Hints & Solutions
Chemistry
PART – A

1. A (Concept Code: C120608)

Sol. For I. $i = 1 - \alpha + \frac{\alpha}{2}$

$1 - \frac{\alpha}{2} = 1 - \frac{1}{2} = 0.5$

π = iCRT = 0.5 $\times$ 2RT

II. i = 1 + α = 2

π = 2 $\times$ 0.5 $\times$ RT

So both are isotonic

2. C (Concept Code: C111903)

Sol. $\Delta H_{neutralization} = \Delta H_{n(SA/SB)} + \Delta H_i$

$-13.2 = -13.7 + \Delta H_{ionization}$

$\Delta H_{ionization} = 0.5$ or 5×10^{-1}

3. D (Concept Code: C120207)

Sol. $HgCl_2$ is covalent halide.

4. C (Concept Code: C120205)

Sol. AgBr shows both Schottky and Frenkel defect.

5. ABCD (Concept Code: C120601)

Sol. based on Raoult's law $P_T = P_A^0 X_A^0 + P_B^0 X_B^0$

6. ABC (Concept Code: C120504)

Sol. Nernst equation for half-cell reaction

$M^{n+} + ne^- \longrightarrow M$

$$E_{red} = E_{red}^o - \frac{2.303RT}{nF} \log \frac{1}{\left[M^{n+}\right]}$$

On addition of CN^- (AgCN ppt and Ag^+ conc. dec)

7. ABCD (Concept Code: C120308)

Sol. Fact based.

8. ACD (Concept Code: C110504)

Sol. Except B(Strong base + salt of strong acid & strong base) all are buffer (weak acid + salt of weak acid & strong base).

9. ABC (Concept Code: C120201)

Sol. $(A)\ 3HgS + 6HCl + 2HNO_3 \longrightarrow 3HgCl_2 + 3S + 4H_2$

$(B)\ Hg + Cl_2 \longrightarrow HgCl_2$

$(C)\ Hg_2Cl_2 + Hg \longrightarrow 2HgCl_2$

10. AC (Concept Code: C113616)

Sol. Si has vacant d-orbitals and lone pairs over nitrogen is involved in back bonding($d\pi$ - $p\pi$).

PART – B

1. **A → PQT** **B → PST** **C → RS** **D → P**
(Concept Code: C124602, C121402, C122833)

2. **A → PR** **B → Q** **C → Q** **D → S** (Concept Code: C123201)

Sol. A → PR : for reversible isothermal process

$W = 2.303nRT \log \frac{V_2}{V_1} = 2.303\ nRT\log \frac{P_1}{P_2}$

B → Q : for adiabatic process PV^{γ} = constant

C → Q : $W = \frac{nR}{\gamma - 1}(T_2 - T_1)$ for adiabatic process also PV^{γ} = constant

D → S : Irrversible isothermal process

3. **A → Q** **B → R** **C → S** **D → Q** (Concept Code: C120609)

Sol. A → $i = 1 + \alpha = 2 \Rightarrow \Delta T_b = iK_b = 2K_b$
B → $i = 1 + 2 \times 0.75 = 2.5$ $\Delta T_b = 2.5\ K_b$
C → $i = 1 + 4 \times 0.5 = 3$ $\Delta T_b = 3\ K_b$
D → $i = 1 + 4 \times 0.25 = 2$ $\Delta T_b = 2\ K_b$

4. **A → T** **B → R** **C → PS** **D→PQ** (Concept Code:C120201)

Sol. A → T
B → (These dissolve as soluble nitrate in 50% HNO_3)
C → (50% HNO_3)

$$\left.\begin{array}{l} Pb^{2+} + I^- \longrightarrow PbI_2 \\ Pb^{2+} + CrO_4^{2-} \longrightarrow PbCrO_4 \end{array}\right\} \text{Yellow}$$

D → $2BiCl_3 + 3Na_2SnO_2 + 6NaOH \longrightarrow 2Bi + 3Na_2SnO_2 + 6NaCl + 3H_2O$

$Bi^{3+} + 3KI \longrightarrow \underset{\text{Black}}{BiI_3}$

PART – C

1. 0 (Concept Code: C123204)

Sol. For isothermal reversible process

$$\Delta S_{universe} = \Delta S_{system} + \Delta S_{surrounding} = \frac{q_{rev}}{T} - \frac{q_{rev}}{T} = 0$$

2. 2 (Concept Code: C120504)

Sol. $E_{Cell} = \frac{0.0591}{n}\log\frac{0.1\times 10^{-x}}{10^{-11}}$

$0.48 = \frac{0.0591}{1}\log 10^{10-x}$

Solving x = 2

3. 6 (Concept Code: C120201)

Sol. Black coloured sulphides (PbS, CuS, HgS & Ag_2S, NiS, CoS)

4. 3 (Concept Code: C120308)

Sol. C.No. 12, No. of atoms = 4

$\text{Ratio} = \frac{12}{4} = 3$

5. 3 (Concept Code: C121701)

Sol. Buna-S, Nylon-2-Nylon-6, Bakelite are co-polymers

6. 2 (Concept Code: C120609)

Sol. $\pi = iCRT$

$2.69 = i \times 0.1 \times 0.082 \times 298$

$i = 1.1$

For monobasic acid $HA \rightleftharpoons H^+ + A^-$

$i = 1 + \alpha$

$\alpha = 0.1$

So $[H^+] = C\alpha = 0.1 \times 0.1 = 10^{-2}$

$\therefore$ pH = $-\log(10^{-2}) = 2$

Mathematics
PART – A

1. Any point on the given parabola is $(t^2, 2t)$. The equation of the tangent at (1, 2) is $x - y + 1 = 0$.

The image (h, k) of the point $(t^2, 2t)$ in $x - y + 1 = 0$ is given by $\frac{h - t^2}{1} = \frac{k - 2t}{-1} = \frac{-2(t^2 - 2t + 1)}{1+1}$

$\therefore \quad h = t^2 - t^2 + 2t - 1 = 2t - 1$

and $\quad k = 2t + t^2 - 2t + 1 = t^2 + 1$

Eliminating t from h = 2t – 1 and $k = t^2 + 1$

We get, $(h+1)^2 = 4(k-1)$

The required equation of reflection is $(x+1)^2 = 4(y-1)$

2. Let $\Delta(x) = A + Bx + Cx^2 + Dx^3 + ...$

$$\therefore \Delta(0) = \begin{vmatrix} 0 & 1 & 0 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{vmatrix} = 0 \Rightarrow A = 0$$

$$\Delta'(0) = \begin{vmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{vmatrix} + \begin{vmatrix} 0 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 0 \end{vmatrix} + \begin{vmatrix} 0 & 1 & 0 \\ 0 & 1 & 0 \\ 0 & 1 & 0 \end{vmatrix} = 1$$

$\therefore \quad B = 1$

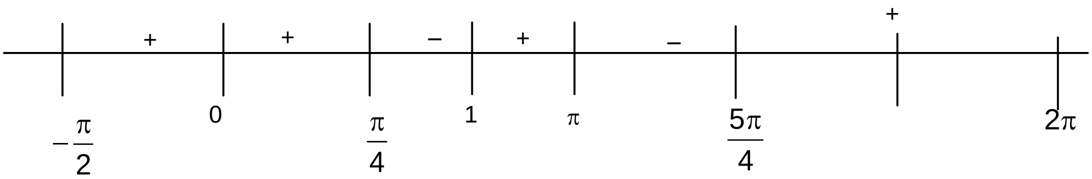
$\Rightarrow$ Then $\Delta(x) = x + Cx^2 + Dx^3 + ...$

$\therefore \Delta(x)$ is divisible by x.

3. By property, $\text{adj}\, A^T - (\text{adj}\, A)^T = O^*$ null matrix.

4. $f'(x) = (e^x - 1)(x - 1)(\sin x - \cos x)\sin x$

Sign scheme of $f'(x)$ is



Clearly, $f(x)$ is increasing in $\left(-\frac{\pi}{2}, \frac{\pi}{4}\right) \cup (1, \pi) \cup \left(\frac{5\pi}{4}, 2\pi\right)$ and decreasing in $\left(\frac{\pi}{4}, 1\right) \cup \left(\pi, \frac{5\pi}{4}\right)$.

5. We have $\left[\vec{p}\ \ \vec{q}\ \ \vec{r}\right] = \frac{1}{\left[\vec{a}\ \ \vec{b}\ \ \vec{c}\right]}$

Therefore, $\left[\vec{p}\ \ \vec{q}\ \ \vec{r}\right] > 0$

$(a) x > 0, x[\vec{a}\ \ \vec{b}\ \ \vec{c}] + \frac{[\vec{p}\ \ \vec{q}\ \ \vec{r}]}{x} \geq 2$ (Using $AM \geq GM$)

(b) similarly, use $AM \geq GM$

6. We have,

$D = (b-c)^2 - 4a(a-b-c) > 0$

$\Rightarrow b^2 + c^2 - 2bc - 4a^2 + 4ab + 4ac > 0$

$\Rightarrow c^2 + (4a - 2b)c - 4a^2 + 4ab + b^2 > 0$ for all $c \in R$

Discriminant of the above expression in c must be negative.

Hence, $(4a-2b)^2 - 4(-4a^2 + 4ab + b^2) < 0$

$\Rightarrow 4a^2 - 4ab + b^2 + 4a^2 - 4ab - b^2 < 0$

$\Rightarrow a(a-b) < 0$

$\Rightarrow a < 0$ and $a - b > 0$ or $a > 0$ and $a - b < 0$

$\Rightarrow b < a < 0$ or $b > a > 0$

7. $\because 2\cos\theta = x + \frac{1}{x}$

$x^2 - 2x\cos\theta + 1 = 0$

$\therefore\ x = \frac{2\cos\theta \pm \sqrt{(4\cos^2\theta - 4)}}{2} = \cos\theta \pm i\sin\theta$

Let $x = e^{i\theta}$

Similarly $y = e^{i\phi}$

Alternate (A) :

$\frac{x}{y} + \frac{y}{x} = e^{i(\theta-\phi)} + e^{-i(\theta-\phi)}$

$= 2\cos(\theta - \phi)$

Alternate (B) :

$x^m y^n + \frac{1}{x^m y^n} = e^{i(m\theta+n\phi)} + e^{-i(m\theta+n\phi)}$

$= 2\cos(m\theta + n\phi)$

Alternate (C):

$\frac{x^m}{y^n} + \frac{y^n}{x^m} = e^{i(m\theta-n\phi)} + e^{-i(m\theta-n\phi)}$

$= 2\cos(m\theta - n\phi)$

Alternate (D):

$xy + \frac{1}{xy} = e^{i(\theta+\phi)} + e^{-i(\theta+\phi)} = 2\cos(\theta+\phi)$

8. Let $\Delta = \begin{vmatrix} \sqrt{6} & 2i & 3+\sqrt{6} \\ \sqrt{12} & \sqrt{3}+\sqrt{8}\,i & 3\sqrt{2}+\sqrt{6}\,i \\ \sqrt{18} & \sqrt{2}+\sqrt{12}\,i & \sqrt{27}+2i \end{vmatrix}$

Applying $R_2 \to R_2 - \sqrt{2}R_1$ and $R_3 \to R_3 - \sqrt{3}R_1$

$\therefore \Delta = \begin{vmatrix} \sqrt{6} & 2i & 3+\sqrt{6} \\ 0 & \sqrt{3} & i\sqrt{6}-\sqrt{12} \\ 0 & \sqrt{2} & 2i-\sqrt{18} \end{vmatrix} = \sqrt{6}(-\sqrt{6})$

= –6 (real and rational)

9. Since the greatest integer function is discontinuous at integral values of x, then for a given limit to exist both left and right hand limit must be equal.

L.H.L = $\lim_{x\to 1^-}\left(2-x+a[x-1]+a[x-1]+b[1+x]\right)$

$=2-1+a(-1)+b(1)=1-a+b$

R.H.L. = $\lim_{x\to 1^+}\left(2-x+a[x-1]+b[1+x]\right)$

$=2-1+a(0)+b(2)=1+2b$

On comparing we have – a = b

10. Use basic properties of log.

PART – B

1. $F'(x)=(x-1)(x-2)^2$ and F is continuously differentiable throughout R. $F'(x)=0$

$\Rightarrow x=1,\ x=2$. For $x<1, F'(x)<0$ and for $x>1, F'(x)>0$.

Hence x = 1 is point of minimum. Moreover F increases on $(1, \infty)$ and decreases on $(-\infty, -1)$. At x = 2, F' (x) does not change sign, so there is no extremum at x = 2. The minimum value

$F(1)=\int_0^1 (t-1)(t-2)^2\,dt=\int_{-1}^0 t(t-1)^2\,dt$

$=\dfrac{-17}{12}\in(-4, -1)$

2. Putting $V=\dfrac{y}{x}$, we obtain $V+x\dfrac{dV}{dx}=V+\tan V$

$\Rightarrow \dfrac{dx}{x}=\cot V\ dV$

Integrating $\log x=\log\sin V+\text{Const.}$

$\Rightarrow x=C\ \sin\dfrac{y}{x}$

Putting $x=1, y=\dfrac{\pi}{2}$, we have C = 1

Thus, $x=\sin\left(\dfrac{y}{x}\right)\Rightarrow y=x\sin^{-1}x=f(x)$

f is defined on $[-1, 1]$ and the range of f is $\left[\dfrac{-\pi}{2}, \dfrac{\pi}{2}\right]$.

Clearly, f is continuous on its domain which is $[-1, 1]$ and $f(x)\le\dfrac{\pi}{2}<2$ for all $x\in[-1,1]$

3.

(A) $|\vec{a}+\vec{b}|=|\vec{a}+2\vec{b}|$

$\Rightarrow a^2+b^2+2\vec{a}.\vec{b}=a^2+4b^2+4\vec{a}.\vec{b}$

$\Rightarrow 2\vec{a}.\vec{b}=-3b^2<0$

Hence, angle between $\vec{a}$ and $\vec{b}$ is obtuse.

(B) $|\vec{a}+\vec{b}|=|\vec{a}-2\vec{b}|$

$\Rightarrow\ a^2+b^2+2\vec{a}.\vec{b}=a^2+4b^2-4\vec{a}.\vec{b}$

$\Rightarrow\ 6\vec{a}.\vec{b}=3b^2$

Hence, angle between $\vec{a}$ and $\vec{b}$ is acute.

(C) $|\vec{a}+\vec{b}|=|\vec{a}-\vec{b}|$

$\Rightarrow \vec{a}.\vec{b}=0$

$\Rightarrow$ $\vec{a}$ is perpendicular to $\vec{b}$.

(D) $\vec{c}\times\left(\vec{a}\times\vec{b}\right)$ lies in the plane of vector $\vec{a}$ and $\vec{b}$. A vector perpendicular to this plane is parallel to $\vec{a}\times\vec{b}$. Hence, angle is 0^o.

4. Let X = the number of steps taken in the forward direction, then $X \sim B(n, p)$ with n = 11, p = 0.4.

$p_1 = P(X=5)+P(X=6)$

$= {}^{11}C_5\, p^5q^6 + {}^{11}C_6\, p^6q^5$

$= {}^{11}C_5\,(pq)^5 = {}^{11}C_5\,(0.24)^5$

$p_3 = P(X=4)+P(X=7)$

$= {}^{11}C_4\, p^4q^7 + {}^{11}C_7\, p^7q^4$

$= {}^{11}C_4\,(pq)^4\,(1-3pq)$

$= {}^{11}C_4\,(0.24)^4\,(0.28)$

$p_{10} = 0$ and $p_{11} = P(X=0)+P(X=11)$

$=(0.4)^{11}+(0.6)^{11}$

PART – C

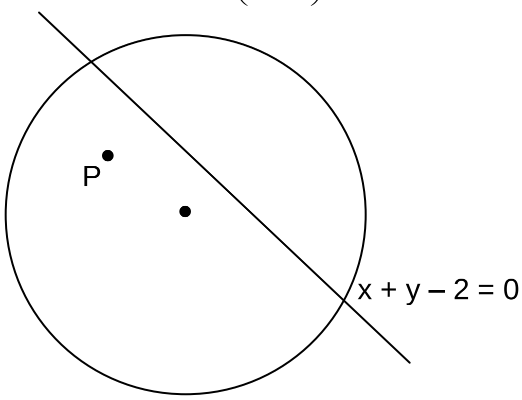
1. Let $\dfrac{3iz_2}{5z_1} = k$, where $k \in R$

$\Rightarrow \dfrac{z_2}{z_1} = -\dfrac{5i}{3}k = ai\,(\text{say})$

Now, $5\left|\dfrac{3z_1+7z_2}{3z_1-7z_2}\right| = 5\left|\dfrac{3+7ai}{3-7ai}\right| = 5$

2. The given circle $S(x,y) \equiv x^2+y^2-x-y-6=0$ ……….(i)

has centre at $C \equiv \left(\dfrac{1}{2}, \dfrac{1}{2}\right)$



According to the required conditions, the given point $P(\alpha-1, \alpha+1)$ must lie inside the given circle,

i.e. $S(\alpha-1, \alpha+1) < 0$

$\Rightarrow \quad (\alpha-1)^2+(\alpha+1)^2-(\alpha-1)-(\alpha+1)-6<0$

$\Rightarrow \quad \alpha^2-\alpha-2<0$, i.e., $(\alpha-2)(\alpha+1)<0$

$\Rightarrow \quad -1<\alpha<2$ (Using sign scheme from algebra) ………..(ii)

$L(x,y) \equiv x+y-2=0$ ………..(iii)

Since $L\left(\dfrac{1}{2}, \dfrac{1}{2}\right) = \dfrac{1}{2}+\dfrac{1}{2}-2<0$,

i.e. , $\alpha<1$ …………(iv)

Inequalities (ii) and (iv) together give the perimissible values of α as $-1<\alpha<1$

3. Let $f(x)+\frac{a}{30}=0$ where $f(x)=\frac{x^3-6x^2+11x-6}{x^3+x^2-10x+8}$

$=\frac{(x-1)(x-2)(x-3)}{(x-1)(x-2)(x+4)}$

$=\frac{(x-3)}{x+4}, x\neq 1,2,-4$

Range of $f(x)=R-\left\{1,-\frac{2}{5},-\frac{1}{6}\right\}$

So, the equation does not have solution if

$\frac{a}{30}=-1,\frac{2}{5},\frac{1}{6}$

$\therefore$ a = – 30, 12, 5

4. Let $I=\int\frac{(5x^4+4x^5)}{(x^5+x+1)^2}dx$

Dividing above and below by x^{10}, we get

$I=\int\frac{\left(\frac{5}{x^6}+\frac{4}{x^5}\right)dx}{\left(1+\frac{1}{x^4}+\frac{1}{x^5}\right)^2}$

Putting $1+\frac{1}{x^4}+\frac{1}{x^5}=t,$

$\left(-\frac{4}{x^5}-\frac{5}{x^6}\right)dx=dt$

or $\left(\frac{4}{x^5}+\frac{5}{x^6}\right)dx=-dt,$ we get

$I=-\int\frac{dt}{t^2}=\frac{1}{t}+C=\frac{1}{\left(1+\frac{1}{x^4}+\frac{1}{x^5}\right)}+C$

$=\frac{x^5}{(x^5+x+1)}+C$

$f(1)=\frac{1}{3}$

5. Given, $y=1+\frac{8}{x^2}$

Here, y is always positive. So, the curve lies above the x – axis.

Required area $=\int_2^4 ydx=\int_2^4\left(1+\frac{8}{x^2}\right)dx$

$=\left[x-\frac{8}{x}\right]_2^4=4$

If $x=a$ bisects the area, we have $\int_2^a\left(1+\frac{8}{x^2}\right)dx=\left[x-\frac{8}{x}\right]_2^a$

$=\left[a-\frac{8}{a}-2+4\right]=\frac{4}{2}$

$\Rightarrow \quad a-\frac{8}{a}=0$

$\Rightarrow \quad a^2 = 8$

$\Rightarrow \quad a = \pm 2\sqrt{2}$

Since, $a > 2$, $a = 2\sqrt{2}$.

6. If the given points are A, B and C then $\vec{AB} = k\left(\vec{BC}\right)$

$\Rightarrow 2\hat{i} - 8\hat{j} = k\left[\left(a-12\right)\hat{i} + 16\hat{j}\right]$

Comparing the coefficients of $\hat{i}$ and $\hat{j}$, we get –8 = 16k

$\Rightarrow k = -\frac{1}{2}$

$2 = k\left(a-12\right) = -\frac{1}{2}\left(a-12\right)$

$\Rightarrow a = 8$

Physics
PART – A

1. **D** P120409

Sol. $m\omega^2 r = eE$

$\Rightarrow \quad \Delta V = \int E.dr = \int_0^a \frac{e\omega^2 r dr}{m}$

2. **B** P120405

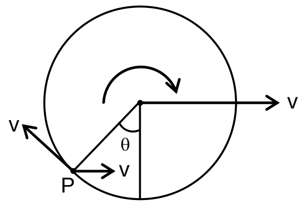
Sol. $Q = \frac{\Delta\phi}{R}$

3. **A** P111826

Sol. Velocity of point P

$= \sqrt{(v - v\cos\theta)^2 + (v\sin\theta)^2}$

$= 2v\sin\left(\frac{\theta}{2}\right)$



4. **B** P120305

Sol. $d = \frac{mv_0}{qB} + \frac{2mv_0}{2qB}$

5. **ABD** P111822

Sol. By conservation of angular momentum,

$I_1\omega_i = \left(I_1 + I_2\right)\omega_f$

$\omega_f = \omega_1 / 3$

$E_i = \frac{1}{2} I_1 \omega_i^2$

$E_f = \frac{1}{2}\left(I_1 + I_2\right)\omega_f^2$

Ratio of the heat produced to initial kinetic energy $= \frac{E_i - E_f}{E_i} = \frac{2}{3}$

6. **ABD** P120406

Sol. The power delivered by magnetic field is zero. Hence, loss of energy in conducting rod is equal to heat dissipated in the resistor.

7. **ABD** P111010

Sol. Bernoulli's theorem for an orifice at depth 'x' in liquid '3d'.

$P_o + \left(dg\frac{H}{2} + 3dg.x\right) = P_o + \frac{1}{2}\times 3d\times v^z$ ...(1)

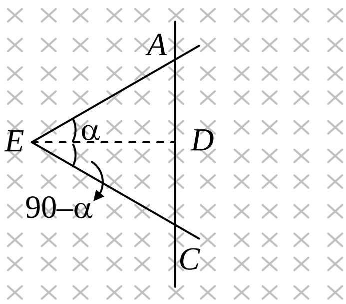
$\frac{H}{2} - x = \frac{1}{2}gt^2$ ...(2)

R = Vt ...(3)

Solve for R and apply maxima/minima.

8. **BD** P121705

Sol. At time t, the distance traveled by the rod is



$ED = vt$

$\tan\alpha = \frac{AD}{ED}$ or $AD = ED\tan\alpha$

$AD = vt\tan\alpha$

$\tan(90-\alpha) = \frac{DC}{ED}$ or $DC = at\cot\alpha$

So, $AC = AD + DC = vt(\tan\alpha + \cot\alpha)$

Induced emf = $Bvl = Bv(AC)$

$= Bv.vt(\tan\alpha + \cot\alpha)$

Induced emf $= Bv^2t(\tan\alpha + \cot\alpha)$

Hence, Induced emf $\propto t$ and v^2

Therefore, choices (B) and (D) are correct and choices (A) and (C) are wrong.

9. **AC** P121720

Sol. $I = \frac{E}{R}\left(1 - e^{-Rt/L}\right)$; $\frac{dI}{dt} = \frac{E}{L}\left(e^{-Rt/L}\right)$

10. **BD** P120308

Sol. In both case (b) and (d), $\vec{F}_{net} = 0$ so it passes the region undeviated.

PART – B

1. **A → P** **B → PQS** **C → QS** **D → QRS**
P120414

2. **A → PR** **B → PR** **C → QS** **D → PQRS**
P120305

Sol. Time varying magnetic field produces electric field and this electric field can apply force on a stationary charge.

3. **A → T** **B → S** **C → R** **D → T**
P120216

Sol. $q = CV - (CV - q_o)\,e^{-\frac{t}{CR}}$

$i = \frac{CV - q_o}{CR}e^{-\frac{t}{CR}}$

$U = \frac{q^2}{2C}$

4. **A → R** **B → S** **C → P** **D → Q**
P111820

Sol. (A) $\frac{mg}{2}\frac{\ell}{4} = T\frac{3\ell}{4} \Rightarrow T = \frac{mg}{6}$

(B) $f_r = mg\frac{\sqrt{3}}{2}$

(C) $N = \frac{mg}{2} \times \frac{4}{7} = \frac{2mg}{7}$

(D) $N = \frac{mg}{2} - \frac{mg}{6} = \frac{mg}{3}$

PART – C

1. **4** P110603

Sol. $\frac{m_A \ell^2}{m_B \ell^2} = 3$

$\therefore \frac{m_A}{m_B} = 3$

$x_{CM} = \frac{m_B \ell}{m_A + m_B} = \frac{\ell}{4}$

2. **8** P110502

Sol $F.x - \mu m_1 g x - \frac{1}{2}kx^2 = 0$

$kx = \mu m_2 g$ for just shifting m_2

$F.x - \mu m_1 g x - \frac{1}{2}\mu m_2 g x = 0$

$F = \mu\left(m_1 + \frac{m_2}{2}\right)g = 0.4\left(1 + \frac{2}{2}\right)(10) = 8N$

3. **2** P120410

Sol. At any time length of each wire $= l - 2vt$

Induced emf $= 4\,Bv(l - 2vt)$

Induced current $= \frac{4Bv(l-2vt)}{4\lambda(l-2vt)} = \frac{Bv}{\lambda}$, $F = B\left(\frac{Bv}{\lambda}\right)(l - 2vt) = \frac{B^2 v}{\lambda}(l - 2vt)$

$= \frac{(2)^2 \times 5}{0.5}(15 - 2 \times 5 \times 1) = 200\ N$

4. **3** P120306

Sol. Initially the rod will be in equilibrium if

$2T_o = Mg$ with $T_o = kx_o$ …(i)

when the current I is passed through the rod, it will experience a force

F = BIL vertically up,

In equilibriums

2T + BIL = Mg with T = kx …(ii)

from (i) & (ii)

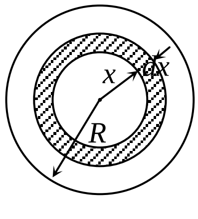
$\frac{T}{T_o} = \frac{Mg - BIL}{Mg}$ i.c. $\frac{x}{x_o} = 1 - \frac{BIL}{Mg}$

or, $B = \frac{Mg(x_o - x)}{I\ L\ x_0}$

Putting the values we get $B = 1.5 \times 10^{-2}\,T$.

5. **1** P120413

Sol. $d\varphi = (2\pi x dx)kxt^2$



$\varphi = \frac{2}{3}kt^2\pi x^3$

$\frac{d\varphi}{dt} = \frac{4k\pi t x^3}{3}$

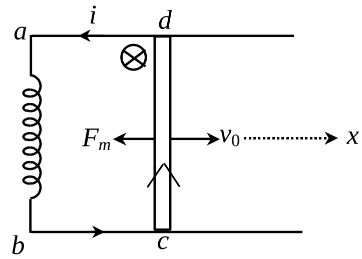
$E2\pi x = \frac{4\pi ktx^3}{3}$; $E = \frac{2}{3}ktx^2$; $d\tau = \left(\frac{2}{3}ktx^2\right)\frac{Q}{\pi R^2}(2\pi x dx)x$

$\int d\tau = \frac{4}{3}\frac{ktQ}{R^2}\int_0^R x^4 dx$ $\Rightarrow$ $\tau = \frac{4}{3}\frac{ktQ}{R^2}\frac{R^5}{5}$

At t = 15sec, τ = 1 N-m

6. **4** P120401

Sol. Let any instant of time, velocity of the rod is v towards right.



The current in the circuit is i. In the figure,

$$V_a - V_b = V_d - V_c$$

i.e. $Ldi = Bldx$

Integrating, we get $Li = Blx$

Magnetic force on the rod at this instant is

$$F_m = ilB = \frac{B^2l^2}{L}x \quad \dots (i)$$

Since, this force is in opposite direction of $\vec{v}$, so from Newton's second law we can write,

$$m\left(\frac{d^2x}{dt^2}\right) = -\frac{B^2l^2}{L}x$$

Comparing this with equation of SHM, i.e.

$$\frac{d^2x}{dt^2} = -\omega^2 x \quad \dots (ii)$$

We have, $\omega = \frac{Bl}{\sqrt{mL}}$

So $T = \frac{2\pi}{\omega} = 2\pi\frac{\sqrt{mL}}{Bl} = 2\pi\frac{\sqrt{8\times 2}}{\pi\times 2} =$ 4 sec.