SOLUTIONS

Joint Entrance Exam | IITJEE-2025

23rd JANUARY 2025 | Morning Shift

MATHEMATICS

SECTION – 1

1.(1) Sum of first four term $= \frac{1}{5}$ sum of next four terms

$$\Rightarrow \quad \frac{4}{2}(2a+3d) = \frac{1}{5}(4a+22d)$$

$$\Rightarrow \quad (4a+6d)\cdot 5 = 4a+22d$$

$$\Rightarrow \quad 20a+30d = 4a+22d$$

$$\Rightarrow \quad 16a = -8d \quad \Rightarrow \quad \boxed{a = -\frac{d}{2}}$$

$$\Rightarrow \quad \boxed{d=-6}\boxed{a=3}$$

$$\Rightarrow \quad \frac{20}{2}[2(3)+19(-6)] = -1080$$

2.(2) $D_1 \to 1, 1, 2, 2, 3, 4$

$D_2 \to 1, 2, 2, 3, 3, 4$

Sum 4 = 1 + 3 = 3 + 1 = 2 + 2

Sum 5 = 2 + 3 = 3 + 2 = 1 + 4 = 4 + 1

Required probability

$$= \frac{2}{6}\times\frac{2}{6}+\frac{1}{6}\times\frac{1}{6}+\frac{2}{6}\times\frac{2}{6}+\frac{2}{6}\times\frac{2}{6}\times\frac{2}{6}+\frac{1}{6}\times\frac{2}{6}+\frac{2}{6}\times\frac{1}{6}+\frac{1}{6}\times\frac{1}{6} = \frac{18}{36} = \frac{1}{2}$$

3.(1) $$\left|\frac{\bar{z}-1}{\bar{z}+\frac{i}{2}}\right| = \frac{2}{3}$$

$$3\,|x-iy-i| = 2\,|x-iy+\frac{i}{2}|$$

$$9(x^2+(y+1)^2) = 4(x^2+(y-1/3)^2)$$

$$9x^2+9y^2+18y+9 = 4x^2+4y^2-4y+1$$

$$5x^2+5y^2+22y+8 = 0$$

Centre $\Rightarrow (0, -\frac{11}{5})$ $\qquad \left|\frac{1}{2}\begin{vmatrix} 0 & 0 & 1 \\ 0 & -11/5 & 1 \\ \alpha & 0 & 1 \end{vmatrix}\right| = 11$

$$\Rightarrow \quad \left(-\frac{11}{5}\alpha\right)^2 = (11\times 2)^2$$

$$\Rightarrow \quad \alpha^2 = 100$$

4.(1) For infinitely many solutions

$$D = \begin{vmatrix} \lambda-1 & \lambda-4 & \lambda \\ \lambda & \lambda-1 & \lambda-4 \\ \lambda+1 & \lambda+2 & -(\lambda+2) \end{vmatrix} = 0$$

$$(\lambda-3)(2\lambda+1)=0$$

$$D_x = \begin{vmatrix} 5 & \lambda-4 & \lambda \\ 7 & \lambda-1 & \lambda-4 \\ 9 & \lambda+2 & -(\lambda+2) \end{vmatrix} = 0$$

$$2(3-\lambda)(23-2\lambda)=0$$

Similarly

$$D_y = -2(2\lambda-7)(\lambda-3)=0$$

$$\& \ D_z = 0 \ \forall \ \lambda \in R$$

Hence,

$\lambda = 3$

$\Rightarrow \lambda^2 + \lambda = 9+3 = 12$

5.(4) Area of $\Delta ABC = \frac{1}{2}\left|\overrightarrow{AB} \times \overrightarrow{AC}\right|$

$$= \frac{1}{2}\left|5\hat{i}+3\hat{j}+\hat{k}\right| = \frac{1}{2}\sqrt{35}$$

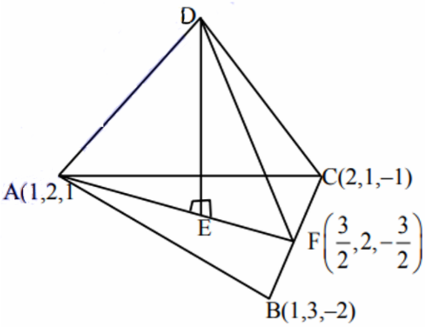
Volume of tetrahedron

$$= \frac{1}{3} \times \text{Base area} \times h = \frac{\sqrt{805}}{6\sqrt{2}}$$

$$\frac{1}{3} \times \frac{1}{2}\sqrt{35} \times h = \frac{\sqrt{805}}{6\sqrt{2}}$$

$$h = \sqrt{\frac{23}{2}}$$

$$AE^2 = AD^2 - DE^2 = \frac{13}{18} \quad \therefore \qquad AE = \sqrt{\frac{13}{18}}$$



$$\overrightarrow{AE} = |AE| \cdot \left(\frac{\hat{i}-5\hat{k}}{\sqrt{26}}\right)$$

$$= \sqrt{\frac{13}{18}} \cdot \left(\frac{\hat{i}-5\hat{k}}{\sqrt{26}}\right)$$

$$= \sqrt{\frac{13}{18}} \cdot \left(\frac{\hat{i}-5\hat{k}}{\sqrt{26}}\right) = \frac{\hat{i}-5\hat{k}}{6}$$

P.V. OF E $= \frac{\hat{i}-5\hat{k}}{6} + \hat{i} + 2\hat{j} + \hat{k} = \frac{1}{6}(7\hat{i} + 12\hat{j} + \hat{k})$

6.(2) Total words = 8!

Total words in which vowels are together $= 6! \times 3!$

Words in which all vowels are not together

$= 8! - 6! \times 3!$

$= 6![56 - 6]$

$= 720 \times 50 = 36000$

7.(3) $\frac{x}{2} \le x \le \frac{3\pi}{4}$

$\cos^{-1}\left(\frac{12}{13}\cos x + \frac{5}{12}\sin x\right)$

$\cos^{-1}(\cos x \cos\alpha + \sin x \sin\alpha)$

$\cos^{-1}(\cos(x - \alpha))$

$\Rightarrow \quad x - \alpha$ because $x - \alpha \in (0, \pi)$

$\Rightarrow \quad x - \tan^{-1}\frac{5}{12}$

8.(4) $\lim\limits_{x \to 0^-} \frac{2}{x}\{\sin(k_1 + 1)x + \sin(k_2 - 1)x\} = 4$

$\Rightarrow \quad 2(k_1 + 1) + 2(k_2 - 1) = 4$

$\Rightarrow \quad k_1 + k_2 = 2$

$\Rightarrow \quad \lim\limits_{x \to 0^+} \frac{2}{x}\ln\left(\frac{2 + k_1 x}{2 + k_2 x}\right) = 4$

$\Rightarrow \quad \lim\limits_{x \to 0^+} \frac{2}{x}\ln\left(1 + \frac{(k_1 - k_2)x}{2 + k_2 x}\right) = 2$

$\Rightarrow \quad \frac{k_1 - k_2}{2} = 2$

$\Rightarrow \quad k_1 - k_2 = 4$

$\therefore \quad k_1 = 3, k_2 = -1$

$k_1^2 + k_2^2 = 9 + 1 = 10$

9.(3) Consider a unit circle $x^2 + y^2 = 1$

Clearly $6\theta = \frac{\pi}{2} \Rightarrow \theta = \frac{\pi}{12}$

$\overrightarrow{OC} = \alpha\overrightarrow{OA} + \beta\overrightarrow{OB}$

$\hat{j} = \alpha\hat{i} + \beta(\cos\theta\hat{i} + \sin\theta\hat{j})$

$\Rightarrow \quad \alpha + \beta\cos\theta = 0$ and $\beta\sin\theta = 1$

$\Rightarrow \quad \beta\sin\frac{\pi}{12} = 1 \Rightarrow \beta\sin\left(\frac{\pi}{4} - \frac{\pi}{6}\right) = 1 \Rightarrow \beta\left(\frac{\sqrt{3} - 1}{2\sqrt{2}}\right) = 1 \Rightarrow \sqrt{2}\left(\sqrt{3} - 1\right)\beta = 4$

Now $\alpha = -\beta\cos\frac{\pi}{12} = -\cot\frac{\pi}{12} = \frac{1+\sqrt{3}}{1-\sqrt{3}} = \frac{(1+\sqrt{3})^2}{-2} = -2-\sqrt{3}$

$\alpha + \sqrt{2}\left(\sqrt{3}-1\right)\beta = 2-\sqrt{3}$

10.(3) $I(x) = \int \frac{dx}{(x-11)^{11/13}(x+15)^{15/13}}$

Put $\frac{x-11}{x+15} = t \Rightarrow \frac{26}{(x+15)^2}dx = dt$

$$I(x) = \frac{1}{26}\int \frac{dt}{t^{11/13}} = \frac{1}{26}\cdot\frac{t^{2/13}}{2/13}$$

$$I(x) = \frac{1}{4}\left(\frac{x-11}{x+15}\right)^{2/13} + C$$

$$I(37) - I(24) = \frac{1}{4}\left(\frac{26}{52}\right)^{2/13} - \frac{1}{4}\left(\frac{13}{39}\right)^{2/13}$$

$$= \frac{1}{4}\left(\frac{1}{2^{2/13}} - \frac{1}{3^{2/13}}\right) = \frac{1}{4}\left\{\left(\frac{1}{4^{1/13}} - \frac{1}{9^{1/13}}\right)\right\} \Rightarrow b = 4,\ c = 9$$

11.(2) $\frac{x-3}{7} = \frac{7-2}{-1} = \frac{z+1}{-2} = \lambda$

$\Rightarrow \quad 7\lambda+3,\ -\lambda+2,\ -2\lambda-1$

dr's of QP $\Rightarrow$

Now $(7\lambda-7)\cdot 7 - (-\lambda+5) + (2\lambda)\cdot 2 = 0$

$54\lambda - 54 = 0 \Rightarrow \lambda = 1$

$\therefore \quad P = (10,\ 1,\ -3)$

$\overrightarrow{PQ} = -4\hat{j} + 2\hat{k}$

$\overrightarrow{PR} = -7\hat{i} - 3\hat{j} + 4\hat{k}$

$$\text{Area} = \left|\frac{1}{2}\begin{vmatrix} i & j & k \\ 0 & -4 & 2 \\ -7 & -3 & 4 \end{vmatrix}\right| = 3\sqrt{30}$$

12.(3) A $= \{1,\ 2,\ 3,\ 4\}$

For relation to be reflexive

$\{(1,\ 1)(2,\ 2)(4,\ 4)(2,\ 1)(3,\ 2)(3,\ 1)(1,\ 3)\}$ needs to be added to R.

$\therefore$ Minimum number of elements = 7

13.(2) Let $\ln x = t \Rightarrow \frac{dx}{x} = dt$

$$I = \int_2^4 \frac{e^{\frac{1}{1+t^2}}}{e^{\frac{1}{1+t^2}} + e^{\frac{1}{1+(6-t)^2}}}dt$$

$$I=\int_{2}^{4}\frac{e^{\frac{1}{1+(6-t)^2}}}{e^{\frac{1}{1+(6-t)^2}}+e^{\frac{1}{1+t^2}}}dt$$

$$2I=\int_{2}^{4}dt=\left(t\right)_2^4=4-2=2$$

$I\ =1$

14.(2) Median $=\ell+\left(\dfrac{\frac{N}{2}-F}{f}\right)\times h$

$$=12+\left(\frac{\frac{N}{2}-18}{12}\right)\times 6=14$$

$$\Rightarrow\qquad\left(\frac{\frac{N}{2}-18}{12}\right)\times 6=2$$

$$\frac{N}{2}-18=4\Rightarrow\qquad N=44$$

15.(1) For $D_{fog}\Rightarrow g(x)>0$

$$\frac{x^4-2x^3+3x^2-2x+2}{2x^2-2x+1}>0$$

$$\Rightarrow\qquad x^4-2x^3+3x^2-2x+2>0$$

$$\Rightarrow\qquad (x^4+3x^2+2)-2x(x^2+1)>0$$

$$\Rightarrow\qquad (x^2+1)(x^2-2x+2)>0\Rightarrow x\in R$$

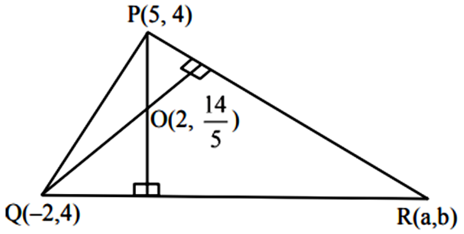
16.(3) Equation of lines $QR = 5x + 2y + 2 = 0$

Equation of lines $PR = 10x - 3y - 38 = 0$

$\therefore$ Point R (2, –6)

Centroid $=\left(\dfrac{5-2+2}{3},\dfrac{4+4-6}{3}\right)=\left(\dfrac{5}{3},\dfrac{2}{3}\right)$

$$c+2d=\frac{5}{3}+\frac{4}{3}=3$$



17.(2) $\left[A\left(\text{adj}(A^{-1})+\text{adj}(B^{-1})\right)^{-1}\cdot B\right]^{-1}$

$$B^{-1}\cdot\left(\text{adj}(A^{-1})+\text{adj}(B^{-1})\right)\cdot A^{-1}$$

$$B^{-1}\text{adj}(A^{-1})A^{-1}+B^{-1}\left(\text{adj}(B^{-1})\right)\cdot A^{-1}$$

$$B^{-1}\left|A^{-1}\right|I+\left|B^{-1}\right|IA^{-1}$$

$$\frac{B^{-1}}{|A|}+\frac{A^{-1}}{|B|}$$

$$\Rightarrow \qquad \frac{\text{adj}\,B}{|B|\,|A|}+\frac{\text{adj}\,A}{|A|\,|B|}$$

$$=\frac{1}{|A|\,|B|}(\text{adj}\,B+\text{adj}\,A)$$

18.(2) $\sin 70°(\cot 10°\cdot\cot 70°-1)$

$$=\sin 70°\frac{(\cos 10°\cos 70°-\sin 10°\sin 70°)}{\sin 10°\cdot\sin 70°}$$

$$=\sin 70°\left(\frac{\cos 80°}{\sin 10°\sin 70°}\right)$$

$$=\frac{\cos 80°}{\sin 10°}=\frac{\sin 10°}{\sin 10°}=1$$

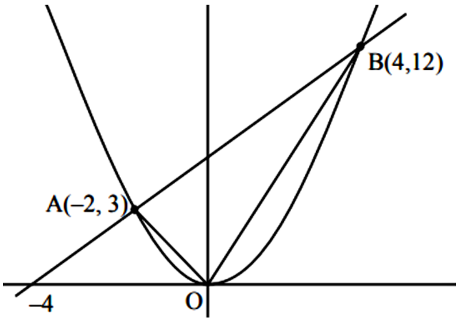
19.(1) $x^2=\frac{4}{3}y$

Put $x=\frac{2t}{3}, y=\frac{t^2}{3}$ in $3x-2y+12=0$

$$2t-\frac{2t^2}{3}+12=0 \Rightarrow \qquad 3t-t^2+18=0$$

$$\Rightarrow \qquad t=-3, 6$$

$$\Rightarrow \qquad A(-2, 3) \;\&\; B(4, 12)$$



$$m_{OA}=-\frac{3}{2},\ m_{OB}=3$$

$$\tan\theta=\left(\frac{\frac{-3}{2}-3}{1-\frac{9}{2}}\right)=\frac{9}{7}$$

20.(3) $\frac{dy}{dx}=\frac{2(3+y)\cdot e^{2x}}{7+e^{2x}}$

$$\frac{dy}{dx}-\frac{2y\cdot e^{2x}}{7+e^{2x}}=\frac{6\cdot e^{2x}}{7+e^{2x}}$$

$$\text{I.F.}\ =e^{-\int\frac{2e^{2x}}{7+e^{2x}}dx}=\frac{1}{7+e^{2x}}$$

$$\therefore \qquad y\cdot\frac{1}{7+e^{2x}}=\int\frac{6e^{2x}}{(7+e^{2x})^2}dx$$

$$\frac{y}{7+e^{2x}}=\frac{-3}{7+e^{2x}}+C$$

$$(0,5) \Rightarrow \frac{5}{8} = \frac{-3}{8} + C \Rightarrow C = 1$$

$$\therefore \qquad y = -3 + 7 + e^{2x}$$

$$y = e^{2x} + 4$$

$$\therefore \qquad k = 8$$

SECTION – 2

21.(612) $$\frac{\lfloor\underline{6}}{\lfloor\underline{r_1}\lfloor\underline{r_2}\lfloor\underline{r_3}}(1)^{r_1}(2)^{\frac{r_2}{3}}(3)^{\frac{r_3}{2}}$$

r_1	r_2	r_3
6	0	0
4	0	2
2	0	4
0	0	6
3	3	0
1	3	2
0	6	0

$$= \frac{\lfloor\underline{6}}{\lfloor\underline{6}\lfloor\underline{0}\lfloor\underline{0}} + \frac{\lfloor\underline{6}}{\lfloor\underline{4}\lfloor\underline{0}\lfloor\underline{2}}(3) + \frac{\lfloor\underline{6}}{\lfloor\underline{2}\lfloor\underline{0}\lfloor\underline{4}}(3)^2 + \frac{\lfloor\underline{6}}{\lfloor\underline{0}\lfloor\underline{0}\lfloor\underline{6}}(3)^3 + \frac{\lfloor\underline{6}}{\lfloor\underline{3}\lfloor\underline{3}\lfloor\underline{0}}(2) + \frac{\lfloor\underline{6}}{\lfloor\underline{1}\lfloor\underline{3}\lfloor\underline{2}}(2)^1(3)^1 + \frac{\lfloor\underline{6}}{\lfloor\underline{0}\lfloor\underline{6}\lfloor\underline{0}}(2)^2$$

$$= 1 + 45 + 135 + 27 + 40 + 360 + 4 = 612$$

22.(19) $$\left|\frac{a - 0 + 1}{\sqrt{2}}\right| = r \Rightarrow (a+1)^2 = 2r^2 \qquad \ldots(1)$$

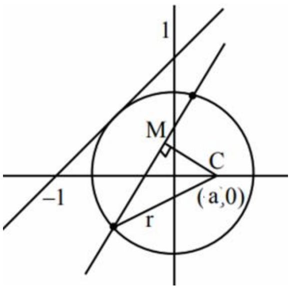
Now $$\left(\frac{-3a + 0 - 1}{\sqrt{9+4}}\right)^2 + \left(\frac{2}{\sqrt{13}}\right)^2 = r^2$$

$$\Rightarrow \qquad (3a+1)^2 + 4 = 13r^2 \qquad \ldots(2)$$

$$\Rightarrow \qquad (3a+1)^2 + 4 = 13\frac{(a+1)^2}{2}$$

$$\Rightarrow \qquad a = \frac{-1}{5}, 3$$

$$\therefore \qquad r = 2\sqrt{2}$$

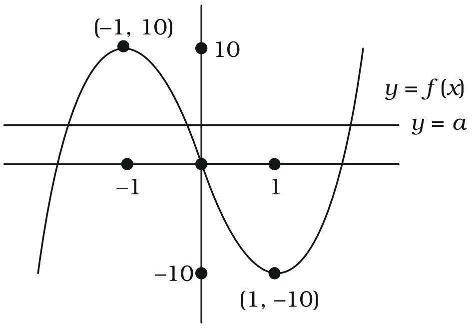


$$\alpha e = 3 \text{ and } 2\alpha = 4\sqrt{2}$$

$$\alpha^2 e^2 = 9 \Rightarrow \alpha = 2\sqrt{2} \Rightarrow \alpha^2 = 8$$

$$\Rightarrow \qquad \beta^2 = 1 \;\therefore \qquad 2\alpha^2 + 3\beta^2 = 19$$

23.(30) $5x^3 - 15x - a = 0$



$f(x) = 5x^3 - 15x$

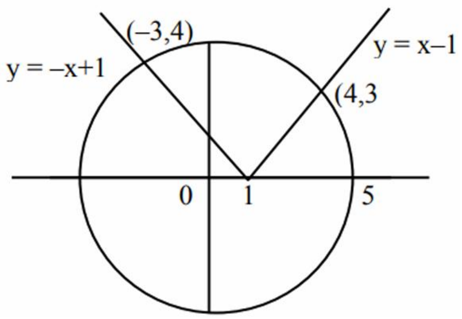
$f'(x) = 15x^2 - 15 = 15(x-1)(x+1)$

$a \in (-10, 10)$ for three distinct real roots

$\alpha = -10, \beta = 10$

$\beta - 2\alpha$ is equal to 30

24.(77) $A = 25\pi - \int_{-3}^{4} \sqrt{25 - x^2}\,dx + \frac{1}{2} \times 4 \times 4 + \frac{1}{2} \times 3 \times 3$



$25\pi - \left[\frac{x}{2}\sqrt{25 - x^2} + \frac{25}{2}\sin^{-1}\frac{x}{5}\right]_{-3}^{4} + \frac{25}{2}$

$A = \frac{75\pi}{4} + \frac{1}{2}$

$A = \frac{1}{4}(75\pi + 2)$

$b = 75, c = 2$

$b + c = 75 + 2 = 77$

25.(117) $(\because f(1) = 0)$ and both roots are equal

$x =$ 1 is a root and also other root is 1

$\alpha + \beta = -\frac{b(c-a)}{a(b-c)} = 2$

$\Rightarrow \quad -bc + ab = 2ab - 2ac$

$\Rightarrow \quad 2ac = ab + bc$

$\Rightarrow \quad 2ac = b(a + c)$

$\Rightarrow \quad 2ac = 15b \qquad \ldots.(1)$

$\Rightarrow \quad 2ac = 15\left(\frac{36}{5}\right) = 108$

$a + c = 15$

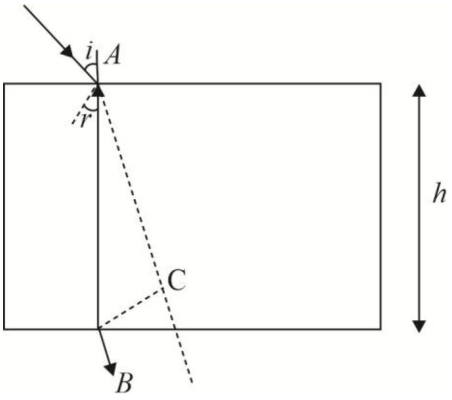
$a^2 + c^2 + 2ac = 225$

$a^2 + c^2 = 225 - 108 = 117$

PHYSICS

SECTION – 1

26.(1)



$$AB = \frac{h}{\cos r}$$

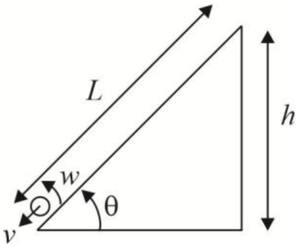
$\angle BAC = i - r$ So $BC =$ lateral shift

$$= AB\sin(i-r)$$

$$= \frac{h\sin(i-r)}{\cos r}$$

27.(2) Initially charge on capacitor is zero and current is maximum.

28.(3)



$$mgh = mgL\sin\theta = \frac{1}{2}mv^2\left(1+\frac{2}{5}\right).$$

$$\frac{v_1^2}{v_2^2} = \frac{\sin 30^\circ}{\sin 45^\circ} = \frac{\sqrt{2}}{2} = \frac{1}{\sqrt{2}}$$

29.(3) $625 = ms\Delta T + mL$

$$625 = [37500 + 25000]m$$

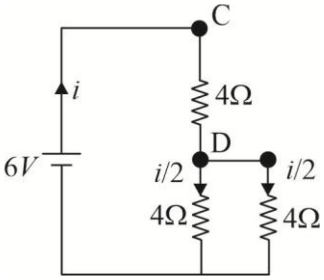
$$m = \frac{1}{100}kg = 10\,gm$$

30.(2) $[\alpha] = \left[\frac{\phi}{\sigma}\right]$ and $[\beta] = \left[\frac{\phi}{\lambda}\right]$

$$\left(\frac{\alpha}{\beta}\right) = \left[\frac{\lambda}{\sigma}\right]\left[\frac{\frac{Q}{L}}{\frac{Q}{L^2}}\right] = [L]$$

31.(3) Diode is forward baised.

So,



$$\text{Req} = 4 + 2 = 6\Omega$$

$$i = \frac{6}{6} = 1A$$

$$V_{CD} = 4 \times 1 = 4V \qquad V_{AB} = 4 \times \frac{1}{2} = 2V$$

32.(3) $T = 2\pi\sqrt{\frac{m}{A\rho g}} = 2\pi\sqrt{\frac{1}{100} \times \frac{1}{0.1 \times 0.1 \times 10^3 \times 10}}$

$$= 2\pi \times 10^{-2}$$

$\Rightarrow \qquad y = 2$

33.(1) $\lambda_2 = 3\lambda_1$

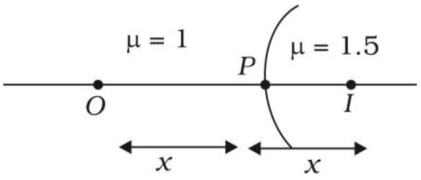
$$t_2 = \frac{t_1}{3}$$

After one half life of n_1 :

$$N_1 = \frac{N_0}{2} \text{ and } N_2 = \frac{N_0}{2^3} = \frac{N_0}{8}$$

$$\frac{N_2}{N_1} = \frac{1}{4}$$

34.(3)



$$\frac{1.5}{x} - \frac{1}{-x} = \frac{1.5-1}{R}$$

$$x = 5R$$

35.(4) $[A] = L$

$[B] = L$

$$[C] = \frac{L}{T^2}$$

$[D] = L$

$$\left[\frac{ABC}{D}\right]=\frac{L^2}{T^2}$$

36.(4) Dimensions of $K=\left[\frac{\tau}{\theta}\right]=\left[ML^2T^{-2}\right]$

Current sensitivity $=\frac{\theta}{I}=\frac{NAB}{K}$

Voltage sensitivity $=\frac{NAB}{KR}$; R will also change with 'N'.

37.(2) Theory

38.(1) $\lambda=\frac{h}{mv}=\frac{6.63\times10^{-34}}{10^{-30}\times2.21\times10^{6}}$

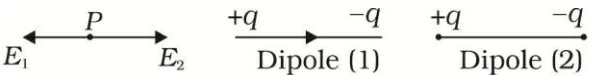
$$=3\times10^{-10}\,m$$

$\Rightarrow$ X-Rays

39.(4) With temperature increase viscosity decreases so hot water flows faster.

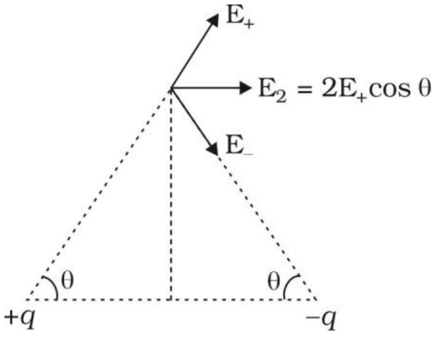
Soap will cause a reduction in surface tension.

40.(2)



$$E_1=\frac{kq}{(r-a)^2}-\frac{kq}{(r+a)^2}=\frac{kq(4ra)}{(r^2-a^2)^2}$$

$$E_2=\frac{2kqa}{\left(r^2+a^2\right)^{3/2}}$$



$E_1=E_2$

$$\Rightarrow \qquad \left(r^2+a^2\right)^{3/2}=\frac{\left(r^2-a^2\right)}{2r}$$

$$4r^2\left(r^2+a^2\right)^3=\left(r^2-a^2\right)^4$$

If $\frac{a}{r}=x$

$$4(1+x^2)^3=(1-x^2)^4$$

It can be verified that $x\sim3$ satisfies the equation.

41.(1) Area under the curve $= \frac{1}{2}(200+400)\times 2 + 28.5\times 400$

$$= 600 + 11400$$

$$= 12000 = 12\,km$$

42.(3) $E_0 = 57\times 5\frac{N}{C}$

$$B_0 = \frac{E_0}{C} = \frac{57\sqrt{5}}{3\times 10^8}$$

$$\hat{c} = \frac{3\hat{i}+4\hat{j}}{5}$$

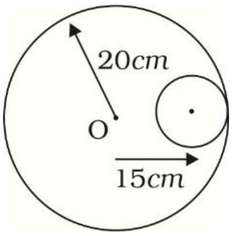
$$\hat{E} = \frac{4\hat{i}-3\hat{j}}{5}$$

$$\hat{B} = \hat{c}\times\hat{E} = -\hat{k}$$

$$\vec{B} = \frac{57\times 5}{3\times 10^8}\left[7.5\times 10^6 t - 5\times 10^{-3}(3x+4y)\right](-\hat{k})$$

43.(2) $L = \left(\frac{\mu_0 N^2 A}{l}\right)\mu_r$

44.(2)



$$r_{cm} = \frac{m\times 0 - \dfrac{m\times\pi\times(5)^2\times 15}{\pi(20)^2}}{m - \dfrac{m\times\pi(5)^2}{\pi(20)^2}}$$

$$= 1\,cm$$

45.(4) $\frac{1}{f_{eq}} = \frac{1}{f_m} - \frac{2}{f_l}$

$$= \frac{2}{|R_2|} - 2\left(\frac{\mu_2}{\mu_1}-1\right)\left(\frac{1}{|R_1|}+\frac{1}{|R_2|}\right)$$

$$f_{eq} = \frac{\mu R_1 R_2}{2\left(\mu_1|R_1| + (\mu_2-\mu_1)(|R_1|+|R_2|)\right)}$$

Object must be placed at C i.e. at a distance $2f_{eq}$ for image to be formed at same position.

$$x = 2f_{eq}$$

$$\frac{\mu_1|R_1||R_2|}{\mu_2\left(|R_1|+|R_2|\right)-\mu_1|R_2|}$$

SECTION – 2

46.(0) $\frac{F_E}{F_G} = \frac{1}{4\pi\varepsilon_0} q_1 q_2 \times \frac{1}{Gm_1 m_2}$

$$= \frac{9\times10^9 \times 6.67\times10^{-19} \times 9.6\times10^{-10}}{6.67\times10^{-11} \times 19.2\times10^{-27} \times 9\times10^{-27}}$$

$$= 0.5\times10^{45}$$

47.(273) Process is adiabatic

$$TV^{u-1} = const.$$

$$273\,V^{0.5} = \left(\frac{V}{4}\right)^{0.5}$$

$$T = 273\times2 = 546$$

$$\Delta T = 273$$

48.(152) Data given is inconsistent.

49.(3) EMF induce across inductor

$$V_L = 3\times8 = 24V$$

$$V_R = 12 + 24 = 36$$

$$i = \frac{V_R}{R} = \frac{136}{12} = 3A$$

50.(3) $\vec{A} \perp \vec{B}$ so $\vec{A}\cdot\vec{B} = 0$

$$4 - 6n + 8p = 0 \qquad .....(i)$$

Also, $\left|\vec{A}\right| = \left|\vec{B}\right|$ so $4 + 9n^2 + 4 = 4 + 4 + 16p^2$

$$\Rightarrow 16p^2 = 9n^2$$
$$4p = \pm3n$$

$$\Rightarrow \qquad n = \frac{1}{3} \text{ or } n^{-1} = 3$$

CHEMISTRY

SECTION – 1

51.(4) Iridium, Platinum and Osmium belongs to period 6. While palladium belongs to period 5.

52.(1) p: Anti Aromatic

q: Aromatic

r: Non-Aromatic

Stability order q > r > p

53.(3) For precipitation of $\left[A^{2+}\right]$

$$\left[A^{2+}\right]\left[OH^{-}\right]^{2} \geq 9\times10^{-10}$$

$$\left[OH^{-}\right] \geq 3\times10^{-5}$$

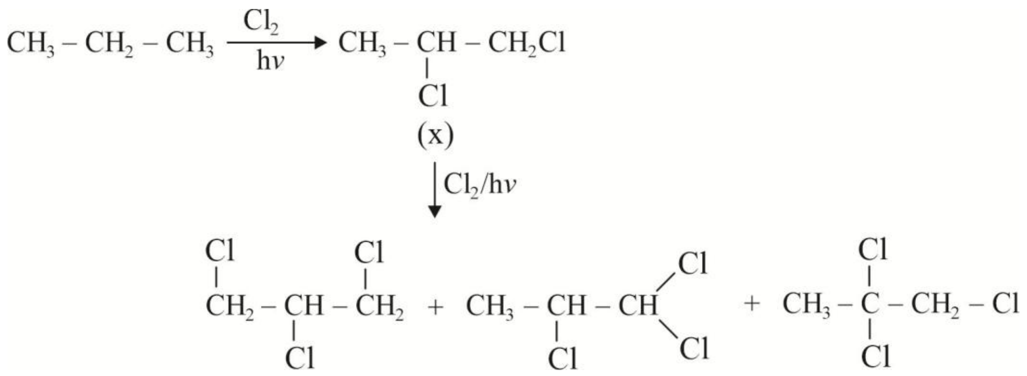
For precipitation of B^{3+}

$$\left[B^{3+}\right]\left[OH^{-}\right]^{3} \geq 27\times10^{-18}$$

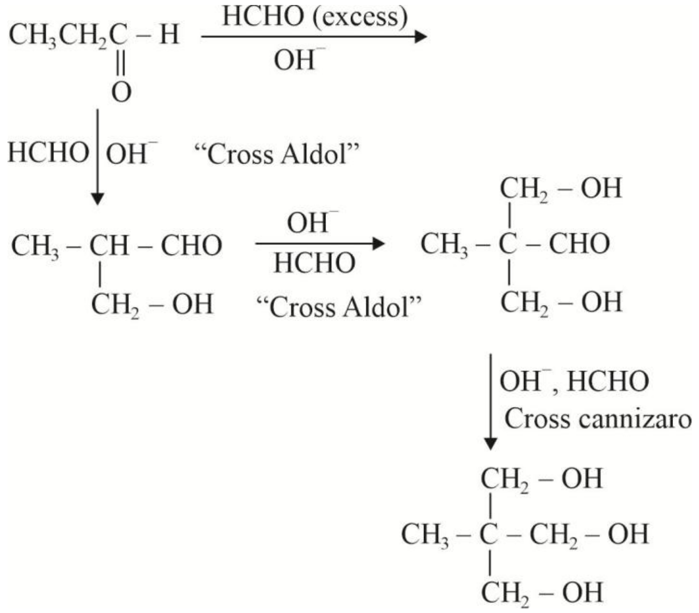
$$\left[OH^{-}\right] \geq 3\times10^{-6}$$

As NH_4OH is added B^{3+} will precipitate first.

54.(4)



55.(1)



56.(1) (A) Swartz reaction: Ethyl fluoride

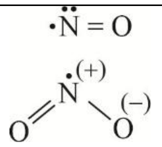
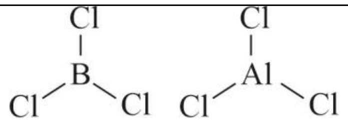
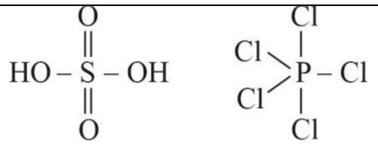
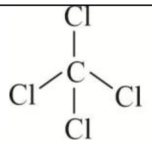
(B) Sandmeyer rection: Cyanobenzene

(C) Wurtz fitting reaction: Ethyl benzene

(D) Finkelstein reaction : Ethyl Iodide

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

57.(2)

I.		(C)	Molecules with incomplete octet and odd e^-
II.		(B)	Molecules with incomplete octet
III.		(D)	Molecules with expanded octet
IV.	 $O=C=O$	(A)	Molecules obeying octet rule

58.(4)

$Co^{2+}: s^0d^7$

→ $t_{2g}^6e_g^1$ (Low spin complex) or $t_{2g}^5e_g^2$ (High spin complex)

→ Unpaired $\bar{e}$s = 3

→ Magnetic moment = 3.95 BM

59.(3) $\frac{1}{\lambda} = R_H\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$$\frac{1}{9\times10^{-5}} = 10^5\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

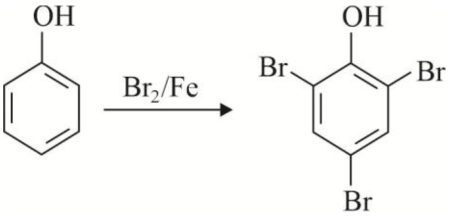
$$\frac{1}{9} = \frac{1}{n_1^2} - \frac{1}{n_2^2}$$

$n_1 = 3$

$n_2 = \infty$

Satisfied

60.(2)



1 mole $Ph-OH \equiv 3$ mole Br_2

$$n_{PhOH} = \frac{2}{94}$$

$$n_{Br_2} = \frac{2}{94}\times3$$

$$g_{Br_2} = \frac{2}{94}\times3\times160 = 10.2\,g$$

61.(1) $$\underbrace{\overset{+6}{Fe}O_4^{2-} \xrightarrow[\Delta G_1^0]{2V} Fe^{3+} \xrightarrow[\Delta G_1^0]{0.8V} Fe^{2+}}_{\Delta G_3^0}$$

$$\Delta G_3^0 = \Delta G_1^0 + \Delta G_2^0$$

$$-(4)(F)(E^\circ) = -(3)(F)(2) + \left[-(1)(F)(0.8)\right]$$

$$E^o = \frac{6+0.8}{4} = 1.7\,V$$

62.(1) Statement I : Correct statement

Statement II : Correct statement

63.(4) $\Delta T_f = i K_f m$

$0.558 = i(1.86)[0.1]$

$i = 3$

i.e. the molecule dissociates into 3 particles.

64.(2) B and D are 3° amines and do not reacts with hinsberg reagent.

65.(3) 1: Due to odd e^- NO_2 can dimerize easily.

2: 'N' can't expand it's octet due to absence of 'd' orbitals in 2nd shell

3: SO_2 can act both as oxidizing/reducing agent as it is in intermediate oxidation state.

4: Basic strength of $PH_3 < NH_3$ as charge density of 'N' is high due to small size.

66.(2)

Ice (–5°C)

$\downarrow$ (1) $\quad \Delta S_1 = \int_{268}^{273} \frac{C_P}{T} dT$

Ice (0°C)

$\downarrow$ (2) $\quad \Delta S_2 = \frac{\Delta H_{fusion}}{T_f}$

Water (0°C)

$\downarrow$ (3) $\quad \Delta S_3 = \int_{273}^{373} \frac{C_P dT}{T}$

Water (100°C)

$\downarrow$ (4) $\quad \Delta S_4 = \frac{\Delta H_{vap}}{T_b}$

Steam (100°C)

$\downarrow$ (5) $\quad \Delta S_5 = \int_{373}^{383} \frac{C_P dT}{T}$

Steam (110°C)

$$\Delta S_{total} = \Delta S_1 + \Delta S_2 + \Delta S_3 + \Delta S_4 + \Delta S_5$$

67.(3) In Lassaigne's test, covalent organic molecules are transformed into ionic compounds.

$$6CN^- + Fe^{+2} \rightarrow \left[Fe(CN)_6\right]^{-4}$$

$$3\left[Fe(CN)_6\right]^{-4} + 4Fe^{+3} \xrightarrow{xH_2O} \underset{\text{(Prussian Blue)}}{Fe_4\left[Fe(CN)_6\right]_3 \cdot xH_2O}$$

68.(2) V^{+2}, Cr^{+3} and Mn^{+3} ions (aqueous solution) are violet colour

69.(2) Moles of CO_2 left = 2.8×10^{-3}

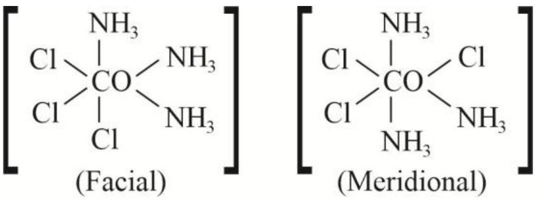
$$\text{Moles of } CO_2 \text{ removed } = \frac{10^{21}}{6.02\times10^{23}}$$

$$\text{Moles of } CO_2 \text{ initially } = 2.8\times10^{-3} + \frac{10^{21}}{6.02\times10^{23}}$$

$$\text{Mass of } CO_2 \text{ initially (mg) } = \left(2.8\times10^{-3} + \frac{10^{21}}{6.02\times10^{23}}\right)\times44\times100$$

$$= 196.2 \text{ mg}$$

70.(3)



(Facial) (Meridional)

SECTION – 2

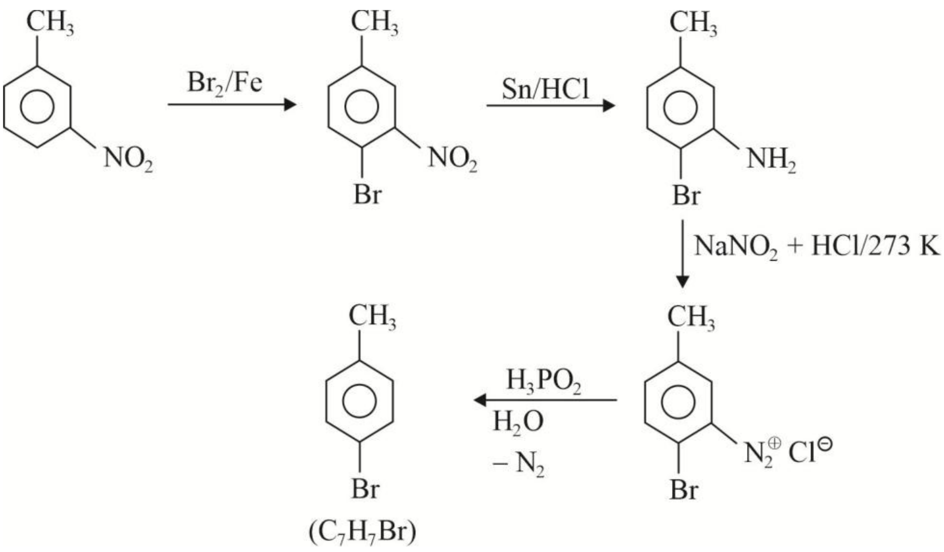
71.(7) $C_2H_5NH_2 + H_2O \rightleftharpoons C_2H_5\overset{+}{N}H_3 + \overset{-}{O}H$

$\left[\overset{-}{O}H\right] = \sqrt{K_b \times C}$ (pH = 9 ⇒ pOH = 5)

$K_b = \dfrac{10^{-10}}{10^{-3}} = 10^{-7}$ $(c = 1\,mM = 10^{-3}M)$

$\therefore \quad x = 7$

72.(171)



∴ Molecular mass of product is 171

73.(40) Mass of organic compound = 160 mg

Mass of Barium sulphate = 466 mg

Moles of $BaSO_4 = \dfrac{466\times10^{-3}}{233} = 2\times10^{-3}$

$\therefore$Moles of sulphur = 2×10^{-3}

∴ Mas of sulphur = $2\times10^{-3}\times32$

% of sulphur in organic compound $= \dfrac{2\times32\times10^{-3}}{160\times10^{-3}}\times100 = 40\%$

74.(897)

$$\begin{array}{llll} & 2N_2O_5 \longrightarrow & 2N_2O_4 & +O_2 \\ t=0 & 0.6 & - & - \\ t=100\,\text{sec} & 0.6-x & x & \dfrac{x}{2} \end{array}$$

$(k = 4.606\times10^{-2}S^{-1})$ (1^{st} order)

$$\ln\left(\frac{0.6}{0.6-x}\right) = kt$$

$$2.303\log\left(\frac{0.6}{0.6-x}\right) = 4.606\times10^{-2}\times100$$

$$\frac{0.6}{0.6-x} = 10^2$$

$0.6 = 0.6\times100-100x$

$100x = 60-0.6$

$100x-59.4$

$$x = \frac{59.4}{100}$$

$x = 0.594$

at $t = 100$ sec $\quad P_T = 0.6 - x + x + \frac{x}{2}$

$P_T = 0.6 + \frac{x}{2}$

$P_T = 0.897$

$\therefore \quad 897 \times 10^{-3}$ atm

75.(2850)

$\Delta H^\circ = 55\,\text{kJ}$

$\Delta S^\circ = 175\,\text{J}$

$\Delta G^\circ = ?\ (\text{J / mol})$

$T = 298\,\text{K}$

$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$

$= 55000 - 298 \times 175$

$= 55000 - 52150$

$\Delta G^\circ = 2850\ \text{J / mol}$