1 - JEE Main Maths 24-Jan 2026 Shift -1

Q1 Solution:
(2)

$\frac{1}{26!}\left(\frac{26!}{25!1!}+\frac{26!}{3!23!}+\frac{26!}{5!21!}+\cdots+13\text{ terms}\right)$

$=\frac{1}{26!}\left({}^{26}C_1+{}^{26}C_3+{}^{26}C_5+\cdots+13\text{ terms}\right)$

$=\frac{1}{26!}\left({}^{26}C_1+{}^{26}C_3+{}^{26}C_5+\cdots+{}^{26}C_{25}\right)$

$\Rightarrow S=\frac{1}{26!}\times 2^{25}$

$\Rightarrow 13S=\frac{2^{24}}{25!}$

so $n+k=25+24=49$

Q2 Solution:
(3)

$\vec{c}=\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ 2 & 1 & -2\\ 1 & 1 & 0\end{vmatrix}$

$\vec{c}=2\hat{i}+2\hat{k}+\hat{k},\quad |\vec{c}|=3$

$\left|\vec{c}\times\vec{d}\right|=3$

$\left|\vec{c}\right|\left|\vec{d}\right|\sin\frac{\pi}{4}=3\Rightarrow\left|\vec{d}\right|=\sqrt{2}$

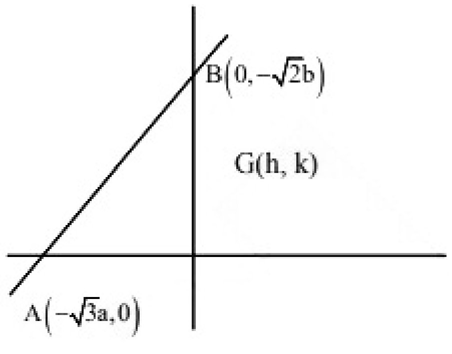
$\left|\vec{d}-\vec{a}\right|=\sqrt{11}$

$\Rightarrow |\vec{a}|^2+|\vec{d}|^2-2\vec{a}\cdot\vec{d}=11$

$9+2-2\vec{a}\cdot\vec{d}=11$

$\vec{a}\cdot\vec{d}=0$

Q3 Solution:
(2)



$AB=8$

$3a^2+2b^2=64$

Centroid $G\,(h,k)$

$h=-\frac{\sqrt{3}a}{3},\ k=-\frac{\sqrt{2}b}{3}$

$a = -\sqrt{3}h,\ \ b = -\frac{3}{\sqrt{2}}k$

$9h^2 + 9k^2 = 64$

$x^2 + y^2 = \frac{64}{9}$

$r = \frac{8}{3}$

Q4 Solution:
(2)

Solving $\left|\frac{z-6i}{z-2i}\right| = 1 \Rightarrow y = 4 \quad \cdots (1)$

(where $z = x + iy$)

Now solving $\left|\frac{z-8+2i}{z+2i}\right| = \frac{3}{5}$

$\Rightarrow x^2 + y^2 - 25x + 4y + 104 = 0 \quad \cdots (2)$

Solving (1) & (2) $\Rightarrow z = 17 + 4i$ & $8 + 4i$

$\Rightarrow \sum |z|^2 = (17)^2 + (4)^2 + (8)^2 + (4)^2 = 385$

Q5 Solution:
(1)

$\cot x = \frac{5}{12} \Rightarrow \cos x = -\frac{5}{13} = 2\cos^2\frac{x}{2} - 1$

$\cos\left(\frac{x}{2}\right) = -\frac{2}{\sqrt{13}}$ or $\frac{2}{\sqrt{13}}$ (rejected)

$\left\{\because \frac{x}{2} \in \left(\frac{\pi}{2}, \frac{3\pi}{4}\right)\right\}$

$\left(\sin 7x \cdot \frac{\sin 13x}{2} + \cos 7x \cdot \frac{\cos 13x}{2}\right) + \left(\sin 7x \cdot \frac{\cos 13x}{2} - \cos 7x \cdot \frac{\sin 13x}{2}\right)$

$= \cos\left(7x - \frac{13x}{2}\right) + \sin\left(7x - \frac{13x}{2}\right)$

$= \cos\frac{x}{2} + \sin\frac{x}{2}$

$= -\frac{2}{\sqrt{13}} + \frac{3}{\sqrt{13}} = \frac{1}{\sqrt{13}}$

Q6 Solution:
(4)

(a, b)	(c, d)
(1, 1)	×
(1, 2)	×
(1, 3)	(1, 2)
(1, 4)	(2, 2)
(2, 1)	(1, 1)
(2, 2)	(2, 1)
(2, 3)	(3, 1)
(2, 4)	(4, 1)
(3, 1)	×
(3, 2)	×
(3, 3)	(1, 3)
(3, 4)	(2, 3)

(4, 1) (1, 2)
(4, 2) (2, 2)
(4, 3) (3, 2)
(4, 4) (4, 2)

Q7 Solution:
(3)

For POI

$2\lambda + 1 = 5\mu + 4;\ \ 3\lambda + 2 = 2\mu + 1;\ \ 4\lambda + 3 = \mu$

$\Rightarrow \lambda = \mu = -1$

$R(-1, -1, -1),\ P(2\lambda + 1, 3\lambda + 2, 4\lambda + 3)$

$PR^2 = 29 \Rightarrow (2\lambda + 2)^2 + (3\lambda + 3)^2 + (4\lambda + 4)^2 = 29$

$\Rightarrow \lambda = 0 \text{ or } \lambda = -2\ (\text{Reject})$

$\Rightarrow P(1, 2, 3)$

$Q(5\mu + 4, 2\mu + 1, \mu)$

$|PQ| = \sqrt{\frac{47}{3}} \Rightarrow PQ^2 = \frac{47}{3}$

$\Rightarrow (5\mu + 3)^2 + (2\mu - 1)^2 + (\mu - 3)^2 = \frac{47}{3}$

$\Rightarrow \mu = -\frac{1}{3}$

$Q = \left(\frac{7}{3}, \frac{1}{3}, -\frac{1}{3}\right)$

$(QR)^2 = \left(\frac{7}{3} + 1\right)^2 + \left(\frac{1}{3} + 1\right)^2 + \left(-\frac{1}{3} + 1\right)^2$

$= \frac{100 + 16 + 4}{9} = \frac{120}{9}$

$\Rightarrow 27 \times (QR)^2 = 27 \times \frac{120}{9} = 360$

Q8 Solution:
(4)

$f(x) = \begin{cases} 2\alpha x^2 + 2\beta x - 4\alpha, & x < 1 \\ (\alpha + 3)x + \alpha - \beta, & x \geq 1 \end{cases}$

$f(1^+) = 2\alpha - \beta + 3,\ f(1^-) = -2\alpha + 2\beta$

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

$f'(1^+) = 4\alpha + 2\beta,\ f'(1^-) = \alpha + 3$

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

Solving (1) & (2)

We get $\alpha = \frac{3}{17},\ \beta = \frac{21}{17}$

$\Rightarrow 34(\alpha + \beta) = 34 \times \frac{27}{17} = 48$

Q9 Solution:

(1)

$18x^2 - 11x + 1 > 0$

$(2x - 1)(9x - 1) > 0$

$x < \frac{1}{9}$ or $\frac{1}{2} < x$

Also $10x^2 - 17x + 7 > 0$

$(x - 1)(10x - 7) > 0$

$x < \frac{7}{10}$ or $1 < x$

and $10x^2 - 17x + 7 \neq 1$

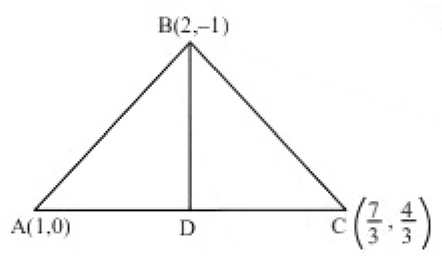
$x \in \left(-\infty, \frac{1}{9}\right) \cup \left(\frac{1}{2}, \frac{7}{10}\right) \cup \left(1, \infty\right) - \left\{\frac{6}{5}\right\}$

$90\left(a + b + c + d + e\right) = 90\left(\frac{1}{9} + \frac{1}{2} + \frac{7}{10} + 1 + \frac{6}{5}\right)$

$= 10 + 45 + 63 + 90 + 108 = 316$

Q10 Solution:

(1)



$\frac{BD}{DC} = \frac{AB}{AC} = \frac{\sqrt{2} \times 3}{5\sqrt{2}} = \frac{3}{5}$

$D = \left(\frac{12}{8}, \frac{4}{8}\right) = \left(\frac{3}{2}, \frac{1}{2}\right)$

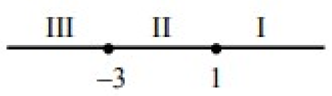
Slope of $AD = \frac{-3/2}{1/2} = -3$

$3x + y = 5$

$\alpha = 3,\ \beta = 1;\ \ \alpha^2 + \beta^2 = 10$

Q11 Solution:

(1)



(I)

$x^2 + 3x + x - 1 - 2 = 0$

$x^2 + 4x - 3 = 0$

$x = -2 + \sqrt{7}$ (rejected), $-2 - \sqrt{7}$ (rejected)

(II)

$x^2 + 3x + 1 - x - 2 = 0$

$x^2 + 2x - 1 = 0$

$x = -1 + \sqrt{2}, \ -1 - \sqrt{2}$

(III)

$-x^2 - 3x + 1 - x - 2 = 0$

$x^2 + 4x + 1 = 0$

$x = -2 - \sqrt{3}, \ -2 + \sqrt{3} \ (\text{rejected})$

Q12 Solution:
(1)

10 defective & 90 non-defective

Req. probability $= (7 \text{ defective \& } 1 \text{ fair}) \text{ or } (8 \text{ defective})$

Req. probability $= \frac{(10^7 \times 90) \times 8 + 10^8}{100^8}$

$= \frac{72 \times 10^8 + 10^8}{100^8} = \frac{73}{10^8}$

Q13 Solution:
(4)

Let first 10 numbers are $x_1, x_2, \ldots, x_9, \alpha$

$\Rightarrow \alpha + \sum_{i=1}^{9} x_i = 100 \Rightarrow \sum_{i=1}^{9} x_i = 100 - \alpha$

Variance $= \left(\frac{\sum x_i^2}{n}\right) - \left(\frac{\sum x_i}{n}\right)^2$

$\Rightarrow \frac{\sum x_i^2}{n} = 98$

$\Rightarrow x_1^2 + x_2^2 + \cdots + x_9^2 + \alpha^2 = 1020 \Rightarrow \sum x_i^2 = 1020 - \alpha^2$

In second case, let numbers are $x_1, x_2, \ldots, x_9, \beta$

$100 - \alpha + \beta = 101 \Rightarrow \alpha - \beta + 1 = 0$

$\frac{\sum x_i^2 + \beta^2}{10} - (10.1)^2 = 1.99$

$\Rightarrow \beta^2 - \alpha^2 = 20$

$\alpha = \frac{19}{2}, \ \beta = \frac{21}{2}$

$\alpha + \beta = \frac{19 + 21}{2} = 20$

Q14 Solution:
(1)

$E = \frac{\frac{\sqrt{3}}{\sin 20°} - \frac{1}{\cos 20°}}{\frac{1}{2} \cdot \frac{1}{4} \cdot \cos 60°}$

$= \frac{\sqrt{3}\cos 20° - \sin 20°}{\cos 20° . \sin 20°} \cdot 16$

$= \frac{\left(\frac{\sqrt{3}}{2}\cos 20° - \frac{1}{2}\sin 20°\right) 32 \times 2}{2\cos 20° . \sin 20°}$

$= \frac{\sin 40°}{\sin 40°} \times 64 = 64$

Q15 Solution:
(4)

$S_n = \frac{n}{2}\left(a_1 + a_n\right) = \frac{525}{2},\ d = \frac{-3}{4}$

$\frac{n}{2}\left[a_1 + \frac{a_1}{4}\right] = \frac{525}{2}$

$\frac{5a_1 n}{4} = 525$

$a_1 n = 420$

$a_n = a_1 + \left(n - 1\right)\left(\frac{-3}{4}\right)$

$\Rightarrow \frac{-3}{4}a_1 = \left(\frac{-3}{4}\right)\left(n - 1\right) \Rightarrow a_1 = n - 1$

$n(n - 1) = 420$

$n^2 - n - 420 = 0$

$(n - 21)(n + 20) = 0$

$n = 21,\ a_1 = 20$

$\sum_{i=1}^{17} a_i = \frac{17}{2}\left[2a_1 + 16d\right]$

$= \frac{17}{2}\left[40 + 16\left(\frac{-3}{4}\right)\right]$

$= \frac{17}{2}\left[40 - 12\right]$

$= 17 \times 14 = 238$

Q16 Solution:
(4)

$P_n = 729 \cdot 81 \cdot 9 \quad \ldots \quad \left(\text{n terms}\right)$

$= 3^6 \cdot 3^4 \cdot 3^2 \quad \ldots \quad 3^{-2n+8}$

$P_n = 3^{6+4+2+\cdots+(-2n+8)} = 3^{n(7-n)}$

$P_n^{1/n} = 3^{7-n}$

$\Rightarrow \sum_{n=1}^{40} (P_n)^{1/n} = 3^6 + 3^5 + \cdots \quad \left(40 \text{ terms}\right)$

$= 3^6\left[\frac{1 - \left(\frac{1}{3}\right)^{40}}{1 - \frac{1}{3}}\right]$

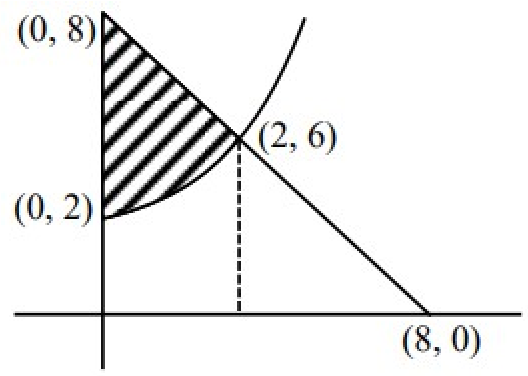
$= 3^6 \frac{\left[3^{40} - 1\right] \times 3^1}{3^{40} \times 2}$

$\sum (P_n)^{1/n} = \frac{\left(3^{40} - 1\right)}{2 \times 3^{33}},$

$\alpha = 40,\ \beta = 33$

$\alpha + \beta = 73$

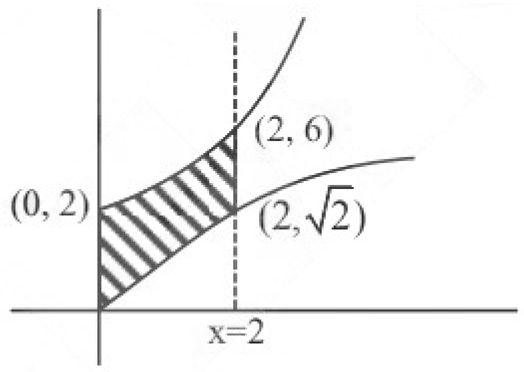
Q17 Solution:
(4)



$A_1 = \int_0^2 \left(\left(8 - x \right) - \left(x^2 + 2 \right) \right) dx$

$= \int_0^2 \left(6 - x - x^2 \right) dx$

$A_1 \left(6x - \frac{x^2}{2} - \frac{x^3}{3} \right)_0^2 = 12 - 2 - \frac{8}{3} = 10 - \frac{8}{3} = \frac{22}{3}$



$A_2 = \int_0^2 \left(x^2 + 2 \right) dx - \frac{2}{3}\left(2\sqrt{2} \right)$

$A_2 = \left(\frac{x^3}{3} + 2x \right)_0^2 - \frac{4\sqrt{2}}{3}$

$A_2 = \frac{8}{3} + 4 - \frac{4\sqrt{2}}{3} = \frac{20}{3} - \frac{4\sqrt{2}}{3}$

$A_1 - A_2 = \frac{2}{3} + \frac{4\sqrt{2}}{3}$

Q18 Solution:
(2)

$f\left(0 \right) = \lim_{x \to 0} \frac{e^{\tan x} - e^x + ln\left(\sec x + \tan x \right) - x}{\tan x - x}$

Applying L'Hospital rule

$\Rightarrow f\left(0 \right) = \lim_{x \to 0} \frac{e^{\tan x} . \sec^2 x - e^x + \sec x - 1}{\sec^2 x - 1}$

$\Rightarrow f\left(0 \right) = \lim_{x \to 0} \frac{e^{\tan x}\left(\sec^2 x - 1 \right) + \left(e^{\tan x} - e^x \right) + \sec x - 1}{\tan^2 x}$

$\Rightarrow f\left(0 \right) = \lim_{x \to 0} \left(e^{\tan x} + \frac{e^x\left(e^{\tan x - x} - 1 \right)}{\tan^2 x} + \frac{1}{\sec x + 1} \right)$

$\Rightarrow f\left(0 \right) = 1 + 0 + \frac{1}{2} = \frac{3}{2}$

Q19 Solution:
(1)

$f\left(t \right) = \int \frac{1 - \sin(\ln t)}{1 - \cos(\ln t)} dt$

Let $\ln t = x \Rightarrow t = e^x \Rightarrow dt = e^x dx$

$= \frac{1}{2} \int \left(cosec^2 \frac{x}{2} - 2\cot \frac{x}{2} \right) e^x dx - t\cot\left(\frac{\ln t}{2} \right) + C$

$\left(\because \int \left(f\left(x\right)+f'\left(x\right)\right)e^{x}dx=f\left(x\right).e^{x}+C\right)$

Now $f\left(e^{\pi/2}\right) = -e^{\pi/2}\cot\left(\frac{\pi}{4}\right)+C = -e^{\pi/2}$ (given)

$\Rightarrow C=0$

Now $f\left(e^{\pi/4}\right) = -e^{\pi/4}\cot\left(\frac{\pi}{8}\right)+C = -e^{\pi/4}\left(\sqrt{2}+1\right)$

Q20 Solution:
(4)

$2ae=8 \Rightarrow a=5$

$b^2=a^2\left(1-e^2\right)$

$b^2=a^2\times\frac{9}{25} \Rightarrow b^2=9$

$E_1: \frac{x^2}{25}+\frac{y^2}{9}=1$

$\ell_1: \frac{2b^2}{a}=\frac{2\times 9}{5}=\frac{18}{5}$

$A^2=B^2\left(1-e^2\right) \Rightarrow A^2=\frac{9}{25}B^2 \Rightarrow A=\frac{3}{5}B$

$2\ell^2=9\ell_2 \Rightarrow 2\left(\frac{18}{5}\right)^2=9\ell_2 \Rightarrow \ell_2=\frac{4\times 18}{25}$

$\frac{2A^2}{B}=\frac{72}{25} \Rightarrow A^2=\frac{36}{25}B$

$\frac{9}{25}B^2=\frac{36}{25}B \Rightarrow B=4$

Distance between foci $=2Be=2\times\frac{4}{5}\times 4=\frac{32}{5}$

Q21 Solution:
(64)

$\int_0^{36} f\left(\frac{tx}{36}\right)dt=4\alpha f\left(x\right)$, Put $\frac{tx}{36}=y$

$\frac{dy}{dt}=\frac{x}{36}$

$\int_0^{x}\frac{f(y)36dy}{x}=4\alpha f\left(x\right)$

$\int_0^{x} f\left(y\right)dy=\frac{\alpha f(x)x}{9}$

$f\left(x\right)=\frac{\alpha}{9}\left(f\left(x\right)+xf'\left(x\right)\right)$

$\left(1-\frac{\alpha}{9}\right)f\left(x\right)=\frac{\alpha x}{9}f'\left(x\right) \Rightarrow (9-\alpha)f(x)=\alpha xf'(x)$

$\frac{f'(x)}{f(x)}=\left(\frac{9}{\alpha}-1\right)\frac{1}{x}$

$\log_e f\left(x\right)=\left(\frac{9}{\alpha}-1\right)\log_e x+\log_e c$

$f\left(x\right)=cx^{\left(\frac{9}{\alpha}-1\right)}$ For standard parabola,

$\frac{9}{\alpha}-1=2$

$\alpha=3$

$f(x)=cx^2$

Passing through $(2, 1)$

$1 = 4c \Rightarrow c = \frac{1}{4}$

$y = \frac{x^2}{4}$ passing through $(-4, \beta)$

$\beta = 4$

$\beta^x = 4^3 = 64$

Q22 Solution:
(312)

$$\begin{pmatrix} a_1 & b_1 \\ a_2 & b_2 \\ a_3 & b_3 \end{pmatrix}_{3\times 2}$$

$$A^T A = \begin{pmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \end{pmatrix}_{2\times 3} \begin{pmatrix} a_1 & b_1 \\ a_2 & b_2 \\ a_3 & b_3 \end{pmatrix}_{3\times 2}$$

$$= \begin{pmatrix} a_1^2 + a_2^2 + a_3^2 & \cdots \\ \cdots & b_1^2 + b_2^2 + b_3^2 \end{pmatrix}$$

$\text{Tr}(A^T A) = a_1^2 + a_2^2 + a_3^2 + b_1^2 + b_2^2 + b_3^2 = 5$

$\{2, 1, 0, 0, 0, 0\}$

$\{2, -1, 0, 0, 0, 0\}$

$\{-2, 1, 0, 0, 0, 0\}$

$\{-2, -1, 0, 0, 0, 0\}$

$\{1, 1, 1, 1, 1, 0\}$

No. of ways $= \frac{6!}{4!} \times 4 + 2 \times \frac{6!}{5!} + 2 \times \frac{6!}{4!} + 2 \times \frac{6!}{3!2!}$

$= \frac{6!}{3!} + 2 \times 6 \times 2 + 2 \times 15 \times 2 \times \frac{6!}{3!}$

$= 120 + 120 + 12 + 60 = 312$

Q23 Solution:
(42)

(1) all different

5, 0, 1, 9 $\Rightarrow {}^4C_3 = 6$ ways

(2) 2 alike, 2 different

5, 0, 0, 1 $\Rightarrow$ 3 ways

5, 1, 1, 2 $\Rightarrow$ 3 ways

5, 2, 2, 0 $\Rightarrow$ 3 ways

5, 2, 2, 9 $\Rightarrow$ 3 ways

5, 5, 0, 2 $\Rightarrow$ 6 ways

$5, 5, 2, 9 \Rightarrow 6$ ways

$5, 1, 9, 9 \Rightarrow 3$ ways

(3) 3 alike, 1 different

$5, 5, 5, 0 \Rightarrow 3$ ways

$5, 5, 5, 9 \Rightarrow 3$ ways

(4) 2 alike, 2 other alike

$5, 5, 1, 1 \Rightarrow 3$ ways

Total ways $= 42$

Q24 Solution:
(6)

$d_1 = \langle 4, 1, 1 \rangle$ and $d_2 = \langle 1, 1, 0 \rangle$

$$d_L = d_1 \times d_2 = \begin{vmatrix} i & j & k \\ 4 & 1 & 1 \\ 1 & 1 & 0 \end{vmatrix} = \langle -1, 1, 3 \rangle$$

Line L passes through $P\langle 1, 1, 1 \rangle$ with direction $d_L = \langle -1, 1, 3 \rangle$

$r(t) = \langle 1, 1, 1 \rangle + t\langle -1, 1, 3 \rangle = \langle 1 - t, 1 + t, 1 + 3t \rangle$

For point Q, $\quad x = 0 \Rightarrow t = 1$

$Q = \langle 0, 2, 4 \rangle$

Another line parallel to L passes through $S\langle 1, 0, -1 \rangle$

$r'(\mu) = \langle 1, 0, -1 \rangle + \mu\langle -1, 1, 3 \rangle = \langle 1 - \mu, \mu, -1 + 3\mu \rangle$

For point R, $x = 0 \Rightarrow \mu = 1$

$R = \langle 0, 1, 2 \rangle$

Area of parallelogram with adjacent vectors $\overrightarrow{PQ}$ and $\overrightarrow{PS}$

$\overrightarrow{PQ} = \left\langle -1, 1, 3 \right\rangle$

$\overrightarrow{PS} = \left\langle 0, -1, -2 \right\rangle$

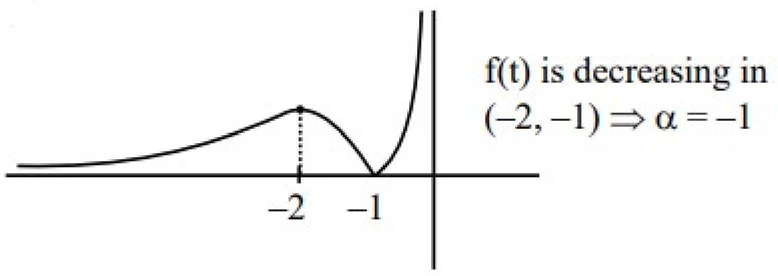
Area of parallelogram

$$\overrightarrow{PQ} \times \overrightarrow{PS} = \begin{vmatrix} i & j & k \\ -1 & 1 & 3 \\ 0 & -1 & -2 \end{vmatrix} = \langle 1, -2, 1 \rangle$$

Area $= \sqrt{1^2 + (-2)^2 + 1^2} = \sqrt{6}$

Q25 Solution:
(4)

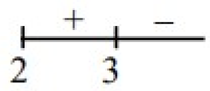
Drawing graph of $f(t)$ for $t < 0$



$g(x) = \log_e(x-2) - x^2 + 4x + 1,\ \ x > 2$

$g'(x) = \frac{2}{x-2} - 2(x-2),\ \ x > 2$

$g'(x) = \frac{1-(x-2)^2}{x-2} = \frac{-(x-3)(x-1)}{x-2}$



as $x > 2$

maxima occur at $x = 3$

$g(3) = 2\log_e 1 - 9 + 12 + 1 = 4$

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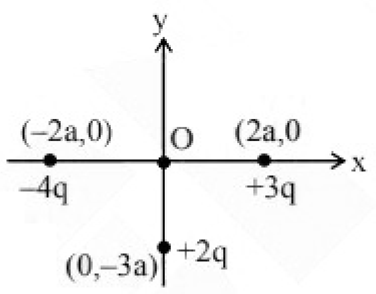
Q26 Solution:
(1)

Brewster's law

$\tan\theta = \mu_{\text{rel}} = \sqrt{3}$

$\theta = 60°$

Q27 Solution:
(2)

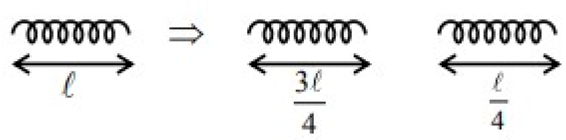


$\vec{p} = q_1\vec{r}_1 + q_2\vec{r}_2 + q_3\vec{r}_3$

$\vec{p} = (2q)(-3a)\hat{j} + (3q)(2a)\hat{i} + (-4q)(-2a)\hat{i}$

$\vec{p} = 2qa(7\hat{i} - 3\hat{j})$

Q28 Solution:
(2)



$K\ell = \text{constant}$

$K\ell = K'\left(\frac{\ell}{4}\right)$

$K' = 4K$

$K' = 60\text{N/m}$

Q29 Solution:
(4)

Magnetic induction

$\text{F} = \text{qvB}$

$[B] = \left[\frac{F}{qv}\right]$

$[B] = [MT^{-2}A^{-1}]$

Magnetic Flux (ϕ)

$\phi = (B) \cdot (\text{Area})$

$[\phi] = [ML^2T^{-2}A^{-1}]$

Magnetic Permeability

$[\mu] = [MLT^{-2}A^{-2}]$

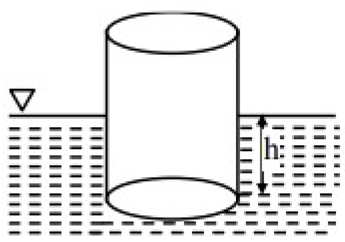
Self inductance

Using $U = \frac{1}{2}LI^2$

$[\text{Self inductance}] = [ML^2T^{-2}A^{-1}]$

A - III, B - IV, C - I, D - II

Q30 Solution:
(4)



At equilibrium

$\rho Ahg = Mg$

After displacing by x,

$Ma = -\rho A(h + x)g + Mg$

$Ma = -\rho Ahg - \rho Axg + Mg$

$Ma = -\rho Axg$

$a = \left(\frac{-\rho Ag}{M}\right)x$

on comparing with,

$a = -\omega^2 x$

$\omega = \sqrt{\frac{\rho Ag}{M}}$

$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{M}{\rho Ag}}$

Q31 Solution:
(4)

$f_o = 2\text{cm},\ f_e = 5\text{cm}$

$\ell = 10\text{cm},\ D = 25\text{cm}$

$M = \frac{\ell}{f_o} \cdot \frac{D}{f_e} = 25$

Q32 Solution:
(4)

Initially, $\frac{2}{3} = \frac{x}{100 - x}$

$\Rightarrow x = 40\text{cm}$

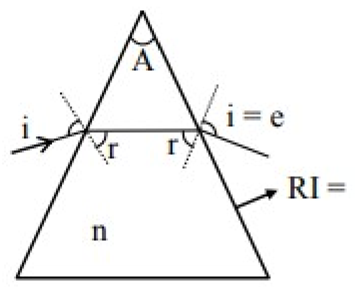
Now when R connected in parallel

$\frac{2}{\frac{3R}{3+R}} = \frac{40 + 22.5}{60 - 22.5} = \frac{62.5}{37.5}$

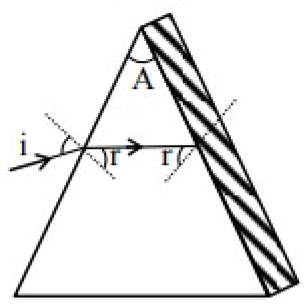
$\therefore R = 2\Omega$

Q33 Solution:
(3)

$i = e\ \&\ r = \frac{A}{2}$ for minimum deviation



For TIR ; $r = \theta_c$



$\sin r = \sin\theta_c$

$\sin r = \frac{n/2}{n}$

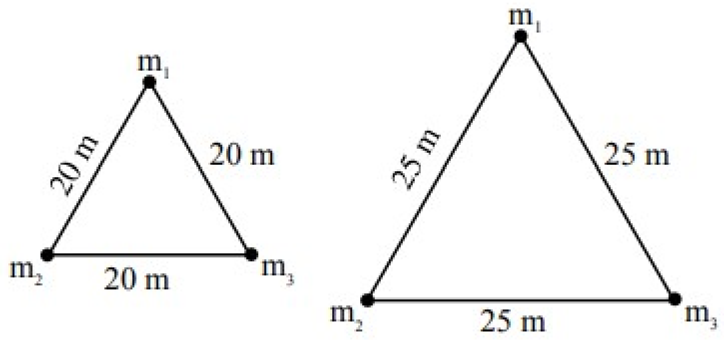
$\sin r = \frac{1}{2}$

$\sin\frac{A}{2} = \sin 30°$

$\frac{A}{2} = 30°$

$A = 60°$

Q34 Solution:
(2)



Work done by external agent:

$W_{\text{ext}} = \Delta U$

$U_i = -\frac{Gm_1m_2}{r_i} - \frac{Gm_2m_3}{r_i} - \frac{Gm_1m_3}{r_i} : r_i = 20\text{m}$

$U_f = -\frac{Gm_1m_2}{r_f} - \frac{Gm_2m_3}{r_f} - \frac{Gm_1m_3}{r_f} : r_f = 25\text{m}$

$U_i = \frac{-6.67 \times 10^{-11}}{20}\left[200 \times 300 + 300 \times 400 + 200 \times 400\right]$

$= \frac{-6.67 \times 10^{-11}}{20} \times 26 \times 10^4 = -86.71 \times 10^{-8}\text{J}$

$U_f = \frac{-6.67 \times 10^{-11}}{25}\left[200 \times 300 + 300 \times 400 + 200 \times 400\right]$

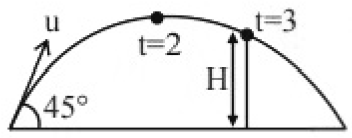
$= \frac{-6.67 \times 10^{-11}}{25} \times 26 \times 10^4 = -693.68 \times 10^{-9}$

$= -69.36 \times 10^{-8}\text{J}$

$\Delta U = U_f - U_i = 1.74 \times 10^{-7}\text{J}$

Q35 Solution:
(2)

$T = \frac{2u_y}{g} = 4$



$\Rightarrow u_y = \frac{40}{2} = 20\text{m/s}$

$y = u_y \Delta t - \frac{1}{2}g(\Delta t)^2$

$\Rightarrow H = 20 \times 3 - 5 \times 9$

$= 60 - 45$

$= 15\text{m}$

Q36 Solution:
(3)

Radio wave ⇒ Produced by rapid acceleration of electrons
Microwave ⇒ By magnetron valve
Infrared wave ⇒ Change in vibrational modes
X ray ⇒ Transition of inner shell electrons from high energy level to low energy level.

A – IV, B – I, C – II, D – III

Q37 Solution:
(4)

$\text{Power factor} = \frac{R}{Z}$

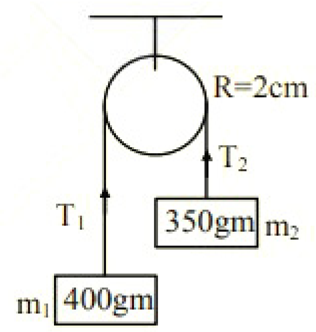
$Z = \sqrt{R^2 + \left(X_L - X_C\right)^2}$

$= \sqrt{60^2 + (150 - 70)^2} = 100\Omega$

$\therefore \text{Power factor} = \frac{60}{100} = \frac{6}{10}$

Then $a = 6$

Q38 Solution:
(3)



$S = ut + \frac{1}{2}at^2$

$a = \frac{2s}{t^2} = \frac{2 \times 0.81}{81} = 0.02\,\text{m/s}^2$

$m_1 g - T_1 = m_1 a$

$T_2 - m_2 g = m_2 a$

$\left(T_1 - T_2\right)R = I \cdot \frac{a}{R}$

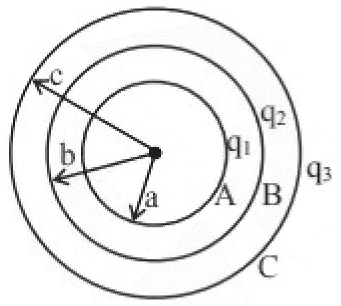
$\therefore a = \frac{\left(m_1 - m_2\right)g}{m_1 + m_2 + \frac{I}{R^2}}$

$0.02 = \frac{\left(400 - 350\right)\left(10^{-3}\right)g}{\left(400 + 350\right)\left(10^{-3}\right) + \frac{I}{R^2}}$

$\frac{I}{R^2} = \frac{50 \times 10^{-3} g}{0.02} - 750 \times 10^{-3} = 23.75$

$I = 23.75 \times 4 \times 10^{-4} = 9.5 \times 10^{-3}\,\text{kg m}^2$

Q39 Solution:
(2)



$V_A = \frac{Kq_1}{a} + \frac{Kq_2}{b} + \frac{Kq_3}{c} = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{a} + \frac{q_2}{b} + \frac{q_3}{c}\right)$

$V_B = \frac{Kq_1}{b} + \frac{Kq_2}{b} + \frac{Kq_3}{c} = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1 + q_2}{b} + \frac{q_3}{c}\right)$

$V_C = \frac{Kq_1}{c} + \frac{Kq_2}{c} + \frac{Kq_3}{c} = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1 + q_2 + q_3}{c}\right)$

Q40 Solution:
(3)

$T = \alpha YA(27 - (-43))$ ...(i)

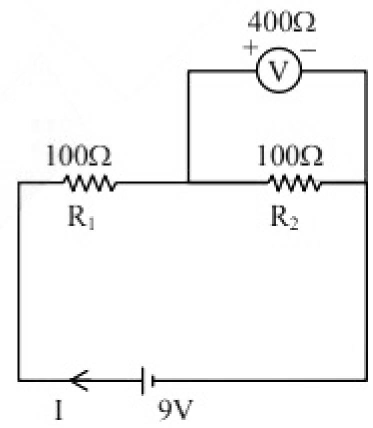
$1.4T = \alpha YA(27 - \theta)$ ...(ii)

Using (ii)/(i):

$1.4 = \frac{27 - \theta}{70}$

$27 - \theta = 98 \therefore \theta = -71°\text{C}$

Q41 Solution:
(1)



Current in circuit

$I = \frac{E}{R_{\text{eq}}}$

$R_{\text{eq}} = 100 + \frac{400 \times 100}{400 + 100} = 180\Omega$

$\therefore I = \frac{9}{180} = \frac{1}{20}\text{A}$

Reading of voltmeter $= V = I \times 80 = \frac{1}{20} \times 80 = 4\text{V}$

Q42 Solution:
(2)

$V \propto \frac{Z}{n}$

$r \propto \frac{n^2}{Z}$

Thus, $r \propto \frac{n}{V}$

Radii are same then

$\frac{n_1}{V_1} = \frac{n_2}{V_2}$

$\frac{n_1}{n_2} = \frac{3 \times 10^5}{2.5 \times 10^5} = \frac{6}{5}$

Possible order is 6 and 5

Q43 Solution:
(1)

$V = ar^3 + b$

$E = -\frac{dV}{dr} = -3ar^2$

$\phi_{\text{closed}} = \frac{q_{\text{enc}}}{\varepsilon_0}$

$q_{\text{enc}} = \varepsilon_0 \cdot E \cdot A$

$= \varepsilon_0 \left(-3a \cdot (1)^2 \right) \ 4\pi (1)^2$

$= -12\pi a \varepsilon_0$

$\therefore x = -12$

Q44 Solution:
(3)

Theoretical

Q45 Solution:
(4)

$Q = ms\Delta T = 4 \times 4200 \times 16\text{J} = 268800\text{J}$

$W = P\Delta V$

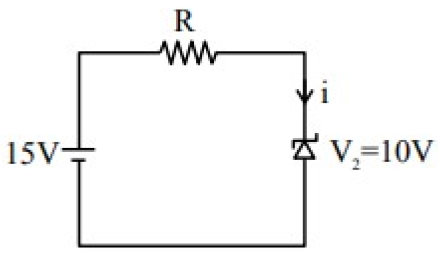
$\Delta V = \left(\frac{m}{\rho_f} - \frac{m}{\rho_i} \right) = 4\left[\frac{1}{998} - \frac{1}{1000} \right]$

$P = 10^5 \text{Pa}$

$\therefore W = 10^5 \times 4\left[\frac{1}{998} - \frac{1}{1000} \right] = \frac{8 \times 10^5}{10^3 \times 998} \approx 0.8\text{J}$

$\Delta U = Q - W = 268799.2\text{J}$

Q46 Solution:
(125)



$P_D = 0.4\text{W} = 10i$

$i = 0.04\text{A}$

$R = \frac{15 - 10}{0.04} = \frac{5}{0.04} = 125\Omega$

Q47 Solution:
(3730)

As per NTA

$V = \text{constant}$

so $P \propto T$

$T_i = 50°\text{C} = 323\text{K}$

$T_f = 100°\text{C} = 373\text{K}$

$\Rightarrow \frac{P_f}{P_i} = \frac{T_f}{T_i}$

$\Rightarrow \frac{P_f}{3.23\text{kPa}} = \frac{373}{323}$

$\Rightarrow P_f = 3730\text{Pa}$

Other Solution:

As volume is constant

$\therefore P \propto T$

Since T is doubled (must be in Kelvin),so pressure must be doubled

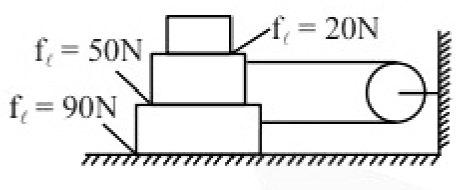
$\therefore P_f = 2P_i$

$P_f = 2 \times 3.23 = 6.46\text{kPa}$

$P_f = 6460\text{Pa}$

Q48 Solution:
(210)

For 8 kg to move with constant velocity, $F_{\text{net}} = 0$



$\therefore F = 90 + T + 50 \ \left(\text{for 8 kg block}\right)$

$T = 20 + 50 \ \left(\text{for 6 kg block}\right)$

$\therefore F = 210\text{N}$

Q49 Solution:
(64)

$\tau = \mu B \sin\theta \ \Rightarrow \ 0.016 = \mu \times B \times \frac{1}{2}$

$\Rightarrow \mu = \frac{0.032}{B}$

$W_{\text{ext}} = U_f - U_i = \mu B - \left(-\mu B\right) = 2\mu B$

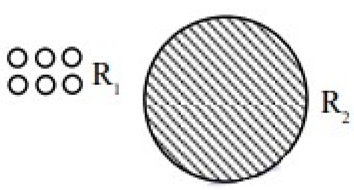
$= 2 \times \frac{0.032}{B} \times B$

$= 0.064\text{J}$

Q50 Solution:
(160)

$V_T = \frac{2r^2 g}{9\eta}\left(\sigma - \rho\right)$

$V_T \propto r^2$



64 drops

$64\left(\frac{4}{3}\pi R_1^3\right) = \frac{4}{3}\pi R_2^3$

$R_2 = 4R_1$

$$\frac{(V_T)_1}{(V_T)_2} = \left(\frac{R_1}{R_2}\right)^2 = \left(\frac{1}{4}\right)^2$$

$$\frac{10}{(V_T)_2} = \frac{1}{16}$$

$(V_T)_2 = 160\,\text{cm/sec}$

3 - JEE Main Chemistry 24-Jan 2026 Shift -1

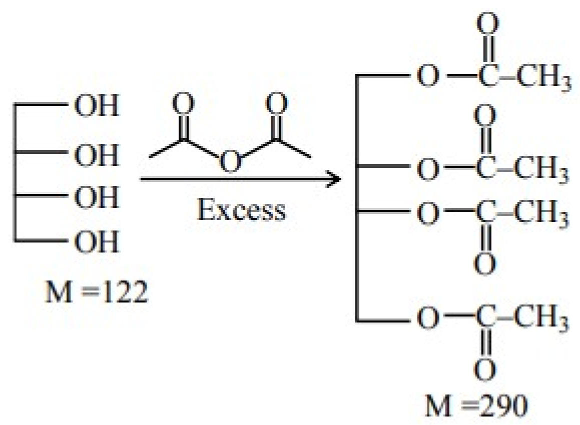
Q51 Solution:
(3)

$MgCl_2$, $AlCl_3$, $CuCl_2$ are water soluble at room temperature.

$AgCl$, Hg_2Cl_2 are sparingly soluble in water.

$PbCl_2$ is soluble in hot water.

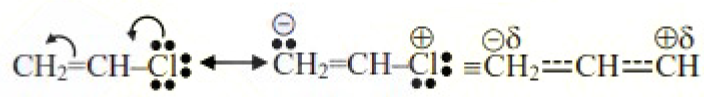
Q52 Solution:
(4)



No. of OH groups $= \frac{290 - 122}{42} = 4$

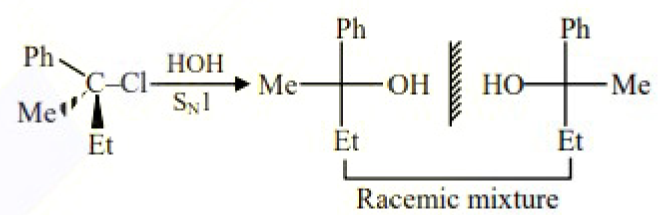
Q53 Solution:
(2)

Statement-I :



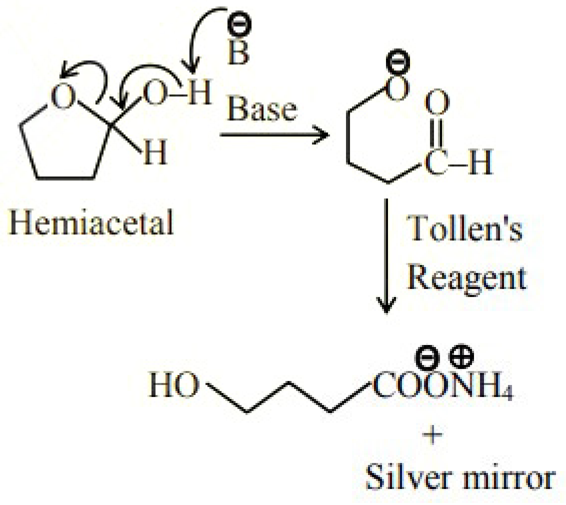
C–Cl bond is strong in vinyl chloride because of double bond character.

Statement-II :



Racemic mixture is optically inactive, which can not rotate PPL.

Q54 Solution:
(3)



Q55 Solution:
(3)

Common Name (Theory based)

Q56 Solution:
(1)

Correct order of stability

$$\underset{+M}{A} > C > \underset{-M}{D} > \underset{-M}{B}$$

EDG increase stability

EWG decreases stability

Q57 Solution:
(2)

(A) Dipole moment : $NF_3 < NH_3$

(B) BeH_2 is 'sp' hybridized, linear molecule with zero dipole moment.

(C) $O_2^{2-} \Rightarrow$ bond order $= 1$
$F_2 \Rightarrow$ bond order $= 1$

(D) Formal charge on central oxygen atom in O_3 is $+1$

(E) In NO_2, nitrogen does not follow octet rule.

Q58 Solution:
(2)

Given:

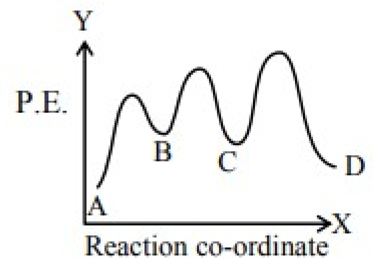
$A \rightarrow D;\ \Delta_r H = (+)\text{ve} = E_D - E_A \therefore E_D > E_A$

Mechanism

$A \rightarrow B;\ \Delta_r H = (+)\text{ve} \Rightarrow E_B > E_A$

$B \rightarrow C;\ \Delta_r H = (-)\text{ve} \Rightarrow E_C < E_B$

$C \rightarrow D;\ \Delta_r H = (-)\text{ve} \Rightarrow E_D < E_C$



Q59 Solution:
(3)

$$\frac{K_{\text{catalyst}}}{K_{\text{uncatalyst}}} = e^{\frac{\Delta E_a}{RT}}$$

$$\ln\left(\frac{K_{\text{catalyst}}}{K_{\text{uncatalyst}}}\right) = \frac{\Delta E_a}{RT}$$

$$\log\left(\frac{K_{\text{catalyst}}}{K_{\text{uncatalyst}}}\right) = \frac{\Delta E_a}{2.303RT}$$

$$= \frac{10 \times 1000}{2.303 \times 8.314 \times 300}$$

$$\log\left(\frac{K_{\text{catalyst}}}{K_{\text{uncatalyst}}}\right) = 1.741$$

Q60 Solution:
(2)

Paramagnetic species:

$[CoF_6]^{3-}$, $[TiF_6]^{3-}$, $[Fe(CN)_6]^{3-}$

Diamagnetic species: V_2O_5

In $K_4[Fe(CN)_6] \Rightarrow$ No. of unpaired electron $= 0$

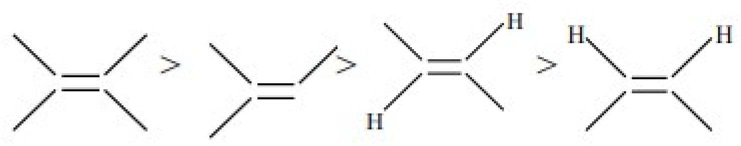
$K_3[Fe(CN)_6] \Rightarrow$ No. of unpaired electron $= 1$

$[Fe(H_2O)_6]SO_4 \cdot H_2O \Rightarrow$ No. of unpaired electron $= 4$

$[Fe(H_2O)_6]Cl_3 \Rightarrow$ No. of unpaired electron $= 5$

Q61 Solution:
(3)

Stability order :



αH = 12 | αH = 9 | αH = 6 trans | αH = 6 cis

Trans is more stable than cis

Q62 Solution:
(4)

$x = H_2$ (gas), $y = CO_2$ (gas)

Sum of molar mass $= 2 + 44 = 46$

Q63 Solution:

(1)

In $K_3[Co(CO_3)_3] \Rightarrow sp^3d^2$ hybridized, octahedral

$\Rightarrow$ 4 unpaired electron

$\Rightarrow$ 4.9 B.M.

$[Ni(CN)_4]^{2-} \Rightarrow dsp^2$ hybridized, square planar

$\Rightarrow$ 0 unpaired electron

$\Rightarrow$ 0 B.M.

$[MnBr_4]^{2-} \Rightarrow sp^3$ hybridized, tetrahedral

$\Rightarrow$ 5 unpaired electron

$\Rightarrow$ 5.9 B.M.

$[CoF_6]^{3-} \Rightarrow sp^3d^2$ hybridized, octahedral

$\Rightarrow$ 4 unpaired electron

$\Rightarrow$ 4.9 B.M.

Q64 Solution:

(3)

(A) $W_{\text{rev.}} = -\int P_{\text{gas}} dV$

$W_{\text{rev. iso. exp.}} = -nRT\ln\left(\frac{V_f}{V_i}\right)$

$(A) \rightarrow (II)$

(B) Free expansion

$W_{\text{irrev.}} = -P_{\text{ext}}\Delta V$

$P_{\text{ext}} = 0 \Rightarrow W = 0$

$(B) \rightarrow (I)$

(C) Irreversible expansion

$W_{\text{irrev.}} = -P_{\text{ext}}\Delta V$

$= -P_{\text{ext}}(V_f - V_i)$

$(C) \rightarrow (III)$

(D) Irreversible compression

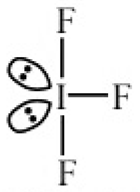
$W_{\text{irrev.}} = -P_{\text{ext}}\Delta V$

$= -P_{\text{ext}}(V_i - V_f)$

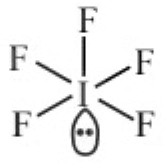
$(D) \rightarrow (IV)$

Q65 Solution:

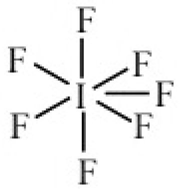
(3)



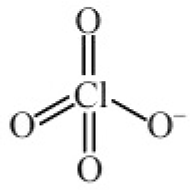
Hybridisation sp^3d
(T-shape)



Hybridisation sp^3d^2
(Squar pyramidal)



Hybridisation sp^3d^3
(Pentagonal bipyramidal)



Hybridisation sp^3
(Tetrahedral)

Q66 Solution:
(2)

Metallic character of s-block elements is greater than p-block elements.

Anionic radius is greater than atomic radius but cationic radius is always less than atomic radius for any element.

Q67 Solution:
(3)

Mass of solute 'A' $= 0.3$ g

Moles of solute 'A' $= \frac{0.3\text{ g}}{60\text{ g mol}^{-1}} = \frac{1}{200}$ mol

Mass of solute 'B' $= 0.9$ g

Moles of solute 'B' $= \frac{0.9\text{ g}}{180\text{ g mol}^{-1}} = \frac{1}{200}$ mol

Total molarity of all solutes $= \frac{2/200}{100} \times 1000 = \frac{1}{10}$ M

$\therefore \quad \pi = \frac{1}{10} \times 0.082 \times 300$

$\pi = 2.46$ atm

Q68 Solution:
(1)

Electron withdrawing groups increases stability of carbanion and electron donating groups decreases stability of carbanion.

Q69 Solution:
(4)

0.4 mol $\left[Co(NH_3)_5SO_4\right]Br + 0.4$ mol $\left[Co(NH_3)_5Br\right]SO_4$ are present in 4 lit. solution.

2 lit. of mixture will contain 0.2 mol of each complex.

2 lit. mixture on reaction with excess $AgNO_3$, 0.2 mol AgBr will be formed (Y).

2 lit. mixture on reaction with excess $BaCl_2$, 0.2 mol $BaSO_4$ will be formed (Z).

Q70 Solution:
(4)

$P^\circ = 640$ mm Hg
$P_s = 600$ mm Hg
$\Delta P = 40$ mm Hg

moles of solute $= \frac{W}{M}$

$\frac{\Delta P}{P^\circ} = i \cdot X_{\text{solute}}$

Again:

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

$2 = i \times 0.52 \times \frac{W/M}{100} \times 1000$

$i = \frac{2}{5.2} \times \frac{M}{W}$

$X_{\text{solute}} = \frac{40}{640} \times \frac{1}{i} = \frac{1}{16} \times \frac{5.2}{2} \times \frac{W}{M}$

$X_{\text{solute}} = \frac{1.3}{8} \times \frac{W}{M}$

Q71 Solution:
(15)

$P_{N_2} = \left(715 - 15\right) \text{ mm} = \frac{700}{760} \text{ atm}$

$V_{N_2} = 70 \text{ ml} = \frac{70}{1000} \text{ L}$

$n_{N_2} = \frac{PV}{RT} = \frac{\left(\frac{700}{760}\right)\left(\frac{70}{1000}\right)}{0.0821 \times 300}$

$W_{N_2} = \frac{700}{760} \times \frac{70}{1000} \times \frac{1}{0.0821 \times 300} \times 28$

$\% \quad N = \frac{W_{N_2}}{0.5} \times 100 = \frac{700}{760} \times \frac{70}{1000} \times \frac{1}{0.0821 \times 300} \times \frac{28}{0.5} \times 100$

$= 14.65\% \approx 15$

Q72 Solution:
(111)

Eq of Cu = Eq of O_2

$\frac{300 \times 10^{-3} \times 2}{63.54} = n_{O_2} \times 4$

$2.36 \times 10^{-3} = n_{O_2}$

When current is further passed

$n_{O_2} \times 4 = \frac{600 \times 28 \times 60}{96500 \times 1000}$

$n_{O_2} = 2.611 \times 10^{-3}$

Total O_2 released

$= \left[10^{-3} \times \left(2.36 + 2.611\right)\right] \times 22400 \text{ ml}$

$= 111.35 \text{ ml}$

Q73 Solution:
(12)

$Cr_2O_7^{2-} + 14H^+ + 6I^- \rightarrow 2Cr^{3+} + 3I_2 + 7H_2O$

no. of moles e^- involved $= x = 6$

$Cr_2O_7^{2-} + 3S^{2-} + 14H^+ \rightarrow S + 2Cr^{3+} + 7H_2O$

No. of moles e^- involved $= y = 6$

Sum of $x + y = 6 + 6 = 12$

Q74 Solution:
(4)

$XS(s) \rightleftharpoons X^{2+}(aq) + S^{2-}(aq)$

For precipitation of XS(s)

$[X^{2+}][S^{2-}] \geq K_{sp}(XS)$

$[S^{2-}] \geq \frac{1 \times 10^{-22}}{0.01} = 10^{-20}$

$YS(s) \rightleftharpoons Y^{2+}(aq) + S^{2-}(aq)$

For precipitation of YS(s)

$[Y^{2+}][S^{2-}] \geq K_{sp}(YS)$

$[S^{2-}] \geq \frac{4 \times 10^{-16}}{10^{-2}} = 4 \times 10^{-14}$

Now, $H_2S(aq) \rightleftharpoons 2H^+(aq) + S^{2-}(aq)$

$\frac{[S^{2-}][H^+]^2}{[H_2S]} = K_{a1} \times K_{a2} = 1 \times 10^{-21}$

$[S^{2-}] = \frac{1 \times 10^{-21} \times [H_2S]}{[H^+]^2} \geq 4 \times 10^{-14}$

$[H^+]^2 \leq \frac{1}{4} \times 10^{-7} \times 10^{-1}$

$[H^+] \leq \frac{1}{2} \times 10^{-4} \Rightarrow pH \geq 4.3$

Q75 Solution:
(54)

$\Delta E(L_1) = 13.6\ Z^2\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = 13.6\ Z^2 \times \frac{3}{4}$

$\Delta E(B_1) = 13.6\ Z^2\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = 13.6\ Z^2 \times \frac{5}{4 \times 9}$

$\frac{\Delta E(L_1)}{\Delta E(B_1)} = \frac{3}{5} \times 9 = \frac{27}{5} = x$

$x = \left(\frac{27}{5} \times 10\right) \times 10^{-1} = 54 \times 10^{-1}$