= 100 \times 1 \times 0.5 \times 400 \times 10^{-4} \sin 90°$

$= 2$ Nm

(61) Answer [C]

$$S = \frac{GI_g}{I \cdot I_g} \quad I = nIg$$

$$S = \frac{G}{n-1} \ \therefore n - 1 = GS^{-1}, \therefore n = \frac{G}{s} + 1$$

(62) Answer [B]

$$R_s = \frac{V}{I_g} - G, \quad V = n \cdot I_g G$$

$$= \frac{nI_g h}{I_g} - G = (n-1)G$$

(63) Answer [A]

Resistance of Galvanometer after connection of R_s

$= G + Rs = G + (n-1)G = nG$

(64) Answer [D]

$$Rs = \frac{V}{I_g} - G$$

$$= \frac{3}{20 \times 10^{-3}} - 10 = 140\ \Omega$$

(65) Answer [A]

$$S = \frac{GI_g}{I \cdot I_g} \quad Ig = \frac{0.5}{100} I \ \therefore I = 200\ I_g$$

$$= \frac{GI_g}{200I_g \cdot I_g} = \frac{G}{199} \text{ Resistance of Ameter}$$

$$\frac{1}{R} = \frac{1}{G} + \frac{1}{S} = \frac{1}{G} + \frac{1}{G/199} = \frac{200}{G}$$

$$\therefore R = \frac{G}{200}$$

(66) Answer [D]

$$S = \frac{GI_g}{I - I_g} \quad I_g = 10\ I = 100$$

$$= \frac{G(10)}{100-10} = \frac{99 \times 10}{90} = 11\ \Omega$$

(67) Answer [D]

$$R_s = \frac{V}{I_g} - G$$

$$= \frac{100}{10 \times 10^{-3}} - 25 = 9975\ \Omega$$

(68) Answer [B]

Theoretically, $I = \frac{V}{R} = \frac{100}{20} = 5$ A

$$I' = \frac{V}{R+G} = \frac{100}{25} = 4\text{A}$$

$\therefore I - I' = 5 - 4 = 1$A (After connection of galvanometer)

(69) Answer [A]

Resistance of ammeter

$$= \frac{Gs}{G+S} = \frac{200 \times 20}{200+20} = \frac{200}{11}\ \Omega$$

Current flow in circuit

$$I = \frac{V}{R+4} = \frac{10}{\frac{200}{11}+4} = \frac{110}{244} = \frac{55}{122}\ A$$

(70) Answer [A]

$$I_g = \frac{IS}{G+S},\ 20 = \frac{50 \times 12}{G+12}$$

$$G + 12 = \frac{50 \times 12}{20},\ \therefore\ G = 30 - 12 = 18\ \Omega$$

(71) Answer [A]

$$S_1 = \frac{GI_g}{I - I_g} \text{ and } S_2 = \frac{GI_g}{2I - I_g}$$

$$\therefore\ \frac{S_1}{S_2} = \frac{2I - I_g}{I - I_g}$$

(72) Answer [A]

For Galvamometer $I_g = \dfrac{V}{G+R}$

$$\therefore\ I_g = \frac{3}{50+2950} = 0.001\ A$$

Here, voltage V is equal

$30 + 141 = 20 + 141$

$30 \times (G + R) \times 0.001 = 20(G + x) \times 0.001$

$30 \times (50 + 2950) \times 0.001 = 20(50 + x)\ 0.001$

$$\frac{3 \times 3000}{2} = 50 + x\ \therefore\ x = 4450\ \Omega$$

(73) Answer [A]

10 mΩ resistor should connect parallel with galvanometer. $n = \dfrac{I}{I_g} = \dfrac{6}{4 \times 10^{-3}} = 1500$

$$s = \frac{G}{n-1} = \frac{15}{1500-1} \approx 10 \times 10^{-3}\,\Omega = 10\ m\,\Omega$$

(74) Answer [D]

$$\frac{I}{I_g} = 1 + \frac{G}{S},\ \frac{1}{100 \times 10^{-3}} = 1 + \frac{1000}{S}$$

$$\therefore\ S = \frac{1000}{9} = 111\ \Omega$$

(75) Answer [A]

$$\frac{I_g}{I} = \frac{S}{G+s} = \frac{2.5}{27.5} = \frac{1}{11}$$

(76) Answer [A]

Torque on electrically charged coil is

$\tau = NIAB \sin\theta$

The graph of $\tau \to \theta$ is like curve of $\sin\theta$ which represents by graph A.

(77) Answer [B]

If bar magnet having magnetic pole strength p and length l is bisected in two equal parts of length $l/2$, then each part act as an independent magnet. However pole strength of each of those remains unchanged while magnetic dipole moment is halved.

(81) Answer [A]

8 : 1 on axis of small magnet $B \propto \dfrac{1}{Z^3}$

$$\therefore\ \frac{B_1}{B_2} = \left(\frac{Z_2}{Z_1}\right)^3 = \left(\frac{48}{29}\right)^3 = \frac{8}{1}$$

(82) Answer [D]

Magnetic field on equator ilne of small magnet.

$$B_1 = \frac{\mu_0 m}{4\pi d_1^3}$$

Magnetic field on axis of small magnet

$$B_2 = \frac{2\mu_0 m}{4\pi d_2^3},\ \text{But } B_1 = B_2\ \frac{\mu_0 m}{4\pi d_1^3} = \frac{2\mu_0 m}{4\pi d_2^3}$$

$$\therefore\ \frac{d_1^3}{d_2^3} = \frac{1}{2}\ \therefore\ \frac{d_1}{d_2} = \frac{1}{2^{1/3}} = 2^{-1/3}$$

(83) Answer [B]

$$F = \frac{\mu_0}{4\pi}\frac{P_1 P_2}{r^2}$$

$$= \frac{4\pi \times 10^{-7}}{4\pi} \times \frac{40 \times 3200}{(0.1)^2} = 1.28\ N$$

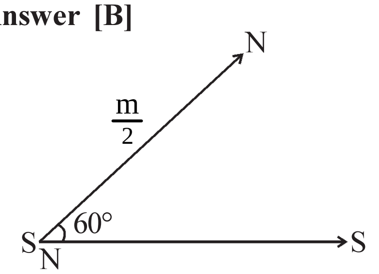
(84) Answer [B]

$$F = PB \therefore P = \frac{F}{B} = \frac{1.44 \times 10^{-4}}{0.36 \times 10^{-4}} = 4 \text{ Am}$$

$$m = 2lP \therefore 2l = \frac{m}{P} = \frac{0.1}{4} = 2.5 \times 10^{-2} \text{ m}$$

$$= 2.5 \text{ cm}$$

(85) Answer [B]



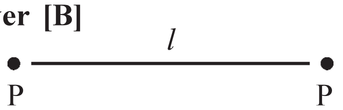
- Bending of rod having magnetic dipole m from its center the dipole moment of each part is m_2.
- Angle becomes 120° between both dipole moment Resultant magnetic dipole moment is

$$= \sqrt{\left(\frac{m}{2}\right)^2 + \left(\frac{m}{2}\right)^2 + \left(\frac{m}{2}\right)\left(\frac{m}{2}\right)} \cos 120°$$

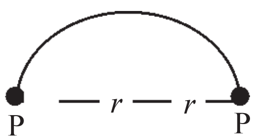
$$= \sqrt{\left(\frac{m}{2}\right)^2 + \left(\frac{m}{2}\right)^2 + 2\left(\frac{m}{2}\right)^2 (-1/2)}$$

$$= \frac{m}{2}$$

(86) Answer [B]



$l = \pi r$

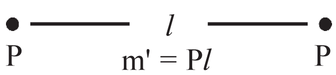


$r = l/\pi$

$\therefore \quad m = P(l) \qquad m' = P(2r)$

$$= \frac{2Pl}{\pi} = \frac{2m}{\pi}$$

(87) Answer [C]



Both ends of rod makes angle of 60° Length of conic becomes equal to rdius of circle.

$$\text{radius} = \frac{\text{arc}}{\text{angle}} = \frac{L}{60°} = \frac{L}{\pi/3} = \frac{3L}{\pi}$$

$$m' = P\frac{3L}{\pi} = \frac{3PL}{\pi} = \frac{3m}{\pi}$$

(88) Answer [A]

On axis of coil having current

$$B(x) = \frac{\mu_0}{4\pi}\frac{2m}{x^3}, \; m = \frac{4\pi B(x) x^3}{2\mu_0}$$

$$= \frac{4\pi \times 10^{-4} \times 0.001}{2 \times 4\pi \times 10^{-7}} = 0.5 \text{ Am}^2$$

(89) Answer [A]

$N I A = nl I A$

$= 10 \times 6 \times 1.0 \times 3.0 \times 10^{-4}$

$= 1.8 \times 10^{-2} \text{ Am}^2$

(90) Answer [A]

Unit of B

$$= \frac{N}{Am} = \frac{M^1 L^1 T^{-2}}{C/T \; L} = M^1 T^{-1} C^{-1}$$

(91) Answer [A]

Force between two short bar magnet

$$F = \frac{\mu_0}{4\pi}\frac{6m_1m_2}{r^4} \therefore F \propto \frac{1}{r^4}$$

$$\therefore \frac{F_2}{F_1} = \left(\frac{r_1}{r_2}\right)^4, \therefore F_2 = F_1\left(\frac{r_1}{r_2}\right)^4$$

$$= 4.8\left(\frac{4}{24}\right)^4 = 4.8 \times \frac{1}{64} = 0.37 \times 10^{-2} \text{ N}$$

(92) Answer [A]

Repulsive force between two magnet = Weight of one magnet

$$\frac{\mu_0}{4\pi}\frac{(P)(P)}{r^2} = m'g$$

$$P^2 = \frac{50 \times 10^{-3} \times 9.8 \times r^2}{10^{-7}}$$

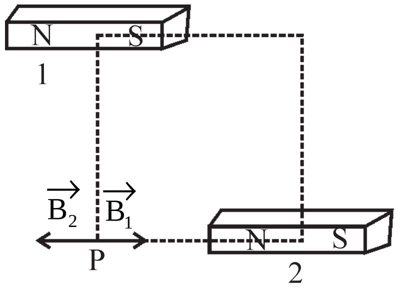
$$= \frac{50 \times 10^{-3} \times 9.8 \times 9 \times 10^{-6}}{10^{-7}} = 6.64 \text{ Am}^2$$

(93) Answer [C]

$P = \frac{m}{2l} = \frac{6.64}{0.1} = 66.4$ Am Here resultant magnetic dipole moment

$m' = \sqrt{m^2 + m^2} = \sqrt{2}\,m$ On axis of given magnet $B = \frac{\mu_0}{4\pi}\frac{2m'}{d^3} = \frac{\mu_0}{4\pi}\frac{2\sqrt{2}m}{d^3}$

(94) Answer [A]



Magnetic field at P due to magnet (1) is

$$B_1 = \frac{\mu_0}{4\pi}\frac{m}{d^3} = 10^{-7} \times \frac{1000}{(0.1)^3} = 0.1 \text{ T}$$

Magnetic field at P due to magnet (2) is

$$B_2 = \frac{\mu_0}{4\pi}\frac{2m}{d^3} = \frac{10^{-7} \times 2 \times 1000}{(0.1)^3} = 0.2 \text{ T}$$

Resultant magnetic field at P is

$B = B_1 - B_2 = 0.2 - 0.1 = 0.1$ T

(95) Answer [C]

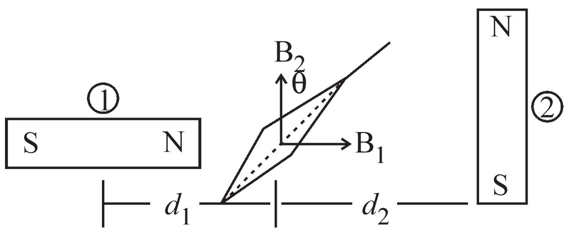
In equilibrium condition,

$B_1 \times m = B_2 \times m$

$B_1 m\sin(90 - \theta) = B_2 m\sin\theta$, $B_1 \cos\theta = B_2 \sin\theta$

$B_1 = B_2 \tan\theta$

$$\frac{\mu_0}{4\pi}\frac{2m}{d_1^3} = \frac{\mu_0}{4\pi}\frac{m}{d_2^3}\tan\theta$$



$$\therefore \left(\frac{d_2}{d_1}\right)^3 = \frac{\tan\theta}{2}, \therefore \left(\frac{d_2}{d_1}\right)^3 = 2\cot\theta$$

$$\therefore \frac{d_1}{d_2} = (2\cot\theta)^{1/3}$$

(96) Answer [A]

Here, $m = NIA = NI\pi r^2$

$= 20 \times 3 \times 16 \times 10^{-4} \times 3.14$

$= 3014.8 \times 11^{-4}$ Am^2

Potential energy of dipole $U = -mB\cos\theta$

$= -3014.8 \times 10^{-4} \times 0.5 \times \cos\theta$

$= -0.15072 = -0.15$ J

(97) Answer [B]

$\tau = mB \sin\theta$

$$\therefore m = \frac{\tau}{B\sin\theta} = \frac{4.5\times10^{-2}}{0.25 \times \sin 30^\circ} = 0.36 \text{ JT}^{-1}$$

(98) Answer [C]

Initial torque $\tau_1 = mB\sin 90^\circ = mB$

Torque by deflection $\tau_2 = \tau_{1/2}$

$\therefore mB\sin\theta_2 = \frac{mB}{2}$, $\sin\theta_2 = 1/2$

$\therefore \theta_2 = 30^\circ$

Magnet needs deflection $\theta = 90^\circ - \theta_2$

$= 90^\circ - 30^\circ = 60^\circ$

(99) Answer [B]

$W = U_2 - U_1$

$= - mH\cos\theta - (-mH\cos 0)$

$= - mH\cos\theta + mH = mH(1 - \cos\theta)$

(100) Answer [A]

$W = U_2 - U_1$

$= - mB\cos\theta_2 - (-mB\cos\theta_1)$

$= 5 \times 7 \times 10^{-4} (\cos 30 - \cos 45^\circ)$

$= 5 \times 7 \times 10^{-4} (0.8660 - 0.7072)$

$= 5.56 \times 10^{-4}$ J

(101) Answer [A]

$W = mB(1 - \cos\theta)$

$= NIAB(1 - \cos 180^\circ) = NIAB(1 + 1)$

$= 2NIAB = 2NI(\pi r^2)B$

$= 2 \times 50 \times 2 \times 3.14 \times (4 \times 10^{-2})^2 \times 0.1$

$= 0.1$ J

(102) Answer [A]

$$T = 2\pi\sqrt{\frac{I}{mB}}$$

$$\therefore B = \frac{4\pi^2 I}{T^2 m} = \frac{4 \times (3.14)^2 \times 8 \times 10^{-6}}{1^2 \times 10^{-1}}$$

$$= 3.15 \times 10^{-3}\ T$$

(103) Answer [B]

$$T = 2\pi\sqrt{\frac{I}{mB}},\ T_1 = 2\pi\sqrt{\frac{I}{m_1 B}}$$

$$T_2 = 2\pi\sqrt{\frac{I}{m_2 B}},\ \therefore \frac{T_2}{T_1} = \sqrt{\frac{m_1 B}{m_2 B}}$$

$$\therefore \frac{1}{2} = \sqrt{\frac{m_1}{m_2}}\ \therefore \frac{m_1}{m_2} = \frac{1}{4}$$

(104) Answer [A]

$$T = 2\pi\sqrt{\frac{I}{mB}}\ \therefore T \propto \frac{1}{\sqrt{m}}$$

$$\frac{T_2}{T_1} = \sqrt{\frac{m_1}{m_2}} = \sqrt{\frac{2lP}{2l4P}} = \frac{1}{2}$$

$$\therefore T_2 = \frac{1}{2}\ T_1 = \frac{1}{2} \times 2 = 1$$

(105) Answer [A]

$$\tau = mB\sin\theta \therefore \frac{d\tau}{d\theta} = mB\cos\theta$$

$\left(\frac{d\tau}{d\theta}\right)$ for maximum $\cos\theta = 1$, $\therefore \theta = 0$

(106) Answer [B]

$$T = 2\pi\sqrt{\frac{I}{mB}}\ \therefore T \propto \frac{1}{\sqrt{m}}$$

$$\therefore \frac{T_2}{T_1} = \sqrt{\frac{m_1}{m_2}}\quad m_1 = 100\ m_2 = 100 - 36 = 64$$

$\therefore \frac{T_2}{T_1} = \sqrt{\frac{100}{64}} = \frac{10}{8}$ For maximum $\cos\theta = 1$

$\therefore T_2 = 1.25\ T_1$ increment in periodic time is 25 %

(107) Answer [C]

$$\frac{m_1}{m_2} = \frac{T_2^2 + T_1^2}{T_2^2 - T_1^2} = \frac{6^2 + 4^2}{6^2 - 4^2} = \frac{52}{20} = \frac{2.6}{1}$$

(108) Answer [C]

$$\frac{B_V}{B_H} = \tan\phi,\ B_V = B_H$$

$$\therefore \tan\phi = 1 = \tan 45°,\ \therefore \phi = 45°$$

(109) Answer [D]

$$\tan\phi = \frac{B_V}{B_H},\ B_H = \sqrt{3}\ B_V$$

$$= \frac{B_V}{\sqrt{3}B_V} = \frac{1}{\sqrt{3}} = \tan\frac{\pi}{6}$$

$$\therefore \phi = \frac{\pi}{6}\ rad$$

(110) Answer [D]

In perpendicular plane with magnetic meridian

$$\tan\phi = \frac{B_V}{B_H\cos 90°} = \frac{B_V}{0} = \infty \Rightarrow \phi = \frac{\pi}{2}$$

(111) Answer [A]

$$\tan\phi = \frac{B_V}{B_H},\ B_H = 1.732\ B_V$$

$$= \frac{B_V}{1.732 B_V} = \frac{1}{\sqrt{3}} = \tan 30°,\ \phi = 30°$$

(112) Answer [A]

$$\frac{Bh_1}{Bh_2} = \frac{B\cos 30°}{B\cos 45°} = \frac{\sqrt{3}/2}{\frac{1}{\sqrt{2}}}$$

$$= \sqrt{3} : \sqrt{2}$$

(113) Answer [B]

Here, neutral point is on axial line.

$$B|Z| = \frac{\mu_0 m}{4\pi 2^3},\ B_h.$$

$$B_h = \frac{4\pi \times 10^{-7}}{4\pi} \times \frac{1.6}{(0.2)^3}$$

$$B_h = 2 \times 10^{-5}\ T$$

(114) Answer [D]

On equator of magnet

$B(y) = \frac{\mu_0 m}{4\pi y^3}$, $0.4 \times 10^{-4} = \frac{10^{-7} \times m}{(6.4 \times 10^6)^3}$

$m = 1.05 \times 10^{23}$ Am^2

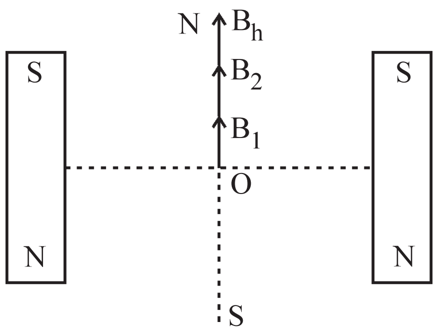
(115) Answer [D]

Here, $B_h = \frac{\mu_0}{4\pi} \frac{2mx}{(x^2 - l^2)^2}$

$3.2 \times 10^{-5} = \frac{4\pi \times 10^{-7}}{4\pi} \frac{m(0.4)}{(0.4)^2 - (0.1)^2}$

$\therefore$ m = 9 Am^2, $P = \frac{m}{22} = \frac{9}{2 \times 0.1} = 45$ Am

(116) Answer [D]



Resultant magnetic field $B = B_1 + B_2 + B_h$

$= \frac{\mu_0 M_1}{4\pi r^3} + \frac{\mu_0 M_2}{4\pi r^3} + 3.6 \times 10^{-5}$

$= \frac{\mu_0}{4\pi r^3}(M_1 + M_2) + 3.6 \times 10^{-5}$

$= \frac{10^{-7}(1.2 + 1.0)}{10.11^3} + 3.6 \times 10^{-5}$

$= 2.2 \times 10^{-4} + 0.36 \times 10^{-4} = 2.56 \times 10^{-4}$ T

(117) Answer [B]

$\mu_r = 1 + \chi_m$, μ_r = km

$\therefore X_m$ = km – 1 = 0.075 – 1 = – 0.925

(118) Answer [D]

$H = nI$, $B = \mu_r H$

$= \mu_r nI = 5000 \times 4\pi \times 10^{-7} \times 100 \times 3$

= 1.88 T

(119) Answer [C]

$m = \frac{m_1}{V} = \frac{1.2}{0.15 \times 0.02 \times 0.01}$

$= 4 \times 10^4$ Am^{-1}

(120) Answer [B]

$H = nI = \frac{N}{l} I$

$\therefore I = \frac{Hl}{N} = \frac{3 \times 10^{-3} \times 0.1}{50} = 0.6$ A

(121) Answer [B]

$B = \frac{\phi}{A} = \frac{2.4 \times 10^{-5}}{0.2 \times 10^{-4}} = 1.2$ T

$M = \frac{B}{\mu_0} - H = \frac{1.2}{4 \times 3.14 \times 10^{-7}} - 1600$

M = 953800 Am^{-1}

$\chi_m = \frac{M}{H} = \frac{953800}{1600} = 596$

(122) Answer [A]

$\chi_m \propto \frac{1}{T} \therefore \frac{\chi_{m_2}}{\chi_{m_1}} = \frac{T_1}{T_2}$

$\therefore \chi_{m_2} = \chi_{m_1} \times \frac{T_1}{T_2}$

$= 6 \times 10^{-3} \times \frac{273 - 73}{273 - 173} = 1.2 \times 10^{-2}$

(123) Answer [A]

Total magnetic dipole moment of cylinder

$m = M \times V = M\,\pi r^2 l$

$= 5 \times 10^3 \times 3.14 \times (0.01)^2 \times 0.05$

$= 7.85 \times 10^{-2}\ T^{-1}$

(124) Answer [C]

Periodic time in vertical plane $T_1 = 2\pi\sqrt{\dfrac{I}{mB_v}}$

Periodic time in horizontal plane $T_2 = 2\pi\sqrt{\dfrac{I}{mB_h}}$

$\therefore \dfrac{T_1}{T_2} = \sqrt{\dfrac{B_h}{B_v}} \quad \therefore \dfrac{2}{2} = \sqrt{\dfrac{B_h}{B_v}}$

$\therefore \dfrac{B_h}{B_v} = 1 = \tan\phi = \tan 45° \Rightarrow \phi = 45°$

(125) Answer [C]

Periodic time of magnet only, $T = 2\pi\sqrt{\dfrac{I}{mB_h}}$

$\therefore \dfrac{T'}{T} = \sqrt{2} \quad \therefore T' = \sqrt{2}\,T$

Periodic time after wood contact

$T' = 2\pi\sqrt{\dfrac{2I}{mB_h}}$ I will change. M is constant.

$\therefore \dfrac{T'}{T} = \sqrt{2} \quad \therefore T' = \sqrt{2}\,T$

(126) Answer [C]

$n = \dfrac{\rho NA}{A}$

$= \dfrac{7.8 \times 10^3 \times 6.02 \times 10^{23}}{56} = 8.38 \times 10^{28}$

Total number of atoms $N = nV$

$= 8.38 \times 10^{28} \times 5 \times 10^{-2} \times 10^{-2} \times 10^{-2}$

$= 4.19 \times 10^{25}$

Saturated magnetic moment of iron rod.

$M = N.m$

$= 4.19 \times 10^{23} \times 1.8 \times 10^{-23}$

$= 7.542\ Am^2 \approx 7.54\ Am^2$

(127) Answer [C]

For each magnet $T' = 2\pi\sqrt{\dfrac{I}{mB_h}}$

Periodic time for mixture of both magnet

$T = 2\pi\sqrt{\dfrac{2I}{\sqrt{2}\,mB_h}}$

$\therefore \dfrac{T'}{T} = \sqrt{\dfrac{\sqrt{2}}{2}} = \sqrt{\dfrac{1}{\sqrt{2}}} = \dfrac{1}{2^{1/4}}$

$\therefore T' = 2^{-1/4}\ T$

(130) Answer [A]

$\chi = C\,\dfrac{1}{T}$

$C = \dfrac{\chi}{1/T} = \dfrac{0.4}{7 \times 10^{-3}} = 57\ K$

(131) Answer [A]

A cyclotron is an instrument to accelerate charged particle. If accelerate the light particle like electron then its speed equal to velocity of light. Noticable difference observed in its mass. Thus, assertion and reason both are true and reason gives the true explanation of assertion.

(132) Answer [B]

For solenoid b, $B = \frac{\mu_0 nI}{2}(\sin\alpha_1 + \sin\alpha_2)$

Above equation indicate that B, length and area independent for solenoid. assertion and reason both are true but reason doesn't explain assertion.

(133) Answer [C]

The direction of magnetic field forms by conducting wire having current I can be obtained by right hand thumb rule. When wire having conducting current diverted in circular, then magnetic field is near to center and almost in linear line on chep means the direction of magnetic flux decided from direction of electric current. Thus, assertion is true and reason is wrong.

(134) Answer [D]

In case of conducting wire d, the charge flowing from its whole cross-section. So, magnetic field produced in both inside and outside region of wire and this field decreases with going far away from axis of wire. This assertion and reason both are wrong.

(136) Answer [B]

$m = IA = I(\pi r^2)$ $\therefore$ If twice the $m \alpha r^2$ r then $m^1 = 4m$,

(138) Answer [D]

Force $F = \frac{3\mu_0 M_1 M_2}{2\pi x^4}$ for two small magnet on one axis, when statement with cause is ture. Because $F = \frac{\mu_0}{4\pi}\frac{P_1 P_2}{x^2}$.

(139) Answer [D]

If the angle is θ at center by given circle having electric current I then the magnetic field produced at center is. $B = \frac{\mu_0 I\theta}{4\pi r}$

Here $r = a$ $\theta = 3d = \pi/6$

$$\therefore B = \frac{\mu_0 I}{4\pi a} \cdot \pi/6 = \frac{\mu_0 I}{2\pi a}$$

(140) Answer [B]

Magnetic field produced at O due to arc BC

$B = \frac{\mu_0 I\theta}{4\pi r}$ So, $r = b$ $\theta = 30° = \pi/6$

$$B = \frac{\mu_0 I}{4\pi b} \cdot \pi/6 = \frac{\mu_0 I}{24b}$$

(141) Answer [B]

$\frac{\mu_0 I}{24}\left(\frac{b-a}{ab}\right)$ The magnetic field produced at point O due to AB and CD of loop ABCD

$$\vec{B}_{net} = \vec{B}_1 - \vec{B}_2$$

$$= \frac{\mu_0 I}{24}\left[\frac{1}{a} - \frac{1}{b}\right] = \frac{\mu_0 I}{24}\left(\frac{b-a}{ab}\right)$$

(142) Answer [B]

Force acting on AD and BC is zero. The magnetic field produced by linear wire having electric current I_1 is parallel with path of arc AD and BC so the force $F = BIl\sin\theta$ acts on this part is zero.

●

14 Electro Magnetic Induction and AC Current

(1) Answer [C]

$$\phi = \frac{\mu_0 I}{2R}\ \pi r^2 = \frac{4\pi \times 10^{-7} \times 1 \times \pi \times 10^{-4}}{2 \times 1}$$

$= 2 \times 10^{-10}$ (Taking $\pi^2 = 10$)

$\phi = 2 \times 10^{-10}$ Wb

$= 2 \times 10^{-10} \times 10^8$ maxwell $= 0.02$ maxwell

(2) Answer [D]

$$\phi = \frac{\mu_0 Ib}{2\pi}\ ln\left[\frac{L+a}{a}\right]$$

$$= \frac{4\pi \times 10^{-7} \times 10 \times 1 \times 10^{-2}}{2\pi}\ ln\left[\frac{2+2}{2}\right]$$

$= 2 \times 10^{-8} \times 0.2303 \times 0.3010$

$= 2 \times 0.693 \times 10^{-8}$

$= 1.386 \times 10^{-8}$ Tm^2

$= 1.386$ G cm^2

(3) Answer [C]

$$\phi_m = BAN \cos(0),\ \frac{\phi_m}{2} = BAN \cos \omega t$$

$$\therefore\ \cos\omega t = \frac{1}{2} \Rightarrow \omega t = \frac{\pi}{3}$$

$$\therefore\ t = \frac{\pi}{3} \times \frac{1}{\omega} = \frac{\pi}{3} \times \frac{1}{2\pi} = \frac{1}{6}\ s$$

(4) Answer [B]

$BAN_1 \cos\omega_1 t = BAN_2 \cos\omega_2 t$

$$\Rightarrow \frac{\cos\omega_2 t}{\cos\omega_1 t} = \frac{N_1}{N_2} = \frac{10}{20} = \frac{1}{2}$$

$$= \frac{\cos\frac{\pi}{3}}{\cos 2\pi},\ \frac{\omega_2}{\omega_1} = \frac{1}{6}$$

(5) Answer [B]

$$\phi = BA\cos\theta, = \frac{\mu_0 NI}{l}\ \pi r^2 \cos(0)$$

$= 32\pi^2 \times 10^{-7}$ Wb

(6) Answer [C]

$B = 0.3$ T, $A = 2$ cm $\times$ 4 cm $= 8 \times 10^{-4}$ m^2

Flux associated with plane,

$\therefore\ \phi = AB\cos\theta = (8 \times 10^{-4})(0.3)\cos 60°$

$= 1.2 \times 10^{-4}$ Wb

(7) Answer [D]

magnetic flux associated with loop at time t is

$\phi = AB \sin\omega t$

$$\text{Induced } emf\ \ \varepsilon = \frac{-d\phi}{dt} = -AB_0\omega \cos\omega t$$

$$\therefore\ I = \frac{\varepsilon}{R} = \frac{-AB_0\omega}{R} \cos\omega t$$

$$Q = \int_0^{5\times10^{-3}} I dt = \frac{-AB_0\omega}{R}\int_0^{5\times10^{-3}} \cos\omega t\ dt$$

$\therefore\ Q = 50\ \mu$C (neglect the negative sign)

(8) Answer [B]

Here, redius of cross section $r = 10$ cm is equal and $\theta = 0$ for Solenoid and coil.

$\therefore$ Induced electromagnetic force is

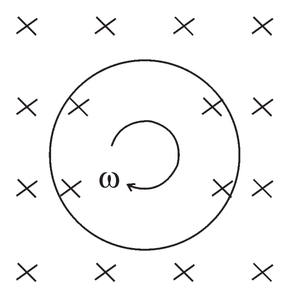
$$e = \left|\frac{\Delta\phi}{\Delta t}\right| = \frac{NA(B_2 - B_1)}{\Delta t}$$

$$= \frac{N\pi r^2 \mu_0 n (I_2 - I_1)}{\Delta t}$$

$$= \frac{100 \times \pi \times 10^{-2} \times 4 \times \pi \times 500(2-0) \times 10^{-7}}{10^{-3}}$$

$= 3.95$ V

(9) Answer [B]



In situation (i), the number of magnetic lines passing through plane of coil will not change with time.

Finally, induced *emf* will not produced.

So, *emf* = 0

In situation (ii), undertaking the rotation with angular speed ω with respect to diameter, the magnetic fiux does not change with time. But time duration is equal to 1 periodic time so, result is zero.

(10) Answer [C]

$$\therefore I = \frac{\varepsilon}{R+G} = \frac{N(\phi_2 - \phi_1)}{(R+G)t}$$

$$= \frac{8 \times 10^{-5}(18-12)}{(8+64)\,4 \times 10^{-3}}$$

$$\therefore I = \frac{8 \times 6 \times 10^{-2}}{72 \times 4} = 1.6 \times 10^{-3}\text{ A}$$

(11) Answer [A]

magnetic flux $\phi = \text{BA}\cos\omega t$

Induced *emf* $\varepsilon = \frac{-d\phi}{dt} = -\text{BA}\omega\sin\omega t$

Power $\text{P} = \frac{\varepsilon^2}{\text{R}} = -\frac{\text{B}^2\text{A}^2\omega^2}{\text{R}}\sin^2\omega t$

$$\therefore \text{Average power} < \text{P} > = \frac{\text{B}^2\text{A}^2\omega^2}{\text{R}} < \sin^2\omega t >$$

$$\therefore < \text{P} > = \frac{\text{B}^2\text{A}^2\omega^2}{2\text{R}} = \frac{\text{B}^2\pi^2 r^4\omega^2}{8\text{R}}$$

$$\therefore < \sin^2\omega t > = \frac{1}{2},\ \left(\text{A} = \frac{\pi r^2}{2}\right)$$

$$\therefore < \text{P} > = \frac{4 \times (\pi)^2 \times 625 \times 10^{-8} \times 100 \times (\pi)^2}{8 \times 4}$$

$$= 78.125 \times 10^{-4} = 7.81 \times 10^{-3}\text{ W}$$

(12) Answer [B]

$$\varepsilon = \frac{-d\phi}{dt} = \frac{-d}{dt}[\text{BA}] \qquad (\theta = 0)$$

Here, as ring comes out with velocity from finite magnetic field, the effective area A decreases with time in magnetic field.

$$\therefore \varepsilon = -\text{B}\frac{d\text{A}}{dt},\ \text{But } \frac{d\text{A}}{dt} = -2rv$$

$$\Rightarrow \varepsilon = 2r\text{B}v$$

$$= 2 \times 5 \times 10^{-2} \times 5 \times 10^{-3} \times 20 \times 10^{-2}$$

$$= 1 \times 10^{-4}\text{ V}$$

According to Lentz law, induced current in ring produce magnetic field in vertical direction. So, point R is at high electric potential.

(13) Answer [D]

$$\varepsilon = \frac{-d\phi}{dt} = \frac{-d}{dt}\text{BA} = \frac{-d}{dt}\left[\frac{\mu_0 I a^2}{2\pi x}\right]$$

$$= \frac{\mu_0 I a^2}{2\pi x^2}\frac{dx}{dt} \qquad \text{(neglect the negative sign)}$$

$$\frac{dx}{dt} = v,\ \therefore\ \varepsilon = \frac{\mu_0 I a^2}{2\pi x^2}\cdot v$$

$$= \frac{4\pi \times 10^{-7} \times 1 \times 4 \times 10^{-4} \times 50 \times 10^{-2}}{2\pi \times (5)^2}$$

$$= 16 \times 10^{-13} = 1.6 \times 10^{-6}\ \mu\text{V}$$

(14) Answer [C]

$$< \text{P} > = \frac{\varepsilon^2}{\text{R}},\ \varepsilon = \frac{-\text{NBA}(\cos\theta_2 - \cos\theta_1)}{\Delta t}$$

$$\varepsilon = \frac{-250 \times 0.3 \times 10^{-2}}{500 \times 10^{-3}}[\cos 90 - \cos 0]$$

$$\varepsilon = 1.5\text{ V}$$

$$\therefore (\text{P}) = \frac{\varepsilon^2}{\text{R}} = \frac{(1.5)^2}{225} = 10\text{ mW}$$

(15) Answer [D]

$$\varepsilon = \frac{-\text{NAB}(\cos\theta_2 - \cos\theta_1)}{\Delta t}$$

$$= \frac{-\text{NAB}}{\Delta t}[\cos(135°) - \cos 45°]$$

$$= \frac{-\text{NAB}}{\Delta t}[\cos(90° + 45°) - \cos 45°]$$

$$= \frac{-\text{NAB}}{\Delta t}[-\sin 45° - \cos 45°]$$

$$= \frac{\text{NAB}}{\Delta t}[\sin 45° + \cos 45°]$$

$$= \frac{150 \times 4 \times 4 \times 10^{-4} \times 3.14 \times 0.4 \left[\frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}}\right]}{1.41}$$

$= 301.4$ mV

(16) Answer [B]

$$\varepsilon = \frac{-d\phi}{dt} = \frac{-d}{dt}\left[\frac{\mu_0 I}{2\pi r} \cdot \pi a^2\right]$$

$$= \frac{\mu_0 I a^2}{2} \cdot \frac{1}{r^2}\frac{dr}{dt}, \quad \frac{dr}{dt} = v$$

$$\Rightarrow \varepsilon = \frac{\mu_0 I a^2}{2r^2} \cdot v$$

$$= \frac{4\pi \times 10^{-7} \times 2 \times \left(4 \times 10^{-4}\right) \times 2 \times 10^{-2}}{2 \times 4}$$

$= 25.12 \times 10^{-13} = 2.512 \times 10^{-6}$ μV

(17) Answer [C]

$$E = \frac{e}{l} = \frac{Bvl}{l} = Bv,\ v = gt,\ B = B_h \cos 60$$

$\therefore$ E $= B_h \cos 60\ gt$

$= 7 \times 10^{-5} \times \frac{1}{2} \times 10 \times 4$

$= 1.4 \times 10^{-3}$ Vm^{-1}

(18) Answer [D]

In given condition,

$$\frac{v_t}{v_0} = exp\left(\frac{-B^2 l^2}{mR}\right)t = 0.3679 \qquad ...(1)$$

$$\therefore\ e^{\left(\frac{B^2 l^2}{mR}\right)\cdot t} = \frac{1}{0.3679} = 2.718 = e^1$$

$$\text{But, } \frac{B^2 l^2}{mR} = \frac{4 \times 100 \times 10^{-4}}{40 \times 10^{-3} \times 10} = 10^{-1}$$

$\therefore\ e^{0.1t} = e^1 \Rightarrow 0.1t = 1,\ \therefore\ t = 10$ s

(19) Answer [C]

Induced current in loop is $I = \frac{Bvl}{R}$

(R is equivalent resistance)

$$\therefore\ R = \frac{Bvl}{I} = \frac{2 \times 40 \times 10^{-3} \times 10 \times 10^{-2}}{1 \times 10^{-3}}$$

$= 8\ \Omega$, If r is the equivalent resistance of network then,

$8 = R_1 + r \Rightarrow r = 8 - 2 = 6\ \Omega$

Here network is Wheatstone bridge. Its each side have equal resistance r' then,

$$\frac{2r' \times 2r'}{4r'} = 6 \Rightarrow r' = 6\ \Omega$$

(20) Answer [C]

$$|\varepsilon| = \frac{\mu_0 I v}{2\pi} ln\left(\frac{b}{a}\right) = \frac{4\pi \times 10^{-7} \times 1 \times 2}{2\pi} ln\left(\frac{10}{5}\right)$$

$= 4 \times 10^{-7}\ ln\,(2) = 2.77 \times 10^{-7} = 0.277$ μV and D end is negative.

(21) Answer [C]

If PQ rod is far by distance x from resistor R then, the induced current I is

$$I = \frac{Bvl}{R + 2x + 2},\ \therefore\ R + 4x = \frac{Bvl}{I}$$

$$\therefore\ 4x = \frac{Bvl}{I} - R = \frac{35 \times 0.3 \times 2 \times 10^{-5}}{100 \times 10^{-6}} - R$$

$= 21 - 17 = 4,\ \therefore\ x = 1$ m, $\therefore\ x = 100$ cm

(22) Answer [A]

Here velocity of rod at time t is $v_t = v_0 \cdot e^{-kt}$

Where $k = \frac{B^2 l^2}{mR}$

$$\therefore\ \frac{dx}{dt} = v_0 \cdot e^{-kt}$$

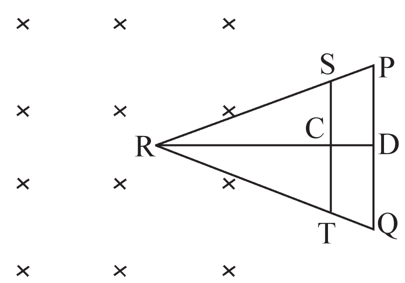
If wire becomes stationary at time $t = \infty$

$$\int_0^x dx = v_0 \int_0^\infty e^{-kt}\ dt$$

$$\therefore\ x = \frac{-v_0}{k}\left[e^{-kt}\right]_0^\infty = \frac{-v_0}{k}(0 - 1)$$

$$x = \frac{-v_0}{k} = \frac{v_0 mR}{B^2 l^2} = \frac{4 \times 50 \times 10^{-3} \times 10}{4 \times 2500 \times 10^{-4}} = 2\text{ m}$$

(23) Answer [C]



Suppose, loop travels distance CD in time t then,

CD = vt, RD = b (Assume)

$\therefore$ From figure $\frac{RC}{RD} = \frac{CT}{QD}$

$$\Rightarrow \frac{RD - CD}{RD} = \frac{CT}{QD}$$

$$\Rightarrow \frac{b - vt}{b} = \frac{CT}{\frac{a}{2}} \qquad \left(QD = \frac{a}{2}\right)$$

$$\Rightarrow CT = \frac{a(b - vt)}{2b}$$

But, $ST = 2CT = \frac{2a(b - vt)}{2b}$

$\therefore$ Induced *emf* at time t is $|e| = Bv\,(ST)$

$$\therefore \text{ induced current, } i = \frac{|e|}{r} = \frac{Bv}{r}\left(a - \frac{a}{b}vt\right)$$

$$\Rightarrow i = \frac{-Bv^2a}{rb}t + \frac{Bva}{r}$$

This equation is simillar to $y = mx + c$ and slope is negative. So, negative slope of $i \rightarrow t$ graph is linear means accord with option (C).

(24) Answer [D]

Suppose induced *emf* at time t is 50 μV.

$$\therefore e = \frac{B(\pi L^2)}{t} \Rightarrow t = \frac{B\pi L^2}{\varepsilon}$$

$$\therefore t = \frac{2 \times 10^{-5} \times \pi \times 1}{50 \times 10^{-6}} = \frac{20\pi}{50} = \frac{2\pi}{5}$$

Means, rod completed one revolution. Then, on its both end induced *emf* is 50 μV.

(25) Answer [B]

Here induced *emf* $|e| = \frac{-B\Delta A}{t}$

Length of one side of square loop = $\frac{2\pi r}{4}$

$$\therefore \Delta A = \left(\frac{\pi r}{2}\right)^2 - \pi r^2 = \pi r^2\left(\frac{\pi}{4} - 1\right)$$

$$\therefore e = \frac{B\pi r^2}{t}\left(1 - \frac{\pi}{4}\right)$$

$$= \frac{0.4 \times \pi \times 64 \times 10^{-4}}{2}\left(\frac{4 - 3.14}{4}\right)$$

$= 8.64 \times 10^{-4}$ V

(26) Answer [D]

Assume that freely falling loop enters magnetic field. It travels distance d with velocity v in time t.

$$\therefore v = \sqrt{2gd}$$

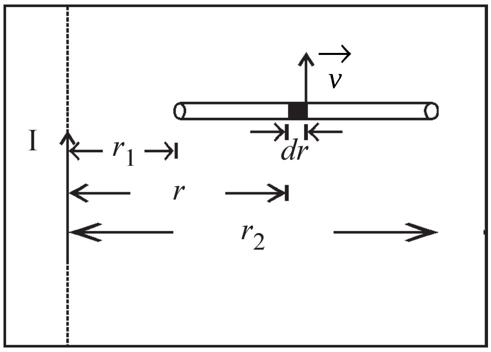
At this time Lentz force = gravitational force

$$\therefore BIl = mg, \quad I = \frac{Bvl}{R}$$

$$\Rightarrow \frac{B^2l^2\sqrt{2gd}}{R} = mg \Rightarrow d = \frac{m^2gR^2}{2B^4l^4}$$

$$d = \frac{(50)^2 \times 10^{-6} \times 10 \times (15)^2}{2 \times (2)^4 \times (0.40)^4} \cong 6.9 \text{ m}$$

(27) Answer [C]



If the induced *emf* is de in rod having length dr far by distance r from conducting wire as shown in figure.

$$de = Bvdr = \frac{\mu_0 Iv}{2\pi}\frac{dr}{r} \qquad ...(1)$$

Integrating equation (1) in limits of r_1 to r_2,

$$e = \frac{\mu_0 Iv}{2\pi}\int_{r_1}^{r_2}\frac{1}{r}dr, \ \therefore e = \frac{\mu_0 Iv}{2\pi}\, ln\left[\frac{r_2}{r_1}\right]$$

(28) Answer [A]

$$\text{Power } P = Fv = BIvl = \frac{B^2v^2l^2}{R} \Rightarrow P \propto v^2$$

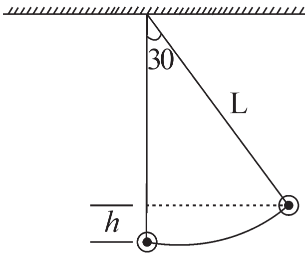
(29) Answer [D]

When distance x increases, $\frac{dB}{dt}$ increases and induced *emf* for given condition is negative. When loop is in fall field at that time $\frac{dB}{dt} = 0$, induced $emf = 0$.

When loop comes out from field then $\frac{dB}{dt}$ decreases and *emf* becomes positive. So, this condition describes by graph (D).

(30) Answer [A]

Here, from figure



$$v^2 = 2gh = 2gL(1 - \cos\theta) = 2gL\left(2\sin^2\frac{\theta}{2}\right)$$

$$\Rightarrow v = 2\sqrt{gL}\,\sin\frac{\theta}{2} = 2 \times 3.16 \times 0.2588$$

$= 1.64\ ms^{-1}$, ..

$|e| = BvL = 0.35 \times 10^{-4} \times 1.67 \times 1$

$= 57 \times 10^{-6}$ V

(31) Answer [D]

Mutual inductance $M = \frac{\mu_0 A N_1 N_2}{l}$

$$\therefore M = \frac{4\pi \times 10^{-7} \times \pi \times 25 \times 10^{-4} \times 10^3 \times 10^2}{1 \times 4}$$

$= 25 \times 10^{-5}$ H,

Induced *emf* $|e| = M\frac{dI}{dt}$

$$= 25 \times 10^{-5} \times \frac{5 - 0}{10 \times 10^{-3}} = 125 \times 10^{-3}$$

$= 125\ mV$

(32) Answer [D]

Increase of current for series L – R connection of DC circuit at time t is, $I = I_0\left(1 - e^{\frac{-t}{\tau}}\right)$

$$\tau = \frac{L}{R} = \frac{5}{100} = 0.05 \text{ s}$$

$$I_0 = \frac{E}{R} = \frac{6}{100} = 0.06 \text{ A},\ i = \frac{I_0}{2}$$

$$\Rightarrow \frac{I_0}{2} = I_0\left(1 - e^{\frac{-t}{\tau}}\right) \Rightarrow \frac{1}{2} = 1 - e^{\frac{-t}{\tau}}$$

$$\Rightarrow e^{\frac{-t}{\tau}} = 1 - \frac{1}{2} = \frac{1}{2},\ \therefore e^{\frac{-t}{\tau}} = 2$$

$$\therefore \frac{t}{\tau} = ln\,(2) = 0.693,$$

$$\therefore t = 0.693 \times \tau = 34.6 \text{ ms}$$

$$\text{Now, } V_L = -L\frac{di}{dt} = -L\frac{d}{dt}\left[I_0\left(1 - e^{\frac{-t}{\tau}}\right)\right]$$

$$\therefore V_L = -LI_0\left(-\frac{1}{\tau}\right)e^{\frac{-t}{\tau}} = \frac{LI_0}{\tau}e^{\frac{-t}{\tau}} = 0.8 \text{ V}$$

(33) Answer [C]

Here Steady current, $I_0 = \frac{\varepsilon}{R} = \frac{18}{24} = \frac{3}{4}$ A

Energy stored in inductor

$$U = \frac{1}{2}LI_0^2 = \frac{1}{2} \times 100 \times 10^{-3} \times \left(\frac{3}{4}\right)^2$$

$= 0.028$ J

loss of power due to resistance $P = I_0^2 R$

$$= \left(\frac{3}{4}\right)^2 \times 24 = 13.5 \text{ W}$$

(34) Answer [C]

Current is decaying in L – R, DC series circuit then, current at time t is,

$$I = I_0 \cdot e^{\frac{-t}{\tau}},$$

$$\tau = \frac{L}{R} = \frac{100 \times 10^{-3}}{50} = 2 \times 10^{-3} \text{ s},$$

$$I = \frac{I_0}{2},\ \therefore \frac{I_0}{2} = I_0 \cdot e^{\frac{-t}{\tau}}$$

$\Rightarrow e^{\frac{-t}{\tau}} = 2, \therefore \frac{t}{\tau} = ln(2) = 0.693$

$\therefore$ t = $0.693 \times \tau = 0.693 \times 2 \times 10^{-3}$

= 1.386 *m*s

(35) Answer [A]

The magnetic flux passing though space between both wire is,

$$\phi = \frac{\mu_0 lI}{2\pi} \; ln\left(\frac{b}{a}\right) = \frac{4\pi \times 10^{-7} \times 100 \times 2}{2\pi}$$

$$ln\left(\frac{5\times10^{-3}}{1\times10^{-3}}\right) = 6.44 \times 10^{-5}\ Wb$$

Self inductance $L = \frac{\phi}{I} = \frac{6.44\times10^{-5}}{2} = 32.2\ \mu H$

(36) Answer [B]

magnetic energy density $\rho_B = \frac{B^2}{2\mu_0}$ $B = \frac{\mu_0 NI}{l}$

$$\therefore \rho_B = \frac{(\mu_0 NI)^2}{2l^2\mu_0} = \frac{\mu_0 N^2 I^2}{2l^2}$$

$$= \frac{4\pi\times10^{-7}\times4\times10^{6}\times4}{2\times2\times2} = 2.51\ Jm^{-3}$$

total energy $U = \rho_B \times V = \rho_B \times \pi r^2 \times l$

$= 14.2 \times 10^{-3}$ J

(37) Answer [D]

Length of big square loop's side is L = 5 m

Length of smalll square loop's side is $l = 4 \times 10^{-3}$ m

The magnetic field at center due to one side is

$$B_1 = \frac{\mu_0 I}{4\pi \frac{L}{2}} (\sin\theta_1 + \sin\theta_2)$$

$$\therefore B_1 = \frac{\mu_0 I}{2\pi L}\sqrt{2}$$

$\therefore$ total magnetic field generated at center is $B = 4 \times B_1$

$$= \frac{2\sqrt{2}\,\mu_0 I}{\pi L},$$

Matual inductance $M = \frac{\phi}{I} = \frac{BA}{I} = \frac{2\sqrt{2}\,\mu_0 I}{\pi L I} \times l^2$

$$\therefore M = \frac{2\times\sqrt{2}\times4\pi\times10^{-7}}{\pi\times5} \times 16\times10^{-6}$$

$= 3.6 \times 10^{-6}\ \mu H$

(38) Answer [C]

Here, $\phi = \frac{\mu_0 I}{2R} \times N\pi r^2$

Mutual inductance $M = \frac{\phi}{I} = \frac{\mu_0 I N\pi r^2}{2RI}$

$$= \frac{\mu_0 N\pi r^2}{2R}$$

$$\therefore M = \frac{4\pi\times10^{-7}\times10\times\pi\times25\times10^{-4}}{2\times5}$$

$= 1 \times 10^{-8}$ H

(39) Answer [B]

$r_1 = 20 \times 10^{-2}$ m, $r_2 = 4 \times 10^{-2}$ m

$B = \frac{\mu_0 NI}{2\pi r_1}$, $\phi = NB\pi r_2^2$

$$\therefore L = \frac{\phi}{I} = \frac{\mu_0 N^2 \cdot r_2^2}{2r_1} = 4.52\ H$$

(40) Answer [D]

Stored magnetic energy $U = \frac{1}{2}LI^2$, $\left(L = \frac{N\phi}{I}\right)$

$$\therefore U = \frac{1}{2}\frac{N\phi}{I} I^2 = \frac{N\phi I}{2}$$

$\therefore$ Magnetic energy density $\rho_B = \frac{U}{Al} = \frac{N\phi I}{2\pi r^2 l}$

$$\therefore \rho_B = \frac{100\times5\times10^{-5}\times1}{2\times3.14\times4\times10^{-4}\times10\times10^{-2}}$$

$= 19.9\ Jm^{-3}$

(41) Answer [C]

As current I pass from loop, the magnetic field at center is $B = \frac{\mu_0 NI}{2a}$, magnetic flux ϕ = BAN

$\therefore$ Self inductance $L = \frac{\phi}{I}$, $\therefore L = \frac{\mu_0 N^2 \pi a}{2}$

$$= \frac{4\pi \times 10^{-7} \times 10^{6} \times \pi \times 100 \times 10^{-4}}{2} = 20 m\text{H}$$

(42) Answer [D]

Self induced *emf* in first coil is $e_1 = -L_1 \frac{dI_1}{dt}$

Self induced *emf* in second coil is, $e_2 = -L_2 \frac{dI_1}{dt}$

mutual inductance of system $M = \frac{-e_2}{dI_1/dt} = \frac{-e_1}{dI_2/dt}$

$$\therefore M^2 = \frac{e_1 e_2}{\left(\frac{dI_1}{dt}\right)\left(\frac{dI_2}{dt}\right)} = L_1 L_2$$

$$\therefore \quad M = \sqrt{L_1 L_2}$$

(43) Answer [C]

Here L – R, DC circuit. So, current passes from R and first bulb B will bright when closed the key K. When current increases gradually with time in inductor and B_1 will bright. Finally, steady current pass in circuit so both bulb will equally bright.

(44) Answer [A]

Here, magnetic field on axis at distance l due to first loop is

$$B_1 = \frac{2\mu_0}{4\pi} \frac{I_1 A}{l^3} \quad (I_1\text{A magnetic moment})$$

$$\therefore \phi = B_1 A_2 \therefore M = \frac{\phi}{I_1} = \frac{\mu_0 \pi a^4}{2l^3}$$

$$M = \frac{4\pi \times 10^{-7} \times \pi \times 25 \times 25 \times 10^{-8}}{2 \times 25 \times 5}$$

$= 100 \times 10^{-15} = 1 \times 10^{-13}$ H

$= 1 \times 10^{-7}$ μH

(45) Answer [B]

$$I_t = I_0 \cdot \left[1 - e^{\frac{-t}{\tau}}\right], \ I = \frac{3}{4} I_0$$

$$\therefore \frac{3}{4} I_0 = I_0 \left[1 - e^{\frac{-t}{\tau}}\right], \therefore \ e^{\frac{-t}{\tau}} = 1 - \frac{3}{4} = \frac{1}{4}$$

$$\therefore \ e^{\frac{-t}{\tau}} = 4, \ \therefore \ \frac{t}{\tau} = ln\,(4)$$

$$\Rightarrow \ \tau = \frac{L}{R} = \frac{t}{ln(4)} = \frac{4}{2.303 \times 0.6021} = 2.88 \text{ s}$$

(46) Answer [B]

ϕ_t = NAB cosωt ⇒ V = NABω sinωt

Here, sinωt = 1 then V = V_m થાય.

$$\Rightarrow \ \sin\omega t = 1 \Rightarrow \omega t = \frac{\pi}{2}$$

$$\therefore t = \frac{\pi}{2} \times \frac{2}{50\pi} = \frac{1}{50} \text{ s} = 2 \times 10^{-2} \text{ s}$$

(47) Answer [B]

Voltage between two ends of winding

$$V_1 = \frac{P}{I} = \frac{40}{2} = 20 \text{ V}$$

electromotive force = 20 + 200 = 220 V

(48) Answer [A]

Vottage is maximum at $t = 0$ time.

⇒ V = Vm cosωt

At V = 0, Vm cosωt = 0

$$\Rightarrow \cos\omega t = 0 \ (V_m \neq 0), \ \therefore \ \omega t = \frac{\pi}{2}$$

$$\therefore \ \omega = \frac{\pi}{2t} = \frac{\pi \times 10^3}{2 \times 50} = 10\pi \ rads^{-1}$$

(49) Answer [C]

Here voltage is V = V_m cosωt.

At time $t = \frac{1}{2\pi}$, V = 3.464 V

$$\therefore \ 3.464 = 4 \cos \frac{2\pi f}{2\pi}$$

$\therefore$ 0.8660 = cos$f$

$$\therefore f = 30° = \frac{\pi}{6} = \frac{3.14}{6} = 0.5233 \text{ Hz}$$

(50) Answer [C]

V = 120 sin (100πt) cos (100πt)

= 60 [2sin (100πt) cos (100πt)]

∴ V = 60 sin(200πt) [∵ 2sinθcosθ = sin2θ]

Compare above equation with

$V = V_m \sin\omega t$, $V_m = 60$ V

and $\omega = 200\pi$ rad s^{-1}, $\therefore\ 2\pi f = 200\pi$

$\therefore\quad f = 100$ Hz

(54) Answer [C]

As speed of *dC* motor increases, angular speed ω increases and resulting back *emf* increases.

So, according to

$I = \dfrac{E - k\omega}{R}$ Flow of armature decreases.

(55) Answer [B]

back *emf* $\propto \omega \Rightarrow \dfrac{e}{2} = \dfrac{3\omega_1}{\omega_1} \Rightarrow e = 6$ V

(56) Answer [D]

$e_1 \propto \omega_1, e_2 \propto \omega_2$

$\Rightarrow \dfrac{e_2}{e_1} = \dfrac{\omega_2}{\omega_1} \Rightarrow \omega_2 = \dfrac{120}{100} \times 1500 = 1800$

(57) Answer [C]

$I = \dfrac{E - e}{R} \Rightarrow e = E - IR = 200 - (1.5 \times 20)$

$= 200 - 30 = 170$ V

(58) Answer [C]

$$\text{Efficiency } n = \frac{emf\,(e)}{\text{supply voltage E}} \times 100$$

$$\Rightarrow e = \frac{30 \times E}{100} = \frac{30 \times 50}{100} = 15 \text{ V}$$

$$\text{Now, } I = \frac{E - e}{R}$$

$$\Rightarrow R = \frac{E - e}{I} = \frac{50 - 15}{7} = \frac{35}{7} = 5\ \Omega$$

(59) Answer [A]

Solution : The force $\vec{F} = e\left(\vec{v} \times \vec{B}\right)$ acting on free electron of conducting rod is zero. Because $\vec{v} \parallel \vec{B}$. So, potential difference is not generated at the end of rod. Thus option (A) is true.

(60) Answer [D]

Both the coil travells in field-free region from magnetic field, then the rate of time change in area of square coil is constant So, Induced electromagnctic force is also constant. While the rate of time change in area is vary for circular coil. (Moreover, the rate of change of magnetic field is also changes). Thus, statement (D) is true.

(61) Answer [A]

Solution : Resistive force acts due to the eddy current. So, according to Lentz's law, the caues protest by induced emf and gravitational accelertion acts on rod is decreases. Thus, option (A) is true.

(62) Answer [D]

Solution : When soft iron rod enters in the coil then its effective resistance doesn't change. So, no change is observed in bulb's brightness thus, option (D) is true.

(65) Answer [A]

Solution : There is no motion of ring C relative to ring B till then no induced current forms due to the current passing in ring C. When field A travells towards ring B then according to Lentz's law, the induced current forms in ring B is in anti-clockwise direction. Thus, option (A) is true.

(68) Answer [C]

$$|\,e\,| = \frac{d}{dt}(Bxd) = Bd\frac{dx}{dt} = Bvd$$

Where v is velocity of MN rod.

(69) Answer [D]

total resistance of closed loop $R + 2\lambda x$

for that induced current

$I = \dfrac{|e|}{R + 2\lambda x} = \dfrac{Bvd}{R + 2\lambda x}$ (Resistance of MN rod is negligible.)

(70) Answer [D]

$$\text{Force on rod is, } F = IBd = \frac{B^2 d^2 v}{R + 2\lambda x}$$

$$\therefore\ m\frac{dv}{dt} = \frac{B^2 d^2}{R + 2\lambda x}\ \frac{dx}{dt}$$

$$\therefore\ dv = \frac{B^2 d^2}{m} \times \frac{dx}{R + 2\lambda x}$$

$$\Rightarrow v = \int_0^v dv = \frac{B^2d^2}{m} \int_0^x \frac{dx}{R + 2\lambda x}$$

$$\Rightarrow v = \frac{B^2d^2}{2\lambda m} \log_e\left(\frac{R + 2\lambda x}{R}\right)$$

(71) Answer [C]

Suppose, velocity of rod is v at one moment in X-direction. Electromotive force produced due to magnetic field B in Y-direction is $e = BLv$

$\therefore$ Induced current $I = \frac{BLv}{R}$ (R is resistance)

Now, due to current I passing in rod having length L in magnetic field the resistive force is equal to the tension force by string on rod.

$F = BIL = T$

$\therefore$ Equation of block's motion

$F = ma = mg - T = mg - BIL,$

$\therefore$ acceleration of block $a = g - \frac{BIL}{m}$

$\therefore\ a = g - \frac{B^2L^2v}{mR}$ (putting value of I)

(72) Answer [D]

When rod gets the final velocity v then, acceleration on block $a = 0$.

$\therefore\ 0 = g - \frac{B^2L^2v_t}{mR}$

$\therefore$ terminal velocity $v_t = \frac{mgR}{B^2L^2}$

(73) Answer [B]

When velocity v of rod becomes halved of final velocity v_t then, $v = \frac{v_t}{2} = \frac{mgR}{2B^2L^2}$

$\therefore$ acceleration $a = g - \frac{B^2L^2v_t}{2mR}$

$= g - \frac{B^2L^2}{2mR} \times \frac{mgR}{2B^2L^2}$ (putting value of v_t)

$= \frac{g}{2}$

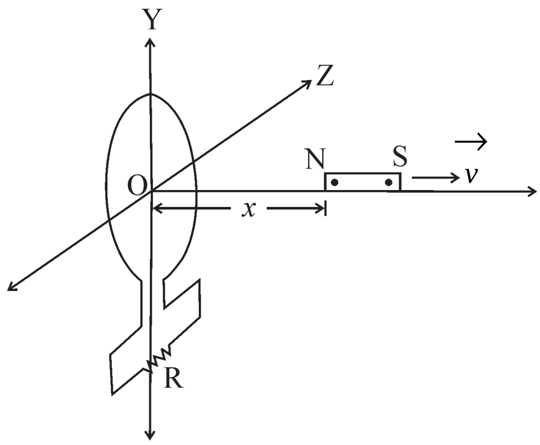
(74) Answer [C]

According to figure, magnetic field is

$B = \frac{\mu_0}{2\pi} \frac{Mx}{(x^2 - l^2)^{\frac{3}{2}}}$, But $x >> l$

So, $B = \frac{\mu_0 M}{2\pi x^3}$

(75) Answer [D]



magnetic flux associated with loop

$\phi = BA = \frac{\mu_0 M}{2\pi x^3} \times \pi a^2$

$= \frac{\mu_0 M a^2}{2x^3}$ taking $x = 2a$, $\phi = \frac{\mu_0 M}{16a}$

(76) Answer [B]

Induced current from loop II at $(x = 2a)$

$e = \frac{-d\phi}{dt} = \frac{-d\phi}{dx} \times \frac{dx}{dt} = -v\frac{d\phi}{dt}$

$= \frac{\mu_0 M a^2 v}{2} \frac{d}{dx}\left(\frac{1}{x^3}\right)$

$= \frac{3}{2}\frac{\mu_0 Ma^2 v}{x^4}$ taking $x = 2a$, $e = \frac{3\mu_0}{32}\frac{Mv}{a^2}$

(77) Answer [A]

Induced current from loop (for $x = 2a$)

$$I = \frac{e}{R} = \frac{3\mu_0}{32}\frac{Mv}{Ra^2}$$

$\therefore$ megnetic moment of loop $M_0 = I\pi a^2$

$$= \frac{3\pi\mu_0}{32}\frac{Mv}{R}$$

(78) Answer [C]

The magnetic field produced due to current $2I$ of large loop at the center of small ring

$$B = \frac{2\mu_0 IR^2}{2\left(R^2 + x^2\right)^{\frac{3}{2}}} \text{ taking } x = \sqrt{3}R \quad B = \frac{\mu_0 I}{8R}$$

(79) Answer [A]

Here radius of small loop $\frac{R}{N}$ is very small compare to distance $x = \sqrt{3}R$,

So, magnetic flux associated with this is

$\phi = B \times$ area of small loop

$$= \frac{\mu_0 I}{8R} \times \pi\left(\frac{R}{100}\right)^2$$

$$= \frac{\mu_0 I\pi}{8R} \times \frac{R^2}{10^4} = \frac{5\pi\mu_0 IR}{4} \times 10^{-5}$$

(80) Answer [A]

Mutual inductance for system of both rings.

$$M_{12} = \frac{\phi}{I_1} = \frac{\phi}{2I},\ M_{12} = \frac{\phi}{I_2} = \frac{\phi}{I}$$

For very small (order of 10^{-12}) magnetic flux associated with ring (2),

$M_{12} = \frac{\phi}{I} = M$ option is more appropriate.

(81) Answer [B]

magnetic moment of large ring

$$M = I_1\pi r_1^2 = 2\pi IR^2$$

magnetic moment of small ring $m = I_2\pi r_2^2$

$$= \frac{\pi IR^2}{10^4},\ \therefore \frac{M}{m} = \frac{2\pi IR^2}{\pi IR^2} \times 10^4$$

$= 2 \times 10^4$

(83) Answer [B]

Here, $M = k\sqrt{L_1 L_2} = 0.3\sqrt{400} = 6\ mH$

(*a*) For parallel connection $L = \frac{L_1 L_2 - M^2}{L_1 + L_2 + 2M}$

$$= \frac{(10 \times 40) - 36}{50 + 12} = 5.87 \times 10^{-3}\ H$$

(*b*) For series connection $(M \neq 0) : L = L_1 + L_2 - 2M$

$= 50 - 12 = 38 \times 10^{-3}$ H

(*c*) For series connection $(M \neq 0) : L = L_1 + L_2 + 2M$

$= 50 + 12 = 62 \times 10^{-3}$ H

(megnetic flux in one direction)

(*d*) For parallel connection $(M = 0)$,

$$L = \frac{L_1 L_2}{L_1 + L_2} = \frac{400}{50} = 8 \times 10^{-3}\ H$$

(84) Answer [A]

For given circuit

$$| Z | = \frac{1}{(\omega C - 1/\omega L)^2}$$

Here if value of $\left(\omega C - \frac{1}{\omega L}\right)^2$ is minimum then,

| Z | becomes maximum means infinite

$\therefore$ | Z | = infinite

$$\therefore \omega C - \frac{1}{\omega L} = 0 \Rightarrow \omega = \frac{1}{\sqrt{LC}}$$

$$\therefore \omega = \frac{1}{\sqrt{4 \times 2.5 \times 10^{-3}}} = 10$$

$$\therefore \text{ frequency } f = \frac{2\pi}{\omega} = \frac{6.28}{10} = 0.628 \text{ Hz}$$

| Z | = infinite So, I = 0.

(85) Answer [A]

For given circuit,

$$| Z | = \sqrt{\frac{R^2 (X_L - X_C)^2}{(X_L - X_C)^2 + R^2}}$$

$$= \sqrt{\frac{100\,(7850 - 6369)^2}{(7850 - 6369)^2 + 100}} = 10\ \Omega$$

(86) Answer [D]

For first case, $I^2 = \dfrac{V^2}{R^2 + X_c^2}$ ...(1)

For second case, $\dfrac{I^2}{16} = \dfrac{V^2}{R^2 + 25\,X_c^2}$ ...(2)

$\begin{pmatrix} \omega' = \omega/5 \\ I' = I/4 \end{pmatrix}$ taking ratio of equation (1) and (2)

$$16 = \frac{R^2 + 25\,X_c^2}{R^2 + X_c^2}$$

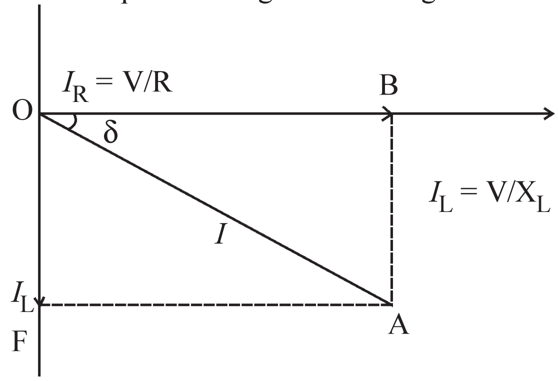
$$\Rightarrow 16\,R^2 + 16\,X_c^2 = R^2 + 25\,X_c^2$$

$$\Rightarrow 9\,X_c^2 = 15\,R^2$$

$$\therefore \frac{X_c}{R} = \sqrt{\frac{15}{9}} = 1.30$$

(87) Answer [C]

Given circuit L – R is parallel AC circuit. Its phaser diagram is as given bellow.



From phaser diagram,

R = 20 Ω, $X_L = 63.7 \times 314 \times 10^{-3} = 20\ \Omega$

$$\tan\delta = \frac{R}{X_L},\ \therefore \delta = \tan^{-1}\frac{R}{X_L}$$

$$\therefore \delta = \tan^{-1}\left[\frac{20}{20}\right] = 45°, \text{ forward}$$

(88) Answer [A]

In L–C–R series AC circuit at the time of resonance, $X_L = X_C$ and | Z | = R.

$\therefore$ | Z | = 20 Ω

$$\text{Now, } \omega L = \frac{1}{\omega C} \Rightarrow \frac{1}{\omega^2 L} = \frac{1}{4\pi^2 f^2 L}$$

$$\therefore C = \frac{1}{4 \times (3.14)^2 \times (72.70)^2 \times 0.16}$$

$$= 2.99 \times 10^{-5} \cong 30\ \mu F$$

(89) Answer [C]

$V_m = \sqrt{2}\ V_{rms} = 1.41 \times 200 = 282$ V

(90) Answer [C]

$$X_L = \omega L = 2\pi f L = \frac{50}{\pi} \times 2\pi \times 1 = 100$$

R = 100

for, L – R circuit $\delta = \tan^{-1}\left[\dfrac{X_L}{R}\right]$

$$\therefore \delta = \tan^{-1}\left[\frac{100}{100}\right]$$

$\therefore \delta = \tan^{-1}(1),\ \therefore \delta = 45°$

In L – R circuit voltage (V) leads to current.

(91) Answer [A]

Observation of ameter is I_{rms}. Here due to AC circuit I_{rms},

$$I_{rms} = \frac{V_{rms}}{|Z|} = \frac{V_m}{\sqrt{2}\, X_C},\ V_m = 200$$

$$X_C = \frac{1}{100 \times 10^{-6}} = \frac{1}{10^{-4}} = 10^4$$

$$\therefore I_{rms} = \frac{200 \times 10^{-4}}{1.41} = 141.8 \times 10^{-4}\ \text{A}$$

$= 14.18 \times 10^{-3}$ A $= 14.18$ mA

(92) Answer [B]

$$X_C = \frac{1}{\omega C},\ \Rightarrow C = \frac{1}{X_C \omega}$$

$$\omega = 2\pi f = 2\pi \times \frac{400}{\pi},\ X_C = 25\ \Omega$$

$$\therefore C = \frac{1}{25 \times 800} = 50 \times 10^{-6}\ \text{F}$$

$\therefore$ C = 50 μF

(93) Answer [C]

For L – R series AC circuit

$$\tan\delta = \frac{\omega L}{R},\ X_L = 2\pi f L = 400\ \Omega$$

$$R = 200\ \Omega,\ \therefore\ \delta = \tan^{-1}\left(\frac{X_L}{R}\right)$$

$$\therefore \delta = \tan^{-1}\left[\frac{400}{200}\right] = \tan^{-1}[2],\ \therefore\ \delta = 63°$$

$$\therefore \text{Difference in time } \Delta t = \frac{\delta}{\omega} = \frac{63 \times \pi}{180 \times 400}$$

$= 2.74 \times 10^{-3}$ s

(94) Answer [B]

$$f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{50 \times 500 \times 10^{-15}}}$$

$$= \frac{10^6}{10\pi} = \frac{100 \times 10^4}{10 \times 3.14} = 31.8 \times 10^3\ \text{Hz}$$

= 31.8 kHz

(95) Answer [C]

For LC series AC circuit, for inductor voltage phaser V_L is ahead of $\frac{\pi}{2}$ then I. For capacitor voltage phaser V_C is less of $\frac{\pi}{2}$ I.

So, option (C) is true.

(96) Answer [A]

For parallel RL - AC circuit, Voltage phaser V_L ahead of $\frac{\pi}{2}$ than current phaser for inductor. While phase-difference between phaser of resistance V_R and I is zero. Thus, option (A) is true.

(97) Answer [B]

Due to RL series AC circuit, $V_m = V_L + V_R$

But $V_L = V_R$ is given

$\therefore$ Assume that $V_L = V_R = V$, $V_m = 2$ V

$\therefore$ $2V = V_{rms}\sqrt{2} = 1.414 \times 100 = 141.4$

$\therefore$ V = 70.7 V

(98) Answer [C]

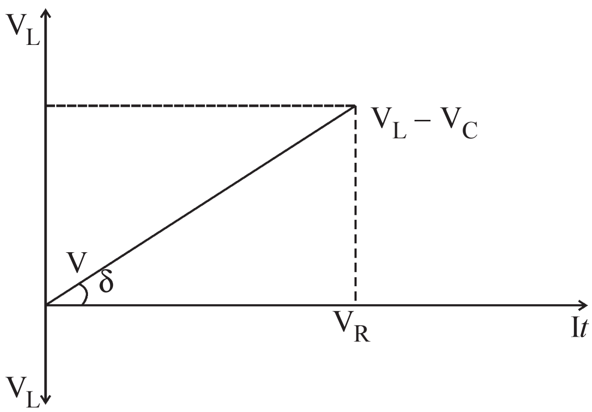
$V = 200 \sin (100)t$ with $V = V_m \sin\omega t$, $V_m = 200$ V, $\omega = 100$ rad s^{-1},

$$\text{Now, power } P = \frac{V_m I_m}{2} \cos\delta = \frac{V_m \times V_m}{2|Z|} \cos\delta$$

$$= \frac{200 \times 200}{2 \times 110} \times \cos 60 = \frac{100 \times 20}{11 \times 2} = 90.90\ \text{W}$$

(99) Answer [B]

Phaser of L – C – R Series AC circuit is as following.



From phaser diagram, $V^2 = V_R^2 (V_L - V_C)^2$

$\Rightarrow (V_L - V_C)^2 = V^2 - V_R^2$

$\therefore V_L - V_C = \sqrt{52900 - 100} = 229.7$

$\therefore V_C = 250 - 229.7 = 20.3$ V

(100) Answer [D]

Power $P = V_{rms}\ I_{rms}\ \cos\delta$

But $\cos\delta = \frac{R}{|Z|} = \frac{R\,I_{rms}}{V_{rms}}$

$\therefore$ Power $P = V_{rms}\ I_{rms} \times \frac{R\,I_{rms}}{V_{rms}}$

$\therefore P = I^2_{rms}\,R$

$\therefore R = \frac{P}{I^2_{rms}} = \frac{108}{25} = 4.3\ \Omega$

Note : AC voltage apply to coil, the circuit becomes L – R series circuit.

(101) Answer [C]

At time of resonance,

$$I_{rms} = \frac{V_{rms}(R)}{|Z|} = \frac{V_{rms}(R)}{R} = \frac{10}{1000} = 0.01\ A$$

Now, $X_L = \omega L = \frac{1}{\omega C}$

$$\Rightarrow \omega L = \frac{100 \times 10^4}{2 \times 200} = 12.5 \times 200 = 2500\ \Omega$$

$V_{rms}(L) = I_{rms}\,\omega_L = 1 \times 10^{-2} \times 2500$

$= 25$ V

(102) Answer [D]

$$|Z| = \sqrt{R^2 + (X_L - X_C)^2}$$

$$= \sqrt{(100)^2 + \left(50\pi - \frac{1000}{\pi}\right)^2}$$

$$= \sqrt{10{,}000 + (157 - 318.47)^2} = 189.9\ \Omega$$

(103) Answer [D]

Here, $f \propto \frac{1}{\sqrt{C}}$, $\therefore \frac{f_1}{f_2} = \sqrt{\frac{C_1}{C_2}} = \sqrt{\frac{C_1}{16C_1}} = \frac{1}{4}$

$\therefore f_2 = \frac{f_1}{4}$, taking $f_1 = f, f_2 = \frac{f}{4}$

(104) Answer [C]

For L – R series circuit,

$|Z| = \sqrt{R^2 + X_L^2}$

minimum value of $|Z|$ becomes R then,

$I_m = \frac{V_m}{R}$

Now, $I = \frac{V_m}{|Z|}$ But for $I = \frac{I_m}{2}$,

$$\frac{I_m}{2} = \frac{V_m}{|Z|} = \frac{I_m R}{|Z|}$$

$$\therefore \frac{1}{2} = \frac{R}{|Z|} = \frac{R}{\sqrt{(R^2 + X^2_L)}}$$

$$\therefore \frac{1}{2} = \frac{1}{\sqrt{1 + \left(\frac{X_L}{R}\right)^2}},\ \therefore 4 = 1 + \left(\frac{X_L}{R}\right)^2$$

$$\therefore 3 = \left(\frac{X_L}{R}\right)^2 \Rightarrow X_L = \sqrt{3}\,R\ X_L = \omega L \text{ taking}$$

$$\therefore L = \frac{\sqrt{3}R}{\omega} = \frac{\sqrt{3} \times 10}{20} = 0.8660\ H$$

(105) Answer [A]

$X_L = \omega L = 70 \times 10^3 \times 100 \times 10^{-6} = 7\ \Omega$

$$X_C = \frac{1}{\omega C} = \frac{1}{70 \times 10^3 \times 10^{-6}} = 14.28\ \Omega$$

Here $X_C > X_L$ So, circuit behave as a R – C series circuit.

(106) Answer [A]

Compare equation $V = 200 \cos \omega t$ with

$V = V_m \cos \omega t$, $V_m = 200$ V

$X_L = \omega L = 2000 \times 5 \times 10^{-3} = 10\ \Omega$

$$X_C = \frac{1}{\omega C} = \frac{1}{2000 \times 50 \times 10^{-6}} = 10\ \Omega$$

Here $X_L = X_C$ So, $|Z| = R = 6 + 4 = 10\ \Omega$ (Here resistance of inductor is 4 Ω So, total resistance of circuit is $(4 + 6) = 10\ \Omega$.)

$$\therefore I_m = \frac{V_m}{|Z|} = \frac{200}{10} = 20 \text{ A}$$

(107) Answer [D]

For given circuit

$$\delta = \tan^{-1} = \left[\frac{X_L - X_C}{R}\right], X_L = \omega L = 2\pi f L$$

$$= 2\pi \times 50 \times \frac{200}{\pi} \times 10^{-3} = 20\ \Omega$$

$$X_C = \frac{1}{2\pi f C} = \frac{\pi}{2\pi \times 50 \times 10^{-3}} = 10\ \Omega$$

$$\therefore \delta = \tan^{-1}\left[\frac{20 - 10}{10}\right] = \tan^{-1}[1]$$

$\therefore \delta = 45°$

(108) Answer [D]

Here $\delta_1 = -25°$, $\delta_2 = 20°$

$\therefore$ phase difference $\delta = \delta_2 - \delta_1 = 20° - (-25°) = 45°$

$V_m = 100\sqrt{2}$, $I_m = 10\sqrt{2}$

For L – C – R series circuit

$$\tan\delta = \frac{X_L - X_C}{R}, \therefore \tan 45° (R) = X_L - X_C$$

$\therefore R = X_L - X_C$ ...(1)

$$|Z| = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{R^2 + R^2}$$

$$= \sqrt{2} R, \therefore \frac{|Z|}{R} = \sqrt{2}$$

(109) Answer [A]

If $V = V_m$ then $\sin \omega t_1 = +1 \Rightarrow \omega t_1 = \frac{\pi}{2}$

$$\therefore t_1 = \frac{\pi}{2\omega},$$

At time $t = t_2$,

If $I = I_m$ then $\sin(\omega t_2 - \delta) = +1$

$$\Rightarrow \omega t_2 - \delta = \frac{\pi}{2}, \therefore t_2 = \frac{\pi}{2\omega} + \frac{\delta}{\omega}$$

$\therefore$ time difference $\Delta t = t_2 - t_1$

$$= \frac{\pi}{2\omega} - \frac{\pi}{2\omega} + \frac{\delta}{\omega} = \frac{\delta}{\omega}, \therefore \Delta t = \frac{\delta}{\omega} \quad ...(1)$$

$$\text{But here } \delta = \tan^{-1}\left[\frac{\omega L}{R}\right]$$

$$= \tan^{-1}\left[\frac{100\pi \times 0.5}{100}\right] = \tan^{-1}[1.57]$$

$$\therefore \delta = 57.5° = \frac{57.5 \times \pi}{180} \text{ rad},$$

$$\Delta t = \frac{57.5 \times \pi}{180 \times 100\pi} = 3.2 \times 10^{-3} \text{ s} = 3.2\ ms$$

(110) Answer [D]

Here voltage of source valtage changing as $\sin\omega t$.

$\Rightarrow V = Vm \sin\omega t$

Suppose voltage at time t_1 and current at time t_2 gets its maximum value.

$$\therefore \sin\omega t_1 = +1 \Rightarrow \omega t = \frac{\pi}{2} \Rightarrow t_1 = \frac{\pi}{2\omega}$$

$\sin(\omega t_2 + \delta) = +1$

$$\Rightarrow \omega t_2 + \delta = \frac{\pi}{2} \Rightarrow t_2 = \frac{\pi}{2\omega} - \frac{\delta}{\omega}$$

$$\therefore \text{time difference } \Delta t = \frac{\delta}{\omega}$$

$$\text{But } \delta = \tan^{-1}\left[\frac{1}{\omega CR}\right]$$

$= \tan^{-1}\left[\frac{1}{120\pi \times 40 \times 10^{-4}}\right] = \tan^{-1}[0.663]$

$\therefore \delta = 33.5° = \frac{33.5 \times \pi}{180}$ rad

$\therefore \Delta t = \frac{33.5 \times \pi}{180 \times 120\pi} = 1.55 \times 10^{-3}$ s

$= 1.55$ *ms*

(112) Answer [D]

Here $V = -L\frac{dI}{dt} = LI_o \frac{d}{dt}[1 - e^{-Rt/L}]$

$= -LI_o \frac{R}{L} e, \therefore V = Vo \cdot e^{-Rt/L}$

at time $t = 0$, $V = V_0$, at time $t >> 0$, $I = 0$.

This voltage changes expnentially with time. So, option [D] is true.

(113) Answer [D]

For L – C – R AC circuit,

$$I_{rms} = \frac{V_{rms}}{\sqrt{R^2 + (\omega L - 1/\omega C)^2}}$$

If f changes then ωL and $\frac{1}{\omega C}$ will change when $\omega = \omega o$ (resonant frequency) then I becomes I_{max} and then decreases while I decreases so, option D is true.

(114) Answer [C]

$Q = \frac{\omega}{\Delta\omega}$ But $\Delta\omega = \frac{R}{L}$

$\therefore Q = \frac{\omega L}{R} = \frac{2\pi f L}{R}$

$= \frac{2 \times 3.14 \times 50 \times 25 \times 10^{-3}}{10} = 0.785$

(115) Answer [B]

$\tan 45 = \frac{X_L - X_C}{R} = 1$

$\Rightarrow X_L - X_C = R \Rightarrow \omega L - \frac{1}{\omega C} = R$

$\Rightarrow \omega L - R = \frac{1}{\omega C} \Rightarrow C = \frac{1}{\omega(\omega L - R)}$

$\therefore C = \frac{1}{2\pi f[2\pi f L - R]}$

$= \frac{1}{314[(314 \times 2) - 10]} = \frac{1}{194052}$

$= 5.1 \times 10^{-6}$ F $\cong 5\mu$F

(117) Answer [B]

$X_L = 3 \times 10^{-3} \times 10^3 = 3\ \Omega$, $R = 4\ \Omega$

$\therefore |Z| = \sqrt{16 + 9} = 5\ \Omega$

Observation of Ameter $= I_{rms} = \frac{V_{rms}}{|Z|} = \frac{V_m}{\sqrt{2}|Z|}$

$= \frac{4}{1.41 \times 5} = 0.56$ A

(118) Answer [C]

If periodic time is T of revolution for AC current, then it reverse its direction at time $\frac{T}{2}$.

$\therefore \frac{T}{2} = 1 \times 10^{-2} \Rightarrow T = 2 \times 10^{-2}$

$\therefore f = \frac{1}{T} = \frac{1}{2 \times 10^{-2}} = 50$ Hz

(119) Answer [B]

efficiency $\eta = \frac{\text{output power } P_{out}}{\text{input power } P_{in}}$

$= \frac{E_S I_S}{E_P I_P}$

$\therefore \eta = \frac{10 \times 88}{220 \times 5} = \frac{880}{1100} = 0.8 = 80\ \%$

(120) Answer [D]

input power $P_i = E_P I_P = 4000$

$\Rightarrow I_P = \frac{4000}{E_P} = \frac{4000}{100} = 40$ A

$\eta = \frac{P_{out}}{P_{in}} \Rightarrow P_{out} = \eta \times P_{in}$

$= 0.75 \times 4000 = 3000$ W

Now $I_S = \frac{P_{out}}{E_S} = \frac{3000}{200} = 15$ A

$\therefore \frac{I_P}{I_S} = \frac{40}{15} = 2.66$

(121) Answer [C]

Here $E_P = \frac{N_P}{N_S} \times E_S = \frac{400}{2000} \times 1000 = 200$ V

$I_P = \frac{P_{out}}{\eta\ E_P} = \frac{12000}{0.9 \times 200} = \frac{200}{3}$ A

$\therefore$ loss of power in primary coil = $I^2{}_P \times R_P$

$= \frac{200 \times 200}{3 \times 3} \times 0.9 = 4000$ W

Now, $I_S = \frac{P_{out}}{E_S} = \frac{12{,}000}{1000} = 12$ A

loss of power in secondary coil = $I^2{}_S\ R_S$

$= 12 \times 12 \times 5 = 720$ W

(122) Answer [C]

$N_S = \frac{E_S}{E_P} \times N_P = \frac{4400}{220} \times 1000 = 20{,}000$

$I_S = \frac{P_{out}}{E_S} = \frac{\eta P_{in}}{E_S} = \frac{0.8 \times 6600}{4400} = 1.2$ A

(123) Answer [A]

Current in transmission line $I = \frac{\text{Power}}{\text{Voltage}}$

$= \frac{25000}{250} = 100$ A

Power loss = $I^2R = (100)^2 \times 1 = 10$ kW

$\therefore$ Power loss in percentage = $\frac{10 \times 10^3}{25 \times 10^3} \times 100$

= 40 %

(127) Answer [B]

Solution :

The power used is zero for the flow of current in each cycle by the capacitor having appropiate value of capacitance. Hence, it is used in circuit instead of choke coil and the power loss is zero. Here, assertion and reason both are true but reason doesn't gives true explanation of assertion.

Thus, option (B) is true.

(128) Answer [B]

Solution :

AC current is also shows the magnetic effects like DC current. But, its value and direction varies continuously with time.

Thus, option (B) is true.

(129) Answer [D]

Solution :

DC ameter made on theory of thermal effect of electric current. Heat energy generated according to $H = I^2R$ So, the same section are not marked on the dial of AC ameter.

Thus, option (D) is true.

(130) Answer [B]

The average value of AC voltage or current during half cycle is $\langle V \rangle = 0.636\ V_m$ or $\langle I \rangle = 0.636\ I_m$. Simillarly the average value is observed for second half circle but its direction is opposite. Thus, average value becomes zero for one full cycle. Hence, average value always obtained on half cycle.

Thus, option (B) is true.

(131) Answer [D]

$\phi = NBA \cos\theta$ from $\theta = 0 \Rightarrow \phi = BAN$

$\theta = 90 \Rightarrow \phi = 0$,

$\theta = 60 \Rightarrow \phi = \frac{BAN}{2}$

$\theta = 30 \Rightarrow \phi = \frac{\sqrt{3}}{2}$ BAN

(132) Answer [C]

Here $\phi = BAN \cos\omega t$

$\therefore\ V = -\frac{d\phi}{dt} = -$ BAN $\omega \sin \omega t$

$= -V_m \sin \omega t$ this graph is like *sin* plot.

(133) Answer [C]

Compare given equation with $V = Vo \sin(\omega t + \theta)$

$Vo = 100$ V, $\omega = 100\ \pi$ rad s^{-1}

at time t = 0, $V = 100 \sin \frac{\pi}{3}$

$\therefore$ at initial time $\theta = \frac{\pi}{3}$

(134) Answer [B]

After removing C form LR circuit

$\therefore \tan\delta = \dfrac{X_L}{R} \Rightarrow X_L = R\tan\delta$

Removing L form CR circuit $\therefore \tan\delta = \dfrac{X_C}{R}$

$\Rightarrow X_C = R\tan\delta$

$|Z| = \sqrt{R^2 + (X_L - X_C)^2}$

$= \sqrt{R^2 + (R\tan\delta - R\tan\delta)^2} = R$

$\therefore |Z| = 100\ \Omega$

(135) Answer [C]

$I_m = \dfrac{V_m}{|Z|} = \dfrac{200}{100} = 2A$

(136) Answer [C]

Power loss in circuit $P = \dfrac{I_m V_m}{2} \cos 60°$

$= \dfrac{2 \times 200}{4} \times \dfrac{1}{2} = 50\ W$

(137) Answer [B]

In R – C circuit, charging condition of capacitor then, $q = q_0 (1 - e^{-t/\tau})$, taking $t = 2\tau$,

$q = q_0 [1 - e^{-2\tau/\tau}]$, $\therefore q = q_0 [1 - e^{-2}]$

(138) Answer [C]

Open key K_1 and closing key K_2, circuit acts as L–C circuit and angular frequency of charge q is ω, which is given by $\dfrac{1}{\sqrt{LC}}$.

Now at time t = 0, $q \neq 0$ but,

$q = q_0 \cos(\omega t + \phi) \Rightarrow \dfrac{d^2q}{dt^2} = \omega^2 q$

$\therefore q = -\dfrac{1}{\omega^2} \times \dfrac{d^2q}{dt^2}$, $\therefore q = -LC \dfrac{d^2q}{dt^2}$

(139) Answer [D]

The electrical energy is stored between two plates of capacitor at time $2t = 0$ in LC circuit. As time passes then for $t > 0$ this energy distributed between inductor and capacitor. Here charge q continuosly change with time as following equation.

$q = q_0 \cos\omega t$ Where $\omega = \dfrac{1}{\sqrt{LC}}$

$\therefore I = \dfrac{dq}{dt} = -\omega q_0 \sin \omega t$, current is AC

$\therefore I_{max} = \omega q_0 = \dfrac{1}{\sqrt{LC}} \times CV = \sqrt{\dfrac{C}{L}} \times V$

(140) Answer [C]

$|Z| = \sqrt{10^2 + (2\pi f L)^2} = \sqrt{10^2 + 10^2}$

$= 10\sqrt{2}\ \Omega$

(1) $I_m = \dfrac{V_m}{|Z|} = \dfrac{V_{rms} \times \sqrt{2}}{Z}$

$\therefore I_m = \dfrac{200 \times \sqrt{2}}{10 \times \sqrt{2}} = 20\ A$

(2) $\delta = \tan^{-1}\left(\dfrac{X_L}{R}\right) = \tan^{-1}\left[\dfrac{10}{10}\right] = \tan^{-1}(1)$

$\Rightarrow \delta = 45°$

(3) at t = 0 time $I = 20 \sin\left(\dfrac{-\pi}{4}\right) = -10\sqrt{2} = 14.14\ A$

(4) Here, periodic time

$T = \dfrac{2\pi}{\omega} = \dfrac{2\pi}{100\pi} = \dfrac{1}{50} = 2 \times 10^{-2}$

current is $I = I_0 \sin(\omega t - \delta)$ So,

$0 = 20 \sin\left(\dfrac{2\pi t}{T} - \dfrac{\pi}{4}\right)$

$\Rightarrow \sin\left(\dfrac{2\pi t}{T} - \dfrac{\pi}{4}\right) = 0 \Rightarrow 2t = \dfrac{T}{4}$

$t = \dfrac{T}{8} = \dfrac{0.02}{8} = 0.0025\ s$

(143) Answer [A]

At time of resonance $|Z| = |Z|_{min} = R = 40\ \Omega$

$I_{rms} = \dfrac{V_{rms}}{|Z|_{min}} = \dfrac{230}{40} = 5.75\ A$

$V_{L(rms)} = I_{rms} \times WL = 5.75 \times 50 \times 5$

$= 1437.5\ V$

$V_{Lrms} + V_{Crms} = 1437.5 - 1437.5 = 0$

(Below resonance condition $(\omega_0 L = 1/\omega_0 C)$

●

15 Electro Magnetic Waves

(2) Answer [C]

$(\vec{E} \times \vec{B}) \perp \vec{B}$

So, $(\vec{E} \times \vec{B}) \cdot \vec{B} = 0$.

(4) Answer [A]

Vector $\vec{E}$ is direction of positive charge to negative charge and direction of magnetic field $\vec{B}$ due to current, formed for given situation, perpendicular coming out from page.

(5) Answer [D]

$\omega = 2\pi f \Rightarrow \sqrt{\frac{k}{m}} = \sqrt{\frac{2 \times 10^{-5}}{5 \times 10^{-6}}} = 2$

$\Rightarrow f = \frac{2}{2\pi} = \frac{1}{\pi}$

(6) Answer [A]

From equation $p = p_0 \cos\omega t$, it is clear that this dipole moment change with time as cosine function.

(9) Answer [B]

Energy density $\rho = \varepsilon_o E_{rms}^2$

$= \frac{\varepsilon_o E_o^2}{2} = \frac{8.85 \times (8.484)^2 \times 10^{-6} \times 10^{-12}}{2}$

$= 318.5 \times 10^{-19}\ Wm^{-3}$

(10) Answer [B]

Intensity $I = c\ \varepsilon_o E^2_{rms} = \frac{c\ \varepsilon o\ E_m^2}{2}$

$\therefore E_m^2 = \frac{2I}{c\varepsilon_o} = \frac{2 \times 1.33}{3 \times 8.85 \times 10^{-12} \times 10^8}$

$\cong 1000$, $\therefore E_m = 10\sqrt{10}$ only x component of Em. So, $E_x = 10\sqrt{10}$

(11) Answer [C]

Rediation pressure $P = \frac{U}{c}$, $I = c\varepsilon_o E^2_{rms}$

$\therefore \frac{U}{At} = \frac{c\varepsilon_o E_m^2}{2}$ $\quad A = 1$ unit $t = 1s$

$\therefore \frac{U}{c} = \frac{\varepsilon_o E_m^2}{2}$, $\therefore P = \frac{\varepsilon o\ E_m^2}{2}$

$= \frac{8.85 \times 10^{-12} \times 100}{2} = 4.425 \times 10^{-10}\ Pa$

$= 4.42 \times 10^{-10}\ Pa$

(12) Answer [C]

momentum on surface per unit time per unit area is equal to pressure.

$\therefore P = I/c = \frac{1480}{3 \times 10^8} = 4.93 \times 10^{-6}\ Pa$

(13) Answer [D]

$n = \sqrt{\mu_r K} \Rightarrow 1.5 = \sqrt{\mu_r K}$

$\therefore \frac{2.25}{K} = \mu_r = \frac{\mu}{\mu_o}$

$\therefore \frac{\mu}{\mu_o} = \frac{2.25}{2} \Rightarrow \mu = \frac{2.25 \times 4\pi \times 10^{-7}}{2}$

$= 4.5\ \pi \times 10^{-7}\ TmA^{-1}$

(14) Answer [B]

$I \propto E^2 \Rightarrow I = KE^2$, $\therefore K = \frac{I}{E^2}$

$\therefore$ Dimensional formulla of K

$= \frac{\text{Dimensional formula of I}}{(\text{Dimensional formula of E})^2}$

$= \frac{M^1\ L^o\ T^{-3}}{[M^1\ L^1\ T^{-3}\ A^{-1}]^2} = M^{-1}\ L^{-2}\ T^{+3}\ A^{+2}$

(15) Answer [D]

$E_{rms} = \sqrt{\frac{I}{\varepsilon_o c}} = \sqrt{\frac{P}{A\ \varepsilon_o c}}$

$\therefore E_{rms} = \sqrt{\frac{50}{25.8 \times 8.85 \times 10^{-12} \times 3 \times 10^8}} = 27$

$B_{rms} = \frac{E}{c} = 9 \times 10^{-8}$

(16) Answer [D]

Energy stored in volume ΔV,

$U_E = \frac{1}{2}\ \varepsilon_0\ E^2\ \Delta V$

taking $E = E_o \sin(kx - \omega t)$

$U_E = \frac{1}{2}\ \varepsilon_0 [E_0^2 \sin^2(kx - \omega t)]\ \Delta V$

$= \frac{1}{2}\ \varepsilon_0\ E_0^2\ \Delta V\ [1 - \cos^2(kx - \omega t)]$

This equation shows that, frequency of oscillation in energy is double than frequency of scillation in wave.

(17) Answer [D]

$\rho_0 = \frac{1}{2}\ \varepsilon_0\ E_0^2$

$\therefore$ Energy in given cylinder $= \rho_0\ \Delta V$

$\Rightarrow \frac{1}{2} \times 8.85 \times 10^{-12} \times (50)^2 \times 5 \times 10^{-4}$

$= 5.5 \times 10^{-12}\ J$

(18) Answer [A]

$I = \rho\, c = \frac{1}{2}\, \varepsilon_0\, E_0^2\, c \qquad E_0^2 = c^2 B_0^2$

$\therefore\ I = \frac{1}{2}\, \varepsilon_0\, c^3\, B_o^2,\ \therefore\ B_o = \sqrt{\frac{2I}{\varepsilon_0 c^3}}$

$= \sqrt{\frac{2 \times 1380}{8.85 \times 10^{-12} \times (3 \times 10^8)^3}} = 3.4 \times 10^{-6}$ T

(19) Answer [A]

$k = \frac{2\pi}{\lambda},\ \omega = 2\pi f = \frac{2\pi c}{\lambda}$

$\omega k = 2\pi f\ \frac{2\pi}{\lambda} = \left(\frac{2\pi}{\lambda}\right)^2 c$

$\frac{k}{\omega} = \frac{2\pi}{\lambda} \times \frac{1}{2\pi f} = \frac{2\pi}{\lambda} \times \frac{\lambda}{2\pi c} = \frac{1}{c}$

Thus, physical quantity $\frac{k}{\omega}$ is independent of wavelength λ.

(20) Answer [A]

If the existance of a single magnetic monopole then magnetic charge q_m exist. In this situation, Gauss's theorem is as follows :

$\oint \vec{B} \cdot d\vec{a} = \frac{q_m}{\varepsilon_o}$

(21) Answer [D]

Pointing vector $S = \frac{EB}{\mu_0}$

$B = \frac{\mu_0 I}{2\pi a l},\ \frac{E - V}{l} = \frac{IR}{l}$

$\therefore\ S = \left(\frac{R}{l}\right)\left(\frac{\mu_0 I}{2\pi a}\right)\frac{1}{\mu_0} = \frac{I^2 R}{2\pi a l}$

(27) Answer [C]

$c = \frac{E_o}{B_o}\ \therefore\ B_o = \frac{E_o}{c} = \frac{300}{3 \times 10^8} = 10^{-6}$ T

But $\vec{E} \times \vec{B} \parallel \vec{C}$

Here $\vec{B}$ is in +Z direction and $\vec{E}$ is in Y direction and $\vec{c}$ in +X direction.

So, $\vec{B}$, 10^{-6} T is in +Z–direction.

(28) Answer [A]

Maximum electric force on electron is,

$F_e = qE = (1.6 \times 10^{-19}) \times 300$
$= 4.8 \times 10^{-17}$ N

(29) Answer [B]

Maximum magnetic force on electron

$F_m = qvB_o = 1.6 \times 10^{-19} \times 2 \times 10^7 \times 10^{-6}$
$= 3.2 \times 10^{-18}$ N

(30) Answer [B]

$E_o = cB_o = \left[3 \times 10^8\ ms^{-1}\right]\ (200 \times 10^{-6}\ T)$
$= 60000$ N/C $= 6 \times 10^4$ Nc^{-1}

(31) Answer [D]

$U = \frac{1}{2}\, E_o^2\, \varepsilon_o$

$= \frac{1}{2}\ (8.85 \times 10^{-12}\ c^2 N^{-1} m^{-2})\ (60000\ Nc^{-1})^2$
$= 0.016\ Jm^{-3}$

(32) Answer [A]

For $S = \frac{E_o B_o}{\mu_0}$ the pointing vector

$S = \frac{6 \times 10^4 \times 2 \times 10^{-4}}{4\pi \times 10^{-7}} = 0.995 \times 10^7$
$= 9.55 \times 10^6$

(33) Answer [B]

$E_o = \sqrt{2}\ E_{rms} = 1.414 \times \sqrt{\frac{I}{\varepsilon_0 c}}$

$= 1.414 \times \sqrt{\frac{7.96 \times 10^{-3}}{8.85 \times 10^{-12} \times 3 \times 10^8}}$
$= 2.45\ Nc^{-1}$

(34) Answer [C]

Intensity of Radiation $I = \frac{U}{A} = \frac{2\%(P)}{4\pi R^2}$

$= \frac{40}{4 \times 3.14 \times (20)^2}$ (for t = 1 second)
$= 7.96 \times 10^{-3}\ Wm^{-2}$

(35) Answer [B]

Momentum gain by surface in one second is force.

$\therefore\ F = \frac{U}{c} = \frac{40}{3 \times 10^8}\ \therefore\ F = 1.33 \times 10^{-7}$ N

(36) Answer [B]

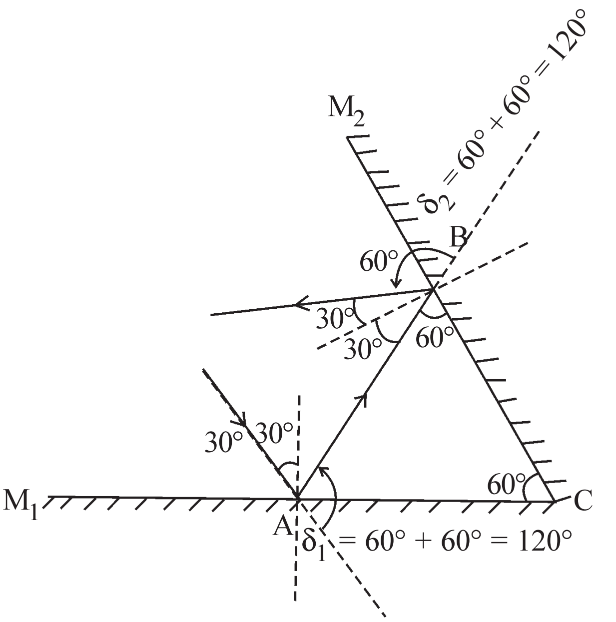
Energy density

$\therefore\ \rho = \frac{I}{c} = \frac{7.96 \times 10^{-3}}{3 \times 10^8}$
$= 2.653 \times 10^{-11}\ Jm^{-3}$

●

Optics

(1) Answer [B]

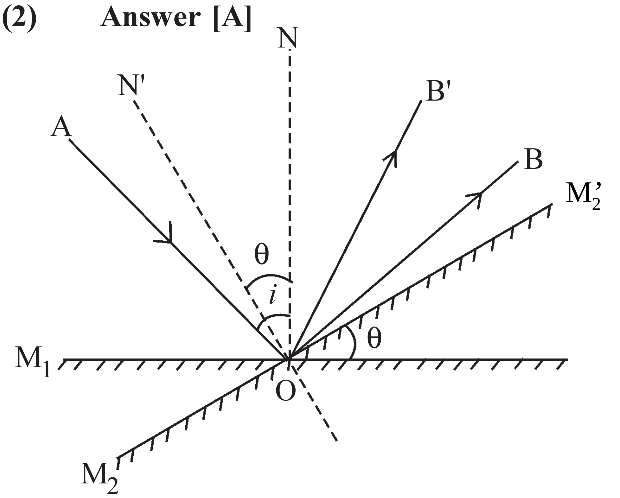


From reflection on M_1 δ_1, = 60° + 60° = 120°

From reflection on M_2 δ_2, = 60° + 60° = 120°

total deviation $\rho = \rho_1 + \rho_2 = 240°$

(2) Answer [A]



i = Rotate by θ angle, Initial incident angle

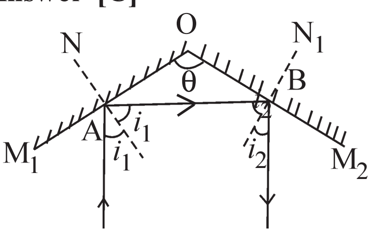
$\angle AOB = 2i$ (incident angle = reflection angle)

$\angle AOB' = \angle AON' + \angle N'OB'$

$= i - \theta + i - \theta = 2i - 2\theta$

$\therefore$ Reflected ray rotated by angle 2θ

(3) Answer [C]



for parallel rays $\delta = 180°$, $\delta = \delta_1 + \delta_2$

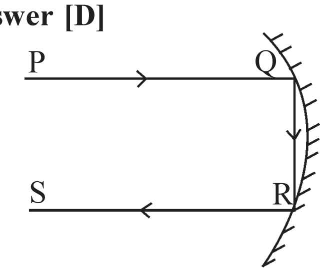
$180° = (180° - 2i_1) + (180° - 2i_2)$

$i_1 + i_2 = 90°$ ...(1)

ΔOAB for $(90 - i_1) + (90° - i_2) + \theta = 180°$

$i_1 + i_2 = \theta$, $\theta = 90°$ [from equation (i)]

(4) Answer [D]



Possible by one concave mirror.

(5) Answer [A]

Magnification of mirror $= \dfrac{f}{f-u}$

Value $= \dfrac{f}{u-f}$

Volume of image = (magnification)^2 × length

$= \left(\dfrac{f}{u-f}\right)^2 b$

(6) Answer [C]

$$v_i = -\left(\frac{R}{2u-R}\right)^2 v_o$$

$$-v_o = \left(\frac{R}{2u-R}\right)^2 v_o \; [v_i = -v_o]$$

$$\frac{R}{2u-R} = 1, \therefore u = R$$

(7) Answer [B]

Magnification is same so, one is true image and second is virtual image.

$$-m_1 = m_2, \Rightarrow -\frac{f}{f-u_1} = \frac{f}{f-u_2}$$

$$u_1 - f = f - u_2 \Rightarrow u_1 + u_2 = 2f$$

$$f = \frac{u_1 + u_2}{2}$$

(8) Answer [A]

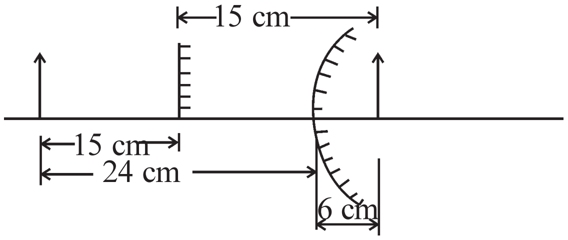
$$m = \frac{f}{f-u}$$

$$-n = \frac{-f}{-f+u} \quad [f, u \text{ taking negative } m = -n]$$

$$n = \frac{f}{-f+u}, \; -f+u = \frac{f}{n}, \; u = \frac{f}{n} + f$$

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

(9) Answer [A]



$u = -24$ cm, $v = 6$ cm

$$f = \frac{uv}{u+v} = \frac{-24 \times 6}{-24+6} = 8 \text{ cm}$$

(10) Answer [B]

$$m = \frac{f}{f-u} = \frac{-15}{-15-(-20)}$$

So length becomes $(3 \times 3) = 9$ cm and area is 81 cm^2.

(11) Answer [C]

$n \sin\theta$ = constant

$n_{(air)} \sin\theta_{(air)} = n_{(water)} \sin\theta_{(water)}$

$1 \times \sin 30° = 1.33 \sin\theta_{(water)}$

$$\sin\theta_{(water)} = \frac{1}{2 \times 1.33} = \frac{1}{2.66}$$

$$\theta \text{ (water)} = \sin^{-1} \frac{1}{2.66}$$

(12) Answer [A]

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$$\sin\theta_1 = n \sin\frac{\theta_1}{2} \quad [\theta_1 = 2\theta_2, \theta_2 = \frac{\theta_1}{2}]$$

$$2 \sin\frac{\theta_1}{2} \cos\frac{\theta_1}{2} = n \sin\frac{\theta_1}{2}$$

$$\frac{n}{2} = \cos\frac{\theta_1}{2} \Rightarrow \frac{\theta_1}{2} = \cos^{-1}\frac{n}{2}$$

$$\theta_1 = 2\cos^{-1}\frac{n}{2}$$

(13) Answer [B]

$$x = \frac{t \sin(\theta_1 - \theta_2)}{\cos\theta_2}$$

$= \frac{t(\theta_1 - \theta_2)}{1}$ [θ_1 is very small so θ_2 is also small, $\therefore \sin(\theta_1 - \theta_2) \approx \theta_1 - \theta_2$, $\cos\theta_2 \approx 1$] $= t\,\theta_1\left(1 - \frac{\theta_2}{\theta_1}\right)$

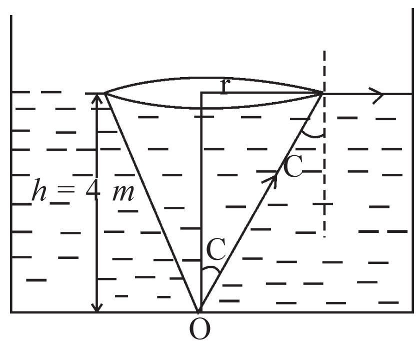
$$= t\,\theta\left(1 - \frac{n_1}{n_2}\right)$$

$[n_1\theta_1 = n_2\theta_2, \; \therefore \frac{n_1}{n_2} = \frac{\theta_2}{\theta_1} \; (\theta_1 = \theta)$

$$= t\,\theta\left(1 - \frac{1}{n}\right) \qquad [n_1 = 1, n_2 = n]$$

$$= t\,\theta\left(\frac{n-1}{n}\right)$$

(14) Answer [D]



$\sin C = \frac{1}{n}$, from figure $\sin c = \frac{r}{\sqrt{h^2 + r^2}}$

by comparison $\frac{1}{n} = \frac{r}{\sqrt{h^2+r^2}} \quad \frac{3}{5} = \frac{r}{\sqrt{16 + r^2}}$,

$\therefore r = 3$ m, $\therefore d = 2r = 6$ m

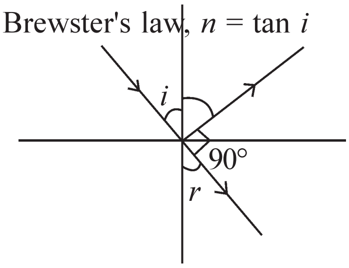
(15) Answer [A]

$$\text{Virtual depth} = \frac{t/2}{n_1} + \frac{t/2}{n_2}$$

$$= \frac{t}{2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right) = t\,\frac{(n_1 + n_2)}{2n_1 n_2}$$

(16) Answer [C]

From Brewster's law, $n = \tan i$ ...(1)



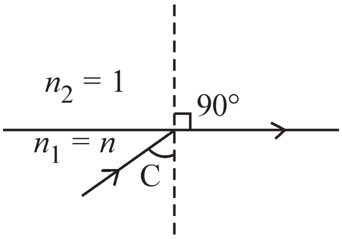
For total internal reflection $\sin C = \frac{1}{n}$

$\therefore\ n = \frac{1}{\sin C}\ \ \therefore\ \tan i = \frac{1}{\sin C}$

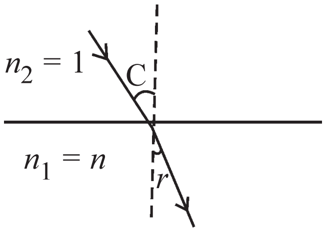
$\therefore\ i = \tan^{-1}(\sin^{-1} C)$

(17) Answer [D]

$n_1 \sin C = n_2 \sin 90°$



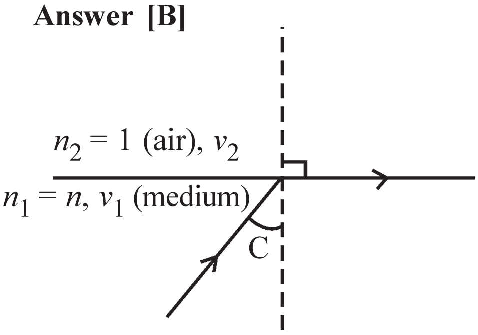
$n = \frac{1}{\sin C}$, $\sin C = \frac{1}{n}$ ...(1)



$n = \frac{\sin C}{\sin r}$, $\sin r = \frac{\sin C}{n}$

$\sin r = \frac{1}{n^2}$ from equation (1))

(18) Answer [B]



$n_1 \sin C = n_2 \sin 90°$, $\sin C = \frac{n_2}{n_1} = \frac{v_1}{v_2}$

$\sin C = \frac{v_1}{v_2} = \frac{5\,x/t_2}{x/t_1} = 5\,\frac{t_1}{t_2}$

$C = \sin^{-1} 5\,\frac{t_1}{t_2}$

(19) Answer [A]

$$n = \frac{\sin\left(\frac{A+\delta m}{2}\right)}{\sin(A/2)}$$

$$\cot\left(\frac{A}{2}\right) = \frac{\sin\left(\frac{A+\delta m}{2}\right)}{\sin(A/2)}$$

$$\frac{\cos A/2}{\sin A/2} = \frac{\sin\left(\frac{A+\delta m}{2}\right)}{\sin(A/2)}$$

$$\sin(90° - A/2) = \sin\left(\frac{A+\delta m}{2}\right)$$

$180° - A = A + \delta m$

$\therefore\ \delta m = 180° - 2A$

(20) Answer [C]

$i + e = A + \delta$

$2i = A + \delta m$ $\quad$ ($i = e$ then $\delta = \delta m$)

$2 \times 50° = 60° + \delta m$, $\delta m = 40°$

(21) Answer [B]

$$n = \frac{\sin\left(\frac{A+\delta m}{2}\right)}{\sin(A/2)}$$

$$\therefore\ \sqrt{2} = \frac{\sin\left(\frac{60° + \delta m}{2}\right)}{\sin 30°}$$

$$\frac{1}{\sqrt{2}} = \sin\left(\frac{60° + \delta m}{2}\right) \quad (\sin 30° = 1/2)$$

$$\therefore\ \sin 45° = \sin\left(\frac{60° + \delta m}{2}\right)$$

$$45° = \frac{60° + \delta m}{2} \Rightarrow \delta m = 30°$$

(22) Answer [D]

$$n = \frac{\sin\left(\frac{A + \delta m}{2}\right)}{\sin(A/2)}, \quad \sqrt{2} = \frac{\sin\left(\frac{A + A}{2}\right)}{\sin(A/2)}$$

$$= \frac{\sin A}{\sin(A/2)} = \frac{2\sin(A/2)\cos(A/2)}{\sin(A/2)}$$

$$\therefore \cos(A/2) = \frac{1}{\sqrt{2}}, \quad \therefore \cos 45° = \frac{1}{\sqrt{2}}$$

$$\therefore \quad A/2 = 45° \Rightarrow A = 90°$$

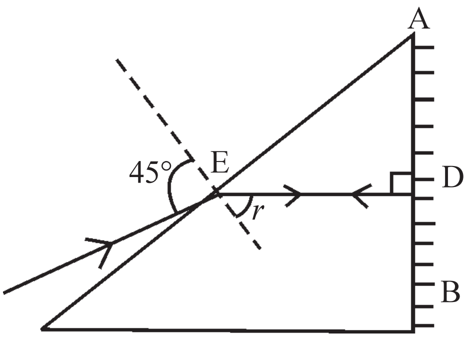
(23) Answer [B]

$\delta_1 = A(\mu - 1) = 4°(1.5 - 1) = 2°$,

For plane mirror $i = 2°$, $\delta_2 = 180° - 2i = 176°$,

$\delta = \delta_1 + \delta_2 = 178°$ (clock wise)

(24) Answer [C]

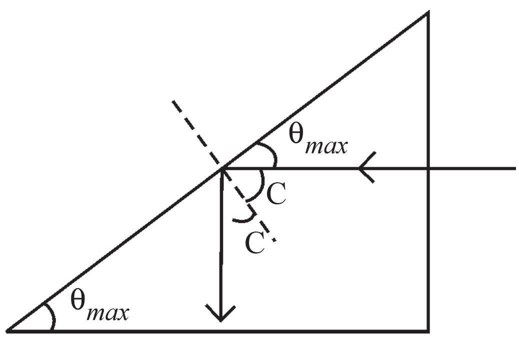


$$n = \frac{\sin i}{\sin r}, \quad \sqrt{2} = \frac{\sin 45°}{\sin r}$$

$$\sin r = \frac{1}{\sqrt{2}} \times \frac{1}{\sqrt{2}} = \frac{1}{2}, \; r = 30°, \Delta AED$$

$$\therefore \angle A + (90° - 30°) = 90°, \; \therefore \angle A = 30°$$

(25) Answer [A]



Incident angle on hypotanous is $C = 90 - \theta_{max}$

$$n = \frac{1}{\sin C} = \frac{1}{\sin(90° - \theta_{max})}$$

$$= \frac{1}{\cos\theta_{max}}, \; \cos\theta_{max} = \frac{1}{n}$$

$$\theta_{max} = \cos^{-1}\frac{1}{n}$$

(26) Answer [A]

For lens $m = \frac{f}{u - f}$, If movement of lens towards object then on image is real and second is virtual $m_1 = -m_2$

$$\frac{f}{u_1 - f} = \frac{f}{f - u_2}, \quad \frac{1}{20 - f} = \frac{1}{f - 15}$$

$f - 15 = 20 - f$, $f = 17.5$ cm

(27) Answer [B]

Suppose, lens is at constant position and screen moves away from lens with velocity v.

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}, \; 0 = \frac{-1}{v^2}\frac{dv}{dt} + \frac{1}{u^2}\frac{du}{dt}$$

$$\frac{du}{dt} = \frac{u^2}{v^2}\frac{dv}{dt}, \; \dot{u} = \frac{1}{m^2}\dot{v}$$

Velocity of screen $= \frac{v}{m^2}$

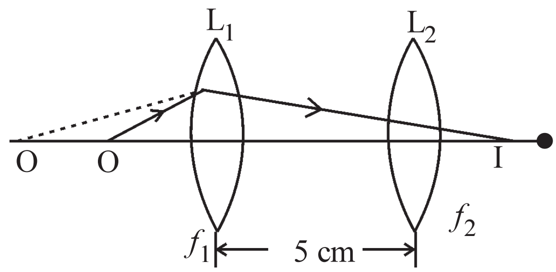
Now object moves toward lens (towards screen) relative to lens with velocity 0.5 ms^{-1}. So, relative velocity of screen with respect to object v_{os} is

$$= v - \frac{v}{m^2} = \left(1 - \frac{1}{m^2}\right)v = \left(1 - \frac{1}{\left(\frac{1}{2}\right)^2}\right)v$$

$= -3v = -3 \times 0.5 = -1.5$ ms^{-1}

1.5 ms^{-1}

(28) Answer [C]



(1) For L_1, $\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u_1}$

$$\frac{1}{20} = \frac{1}{v_1} - \frac{1}{-10}, \; \frac{1}{v_1} = \frac{1}{20} - \frac{1}{10} = \frac{-1}{20}$$

$v_1 = -20$ cm (Virtual) image formed at side of object which is virtual for second lens.

(2) For L_2, $\frac{1}{f_2} = \frac{1}{v_2} - \frac{1}{u_2}$

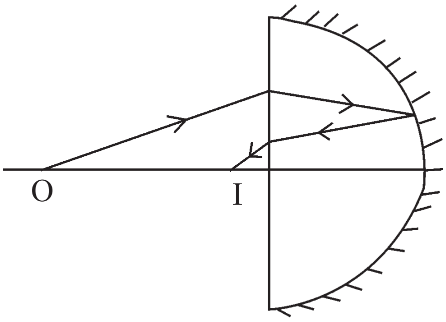
$\frac{1}{10} = \frac{1}{v_2} - \frac{1}{-25}$, $u_2 = -(20 + 5)$ cm

$\frac{1}{v_2} = \frac{1}{10} - \frac{1}{25} = \frac{5-2}{50}$

$v_1 = \frac{50}{3}$ cm (Right side of L_2)

$m = \frac{v_1}{u_1} \times \frac{v_2}{u_2} = \frac{20}{10} \times \frac{50}{3 \times 25} = \frac{4}{3}$

(29) Answer [D]



Refraction two times and one time reflection (f_1 for lens, f_m for mirror)

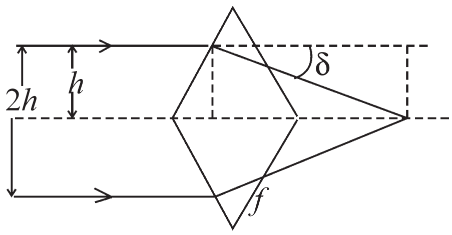
$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{1}{f_m} = \frac{2}{f_1} - \frac{1}{f_m}$

$= \frac{2(n-1)}{R} - \frac{2}{R} = \frac{2n-2-2}{R}$

$= -3/R$ $\quad (n = 1.5)$

$\therefore f = -R/3$

(30) Answer [A]



(i) $\tan \delta = \frac{h}{f}$

$\delta = \frac{h}{f}$ $\quad$ [$\tan \delta \approx \delta$ very small]

(ii) For amall prism $\delta = (n-1)$ A

By comparison $\frac{h}{f} = (n-1)$ A, $\therefore f = \frac{h}{(n-1)A}$

(31) Answer [B]

Focal length of convex lens is 10 cm So, equivalent focal length for system of its pieces. $= \frac{f_1 f_2}{f_1 + f_2}$

$= \frac{10 \times 10}{10 + 10} = 5$ cm, $\frac{hi}{ho} = m$

$\therefore \frac{hi}{ho} = \frac{f}{u+f}$, $hi = \frac{f}{u+f}\, ho$

$= \frac{5}{-7.5+5} \times 1$ $\quad$ [taking negative u]

$= 2$ cm

(32) Answer [D]

$\frac{1}{f} = P = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

(i) Power in air $P_a = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$10 = (1.5 - 1)\left(\frac{1}{R} - \frac{1}{-R}\right)$

$= 0.5 \times \frac{2}{R}$ $\quad \begin{bmatrix} R_1 = R \\ \text{taking } R_2 = -R \end{bmatrix}$

$R = 0.1$ m

(ii) $P_1 = (1.5 - 1)\left(\frac{1}{R}\right) = 0.5 \times \frac{1}{0.1} = 5$ D

(iii) $P_2 = (1.33 - 1.5)\left(-\frac{1}{0.1}\right)$

$= (-0.17) \times \left(\frac{1}{-0.1}\right) = 1.7$ D

(iv) $P = P_1 + P_2 = 5 + 1.7 = 6.70$ D

(33) Answer [B]

$\eta_{wa} = 4/3$, $\eta_{ga} = 3/2$, $P_a = +5\text{ D} = \frac{1}{f_a}$

$f_a = \frac{1}{5} = 0.2$ m, $\frac{1}{f} = (n_{21} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

(i) $\frac{1}{f_a} = (\eta_{ga} - 1)\, x$, $\left[\frac{1}{R_1} - \frac{1}{R_2} = x\right]$

(ii) $\frac{1}{f_w} = (\eta_{gw} - 1)\, x$, $\frac{f_w}{f_a} = \frac{\eta_{ga} - 1}{\eta_{gw} - 1}$ $\frac{\text{equation } (i)}{\text{equation } (ii)}$

$$= \frac{\frac{3}{2}-1}{\frac{9}{8}-1} = 4, \quad \left[\eta_{gw} = \frac{\eta_{ga}}{\eta_{wa}} = \frac{\frac{3}{2}}{\frac{4}{3}} = 9/8\right]$$

$f_W = f_a \times 4 = 0.2 \times 4 = 0.8$ m

$\therefore P_W = \frac{1}{f_W} = 1.25$ D

(34) Answer [A]

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

(i) $\frac{1}{f_A} = (n_A - 1)\left(\frac{1}{R_A} - \frac{1}{-R_A}\right)$

$= 0.63\left(\frac{1}{0.9\,R_B} + \frac{1}{0.9R_B}\right)$ [$R_A = 0.9\,R_B$]

$= 0.63 \times \frac{2}{0.9\,R_B}$

(ii) $\frac{1}{f_B} = (n_B - 1)\left(\frac{1}{R_B} - \frac{1}{-R_B}\right)$

$= (n_B - 1)\frac{2}{R_B}$, But $f_A = f_B$

$\therefore 0.63 \times \frac{2}{0.9\,R_B} = (n_B - 1) \times \frac{2}{R_B}$

$0.7 = n_B - 1$, $n_B = 1.7$

(35) Answer [B]

$P_1 = \frac{1}{f_1}$ (convex lons) $= \frac{1}{0.25} = 4$ D

$P_2 = \frac{1}{f_2} = -\frac{1}{0.20} = -5$ D

$P = P_1 + P_2 - d\,P_1\,P_2$

$0 = 4 - 5 - d\,(4)\,(-5)$, $\therefore 20\,d = 1$

$\therefore d = \frac{1}{20} = 0.05$ m $= 5$ cm

(36) Answer [A]

$$f = \frac{D^2 - d^2}{4D} = \frac{100^2 - 40^2}{4 \times 100}$$

$= 21$ cm $= 0.21$ m, $P = \frac{1}{f} = \frac{1}{0.21} = 4.76 \approx 5$ D

(37) Answer [B]

$f_o = 1$ cm $f_e = 5$ cm $v_e = -25$ cm

$v_o + |u_e| = 12.2$ cm ...(1)

(i) $\frac{1}{f_e} = \frac{1}{v_e} - \frac{1}{u_e}$, $\frac{1}{5} = -\frac{1}{25} - \frac{1}{u_e}$

$\therefore u_e = -4.166 = -4.2$ cm

From equation (1), $v_0 + 4.2 = 12.2$

$v_0 = 8$ cm

(ii) $\frac{1}{f_o} = \frac{1}{v_o} - \frac{1}{u_o}$, $\frac{1}{1} = \frac{1}{8} - \frac{1}{u_o}$

$u_o = -1.41$ cm, ≈ -1.1 cm

(iii) $|m| = \frac{v_o}{u_o}\left(1 + \frac{D}{f_e}\right) = \frac{8}{1.1}\left(1 + \frac{25}{5}\right)$

$= 43.6, \approx 44$

(38) Answer [D]

$m_\alpha = \frac{f_o}{f_e} = 10$, $f_e = 5$ cm, $D = 25$ cm

$m_D = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right) = 10\left(1 + \frac{5}{25}\right) = 12$

(39) Answer [C]

$m = \frac{f_o}{f_e}$, distance between two lens $= f_o + f_e$

putting slit instead of objective $u = f_o + f_e$

for lens $m = \frac{f}{f+u}$

$$\frac{y}{x} = \frac{f_e}{f_e - (f_o + f_e)} = -\frac{f_e}{f_o}$$

Value $\frac{f_o}{f_e} = \frac{x}{y}$, $\therefore m = \frac{x}{y}$

(40) Answer [A]

$m = \frac{\beta}{\alpha}$ ...(ii)

$\alpha = \frac{3.5 \times 10^6}{3.8 \times 10^8} = \frac{3.5}{380}$ rad,

$m = \frac{f_o}{f_e} = \frac{200}{10} = 20$ ...(ii)

$20 = \frac{\beta}{\alpha}$, $\beta = 20 \times \alpha = 20 \times \frac{3.5}{380}$ rad

$= 20 \times \frac{3.5}{380} \times \frac{180°}{\pi} = 10.559°, \approx 11°$

(41) Answer [D]

$f_o = 200$ cm, $f_e = 4$ cm

(i) $m = \frac{f_O}{f_e} = \frac{50}{5} = 10$

(ii) tube length = $f_O - |f_e|$

= 50 – 5 (eye piece is concave lens) = 45 cm

(42) Answer [A]

$f = -\frac{1}{P} = -\frac{1}{1} = -1$ m

(i) $x = 20$ cm = 0.2 m, $P = \frac{x-y}{xy} - 1 = \frac{0.2-y}{0.2\,y}$

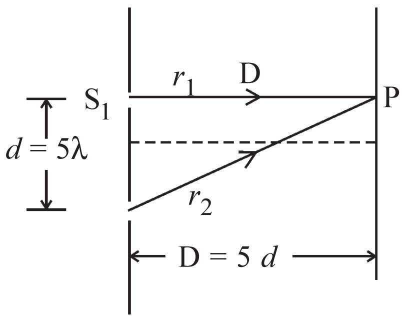
$\therefore y = 0.25$ m = 25 cm

(ii) $x = 75$ cm = 0.75 m $-1 = \frac{0.75-y}{0.75\,y}$

$y = 3$ m = 300 cm

(43) Answer [B]

path difference = $\sqrt{D^2+d^2} - D$



$= D\left(1+\frac{d^2}{D^2}\right)^{\frac{1}{2}} - D = D\left(1+\frac{d^2}{2D^2}\right) - D$

(D >> d, from Binomial theorem = $\frac{d^2}{2D}$

$= \frac{25\lambda^2}{2\times 25\lambda}$ [$d = 5\lambda$, $D = 5d = 25\lambda$]

$= \frac{\lambda}{2}$, $I = I_o \cos^2 \delta/2$

$= I_o \cos^2\left(\frac{k(r_2-r_1)}{2}\right) = I_o \cos^2 \frac{2\pi}{2\lambda}\times\frac{\lambda}{2}$

$= I_o \cos^2 \frac{\pi}{2}$ $\therefore$ I= O

(44) Answer [D]

path difference = $d \sin\theta$

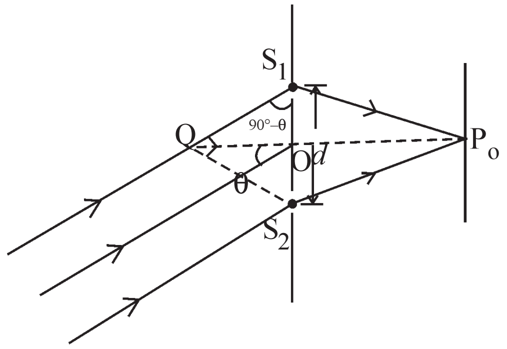
For maximum intensity $d \sin\theta = n\lambda$

$\sin\theta = \frac{n\lambda}{d}$ $n = 0, 1, 2,$

$= \frac{n}{2}$, $\sin\theta = 0, \pm\frac{1}{2}, \pm 1$

$\theta = 0°, 30°, 90°, 150°, 180°, 210°, 270°, 360°$

(45) Answer [C]



Path difference between two rays at point Po

$= QS_1$ [$S_1O = S_2O$] $= d\cos(90° - \theta)$

$= d\sin\theta = d\times\frac{\lambda}{2d} = \frac{\lambda}{2}$

$= (2n-1)\,\lambda/2$, Where $n = 1$

Destructive interference, $I_{P_o} = 0$

(46) Answer [A]

(i) Intensity of centeral bright fringe = I_o

(ii) path difference between two consecutive fringes = 2π rad

$\therefore$ Phase difference at $\frac{1}{4}$ distance of distance between two consecutive fringes

$= \frac{2\pi}{4} = \frac{\pi}{2}$

$I = I_o \cos^2(\delta/2) = I_o \cos^2(\pi/4)$

$= I_o\times\frac{1}{2} = I_o/2$, $\therefore$ ratio $= \frac{I_o}{I_o/2} = 2$

(47) Answer [B]

In Young's experiment plate having thick ness t and refractive index n putting in, path of ray, path difference = $(n-1)\,t$ displacement of fring,

first plate, $y = \frac{D}{d}(n_1 - 1)\,t$

Second plate, $\frac{3}{2}\,y = \frac{D}{d}(n_2 - 1)\,t$

taking ratio, $\frac{3}{2} = \frac{n_2-1}{n_1-1}$

$\frac{3}{2} = \frac{n_2-1}{1.5-1}$, $\therefore n_2 = 1.75$

(48) Answer [A]

Shift $x = \frac{D}{d}(n-1)t$

distance between same type of consecutive fringes $= \frac{\lambda D}{d}$

number of Shifted of same type fringes

$$= \frac{\text{total shift}}{\text{distance between same type of consecutive fringes}}$$

$$= \frac{D}{d}\frac{(n-1)td}{\lambda D} = \frac{(n-1)}{\lambda}t$$

$$= \frac{(1.6-1)\times 1.8\times 10^{-5}}{600\times 10^{-9}} = 18$$

(49) Answer [C]

(i) For bright fringes, $\frac{dx}{D} = n\lambda$,

$$x_2 = \frac{2\lambda D}{d}$$

(ii) For bark fringes, $\frac{dx}{D} = (2n-1)\frac{\lambda}{2}$,

$x_3 = \frac{7}{2}\frac{\lambda D}{d} = 3.5\frac{\lambda D}{d}$ total distance $= x_2 + x_3$

$$= \frac{\lambda D}{d}(2+3.5) = \frac{4\times 10^{-5}\times 100\times 5.5}{0.055}$$

$= 400 \times 10^{-3} = 0.4$ cm

(50) Answer [C]

Assume that dark fringe is obtained at distance x.

path difference$= (2n-1)\lambda/2$, where $n = 1, 2, 3...$

$r_2 - r_1 = (2n-1)\lambda/2$

$\sqrt{x^2 + (2\lambda)^2} - x = (2n-1)\lambda/2$

$\sqrt{x^2 + 4\lambda^2} = x + \frac{3}{2}\lambda$ $\quad (n = 1)$

$$x = \frac{7\lambda}{12}$$

(51) Answer [D]

$$\frac{I_1}{I_2} = 4 = \alpha$$

Visibility of fringes $= \frac{I_{max} - I_{min}}{I_{max} + I_{min}} = \frac{2\sqrt{\alpha}}{\alpha + 1}$

$= \frac{2\times 2}{4+1}$ $[\alpha = 4] = \frac{4}{5}$

(52) Answer [C]

$\frac{\overline{x}_1}{2} = \frac{\lambda_1 D}{2d}$, $\frac{\overline{x}_2}{2} = \frac{\lambda_2 D}{2d}$, $\therefore \frac{\overline{x}_2}{\overline{x}_1} = \frac{\lambda_2}{\lambda_1}$

$\therefore \overline{x}_2 = \frac{\overline{x}_1}{n} = 2/1.33 = 1.50$ mm

(53) Answer [B]

$$x_5 - x_1 = \frac{5\lambda D}{d} - \frac{\lambda D}{d} = \frac{4\lambda D}{d}$$

$$d = \frac{4\lambda D}{x_5 - x_1} = \frac{4\times 550\times 10^{-9}\times 0.5}{0.4\times 10^{-3}}$$

$= 2.75 \times 10^{-3}$ m $= 2.75$ *m*m

$\sin\theta_1 = \lambda/d = 2 \times 10^{-4}$, $\theta_1 = 2 \times 10^{-4}$ rad

(54) Answer [A]

width of central maxima = distance between first two minimum.

$\sin\theta_1 = \lambda/d$, $\quad \tan\theta_1 = \frac{x}{D}$

$\sin\theta_1 = \tan\theta_1$ (because θ_1 is small)

$\frac{h}{d} = \frac{x}{D}$, $x = \frac{\lambda D}{d}$

Width $2x = \frac{2\lambda D}{d} = \frac{600\times 10^{-9}\times 0.6\times 2}{0.6\times 10^{-3}}$

$= 1.2 \times 10^{-3}$ m $= 1.2$ mm

(55) Answer [D]

$\sin\theta_1 = \frac{\lambda}{d}$, $\quad \tan\theta_1 = \frac{x}{D}$

$\sin\theta_1 = \tan\theta_1$ (because θ_1 is small), $\frac{x}{D} = \frac{h}{d}$

$\therefore d = \frac{\lambda D}{x} = \frac{5\times 10^{-7}\times 1}{5\times 10^{-3}} = 10^{-4}$ m $= 0.1$ *m*m

(56) Answer [C]

linear width of central maxima $= \frac{d}{2}$

$\frac{2\lambda D}{d} = \frac{d}{2}$, $4\lambda D = d^2$, $d = \sqrt{4\lambda D}$

(57) Answer [A]

$d = \sqrt{Z_f \lambda}$

$= \sqrt{15\times 600\times 10^{-9}} = 3 \times 10^{-3}$ m $= 3$ *m*m

(58) Answer [B]

Width of central maxima = $\frac{2\lambda D}{d}$

(i) Initial width $\alpha \frac{\lambda D}{d}$ ...(1)

(ii) Final width $\propto \frac{(2\lambda)(3D)}{\left(\frac{3}{2}d\right)}$

$\propto 4\frac{\lambda D}{d}$, $\therefore$ Four times larger.

(59) Answer [C]

For brigth fringe, $d \sin\theta = n\lambda$

$\frac{\sin\theta}{N} = n\lambda$

[for maximum n, $\sin\theta = 1$ = maximum value]

$n = \frac{1}{N\lambda} = \frac{1}{1.25 \times 10^5 \times 800 \times 10^{-9}} = 10$

total bright fringes = $2n + 1 = 21$

(60) Answer [A]

$\theta = \frac{1.22\lambda}{D} = \frac{1.22 \times 6 \times 10^{-7}}{4.88}$

$= 1.5 \times 10^{-7}$ rad $= 1.5 \times 10^{-7} \times 2 \times 10^5$ s

$= 3 \times 10^{-2}$ s

(61) Answer [C]

(i) R. P $= \frac{D}{1.22\lambda} \propto \frac{1}{\lambda}$ ...(1)

(ii) $\lambda = \frac{h}{\sqrt{2meV}} \propto \frac{1}{\sqrt{V}}$ ...(2)

$\therefore$ R.P $\propto \sqrt{V}$, $\frac{R'}{R} = \sqrt{\frac{90}{10}} = 3$, R' = 3R

(62) Answer [C]

$I = \frac{I_o}{2}(\cos^2 30°)^4$ [For 5 polaroid]

$= \frac{I_o}{2}\left(\frac{\sqrt{3}}{2}\right)^8 = \frac{I_o}{2} \times \frac{3^4}{(2)^8} = I_o \frac{81}{512}$

$\therefore \frac{I}{I_o} = \frac{81}{512}$

(63) Answer [A]

Energy per one revolution is

$= I_{ave} \times$ area $\times$ periodic time ...(1)

$I_{ave} = \frac{I_o}{2}$, $I_o = \frac{\text{Energy}}{\text{Area} \times \text{time}}$

$= \frac{3 \times 10^{-3}}{3 \times 10^{-4} \times 1} = 10$ J, $\omega = 3.14$ rad s^{-1}

$\therefore \frac{2\pi}{T} = 3.14$, $\therefore$ T = 2 s

putting values in equation (1)

Energy $= \frac{10}{2} \times 3 \times 10^{-4} \times 3.14 = 47.1 \times 10^{-4}$ J

(64) Answer [D]

Intensity of emitted light from first poleroid is $= \frac{I_o}{2}$

Intensity of emitted light from second poleroid $I' = \frac{I_o}{2}\cos^2(45°) = \frac{I_o}{4}$

Intensity of emitted light from third poleroid

$I = \frac{I_o}{4}\cos^2(45°) = \frac{I_o}{8}$

(65) Answer [A]

$n = \frac{c}{v} = \frac{3 \times 10^8}{2 \times 10^8} = 1.5$, $n = \tan\theta_P$

$1.5 = \tan\theta_P$, $\theta_P = 56.3°$

$\therefore r = 90° - 56.3° = 37.7°$

(66) Answer [B]

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ $\therefore \frac{1}{v} = \frac{1}{u} - \frac{1}{f}$

(For concave mirror, u and f are negative)

(i) $u < f$ image is virtual, $\therefore v$ positive

u is between O and f

(ii) $u < f$, true image v negative

u is between f and ∞, $u \to \infty$, $v = -f$

$u \to f$, $V \to \pm\infty$

(67) Answer [C]

Concave mirror $m = \frac{f}{f - u}$

$-4 = \frac{-20}{-20 - u}$ (f negative)

$\therefore 80 + 4u = -20$, $\therefore u = -25$ cm

(68) Answer [D]

$f = \frac{R}{2} = \frac{1}{2}(v - d) = \frac{1}{2}(60 - 10) = 25$ cm

(69) Answer [A]

$m = \frac{f}{f-u}$ (for mirror)

$\therefore \frac{1}{4} = \frac{12}{12-u}, \therefore u = -36$ cm

$m = \frac{1}{4}, \therefore -\frac{v}{u} = \frac{1}{4}, \frac{-v}{-36} = \frac{1}{4} \therefore v = 9$ cm

$|u| + v = 36 + 9 = 45$ cm

(70) Answer [A]

Ray is not bending when propagate. from first medium to second medium. So $n_1 = n_2$. While propagating from second to third medium it bend away from normal.

$\therefore n_1 = n_2 > n_3$

(71) Answer [B]

for lense, $m = \frac{f}{f+u}$

$-m = \frac{-f}{-f+u}$ [taking m, f is negative]

$\therefore u = \frac{(m+1)f}{m}$

$\therefore m = \frac{v}{u} - \therefore v = mu = (m+1)f$

But $u + v = d \therefore \frac{(m+1)f}{m} + (m+1)f = d$

$\therefore f = \frac{md}{(m+1)^2}$

(72) Answer [C]

$$n = \frac{\sin\left(\frac{A+\delta m}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin A}{\sin\left(\frac{A}{2}\right)} \quad \delta_m = A,$$

$$n = \frac{2\sin\left(\frac{A}{2}\right)\cos\left(\frac{A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$\therefore \sqrt{3} = 2\cos\left(\frac{A}{2}\right)$

$\therefore \cos\left(\frac{A}{2}\right) = \cos 30° = \frac{\sqrt{3}}{2}$

$\therefore \frac{A}{2} = 30°, \therefore A = 60°$

(73) Answer [A]

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \Rightarrow \frac{1}{f} = \frac{1}{0.5} - \frac{1}{-0.2}$ (u ઋણ)

$\frac{1}{f} = \frac{0.7}{0.1}, f = \frac{1}{2} = 0.143$ m

(74) Answer [C]

$\frac{h_i}{h_o} = \frac{n\,(\text{thin})}{n\,(\text{thick})}, h_i = \frac{6.65}{1.33} \times 1 = 5$

$h_o - h_i = 6.65 - 5 = 1.65$ m height increases.

(90) Answer [D]

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}, \frac{-1}{15} = \frac{-1}{20} + \frac{1}{v}$ (f, u ઋણ)

$\therefore \frac{1}{v} = \frac{-1}{15} + \frac{1}{20} = \frac{-4+3}{60}$

$\therefore v = -60$ cm

(95) Answer [D]

Reflection of A is A'.

$u = -30$ cm, $f = -18$ cm

$v = (?), \frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$\frac{-1}{18} = \frac{-1}{30} + \frac{1}{v}, \therefore v = -45$ cm

$\therefore$ distance is 45 cm

(97) Answer [B]

$\overline{x} = \frac{\lambda D}{d}$

$= \frac{5 \times 10^{-7} \times 1}{10^{-4}} = 5 \times 10^{-3}$ m $= 5$ mm

(98) Answer [D]

$d \sin\theta = n\lambda$ (Bright fringe)

$\sin\theta_3 = \frac{3\lambda}{d} = \frac{3 \times 5 \times 10^{-7}}{10^{-4}} = 15 \times 10^{-3}$

$\theta_3 = 0.015$ rad [$\sin\theta = \theta$]

(99) Answer [A]

$\frac{dx}{D} = (2n-1)\frac{\lambda}{2}$ (dark fringe)

$x = \frac{7\lambda}{2}\frac{D}{d} = \frac{3.5 \times 5 \times 10^{-7} \times 1}{10^{-4}}$

$= 1.75 \times 10^{-2}$ m

(100) Answer [D]

$\frac{\overline{x}}{2} = \frac{5mm}{2} = 2.5$ mm $= 0.25$ cm

●

17 Dual Nature of Matter and Radiation

(1) Answer [B]

Work function $\phi_0 = \frac{hc}{\lambda o} \Rightarrow \phi_0 \propto \frac{1}{\lambda o}$

For tungsten $\phi_1 \propto \frac{1}{\lambda_1}$, For sodium $\phi_2 \propto \frac{1}{\lambda_2}$

$$\therefore \frac{\phi_1}{\phi_2} = \frac{\lambda_2}{\lambda_1} \Rightarrow \lambda_1 = \frac{\lambda_2 \phi_2}{\phi_1}$$

$$= \frac{(5460)(2.3)}{4.6} = 2730 \text{ Å}$$

(2) Answer [C]

$$\frac{1}{2} mv^2_{max} = ev_o$$

$$v_o = \frac{mv^2_{max}}{2e} = \frac{v^2_{max}}{2(e/m)} = \frac{(5 \times 10^6)^2}{2(e/m)}$$

$$= \frac{(5 \times 10^6)^2}{(2)(1.8 \times 10^{11})} = 6.95 \text{ V}, \approx 7 \text{ V}$$

(3) Answer [B]

Number of emitted photo electron is directly proportional to intensity if incident light $\Rightarrow$ number of emitted photons is 4 times higher.

While maximum kinetic energy is not dependent on intensity but depends on frequency of incident light.

$\therefore$ Here maximum kinetic energy remains constant.

(4) Answer [A]

$$\frac{hc}{\lambda} - \phi_0 = \frac{1}{2} mv^2_{max} \Rightarrow \frac{1}{2} mv_1^2 = \frac{hc}{\lambda} - \phi_0$$

and $\frac{1}{2} mv_2^2 = \frac{hc}{3\lambda/4} - \phi_0 = \frac{4hc}{3\lambda} - \phi_0$

$$\therefore \frac{1}{2} mv_2^2 = \frac{4}{3}\left(\frac{1}{2} mv_1^2 + \phi_0\right) - \phi_0$$

$$= \frac{2}{3} mv_1^2 + \frac{4}{3}\phi_0 - \phi_0$$

$$= \frac{4}{3}\left(\frac{1}{2} mv_1^2\right) + \frac{2}{3}\frac{\phi_0}{m}$$

$$\therefore v_2^2 = \frac{4}{3} v_1^2 + \frac{2\phi_0}{3m}$$

$$v_2 = \sqrt{\frac{4}{3} v_1^2 + \frac{2\phi_o}{3m}} \Rightarrow v_2 > v\left(\frac{4}{3}\right)^{\frac{1}{2}}$$

(5) Answer [A]

$$\frac{hc}{\lambda} - \phi_0 = \frac{1}{2} mv^2_{max} = eVo$$

$$\therefore \frac{hc}{\lambda} = \phi_0 + eVo$$

$$\therefore \frac{hc}{0.6 \times 10^{-6}} = \phi_0 + e(0.5) \quad ...(1)$$

and $\frac{hc}{0.4 \times 10^{-6}} = \phi_0 + e(1.5) \quad ...(2)$

Taking ratio of equation (1) and (2)

$$\frac{0.4 \times 10^{-6}}{0.6 \times 10^{-6}} = \frac{\phi_0 + 0.5e}{\phi_0 + 1.5e}$$

$$\therefore \frac{2}{3} = \frac{\phi_0 + 0.5e}{\phi_0 + 1.5e} \Rightarrow 2(\phi_0 + 1.5e)$$

$= 3(\phi_0 + 0.5e)$, $\therefore 2\phi_0 + 3e = 3\phi_0 + 1.5e$

$\therefore \phi_0 = 1.5 \text{ e J} = 1.5 \text{ eV}$

(6) Answer [C]

From $\frac{hc}{\lambda} = \frac{hc}{\lambda o} + eV_o$,

$$\frac{hc}{\lambda} - \frac{hc}{\lambda o} = e(4V_o), \therefore hc\left(\frac{1}{\lambda} - \frac{1}{\lambda o}\right) = e(4V_o)$$

$$hc\left(\frac{\lambda o - \lambda}{\lambda - \lambda o}\right) = e(4V_o) \quad ...(1)$$

and $\frac{hc}{2\lambda} - \frac{hc}{\lambda o} = e(V_o) \Rightarrow hc\left(\frac{1}{2\lambda} - \frac{1}{\lambda o}\right) = e(V_o)$

and $hc\left(\frac{\lambda o - 2\lambda}{2\lambda\lambda o}\right) = eV_o \quad ...(2)$

Taking ratio of equation (1) and (2)

$$\frac{hc\dfrac{(\lambda_o-\lambda)}{\lambda\lambda_o}}{hc\left(\dfrac{\lambda_o-2\lambda}{2\lambda\lambda_o}\right)} = \frac{e(4V_o)}{eV_o}$$

$$\Rightarrow \frac{2(\lambda_o-\lambda)}{\lambda_o-2\lambda} = 4,$$

$\therefore\ 2\lambda o - 2\lambda = 4\lambda o - 8\lambda \quad \therefore\ \lambda o = 3\lambda$

(7) Answer [B]

$hf - \phi_0 = eV_o$ and $2hf - \phi_o = eV_o'$

$\therefore\ \dfrac{eV_o'}{eV_o} = \dfrac{2hf-\phi_0}{hf-\phi_0}$, $\therefore\ V_o' > 2V_o$

(8) Answer [C]

Ultraviolet and visible light simultaneously incident on surface of sodium metal. Here, due to the higher frequency of ultraviolet rediation, the value of stopping potential is higher in case of ultraviolet radiation.

(9) Answer [C]

$E - \phi_0 = \frac{1}{2}\ mv^2_{max}$

$\therefore\ v_{max} = \sqrt{\dfrac{2(E-\phi o)}{m}}$

In first case $v_1 = \sqrt{\dfrac{2(1-0.5)}{m}}$

$= \sqrt{\dfrac{2(0.5)}{m}} = \sqrt{\dfrac{1}{m}}$

In second case $v_2 = \sqrt{\dfrac{2(5-0.5)}{m}}$

$= \sqrt{\dfrac{2(4.5)}{m}} = \sqrt{\dfrac{9}{m}}$

$\therefore\ \dfrac{v_1}{v_2} = \left(\sqrt{\dfrac{1}{m}}\right)\left(\sqrt{\dfrac{m}{9}}\right) = \sqrt{\dfrac{1}{9}} = \dfrac{1}{3}$

(10) Answer [B]

$\frac{1}{2}\ mv^2_{max} = \dfrac{hc}{\lambda} - \dfrac{hc}{\lambda_o}$

Here value of $\frac{1}{2}\ mv^2_{max}$ is positive,

$\therefore$ Emission of photo electrons is possible if

$\dfrac{hc}{\lambda} \geq \dfrac{1}{\lambda_o} \Rightarrow \dfrac{1}{\lambda} \geq \dfrac{1}{\lambda_o}$, $\therefore\ \lambda_o \geq \lambda$

$\therefore\ \lambda \leq \lambda_o$

(11) Answer [A]

Photo electric current is directly proportional to intensity of incident radiation.

And Intensity $\propto \dfrac{1}{\text{distance}^2} \Rightarrow I \propto \dfrac{1}{d^2}$

$\therefore\ I_1 \propto \dfrac{1}{d_1^2}$ and $I_2 \propto \dfrac{1}{d_2^2}$

$\therefore\ \dfrac{I_1}{I_2} = \dfrac{d_2^2}{d_1^2} = \dfrac{(4)^2}{(1)^2} = 16$

$\therefore\ I_2 = \dfrac{I_1}{16} = \dfrac{16}{16} = 1mA$ means current flows. $(\because$ Current α Intensity)

(12) Answer [D]

From $hf - hf_o = \frac{1}{2}\ mv^2_{max}$

$h(2f_o) - hf_o = \frac{1}{2}\ mv_1^2 \Rightarrow hf_o = \frac{1}{2}\ mv_1^2$

$h(5f_o) - hf_o = \frac{1}{2}\ mv_2^2 \Rightarrow 4hf_o = \frac{1}{2}\ mv_2^2$

$\therefore\ \dfrac{hf_o}{4hf_o} = \dfrac{\frac{1}{2}mv_1^2}{\frac{1}{2}mv_2^2}$, $\therefore\ \dfrac{v_1^2}{v_2^2} = \dfrac{1}{4}$

$\dfrac{v_1}{v_2} = \dfrac{1}{2} \Rightarrow v_2 = 2v_1 = 2 \times 2 \times 10^6$

$= 4 \times 10^6\ ms^{-1}$

(13) Answer [A]

$\dfrac{hc}{\lambda} - \phi_0 = K_{max} \Rightarrow \dfrac{hc}{\lambda} = K_{max} + \phi_0$

Here $\frac{hc}{\lambda_1} = K_1 + \phi_0$ ...(1)

and $\frac{hc}{\lambda_2} = K_2 + \phi_0$ ...(2)

Taking ratio of equation (1) and (2)

$$\frac{\lambda_2}{\lambda_1} = \frac{K_1 + \phi_0}{K_2 + \phi_0}$$

$\therefore \lambda_2 K_2 + \lambda_2\phi_0 = K_1\lambda_1 + \lambda_1\phi_0$

$\therefore \lambda_2 K_2 - \lambda_1 K_1 = \lambda_1\phi_0 - \lambda_2 \phi_0$

$\therefore \lambda_2 K_2 - \lambda_1 K_1 = (\lambda_1 - \lambda_2) \phi_0$

$$\therefore \phi_0 = \frac{\lambda_2 K_2 - \lambda_1 K_1}{\lambda_1 - \lambda_2}$$

(14) Answer [D]

from $hf - \phi_0 = \frac{1}{2} mv^2_{max}$,

$5\phi_0 - \phi_0 = \frac{1}{2} mv_1^2$ and $10 \phi_0 - \phi_0 = \frac{1}{2} mv_1^2$

$\therefore 4\phi_0 = \frac{1}{2} mv_1^2$ and $9\phi_0 = \frac{1}{2} mv_2^2$

$$\therefore \frac{4\phi_o}{9\phi_o} = \frac{\frac{1}{2} mv_1^2}{\frac{1}{2} mv_2^2} \Rightarrow \frac{4}{9} = \frac{v_1^2}{v_2^2}$$

$$\therefore \frac{v_1}{v_2} = \frac{2}{3}$$

(15) Answer [C]

from $hf = \phi_0 + \frac{1}{2} mv^2_{max}$,

$h(8 \times 10^{14}) = \phi_0 + 0.5$ ...(1)

and $h(12 \times 10^{14}) = \phi_0 + 2$ ...(2)

taking ratio of equation (1) and (2)

$$\therefore \frac{h(12 \times 10^{14})}{h(8 \times 10^{14})} = \frac{\phi_0 + 2}{\phi_0 + 0.5}$$

$$\therefore \frac{3}{2} = \frac{\phi_0 + 2}{\phi_0 + 0.5} \Rightarrow 3\phi_0 + 1.5 = 2\phi_0 + 4$$

$\therefore \phi_0 = 2.5$, $\therefore$ work function $\phi_0 = 2.5$ eV

(16) Answer [C]

$$\frac{1}{2} mv^2_{max} = \frac{hc}{\lambda} - \phi_0$$

$$\therefore v^2_{max} = \frac{2}{m}\left(\frac{hc}{\lambda} - \phi_0\right) = \left(2\frac{(hc - \lambda\phi_0)}{m\lambda}\right)$$

$$\therefore v_{max} = \left[\frac{2(hc - \lambda\phi_0)}{m\lambda}\right]^{\frac{1}{2}}$$

(17) Answer [A]

$$eV_o = \frac{hc}{\lambda} - \frac{hc}{\lambda o} \Rightarrow eV_o = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda o}\right)$$

For first case, $e(3V_o) = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda o}\right)$ ...(1)

For second case, $e(V_o) = hc\left(\frac{1}{2\lambda} - \frac{1}{\lambda o}\right)$ ...(2)

taking ratio of equation (1) and (2)

$$3 = \frac{\left(\frac{1}{\lambda} - \frac{1}{\lambda o}\right)}{\left(\frac{1}{2\lambda} - \frac{1}{\lambda o}\right)}$$

$$\therefore 3\left(\frac{1}{2\lambda} - \frac{1}{\lambda o}\right) = \frac{1}{\lambda} - \frac{1}{\lambda o}$$

$$\therefore \frac{3}{2\lambda} - \frac{3}{\lambda o} = \frac{1}{\lambda} - \frac{1}{\lambda o} \Rightarrow \frac{3}{\lambda o} - \frac{1}{\lambda o} = \frac{3}{2\lambda} - \frac{1}{\lambda}$$

$$\frac{2}{\lambda o} = \frac{1}{2\lambda}, \therefore \lambda_o = 4\lambda$$

(18) Answer [B]

When $\lambda = \lambda_o$ (threshold wavelength) the value of stopping potential is zero.

$\left(\because eV_o = \frac{hc}{\lambda} - \frac{hc}{\lambda o}\right.$, putting $\lambda = \lambda_o$ $\left.V_o = 0\right)$

$$\therefore \lambda_o = \frac{hc}{\phi o}$$

$$= \frac{(6.6 \times 10^{-34})(3 \times 10^8)}{4.2 \times 1.6 \times 10^{-19}}$$

$= 2.946 \times 10^{-7}$ m $= 2946$ Å

(19) Answer [A]

$eV_o = h(f - f_o) \Rightarrow V_o = \frac{h}{e}(f - f_o)$

$= \frac{(6.63 \times 10^{-34})[8.2 \times 10^{14} - 3.3 \times 10^{14}]}{1.6 \times 10^{-19}}$

$= 2.03$ V

(20) Answer [D]

If maximum kinetic energies of emitted photo electrons is K_1 and K_2 with respect to frequency of incident light f and $3f$, respectively then $hf = K_{max} + \phi_0$. (where ϕ_0 = work function of metal from this)

$hf = K_1 + \phi_0$ ...(1)

and $h(3f) = K_2 + \phi_0$ ...(2)

$\therefore$ taking ratio of equation (2) and (1)

$3 = \frac{K_2 + \phi_0}{K_1 + \phi_0}$, $\therefore 3K_1 + 3\phi_0 = K_2 + \phi_0$

$\therefore K_2 = 3K_1 + 2\phi_0$

i.e. maximum kinetic energy is more than three times.

(21) Answer [D]

Here the value of frequency of incident light is halved, it is less than the frequency. So, photo electric current becomes zero. ($\because$ photo electric effect will not observe)

(22) Answer [A]

from, $K_{max} = \frac{hc}{\lambda} - \phi_0$,

(Where ϕ_0 = work function)

$K_1 = \frac{hc}{\lambda_1} - \phi_0$ and $K_2 = \frac{hc}{\lambda_2} - \phi_0$

$\therefore \Delta K = K_1 - K_2 = \left(\frac{hc}{\lambda_1} - \phi_0\right) - \left(\frac{hc}{\lambda_2} - \phi_0\right)$

$= hc\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right) = hc\left(\frac{\lambda_2 - \lambda_1}{\lambda_1 \lambda_2}\right)$

putting values in equation

$\therefore \Delta K = K_1 - K_2 = 5.94 \times 10^{-19}$ J

$= 3.71$ eV

(23) Answer [B]

frequency of incident light $f = 6 \times 10^{14}$ Hz

$\therefore$ Energy $= \frac{6.63 \times 10^{-34} \times 6 \times 10^{14}}{1.6 \times 10^{-19}} = 2.49\ eV$

(in eV) Work function) 1.59 eV is given.

$\therefore K_{max} = E - \phi_0 = 2.49 - 1.59 = 0.9$ eV

(24) Answer [D]

from work function $\phi_0 = \frac{hc}{\lambda_0}$,

$\lambda_o = \frac{hc}{\phi_0} = \frac{(6.625 \times 10^{-34})(3 \times 10^8)}{3.2 \times 1.6 \times 10^{-19}}$

$= 3.881 \times 10^{-7}$ m

$= 3881 \times 10^{-10}$ m $= 3881$ Å

(25) Answer [D]

$\phi_0 = 1.6\ eV$, $V_o = 1$ Volt $\Rightarrow eV_o = 1\ eV$

Here, $eV_o = hf - \phi_0 \Rightarrow hf = eV_o + \phi_0$

$= 1 + 1.6 = 2.6\ eV$

Wavelength of incident light

$\lambda = \frac{hc}{E} = \frac{12375\, eV\, \text{Å}}{2.6\,(eV)}$ ($\because hc = 12375$ eV Å)

$= 4759.6$ Å ≈ 4760 Å

$\therefore$ Which is in visible (4000 Å to 8000 Å) light range.

(26) Answer [A]

$\lambda_1 = 2.5 \times 10^{-13}$ m and $\lambda_2 = 5000$ Å

Energy of one photon of γ-rays having wavelength λ_1 is equal to energy of n photon having wavelength λ_2.

$\therefore \frac{hc}{\lambda_1} = n\frac{hc}{\lambda_2}$

$\therefore n = \frac{\lambda_2}{\lambda_1} = \frac{5000 \times 10^{-10}}{2.5 \times 10^{-13}}$

$= 2000 \times 10^3 = 2 \times 10^6$

(27) Answer [D]

$E = \left(\frac{20}{100}\right)(2) = 0.4$ J (Rediation energy in one second) Now, if there are n photon in radiation energy within 1 second then,

$$E = nhf = \frac{nhc}{\lambda} \Rightarrow n = \frac{E\lambda}{hc}$$

$$= \frac{(0.4)(400 \times 10^{-9})}{(6.6 \times 10^{-34})(3 \times 10^{8})}$$

$= 8.08 \times 10^{17}$ Photon/s

(28) Answer [B]

$$\text{Power } P = nhf = \frac{nhc}{\lambda} \Rightarrow n = \frac{P\lambda}{hc}$$

$$= \frac{(6 \times 10^{-3})(660 \times 10^{-9})}{(6.6 \times 10^{-34})(3 \times 10^{8})} = 2 \times 10^{16}$$

(29) Answer [A]

$$\frac{P_1}{P_2} = \frac{n_1 h f_1}{n_2 h f_2} = \frac{n_1 h\left(\frac{c}{\lambda_1}\right)}{n_2 h\left(\frac{c}{\lambda_2}\right)} = \frac{n_1 \lambda_2}{n_2 \lambda_1}$$

$$= \frac{(10^{14})(3120 \times 10^{-10})}{(1.04 \times 10^{14})(3000 \times 10^{-10})} = 1$$

(30) Answer [C]

number of incident photon in 10 second $= 12 \times 10^{12}$

$\therefore$ number of incident photon in 1 second $= 12 \times 10^{11}$

these photons incident on aread of 0.02 m^2

$\therefore$ number of incident photon on area of 1 m^2 in 1 second,

$$n = \frac{12 \times 10^{11}}{0.02} = 6 \times 10^{13}$$

$\therefore$ Intensity $I = nhf$ (Incident energy on area of 1 m^2 in 1 second) $= n h \frac{c}{\lambda}$

$$= \frac{6 \times 10^{13} \times 6.6 \times 10^{-34} \times 3 \times 10^{8}}{12 \times 10^{-10}}$$

$= 9.9 \times 10^{-3}$ Wm^{-2}

(31) Answer [A]

$$I = \frac{E}{At} \Rightarrow E = IA \ (t = 1 \text{ સેકન્ડ})$$

$= (200 \times 10^{-3})(2 \times 10^{-4}) = 4 \times 10^{-5}$ J

$$\text{Now, } E = nhf = \frac{nhc}{\lambda} \Rightarrow n = \frac{E\lambda}{hc}$$

$$= \frac{(4 \times 10^{-5})(6000 \times 10^{-10})}{(6.6 \times 10^{-34})(3 \times 10^{8})} = 1.21 \times 10^{14}$$

(32) Answer [C]

$$\lambda = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2m\left(\frac{3}{2}KT\right)}} = \frac{h}{\sqrt{3m\,kT}}$$

$$\therefore \lambda \propto \frac{1}{\sqrt{T}}$$

$$\frac{\lambda_{627}}{\lambda_{127}} = \sqrt{\frac{127 + 273}{627 + 273}} = \sqrt{\frac{400}{900}} = \frac{2}{3}$$

$$\therefore \lambda_{127} = \frac{3\lambda}{2} \quad (\because \lambda_{627} = \lambda)$$

(33) Answer [A]

$$\lambda = \frac{h}{P} = \frac{h}{\sqrt{2mE}} \Rightarrow \lambda \propto \frac{1}{\sqrt{E}} \text{ અને } \lambda' \propto \frac{1}{\sqrt{E'}}$$

$$\therefore \frac{\lambda'}{\lambda} = \sqrt{\frac{E}{E^1}} = \sqrt{\frac{E}{3E}} = \frac{1}{\sqrt{3}} \Rightarrow \lambda' = \frac{1}{\sqrt{3}}$$

(34) Answer [A]

$$\lambda = \frac{h}{\sqrt{2mE}}$$

$$= \frac{6.6 \times 10^{-34}}{\sqrt{(2) \times 1.7 \times 10^{-27} \times 8 \times 1.6 \times 10^{-19}}}$$

$(\because 1 \text{ eV} = 1.6 \times 10^{-19} \text{ J})$

$= 1 \times 10^{-11}$ m

(35) Answer [C]

$$\lambda = \frac{h}{\sqrt{2mE}} \Rightarrow \lambda \propto \frac{1}{\sqrt{m}} \Rightarrow \frac{\lambda_P}{\lambda_d}$$

$$= \sqrt{\frac{m_d}{m_P}} = \sqrt{\frac{2m_P}{m_P}} = \frac{\sqrt{2}}{1} \quad (\because m_d = 2m_P)$$

(36) Answer [B]

$$\lambda = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2mqV}} \Rightarrow \lambda \propto \frac{1}{\sqrt{mq}}$$

$$\therefore \frac{\lambda_\alpha}{\lambda_P} = \sqrt{\frac{m_P\, q_P}{m_\alpha\, q_\alpha}}$$

$q_\alpha = 2q_P$, $m_\alpha = 4m_P$, $\lambda = 5200\ \mathring{A}$

$$\therefore \lambda_\alpha = \frac{\lambda}{2\sqrt{2}} = \frac{5200}{2\sqrt{2}} = 1300\sqrt{2}\ \mathring{A}$$

(37) Answer [B]

De broglie wavelength of electron is

$$\lambda = \frac{h}{P} = \frac{h}{\sqrt{2mK}} = \frac{h}{\sqrt{2meV}}$$

where e = electric charge of electron,

m = mass of electron, h = plank constant putting all these values

$$\lambda = \frac{12.27}{\sqrt{V}}\ \mathring{A} = \frac{12.27}{\sqrt{25}} = \frac{12.27}{5} = 2.454\ \mathring{A}$$

$$\text{Now, } P = \frac{h}{\lambda} = \frac{6.6 \times 10^{-34}}{2.454 \times 10^{-10}}\ \text{Js}^{-1}\text{m}^{-1}$$

$$= 2.689 \times 10^{-24} \approx 2.7 \times 10^{-24}\ \text{Kg ms}^{-1}$$

(38) Answer [C]

$$\lambda = \frac{h}{\sqrt{2mK}} \Rightarrow \lambda \propto \frac{1}{\sqrt{K}}$$

$$\therefore \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{K_2}{K_1}} = \sqrt{\frac{9K_1}{K_1}} = 3$$

$$\therefore \lambda_2 = \frac{\lambda_1}{3} = 0.33\lambda$$

$\therefore \lambda_2 = (1 - 0.67)\,\lambda_1 = \lambda_1 - 0.67\,\lambda_1$

$\therefore$ 67% approximate decreases in wavelength.

(39) Answer [A]

$$\lambda = \frac{h}{P} = \frac{h}{\sqrt{2mK}} = \frac{h}{\sqrt{2mqV}}$$

$$\therefore \lambda = \frac{6.6 \times 10^{-34}}{\sqrt{2 \times 1.6 \times 10^{-27} \times 1.6 \times 10^{-19} \times 450}}$$

$= 0.1375 \times 10^{-11}$ m $\approx 0.14 \times 10^{-11}$ m

(40) Answer [C]

Kinetic energy of particle

$$K_1 = \frac{1}{2}\,mv^2 = \frac{1}{2}\left(\frac{h}{\lambda v}\right)v^2$$

$$\left(\therefore \lambda = \frac{h}{P} = \frac{h}{mv} \Rightarrow m = \frac{h}{\lambda v}\right)$$

$$\therefore K_1 = \frac{vh}{2\lambda} \text{ Energy of photon } K_2 = \frac{hc}{\lambda}$$

$$\therefore \frac{K_1}{K_2} = \frac{v}{2c} = \frac{2.25 \times 10^8}{2 \times 3 \times 10^8} = \frac{3}{8}$$

(41) Answer [B]

$$\lambda = \frac{h}{\sqrt{2mE}} \text{ Where } E = 2 \times 10^{-21}\ \text{J} = \text{constant}$$

($\therefore$ Kinetic energy of both particle is equal)

$$\therefore \lambda \propto \frac{1}{\sqrt{m}} \text{ However, } m_P > m_e \Rightarrow \lambda_P < \lambda_e$$

(42) Answer [A]

$$\lambda = \frac{h}{\sqrt{2mE}} \Rightarrow E \propto \frac{1}{m}\ (\because \lambda \text{ is equal})$$

However $m_e < m_P \Rightarrow E_e > E_P$

(43) Answer [B]

$$\lambda = \frac{h}{mv} = \frac{6.6 \times 10^{-34}}{(0.5)\,(1000)}$$

$= 0.0132 \times 10^{-34}$ m $= 1.32 \times 10^{-26}\ \mathring{A}$

(44) Answer [A]

Due to the equal De broglie wavelength $\lambda = \frac{h}{P}$ for both, linear momentum is same for both.

$m_P\, v_P = m_e\, v_e$ where m_P = mass of particle, v_P = Velocity of particle

m_e = mass of electron, v_e = Velocity of electron

$$\therefore v_P = \frac{m_e\, v_e}{m_P} = \frac{(9.1\times10^{-31})(2\times10^{6})}{10^{-9}}$$

$(\therefore\ 1\ \mu g = 10^{-6}\ g = 10^{-9}\ kg)$

$\therefore\ v_P = 18.2 \times 10^{-16}$

$= 1.82 \times 10^{-15}\ ms^{-1}$

(45) Answer [B]

$$\lambda = \frac{h}{mv} \Rightarrow v = \frac{h}{m\lambda}$$

$$= \frac{6.6\times10^{-34}}{(9.1\times10^{-31})(10\times10^{-10})} = 7.25 \times 10^{5}\ ms^{-1}$$

(46) Answer [D]

$$\lambda = \frac{h}{\sqrt{2mQV}} \Rightarrow \lambda \propto \frac{1}{\sqrt{mQ}}$$

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{m_2\, q_2}{m_1\, q_1}} = \sqrt{\frac{(3m)\ (2q)}{(2m)\ (3q)}} = 1 : 1$$

(47) Answer [D]

$$\lambda_P = \lambda_\alpha \Rightarrow \frac{h}{\sqrt{2m_PQ_PV}} = \frac{h}{\sqrt{2m_\alpha Q_\alpha v^1}}$$

$$\therefore\ m_P\, Q_P V = m_\alpha\, Q_\alpha\, V' \Rightarrow V' = \left(\frac{m_p}{m_\alpha}\right)\left(\frac{Q_p}{Q_\alpha}\right)V$$

$$= \left(\frac{1}{4}\right)\left(\frac{1}{2}\right)V\ \ (\therefore\ m_\alpha = 4m_P,\ Q_\alpha = 2Q_P)$$

$$= \frac{V}{8}$$

(48) Answer [A]

$$\text{momentum} = \frac{\text{Energy}}{\text{Velocity of light}} \Rightarrow P = \frac{E}{c} = \frac{hf}{c}$$

$$= \frac{(6.6\times10^{-34})(1.5\times10^{14})}{3\times10^{8}}$$

$= 3.3 \times 10^{-28}\ kg\ ms^{-1}$

(49) Answer [B]

$$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2meV}}\ \ \lambda' = \frac{h}{\sqrt{2meV^1}}$$

$$(\therefore\ E = \frac{p^2}{2m} \Rightarrow p = \sqrt{2mE} = \sqrt{2meV}\ )$$

$$\therefore\ \frac{\lambda'}{\lambda} = \sqrt{\frac{2meV}{2meV'}} = \sqrt{\frac{m}{m}\frac{V}{(4V)}}$$

$$= \frac{1}{2}\sqrt{\frac{m}{M}} \Rightarrow \lambda' = \frac{\lambda}{2}\sqrt{\frac{m}{M}}$$

(50) Answer [B]

Initial wavelength of photon $\lambda_1 = 1.4 \times 10^{-10}\, m$ and final waveiength of photon

$\lambda_2 = 2.0\ \mathring{A} = 2 \times 10^{-10}\ m$

Now from $E = \frac{hc}{\lambda}$ initial and final energies of photon $E_1 = \frac{hc}{\lambda_1}$ and $E_2 = \frac{hc}{\lambda_2}$

Here energy of electron = decrease in energy of photon

$$= E_1 - E_2 = hc\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right) = hc\frac{(\lambda_2 - \lambda_1)}{\lambda_1\lambda_2}$$

$$= \frac{(6.63\times10^{-34})(3\times10^{8})\ (2.0 - 1.4)\times10^{-10}}{(1.4\times10^{-10})\ (2.0\times10^{-10})}$$

$= 4.262 \times 10^{-16}\ J, \approx 4.6 \times 10^{-16}\ J$

(51) Answer [A]

De Broglie wavelength of electron $\lambda = \frac{h}{P} = \frac{h}{\sqrt{2mK}}$

$\therefore\ \lambda \propto \frac{1}{\sqrt{K}}$ ($\because$ h and m are constants.)

To make $\frac{1}{3}^{rd}$ of De-Broglie wavelength of electron, from $\lambda \propto \frac{1}{\sqrt{K}}$ electron energy should increase 9 times larger.

(52) Answer [B]

mass of moving particle (here electron),

$$m = \frac{m_o}{\sqrt{1-\frac{v^2}{c^2}}}\ \text{where } v = \text{Velocity of electron}$$

$$= \frac{m_o}{\sqrt{1-\frac{(0.6)^2}{c^2}}} = \frac{m_o}{\sqrt{1-\frac{0.36\,c^2}{c^2}}} = \frac{m_o}{\sqrt{1-0.36}}$$

$$= \frac{m_o}{\sqrt{0.64}} = \frac{m_o}{0.8} = \frac{5\,m_o}{4}$$

(53) Answer [D]

$\lambda = \frac{12.27}{\sqrt{V}}$ Å $\Rightarrow 0.5 = \frac{12.27}{\sqrt{V}}$

$\therefore$ V = $\left(\frac{12.27}{0.5}\right)^2 \approx 602$ V

(54) Answer [B]

Kinetic energy of neutron E = $\frac{1}{2}$ mv^2

$\therefore$ P = mv = $\sqrt{2mE}$

Now $\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mE}}$

$= \frac{(6.60\times10^{-34})}{(2)(1.67\times10^{-27})(0.04\times1.6\times10^{-19})}$

= 1.4275 Å ≈ 1.43 Å

(55) Answer [A]

De-Broglie wavelength $\lambda = \frac{h}{p} = \frac{h}{mv}$

$\therefore \lambda = \frac{6.6\times10^{-34}}{(9\times10^{-31})(10^5)}$ = 73.33 Å

(56) Answer [A]

uncertainly in momentum of electron

$\Delta p = \left(\frac{0.005}{100}\right)(9.1\times10^{-31})(50)$

= 2.275×10^{-33} Kg ms^{-1}

$\therefore$ if uncertainty generated in its according place

$\Delta x = \frac{6.625\times10^{-34}}{(2)(3.14)(2.275\times10^{-33})}$ = 0.046 m

= 46×10^{-3} m = 46 mm

(57) Answer [C]

Suppose, length of one dimensional box is L. The maximum uncertainity in position of electron and proton is Δx = L. According to Heisenberg's uncertainty principle,

$\Delta x\, \Delta P = \hbar$, $\therefore \Delta P = \frac{\hbar}{\Delta x} = \frac{\hbar}{L}$ it is equal for both.

(58) Answer [B]

uncertainty in momentum $\Delta p = m\Delta v = \frac{\hbar}{\Delta x}$

$\Rightarrow \Delta v = \frac{h}{2\pi m\Delta x}$

$= \frac{6.625\times10^{-34}}{2\times(3.14)}(1.67\times10^{-29})(6\times10^{-8})$

= 1 ms^{-1}

(59) Answer [A]

$\Delta p = \frac{\hbar}{\Delta x} = \frac{6.625\times10^{-34}}{(2)(3.14)10^{-10}}$

= 1.054×10^{-24} Kg ms^{-1}

(60) Answer [A]

$\phi_0 = \frac{hc}{\lambda_{max}} = \lambda_{max} = \frac{hc}{\phi_0}$

$= \frac{6.63\times10^{-34}\times3\times10^8}{2\times1.6\times10^{-19}}$ = 6200 Å

(61) Answer [D]

Here frequency of incident light $f = \frac{1}{2}(1.3\ f_o) = 0.65\ f_o$ So, photo-electric effect is not observed. ($\because f < f_o$) current is zero.

(62) Answer [A]

Kinetic energy is gain by proton = qV

= e × 1KV = e (10^3) V = KeV

(63) Answer [A]

from $hf - hf_o = \frac{1}{2} mv^2_{max}$

maximum kinetic energy is dopenls on .

(64) Answer [A]

number of emitted electrons is directly proportional to intensity of incident light. It is not dependent on frequency of incident light.

(65) Answer [A]

De-Broglie wavelength due to charged particle accelerated by difference in electric potential of V volt is $\lambda = \frac{h}{\sqrt{2mqV}} \propto \frac{1}{m}$

(if qV is constant then) $\therefore$ mass of electron is less than proton. So, $\lambda_e > \lambda_P$

(66) Answer [C]

Kinetic energy of emitted electren depends on its binding energy (work fanction), cohich is constant for a given surface and doesent depends on the depth from that surface.

(67) Answer [A]

De-broglie wavelength associated with gas particle changes according to $\lambda \propto \frac{1}{\sqrt{T}}$.

Where T = Absolute temperature

$$\lambda = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2m\left(\frac{3}{2}kT\right)}} = \frac{h}{\sqrt{3mkT}} \propto \frac{1}{\sqrt{T}}$$

(68) Answer [C]

Work function = 2.14 eV = $2.14 \times 1.6 \times 10^{-19}$

$= 3.42 \times 10^{-19}$ J

$\therefore K_{max} = hf - \phi_0$

$= (6.63 \times 10^{-34})(6 \times 10^{14}) - 3.42 \times 10^{-19}$

$= 5.58 \times 10^{-20}$ J

(69) Answer [B]

Stopping potential $V_o = \frac{K_{max}}{e}$

$= \frac{5.58 \times 10^{-20}}{1.6 \times 10^{-19}} = 0.3487 \text{ V} \approx 0.349 \text{ V}$

(70) Answer [C]

$\frac{1}{2} mv^2_{max} = K_{max}$

$$\therefore v_{max} = \left[2\left(\frac{K_{max}}{m}\right)\right]^{\frac{1}{2}} = \left[2\frac{(5.58 \times 10^{-20})}{(9.1 \times 10^{-31})}\right]^{\frac{1}{2}}$$

$= 3.50 \times 10^5 \text{ ms}^{-1}$

(71) Answer [C]

$\phi_0 = \frac{hc}{\lambda_0} \Rightarrow \lambda_0 = \frac{hc}{\phi_0}$

$= \frac{(6.6 \times 10^{-34})(3 \times 10^8)}{3.42 \times 10^{-19}}$

$= 5.789 \times 10^{-7} \text{ m} = 5789 \text{ Å}$

(72) Answer [A]

Speed of light $c = f_o \lambda_0 \Rightarrow f_o = \frac{c}{\lambda_0}$

$= \frac{3 \times 10^8}{5789 \times 10^{-10}} = 5.18 \times 10^{14}$ Hz

(74) Answer [D]

De-Broglie wavelength $\lambda = \frac{h}{p} \Rightarrow \lambda \propto \frac{1}{p}$

$\therefore$ graph is rectangular hyperbola.

(75) Answer [D]

According to Elenstein;s equation compare with $hf = hf_o = K_{max}$ compare with $y = mx + C$, Slope is h and intercept on y-axis is hf_o.

(76) Answer [D]

from $V_o = \frac{h}{e} f - \frac{\phi_o}{e}$ from graph $V_2 > V_1$

$\therefore \frac{hf_2}{e} - \frac{\phi_o}{e} > \frac{hf_1}{e} - \frac{\phi_o}{e} \Rightarrow f_2 > f_1$

$\Rightarrow \lambda_1 > \lambda_2$ (from $\lambda \propto \frac{1}{f}$)

(77) Answer [A]

Photoelectric current decreases with increasing wavelength (having frequency) and photo electric current becomes zero after certain fix value (cutoff value.) (Stops).

•

18 Atom and Nucleus

(1) Answer [D]

Potential energy at distance d = Kinetic energy of α – particle

$$\frac{k \times 2e \times Ze}{d} = 10 \text{ MeV}$$

$$\frac{2kze^2}{d} = 10 \times 10^6 \times e, \quad d = \frac{2kze}{10^7}$$

$$= \frac{2 \times 9 \times 10^9 \times 60 \times 1.6 \times 10^{-19}}{10^7}$$

$d = 1.728 \times 10^{-14}$ m

(2) Answer [B]

Kinetic energy of α –particle = Potential energy at a distance 'd'.

$$= \frac{k \times 2e \times 85\, e}{1.85 \times 10^{-14}\, e} \, (eV)$$

$$= \frac{9 \times 10^9 \times 170 \times 1.6 \times 10^{-19}}{1.85 \times 10^{14}} = 13.23 \text{ MeV}$$

(3) Answer [B]

$$\frac{k \times 2e \times Z\cancel{e}}{d} = 27 \times 10^6 \times \cancel{e}$$

$$Z = \frac{27 \times 10^6 \times 1.1 \times 10^{-14}}{9 \times 10^9 \times 2 \times 1.6 \times 10^{-19}} = 103$$

(4) Answer [A]

$$\frac{N_2}{N_1} = \frac{t_2}{t_1} \Rightarrow \frac{N_2}{N_1} = \frac{2.5 \times 10^{-6}}{2 \times 10^{-7}}$$

$\Rightarrow N_2 = 12.5 N_1$

(6) Answer [B]

$$\frac{N_2}{N_1} = \frac{t_2}{t_1} \Rightarrow \frac{27500}{8500} = \frac{t_2}{t_1} \Rightarrow t_2 = 3.2\, t_1$$

(7) Answer [C]

$$E \propto \frac{1}{n^2} \qquad \frac{E_4}{E_3} = \frac{(5)^2}{(4)^2} = \frac{25}{16}$$

(8) Answer [B]

$$E = hf, \; pc = hf \Rightarrow p = \frac{hf}{c}$$

$$= \frac{6.625 \times 10^{-34} \times 400 \times 10^{12}}{3 \times 10^8}$$

$= 8.8 \times 10^{-28}$ kg ms^{-1}

(9) Answer [A]

When Phosphorous added in Silicon then,

$$r = \frac{n^2h^2\in}{\pi me^2Z}$$

Where $\in$ = permittivity of Silicon medium

$$\therefore \quad r = \frac{n^2h^2\in_0 K}{\pi me^2Z}$$

Now, $n = 3$, K = 12, Z = 15 and substituting values of h, $\in_0$, π, m, e.

$r = 380.88 \times 10^{-12}$ m = 380.88 pm

(10) Answer [C]

$$mvr = \frac{nh}{2\pi} \Rightarrow v = \frac{nh}{2\pi mr} \text{ and } r = \frac{n^2h^2\in_0}{\pi zme^2}$$

$$v = \frac{nh\pi zme^2}{2\pi m\, n^2h^2\in_0} = \frac{e^2z}{2nh\in_0}$$

$$\Rightarrow v = \frac{1}{137}\frac{cZ}{n}$$

$$\therefore v = \frac{\left(1.6 \times 10^{-19}\right)^2 \times 1}{2 \times 1 \times 6.62 \times 10^{-34} \times 8.85 \times 10^{-12}}$$

$$\approx \frac{c}{137}$$

(11) Answer [C]

$$p = \frac{h}{\lambda} \qquad \therefore m_H v = h\, R\left[\frac{1}{1} - \frac{1}{25}\right]$$

$$\therefore v = \frac{hR}{m_H} \times \frac{24}{25} \Rightarrow v = 4 \text{ ms}^{-1}$$

(12) Answer [B]

Using $R \propto n^2, E \propto \frac{1}{n^2}$ RE = constant

$\Rightarrow v \propto \frac{1}{n}, T \propto n^3$

(13) Answer [B]

K = –E $\therefore$ K = 3.4 eV

(14) Answer [D]

$L_1 = \frac{h}{2\pi}$ and $L_4 = \frac{5h}{2\pi}$

$\therefore L_4 - L_1 = \frac{4h}{2\pi} = 4L_1$

(15) Answer [B]

If electron transist from $n = 3$ to $n = 1$ in Hydrogen atom then the energy released (–1.5 – 13.6) = 12.1 eV.

Thus, angular momentum $= \frac{3h}{2\pi} - \frac{h}{2\pi} = \frac{2h}{2\pi}$

$= 2.11 \times 10^{-34}$ Js

(16) Answer [C]

$E = \frac{-13.6Z^2}{n^2}$ $eV = -\frac{13.6 \times 4}{4} = -13.6$ eV

(17) Answer [D]

$T \propto n^3 \Rightarrow 1 : 8$

(18) Answer [D]

$A \propto r^2$ and $r \propto n^2$, $\therefore A \propto n^4 \Rightarrow 16 : 1$

(19) Answer [C]

$$E = \frac{me^4Z^2}{8h^2\epsilon_0^2 n^2} = \frac{-me^4}{8\epsilon_0^2 ch^3} \times ch\frac{Z^2}{n^2}$$

$= -Rch\frac{Z^2}{n^2}$, Z = 1, n = 1 $\Rightarrow$ E = – Rch

(20) Answer [B]

$$r \propto n^2 \Rightarrow \frac{r_2}{r_1} = \frac{n_2^2}{n_1^2} \Rightarrow \frac{r_2}{0.528} = \frac{4}{1}$$

$r_2 = 2.112$ Å

(21) Answer [C]

$p = \frac{h}{\lambda} \Rightarrow m_H v = hR\left[\frac{1}{1} - \frac{1}{25}\right]$

$v = \frac{hR}{m_H} \times \frac{24}{25} = 4.178$ ms^{-1}

(22) Answer [C]

If n is quantum number then possible states is $2n^2$.

$n = 1 \rightarrow 2$ states, $n = 2 \rightarrow 8$ states

$n = 3 \rightarrow 18$ states, $n = 4 \rightarrow 32$ states

total 2 + 8 + 18 + 32 = 60 possible states.

(23) Answer [B]

$$\frac{hc}{\lambda_3} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2} \Rightarrow \frac{1}{\lambda_3} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$$

$$\therefore \lambda_3 = \frac{\lambda_1\lambda_2}{\lambda_1 + \lambda_2}$$

(24) Answer [C]

$\frac{1}{\lambda} = R\left(\frac{1}{4} - \frac{1}{16}\right)$

$\therefore f = Rc\left(\frac{1}{4} - \frac{1}{16}\right) \Rightarrow f = \frac{9}{16} \times 10^{15}$ Hz

(25) Answer [A]

$\lambda = \frac{h}{mv}$ and $v = \frac{1}{137}\frac{cZ}{n} \Rightarrow v = \frac{c}{274}$

$$\lambda = \frac{6.625 \times 10^{-34} \times 274}{9.1 \times 10^{-31} \times 3 \times 10^8} \approx 6.6 \times 10^{-10} \text{ m}$$

(26) Answer [D]

$$L = \sqrt{l(l+1)}\frac{h}{2\pi} = \sqrt{7(8)}\frac{h}{2\pi} = \sqrt{56}\frac{h}{2\pi}$$

(27) Answer [D]

Z = 1, 1, 2, 3 respectively

$\frac{1}{\lambda} = R Z^2\left(1 - \frac{1}{4}\right) = R Z^2 \frac{3}{4} \Rightarrow \frac{1}{\lambda} \propto Z^2$

Comparison of any one $\lambda_1 = \lambda_2 = 4\lambda_3 = 9\lambda_4$

(28) Answer [C]

$$n\frac{(n-1)}{2} = \frac{4(4-1)}{2} = 6$$

(29) Answer [C]

minimum wavelength in Lymen series for $n \rightarrow \infty$ in Hydrogen spectra.

$$\frac{1}{\lambda_L} = R\left(\frac{1}{1^2} - \frac{1}{\infty^2}\right) \Rightarrow \lambda_L = \frac{1}{R} = 911 \text{ Å}$$

and maximum wavelength in pfund series substiluting $n = 6$.

$$\frac{1}{\lambda_{\text{pfund}}} = R\left(\frac{1}{5^2} - \frac{1}{6^2}\right) = \frac{11R}{900} \Rightarrow$$

$$\lambda = \frac{900}{11R} = 74583 \text{ Å}, \text{Ratio} = \frac{911}{74583} = 0.012$$

(30) Answer [D]

$n = 5$ for λ_{max} in Bracket series

$$\frac{1}{\lambda} = R\left[\frac{1}{4^2} - \frac{1}{5^2}\right] = \frac{9R}{400}$$

$$\Rightarrow \lambda = \frac{400}{9R} = 40515 \text{ Å}$$

For λ_{min}, $n = \infty \therefore \frac{1}{\lambda} = \frac{R}{16}$

$$\Rightarrow \lambda = \frac{16}{R} = 14585 \text{ Å}$$

$\therefore$ Ratio $\frac{40515}{14585} = 2.78$

(31) Answer [A]

Maximum wavenumber inversly proportional to minimum wavelength. For infrared, the minimum wavelength observed in Paschen series.

and $n \rightarrow \infty$, $\frac{1}{\lambda} = R\left(\frac{1}{3^2} - \frac{1}{\infty^2}\right)$

$$= \frac{R}{9} = 12.18 \times 10^5 \text{ m}^{-1}$$

(32) Answer [A]

Balmer $\frac{1}{\lambda_B} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$,

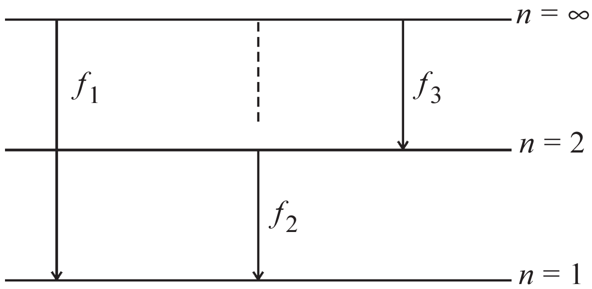
Lyman $\frac{1}{\lambda_L} = R\left(\frac{1}{1^2} \frac{-1}{2^2}\right) \Rightarrow \frac{\lambda_B}{\lambda_L} = \frac{27}{5}$

(33) Answer [A]

$$\frac{1}{\lambda_B} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5R}{36} \Rightarrow \lambda_B$$

$$= \frac{36}{5 \times 1.097 \times 10^7} \Rightarrow \lambda_B = 6563 \text{ Å}$$

(34) Answer [A]



For last line of Lyman series $n = \infty \rightarrow n = 1$

For first line of Lyman series $n = 2 \rightarrow n = 1$

and for last line of Balmer series $n = \infty \rightarrow n = 2$

$$hf_1 = hf_3 + hf_2$$
$$f_1 = f_3 + f_2$$
$$f_1 - f_2 = f_3$$

(35) Answer [A]

For minimum λ, $\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{\infty^2}\right)$

$$\Rightarrow \lambda_{min} = \frac{1}{R}$$

For maximum λ, $\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$

$$\Rightarrow \lambda_{max} = \frac{4}{3R}$$

$$\frac{\lambda_{max}}{\lambda_{min}} = \frac{4}{3R} \times R$$

$$\Rightarrow \lambda_{max} = \frac{4}{3} \times 912 = 1216 \text{ Å}$$

(36) Answer [C]

$$E_4 - E_3 = \frac{-13.6}{(4)^2} - \left(\frac{-13.6}{(3)^2}\right) = 0.66 \text{ } eV$$

(37) Answer [D]

$$E_3 - E_2 = -13.6 \text{ z}^2 \left(\frac{1}{9} - \frac{1}{4}\right)$$

$$47.22 = -13.6 \text{ Z}^2 \times \frac{5}{36} \Rightarrow Z = 5$$

(38) Answer [A]

$$E_3 - E_2 = -\frac{13.6 Z^2}{9} - \left(\frac{-13.6 Z^2}{4}\right)$$

$= 13.6\, z^2 \left(\frac{1}{9} - \frac{1}{4}\right) = 13.6 \times 4 \left(\frac{1}{9} - \frac{1}{4}\right)$

$= 7.55\ eV \Rightarrow$

7.55 V (potential)

(39) **Answer [C]**

$$V_1 - V_2 = V,\ V_1 - \frac{V_1}{(2)^2} = V \left(\because V_n = \frac{V_1}{n^2}\right)$$

$\therefore V_1 = \frac{4}{3} V$

(40) **Answer [B]**

$$E = -\frac{13.6 Z^2}{n^2} = \frac{-13.6 \times (3)^2}{(2)^2} \Rightarrow 30.6\ eV$$

(41) **Answer [C]**

$\lambda_{min} = \frac{hc}{eV} \Rightarrow \lambda_{min} \propto \frac{1}{V} \Rightarrow$ minimum wavelength decreases.

(42) **Answer [B]**

$$E = \frac{hc}{\lambda} = \frac{6.625 \times 10^{-34} \times 3 \times 10^8}{3.3 \times 10^{-10} \times 1.6 \times 10^{-19}}\ (eV)$$

$= 3.8\ keV$

(43) **Answer [C]**

$$\lambda_{min} = \frac{hc}{eV} = \frac{6.62 \times 3 \times 10^8 \times 10^{-34}}{1.6 \times 10^{-19} \times 4 \times 10^6}$$

$= 0.0031\ \mathring{A}$

(45) **Answer [C]**

$$f = C^2 (Z-1)^2 \Rightarrow \frac{c}{\lambda} = C^2 (Z-1)^2$$

$$\Rightarrow (Z-1)^2 = \frac{c}{\lambda \times C^2}$$

$$= \frac{3 \times 10^8}{0.76 \times 10^{-10} \times (4.965)^2 \times 10^{14}}$$

$$\Rightarrow (Z-1)^2 = \frac{3}{0.76 \times 24.65} \times 10^4$$

$$\Rightarrow (Z-1)^2 \approx 1600 \Rightarrow (Z-1) = 40 \Rightarrow Z = 41$$

(46) **Answer [D]**

$$\frac{1}{\lambda} \propto (Z-1)^2 \Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{(81-1)^2}{(65-1)^2}$$

$$= \frac{80 \times 80}{64 \times 64} = \frac{25}{16}$$

(48) **Answer [D]**

$$\lambda_{min} = \frac{hc}{eV} = \frac{6.62 \times 10^{-34} \times 3 \times 10^8}{1.6 \times 10^{-19} \times 66 \times 10^3}$$

$= 0.0187$ nm

If $\lambda_{min} = 0.0187$ then wavelength of 0.01 nm is absent. While wavelength of 0.02 nm is present.

(49) **Answer [A]**

$$\lambda_{min} = \frac{hc}{eV} \text{ then } f_{max} = \frac{eV}{h} \left(\because f = \frac{c}{\lambda}\right)$$

$$\therefore f_{max} \propto V \Rightarrow \frac{f}{2}$$

(50) **Answer [A]**

$$\frac{1}{\lambda} \propto (Z-1)^2 \Rightarrow \frac{\lambda'}{\lambda} = \frac{(41-1)^2}{(21-1)^2}$$

$$= \frac{40 \times 40}{20 \times 20} \Rightarrow \lambda' = 4\lambda$$

(51) **Answer [D]**

$$\lambda_{min} = \frac{hc}{E} = \frac{6.62 \times 10^{-34} \times 3 \times 10^8}{80 \times 10^3 \times 1.6 \times 10^{-19}}$$

$= 0.155 \times 10^{-10}\ m = 0.155\ \mathring{A}$

However, energy of incident electron > energy of K – shell electron, so characteristic spectra observed and continuous spectra observed for minimum wavelength of $0.155\ \mathring{A}$.

(52) Answer [C]

$\lambda_c \propto \frac{1}{V}$ so V increases then λ_c decreases. Transition is not changing so λ_K is constant. But with decreasing λ_c, $\lambda_K - \lambda_c$ increases.

(53) Answer [C]

$13.6 - 12.1\ eV = 1.5\ eV$ means electron reached in orbit $n = 3$. The number of emitted spectral lines is

$$= n\frac{(n-1)}{2} = \frac{3(3-1)}{2} = 3$$

(54) Answer [B]

$$\frac{1}{\lambda_{K_\infty}} = R\,(Z-1)^2\left(\frac{1}{1^2}-\frac{1}{2^2}\right) \qquad ...(1)$$

$$\frac{1}{\lambda_{K_\beta}} = R\,(Z-1)^2\left(\frac{1}{1^2}-\frac{1}{3^2}\right) \qquad ...(2)$$

Taking ratio of (1) and (2)

$$\frac{\lambda_{K_\beta}}{\lambda_{K_\infty}} = \frac{3}{4}\times\frac{9}{8} = \frac{27}{32}$$

$$\therefore\ \lambda_{K_\beta} = \frac{27}{32}\times 0.32\ \mathring{A} = 0.27\ \mathring{A}$$

(55) Answer [B]

$\frac{1}{\lambda} \propto (Z-1)^2$ and $f \propto \frac{1}{\lambda}$

$\therefore\ f \propto (Z-1)^2$

(56) Answer [C]

The force between two neutron and neutron-proton is only strong nuclear force so it is equal $F_2 = F_3$ and (repulsive) between proton - proton coulomb force is opposite to each other so value of F_1 is lower. Thus $F_1 < F_2 = F_3$

(57) Answer [C]

Whole process $3\left({}_1H^2\right) \rightarrow 2He^4 + p + n$

$$\Delta m = m\,({}_2He^4) + (m_p) + (m_n) - 3m\left({}_1H^2\right)$$

$= [(4.001 + 1.007 + 1.008 - 3\,(2.014)]\ u$

$= -0.026u \ \Rightarrow\ 0.026u$ (value)

$E_\sigma = 0.026 \times 931.5 \times 1.6 \times 10^{-19} \times 10^6 = 3.87 \times 10^{-12}$ J

3 deuteron is emmited in each process so,

process for 10^{40} deuteron emission is= $\frac{10^{40}}{3}$

Thus, total energy

$$= E = E_\sigma \times \frac{10^{40}}{3} = 3.87\times 10^{-12}\times\frac{10^{40}}{3}$$

$= 1.29 \times 10^{28}$ J

$$E = Pt \ \Rightarrow\ t = \frac{E}{P} = \frac{1.29\times 10^{28}}{10^{16}}$$

$\therefore\ t = 1.29 \times 10^{12}$ s $\approx 10^{12}$ s

(58) Answer [B]

Initial Binding energy = $236 \times 7.6 = 1793.6$ MeV

Final Binding energy = $2(117) \times 8.5 = 1989$ MeV

$\Delta E_b = 1989 - 1793.6 = 195.4$ MeV ≈ 200 MeV

(59) Answer [D]

Packing fraction $(f) = \frac{\Delta m}{A} = \frac{M-A}{A}$

(61) Answer [B]

$$E = mc^2 = \frac{\left(1.67\times 10^{-27}\right)\times 9\times 10^{16}}{1.6\times 10^{-19}}$$

$= 931.5$ MeV

(64) Answer [C]

$$\Delta m = m\left(2^{He^4}\right) - 2m\left(1^{H^2}\right)$$

$= 4.0024 - 2\,(2.0141) = -0.0258u$

$Q = \Delta mc^2 = (0.0258)\,(931.5) = 24$ MeV

(65) Answer [C]

$E \propto c^2 \ \Rightarrow\ c' = \frac{2}{3}c \ \Rightarrow\ E' = \frac{4}{9}E$

$E - \frac{4}{9}E \ \Rightarrow\ \frac{5}{9}E$ decreases.

(66) Answer [D]

$$10.811 = \frac{(x\times 10.01294) + (100-x)\,(11.00931)}{100}$$

$\therefore\ 1081.1 = (10.01294 - 11.00931)x + 1100.931$

$\therefore\ 0.99637x = 19.831 \Rightarrow x = 19.90\ \%$

and contribution of other is 80.10 %.

(67) Answer [A]

$E = \Delta m \times c^2$

$= \frac{0.03}{100} \times 1 \times 9 \times 10^{16} = 2.7 \times 10^{13}$ J

(68) Answer [D]

$7+2=Z+1 \Rightarrow Z=8, 14+4=A+1 \Rightarrow A=17$

$\therefore\ {}_8O^{17}$

(69) Answer [A]

$\Delta m = (Zm_p + Nm_n) - M$

$= (8 \times 1.007825 + 8 \times 1.008665) - 15.9949$

$= 0.13702$ amu

$$E_{bn} = \frac{\Delta m \times 931}{16} = \frac{0.13702 \times 931}{16}$$

$= 7.973$ MeV

(70) Answer [D]

In 12 g of ${}_6C^{12} \approx 6 \times 10^{23}$ atoms. In each atom, 6 proton, 6 electron and 6 neutron. Thus, total number of each $\approx 6 \times 6 \times 10^{23} \approx 36 \times 10^{23}$

(71) Answer [C]

$$E_{bn} = \frac{0.04 \times 931}{4} = 9.31 \text{ MeV}$$

(72) Answer [D]

Energy corresponding to one proton according to $E = mc^2$.

$$= \frac{1.66 \times 10^{-27} \times 9 \times 10^{16}}{1.6 \times 10^{-19}} = 931 \text{ MeV}$$

$\therefore$ number of proton $= \frac{3724}{931} = 4$

(73) Answer [A]

$$\frac{R_S}{R_{He}} = \frac{R_0 (32)^{\frac{1}{3}}}{R_0 (4)^{\frac{1}{3}}} = \left(\frac{32}{4}\right)^{\frac{1}{3}} = 2 \Rightarrow R_S = 2R_{He}$$

(74) Answer [C]

$c - (a + b) \Rightarrow C - a - b.$

(75) Answer [B]

total B·E· of Li $= 7 \times 5.60 = 39.2$ MeV

total B·E· of He $= 2\,(4 \times 7.06) = 56.48$ MeV

Energy gain in process $= 56.48 - 39.2 = 17.28$ MeV

(76) Answer [C]

mass of reagent $= 2 \times 2.041 = 4.0282$ amu

mass of product $= 3.01605 + 1.00782 = 4.02387$ amu

$\Delta m = 4.0282 - 4.02387 = 0.00433$ amu

$E_{bn} = 0.00433 \times 931 = 4.03$ MeV $= 4$ MeV.

(77) Answer [A]

$$P = \frac{nE}{t} \Rightarrow n = \frac{P}{E}$$

$$= \frac{1.6 \times 10^6}{200 \times 10^6 \times 1.6 \times 10^{-19}} = 5 \times 10^{16}\ s^{-1}$$

(78) Answer [A]

$Z \to Z + 1$ so emission ot β then decrease in Z is 2 and decrease in A is 4 then emission of α and last Z and A is not change means emission of γ. Thus, emission of β, α and γ respectively.

(79) Answer [A]

Suppose, x α – particles and y β – particles are emmited.

$${}_{92}X^{235} \longrightarrow {}_{88}Y^{219}\ x\ {}_2He^4 + y\ {}_{-1}e^0$$

$235 = 219 + 4x + 0y,\ 92 = 88 + 2x - y$

$4x = 16 \Rightarrow x = 4,\ 92 = 88 + 8 - y \Rightarrow y = 4$

$\therefore$ 4 α – particles and 4 β – particles are emmited.

(81) Answer [A]

α–particles produced at A end means ${}_2He^4$ so A end becomes positive. β – particles at B end means due to the producing electon B end becomes negative. Thus electric current flows from positive (A-end) to negative (B-end).

(82) Answer [B]

$$_{90}X^{232} \rightarrow _{82}Pb^{208} + x_2He^4 + y_{-1}e^0$$

$232 = 208 + 4x + 0y \Rightarrow 4x = 24 \Rightarrow x = 6, \alpha = 6$

$90 = 82 + 2x - y \Rightarrow 8 = 2 \times 6 - y \Rightarrow y = 4, \beta = 4$

(83) Answer [B]

$$_5B^{10} + _2He^4 \rightarrow _7N^{13} + _0n^1 \text{ (Neutron)}$$

$A\ (10 + 4 = 13 + 1),\ Z\ (5 + 2 = 7 + 0)$

(84) Answer [C]

$$_6C^{12} + _0n^1 \rightarrow _{-1}e^0 + _7N^{13} \begin{bmatrix} 12 + 1 = 0 + 13 \\ 6 + 0 = -1 + 7 \end{bmatrix}$$

(86) Answer [B]

$$P = \frac{nE}{t} \Rightarrow n = \frac{Pt}{E}$$

$$= \frac{5 \times 1}{200 \times 10^6 \times 1.6 \times 10^{-19}}$$

$n = 0.0156 \times 10^{13} \Rightarrow 1.56 \times 10^{11}\ s^{-1}$

(87) Answer [A]

$$_ZX^A \xrightarrow{\alpha} _{Z-2}X'^{A-4} \xrightarrow{\beta^+} _{Z-3}X''^{A-4}$$

(88) Answer [A]

$$_{88}Ra^{236} \rightarrow 3_2He^4 + _{-1}e^0 + _ZX^A$$

$236 = 12 + 0 + A \Rightarrow A = 224$

$88 = 6 - 1 + Z \Rightarrow Z = 83$

(89) Answer [C]

$$K = \frac{p^2}{2m} \Rightarrow p = \text{constant} \therefore K \propto \frac{1}{m} \Rightarrow \frac{K_1}{K_2} = \frac{m_2}{m_1}$$

$$\Rightarrow \frac{K_1 + K_2}{K_2} = \frac{m_2 + m_1}{m_1} \Rightarrow \frac{Q}{9.78} = \frac{4 + 222}{222}$$

$\Rightarrow Q = 4.87\ MeV$

(90) Answer [B]

$E = mc^2$

$$\therefore \frac{dE}{dt} = c^2 \frac{dm}{dt} \Rightarrow \frac{dm}{dt} = \frac{1}{c^2} \frac{dE}{dt}$$

$$\therefore \frac{dm}{dt} = \frac{2.7 \times 10^{36}}{9 \times 10^{16}} = 3 \times 10^{19}\ kgs^{-1}$$

(91) Answer [A]

$$_{92}X = _ZY + 8_2He^4 + 4_{-1}e^0 + 2_{+1}e^0$$

$\Rightarrow 92 = Z + 16 - 4 + 2,\ Z = 78$

(92) Answer [C]

for two nucleus, $\frac{3}{2}k_BT + \frac{3}{2}k_BT = 7.7 \times 10^{-14}$

$\therefore 3 \times 1.38 \times 10^{-3} \times T = 7.7 \times 10^{-14}$

$\therefore T = 1.86 \times 10^9\ K \approx 10^9\ K$

(94) Answer [A]

total energy of fission = energy of daughter element + energy of α particle

$$E_t = \frac{p^2}{2M} + \frac{p^2}{2m} \quad (\because p = \text{constant})$$

$$\therefore E_t = \frac{p^2}{2}\left[\frac{1}{M} + \frac{1}{m}\right] = \frac{p^2}{2}\left(\frac{m + M}{Mm}\right)$$

$$\therefore E_t = \frac{p^2}{2m}\left(\frac{m + M}{M}\right)$$

Where mass of α-particle = m and mass of daughter element = M

$m = 4$ and $M = 208 - 4 = 204$

Where $\frac{p^2}{2m}$ = energy of α-proticle = E

$$\therefore E_t = \frac{p^2}{2m}\left(\frac{4 + 204}{204}\right), \therefore E_t = \left(\frac{52}{51}\right)E$$

(95) Answer [A]

$$\tau_{\frac{1}{2}} = 100\ \mu s \Rightarrow I = \frac{I_0}{16} \Rightarrow \frac{I}{I_0} = \left(\frac{1}{2}\right)^4$$

$\therefore n = 4 \Rightarrow t = n\tau_{\frac{1}{2}} \Rightarrow t = 4 \times 100 = 400\ \mu s$

(96) Answer [C]

Suppose R_0 is initial activity

$$\therefore \frac{R_1}{R_2} = \frac{R_0\, e^{-\lambda t_1}}{R_0\, e^{-\lambda t_2}} \Rightarrow \frac{R_2}{R_1} = \frac{e^{-\lambda t_2}}{e^{-\lambda t_1}}$$

$$\Rightarrow \frac{R_2}{R_1} = e^{-\lambda t_2 + \lambda t_1} = e^{\lambda(t_1 - t_2)}$$

$\Rightarrow R_2 = R_1\, exp\ \lambda\, (t_1 - t_2)$

$$\Rightarrow R_2 = R_1\, exp\left(\frac{t_1 - t_2}{\tau}\right)$$

(97) Answer [C]

$$n = \frac{t}{\tau_{\frac{1}{2}}} = \frac{19}{3.8} = 5 \Rightarrow \frac{M}{M_0} = \left(\frac{1}{2}\right)^5 = \frac{1}{32}$$

$$\Rightarrow M = \frac{M_0}{32} = \frac{16}{32} = 0.5 \text{ g (undecayed)}$$

$\therefore$ Decayed mass = 16 – 0.5 = 15.5 g

(98) Answer [D]

Decayed mass $\rightarrow \frac{3}{4}$ then undecayed $= \frac{1}{4}$

$$\therefore \frac{N}{N_0} = \frac{1}{4} = \left(\frac{1}{2}\right)^2 \Rightarrow n = 2$$

$$n = \frac{t}{\tau_{\frac{1}{2}}} \Rightarrow t = n \times \tau_{\frac{1}{2}} = 2 \times 30 = 60 \text{ days}$$

(99) Answer [D]

$$\frac{N}{N_0} = \frac{1}{16} = \left(\frac{1}{2}\right)^4 \Rightarrow n = 4$$

$$\tau_{\frac{1}{2}} = \frac{t}{n} = \frac{30}{4} = 7.5 \text{ years}$$

(100) Answer [A]

Decay constant $\lambda = \frac{0.693}{\tau_{\frac{1}{2}}} = \frac{0.693}{7.5} = 0.0924\, yr^{-1}$

(101) Answer [B]

$$A \rightarrow \quad n = \frac{2}{1} = 2,\ B \rightarrow n = \frac{2}{2} = 1$$

$$\left(n = \frac{t}{\tau_{\frac{1}{2}}}\right)$$

$$N_A = N_0\left(\frac{1}{2}\right)^2 = \frac{N_0}{4},\ N_B = N_0\left(\frac{1}{2}\right)^1 = \frac{N_0}{2}$$

$$I = \lambda N \Rightarrow I = \frac{0.693}{\tau_{\frac{1}{2}}} N$$

$$\frac{I_A}{I_B} = \frac{\tau_{\frac{1}{2}B}}{\tau_{\frac{1}{2}A}} \frac{N_A}{N_B} = \frac{2}{1} \times \frac{N_0}{4} \times \frac{2}{N_0} = 1 : 1$$

(102) Answer [C]

$$N = \frac{M}{M_0} N_A = \frac{2.3}{230} \times 6 \times 10^{23} = 6 \times 10^{21}$$

$$I = \lambda N = \frac{0.693}{\tau_{\frac{1}{2}}} N = \frac{0.693 \times 6 \times 10^{21}}{2.4 \times 10^{11}}$$

$$= 1.73 \times 10^{10}$$

(103) Answer [D]

$$t = n\tau_{\frac{1}{2}} \Rightarrow n = \frac{5}{10} = \frac{1}{2} \quad \frac{N}{N_0} = \left(\frac{1}{2}\right)^{\frac{1}{2}}$$

$$\Rightarrow N = \frac{N_0}{\sqrt{2}} = \frac{10^8}{\sqrt{2}}$$

(104) Answer [D]

$$n = \frac{t}{\tau_{\frac{1}{2}}} = \frac{15}{3} = 5 \Rightarrow \frac{M}{M_0} = \left(\frac{1}{2}\right)^5$$

$$\Rightarrow M = \frac{M_0}{32} = \frac{16}{32} = 0.5 \text{ g}$$

(105) Answer [D]

half life time	Undecayed
$\tau_{\frac{1}{2}}$ (5 *min*)	50 %
$2\tau_{\frac{1}{2}}$ (10 *min*)	25 %
$3\tau_{\frac{1}{2}}$ (15 *min*)	12.5 %
$4\tau_{\frac{1}{2}}$ (20 *min*)	6.25 %
$5\tau_{\frac{1}{2}}$ (25 *min*)	3.125 %

(106) Answer [D]

time		Activity
$\tau_{\frac{1}{2}}$	$\rightarrow$	50 %
$2\tau_{\frac{1}{2}}$	$\rightarrow$	25 %
$3\tau_{\frac{1}{2}}$	$\rightarrow$	12.5 %
$4\tau_{\frac{1}{2}}$	$\rightarrow$	6.25 %
$5\tau_{\frac{1}{2}}$	$\rightarrow$	6.25 %

i.e. 12.5 × 5 = 62.5

Thus, approx 63 years + 7 year old. So, ≈ bottle should 70 years old.

(107) Answer [A]

$\tau_{\frac{1}{2}} = 0.693\,\tau \Rightarrow \tau = 1.44\,\tau_{\frac{1}{2}} = 1.44 \times 10 = 14.4\,yr$

(108) Answer [D]

$$I_1 = -\lambda N_1 \Rightarrow N_1 = \frac{-I_1}{\lambda} \;\&\; N_2 = \frac{-I_2}{\lambda}$$

$$\therefore N_1 - N_2 = \frac{1}{\lambda}(I_2 - I_1) = \frac{\tau_{\frac{1}{2}}}{0.693}(I_2 - I_1)$$

$N_1 - N_2 \propto (I_2 - I_1)\,\tau_{\frac{1}{2}}$

(109) Answer [B]

$N_1 = 0.8\,N_0$ and $N_2 = 0.2\,N_0$

$$\frac{N_1}{N_0} = \left(\frac{1}{2}\right)^{n_1} \text{ and } \frac{N_2}{N_0} = \left(\frac{1}{2}\right)^{n_2}$$

$$\frac{N_1}{N_0} = \left(\frac{1}{2}\right)^{\frac{t_1}{\tau_{\frac{1}{2}}}} \quad \dots (1)$$

$$\text{and } \frac{N_2}{N_0}\left(\frac{1}{2}\right)^{\frac{t_2}{\tau_{\frac{1}{2}}}} \quad \dots (2)$$

$$\text{equation } \frac{(2)}{(1)} \Rightarrow \frac{N_2}{N_1} = \left(\frac{1}{2}\right)^{\frac{t_2 - t_1}{\tau_{\frac{1}{2}}}}$$

$$\frac{0.2}{0.8} = \left(\frac{1}{2}\right)^{\frac{t_2 - t_1}{20}} \Rightarrow \frac{1}{4} = \left(\frac{1}{2}\right)^{\frac{t_2 - t_1}{20}}$$

$$\Rightarrow \left(\frac{1}{2}\right)^2 = \left(\frac{1}{2}\right)^{\frac{t_2 - t_1}{20}}$$

$$\Rightarrow 2 = \frac{t_2 - t_1}{20} \Rightarrow t_2 - t_1 = 40 \text{ min.}$$

(110) Answer [C]

$$\tau_{\frac{1}{2}}t = \frac{\tau_{\frac{1}{2}\alpha}\,\tau_{\frac{1}{2}\beta}}{\tau_{\frac{1}{2}\alpha} + \tau_{\frac{1}{2}\beta}} = \frac{8 \times 24}{32} = 6\,yr$$

$\therefore\ \tau_{\frac{1}{2}}$ (total) $= 6\,yr$

$\left(\tau_{\frac{1}{2}}\right) 6yr \rightarrow 50\ \%$

$2\tau_{\frac{1}{2}}\ (12yr) \rightarrow\ 25\ \%$

(111) Answer [C]

Undecayed nucleus $\tau_{\frac{1}{2}}$ (10 days) $\rightarrow 2 \times 10^{16}$

$2\tau_{\frac{1}{2}}$ (20 days) $\rightarrow 1 \times 10^{16}$

$3\tau_{\frac{1}{2}}$ (30 days) $\rightarrow\ 0.5 \times 10^{16}$

$\therefore$ number of decayed nucleus after 30 days
$4 \times 10^{16} - 0.5 \times 10^{16} = 3.5 \times 10^{16}$

(112) Answer [A]

$t = 2\tau = 2 \times 1.44\,\tau_{\frac{1}{2}} = 2.88\,\tau_{\frac{1}{2}}$

$$\Rightarrow \frac{t}{\tau_{\frac{1}{2}}} = 2.88 = n,\ \frac{M}{M_0} = \left(\frac{1}{2}\right)^n = \left(\frac{1}{2}\right)^{2.88}$$

$$\Rightarrow M = 10\left(\frac{1}{2}\right)^{2.88}$$

$\Rightarrow \log M = \log 10 - 2.88 \log 2$
$= 1 - 2.88 \times 0.3010$
$\Rightarrow \log M = 0.1331 \Rightarrow M = 1.358 \approx 1.36$ g

(113) Answer [C]

mass		time
100 g	$\rightarrow$	$t = 0$
50 g	$\rightarrow$	$\tau_{\frac{1}{2}} = 1600$ year
25 g	$\rightarrow$	$2\tau_{\frac{1}{2}} = 3200$ year

(114) Answer [D]

$$N_P = 4N_0\left(\frac{1}{2}\right)^{\frac{t}{\tau_{\frac{1}{2}}}} = 4N_0\left(\frac{1}{2}\right)^t \text{ Similarly,}$$

$$N_Q = N_0\left(\frac{1}{2}\right)^{\frac{t}{\tau_{\frac{1}{2}}}} = N_0\left(\frac{1}{2}\right)^{\frac{t}{2}},\ N_P = N_Q$$

$$\therefore\ 4N_0\left(\frac{1}{2}\right)^t = N_0\left(\frac{1}{2}\right)^{\frac{t}{2}},\ \therefore\ 4\left(\frac{1}{2}\right)^t = \left(\frac{1}{2}\right)^{\frac{t}{2}}$$

$$\therefore\ \frac{2^2}{2^t} = \frac{1}{2^{\frac{t}{2}}} \Rightarrow 2^2 \times 2^{\frac{t}{2}} = 2^t$$

$\Rightarrow 2^{2 + \frac{t}{2}} = 2^t \Rightarrow$ Comparison of ambuse

$$2 + \frac{t}{2} = t$$

$$\therefore\ \frac{t}{2} = 2 \Rightarrow t = 4 \text{ min.}$$

4 min After $N_P = N_Q = 4N_0 \times \left(\frac{1}{2}\right)^{\frac{4}{1}} \Rightarrow \frac{N_0}{4}$

Thus, number of decayed nucleus in P is

$$= 4N_0 - \frac{N_0}{4} = \frac{15N_0}{4}$$

Number of decayed nucleus from Q is

$$= N_0 - \frac{N_0}{4} = \frac{3N_0}{4}$$

number of nucleus in R = number of decayed nucleus in P + number of decayed nucleus in Q

$$= \frac{15N_0}{4} + \frac{3N_0}{4} = \frac{18N_0}{4} = \frac{9N_0}{2}$$

(115) Answer [C]

N_0 = number of nucleus for initial X ($t = 0$)

N = number of nucleus in X at time t

$\therefore$ number of nucleus in Y at time t is $N_0 = N$

$$\therefore \frac{N}{N_0 - N} = \frac{1}{15}$$

$$\therefore \frac{N}{N_0 - N + N} = \frac{1}{15+1}$$

$$\therefore \frac{N}{N_0} = \frac{1}{16} = \left(\frac{1}{2}\right)^4 \Rightarrow n = 4$$

$$t = n\tau_{\frac{1}{2}} = 4 \times 50 = 200 \text{ year}$$

(116) Answer [C]

$$\text{Decayed part} = \frac{7}{8} \Rightarrow \text{Undecayed} \Rightarrow 1 = \frac{7}{8} = \frac{1}{8}$$

$$\frac{N}{N_0} = \frac{1}{8} = \left(\frac{1}{2}\right)^3 \Rightarrow n=3 \Rightarrow t=n\tau_{\frac{1}{2}}\ \tau_{\frac{1}{2}} = \frac{15}{3}$$

$$\therefore \tau_{\frac{1}{2}} = 5\ min.$$

(117) Answer [C]

X is decaying so, its nucleus exponentially decreases, but Y nucleus is produced from decayed X nucleus. So, rate of production of Y nucleus exponentially increases. Thus, option (C) is true.

(118) Answer [A]

$$t = \frac{\tau_{\frac{1}{2}}}{2} \Rightarrow n = \frac{t}{\tau_{\frac{1}{2}}} = \frac{\tau_{\frac{1}{2}}}{\tau_{\frac{1}{2}} \times 2} = \frac{1}{2}$$

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^{\frac{1}{2}} = \frac{1}{\sqrt{2}}$$

(119) Answer [B]

Statement 1 and 2 both are true, But there is no mention of γ -decay in statement 2, So option B is ture.

(120) Answer [B]

Statement 1 and 2 both are true, But there is no complete details of relation (of radius) in statement 2. Thus, option B is true.

(131) Answer [D]

$E_3 - E_2 = 47.2\ eV$

$$\text{from, } E_n \propto \frac{Z^2}{n^2}, -13.6\left(\frac{Z^2}{9}\right)$$

$$-\left[(-13.6)\left(\frac{Z^2}{4}\right)\right] = 47.2$$

$$\Rightarrow 13.6\left[\frac{Z^2}{4} - \frac{Z^2}{9}\right] = 47.2 \Rightarrow Z^2\left(\frac{5}{36}\right) = \frac{47.2}{13.6}$$

$$\Rightarrow Z^2 = \frac{47.2 \times 36}{5 \times 13.6} \Rightarrow Z \approx 5$$

(132) Answer [C]

$$E_4 - E_3 = -13.6\left(\frac{25}{16}\right) - \left(-13.6\left(\frac{25}{9}\right)\right) = 16.53\,eV$$

(134) Answer [B]

Ionization energy required for first orbit ($n = 1$) to $n = \infty \Rightarrow E = 13.6\ (Z)^2$

$= 13.6 \times 25 = 340\ eV$

$$\lambda = \frac{hc}{E} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{340 \times 1.6 \times 10^{-19}}$$

$$= 36.4 \times 10^{-10} = 36.4\ \mathring{A}$$

(135) Answer [B]

total energy (in first orbit) = –340 eV

Kinetic energy = + 340 eV, potential energy = $-2 \times 340 = -680$ eV, angular momentum

$$L = \frac{h}{2\pi} = \frac{6.6 \times 10^{-34}}{2 \times 3.14} = 1.05 \times 10^{-34} \text{ Js}$$

(136) Answer [B]

$$r_n = \frac{n^2}{Z} \times 0.53 \text{ Å} \Rightarrow r_n = \frac{1 \times 0.53 \text{ Å}}{5}$$

$(\because n = 1, Z = 5) = 0.106$ Å

(137) Answer [B]

6 photon means 6 lines

$$n\frac{(n-1)}{2} = 6 \Rightarrow n^2 - n = 12$$

equation satisfied with $n = 4$.

$\therefore$ principle quantum number = 4

(138) Answer [A]

$$E_4 - E_2 = 2.7 \Rightarrow \frac{E_1}{16} - \frac{E_1}{4} = 2.7$$

$\therefore E_1 = -14.4$ eV $\therefore$ Ionization energy = 14.4 eV

(139) Answer [C]

maximum energy $n = 4 \rightarrow n = 1$

$$E_{max} = \frac{E_1}{16} - \frac{E_1}{1} = \frac{-15}{16} \times 14.4 = 13.5 \; eV$$

minimum energy at $n = 4 \rightarrow n = 3$

$$E_{min} = \frac{E_1}{16} - \frac{E_1}{9} = \frac{-7}{16 \times 9} \times 14.4 = 0.79 \; eV$$

$e = 0.79$ eV and E = 13.5 eV

(140) Answer [D]

$$\frac{dN}{dt} = \alpha - \lambda N \Rightarrow \frac{dN}{\alpha - \lambda N} = dt$$

$$\therefore \int_{N_0}^{N} \frac{dN}{\alpha - \lambda N} = \int_0^t dt$$

$$\therefore \left(\frac{-1}{\lambda}\right) \left[ln(\alpha - \lambda N)\right]_{N_0}^{N} = t$$

$$\therefore ln(\alpha - \lambda N) - ln(\alpha - \lambda N_0) = -\lambda t$$

$$\therefore ln \frac{\alpha - \lambda N}{\alpha - \lambda N_0} = -\lambda t, \; \therefore \frac{\alpha - \lambda N}{\alpha - \lambda N_0} = e^{-\lambda t}$$

$$\Rightarrow \alpha - \lambda N = (\alpha - \lambda N_0) e^{-\lambda t}$$

$$\lambda N = \alpha - (\alpha - \lambda N_0) e^{-\lambda t}$$

$$\therefore N = \frac{1}{\lambda}\left[\alpha - (\alpha - \lambda N_0) e^{-\lambda t}\right]$$

(141) Answer [B]

substituting $\alpha = 2\lambda N_0$ and $t = \tau_{\frac{1}{2}}$.

$$N = \frac{1}{\lambda}\left[2\lambda N_0 - (2\lambda N_0 - \lambda N_0)e^{-\lambda \tau_{\frac{1}{2}}}\right]$$

$$\therefore N = \frac{1}{\lambda}\left[2\lambda N_0 - \lambda N_0 e^{-\lambda \times \frac{ln 2}{\lambda}}\right]$$

$$\therefore N = \frac{1}{\lambda}\left[2\lambda N_0 - \frac{\lambda N_0}{2}\right]$$

$$\left(e^{-\ln 2} = e^{-0.693} = \frac{1}{2}\right), \; \therefore N = \frac{3}{2} N_0$$

(142) Answer [D]

$\alpha = 2\lambda N_0$ and $t \rightarrow \infty$ substitute in equation of question : 140, $(\alpha - \lambda N_0)\, e^{-\lambda \infty} = 0$

$$\therefore N = \frac{\alpha}{\lambda} = \frac{2\lambda N_0}{\lambda} = 2N_0$$

(143) Answer [A]

substituting $r = \dfrac{n^2 h^2 \epsilon_0}{\pi m e^2 Z}$ in $v = \dfrac{nh}{2\pi m r}$

$$v = \frac{e^2}{2h\epsilon_0} \frac{Z}{n} = \frac{e^2}{2h\epsilon_0 C} \frac{cZ}{n} = \frac{1}{137} \frac{cZ}{n}$$

$$v = \frac{c}{137} \times \frac{1}{1} = \frac{3 \times 10^8}{137} = 2.2 \times 10^6 \text{ ms}^{-1}$$

•

19 Electronic Deviced and Communication

(1) Answer [D]

$E = \frac{V}{d} = \frac{V}{l} = \frac{2}{0.1} = 20\ Vm^{-1}$, $A = 10^{-4}\ m^2$

$\mu_e = \frac{V_d}{E} \Rightarrow V_d = \mu_e E = 0.14 \times 20 = 2.8\ ms^{-1}$

$I_e = neAV_d$

$= 1.5 \times 10^{16} \times 1.6 \times 10^{-19} \times 10^{-4} \times 2.8$

$I_e = 6.72 \times 10^{-7}$ A

(2) Answer [B]

$n_e = \frac{\sigma}{\mu_e e} = \frac{6400}{0.133 \times 1.6 \times 10^{-19}}$

$= 3.0 \times 10^{23}\ m^{-3}$

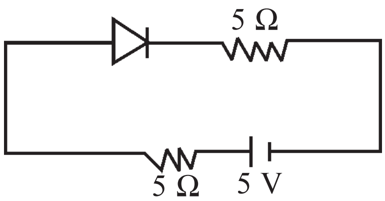
(3) Answer [C]

$n_i^2 = n_e n_h \Rightarrow n_e = \frac{n_i^2}{n_h}$

$= \frac{(1.5 \times 10^{16})^2}{4.5 \times 10^{23}} = 5 \times 10^8\ m^{-3}$

(4) Answer [C]

Diode B is in reverse bias in given circuit. Thus, equivalent circuit is as follow :

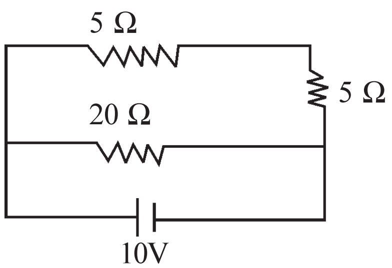


V = IR. 5 = I (5 + 5)

$5 = I(10) \Rightarrow I = \frac{1}{2}$ A = 0.5 A

(5) Answer [C]

In given circuit D_1 is in reverse bias and D_2, D_3 are in forward bias so, equivalent circuit is as follow.

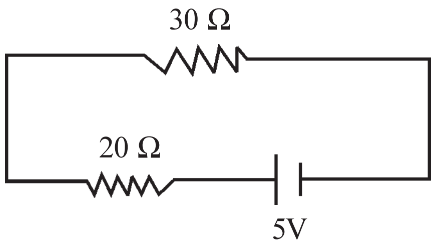


$\therefore R = \frac{(5+5) \times 20}{5+5+20} = \frac{200}{30} = \frac{20}{3}\ \Omega$

$V = IR \Rightarrow I = \frac{V}{R} = \frac{10}{20} \times 3 = \frac{30}{20}$

$I = 1.5$ A

(6) Answer [B]



D_2 diode is in forward bias while D_1 diode is in reverse bias, as circuit shown in figure. So, branch of D_1 diode has infinite resistance while taking resistance of D_2

$\therefore$ current in the circuit is, (According V = IR)

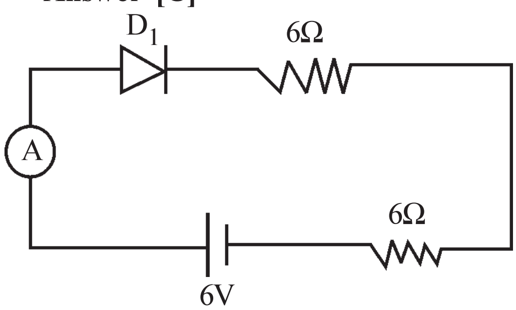
$5 = I(30 + 20)$, $I = \frac{5}{50}$ A

(7) Answer [C]

$V_{rms} = \frac{V_0}{\sqrt{2}} \Rightarrow V_0 = \sqrt{2}\ V_{rms} = \sqrt{2} \times 220$

$= 1.4142 \times 220 = 311.1$ V

(8) Answer [C]



In given circuit diode D_2 is in reverse bias while diode D_1 is in forward bias.

$\therefore$ according to $V = IR$, $6 = I(6 + 6)$

$I = \frac{6}{12} = \frac{1}{2}$ A

(9) Answer [B]

Here diode D is in reverse bias. So circuit is open circuit. So, current is not flowing, According to $V = IR$, $V = 0 \times 2 = 0$.

(10) Answer [C]

$V_{AB} = V_R + V_Z \therefore 15 = V_R + 6$ V

$\therefore V_R = 15 - 6 = 9$ V

(11) Answer [D]

$V = V_{LED} + V_R$, V = 6 V

$6 = 2 + I$ R, $V_{LED} = 2V$

$IR = 4, R = \frac{4}{1} = \frac{4}{10 \times 10^{-3}} = \frac{4000}{10} = 400\Omega$

(12) Answer [C]

$E_g = \frac{hc}{\lambda} = \frac{6.62 \times 10^{-34} \times 3 \times 10^8}{1700 \times 10^{-9} \times 1.6 \times 10^{-19}}$ eV

= 0.73 eV

(13) Answer [C]

Here diode D_2 is in reverse bias in given circuit so current will not flow. However, taking zero resistance of D_1 diode,

$E = IR \Rightarrow 20 = I \times 2000$

$I = \frac{20}{2000} = \frac{1}{100} = 10$ *m*A

(14) Answer [C]

(i) $V_A = -10$ V, $V_B = -5$ V

$R_{AB} = R + \frac{R}{4} + \frac{R}{4} = \frac{3}{2}$ R

(ii) $V_A = -5$ V, $V_B = -10$ V

$R_{AB} = \frac{R}{4} + \frac{R}{2} + \frac{R}{4} = R$

(iii) $V_A = -4$ V, $V_B = -12$ V

$R_{AB} = \frac{R}{4} + \frac{R}{2} + \frac{R}{4} = R$

(C) (ii) = (iii) < (i)

(16) Answer [C]

With decreasing temperature, resistance of metal decreases. Thus, Resistance of Aluminum decrease when resistance of silicon increase.

(17) Answer [B]

According to $V_{rms} = \frac{Vo}{\sqrt{2}}$, Vo is output voltage. V_{rms} is input. Here output is DC voltage.

$\therefore Vo = \sqrt{2}\ V_{rms}$

(18) Answer [B]

In A, C, D, N-type semiconductor is at high potential and P-type semiconductor is at Low potenctial.

$\therefore$ A, C, D diode in reverse bias while B diode is in forward bias.

(19) Answer [A]

(i) $g_m = \frac{A_V}{R_L} = \frac{270}{18 \times 10^3}$

$= 1.5 \times 10^{-2} = 0.015$ mho

(ii) $\beta = \frac{A_V r_i}{R_L} = \frac{270 \times 3 \times 10^3}{18 \times 10^3}$

$= 0.015 \times 3 \times 10^3 = 45$

(20) Answer [C]

(i) $I_C = 96\ \%\ I_E$

$\therefore I_C = 0.96\ I_E$; $I_C = 24$ *m*A

$\therefore I_E = \frac{24}{0.96} = 25$ *m*A

(ii) $\alpha = \frac{I_C}{I_E} = \frac{24}{25} = 0.96$

(21) Answer [D]

(i) $r_i = \frac{\Delta V_{BE}}{\Delta I_B} = \frac{175 \times 10^{-3}}{250 \times 10^{-6}} = 0.7 \times 10^3 = 0.7\,k\Omega$

(ii) $A_V = \frac{\Delta V_{CE}}{\Delta V_{BE}} = \frac{5}{175 \times 10^{-3}}$

$= 0.0286 \times 10^3 = 28.8 \Rightarrow A_V = 28.8$

(22) Answer [B]

$g_m = \frac{\Delta I_C}{\Delta V_{BE}} = \frac{5 \times 10^{-3}}{200 \times 10^{-3}} = 0.025$ *mho*

$A_V = \frac{A_P}{A_i} = \frac{5000}{100} = 50$

$A_V = g_m R_L, \therefore R_L = \frac{A_V}{g_m}$ ...(1)

$R_L = \frac{50}{0.025} = 2000\Omega$

(23) Answer [C]

(i) For input circuit $15 - 200 \times 10^3\ I_B = 0$

$\therefore 200 \times 10^{+3}\ I_B = 15, \therefore I_B = \frac{15}{200 \times 10^{+3}}$

$\therefore$ $I_B = 7.5 \times 10^{-5}$ A

$\therefore$ $I_B = 75 \times 10^{-6}$ A = 75 µA

(ii) For output circuit : $15 - 3 \times 10^3 I_C = 0$

$3 \times 10^{+3} I_C = 15$

$$\therefore I_C = \frac{15}{3 \times 10^{+3}} = 5 \times 10^{-3} \text{ A} = 5\ m\text{A}$$

(iii) $\beta = \frac{I_C}{I_B} = \frac{5 \times 10^{-3}}{7.5 \times 10^{-5}}$, $\therefore$ $B = 0.666 \times 10^2$

$\therefore$ B = 66.6

(24) Answer [B]

(i) $A_V = \frac{A_P}{A_i} = \frac{1000}{150} = \frac{100}{15}$ ...(i)

$$A_V = Ai\ \frac{R_L}{r_i}$$

$$\therefore R_L = \frac{A_V}{A_i}\ ri = \frac{100}{15} \times \frac{500}{150} = 22.22$$

$\therefore$ $R_L = 22.22\ \Omega$

(25) Answer [D]

$$\beta = \frac{\alpha}{1-\alpha} = \frac{0.98}{1-0.98} = 49$$

(i) $A_V = \beta\ \frac{R_L}{r_i} = \frac{49 \times 5 \times 10^3}{70} = 3500$

(ii) $A_P = \beta \times A_V = 49 \times 3500 = 1{,}71{,}500$

(26) Answer [A]

$$\Delta I_B = \frac{\Delta V_{BE}}{r_i} = \frac{0.01}{1000} = 10^{-5} \text{ A},\ B = \frac{\Delta I_C}{\Delta I_B}$$

$\therefore$ $\Delta I_C = \beta \times \Delta I_B = 50 \times 10^{-5}$ A

= 500×10^{-6} A = 500 µA

(27) Answer [C]

$$A_V = \frac{R_L}{r_i}\ \alpha,\ \therefore A_V = \frac{24}{3} \times 0.6 = 4.8$$

(28) Answer [D]

$$\alpha = \frac{I_C}{I_E},\ \therefore 0.50 = \frac{I_C}{I_E}\ \ \therefore I_C = 3.5\ m\text{A}$$

$I_B = I_E - I_C = 7 - 3.5 = 3.5\ m$A

(29) Answer [B]

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$= \frac{1}{2\pi\sqrt{\frac{20}{\pi^2} \times 10^{-3} \times 0.02 \times 10^{-6}}}$$

$= 0.25 \times 10^5 = 25 \times 10^3 = 25$ kHz

(30) Answer [A]

Gate 1 is NOT gate and Gate-2 is AND gate. So, output of NOT gate is $B = \overline{A}$, gate-2 is AND gate so $Y = A \cdot B = A \cdot \overline{A} =$ 0

(31) Answer [D]

Truth table

A	B	A + B	$Y = \overline{A + B}$
0	0	0	1
1	0	1	0
0	1	1	0
1	1	1	0

$\therefore$ NOR gate

(32) Answer [A]

Lower NOT gate reversing input and gives zero. output of G_3 is 1. From second NOT gate, input of G_1 is 1, output of G_1 is 1 so output of G_2 is 0.

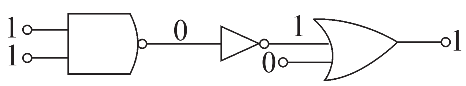
(33) Answer [A]

$Y' = \overline{A \cdot B}$, $Y = \overline{Y'} = \overline{\overline{A \cdot B}} = A \cdot B$

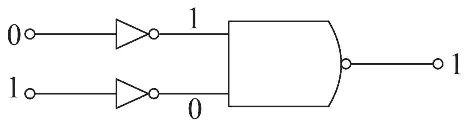
= AND gate

(34) Answer [C]

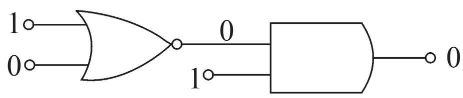
(A)



(B)



(C)



output of A, B, C are 4 1, 1, 0...

(35) Answer [B]

$Y' = \overline{A \cdot B}$, $Y = \overline{Y'} = \overline{\overline{A \cdot B}} = A \cdot B$

(36) **Answer [D]**

$Y' = \overline{A + B}$, $Y = Y' = \overline{\overline{A + B}} = A + B$

(37) **Answer [C]**

Here output of NAND gate is $\overline{A \cdot B}$.

However, this output $\overline{A \cdot B}$ and B are inputs for OR gate. So output $Y = \overline{A \cdot B} + B$

(38) **Answer [A]**

Here A and B are inputs of AND gate. So, output of AND gate is A · B. Hewever, this output is input for NOT gate.

$\therefore$ output $X = \overline{A \cdot B}$

(39) **Answer [D]**

output of G_1 is $\overline{A}$ and output of G_2 is $\overline{B}$ are inputs for NOR gate. so output of NOR gate is $\overline{\overline{A} + \overline{B}}$. So, output is $Y = \overline{\overline{A + B}} = \overline{A \cdot B}$. Which is Boolean equation for NAND gate.

(42) **Answer [C]**

Current flow because of forward bias.

(43) **Answer [B]**

Diffusion of constituent of ions

(44) **Answer [B]**

$$\rightarrow \alpha = \frac{I_C}{I_E} = \frac{I_E - I_B}{I_E}$$

$$\therefore 0.95 = \frac{10 - I_B}{10} \Rightarrow I_B = 0.5\ mA$$

(45) **Answer [C]**

$$\rightarrow A_V = \frac{R_O}{R_i} \times \alpha \Rightarrow A_V = \frac{32}{4} \times 0.5$$

$\therefore A_V = 4$

(46) **Answer [D]**

$$\rightarrow \alpha = \frac{\Delta I_C}{\Delta I_E} \Rightarrow 0.95 = \frac{\Delta I_C}{100}$$

$\Rightarrow \Delta I_C = 95\ mA$

(49) **Answer [B]**

$A = \pi d_T^2 = \pi 2h_T R$, $A \alpha h_T$

$\therefore$ If A becomes double than h_T becomes double.

(50) **Answer [B]**

$$A = \pi d_T^2 = \pi \left(\sqrt{2h_T R}\right)^2 = 2\pi h_T R$$

$= 2 \times 3.14 \times 200 \times 6400 \times 10^3$

$= 803.84 \times 10^7\ m^2$

population density $= 4000\ km^{-2} = 4 \times 10^{-3}\ m^{-2}$

number of people = A × population density

$= 803.84 \times 10^7 \times 4 \times 10^{-3} = 3215.36 \times 10^4$

$\approx 3.2 \times 10^7$

(51) **Answer [A]**

$$d_m = \sqrt{2h_T R} + \sqrt{2h_R R}$$

$$\therefore 45.5 = \sqrt{2h_T 6400} + \sqrt{2 \times 32 \times 10^{-3} \times 6400}$$

$$\therefore 45.5 = \sqrt{2h_T 6400} + 64 \times 0.3$$

$$\therefore \sqrt{2h_T 6400} = 45.5 - 19.2 = 26.3$$

$$\therefore h_T = \frac{(26.3)^2}{2 \times 6400} = 0.054\ km = 50\ m$$

(52) **Answer [B]**

$$E_C = \frac{E_{max} + E_{min}}{2},\ 8 = \frac{E_{max} + E_{min}}{2}$$

$\therefore E_{max} + E_{min} = 16$ ...(1)

Modulation constant $= \dfrac{E_{max} - E_{min}}{E_{max} + E_{min}}$

$0.25 = \dfrac{E_{max} - E_{min}}{16}$, $E_{max} - E_{min} = 4$ ...(2)

From equation (1), (2) $E_{max} = 10$ V

From equation (1), (2) $E_{min} = 6$ V

(53) **Answer [A]**

$f_C = 9\sqrt{N_{max}}$ Here, assume that f_{C_1} is critical frequency of noon and f_{C_2} for morning.

So, $f_C \propto \sqrt{N_{max}}$

$$\frac{f_{C_1}}{f_{C_2}} = \frac{\sqrt{N_{max_1}}}{\sqrt{N_{max2}}} = \sqrt{\frac{3 \times 10^{10}}{10^{10}}}$$

$$\frac{f_{C_1}}{f_{C_2}} = \frac{\sqrt{3}}{1} = 1.732$$

(54) Answer [A]

$f_C = 9\sqrt{N_{max}}$ $\therefore f_C \propto \sqrt{N_{max}}$

$\Rightarrow f_C^2 \propto N_{max}$

$$\frac{f_{C_1}^2}{N_{1max}} : \frac{f_{C_2}^2}{N_{2max}} : \frac{f_{C_3}^2}{N_{3max}}$$

$= 2 \quad : 5 \quad : 8$

$f_{C_1} : f_{C_2} : f_3 = \sqrt{2} : \sqrt{5} : \sqrt{8}$

$f_{C_1} : f_{C_2} : f_{C_3} = \sqrt{2}\ \sqrt{2} : \sqrt{5}\ \sqrt{2} : \sqrt{8}\ \sqrt{2}$

$= 2 : \sqrt{10} : 4$

$\approx 2 : 3 : 4$

(55) Answer [D]

$$Z = \sqrt{\frac{L}{C}} = \sqrt{\frac{0.80\times10^{-6}}{20\times10^{-12}}} = \sqrt{\frac{8}{200}\times10^{6}}$$

$= 2 \times 10^2\ \Omega = 200\ \Omega$

(56) Answer [B]

$$f = \frac{c}{\lambda} \Rightarrow f_3 = \frac{c}{\lambda_3} = f_m = \frac{c}{\lambda m}$$

$\therefore \lambda_m > \lambda_s \Rightarrow f_m < f_s$

However $f_m = \dfrac{1}{2\pi\sqrt{L_m c}}$ & $f_s = \dfrac{1}{2\pi\sqrt{L_s C}}$

$$\therefore \frac{f_m}{f_s} = \sqrt{\frac{L_s}{L_m}} \Rightarrow L_S < L_m$$

(57) Answer [D]

(i) $A_i = \alpha = 0.95$

$$\therefore A_V = \alpha\frac{R_o}{R_i} = 0.95 \times \frac{2000}{200} = 9.5$$

(58) Answer [C]

$A_P = A_V \times A_i = 9.5 \times 0.95 = 9.025$

(59) Answer [D]

$\Delta V_{BE} = 10\ mV = 10^{-2}$ V, $r_i = 1000\ \Omega$

$$\Delta I_B = \frac{\Delta V_{BE}}{r_i} = \frac{10^{-2}}{10^3} = 10^{-5}\text{ A}$$

$$\beta = \frac{\Delta I_C}{\Delta I_B} \Rightarrow \Delta I_C = B\ \Delta I_B = 100 \times 10^{-5}$$

$= 10^{-3}$ A

So, output voltage is $\Delta V_0 = \Delta I_C \times Ro = 5$ V

(60) Answer [A]

$$A_P = \frac{\beta^2 R_L}{r_i} = \frac{100\times100\times5000}{1000} = 50{,}000$$

(61) Answer [C]

$$\alpha = 25/26,\ \beta = \frac{\alpha}{1-\alpha} = \frac{25/26}{1-25/26} = 25$$

$V_{CC} = 8V$, $V_0 = 0.8$ V, $V_{CE} = V_{CC} - V_0$

$= 8 \times 0.8 = 7.2$ V

(62) Answer [B]

$$I_C = \frac{V_0}{R_0} = \frac{0.8}{800} = 10^{-3}\text{ A},$$

$$\alpha = \frac{I_C}{I_E} \Rightarrow I_E = \frac{10^{-3}}{25/26} = \frac{26}{25}\times10^{-3}\text{ A}$$

$$I_B = I_E - I_C = \frac{26}{25}\times10^{-3} - 10^{-3} = 4\times10^{-5}\text{ A}$$

$R_i = 100\ \Omega \Rightarrow V_i = I_B R_i$

$= 4 \times 10^{-5} \times 10^2 = 4 \times 10^{-3}$ V

$$A_V = \frac{V_o}{V_i} = \frac{0.8}{4\times10^{-3}} = 2\times10^2 = 200$$

$A_P = \beta A_V = 25 \times 200 = 5000$

(63) Answer [D]

$$m = \frac{E_S}{E_C} = \frac{20}{40} = 50\%$$

(64) Answer [A]

Carrier wave = 70 MHz = 70000 kHz

Audio wave = 2KHz

USB $= f_c + f_s = 70002$ kHz

LSB $= f_c - f_s = 69{,}998$ kHz

●