1 - JEE Main Maths 21-Jan 2026 Shift -2

Q1 Solution:

(1)

for no solution $\Delta = 0$

$$\begin{vmatrix} 3 & 1 & 4 \\ 2 & \alpha & -1 \\ 1 & 2 & 1 \end{vmatrix} = 0$$

$\Rightarrow 3(\alpha + 2) + 1(-1 - 2) + 4(4 - \alpha) = 0$

$\Rightarrow 19 - \alpha = 0 \Rightarrow \alpha = 19$

For $\alpha = 19$

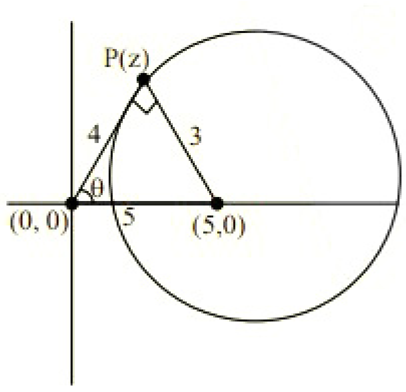
$$\Delta_x = \begin{vmatrix} 3 & 1 & 4 \\ -3 & 19 & -1 \\ 4 & 2 & 1 \end{vmatrix} = 3(21) + 1(-1) + 4(-82)$$

$\neq 0$

$\therefore$ no solution for $\alpha = 19$

Q2 Solution:

(3)



$|z - 5| \leq 3$

For $\arg(z)$ to be maximum, z lies at P.

$z \equiv (4\cos\theta, 4\sin\theta)$

$\equiv \left(4 \cdot \frac{4}{5}, 4 \cdot \frac{3}{5}\right) = \left(\frac{16}{5}, \frac{12}{5}\right) = \frac{16}{5} + \frac{12i}{5}$

Now, $34\left|\frac{5z - 12}{5iz + 16}\right|^2 = 34\left|\frac{(16 + 12i) - 12}{(16i - 12) + 16}\right|^2$

$= 34\left|\frac{4 + 12i}{16i + 4}\right|^2$

$= 34\left(\frac{16 + 144}{256 + 16}\right)$

$= 34\left(\frac{160}{272}\right) = 20$

Q3 Solution:

(3)

x	0	1	2	3
$p(x)$	$\frac{2a + 1}{30}$	$\frac{8a - 1}{30}$	$\frac{4a + 1}{30}$	b

$\sigma^2 = \sum x_i^2 p(x_i) - \mu^2$

$\sigma^2 + \mu^2 = \sum x_i^2 p(x_i)$

$= 0 + 1\left(\frac{8a - 1}{30}\right) + 4\left(\frac{4a + 1}{30}\right) + 9b$

$\Rightarrow \frac{24a + 270b + 3}{30} = 2$

$24a + 270b = 57$

$8a + 90b = 19 \quad ...(1)$

Also,

$\sum p(i) = 1$

$\frac{2a + 1}{30} + \frac{8a - 1}{30} + \frac{4a + 1}{30} + b = 1$

$14a + 30b = 29 \quad ...(2)$

Solving (1) and (2),

$a = 2, \quad b = \frac{1}{30}, \quad \frac{a}{b} = 60$

Q4 Solution:
(4)

$\left|x^2 - 10\right| \leq 6$

$-6 \leq x^2 - 10 \leq 6$

$4 \leq x^2 \leq 16$

$A = [-4, -2] \cup [2, 4]$

$|x - 2| > 1$

$B = (-\infty, 1) \cup (3, \infty)$

$A \cup B = (-\infty, 1) \cup [2, \infty)$

$A \cap B = [-4, -2] \cup (3, 4]$

$A - B = [2, 3]$

$B - A = (-\infty, -4) \cup (-2, 1) \cup (4, \infty)$

Q5 Solution:
(3)

$g\left(x\right) = f\left((\tan x - 1)^2 + a - 1\right)$

$g'\left(x\right) = f'\left((\tan x - 1)^2 + a - 1\right) \cdot 2\left(\tan x - 1\right)\sec^2 x$

$\because \quad f'(a - 1) = 0 \text{ and } f''(x) > 0$

$\therefore \quad f'\left((\tan x - 1)^2 + a - 1\right) > 0$

$g'(x) > 0 \text{ if } \left(\tan x - 1\right) > 0$

$g \text{ is increasing in } x \in \left(\frac{\pi}{4}, \frac{\pi}{2}\right)$

$g'(x) < 0$ if $\tan x - 1 < 0$

g is decreasing in $x \in \left(0, \frac{\pi}{4}\right)$

Q6 Solution:
(1)

$\because \quad \alpha < 1 < \beta$

$f(1) < 0$

$\Rightarrow 1 + 2a + (3a + 10) < 0$

$\Rightarrow 5a + 11 < 0$

$a < \frac{-11}{5}$

$\therefore \quad a \in \left(-\infty, \frac{-11}{5}\right)$

Q7 Solution:
(1)

$x(x+2) + (x+2)(x+4) + \cdots + (x+2n-2)(x+2n) = \frac{8n}{3}$

$\Rightarrow \sum_{r=1}^{n} (x+2r-2)(x+2r) = \frac{8n}{3}$

$nx^2 + 2x\sum_{r=1}^{n}(2r-1) + 4\sum_{r=1}^{n} r(r-1) = \frac{8n}{3}$

$nx^2 + 2xn^2 + \frac{4n(n^2-1)}{3} - \frac{8n}{3} = 0$

$x^2 + 2nx + \frac{4(n^2-1)}{3} - \frac{8}{3} = 0$

$\because |\alpha - \beta| = 2 \Rightarrow \frac{\sqrt{D}}{|a|} = 2 \Rightarrow D = 4$

$\Rightarrow 4n^2 - 4\left(\frac{4(n^2-1)}{3} - \frac{8}{3}\right) = 4$

$\Rightarrow n^2 - \frac{4n^2}{3} = -3$

$\Rightarrow n^2 = 9$

$\Rightarrow n = 3$

Q8 Solution:
(1)

$\frac{dy}{dx} - 2y\cos x = 2\cos x + 3\sin x\cos x$

$\text{I.F.} = e^{-2\sin x}$

$e^{-2\sin x}\ y = \int e^{-2\sin x}(3\sin x\cos x + 2\cos x)\,dx$

$y \cdot e^{-2\sin x} = e^{-2\sin x}\left(-\frac{3}{2}\sin x - \frac{7}{4}\right) + C$

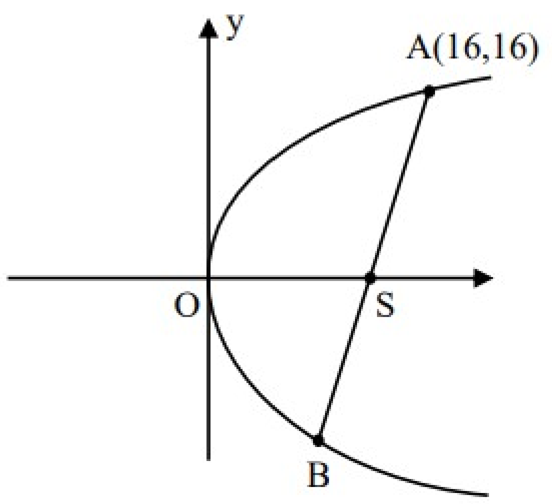
$\Rightarrow y = -\frac{3}{2}\sin x - \frac{7}{4} + Ce^{2\sin x}$

$\because y(0) = -\frac{7}{4} \Rightarrow C = 0$

$y\left(\frac{\pi}{6}\right) = \frac{-3}{2} \cdot \frac{1}{2} - \frac{7}{4} = \frac{-5}{2}$

Q9 Solution:
(1)

$y^2 = 16x$

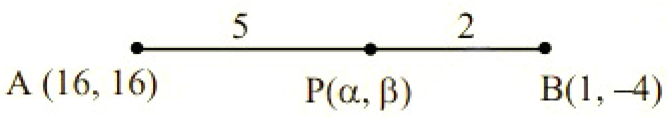


$\because$ parameter of point A is $t = 2$

$\Rightarrow$ Parameter of point B is $t = -\frac{1}{2}$

$\Rightarrow$ Coordinates of B is $(1, -4)$

Case 1:

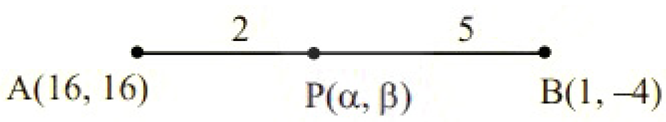


$\alpha = \frac{5 + 32}{7} = \frac{37}{7}$

$\beta = \frac{-20 + 32}{7} = \frac{12}{7}$

$\Rightarrow \alpha + \beta = 7$

Case 2:



$\alpha = \frac{2 + 80}{7}, \quad \beta = \frac{-8 + 80}{7}$

$\alpha + \beta = 22$

So minimum value of $\alpha + \beta = 7$

Q10 Solution:
(1)

$\alpha x + 4y - \sqrt{7} = 0$ touches $3x^2 + 4y^2 = 1$

$\therefore c^2 = a^2m^2 + b^2$

$\frac{7}{16} = \frac{1}{3} \times \frac{\alpha^2}{16} + \frac{1}{4} \Rightarrow \alpha = 3, -3$

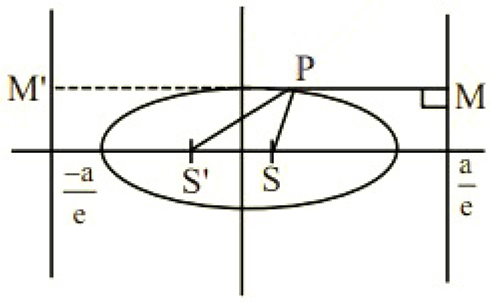
Tangent is $3x + 4y - \sqrt{7} = 0$

Let the point of contact be $P\left(x_1, y_1\right)$

$\therefore$ Tangent is $3xx_1 + 4yy_1 = 1$

$\therefore \frac{3x_1}{3} = \frac{4y_1}{4} = \frac{1}{\sqrt{7}} \qquad \therefore P\left(\frac{1}{\sqrt{7}}, \frac{1}{\sqrt{7}}\right)$

$e = \sqrt{1 - \frac{3}{4}} = \frac{1}{2}$



$PS = e\,(PM)$

$= e\left(\frac{a}{e} - \frac{1}{\sqrt{7}}\right)$

$= \frac{1}{2}\left(\frac{2}{\sqrt{3}} - \frac{1}{\sqrt{7}}\right) = \frac{1}{\sqrt{3}} - \frac{1}{2\sqrt{7}}$

$PS' = e\,(PM')$

$= \frac{1}{2}\left(\frac{a}{e} + \frac{1}{\sqrt{7}}\right) = \frac{1}{2}\left(\frac{1}{\sqrt{7}} + \frac{2}{\sqrt{3}}\right)$

$= \frac{1}{\sqrt{3}} + \frac{1}{2\sqrt{7}}$

Q11 Solution:
(2)

Here $A^n = \begin{bmatrix} 2n+1 & -4n \\ n & -2n+1 \end{bmatrix}$

$\Rightarrow A^{15} = \begin{bmatrix} 31 & -60 \\ 15 & -29 \end{bmatrix}$

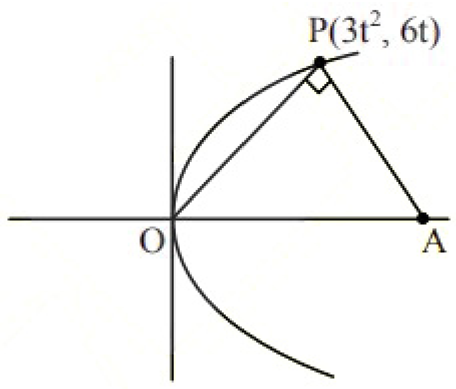
$\Rightarrow A^{15} + B = \begin{bmatrix} 2 & -11 \\ 2 & -11 \end{bmatrix}$

Now $\left(A^{15} + B\right)\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$

$\Rightarrow \begin{bmatrix} 2 & -11 \\ 2 & -11 \end{bmatrix}\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$

$\Rightarrow 2x - 11y = 0$

Q12 Solution:
(3)



$m_{AP} = \frac{-t}{2}$

Equation of AP is

$y - 6t = \frac{-t}{2}\left(x - 3t^2\right)$

Put $y = 0$

$\Rightarrow x = 12 + 3t^2$

$\Rightarrow A\left(12 + 3t^2, 0\right)$

Let centroid of ΔOPA be $G(h, k)$

$\Rightarrow 3h = 0 + 3t^2 + 12 + 3t^2$

$3k = 0 + 6t + 0$

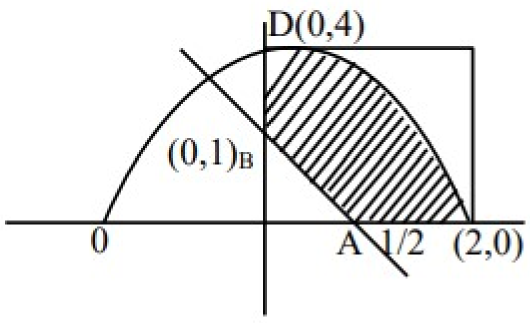
$\Rightarrow t = \frac{k}{2}, \quad h = 2t^2 + 4$

$\Rightarrow h = 2\left(\frac{k^2}{4}\right) + 4$

$\Rightarrow$ Locus of (h, k) is

$y^2 = 2x - 8$

Q13 Solution:
(2)



Required area $= \frac{2}{3} \times 8 - \frac{1}{2} \times \frac{1}{2} \times 1$

$= \frac{16}{3} - \frac{1}{4} = \frac{61}{12} = \frac{\alpha}{\beta}$

$\Rightarrow \alpha + \beta = 73$

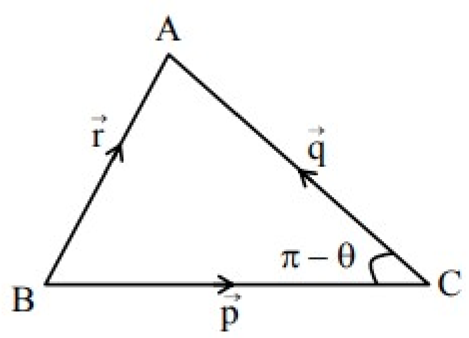
Q14 Solution:
(4)

Exponent of 7 in 101!

$= \left[\frac{101}{7}\right] + \left[\frac{101}{7^2}\right] + \left[\frac{101}{7^3}\right] + \cdots$

$= 14 + 2 = 16$

Q15 Solution:
(3)



$\vec{p} + \vec{q} = \vec{r}$

$\cos\left(\pi - \theta\right) = \frac{|\vec{p}|^2 + |\vec{q}|^2 - |\vec{r}|^2}{2|\vec{p}||\vec{q}|}$

$\frac{-1}{\sqrt{3}} = \frac{12 + 4 - |\vec{r}|^2}{2 \cdot 2\sqrt{3} \cdot 2}$

$|\vec{r}|^2 = 24$

$\therefore \ |\vec{p} \times (\vec{q} - 3\vec{r})|^2 + 3|\vec{r}|^2$

$= |\vec{p} \times (\vec{q} - 3\vec{p} - 3\vec{q})|^2 + 72$

$= |\vec{p} \times (-3\vec{p} - 2\vec{q})|^2 + 72$

$= |-2\vec{p} \times \vec{q}|^2 + 72$

$= 4|\vec{p}|^2|\vec{q}|^2 \sin^2\theta + 72$

$= 4 \cdot 12 \cdot 4 \cdot \frac{2}{3} + 72$

$= 200$

Q16 Solution:
(1)

$f'(x) = 3x^2 + 2xf'(1) + 2f''(2)$

$f''(x) = 6x + 2f'(1)$

$f''(2) = 12 + 2f'(1)$

$\therefore f'(x) = 3x^2 + 2xf'(1) + 2(12 + 2f'(1))$

$f'(x) = 3x^2 + 2(x + 2)f'(1) + 24$

Putting $x = 1$

$f'(1) = 3 + 6f'(1) + 24$

$-5f'(1) = 27 \Rightarrow f'(1) = \frac{-27}{5}$

$\therefore f''(2) = 12 + 2\left(\frac{-27}{5}\right) = 12 - \frac{54}{5} = \frac{6}{5}$

$\therefore f'(x) = 3x^2 - \frac{54}{5}x + \frac{12}{5}$

$\therefore f'(5) = 75 - 54 + \frac{12}{5} = \frac{117}{5}$

Q17 Solution:
(2)

$\frac{a_2}{2a_1} = \frac{a_3}{2a_2} = \frac{a_4}{2a_3} = \cdots = \frac{a_{10}}{2a_9} = \frac{1}{\sqrt{2}}$

$\therefore a_1, a_2, a_3, \ldots, a_{10}$ are in G.P. with common ratio $\sqrt{2}$.

$\sum_{i=1}^{10} a_i = \frac{a_1\left((\sqrt{2})^{10} - 1\right)}{\sqrt{2} - 1} = 62$

$\Rightarrow a_1 = 2(\sqrt{2} - 1)$

Q18 Solution:
(1)

$A = \{2, 3, 5, 7, 9\}$

$y \geq \frac{2x}{3}$

$$\left.\begin{array}{ll} x=2, & y=2,3,5,7,9 \\ x=3, & y=2,3,5,7,9 \\ x=5, & y=5,7,9 \\ x=7, & y=5,7,9 \\ x=9, & y=7,9 \end{array}\right] \Rightarrow \ell = 18$$

To make it symmetric the elements to be added are
$\{(5,2),(7,2),(9,2),(5,3),(7,3),(9,3),(9,5)\}$

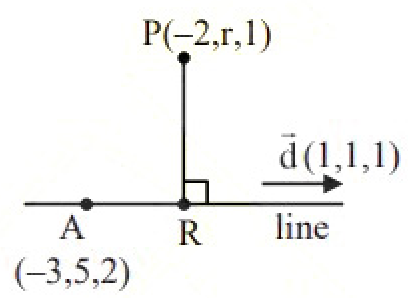
$m = 7$

$\therefore \ell + m = 25$

Q19 Solution:
(4)

Equation of line is : $\frac{x+3}{1} = \frac{y-5}{1} = \frac{z-2}{1} = \lambda$

$\therefore$ General point R on line is $R(\lambda - 3,\ \lambda + 5,\ \lambda + 2)$



$\overrightarrow{PR} \equiv (\lambda - 1,\ \lambda + 5 - r,\ \lambda + 1)$

Now $\overrightarrow{PR} \cdot \vec{d} = 0$

$\Rightarrow (\lambda - 1)1 + (\lambda + 5 - r)1 + (\lambda + 1)1 = 0$

$\Rightarrow 3\lambda - r + 5 = 0$

$\Rightarrow \lambda = \frac{r-5}{3}$

$\therefore\ R \equiv \left(\frac{r-5}{3} - 3,\ \frac{r-5}{3} + 5,\ \frac{r-5}{3} + 2\right)$

$R \equiv \left(\frac{r-14}{3}, \frac{r+10}{3}, \frac{r+1}{3}\right)$

Now

$PR = \sqrt{\frac{14}{3}} \Rightarrow (PR)^2 = \frac{14}{3}$

$\Rightarrow \left(\frac{r-14}{3} + 2\right)^2 + \left(\frac{r+10}{3} - r\right)^2 + \left(\frac{r+1}{3} - 1\right)^2 = \frac{14}{3}$

$\Rightarrow \frac{(r-8)^2}{9} + \frac{(10-2r)^2}{9} + \frac{(r-2)^2}{9} = \frac{14}{3}$

$\Rightarrow (r^2 - 16r + 64) + (100 + 4r^2 - 40r) + (r^2 - 4r + 4) = 42$

$\Rightarrow 6r^2 - 60r + 126 = 0$

$\Rightarrow r^2 - 10r + 21 = 0$

$\Rightarrow r = 3, 7$

Sum of possible values of r is 10

Q20 Solution:
(3)

L_1: $\frac{x-2}{-3}=\frac{y-6}{2}=\frac{z-7}{4}$

Point C on L_1: $(-3\lambda_1+2,\ 2\lambda_1+6,\ 4\lambda_1+7)$

L_2: $\frac{x-4}{2}=\frac{y-3}{1}=\frac{z-5}{3}$

Point D on L_2: $(2\lambda_2+4,\ \lambda_2+3,\ 3\lambda_2+5)$

D.R's of line L_3:

L_3: $\frac{2\lambda_2+3\lambda_1+2}{-3}=\frac{\lambda_2-2\lambda_1-3}{5}=\frac{3\lambda_2-4\lambda_1-2}{16}$

$\lambda_1=-3,\ \lambda_2=2$

$C(11,0,-5)$

$D(8,5,11)$

$|\overrightarrow{CD}|^2=3^2+5^2+16^2=290$

Q21 Solution:
(9)

Let $I=\int_0^1\cot^{-1}\left(1-2x+4x^2\right)dx$

$I=\int_0^1\left(\cot^{-1}\left(2x-1\right)-\cot^{-1}\left(2x\right)\right)dx \qquad ...(1)$

Applying king

$I=\int_0^1\left(-\cot^{-1}\left(2x-1\right)+\cot^{-1}\left(2x-2\right)\right)dx \qquad ...(2)$

From (1) & (2)

$2I=\int_0^1\left(\cot^{-1}\left(2x-2\right)-\cot^{-1}\left(2x\right)\right)dx$

$=\int_0^1\cot^{-1}\left(2x-2\right)dx-\int_0^1\cot^{-1}\left(2x\right)dx$

Applying King

$=\int_0^1\cot^{-1}\left(-2x\right)dx-\int_0^1\cot^{-1}\left(2x\right)dx$

$=\int_0^1\left(\pi-\cot^{-1}\left(2x\right)\right)dx-\int_0^1\cot^{-1}\left(2x\right)dx$

$=\int_0^1\left(\pi-2\cot^{-1}\left(2x\right)\right)dx$

$=\pi-2\int_0^1\cot^{-1}\left(2x\right)dx$

By parts

$=\pi-2\left[\left(x\cot^{-1}(2x)\right)_0^1+\int_0^1\frac{2x}{1+4x^2}dx\right]$

Let $1+4x^2=t$

$8x\,dx=dt$

$=\pi-2\left[\cot^{-1}2+\frac{1}{4}\int_1^5\frac{dt}{t}\right]$

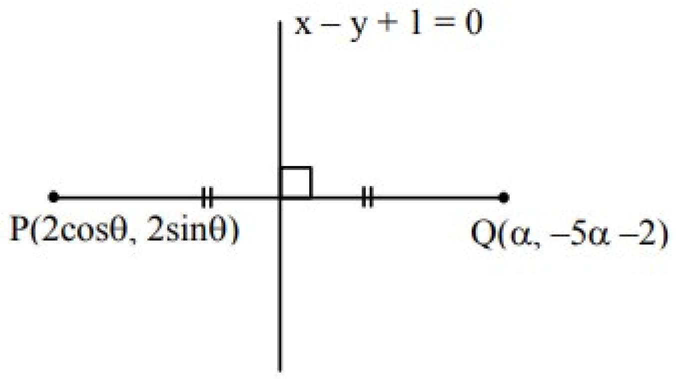
$= \pi - 2\cot^{-1}2 - \frac{1}{2}ln5$

$2I = 2\tan^{-1}2 - \frac{1}{2}ln5$

$\Rightarrow 4I = 4\tan^{-1}2 - ln5$

$\therefore 2a + b = 8 + 1 = 9$

Q22 Solution:
(2)



Mid point of PQ lies on $x - y + 1 = 0$

$\frac{2\cos\theta + \alpha}{2} - \frac{2\sin\theta - 5\alpha - 2}{2} + 1 = 0$

$2\cos\theta + \alpha - 2\sin\theta + 5\alpha + 2 + 2 = 0$

$\cos\theta - \sin\theta + 3\alpha + 2 = 0 \qquad ...(1)$

$\because$ Slope of PQ is -1

$\frac{2\sin\theta + 5\alpha + 2}{2\cos\theta - \alpha} = -1$

$2\sin\theta + 5\alpha + 2 = -2\cos\theta + \alpha$

$\sin\theta + \cos\theta + 2\alpha + 1 = 0 \qquad ...(2)$

Eliminate α from (1) and (2)

$\Rightarrow \cos\theta + 5\sin\theta = 1, \ \theta \in [0, 2\pi]$

$\Rightarrow 5 \times 2\sin\frac{\theta}{2}\cos\frac{\theta}{2} = 2\sin^2\frac{\theta}{2}$

$\therefore \sin\frac{\theta}{2} = 0 \Rightarrow \cos\theta = 1$

or

$\sin\frac{\theta}{2} = 5 \Rightarrow \cos\theta = -\frac{12}{13}$

Sum of all possible values of abscissa of point P is

$= 2 \times 1 + 2\left(\frac{-12}{13}\right) = \frac{2}{13}$

$\therefore$ 13 times sum of all possible values of abscissa of point P is $= 2$

Q23 Solution:
(2)

$\sum_{k=1}^{n}\left(\frac{k^2}{3^x} - 1\right) < \sum_{k=1}^{n}\left[\frac{k^2}{3^x}\right] \le \sum_{k=1}^{n}\frac{k^2}{3^x}$

$\frac{n(n+1)(2n+1)}{6 \cdot 3^x} < \sum_{k=1}^{n}\left[\frac{k^2}{3^x}\right] \le \frac{n(n+1)(2n+1)}{6 \cdot 3^x}$

$$\lim_{n \to \infty} \frac{n(n+1)(2n+1)}{6n^3 \cdot 3^x} < \lim_{n \to \infty} \frac{1}{n^3} \sum_{k=1}^{n} \left[\frac{k^2}{3^x}\right] \le \lim_{n \to \infty} \frac{n(n+1)(2n+1)}{6 \cdot 3^x \cdot n^3}$$

$$\frac{1}{3^{x+1}} < \lim_{n \to \infty} \frac{1}{n^3} \sum_{k=1}^{n} \left[\frac{k^2}{3^x}\right] \le \frac{1}{3^{x+1}}$$

$$\Rightarrow f(x) = \frac{1}{3^{x+1}}$$

$$\Rightarrow 12 \sum_{j=1}^{\infty} f(j) = 12 \sum_{j=1}^{\infty} \frac{1}{3^{j+1}} = 12\left[\frac{1}{9} + \frac{1}{27} + \cdots \infty\right]$$

$$= 12\left(\frac{\frac{1}{9}}{1 - \frac{1}{3}}\right) = 2$$

Q24 Solution:

(32)

$$\prod_{r=0}^{12}\left(\frac{1}{{}^{15}C_r} + \frac{1}{{}^{15}C_{r+1}}\right) = \prod_{r=0}^{12} \frac{\frac{16}{r+1} \cdot {}^{15}C_r}{15C_r \cdot {}^{15}C_{r+1}}$$

$$= \prod_{r=0}^{12} \frac{16}{(r+1) \cdot \frac{15}{r+1} \cdot {}^{14}C_r} = \prod_{r=0}^{12} \frac{\frac{16}{15}}{{}^{14}C_r}$$

$$= \frac{\left(\frac{16}{15}\right)^{13}}{{}^{14}C_0 \cdot {}^{14}C_1 \cdots {}^{14}C_{12}} \Rightarrow \alpha = \frac{16}{15}$$

$$\Rightarrow 30\alpha = 32$$

Q25 Solution:

(65)

$$\left(\sin^{-1}x\right)^2 + \left(\cos^{-1}x\right)^2$$

$$= \left(\sin^{-1}x + \cos^{-1}x\right)^2 - 2\sin^{-1}x\cos^{-1}x$$

$$= \frac{\pi^2}{4} - 2\left(\sin^{-1}x\right)\left(\frac{\pi}{2} - \sin^{-1}x\right)$$

$$= 2\left(\sin^{-1}x - \frac{\pi}{4}\right)^2 + \frac{\pi^2}{8}, \text{ where } \sin^{-1}x \in \left[\frac{-\pi}{3}, \frac{\pi}{4}\right]$$

Then maximum value occurs at $\sin^{-1}x = \frac{-\pi}{3}$

Which is $2\left(\frac{\pi}{3} + \frac{\pi}{4}\right)^2 + \frac{\pi^2}{8} = \frac{29\pi^2}{36}$

$$\Rightarrow m = 29 \text{ and } n = 36$$

$$\therefore m + n = 65$$

2 - JEE Main Physics 21-Jan 2026 Shift -2

Q26 Solution:

(4)

$$U_{e_r} = 75\% \, U_{e_i}$$

$$Q_F^2 = \frac{3}{4} Q_i^2$$

$$Q_i \cos\omega t = \frac{\sqrt{3}}{2} Q_i \Rightarrow t = \frac{T}{12}$$

$t = \frac{\pi}{6}\sqrt{LC}$

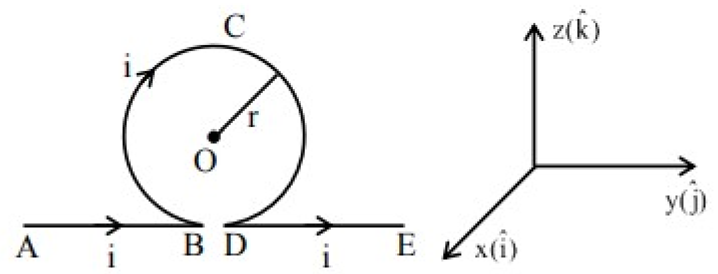
Q27 Solution:
(4)

$V_0 = \frac{2r^2 g}{9n}\left(\rho_B - \rho_L\right)$

$n = \frac{2r^2 g}{9V_0}\left(\rho_B - \rho_L\right)$

$\frac{\Delta n}{n} = \frac{2\Delta r}{r} + \frac{\Delta V_0}{V_0}$

Q28 Solution:
(1)



$\vec{B}_0 = \vec{B}_{AB} + \vec{B}_{DE} + \vec{B}_{BCD}$

$= \frac{\mu_0 i}{4\pi r}\hat{i} + \frac{\mu_0 i}{4\pi r}\hat{i} - \frac{\mu_0 i}{2r}\hat{i}$

$= \frac{\mu_0 i}{2\pi r}\hat{i} - \frac{\mu_0 i}{2r}\hat{i}$

$= \frac{\mu_0 i}{2\pi r}\left(1 - \pi\right)\hat{i}$

$= -\frac{\mu_0 i}{2\pi r}\left(\pi - 1\right)\hat{i}$

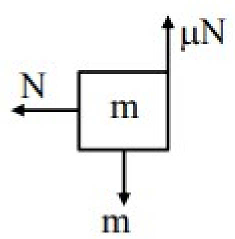
Q29 Solution:
(1)

Using energy conservation

$\left(2\right)\left(\frac{1}{2}mu^2\right) - \frac{Gm^2}{4r} + \frac{KQ^2}{4r} = -\frac{Gm^2}{2r} + \frac{KQ^2}{2r}$

$u = \sqrt{\frac{1}{4mr}\left(KQ^2 - Gm^2\right)}$

Q30 Solution:
(3)



$N = m\omega^2 r, \quad mg = \mu N$

$\mu \times m\omega^2 r = mg$

$\omega = \sqrt{\frac{g}{\mu r}}$

Q31 Solution:
(1)

For maximum power drawn across load

Resistance $R_{\text{Load}} = R_{\text{internal}}$

$R = r$

Q32 Solution:
(1)

$\frac{(2R + x)(R)}{3R + x} = x$

$x^2 + 2Rx - 2R^2 = 0$

$x = \left(\sqrt{3} - 1\right) R$

Q33 Solution:
(2)

$V_{\text{rms}} = \sqrt{\frac{3RT}{M}}$

$V_{\text{rms}_{O_2}} = V_{\text{rms}_{H_2}}$

$T_{O_2} = 273 + 47 = 320K$

$\sqrt{\frac{3RT_{O_2}}{M_{O_2}}} = \sqrt{\frac{3RT_{H_2}}{M_{H_2}}}$

$\frac{T_{O_2}}{M_{O_2}} = \frac{T_{H_2}}{M_{H_2}}$

$\frac{320}{32} = \frac{T_{H_2}}{2}$

$T_{H_2} = 20K$

$T_{H_2} = -253°C$

Q34 Solution:
(4)

$x(t) = t^2 + t + 1$

$v(t) = 2t + 1$

$a(t) = 2$

$F = 4\text{N}$

Displacement $= x(3) - x(2)$

$= 13 - 7 = 6\text{m}$

$W = F \cdot S = 4 \times 6 = 24\text{J}$

Q35 Solution:
(2)

$h = \frac{2T}{\rho g r}$

$h \propto \frac{1}{r}$

If $r_1 > r_2 \Rightarrow h_2 > h_1$

Q36 Solution:
(1)

$\omega = 176 \text{ rad/sec}$

$f_k = \frac{\omega}{2\pi} = \frac{176}{2 \times 22} \times 7$

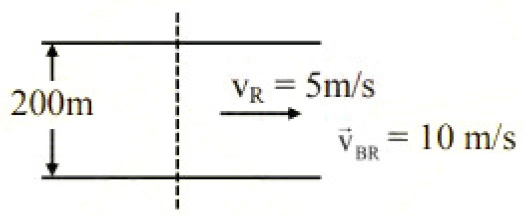
$= \frac{176}{44} \times 7$

$= 4 \times 7 = 28 \text{ Hz}$

So frequency of oscillator

$f = \frac{k}{2} = 14 \text{ Hz}$

Q37 Solution:
(3)



Minimum time :

$t_{\min} = \frac{200}{10} = 20 \text{sec}$

For round trip $= 40 \text{sec}$

Displacement along river bank $= 40 \times 5 = 200 \text{m}$

Q38 Solution:
(1)

Angular momentum $L = \frac{nh}{2\pi}$

$n = \frac{2\pi L}{h}$

Energy $E = -\frac{13.6}{n^2} Z^2$

$E \Rightarrow -\frac{E_0}{n^2} = -0.04 E_0$

$n^2 = 25, \ n = 5$

Q39 Solution:
(2)

$L = m.V_{\text{rel}} \ \ r_{\perp}$

$= 1000 \times \left(36 \times \frac{5}{18}\right) \times 10$

$= 10^5 \text{ kg m}^2 / \text{s}$

Q40 Solution:
(1)

$\frac{6}{R_{AP}} = \frac{4}{R_{PB}};$

$\ell_{AP} + \ell_{PB} = 50 \quad ...(i)$

$\frac{R_{AP}}{R_{PB}} = \frac{\ell_{AP}}{\ell_{PB}} = \frac{3}{2}$

$\ell_{AP} = \frac{3}{5} \times 50 = 30 \text{ cm}$

Q41 Solution:
(4)

Angular fringe width $= \frac{\lambda}{d}$

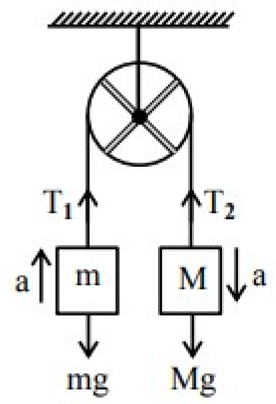
Q42 Solution:
(2)

$L = 52.01 + 153.2 + 0.123$

$= 205.333$

$= 205.3$

Q43 Solution:
(1)



$Mg - T_2 = Ma \quad ...(1)$

$T_1 - mg = ma \quad ...(2)$

$\left(T_2 - T_1\right)r = I\frac{a}{r} \quad ...(3)$

$(1) + (2) + (3)$

$\left(M - m\right)g = \left(M + m + \frac{I}{r^2}\right)a$

Here $I = Mr^2 + \frac{M \times (2r)^2}{12} \times 2$

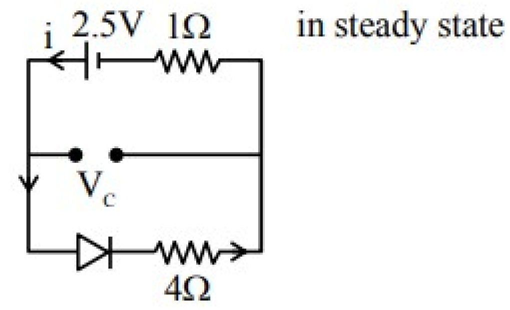
$= \left(1 + \frac{2}{3}\right)Mr^2$

$= \frac{5}{3}Mr^2$

$\left(M - m\right)g = \left[M + m + \frac{5M}{3}\right]a$

$a = \frac{(M - m)g}{\left[M + m + \frac{5M}{3}\right]}$

Q44 Solution:
(2)



$i = \frac{2.5}{5} = 0.5A$

$V_c = 4 \times 0.5$

$V_c = 2V$

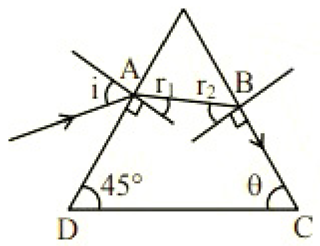
Charge

$Q = CV_c$

$= 5 \times 2$

$= 10\mu C$

Q45 Solution:
(4)



For grazing emergence

$\sin r_2 = \frac{1}{\mu}$

By Snell's Law at incident surface

$1 \times \frac{1}{\sqrt{2}} = \sqrt{2} \sin r_1$

$r_1 = 30°$

$r_1 + r_2 = A$

$A = 75°$

$75° + 45° + \theta = 180°$

$\theta = 60°$

Q46 Solution:
(5)

We know:

Terminal velocity $\propto$ (radius)^2

$\frac{(v_T)_1}{(v_T)_2} = \left(\frac{6}{3}\right)^2$

$(v_T)_2 = \frac{(v_T)_1}{4} = 5$ cm/sec

Q47 Solution:
(1800)

A

$j_c = \sigma E$

$E \Rightarrow E_0 \sin(\omega t - kx)$

$j_c = \sigma E_0 \sin(\omega t - kx)$

$\Rightarrow (j_c)_{\max} = \sigma E_0 \quad \ldots (\text{i})$

$J_d = \frac{i_d}{A} = \frac{1}{A} \times \varepsilon_0 \frac{AdE}{dt}$

$= \varepsilon_0 \times E_0 \omega \cos(\omega t - kx)$

$(j_d)_{\max} = \varepsilon_0 E_0 \omega \quad \ldots (\text{ii})$

(i)/(ii)

$\frac{(j_c)_{\max}}{(j_d)_{\max}} = \frac{\sigma E_0}{\varepsilon_0 \omega E_0} \Rightarrow \frac{\sigma}{\varepsilon_0 \omega}$

$\Rightarrow \frac{10 \times 4\pi \times 9 \times 10^9}{2\pi \times 100 \times 10^6}$

$\Rightarrow 1800$

Q48 Solution:
(10)

$\lambda = \frac{h}{\sqrt{2mqV}}$

$\lambda = \frac{6.6 \times 10^{-34}}{\sqrt{2 \times 18 \times 10^{-46} \times 1.21}}$

$\lambda = 10^{-11}\text{ m} = 10 \times 10^{-12}\text{ m}$

$\alpha = 10$

Q49 Solution:
(350)

$w = 100\text{ J} = nR\Delta T$ for isobaric process.

$Q = nC_p \Delta T = \left(\frac{f}{2} + 1\right) nR\Delta T$

$= \frac{7}{2} \cdot (100) = 350\text{ Joule}.$

Q50 Solution:
(14)

$y_{\text{shift}} = \frac{(\mu - 1) tD}{d}$

$209 \times 10^{-3} = \frac{(\mu - 1) \times 20 \times 10^{-6} \times 1}{0.4 \times 10^{-3}}$

$(\mu - 1) = 0.4$

$\mu = 1.4$

$\frac{\alpha}{10} = 1.4, \ \alpha = 14$

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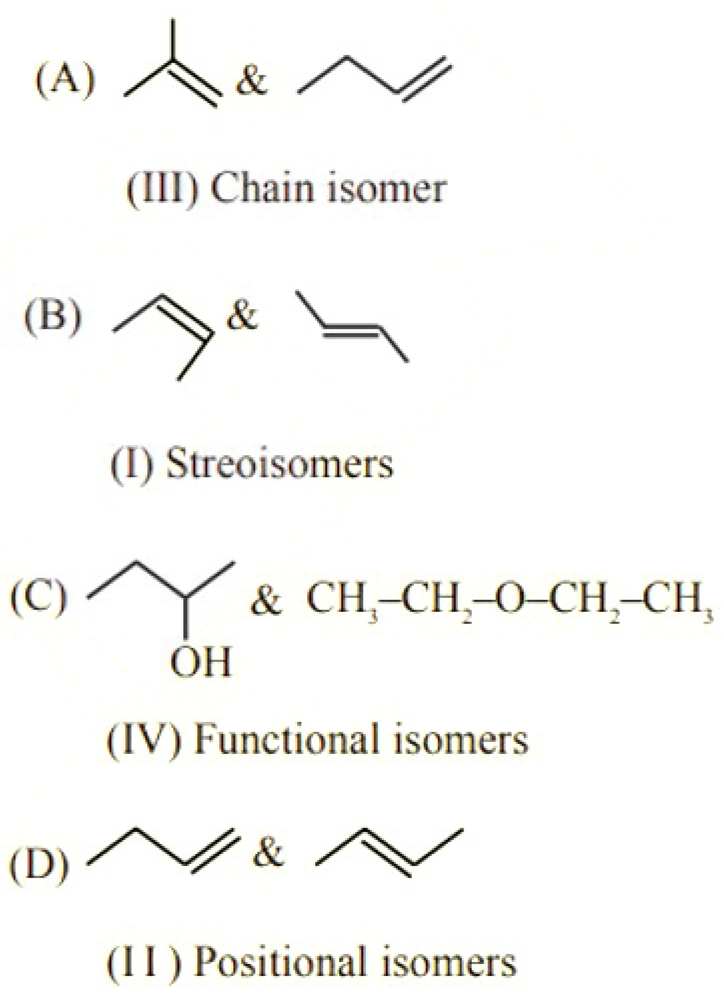
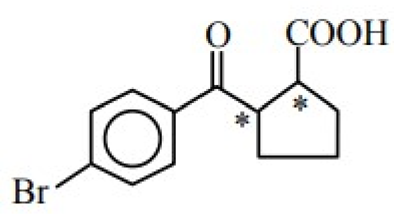
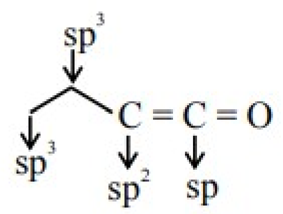
Q51 Solution:
(2)



Q52 Solution:
(3)



Two chiral centre and due to presence of –COOH compound dissolves in $NaHCO_3$.



Q53 Solution:
(4)

This is S_N1 reaction.

Rate of S_N1 reaction $\propto$ stability of carbocation

Q54 Solution:
(4)

$\left[Mn(H_2O)_6\right]^{2+}$ ⇒ CFSE value is zero because of d^5 configuration with WFL in coordination number 6 $\left[Cr(H_2O)_6\right]^{2+}$.

$\left[Cr\left(H_2O\right)_6\right]^{2+}$ ⇒ CFSE value is $-0.6\Delta_o$ because of d^4 configuration with WFL in coordination number 6.

For : $K_3\left[Fe\left(CN\right)_6\right]$, $\mu = \sqrt{1\left(1+2\right)} = \sqrt{3}$ B.M.

For : $Na_4\left[Fe\left(CN\right)_6\right]$, $\mu = \sqrt{0}$ B.M.

Q55 Solution:
(1)

$$\%\text{ of P} = \frac{n_{Mg_2P_2O_7} \times 2 \times 31}{W_{\text{(unknown compound)}}} \times 100$$

$$= \frac{\left(\frac{1.79}{222} \times 2 \times 31\right)}{1} \times 100$$

$$= 49.99\% \approx 50\%.$$

Q56 Solution:
(2)

Statement-I :

Bond energy order is $Cl_2 > Br_2 > F_2 > I_2$

Bond energy increases with increase in bond order.

Statement-II :

Correct order of covalent character

According to Fajan's rule, higher the charge on cation, greater is the covalent character.

$PbCl_2 < PbCl_4$,

$UF_6 > UF_4$,

$SnCl_4 > SnCl_2$

Q57 Solution:
(3)

$4NaCl + K_2Cr_2O_7 + 6H_2SO_4$

$$\longrightarrow 2KHSO_4 + \underset{\text{(Chromyl chloride)}}{2CrO_2Cl_2} + 4NaHSO_4 + 3H_2O$$

In Chromyl chloride Cr is in $+6$ oxidation state.

Q58 Solution:
(1)

$C\left(s\right) + 2H_2\left(g\right) \rightarrow CH_4\left(g\right)$

$-x = \left(\Delta H_{\text{sub}} \text{ of carbon}\right) + 2 \times \left(\text{B.E. of H-H}\right)$

$-4 \times \left(\text{B.E. of C-H}\right)$

$-x = y + 2z - 4\left(\text{B.E. of C-H}\right)$

B.E. of C-H $= \frac{y + 2z + x}{4}$

Q59 Solution:
(3)

Correct order of size is $Mg > Al > Mg^{2+} > Al^{3+}$

Atomic size depends mainly upon $Z_{\text{effective}}$ and shell number.

Generally on moving down the group electron affinity decreases

and on moving across the period electron affinity increases.

In the periodic table Cl has maximum electron affinity.

Halogen has higher electron affinity than Chalcogen.

$Cl > Br > S > O$

Q60 Solution:
(1)

NCERT Name reaction theory based

Q61 Solution:
(4)

A_g	$\rightarrow$	B_g	+	C_g
1		-		-
1 - P		P		P

$P_{\text{total}} = 1 + P$

$1.5 = 1 + P$

$P = 0.5$

$k = \frac{1}{100} \ln \frac{1}{0.5}$

$= \frac{0.693}{100}$

$= 6.9 \times 10^{-3}\ \text{min}^{-1}$

Q62 Solution:
(3)

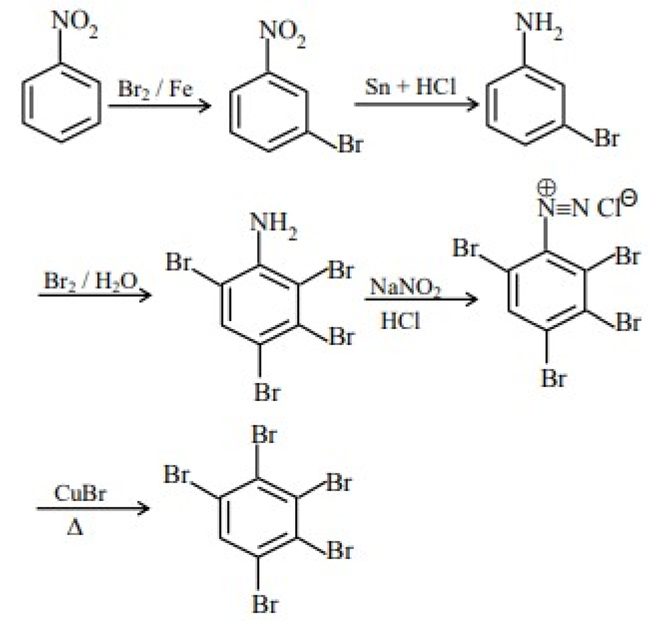
$MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$

$\frac{8.7}{87}$ Excess

$= 0.1$ mole 0.1 mole

Wt. of Cl_2 obtained $= 0.1 \times 71 = 7.1$ g

Q63 Solution:
(1)

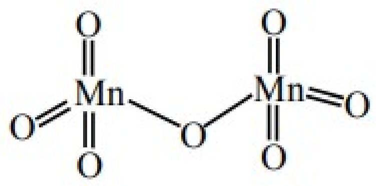


Number of Br atom in major product (P) = 5

Q64 Solution:

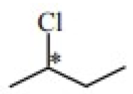
(4)

Mn_2O_7 : Mn in +7 oxidation state.



Q65 Solution:

(2)

 2-Chlorobutane is optically active and chiral molecule

Molecular formula $\Rightarrow C_4H_9Cl$

Molar mass $= 48 + 9 + 35.5 = 92.5$

$\% OC = \frac{48}{92.5} \times 100 = 51.89\%$

Q66 Solution:

(4)

C - H (A) 107 pm

C ≡ N (D) 116 pm

C - O (B) 143 pm

C = O (C) 121 pm

Q67 Solution:

(2)

$\Delta E = 13.6 \ Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$

	Series	n_1	n_2
A)	Paschen (1st line)	3	4
B)	Balmer (2nd line)	2	4
C)	Paschen (3rd line)	3	6
D)	Brackett (4th line)	4	8

So correct ascending order of energy of above lines is:

D < A < C < B

Q68 Solution:
(2)

E°_{cell} remain constant with time.

Q69 Solution:
(4)

Stability order of anion

$$ClO_4^- > CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-O^- > Ph\text{–}O^- > OH^- \text{ and}$$

nucleophlicity order reverse of stability of anion

$$OH^- > Ph\text{–}O^- > CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-O^- > ClO_4^-$$

Q70 Solution:
(4)

Activation energy for enzyme catalysed hydrolysis of sucrose is lower than that of acid catalysed hydrolysis.

During denaturation secondary and tertiary structure of a protein are destroyed but primary structure remains intact.

Q71 Solution:
(200)

$$E^{\circ}_{X^- / MX(s) / M} = E^{\circ}_{M^+ / M} + \frac{0.0591}{n}\log K_{sp}$$

$$= 0.79 + \frac{0.059}{1}\log\left(10^{-10}\right)$$

$$= 0.79 - 0.59$$

$$= 0.20\text{V} = 200\text{mV}$$

Q72 Solution:
(7)

$V^{3+} = (Ar)_{18} 3d^2$

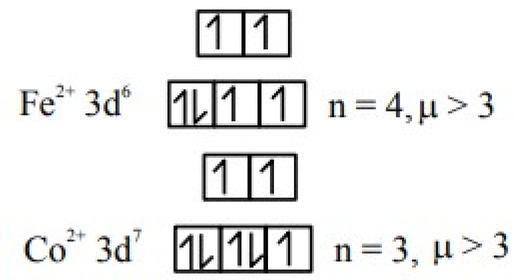
$Ti^{2+} = (Ar)_{18} 3d^2$

$Ni^{2+} = (Ar)_{18} 3d^8$

$Fe^{2+} = (Ar)_{18} 3d^6$

$Co^{2+} = (Ar)_{18} 3d^7$

Only for Fe^{2+} and Co^{2+}, μ is more than 3.0 B.M.



∴ Number of unpaired electrons = 4 + 3 = 7

Q73 Solution:
(100)

$$\begin{array}{cccccc} H_2X & \rightleftharpoons & H^+ & + & HX^- \\ 0.1 - x & & x + y & & x - y \end{array}$$

$$2.5 \times 10^{-8} = \frac{(x+y)(x-y)}{0.1 - x}$$

$$\begin{array}{cccccc} HX^- & \rightleftharpoons & H^+ & + & X^{2-} \\ x - y & & x + y & & y \end{array}$$

$$1 \times 10^{-13} = \frac{(x+y)(y)}{x - y}$$

Approximate : $K_{a1} \gg K_{a2} \Rightarrow$ So $x \gg y$

$x + y \approx x, \quad x - y \approx x$

$$10^{-13} = \frac{x \cdot y}{x}$$

$$y = 10^{-13}$$

$$\left[X^{2-}\right] = 10^{-13}$$

$$\left[X^{2-}\right] = 100 \times 10^{-15}$$

Q74 Solution:
(3)

$$\Delta T_b = i \times K_b \times m$$

$$0.5 = i \times m \times 5$$

$$i \times m = \frac{0.5}{5} = 0.1$$

$$i \times a = \frac{15}{1000}$$

(where a = moles of solute)

Now,

$$\frac{P^\circ - P_s}{P^\circ} = iX_{\text{solute}} = i \times \frac{a}{a + \frac{150}{300}}$$

$$= i \times \frac{a}{\frac{1}{2}} = \frac{15/1000}{1/2} = \frac{30}{1000} = 3 \times 10^{-2} = 3$$

Q75 Solution:
(15)

$$\pi = iCRT$$

$$12 = 2 \times C \times 0.08 \times 300$$

$12 = 2 \times C \times 24$

$C = \frac{1}{4}$ mole/L

then strength of NaCl solution

$= \frac{1}{4} \times 58.5$ g/L

$= 14.625$ g/L

≈ 15 g/L