1 - JEE Main Maths 23-Jan 2026 Shift -1

Q1 Solution:
(1)

$$f\left(\theta\right) = 4\left(\sin^4\left(\frac{7\pi}{2} - \theta\right) + \sin^4\left(11\pi + \theta\right)\right) - 2\left(\sin^6\left(\frac{3\pi}{2} - \theta\right) + \sin^6\left(9\pi - \theta\right)\right)$$

$$f\left(\theta\right) = 4\left(\cos^4\theta + \sin^4\theta\right) - 2\left(\cos^6\theta + \sin^6\theta\right)$$

$$f\left(\theta\right) = 4\left(1 - 2\sin^2\theta\cos^2\theta\right) - 2\left(1 - 3\sin^2\theta\cos^2\theta\right)$$

$$f\left(\theta\right) = 2 - 2\sin^2\theta\cos^2\theta$$

$$f\left(\theta\right) = 2 - \frac{\sin^2\left(2\theta\right)}{2}$$

$$\alpha = f\left(\theta\right)_{\max} = 2$$

$$\beta = f\left(\theta\right)_{\min} = \frac{3}{2}$$

$$\Rightarrow \alpha + 2\beta = 5$$

Ans. = 5 option (1)

Q2 Solution:
(1)

R = {(-2, a), (-1, b), (0, c), (1, d), (2, e)}

a = {-2, -1, 0, 1, 2, 3, 4};
b = {-2, -1, 0, 1, 2, 3, 4}
c = {-2, -1, 0, 1, 2};
d = {-2, -1, 0};
e = {-2}

∴ No. of elements in R
= 7 + 7 + 5 + 3 + 1 = 23 = ℓ

Minimum number of element to be added to make it reflexive = m = 4
⇒ {(1, 1), (2, 2), (3, 3), (4, 4)}

Minimum number of element to be added to make it symmetric = n = 6

⇒ R = {(3, -2), (4, -2), (2, -1), (2, 0), (3, -1), (4, -1)}

∴ ℓ + m + n = 23 + 4 + 6 = 33

Q3 Solution:
(3)

$$I = \int_{\frac{\pi}{24}}^{\frac{5\pi}{24}} \frac{dx}{1 + \sqrt[3]{\tan 2x}} \quad ...\left(1\right)$$

Apply King

$I = \int_{\frac{\pi}{24}}^{\frac{5\pi}{24}} \frac{dx}{1 + \sqrt[3]{\tan 2\left(\frac{\pi}{4} - x\right)}}$

$I = \int_{\frac{\pi}{24}}^{\frac{5\pi}{24}} \frac{dx}{1 + \sqrt[3]{\cot 2x}} \quad \ldots\left(2\right)$

Add (1) + (2) $\Rightarrow 2I = \int_{\frac{\pi}{24}}^{\frac{5\pi}{24}} \left(1\right) dx$

$I = \frac{1}{2}\left(\frac{\pi}{6}\right) = \frac{\pi}{12}$

Q4 Solution:
(2)

Let time taken by mason A alone to complete the work be x days.

So, mason B alone takes $\left(x + 24\right)$ days.

Work done by A in 1 day $= \frac{1}{x}$

Work done by B in 1 day $= \frac{1}{x + 24}$

Work done by A + B in 1 day $= \frac{1}{22.5}$

So, $\frac{1}{x} + \frac{1}{x + 24} = \frac{1}{22.5} = \frac{2}{45}$

$\frac{1}{x} + \frac{1}{x + 24} = \frac{2}{45}$

$\Rightarrow \frac{2x + 24}{x(x + 24)} = \frac{2}{45}$

$45(2x + 24) = 2x(x + 24)$

$90x + 1080 = 2x^2 + 48x$

$2x^2 - 42x - 1080 = 0$

$x^2 - 21x - 540 = 0$

$x = 36$ or $x = -15$

$x = -15$ (rejected)

Ans. = 36 option (2)

Q5 Solution:
(3)

$\left(x^4 + 2x^2 + 1\right)\left({}^nC_0x^0 + {}^nC_1x^1 + {}^nC_2x^2 + {}^nC_3x^3 + \ \ldots\right)$

Coefficient of $x \Rightarrow {}^nC_1$

Coeff. of $x^2 \Rightarrow 2 + {}^nC_2 = 2 + \frac{n(n-1)}{2}$

Coeff. of $x^3 = 2 \cdot {}^nC_1 + {}^nC_3$

$= 2n + \frac{n(n-1)(n-2)}{6} \ \left(\text{if } x \geq 3\right)$

Now according to question

$n + 2n + \frac{n(n-1)(n-2)}{6} = 2\left[2 + \frac{n(n-1)}{2}\right]$

$3n + \frac{n(n-1)(n-2)}{6} = 4 + n\left(n - 1\right)$

$\Rightarrow n^3 - 9n^2 + 26n - 24 = 0$

$\Rightarrow n = 2, 3, 4 \quad \Rightarrow n = 3, 4$

Now checking for $n = 2$

$$\left.\begin{array}{l} \text{Coeff. of } x = 2 \\ \text{Coeff. of } x^2 = 3 \\ \text{Coeff. of } x^3 = 4 \end{array}\right\} \Rightarrow \text{are in A.P.}$$

$\Rightarrow n = 2$ is also the correct choice

Required sum of values of n

$= 2 + 3 + 4 = 9$

Option (3)

Q6 Solution:
(4)

Direction cosines of two lines satisfy the equation

$\Rightarrow 4\ell + m - n = 0 \quad ...(1)$

$2mn + 10n\ell + 3\ell m = 0 \quad ...(2)$

And we know

$\Rightarrow \ell^2 + m^2 - n^2 = 1 \quad ...\left(3\right)$

$\Rightarrow n = 4\ell + m$ putting in eqn. (1)

$\Rightarrow n(2m + 10\ell) + 3\ell m = 0$

$\Rightarrow (4\ell + m)(2m + 10\ell) + 3\ell m = 0$

$\Rightarrow 8\ell m + 40\ell^2 + 2m^2 + 10\ell m + 3\ell m = 0$

$\Rightarrow 40\ell^2 + 21\ell m + 2m^2 = 0$

$\Rightarrow (8\ell + m)(5\ell + 2m) = 0$

Case 1: $8\ell + m = 0 \Rightarrow m = -8\ell$

Case 2: $5\ell + 2m = 0 \Rightarrow m = -\frac{5}{2}\ell$

So direction ratio of L_1 is $\ell, -8\ell, -4\ell$

and direction ratio of L_2 is $\ell, \frac{-5\ell}{2}, \frac{3\ell}{2}$

$$\cos\theta = \left|\frac{\ell^2 + 20\ell^2 - 6\ell^2}{\sqrt{\ell^2 + 64\ell^2 + 16\ell^2}\sqrt{\ell^2 + \frac{25\ell^2}{4} + \frac{9\ell^2}{4}}}\right|$$

$$= \frac{15\ell^2}{\left(9\ell\right)\frac{\sqrt{38}\ell}{2}} = \frac{10}{3\sqrt{38}}$$

Ans. $= \frac{10}{3\sqrt{38}}$

Q7 Solution:
(4)

$$\int e^x\left(\frac{\left(1-x^2\right)+1}{\sqrt{1+x}\,.\,(1-x)^{3/2}}\right)dx$$

$$= \int e^x\left(\frac{\left(1-x^2\right)}{\sqrt{1+x}\,.\,(1-x)^{3/2}}+\frac{1}{\sqrt{1+x}\,.\,(1-x)^{3/2}}\right)dx$$

$$= \int e^x\left(\sqrt{\frac{1+x}{1-x}}+\frac{1}{\sqrt{1+x}\,.\,(1-x)^{3/2}}\right)dx$$

$$= e^x\sqrt{\frac{1+x}{1-x}}+C$$

$$f\left(x\right) = e^x\sqrt{\frac{1+x}{1-x}}-1$$

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

Q8 Solution:
(3)

$$f(x) = \begin{cases} \dfrac{ax^2+2ax+3}{(2x-1)(2x+3)}; & x \neq \dfrac{-3}{2},\ \dfrac{1}{2} \\ b \quad ; & x = \dfrac{-3}{2},\ \dfrac{1}{2} \end{cases}$$

For continuity at $x = \frac{-3}{2}$

LHL = RHL

$$\Rightarrow \lim_{x \to \frac{-3}{2}} \frac{\left(ax^2+2ax+3\right)}{(2x-1)(2x+3)}$$

At $x = \frac{-3}{2} \Rightarrow$ Numerator $= 0$

$$a\left(\frac{-3}{2}\right)^2 + 2a\left(\frac{-3}{2}\right) + 3 = 0$$

$$\frac{9}{4}a - 3a + 3 = 0$$

$$\frac{3a}{4} = 3 \Rightarrow a = 4$$

$$\therefore f(x) = \begin{cases} \dfrac{4x^2+8x+3}{(2x-1)(2x+3)}; & x \neq \dfrac{-3}{2},\ \dfrac{1}{2} \\ b \quad ; & x = \dfrac{-3}{2},\ \dfrac{1}{2} \end{cases}$$

$$f(x) = \begin{cases} \dfrac{(2x+1)(2x+3)}{(2x-1)(2x+3)}; & x \neq \dfrac{-3}{2},\ \dfrac{1}{2} \\ b \quad ; & x = \dfrac{-3}{2},\ \dfrac{1}{2} \end{cases}$$

$$fof(x) = f\left(\frac{2x+1}{2x-1}\right) = \frac{2\left(\frac{2x+1}{2x-1}\right)+1}{2\left(\frac{2x+1}{2x-1}\right)-1}$$

$$= \frac{\frac{4x+2}{2x-1}+1}{\frac{4x+2}{2x-1}-1} = \frac{\frac{6x+1}{2x-1}}{\frac{2x+3}{2x-1}}$$

$$= \frac{6x+1}{2x+3} = \frac{7}{5}$$

$$\Rightarrow 5(6x+1) = 7(2x+3)$$

$30x + 5 = 14x + 21$

$16x = 16$

$\Rightarrow x = 1$

Ans. $x = 1$

Q9 Solution:
(1)

$\left(x^4 dy + 4x^3 y dx\right) = -2\sin x dx$

$\Rightarrow \int d\left(x^4 y\right) = \int -2\sin x dx$

$\Rightarrow x^4 y = 2\cos x + c$

$\Rightarrow x^4 f(x) = 2\cos x + c$

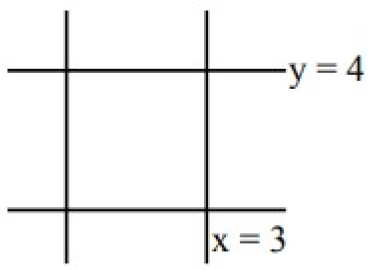
As $f\left(\frac{\pi}{2}\right) = 0$

So, $c = 0$

$\left(\frac{\pi}{3}\right)^4 f\left(\frac{\pi}{3}\right) = 2\cos\frac{\pi}{3}$

$\pi^4 f\left(\frac{\pi}{3}\right) = 81$

Q10 Solution:
(3)



Line is $y = \frac{x}{3} + C$

Line passes thru $\left(\frac{3}{2}, 2\right)$

$2 = \frac{1}{2} + C \Rightarrow C = \frac{3}{2}$

$y = \frac{x}{3} + \frac{3}{2}$

$\Rightarrow 6y = 2x + 9$

Line is $2x - 6y + 9 = 0$

Dist $= \left|\frac{1 + 30 + 9}{\sqrt{40}}\right| = \sqrt{40} = 2\sqrt{10}$

Q11 Solution:
(4)

Mean $= \frac{-18 + x + y + 2 + 9 + 16}{8} = \frac{7}{2}$

$\Rightarrow \frac{x + y + 9}{8} = \frac{7}{2} \Rightarrow x + y + 9 = 28 \quad .....(1)$

Variance $= \frac{\sum z_i^2}{8} - \mu^2 = \frac{293}{4}$

$\Rightarrow \frac{10^2 + 7^2 + 1^2 + x^2 + y^2 + 2^2 + 9^2 + 16^2}{8} - \left(\frac{7}{2}\right)^2 = \frac{293}{4} \quad \ldots.\left(2\right)$

Solving (1) & (2) $\Rightarrow x = 12,\ y = 7$

Mean of $\left(1 + x + y\right),\ \ x,\ \ y, \left|y - x\right|$ is

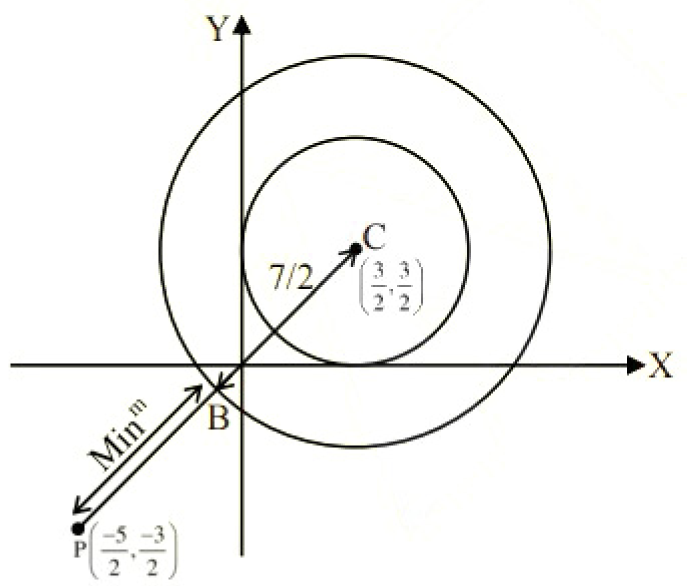
$\Rightarrow \frac{20 + 12 + 7 + 5}{4} = \frac{44}{4} = 11$

Option (4)

Q12 Solution:

(3)

$\frac{3}{2} \leq \left|z - \frac{3}{2}\left(1 + i\right)\right| \leq \frac{7}{2}$



$\min_{z \in S}\left|z - \left(\frac{-5}{2} - \frac{3}{2}i\right)\right| = PB$

$PB = PC - \frac{7}{2} \Rightarrow 5 - \frac{7}{2} = \frac{3}{2}$

Option (3)

Q13 Solution:

(1)

$S = \sum_{r=50}^{100} \frac{{}^{100}C_r}{r+1} = \sum_{r=50}^{100} \frac{1}{r+1} \cdot \frac{r+1}{101} \cdot {}^{101}C_{r+1}$

$S = \frac{1}{101} \sum_{r=50}^{100} {}^{101}C_{r+1}$

$= \frac{1}{101} \times \frac{2^{101}}{2} = \frac{2^{100}}{101}$

Option (1)

Q14 Solution:

(4)

$\log_5\left(\log_7\left(9x - x^2 - 13\right)\right) > 0$

$\Rightarrow 9x - x^2 - 13 > 7$

$x^2 - 9x + 20 < 0 \Rightarrow 4 < x < 5$

$m = 4,\ n = 5$

$\Rightarrow e = \sqrt{1 + \frac{b^2}{a^2}} = \frac{5}{3} \Rightarrow \frac{b^2}{a^2} = \frac{25}{9} - 1 = \frac{16}{9}$

$\frac{b}{a} = \frac{4}{3}$

$\Rightarrow \ \frac{2b^2}{a} = \frac{8m}{3} \Rightarrow \frac{2b^2}{a} = \frac{32}{3}$

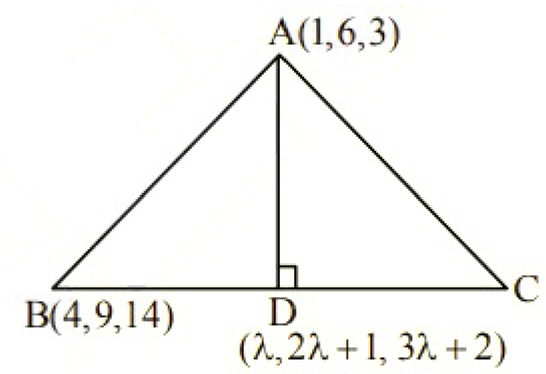
$\Rightarrow \ 2b^2 = \frac{32}{3} \times \frac{3b}{4} \Rightarrow b = 4,\ a = 3$

$b^2 - a^2 = 16 - 9 = 7$

Q15 Solution:

(1)

$\frac{4}{1} = \frac{9-1}{2} = \frac{\alpha-2}{3} \Rightarrow \alpha = 14$



$\overrightarrow{AD} \cdot \left(\hat{i} + 2\hat{j} + 3\hat{k}\right) = 0$

$\left(\lambda - 1\right)\hat{i} + \left(2\lambda - 5\right)\hat{j} + \left(3\lambda - 1\right)\hat{k} = \overrightarrow{AD}$

$\Rightarrow \lambda - 1 + 4\lambda - 10 + 9\lambda - 3 = 0$

$\Rightarrow 14\lambda = 14 \Rightarrow \lambda = 1$

$D = (1, 3, 5)$

$AD = \sqrt{3^2 + 2^2} = \sqrt{13}$

$\text{Ar}\left(\Delta ABC\right) = \frac{1}{2} \times \sqrt{13} \times 10 = 5\sqrt{13}$

Q16 Solution:

(2)

$\vec{d} = \left(\vec{a} \times \vec{b}\right) \times \vec{a}$

$\vec{d} = \left(a^2\right)\vec{b} - \left(\vec{a} \cdot \vec{b}\right)\vec{a}$

$\vec{d} = 6\vec{b} + 8\vec{a}$

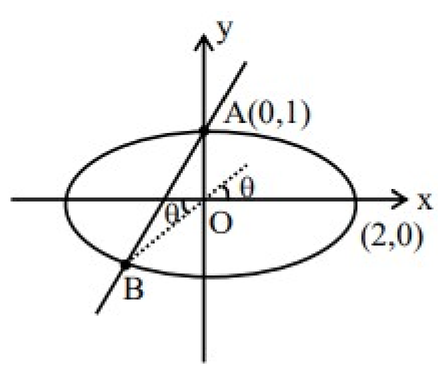
$\left(\vec{a} - \vec{b}\right) \cdot \vec{d} = \left(\vec{a} - \vec{b}\right) \cdot \left(6\vec{b} + 8\vec{a}\right)$

$= 8a^2 - 6b^2 - 2\vec{a} \cdot \vec{b}$

$= 48 - 66 + 16 = -2$

Q17 Solution:

(2)



By solving line & equation of ellipse we get $x = 0$

& $x = -\frac{4}{3}$

$\therefore \quad B\left(-\frac{4}{3}, -\frac{1}{3}\right)$

$m_{OB} = \tan\theta = \frac{1}{4}$

$\because \quad \angle AOB = \frac{\pi}{2} + \theta = \frac{\pi}{2} + \tan^{-1}\left(\frac{1}{4}\right)$

Q18 Solution:
(2)

Let $\cos\alpha = x$

$\cos\beta = y$

$\cos\gamma = z$

$$\begin{vmatrix} 0 & x & y \\ x & 0 & z \\ y & z & 0 \end{vmatrix} = \begin{vmatrix} 1 & x & y \\ x & 1 & z \\ y & z & 1 \end{vmatrix}$$

Expanding both sides, we get

$x^2 + y^2 + z^2 = 1$

i.e. $\cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1$

Statement 1 is false.

Now,

$$\begin{vmatrix} x^2 + x & 1 + x & x - 2 \\ 2x^2 + 3x - 1 & 3x & 3x - 3 \\ x^2 + 2x + 3 & 2x - 1 & 2x - 1 \end{vmatrix} = px + q$$

Put $x = 0$ both sides

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

$\Rightarrow q = -12$

Now put $x = 1$ both sides

$$p + q = \begin{vmatrix} 2 & 2 & -1 \\ 4 & 3 & 3 \\ 6 & 1 & 1 \end{vmatrix} = 42$$

$\Rightarrow p = 54$

Now,

$\frac{p^2}{q^2} = \left(\frac{54}{-12}\right)^2 + 196$

$\Rightarrow p^2 \neq 196q^2$

Statement (2) is false.

Correct option (2).

Q19 Solution:

(1)

$\sqrt{3}\ \left(2\cos^2\theta - 1\right) + 8\cos\theta + 3\sqrt{3} = 0$

$2\sqrt{3}\cos^2\theta + 8\cos\theta + 2\sqrt{3} = 0$

$\left(\sqrt{3}\cos\theta + 1\right)\left(\cos\theta + \sqrt{3}\right) = 0$

$\cos\theta = -\frac{1}{\sqrt{3}}$

as $-\sqrt{3}$ $\left(\text{reject}\right)$

$\therefore\theta$ will have 5 values in $[-3\pi, 2\pi]$

Ans. $= 5 \Rightarrow$ option (1)

Q20 Solution:

(2)

$\left(x - 6\sqrt{x} + 9\right) - \left(2 - \sqrt{3}\right)\left|\sqrt{x} - 3\right| - 2\sqrt{3} = 0$

$\Rightarrow \left|\sqrt{x} - 3\right|^2 - \left(2 - \sqrt{3}\right)\left|\sqrt{x} - 3\right| - 2\sqrt{3} = 0$

$\Rightarrow\ |\sqrt{x} - 3| = 2$ or $|\sqrt{x} - 3| = -\sqrt{3}$ $\left(\text{not possible}\right)$

$\Rightarrow \sqrt{x} = 1$ or 5

$\Rightarrow x = 1$ or 25

$\Rightarrow \alpha = 1$ and $\beta = 25$

Aliter:

Let $x \geq 9$, let $\sqrt{x} = t \Rightarrow t \geq 3$

$\left(\sqrt{3} - 2\right)\left(t - 3\right) + (t - 3)^2 - 2\sqrt{3} = 0$

Let $t - 3 = u$

$u^2 + \left(\sqrt{3} - 2\right)u - 2\sqrt{3} = 0$

$\Rightarrow u = 2$ or $u = -\sqrt{3}$

$\Rightarrow t - 3 = 2$ or $t - 3 = -\sqrt{3}$

$\Rightarrow t = 5$ or $t = 3 - \sqrt{3}$ $\left(\text{rejected}\right)$

$\Rightarrow x = 25$

Now let $0 < x < 9$

$-\left(\sqrt{3} - 2\right)\left(t - 3\right) + (t - 3)^2 - 2\sqrt{3} = 0$

Let $t - 3 = u$

$u^2 - \left(\sqrt{3} - 2\right)u - 2\sqrt{3} = 0$

$\Rightarrow u = \sqrt{3}$ or $u = -2$

$\Rightarrow t = 3 + \sqrt{3}$ $\left(\text{rejected}\right)$ or $t - 3 = -2$

$\Rightarrow t = 1 \Rightarrow x = 1$

$\alpha = 1, \ \beta = 25$

Now $\sqrt{\frac{\beta}{\alpha}} + \sqrt{\alpha\beta} = \sqrt{25} + \sqrt{25} = 10$

Q21 Solution:
(62)

$\text{adj}\left(2A\right) = 2^2 \text{ adj } A \because \text{ adj}\left(kA\right) = k^{n-1} \text{ adj}\left(A\right)$

$= 4 \text{ adj } A$

Now, $A^2\left(\text{ adj}\left(2A\right)\right) = 4A\left(\text{ adj } A\right)$

$= 4A|A|I_3$

$= 24A$

Now, $3 \text{ adj}\left(A^2\left(\text{ adj}\left(2A\right)\right)\right) = 3 \text{ adj}\left(24A\right)$

$= 3(24)^2 \text{ adj } A$

Now, $\left|\text{adj}\left(3 \text{ adj}\left(A^2\left(\text{ adj}\left(2A\right)\right)\right)\right)\right|$

$= \left|\text{adj}\left(3.(24)^2 \text{ adj } A\right)\right|$

$= \left|\left(3.(24)^2\right)^2 \text{ adj}\left(\text{ adj } A\right)\right|$

$= \left|3^6 \cdot 2^{12} \text{ adj}\left(\text{ adj } A\right)\right|$

$= \left(3^6 \cdot 2^{12}\right)^3 \left|\text{ adj}\left(\text{ adj } A\right)\right|$

$= 3^{18} \cdot 2^{36} \cdot |A|^4$

$= 3^{22} \cdot 2^{40}$

$\therefore \ m + n = 62$

Q22 Solution:
(311)

$a - b \geq 10$

Total cases $= 100 \times 99$

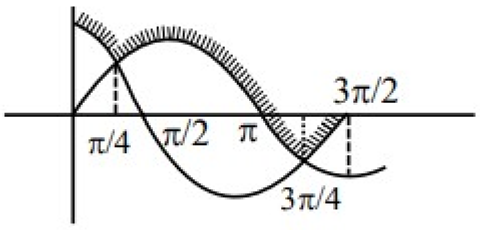
Fav. cases $= 1 + 2 + 3 + \ \dots \ + 90$

Req. Prob $= \frac{1 + 2 + \ \dots \ + 90}{100 \times 99}$

$\frac{m}{n} = \frac{90\left(\frac{91}{2}\right)}{100(99)} = \frac{91}{220}$

$m + n = 311$

Q23 Solution:
(12)



$A = \int_0^{\pi/4} \cos x\, dx + \int_{\pi/4}^{\pi} \sin x\, dx + \int_{\pi}^{5\pi/4} -\sin x\, dx + \int_{5\pi/4}^{3\pi/2} -\cos x\, dx$

$A = (\sin x)_0^{\pi/4} + (\cos x)_{\pi/4}^{\pi} + (\cos x)_{\pi}^{5\pi/4} + \left(\sin x\right)_{5\pi/4}^{3\pi/2}$

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

$A^2 + A = 12$

Q24 Solution:
(1565)

$2f\left(x\right)f'\left(x\right) = f^2\left(x\right) + \left(f'(x)\right)^2$

$\Rightarrow \left(f\left(x\right) - f'(x)\right)^2 = 0$

$\Rightarrow f(x) = f'(x)$

$\Rightarrow ln(f(x)) = x + c \Rightarrow f(x) = c'e^x$

$f(0) = 5 \Rightarrow f(x) = 5e^x$

Mean $= \frac{f(ln1) + f(ln2) + \ldots + f(ln625)}{625}$

$= \frac{5(1 + 2 + \ldots + 625)}{625} = 1565$

Q25 Solution:
(1422)

$P \to 3,\ Q \to 2,\ R \to 2,\ S, T, U, V$

Case I: 3 alike, 1 different

${}^1C_1 \times {}^6C_1 \times \frac{4!}{3!} = 24$

Case II: 2 alike, 2 alike

${}^3C_2 \times \frac{4!}{2!\ 2!} = 18$

Case III: 2 alike, 2 different

${}^3C_1 \times {}^6C_2 \times \frac{4!}{2!} = 540$

Case IV: All 4 different

${}^7C_4 \times 4! = 840$

Total words = 1422

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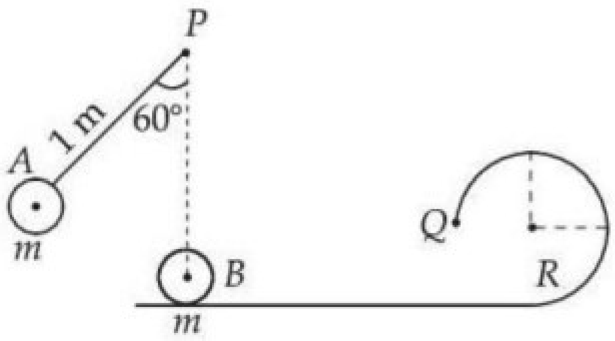
Q26 Solution:
(2)

Theoretical

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

Q27 Solution:
(1)



V_A at lowest point

$$V_A = \sqrt{2gl(1 - \cos\theta)}$$

$$V_A = \sqrt{2 \times 10 \times 1\left(1 - \frac{1}{2}\right)} = \sqrt{10}$$

After collision velocity of B becomes,

$$V_A = \sqrt{10} = V_B \text{ (Same mass)}$$

Now to complete circular motion

$$V_B = \sqrt{5gR}$$

$$R = \frac{1}{5}$$

Q28 Solution:
(1)

$$\varepsilon = vB\ell$$

$$v = \sqrt{2gh} = \sqrt{2 \times 10 \times 200} = 20\sqrt{10}$$

$$\varepsilon = \left(20\sqrt{10}\right)\left(0.5 \times 10^{-4}\right) \ 20$$

$$= 20\sqrt{10} \times 10^{-3} = 20\sqrt{10} \text{ mV}$$

Q29 Solution:
(3)

Conceptual

Q30 Solution:
(4)

$$\frac{\text{Strain}}{\text{Stress}} = \frac{1}{Y} = \text{Slope}$$

Q31 Solution:
(4)

$$\ell_{\text{mean}} = \frac{\ell_1 + \ell_2 + \ell_3 + \ell_4}{4}$$

$$\ell_{\text{mean}} = \frac{20.00 + 19.75 + 17.01 + 18.25}{4}$$

$$= 18.75$$

$$\Delta\ell_{\text{mean}} = \frac{|\Delta\ell_1| + |\Delta\ell_2| + |\Delta\ell_3| + |\Delta\ell_4|}{4}$$

$$= \frac{1.25 + 1 + 1.74 + 0.5}{4} = 1.12$$

So, relative error

$$= \frac{\Delta\ell_{\text{mean}}}{\ell_{\text{mean}}} = \frac{1.12}{18.75} = 0.06$$

Q32 Solution:
(4)

$$\delta_{\text{net}} = 0$$

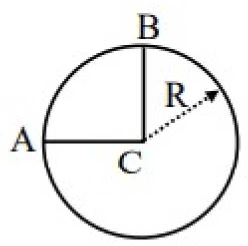
$$\delta_1 + \delta_2 = 0$$

$$(\mu_1 - 1)A_1 + (\mu_2 - 1)A_2 = 0$$

$$A_2 = \frac{(\mu_1 - 1)A_1}{(\mu_2 - 1)}$$

$$A_2 = \frac{(1.72 - 1)}{(1.9 - 1)} \times 5° = 4°$$

Q33 Solution:
(3)



$$\frac{1}{R_{AB}} = \frac{2}{\lambda\pi r} + \frac{1}{\lambda \cdot 2r} + \frac{2}{\lambda \cdot 3\pi r}$$

$$= \frac{1}{\lambda r}\left[\frac{2}{\pi} + \frac{1}{2} + \frac{2}{3\pi}\right]$$

$$= \frac{1}{\lambda r}\left(\frac{12 + 3\pi + 4}{6\pi}\right) = \frac{1}{\lambda r}\left(\frac{16 + 3\pi}{6\pi}\right)$$

$$R_{AB} = \lambda r\left(\frac{6\pi}{16 + 3\pi}\right)$$

Q34 Solution:
(1)

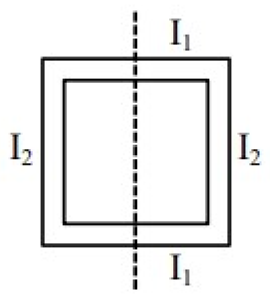
Time period becomes half

and $T \propto \sqrt{\ell}$

So, length ℓ becomes $\frac{\ell}{4}$

So, $\frac{\ell}{4} = \frac{30}{4} = 7.5$

Q35 Solution:
(1)



$I_{\text{net}} = 2\left(I_1 + I_2\right)$

$= 2\left(\frac{M'R^2}{4} + \frac{M'\ell^2}{12}\right) + 2\left(\frac{M'R^2}{2} + M'\left(\frac{\ell}{2}\right)^2\right)$

$= \frac{M'R^2}{2} + \frac{M'R^2}{6} + M'R^2 + \frac{M'\ell^2}{2}$

$= \frac{3M'R^2}{2} + \frac{2M'\ell^2}{3}$

Given masses $M' = \frac{M}{4}$

So, $I = \frac{3\left(M/4\right)R^2}{2} + \frac{2\left(M/4\right)\ell^2}{3}$

$I = \frac{3}{8}MR^2 + \frac{M\ell^2}{6}$

Q36 Solution:
(3)

$\left(KE\right)_A = K = \frac{1}{2}mu^2$

$\left(KE\right)_B = \frac{K}{4} = \frac{1}{2}m\left(\frac{u}{2}\right)^2 = \frac{K}{4} \quad \left(u_B = u\cos 60° = \frac{u}{2}\right)$

$\left(KE\right)_C = K$

Ratio $= \frac{K - K/4}{K}$

$= \frac{3K/4}{K} = \frac{3}{4}$

Q37 Solution:
(4)

For equilibrium $kx = mg$

$U = \frac{1}{2}kx^2 = \frac{1}{2}\frac{m^2g^2}{k}$

$U \propto \frac{m^2}{k}$

$\frac{U_A}{U_B} = \left(\frac{m_A}{m_B}\right)^2\left(\frac{k_B}{k_A}\right) = \left(\frac{1}{2}\right)^2\left(\frac{4}{3}\right) = \frac{1}{3}$

$\frac{E}{U_B} = \frac{1}{3} \Rightarrow U_B = 3E$

Q38 Solution:
(1)

(Dropped)

Q39 Solution:
(2)

$\frac{1}{\lambda} = R\left(1 - \frac{1}{4}\right)$

$\lambda = \frac{4}{3R}$

$\frac{1}{\lambda'} = R\left(\frac{1}{9}\right)$

$\lambda' = \frac{9}{R}$

Q40 Solution:
(3)

$$\lambda = \frac{h}{\sqrt{2mK}} = \frac{h}{\sqrt{2m\left(\frac{3}{2}kT\right)}}$$

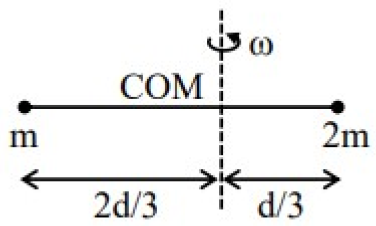
$$\lambda = \frac{h}{\sqrt{3mkT}}$$

$$= \frac{6.63 \times 10^{-34}}{\sqrt{3 \times 5.31 \times 10^{-26} \times 1.38 \times 10^{-23} \times 300}}$$

$$= 2.58 \times 10^{-11} = 25.8 \times 10^{-12}$$

So, $x = 26$

Q41 Solution:
(2)



$L = I\omega$ and $\omega = \frac{L}{I}$

$$\omega = \frac{L}{m\left(\frac{2d}{3}\right)^2 + 2m\left(\frac{d}{3}\right)^2} = \frac{L}{\frac{4}{9}md^2 + \frac{2}{9}md^2} = \frac{L}{\frac{6md^2}{9}}$$

$$\omega = \frac{3L}{2md^2}$$

Q42 Solution:
(1)

Zero error $e = -3 \times LC = -0.03\text{mm}$

Reading taken $= 1\text{mm} + 51\left(0.01\text{mm}\right)$

$= 1.51\text{mm}$

So, correct reading $= 1.51 - \left(-0.03\right)$

$= 1.54\text{mm}$

Q43 Solution:
(4)

$$(\text{K.E.})_{\text{lost}} = \frac{1}{2}\mu V_{\text{rel}}^2\left(1 - e^2\right)$$

$$= \frac{1}{2}\left(\frac{m_1 m_2}{m_1 + m_2}\right)(10 + 30)^2\left(1 - 0\right)$$

$$= \frac{1}{2}\left[\frac{(15)(25)}{40}\right][40]^2$$

$$= 7500\text{J}$$

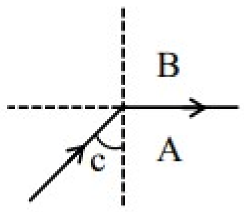
$$(\text{K.E.})_{\text{loss}} = \left(m_1 + m_2\right)\left(S\right)\left(\Delta T\right)$$

$$\left[S = 31 \times 4.2\text{J/kg-°C}\right]$$

$$7500 = (40)(31)(\Delta T)$$

$\Delta T = \frac{7500}{40 \times 31 \times 4.2} = 1.44°C$

Q44 Solution:
(1)



$\mu_A \sin c = \mu_B \sin 90$

$\Rightarrow \sin c = \frac{\mu_B}{\mu_A} = \frac{v_A}{v_B}$

$\therefore \quad \sin c = \frac{2.4 \times 10^8}{2.7 \times 10^8} = \frac{8}{9}$

$\Rightarrow \tan c = \frac{8}{\sqrt{81 - 64}} = \frac{8}{\sqrt{17}}$

$c = \tan^{-1}\left(\frac{8}{\sqrt{17}}\right)$

Q45 Solution:
(3)

$\phi = \frac{Q_{\text{in}}}{\varepsilon_0}$

$\phi = \frac{\frac{q}{4} + \frac{q}{2}}{\varepsilon_0} = \frac{3q}{4\varepsilon_0}$

Q46 Solution:
(2)

Here, $v = \frac{\omega}{K} = \frac{6.27 \times 10^3}{2.09 \times 10^{-5}} = 3 \times 10^8$

So, wave moving in vacuum.

Now, $I = \left(\frac{1}{2}\varepsilon_0 E_0^2\right)c = \frac{1}{2}\varepsilon_0 E_0^2 \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

$= \frac{1}{2}\sqrt{\frac{\varepsilon_0}{\mu_0}} E_0^2 = \frac{1}{2} \times \frac{1}{377} \times 377$

$\frac{1}{d} = \frac{1}{2}$

$d = 2$

Q47 Solution:
(50)

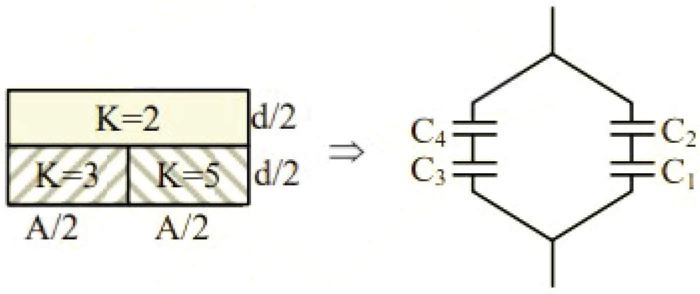
Current is maximum, so resonance

and $\omega = \frac{1}{\sqrt{LC}}$

$C = \frac{1}{\omega^2 L} = \frac{1}{2 \times 10^4}$

$= 50 \times 10^{-6} = 50\mu F$

Q48 Solution:
(8)



$C_1 = \frac{5\varepsilon_0 (A/2)}{d/2} = \frac{5\varepsilon_0 A}{d} = 5C$

$C_2 = \frac{2\varepsilon_0 (A/2)}{d/2} = \frac{2\varepsilon_0 A}{d} = 2C$

C_1 and C_2 in series

$C' = \frac{C_1 C_2}{C_1 + C_2} = \frac{(5C)(2C)}{7C} = \frac{10}{7}C$

$C_3 = \frac{3\varepsilon_0 (A/2)}{d/2} = 3C$

$C_4 = \frac{2\varepsilon_0 (A/2)}{d/2} = 2C$

C_4 and C_3 in series; $C'' = \frac{(2C)(3C)}{5C} = \frac{6}{5}C$

C' and C'' in parallel;

So, $C_{\text{eq}} = C\left(\frac{6}{5} + \frac{10}{7}\right) = C\left(\frac{42 + 50}{35}\right) = \frac{92}{35}C$

$\frac{92}{35}C = \frac{nC}{3}$

$n = \frac{92 \times 3}{35} = 7.9 \approx 8$

Q49 Solution:
(4)

$\beta_1 = \beta_2$

$\frac{D_1 \lambda_1}{d_1} = \frac{D_2 \lambda_2}{d_2}$

$\frac{D_1}{D_2} = \frac{\lambda_2}{\lambda_1}\left(\frac{d_1}{d_2}\right)$

$= 2 \times 2$

$\frac{D_1}{D_2} = 4$

Q50 Solution:
(100)

$\varepsilon_{\text{max}} = \frac{B\omega_{\text{max}}\ l^2}{2} \quad ...(1)$

Using energy conservation,

$mg\ell(1 - \cos 60°) = \frac{1}{2}(m\ell^2)\omega_m^2$

$\omega_m = \sqrt{\frac{g}{\ell}} = 10 \text{ rad/s}$

From eq.(1),

$\varepsilon_{\text{max}} = \frac{2 \times 10 \times 0.01}{2} = 0.1 \text{ V}$

$= 100 \text{ mV}$

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Q51 Solution:
(2)

Statement 1 (True)

Strength of ligand : $Cl^- > Br^-$

Δ_t: $[CoCl_4]^{2-} > [CoBr_4]^{2-}$

$E_{absorbed}$: $[CoCl_4]^{2-} > [CoBr_4]^{2-}$

Statement 2 (False)

Strength of ligand : $I^- < Cl^-$

Δ_t: $[CoI_4]^{2-} < [CoCl_4]^{2-}$

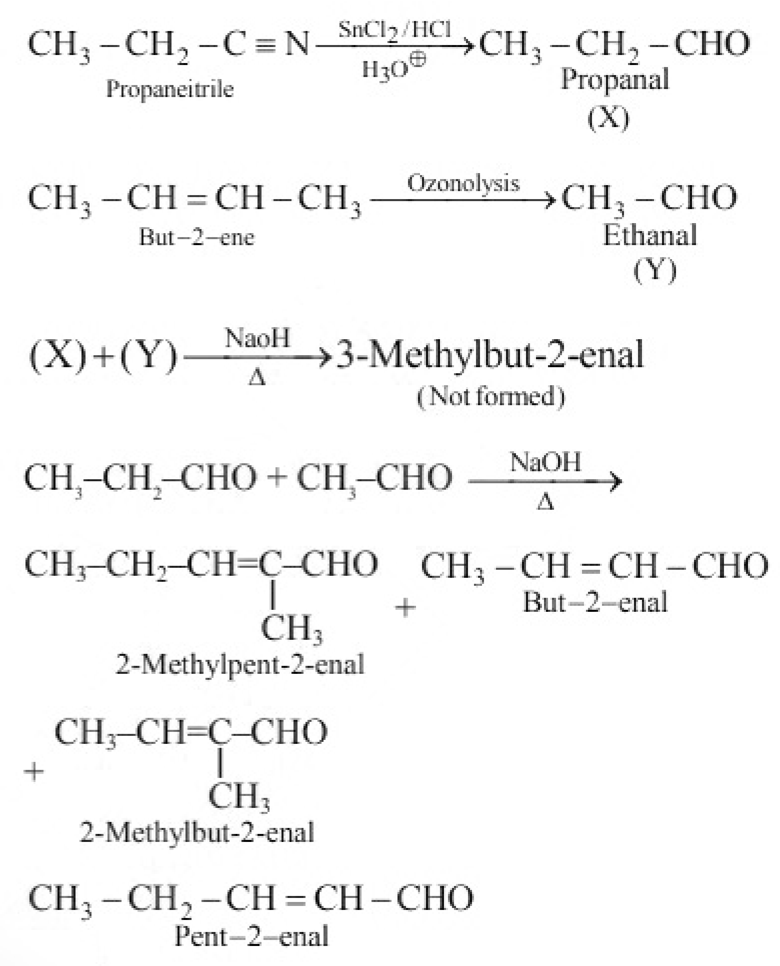
Q52 Solution:
(2)

In Ph-OMe, -OMe is an electron donor group (+M).

Ph - NO_2, -NO_2 is a strong withdrawing group (-M).

Ph-Cl, -Cl is an electron withdrawing group.

Q53 Solution:
(4)



Q54 Solution:
(4)

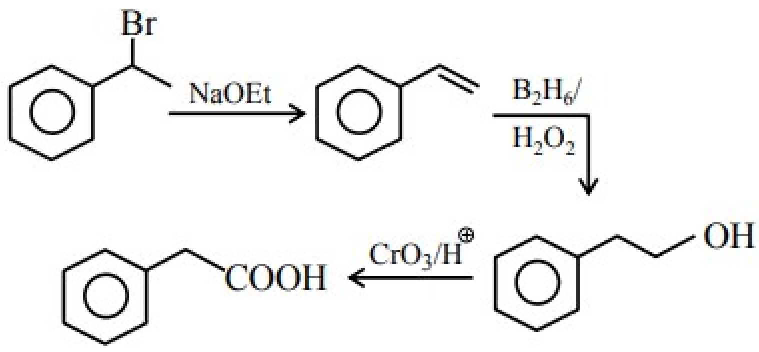
(A) $B^{+3} < Al^{+3} < Ga^{+3} < In^{+3} < Tl^{+3}$: ionic size

(B) B > Tl > In > Ga > Al : EN

(C) B > Tl > Ga > Al > In : IE

(D) Trichlorides and triiodides of group 13th elements are covalent in nature

Q55 Solution:
(4)



Q56 Solution:
(1)

For reaction (i) : $K_P > K_C$

$\Delta n_g > 0$

y - x > 0

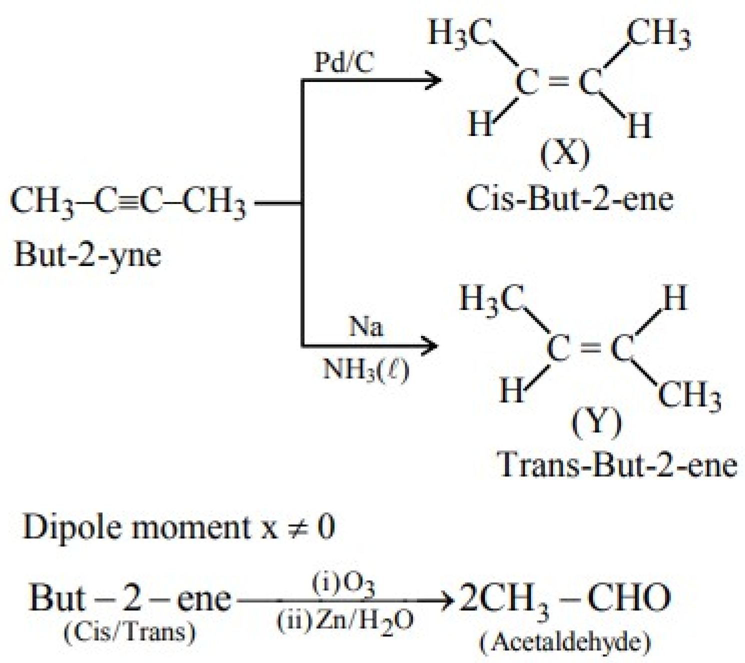
$85.87 = 2.586 \ (0.0821 \times 400)^{y-x}$

Solving y - x = 1

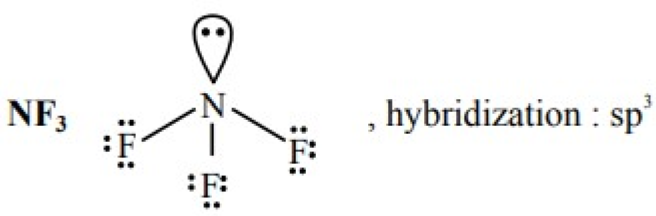
For reaction (ii) : $K_P < K_C$

y - x < 0

Q57 Solution:
(1)



Q58 Solution:
(1)



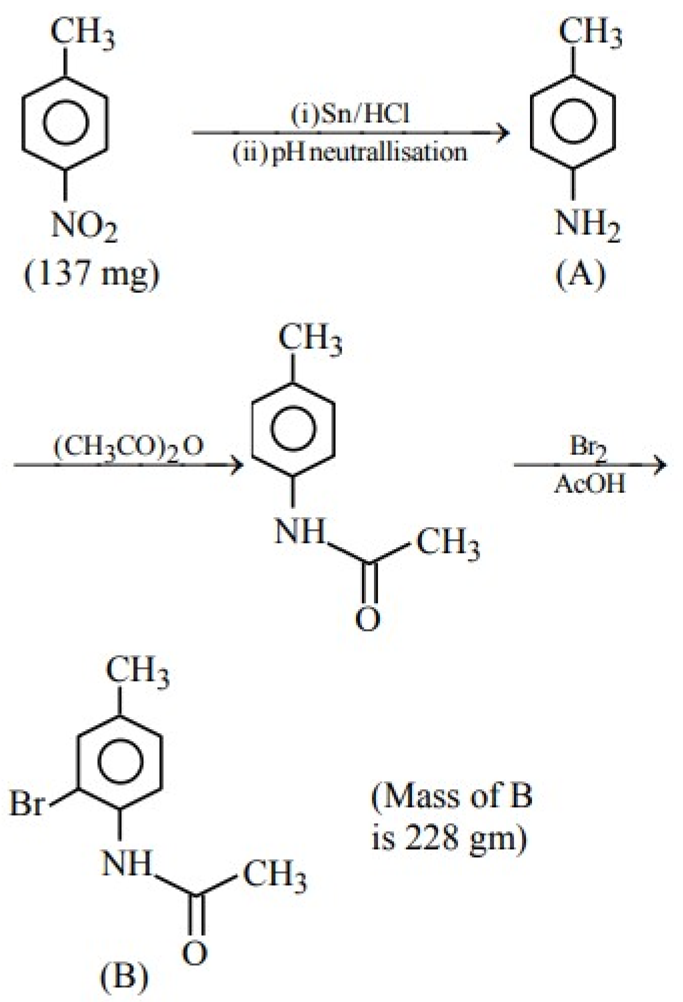
Number of lone pair in NF_3 = 10

Bond angle in NF_3 ≈ 102°

Q59 Solution:
(3)

Compound in option (B) and (C) are acetals (i.e. not having anomeric –OH). Hence they do not give Tollen's test.

Q60 Solution:
(4)



$$\text{Mole} = \frac{137\times10^{-3}}{137} = 0.001 \text{ mole}$$

$\text{Mole of product} = 0.001 \text{ mole}$

$\text{Mass of product} = 0.001\times228 \text{ gm}$

$= 0.228 \text{ gm} = 228 \text{ mg}$

Q61 Solution:
(3)

(A) $\text{n} = 5$

$l = 0 \quad m_l = 0$

$l = 1 \quad m_l = -1, 0, 1 \Rightarrow 2 \text{ electrons}$

$l = 2 \quad m_l = -2, -1, 0, 1, 2 \Rightarrow 2 \text{ electrons}$

$l = 3 \quad m_l = -3, -2, -1, 0, 1, 2, 3 \Rightarrow 2 \text{ electrons}$

$l = 4 \quad m_l = -4, -3, -2, -1, 0, 1, 2, 3, 4 \Rightarrow 2 \text{ electrons}$

Total number of electrons = 8

(B) $n = 3,\ l = 2,\ m_l = -1,\ m_s = +\frac{1}{2} \Rightarrow$ only 1 electron is possible

Q62 Solution:
(2)

$$\underset{5°C}{H_2O(\ell)} \rightarrow \underset{100°C}{H_2O(\ell)} \rightleftarrows \underset{100°C}{H_2O(g)}$$

due to expansion

$w = -ve$

as heat is given to system so $q = +ve$ and internal energy of gas will be more than internal energy of liquid so $\Delta U = +ve$

Q63 Solution:
(4)

In general on moving from left to right in a period ionization energy increases as Z_{eff} increases.

$Al < Si < S < \underset{\searrow}{P} < Cl$

(Ionisation energy of phosphorus is more because of half filled stable configuration)

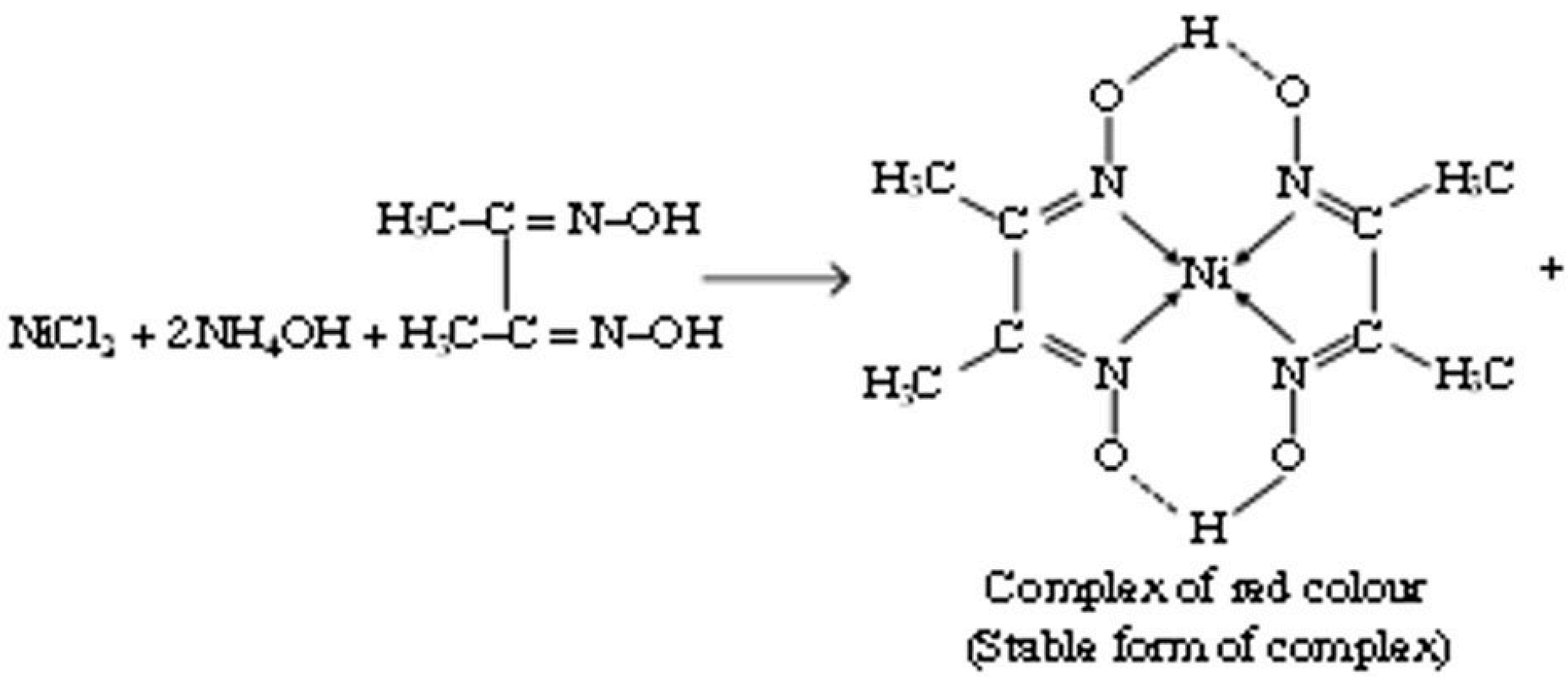
Q64 Solution:
(2)

$E_n = -2.18 \times 10^{-18} \frac{Z^2}{n^2}$ J/atom

For 3rd orbit of Li^{2+} ion

$= -2.18 \times 10^{-18} \times \frac{3^2}{3^2} = -2.18 \times 10^{-18}$ J.

Q65 Solution:
(4)



In the above complex, Ni is present in +2 oxidation number.

A) It is rosy red ppt

B) It is precipitated in basic medium

C) $Ni^{+2}: 3d^8$

Hybridisation : dsp^2

Unpaired e^- = 0

Geometry : Square planar

D) N–Ni–N bond angle is close to 90°

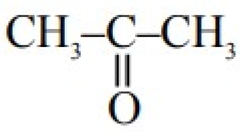
E) 2 five membered metal containing rings are formed.

Q66 Solution:
(1)

$Cl^{-}_{(aq)} + Ag_{(s)} + Fe^{3+}_{(aq)} \rightarrow Fe^{2+}_{(aq)} + AgCl_{(s)}$

$E_{cell} = E^{\circ}_{cell} - \frac{0.059}{1} \log \frac{[Fe^{2+}]}{[Cl^{-}][Fe^{3+}]}$

Q67 Solution:
(1)

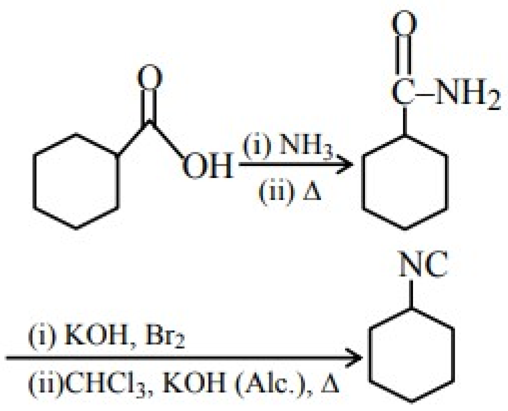
Mixture of CS_2 and  show positive deviation

$P_{CS_2} > P^{\circ}_{CS_2} . X_{CS_2}$

Q68 Solution:
(3)

(A) – IV, (B) – I, (C) – II, (D) – III

Q69 Solution:
(4)



Q70 Solution:
(1)

Theory based

Q71 Solution:
(1825)

$Ba(OH)_{2(aq)} + 2HCl_{(aq)} \rightarrow BaCl_{2(aq)} + 2H_2O_{(l)}$

2.5 mmole 5 mmole

wt of HCl $= 5 \times 36.5$ (milligram)

$= 182.5$ (milligram)

Hence $x = 1825$.

Q72 Solution:
(2)

Pairing energy neglected w.r.t. Δ_o

$\left[Co(ox)_3\right]^{3-} : Co^{3+} : d^6; \quad t_{2g}^{2,2,2} e_g^{0,0}$

$CFSE = 6 \times (-0.4\Delta_0) = -2.4\Delta_o$

$\left[Cr(ox)_3\right]^{3-} : Cr^{3+} : d^3; \quad t_{2g}^{1,1,1} e_g^{0,0}$

$CFSE = 3 \times (-0.4\Delta_o) = -1.2\Delta_o$

$\frac{(CFSE)_{Co^{3+}}}{(CFSE)_{Cr^{3+}}} = 2$

Q73 Solution:
(10)

$[AB]_0 - [AB]_t = kt$

$0.60 - 0.55 = k(100)$

$k = 5 \times 10^{-4}$

Half life $\left(t_{1/2}\right) = \frac{[AB]_0}{2k}$

$= \frac{0.60}{2 \times 5 \times 10^{-4}}$

$= 600$ sec

$= 10$ min

Q74 Solution:
(125)

	$NH_{3(g)}$	$\rightleftharpoons$	$\frac{1}{2}N_{2(g)}$	$+$	$\frac{3}{2}H_{2(g)}$
t = 0	1mole		-		-
$t = t_{eq}$	$1-\alpha$		$\alpha/2$		$3\alpha/2$

$$K_p = \frac{\left(\frac{\alpha}{2}\right)^{1/2}\left(\frac{3\alpha}{2}\right)^{3/2}}{(1-\alpha)}\left[\frac{P_T}{1+\alpha}\right]^1 \qquad \left[\because P_T = \sqrt{3}\text{ atm}\right]$$

$$9 = \frac{\left(\frac{\alpha}{2}\right)^{1/2}\left(\frac{3\alpha}{2}\right)^{3/2}}{(1-\alpha)} \times \frac{(3)^{1/2}}{1+\alpha}$$

$$9 = \frac{9\left(\frac{\alpha}{2}\right)^2}{1-\alpha^2}$$

$1 - \alpha^2 = \frac{\alpha^2}{4}$

$\frac{5\alpha^2}{4} = 1$

$\alpha^2 = 0.8$

$\alpha = (0.8)^{1/2}$

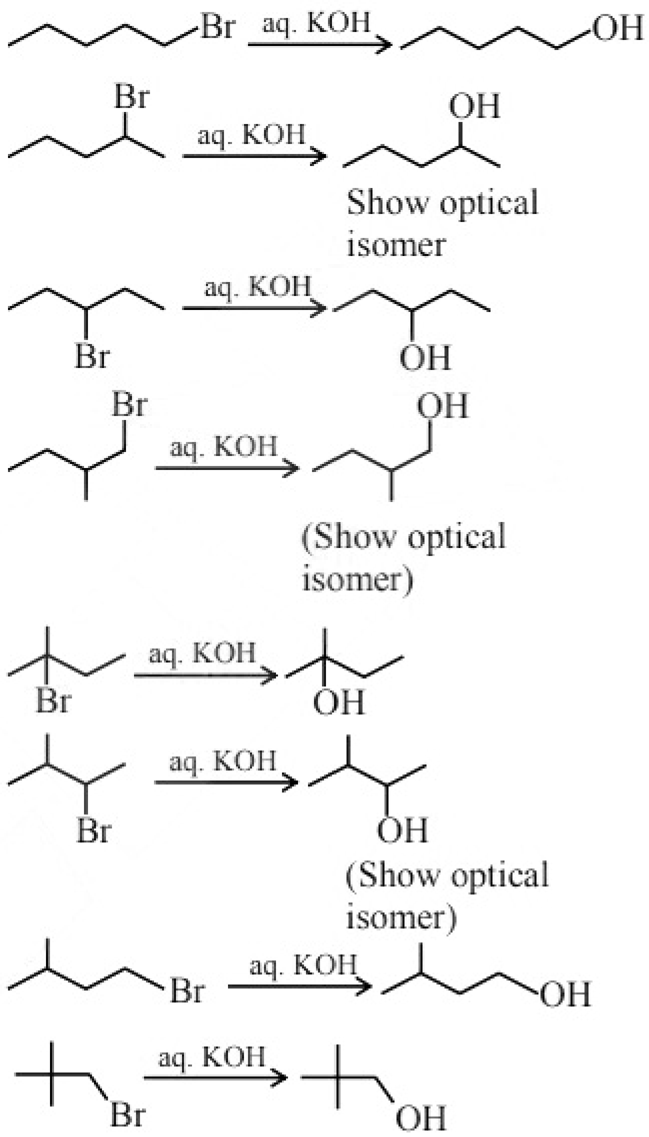
$\alpha = \left[\frac{1}{0.8}\right]^{-1/2}$

$\alpha = \left[125 \times 10^{-2}\right]^{-1/2}$

$x = 125$

Q75 Solution:
(3)

$C_5H_{11}Br$



As per the language given and considering the condition we are going with answer 3 and considering both active isomers we will be giving 6 too.