

JEE-MAIN EXAMINATION – JANUARY 2025

(HELD ON THURSDAY 23rd JANUARY 2025)

TIME : 3:00 PM TO 6:00 PM

MATHEMATICS

TEST PAPER WITH SOLUTION

SECTION-A

1. If in the expansion of $(1+x)^p(1-x)^q$, the coefficients of x and x^2 are 1 and -2 , respectively, then $p^2 + q^2$ is equal to :

- (1) 8 (2) 18
(3) 13 (4) 20

Ans. (3)

Sol. $(1+x)^p(1-x)^q = ({}^pC_0 + {}^pC_1x + {}^pC_2x^2 + \dots)({}^qC_0 - {}^qC_1x + {}^qC_2x^2 + \dots)$

coeff of $x \equiv {}^pC_0 {}^qC_1 + {}^pC_1 {}^qC_0 = 1$

$p - q = 1$

coeff of $x^2 \equiv {}^pC_0 {}^qC_2 - {}^pC_1 {}^qC_1 + {}^pC_2 {}^qC_0 = -2$

$\frac{q(q-1)}{2} - pq + \frac{p(p-1)}{2} = -2$

$q^2 - q - 2pq + p^2 - p = -4$

$1 - (p+q) = -4$

$p + q = 5$

$p = 3$

$q = 2$

so $p^2 + q^2 = 13$

2. Let $A = \{(x, y) \in \mathbf{R} \times \mathbf{R} : |x + y| \geq 3\}$ and

$B = \{(x, y) \in \mathbf{R} \times \mathbf{R} : |x| + |y| \leq 3\}$.

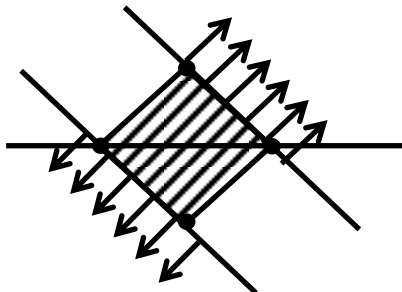
If $C = \{(x, y) \in A \cap B : x = 0 \text{ or } y = 0\}$, then

$\sum_{(x,y) \in C} |x+y|$ is :

- (1) 15 (2) 18
(3) 24 (4) 12

Ans. (4)

Sol.



$C = \{(3,0), (-3,0), (0,3), (0,-3)\}$

$\sum |x+y| = 12$

3. The system of equations

$x + y + z = 6,$

$x + 2y + 5z = 9,$

$x + 5y + \lambda z = \mu,$

has no solution if

(1) $\lambda = 17, \mu \neq 18$

(2) $\lambda \neq 17, \mu \neq 18$

(3) $\lambda = 15, \mu \neq 17$

(4) $\lambda = 17, \mu = 18$

Ans. (1)

Sol. $D = \begin{vmatrix} 1 & 1 & 1 \\ 1 & 2 & 5 \\ 1 & 5 & \lambda \end{vmatrix} = 0$

$\lambda = 17$

$D_z = \begin{vmatrix} 1 & 1 & 6 \\ 1 & 2 & 9 \\ 1 & 5 & \mu \end{vmatrix} \neq 0$

$\mu \neq 18$

4. Let $\int x^3 \sin x dx = g(x) + C$, where C is the constant of integration.

If $8 \left(g\left(\frac{\pi}{2}\right) + g'\left(\frac{\pi}{2}\right) \right) = \alpha\pi^3 + \beta\pi^2 + \gamma, \alpha, \beta, \gamma \in \mathbf{Z}$,

Then $\alpha + \beta - \gamma$ equals :

(1) 55 (2) 47

(3) 48 (4) 62

Ans. (1)

Sol. $\int x^3 \sin x dx = -x^3 \cos x + \int 3x^2 \cos x dx$

$= -x^3 \cos x + 3x^2 \sin x - \int 6x \sin x dx$

$= -x^3 \cos x + 3x^2 \sin x + 6x \cos x - 6 \sin x + c$

So $g(x) = -x^3 \cos x + 3x^2 \sin x + 6x \cos x - 6 \sin x$

$g\left(\frac{\pi}{2}\right) = \frac{3\pi^2}{4} - 6$

$g'(x) = -3x^2 \cos x + x^3 \sin x + 6 \cos x - 6 \sin x$

$g'\left(\frac{\pi}{2}\right) = \frac{\pi^3}{8}$

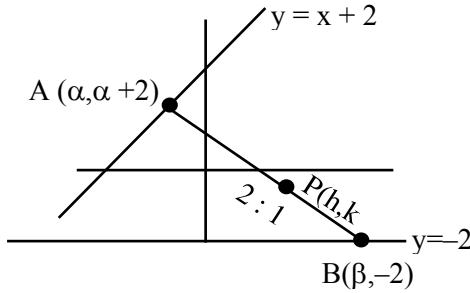
$8 \left(g\left(\frac{\pi}{2}\right) + g'\left(\frac{\pi}{2}\right) \right) = \pi^3 + 6\pi^2 - 48$

So $\alpha + \beta - \gamma = 55$

5. A rod of length eight units moves such that its ends A and B always lie on the lines $x - y + 2 = 0$ and $y + 2 = 0$, respectively. If the locus of the point P, that divides the rod AB internally in the ratio 2 : 1 is $9(x^2 + \alpha y^2 + \beta xy + \gamma x + 28y) - 76 = 0$, then $\alpha - \beta - \gamma$ is equal to :

- (1) 24 (2) 23
(3) 21 (4) 22

Ans. (2)



Sol.

$$A(\alpha, \alpha + 2)$$

$$B(\beta, -2)$$

$$P(h, k)$$

$$h = \frac{3\beta + \alpha}{3}$$

$$k = \frac{-4 + \alpha + 2}{3}$$

$$\alpha = 3k + 2$$

$$2\beta = 3h - \alpha = 3h - 3k - 2$$

$$\text{so } AB = 8$$

$$(\alpha - \beta)^2 + (\alpha + 4)^2 = 64$$

$$\left(3k + 2 - \left(\frac{3h - 3k - 2}{2}\right)\right)^2 + (3k + 2 + 4)^2 = 64$$

$$\frac{(9k - 3h + 6)^2}{4} + (3k + 6)^2 = 64$$

$$9\left[(3k - h + 2)^2 + 4(k + 2)^2\right] = 64 \times 4$$

$$9(x^2 + 13y^2 - 6xy - 4x + 28y) = 76$$

$$\alpha - \beta - \gamma = 13 + 6 + 4 = 23$$

6. The distance of the line $\frac{x-2}{2} = \frac{y-6}{3} = \frac{z-3}{4}$ from

the point (1, 4, 0) along the line $\frac{x}{1} = \frac{y-2}{2} = \frac{z+3}{3}$

is :

- (1) $\sqrt{17}$ (2) $\sqrt{14}$
(3) $\sqrt{15}$ (4) $\sqrt{13}$

Ans. (2)

Sol. Let the parallel line is

$$\frac{x-1}{1} = \frac{y-4}{2} = \frac{z-0}{3}$$

so their point of intersection is

$$(\lambda + 1, 2\lambda + 4, 3\lambda) = (2t + 2, 3t + 6, 4t + 3)$$

$$\lambda = 2t + 1$$

$$2\lambda + 4 = 3t + 6 \Rightarrow t = 0$$

so POI is (2,6,3)

$$\text{so distance} = \sqrt{(2-1)^2 + (6-4)^2 + (3-0)^2} = \sqrt{14}$$

7. Let the point A divide the line segment joining the points P(-1, -1, 2) and Q(5, 5, 10) internally in the ratio r : 1 (r > 0). If O is the origin and

$$(\overrightarrow{OQ} \cdot \overrightarrow{OA}) - \frac{1}{5} |\overrightarrow{OP} \times \overrightarrow{OA}|^2 = 10, \text{ then the value of } r$$

is :

- (1) 14 (2) 3
(3) $\sqrt{7}$ (4) 7

Ans. (4)

Sol. $A \equiv \left(\frac{5r-1}{r+1}, \frac{5r-1}{r+1}, \frac{10r+2}{r+1}\right)$

$$(\overrightarrow{OQ} \cdot \overrightarrow{OA}) - \frac{|\overrightarrow{OP} \times \overrightarrow{OA}|^2}{5} = 10 \dots (1)$$

$$\overrightarrow{OQ} \cdot \overrightarrow{OA} = \frac{5}{r+1} (30r + 2)$$

$$|\overrightarrow{OP} \times \overrightarrow{OA}|^2 = \frac{r^2}{(r+1)^2} (800)$$

so by equation (1)

$$\frac{10}{r+1} (15r + 1) - \frac{1}{5} \frac{r^2 (800)}{(r+1)^2} = 10$$

$$2r^2 - 14r = 0$$

$$r = 7, r \neq 0$$

8. If the area of the region

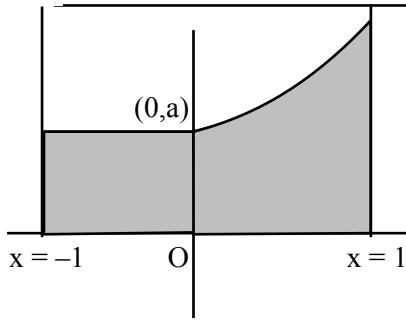
$$\{(x, y) : -1 \leq x \leq 1, 0 \leq y \leq a + e^{|x|} - e^{-x}, a > 0\}$$

$$\text{is } \frac{e^2 + 8e + 1}{e}, \text{ then the value of } a \text{ is :}$$

- (1) 7 (2) 6
(3) 8 (4) 5

Ans. (4)

Sol.



required area is $a + \int_0^1 (a + e^x - e^{-x}) dx$

$$a + [a + e^x + e^{-x}]_0^1$$

$$2a + e - 1 + e^{-1} - 1 = e + 8 + \frac{1}{e}$$

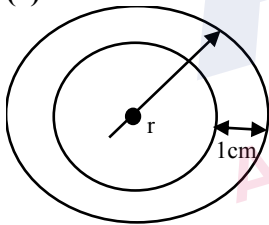
$$2a = 10 \Rightarrow a = 5$$

9. A spherical chocolate ball has a layer of ice-cream of uniform thickness around it. When the thickness of the ice-cream layer is 1 cm, the ice-cream melts at the rate of $81 \text{ cm}^3/\text{min}$ and the thickness of the ice-cream layer decreases at the rate of $\frac{1}{4\pi} \text{ cm/min}$. The surface area (in cm^2) of the chocolate ball (without the ice-cream layer) is :

- (1) 225π (2) 128π
(3) 196π (4) 256π

Ans. (4)

Sol



$$v = \frac{4}{3} \pi r^3$$

$$\frac{dv}{dt} = 4\pi r^2 \frac{dr}{dt}$$

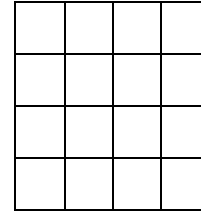
$$81 = 4\pi r^2 \times \frac{1}{4\pi}$$

$$r^2 = 81$$

$$r = 9$$

$$\text{surface area of chocolate} = 4\pi(r - 1)^2 = 256\pi$$

10. A board has 16 squares as shown in the figure :



Out of these 16 squares, two squares are chosen at random. The probability that they have no side in common is :

- (1) $\frac{4}{5}$ (2) $\frac{7}{10}$
(3) $\frac{3}{5}$ (4) $\frac{23}{30}$

Ans. (1)

Sol. Total ways for selecting any two squares = ${}^{16}C_2$
= 120

Total ways for selecting common side squares

$$= \frac{3 \times 4}{\text{Horizontal side}} + \frac{3 \times 4}{\text{vertical side}}$$

$$= 24$$

so required probability

$$= 1 - \frac{24}{120}$$

$$= \frac{4}{5}$$

11. Let $x = x(y)$ be the solution of the differential equation

$$y = \left(x - y \frac{dx}{dy} \right) \sin \left(\frac{x}{y} \right), y > 0 \text{ and } x(1) = \frac{\pi}{2}.$$

Then $\cos(x(2))$ is equal to :

- (1) $1 - 2(\log_2 2)^2$ (2) $2(\log_2 2)^2 - 1$
(3) $2(\log_2 2) - 1$ (4) $1 - 2(\log_2 2)$

Ans. (2)

Sol. $ydy = (xdy - ydx) \sin \left(\frac{x}{y} \right)$

$$\frac{dy}{y} = \left(\frac{xdy - ydx}{y^2} \right) \sin \left(\frac{x}{y} \right)$$

15. The length of the chord of the ellipse $\frac{x^2}{4} + \frac{y^2}{2} = 1$,

whose mid-point is $(1, \frac{1}{2})$, is:

- (1) $\frac{2}{3}\sqrt{15}$ (2) $\frac{5}{3}\sqrt{15}$
(3) $\frac{1}{3}\sqrt{15}$ (4) $\sqrt{15}$

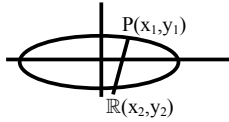
Ans. (1)

Sol. $T = S_1$
 $\frac{x \cdot 1}{4} + \frac{y \cdot \frac{1}{2}}{2} = \frac{1}{4} + \frac{1}{8}$

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

solve with ellipse

$P_R = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
 $= \sqrt{2}|x_2 - x_1|$



$y_2 = \frac{3}{2} - x_2$

$y_1 = \frac{3}{2} - x_1$

$y_2 - y_1 = x_2 - x_1$
 $x^2 + 2y^2 = 4$

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

$6x^2 - 12x + 1 = 0$

$x_1 + x_2 = 2$

$x_1 x_2 = 1/6$

$|x_2 - x_1| = \sqrt{(x_2 + x_1)^2 - 4x_1 x_2}$
 $= \sqrt{4 - 4/6}$

$PR = \sqrt{2} \cdot \frac{\sqrt{5}}{\sqrt{2}\sqrt{3}} = \frac{2}{3}\sqrt{15}$

$= 2\sqrt{5/6}$

16. Let $A = [a_{ij}]$ be a 3×3 matrix such that

$A \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$, $A \begin{bmatrix} 4 \\ 1 \\ 3 \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}$ and $A \begin{bmatrix} 2 \\ 1 \\ 2 \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$, then

a_{23} equals:

- (1) -1 (2) 0
(3) 2 (4) 1

Ans. (1)

Sol. Let $A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$

$A \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \Rightarrow \begin{bmatrix} a_{12} \\ a_{22} \\ a_{32} \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \Rightarrow a_{22} = 0; a_{12} = 0$
 $a_{32} = 1$

$A \begin{bmatrix} 4 \\ 1 \\ 3 \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \Rightarrow \begin{cases} 4a_{11} + a_{12} + 3a_{13} = 0 \\ 4a_{21} + a_{22} + 3a_{23} = 1 \Rightarrow 4a_{21} + 3a_{23} = 1 \\ 4a_{31} + a_{32} + 3a_{33} = 0 \end{cases}$

$A \begin{bmatrix} 2 \\ 1 \\ 2 \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} \Rightarrow \begin{cases} 2a_{11} + a_{12} + 2a_{13} = 1 \\ 2a_{21} + a_{22} + 2a_{23} = 0 \Rightarrow a_{21} + a_{23} = 0 \\ 2a_{31} + a_{32} + 2a_{33} = 0 \end{cases}$

$-4a_{23} + 3a_{23} = 1 \Rightarrow a_{23} = -1$

17. The number of complex numbers z , satisfying $|z| = 1$

and $\left| \frac{z}{\bar{z}} + \frac{\bar{z}}{z} \right| = 1$, is :

- (1) 6 (2) 4
(3) 10 (4) 8

Ans. (4)

Sol. $z = e^{i\theta}$

$\frac{z}{\bar{z}} = e^{i2\theta}$

$\left| \frac{z}{\bar{z}} + \frac{\bar{z}}{z} \right| = 1 \Rightarrow |e^{i2\theta} + e^{-i2\theta}| = 1 \Rightarrow |\cos 2\theta| = \frac{1}{2}$

8 solution

18. If the square of the shortest distance between the lines $\frac{x-2}{1} = \frac{y-1}{2} = \frac{z+3}{-3}$ and $\frac{x+1}{2} = \frac{y+3}{4} = \frac{z+5}{-5}$ is $\frac{m}{n}$, where m, n are coprime numbers, then m + n is equal to:

- (1) 6 (2) 9
(3) 21 (4) 14

Ans. (2)

Sol. $\vec{a} = (2, 1, -3)$

$\vec{b} = (-1, -3, -5)$

$$\vec{p} \times \vec{q} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 2 & -3 \\ 2 & 4 & -5 \end{vmatrix}$$

$$= 2\hat{i} - \hat{j}$$

$$\vec{b} - \vec{a} = -3\hat{i} - 4\hat{j} - 2\hat{k}$$

$$S_d = \frac{|(\vec{b} - \vec{a}) \cdot (\vec{p} \times \vec{q})|}{|\vec{p} \times \vec{q}|}$$

$$= \frac{2}{\sqrt{5}}$$

$$(S_d)^2 = \frac{4}{5}$$

$$m = 4, n = 5 \Rightarrow m + n = 9$$

19. If $I = \int_0^{\frac{\pi}{2}} \frac{\sin^{\frac{3}{2}} x}{\sin^{\frac{3}{2}} x + \cos^{\frac{3}{2}} x} dx$,

then $\int_0^{\frac{\pi}{2}} \frac{x \sin x \cos x}{\sin^4 x + \cos^4 x} dx$ equals:

- (1) $\frac{\pi^2}{16}$ (2) $\frac{\pi^2}{4}$
(3) $\frac{\pi^2}{8}$ (4) $\frac{\pi^2}{12}$

Ans. (1)

Sol. For I

Apply king (P-5) and add

$$2I = \int_0^{\pi/2} dx = \frac{\pi}{2} \Rightarrow I = \frac{\pi}{4}$$

$$I_2 = \int_0^{\pi/2} \frac{x \sin x \cos x}{\sin^4 x + \cos^4 x} dx$$

Apply king and add

$$I_2 = \frac{\pi}{4} \int_0^{\pi/2} \frac{\tan x \sec^2 x dx}{\tan^4 x + 1}$$

put $\tan^2 x = t$

$$\frac{\pi}{8} \int_0^{\infty} \frac{dt}{t^2 + 1}$$

$$= \frac{\pi}{8} \cdot \frac{\pi}{2} = \frac{\pi^2}{16}$$

20. $\lim_{x \rightarrow \infty} \frac{(2x^2 - 3x + 5)(3x - 1)^{\frac{x}{2}}}{(3x^2 + 5x + 4)\sqrt{(3x + 2)^x}}$ is equal to:

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

Ans. (4)

Sol. $\lim_{x \rightarrow \infty} \frac{\left(2 - \frac{3}{x} + \frac{5}{x^2}\right) \left(1 - \frac{1}{3x}\right)^{x/2}}{\left(3 + \frac{5}{x} + \frac{4}{x^2}\right) \left(1 + \frac{2}{3x}\right)^{x/2}}$

$$= \lim_{x \rightarrow \infty} \frac{2}{3} \cdot \frac{e^{\frac{x}{2} \left(1 - \frac{1}{3x} - 1\right)}}{e^{\frac{x}{2} \left(1 + \frac{2}{3x} - 1\right)}}$$

$$= \frac{2}{3} \cdot \frac{e^{-\frac{1}{6}}}{e^{1/3}} = \frac{2}{3} e^{-\frac{1}{2}}$$

SECTION-B

21. The number of ways, 5 boys and 4 girls can sit in a row so that either all the boys sit together or no two boys sit together, is _____.

Ans. (17280)

Sol. A : number of ways that all boys sit together = $5! \times 5!$

B : number of ways if no 2 boys sit together = $4! \times 5!$

$$A \cap B = \phi$$

Required no. of ways = $5! \times 5! + 4! \times 5! = 17280$

22. Let α, β be the roots of the equation $x^2 - ax - b = 0$ with $\text{Im}(\alpha) < \text{Im}(\beta)$. Let $P_n = \alpha^n - \beta^n$. If $P_3 = -5\sqrt{7}i$, $P_4 = -3\sqrt{7}i$, $P_5 = 11\sqrt{7}i$ and $P_6 = 45\sqrt{7}i$, then $|\alpha^4 + \beta^4|$ is equal to _____.

Ans. (31)

Sol. $\alpha + \beta = a$ $\alpha\beta = -b$

$$P_6 = aP_5 + bP_4$$

$$45\sqrt{7}i = a \times 11\sqrt{7}i + b(-3\sqrt{7}i)$$

$$45 = 11a - 3b \quad \dots(1)$$

and

$$P_5 = aP_4 + bP_3$$

$$11\sqrt{7}i = a(-3\sqrt{7}i) + b(-5\sqrt{7}i)$$

$$11 = -3a - 5b \quad \dots(2)$$

$$a = 3, b = -4$$

$$|\alpha^4 + \beta^4| = \sqrt{(\alpha^4 - \beta^4)^2 + 4\alpha^4\beta^4}$$

$$= \sqrt{-63 + 4 \cdot 4^4}$$

$$= \sqrt{-63 + 1024} = \sqrt{961} = 31$$

23. The focus of the parabola $y^2 = 4x + 16$ is the centre of the circle C of radius 5. If the values of λ , for which C passes through the point of intersection of the lines $3x - y = 0$ and $x + \lambda y = 4$, are λ_1 and λ_2 , $\lambda_1 < \lambda_2$, then $12\lambda_1 + 29\lambda_2$ is equal to _____.

Ans. (15)

Sol. $y^2 = 4(x + 4)$

Equation of circle

$$(x + 3)^2 + y^2 = 25$$

Passes through the point of intersection of two lines $3x - y = 0$ and $x + \lambda y = 4$

$$\left(\frac{4}{3\lambda + 1}, \frac{12}{3\lambda + 1} \right), \text{ we get}$$

$$\lambda = -\frac{7}{6}, 1; \quad 12\lambda_1 + 29\lambda_2; \quad -14 + 29 = 15$$

24. The variance of the numbers 8, 21, 34, 47, ..., 320, is _____.

Ans. (8788)

Sol. $8 + (n - 1)13 = 320$

$$13n = 325$$

$$n = 25$$

no. of terms = 25

$$\text{mean} = \frac{\sum x_i}{n} = \frac{8 + 21 + \dots + 320}{25} = \frac{25}{2}(8 + 320)$$

$$\text{variance } \sigma^2 = \frac{\sum x_i^2}{n} - (\text{mean})^2$$

$$= \frac{8^2 + 21^2 + \dots + 320^2}{13} - (164)^2$$

$$= 8788$$

25. The roots of the quadratic equation $3x^2 - px + q = 0$ are 10th and 11th terms of an arithmetic progression with common difference $\frac{3}{2}$. If the sum of the first

11 terms of this arithmetic progression is 88, then $q - 2p$ is equal to _____.

Ans. (474)

Sol. $S_{11} = \frac{11}{2}(2a + 10d) = 88$

$$a + 5d = 8$$

$$a = 8 - 5 \times \frac{3}{2} = \frac{1}{2}$$

Roots are

$$T_{10} = a + 9d = \frac{1}{2} + 9 \times \frac{3}{2} = 14$$

$$T_{11} = a + 10d = \frac{1}{2} + 10 \times \frac{3}{2} = \frac{31}{2}$$

$$\frac{p}{3} = T_{10} + T_{11} = 14 + \frac{31}{2} = \frac{59}{2}$$

$$p = \frac{177}{2}$$

$$\frac{q}{3} = T_{10} \times T_{11} = 7 \times 31 = 217$$

$$q = 651$$

$$q - 2p$$

$$= 651 - 177$$

$$= 474$$

JEE-MAIN EXAMINATION – JANUARY 2025

(HELD ON THURSDAY 23rd JANUARY 2025)

TIME : 3 : 00 PM TO 6 : 00 PM

PHYSICS

TEST PAPER WITH SOLUTION

SECTION-A

26. A ball having kinetic energy KE, is projected at an angle of 60° from the horizontal. What will be the kinetic energy of ball at the highest point of its flight?

- (1) $\frac{(KE)}{8}$ (2) $\frac{(KE)}{4}$
(3) $\frac{(KE)}{16}$ (4) $\frac{(KE)}{2}$

Ans. (2)

Sol. Initial K.E,

$$K.E. = \frac{1}{2} mu^2$$

Speed at heighest point

$$V = u \cos 60^\circ = \frac{u}{2}$$

$$\therefore KE_2 = \frac{1}{2} m \left(\frac{u}{2} \right)^2$$

$$= \frac{1}{4} \times \frac{1}{2} mu^2$$

$$= \frac{KE}{4}$$

27. Two charges $7 \mu\text{C}$ and $-4 \mu\text{C}$ are placed at $(-7 \text{ cm}, 0, 0)$ and $(7 \text{ cm}, 0, 0)$ respectively. Given, $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$, the electrostatic potential energy of the charge configuration is :

- (1) -1.5 J (2) -2.0 J
(3) -1.2 J (4) -1.8 J

Ans. (4)

Sol. P.E. of two charges

$$u = \frac{1}{4\pi\epsilon_0} \frac{q_1q_2}{r}$$

$$r = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$$

$$= 14 \text{ cm}$$

$$\therefore u = \frac{9 \times 10^9 \times 7 \times 10^{-6} \times (-4) \times 10^{-6}}{14 \times 10^{-2}}$$

$$= -1.8 \text{ J}$$

28. The refractive index of the material of a glass prism is $\sqrt{3}$. The angle of minimum deviation is equal to the angle of the prism. What is the angle of the prism?

- (1) 50° (2) 60°
(3) 58° (4) 48°

Ans. (2)

Sol.
$$\mu = \frac{\sin\left(\frac{A + \delta_{\min}}{2}\right)}{\sin\frac{A}{2}}$$

Given $\delta_{\min} = A$

$$\sqrt{3} = \frac{\sin A}{\sin\frac{A}{2}} = \frac{2 \sin\frac{A}{2} \cos\frac{A}{2}}{\sin\frac{A}{2}}$$

$$\cos\frac{A}{2} = \frac{\sqrt{3}}{2}$$

$$A = 60^\circ$$

29. The equation of a transverse wave travelling along a string is $y(x, t) = 4.0 \sin [20 \times 10^{-3} x + 600t]$ mm, where x is in the mm and t is in second. The velocity of the wave is :

- (1) $+30 \text{ m/s}$ (2) -60 m/s
(3) -30 m/s (4) $+60 \text{ m/s}$

Ans. (3)

Sol. $y = 4 \sin (20 \times 10^{-3} x + 600 t)$

Here $\omega = 600 \text{ s}^{-1}$

$$k = 20 \times 10^{-3} \text{ m/s}^{-1}$$

$$\therefore v = \frac{\omega}{k} = \frac{600}{20 \times 10^{-3}}$$

$$= 30 \times 10^{-3} \text{ mm/s}$$

$$= 30 \text{ m/s}$$

& direction is towards -ve x axis

$$\therefore v = -30 \text{ m/s}$$

30. The energy of a system is given as $E(t) = \alpha^3 e^{-\beta t}$, where t is the time and $\beta = 0.3 \text{ s}^{-1}$. The errors in the measurement of α and t are 1.2% and 1.6%, respectively. At $t = 5 \text{ s}$, maximum percentage error in the energy is :

- (1) 4% (2) 11.6%
(3) 6% (4) 8.4%

Ans. (3)

Sol. $\alpha^3 e^{-\beta t}$

$$\ln E = 3 \ln \alpha - \beta t$$

$$\left(\frac{dE}{E}\right)_{\max} = \frac{3d\alpha}{\alpha} + \beta \frac{dt}{t} \times t$$

$$= 3 \times 1.2\% + (0.3 \times 1.6 \times 5)\%$$

$$= 6\%$$

31. In photoelectric effect an em-wave is incident on a metal surface and electrons are ejected from the surface. If the work function of the metal is 2.14 eV and stopping potential is 2V, what is the wavelength of the em-wave?

(Given $hc = 1242 \text{ eVnm}$ where h is the Planck's constant and c is the speed of light in vaccum.)

- (1) 400 nm (2) 600 nm
(3) 200 nm (4) 300 nm

Ans. (4)

Sol. $eV_s = E - \phi$

$$2 \text{ eV} = E - 2.14 \text{ eV}$$

$$E = 4.14 \text{ eV}$$

$$E = \frac{hc}{\lambda}$$

$$\lambda = \frac{1242}{4.14} = 300 \text{ nm}$$

32. A circular disk of radius R meter and mass M kg is rotating around the axis perpendicular to the disk. An external torque is applied to the disk such that $\theta(t) = 5t^2 - 8t$, where $\theta(t)$ is the angular position of the rotating disc as a function of time t .

How much power is delivered by the applied torque, when $t = 2\text{s}$?

- (1) 60 MR^2 (2) 72 MR^2
(3) 108 MR^2 (4) 8 MR^2

Ans. (1)

Sol. $\theta = 5t^2 - 8t$

$$\omega = \frac{d\theta}{dt} = 10t - 8$$

$$\alpha = \frac{d\omega}{dt} = 10$$

$$\therefore p = \tau\omega$$

$$= (I\alpha)\omega$$

$$= \left(\frac{mR^2}{2}\right)\alpha\omega$$

$$= \left(\frac{mR^2}{2}\right)(10)(10t - 8)$$

$$\text{Put } t = 2$$

$$p = 60 \text{ mR}^2$$

33. Water flows in a horizontal pipe whose one end is closed with a valve. The reading of the pressure gauge attached to the pipe is P_1 . The reading of the pressure gauge falls to P_2 when the valve is opened. The speed of water flowing in the pipe is proportional to

- (1) $\sqrt{P_1 - P_2}$ (2) $(P_1 - P_2)^2$
(3) $(P_1 - P_2)^4$ (4) $P_1 - P_2$

Ans. (1)

Sol. By Bernoulli equation

$$P_1 + \frac{1}{2} \times \rho \times 0^2 = P_2 + \frac{1}{2} \rho v^2$$

$$v = \sqrt{2\rho(P_1 - P_2)}$$

34. Match List-I with List-II.

List-I	List-II
(A) Permeability of free space	(I) $[M L^2 T^{-2}]$
(B) Magnetic field	(II) $[M T^{-2} A^{-1}]$
(C) Magnetic moment	(III) $[M L T^{-2} A^{-2}]$
(D) Torsional constant	(IV) $[L^2 A]$

Choose the **correct** answer from the options given below :

- (1) (A)-(I), (B)-(IV), (C)-(II), (D)-(III)
(2) (A)-(II), (B)-(I), (C)-(III), (D)-(IV)
(3) (A)-(IV), (B)-(III), (C)-(I), (D)-(II)
(4) (A)-(III), (B)-(II), (C)-(IV), (D)-(I)

Ans. (4)

39. Given below are two statements. One is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**.

Assertion (A) : The binding energy per nucleon is found to be practically independent of the atomic number A , for nuclei with mass numbers between 30 and 170.

Reason (R) : Nuclear force is long range.

In the light of the above statements, choose the **correct** answer from the options given below :

- (1) (A) is false but (R) is true
- (2) (A) is true but (R) is false
- (3) Both (A) and (R) are true and (R) is the correct explanation of (A)
- (4) Both (A) and (R) are true but (R) is **NOT** the correct explanation of (A)

Ans. (2)

Sol. Conceptual

40. Water of mass m gram is slowly heated to increase the temperature from T_1 to T_2 . The change in entropy of the water, given specific heat of water is $1 \text{ Jkg}^{-1}\text{K}^{-1}$, is :

- (1) zero
- (2) $m(T_2 - T_1)$
- (3) $m \ln\left(\frac{T_1}{T_2}\right)$
- (4) $m \ln\left(\frac{T_2}{T_1}\right)$

Ans. (4)

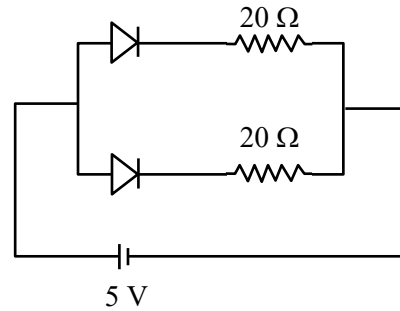
Sol. $dQ = msdT$

$$dS = \frac{dQ}{T} = \frac{msdT}{T}$$

$$\Delta S = \int \frac{msdT}{T} = ms \ln \frac{T_f}{T_i}$$

$$\Delta S = m \ln \frac{T_2}{T_1}$$

41. What is the current through the battery in the circuit shown below?



- (1) 1.0 A
- (2) 1.5 A
- (3) 0.5 A
- (4) 0.25 A

Ans. (3)

Sol. Both are forward biased

hence $R_{eq} = 10 \Omega$

$$i = \frac{V}{R} = \frac{5}{10} = \frac{1}{2} \text{ A}$$

42. A plane electromagnetic wave of frequency 20 MHz travels in free space along the $+x$ direction. At a particular point in space and time, the electric field vector of the wave is $E_y = 9.3 \text{ Vm}^{-1}$. Then, the magnetic field vector of the wave at that point is-

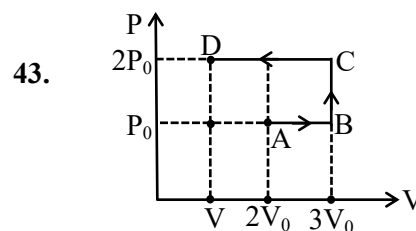
- (1) $B_z = 9.3 \times 10^{-8} \text{ T}$
- (2) $B_z = 1.55 \times 10^{-8} \text{ T}$
- (3) $B_z = 6.2 \times 10^{-8} \text{ T}$
- (4) $B_z = 3.1 \times 10^{-8} \text{ T}$

Ans. (4)

Sol. $E = BC$

$$9.3 = B \times 3 \times 10^8$$

$$B = \frac{9.3}{3 \times 10^8} = 3.1 \times 10^{-8} \text{ T}$$



43.

Using the given P-V diagram, the work done by an ideal gas along the path ABCD is-

- (1) $4 P_0 V_0$
- (2) $3 P_0 V_0$
- (3) $-4 P_0 V_0$
- (4) $-3 P_0 V_0$

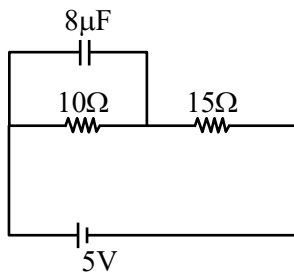
Angular momentum of satellite about common centre of mass,

$$L = \frac{M}{2} \cdot \left(\frac{8R}{9}\right)^2 \cdot \omega$$

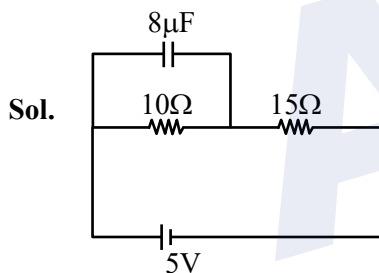
$$L = M \sqrt{GMR \left(\frac{8}{81}\right)}$$

$$x = \frac{81}{8} \approx 10$$

48. At steady state the charge on the capacitor, as shown in the circuit below, is _____ μC .



Ans. (16)



$$i = \left(\frac{5}{25}\right)$$

$$Q = CV$$

$$Q = (8 \times 10^{-6}) \left(\frac{5}{25} \times 10\right)$$

$$Q = \left(\frac{8 \times 5 \times 10^{-2}}{25}\right) = 16 \mu\text{C}$$

49. A time varying potential difference is applied between the plates of a parallel plate capacitor of capacitance $2.5 \mu\text{F}$. The dielectric constant of the medium between the capacitor plates is 1. It produces an instantaneous displacement current of 0.25 mA in the intervening space between the capacitor plates, the magnitude of the rate of change of the potential difference will be _____ Vs^{-1} .

Ans. (100)

$$\text{Sol. } \frac{CdV}{dt} = I_d$$

$$\frac{dV}{dt} = \frac{I_d}{C}$$

$$= \frac{0.25 \times 10^{-3}}{2.5 \times 10^{-6}}$$

$$= 100$$

50. In a series LCR circuit, a resistor of 300Ω , a capacitor of 25 nF and an inductor of 100 mH are used. For maximum current in the circuit, the angular frequency of the ac source is _____ $\times 10^4$ radians s^{-1} .

Ans. (2)

$$\text{Sol. } \omega = \frac{1}{\sqrt{LC}}$$

$$\omega = \frac{1}{\sqrt{25 \times 10^{-9} \times 100 \times 10^{-3}}}$$

$$\omega = \frac{10^6}{5 \times 10} = 2$$

JEE-MAIN EXAMINATION – JANUARY 2025

(HELD ON THURSDAY 23rd JANUARY 2025)

TIME : 3 : 00 PM TO 6 : 00 PM

CHEMISTRY

TEST PAPER WITH SOLUTION

SECTION-A

51. The effect of temperature on spontaneity of reactions are represented as:

	ΔH	ΔS	Temperature	Spontaneity
(A)	+	-	any T	Non spontaneous
(B)	+	+	low T	spontaneous
(C)	-	-	low T	Non spontaneous
(D)	-	+	any T	spontaneous

- (1) (B) and (D) only
(2) (A) and (D) only
(3) (B) and (C) only
(D) (A) and (C) only

Ans. (3)

Sol. $\therefore \Delta G = \Delta H - T\Delta S$

For spontaneity of reaction : $\Delta G = -ve$

52. Standard electrode potentials for a few half cells are mentioned below:

$$E_{\text{Cu}^{2+}/\text{Cu}}^{\circ} = 0.34\text{V}, E_{\text{Zn}^{2+}/\text{Zn}}^{\circ} = -0.76\text{V}$$

$$E_{\text{Ag}^{+}/\text{Ag}}^{\circ} = 0.80\text{V}, E_{\text{Mg}^{2+}/\text{Mg}}^{\circ} = -2.37\text{V}$$

Which one of the following cells gives the most negative value of ΔG° ?

- (1) $\text{Zn}|\text{Zn}^{2+} (1\text{M})||\text{Ag}^{+}(1\text{M}) | \text{Ag}$
(2) $\text{Zn}|\text{Zn}^{2+} (1\text{M})||\text{Mg}^{2+}(1\text{M}) | \text{Mg}$
(3) $\text{Ag}|\text{Ag}^{+} (1\text{M})||\text{Mg}^{2+}(1\text{M}) | \text{Mg}$
(4) $\text{Cu} | \text{Cu}^{2+} (1\text{M})||\text{Ag}^{+}(1\text{M}) | \text{Ag}$

Ans. (1)

Sol. $\therefore \Delta G^{\circ} = -nFE^{\circ}$

$$\begin{aligned} \text{Option (1)} E^{\circ} &= 0.8 + 0.76 \\ &= 1.56 \text{ V} \end{aligned}$$

$$\begin{aligned} \therefore \Delta G^{\circ} &= -2 \times F \times 1.56 \\ &= -3.12 \text{ V} \end{aligned}$$

$$\begin{aligned} \text{Option (2)} E^{\circ} &= -2.37 + 0.76 \\ &= -1.61 \text{ V} \end{aligned}$$

$$\begin{aligned} \therefore \Delta G^{\circ} &= -2 \times F \times (-1.61) \\ &= +3.22 \text{ V} \end{aligned}$$

$$\begin{aligned} \text{Option (3)} E^{\circ} &= -2.37 - 0.8 \\ &= -3.17 \text{ V} \end{aligned}$$

$$\begin{aligned} \therefore \Delta G^{\circ} &= -2 \times F \times (-3.17) \\ &= +6.34 \end{aligned}$$

$$\begin{aligned} \text{Option (4)} E^{\circ} &= 0.8 - 0.34 \\ &= 0.46 \text{ V} \end{aligned}$$

$$\begin{aligned} \Delta G^{\circ} &= -2 \times F \times 0.46 \\ &= -0.92 \text{ V} \end{aligned}$$

53. The α - Helix and β - Pleated sheet structures of protein are associated with its:

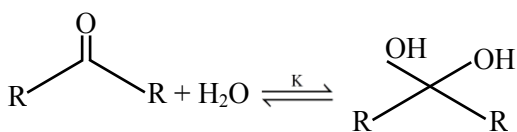
- (1) quaternary structure
(2) primary structure
(3) secondary structure
(4) tertiary structure

Ans. (3)

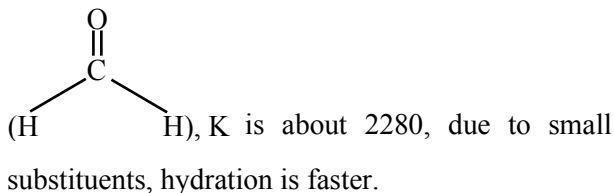
Sol. α -helix and β -pleated sheet belongs to secondary structure of protein, which have hydrogen bonds.

54. Given below are two statements:

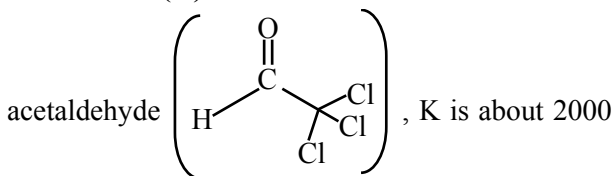
Consider the following reaction



Statement (I) : In the case of formaldehyde



Statement (II) : In the case of trichloro



due to -I effect of -Cl.

In the light of the above statements, choose the **correct** answer from the options given below:

- (1) **Statement I** true but **Statement II** is false
- (2) Both **Statement I** and **Statement II** are true
- (3) **Statement I** is false but **Statement II** is true
- (4) Both **Statement I** and **Statement II** are false

Ans. (2)

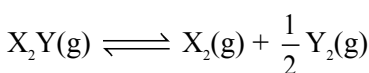
Sol. $k_{eq} = 2280$ is for HCHO

$k_{eq} = 2000$ is for chloral

Both data is given in clayden and warren book.

$k_{eq} > 1$ because HCHO and chloral are more electrophilic.

55. Consider the reaction



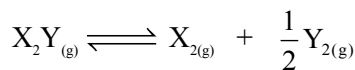
The equation representing correct relationship between the degree of dissociation (x) of $\text{X}_2\text{Y}(\text{g})$ with its equilibrium constant K_p is _____.

Assume x to be very very small.

- | | |
|------------------------------------|--------------------------------------|
| (1) $x = \sqrt[3]{\frac{2K_p}{p}}$ | (2) $x = \sqrt[3]{\frac{2K_p^2}{p}}$ |
| (3) $x = \sqrt[3]{\frac{K_p}{2p}}$ | (4) $x = \sqrt[3]{\frac{K_p}{p}}$ |

Ans. (2)

Sol. 1 mole



1-x mole x mole $\frac{x}{2}$ mole

$$\therefore P_{\text{X}_2\text{Y}} = \frac{1-x}{1+\frac{x}{2}} \times P$$

$$P_{\text{X}_2} = \frac{x}{1+\frac{x}{2}} \times P$$

$$P_{\text{Y}_2} = \frac{x/2}{1+\frac{x}{2}} \times P$$

$$\therefore K_p = \left(\frac{x}{1+\frac{x}{2}} P \right) \left(\frac{x}{2\left(1+\frac{x}{2}\right)} P \right)^{\frac{1}{2}} \bigg/ \left(\frac{1-x}{1+\frac{x}{2}} \right) \times P$$

$$\therefore K_p = \left(\frac{x}{1-x} \right) \left(\frac{x}{2\left(1+\frac{x}{2}\right)} \right)^{\frac{1}{2}} \times p^{\frac{1}{2}}$$

$\therefore x$ to be very very small

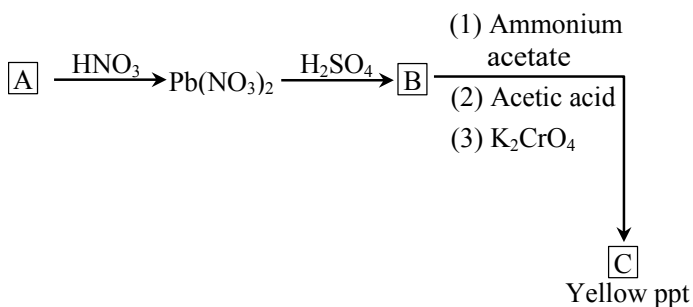
$$\therefore K_p = \frac{x^{3/2}}{(2)^{\frac{1}{2}}} \times P^{\frac{1}{2}}$$

$$\therefore x^{\frac{3}{2}} = \frac{K_p \times 2^{\frac{1}{2}}}{P^{\frac{1}{2}}}$$

$$\therefore x^3 = \frac{K_p^2 \times 2}{P}$$

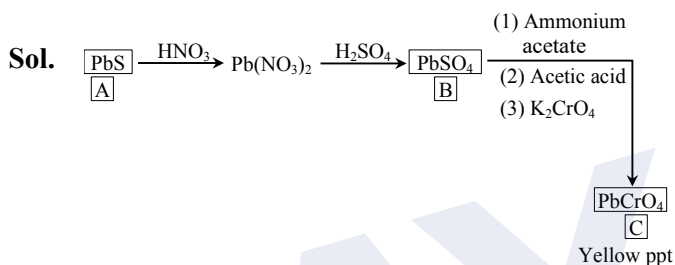
$$x = \left(\frac{K_p^2 \times 2}{P} \right)^{\frac{1}{3}}$$

56. Identify A, B and C in the given below reaction sequence



- (1) $\text{PbCl}_2, \text{PbSO}_4, \text{PbCrO}_4$
 (2) $\text{PbS}, \text{PbSO}_4, \text{PbCrO}_4$
 (3) $\text{PbS}, \text{PbSO}_4, \text{Pb}(\text{CH}_3\text{COO})_2$
 (4) $\text{PbCl}_2, \text{Pb}(\text{SO}_4)_2, \text{PbCrO}_4$

Ans. (2)



57. Given below are two statements:

Statement (I): The boiling points of alcohols and phenols increase with increase in the number of C-atoms.

Statement (II): The boiling points of alcohols and phenols are higher in comparison to other class of compounds such as ethers, haloalkanes.

In the light of the above statements, choose the correct answer from the options given below:

- (1) Both **Statement I** and **Statement II** are false
 (2) **Statement I** is false but **Statement II** is true
 (3) **Statement I** is true but **Statement II** is false
 (4) Both **Statement I** and **Statement II** are true

Ans. (4)

Sol. B.P. \propto M.W.

B.P. \propto Inter molecular hydrogen bonding

Alcohol & Phenol have intermolecular H-bonding

58. When a non-volatile solute is added to the solvent, the vapour pressure of the solvent decreases by 10 mm of Hg. The mole fraction of the solute in the solution is 0.2. What would be the mole fraction of the solvent if decrease in vapour pressure is 20 mm of Hg ?

- (1) 0.6 (2) 0.4
 (3) 0.2 (4) 0.8

Ans. (1)

Sol. $\therefore P^\circ - P \propto X_{\text{solute}}$

and $\therefore 10 \propto 0.2$

$\therefore 20 \propto 0.4$

$$\begin{aligned} \therefore X_{\text{solvent}} &= 1 - X_{\text{solute}} \\ &= 1 - 0.4 \\ &= 0.6 \end{aligned}$$

59. Given below are two statements:

Statement (I) : For a given shell, the total number of allowed orbitals is given by n^2 .

Statement (II) : For any subshell, the spatial orientation of the orbitals is given by $-l$ to $+l$ values including zero.

In the light of the above statements, choose the correct answer from the options given below:

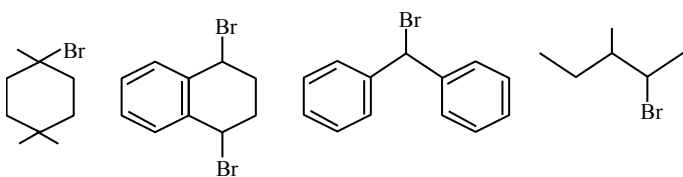
- (1) **Statement I** is true but **Statement II** is false
 (2) **Statement I** is false but **Statement II** is true
 (3) Both **Statement I** and **Statement II** are true
 (4) Both **Statement I** and **Statement II** are false

Ans. (3)

Sol. For a shell total number of orbitals = n^2

Magnetic quantum number have values $(-l$ to $+l)$ including 0.

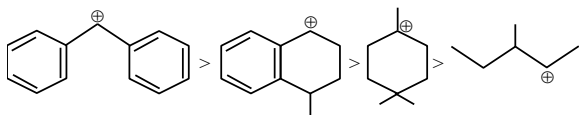
60. The ascending order of relative rate of solvolysis of following compounds is



- (A) (B) (C) (D)
- (1) (D) < (A) < (B) < (C)
 (2) (C) < (B) < (A) < (D)
 (3) (D) < (B) < (A) < (C)
 (4) (C) < (D) < (B) < (A)

Ans. (1)

Sol. Solvolysis or $S_N1 \propto$ stability of carbocation
Stability order



61. Match List - I with List - II.

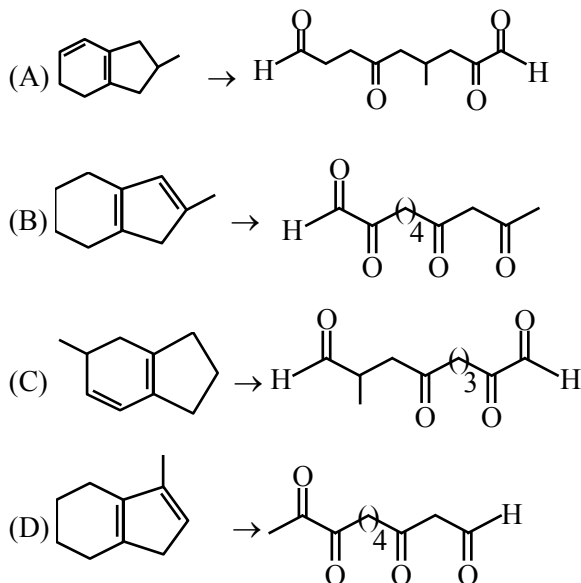
List - I (Isomers of $C_{10}H_{14}$)		List - II (Ozonolysis product)	
(A)		(I)	
(B)		(II)	
(C)		(III)	
(D)		(IV)	

Choose the **correct** answer from the options given below :

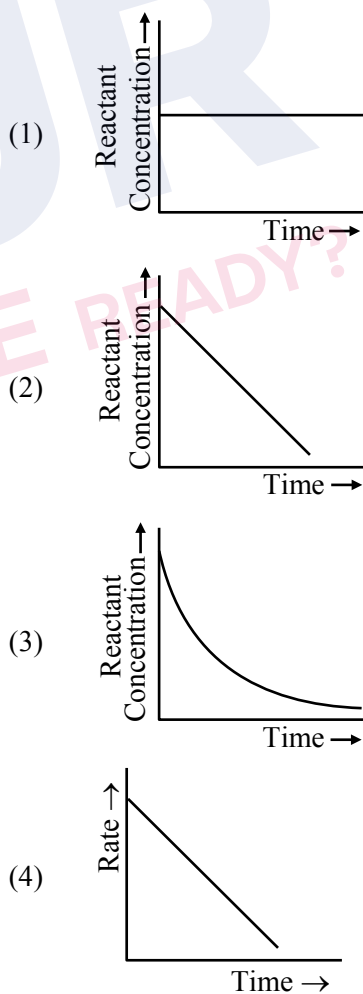
- (1) (A)-(II), (B)-(III), (C)-(I), (D)-(IV)
 (2) (A)-(III), (B)-(IV), (C)-(I), (D)-(II)
 (3) (A)-(III), (B)-(II), (C)-(I), (D)-(IV)
 (4) (A)-(I), (B)-(IV), (C)-(III), (D)-(II)

Ans. (2)

Sol. Ozonolysis product



62. Which of the following graphs most appropriately represents a zero order reaction ?

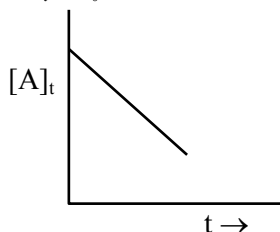


Ans. (2)

Sol. For zero order reaction : $A \rightarrow P$

Rate = k

$[A]_t = a_0 - kt$



63. Match List - I with List - II.

List - I		List - II	
(A)	Bronze	(I)	Cu, Ni
(B)	Brass	(II)	Fe, Cr, Ni, C
(C)	UK silver coin	(III)	Cu, Zn
(D)	Stainless Steel	(IV)	Cu, Sn

Choose the **correct** answer from the options given below :

(1) (A)-(IV), (B)-(II), (C)-(III), (D)-(I)

(2) (A)-(IV), (B)-(III), (C)-(I), (D)-(II)

(3) (A)-(III), (B)-(I), (C)-(IV), (D)-(II)

(4) (A)-(III), (B)-(IV), (C)-(II), (D)-(I)

Ans. (2)

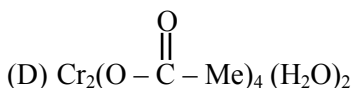
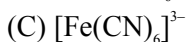
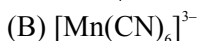
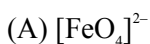
Sol. Bronze \rightarrow Cu, Sn

Brass \rightarrow Cu, Zn

UK silver coin \rightarrow Cu, Ni

Stainless steel \rightarrow Fe, Cr, Ni, C

64. Identify the coordination complexes in which the central metal ion has d^4 configuration.

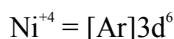
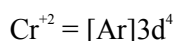
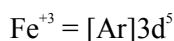
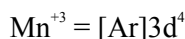
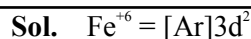


Choose the **correct** answer from the options given below :

(1) (C) and (E) only (2) (B), (C) and (D) only

(3) (B) and (D) only (4) (A), (B) and (E) only

Ans. (3)



65. Given below are the atomic numbers of some group 14 elements. The atomic number of the element with lowest melting point is :

(1) 14 (2) 6

(3) 82 (4) 50

Ans. (4)

Sol. Order of M.P. of group 14 : $\text{C} > \text{Si} > \text{Ge} > \text{Pb} > \text{Sn}$

element M.P. ($^{\circ}\text{C}$)

$Z = 6 = \text{C}$ 3730

$Z = 14 = \text{Si}$ 1410

$Z = 32 = \text{Ge}$ 937

$Z = 50 = \text{Sn}$ 232

$Z = 82 = \text{Pb}$ 327

66. pH of water is 7 at 25°C . If water is heated to 80°C , its pH will :

(1) Decrease

(2) Remains the same

(3) H^+ concentration increases, OH^- concentration decreases

(4) Increase

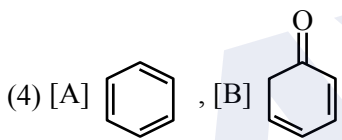
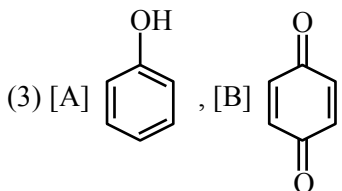
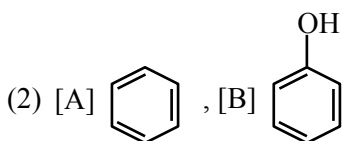
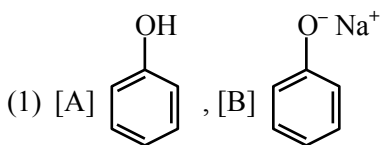
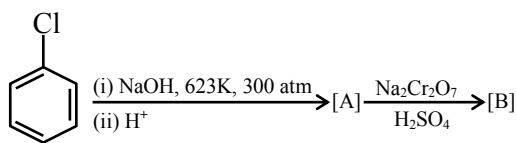
Ans. (1)

Sol. With increase in temperature, K_w of water increases

So, degree of dissociation of water increase

\therefore pH as well as pOH of water decrease.

67. Identify the products [A] and [B], respectively in the following reaction :



Ans. (3)

Sol. A is phenol and B is para benzoquinone.

68. Consider a binary solution of two volatile liquid components 1 and 2 x_1 and y_1 are the mole fractions of component 1 in liquid and vapour phase, respectively. The slope and intercept of the linear plot of $\frac{1}{x_1}$ vs $\frac{1}{y_1}$ are given respectively as :

(1) $\frac{P_1^0}{P_2^0}, \frac{P_2^0 - P_1^0}{P_2^0}$

(2) $\frac{P_2^0}{P_1^0}, \frac{P_1^0 - P_2^0}{P_2^0}$

(3) $\frac{P_1^0}{P_2^0}, \frac{P_1^0 - P_2^0}{P_2^0}$

(4) $\frac{P_2^0}{P_1^0}, \frac{P_2^0 - P_1^0}{P_2^0}$

Ans. (1)

Sol. ∴ For liquid solution of two liquids '1' and '2'

$$P_1 = P_T y_1 = P_1^0 x_1$$

$$\therefore \frac{P_T}{x_1} = \frac{P_1^0}{y_1}$$

$$\therefore \frac{P_2^0 + x_1(P_1^0 - P_2^0)}{x_1} = \frac{P_1^0}{y_1}$$

$$\therefore \frac{P_2^0}{x_1} + (P_1^0 - P_2^0) = \frac{P_1^0}{y_1}$$

$$\therefore \frac{1}{x_1} = \left(\frac{P_1^0}{P_2^0}\right)\left(\frac{1}{y_1}\right) + \left(\frac{P_2^0 - P_1^0}{P_2^0}\right)$$

$$\therefore \text{Slope} = \left(\frac{P_1^0}{P_2^0}\right)$$

$$\therefore \text{Intercept} = \left(\frac{P_2^0 - P_1^0}{P_2^0}\right)$$

69. Given below are two statements about X-ray spectra of elements :

Statement (I) : A plot of $\sqrt{\nu}$ (ν = frequency of X-rays emitted) vs atomic mass is a straight line.

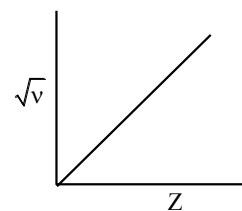
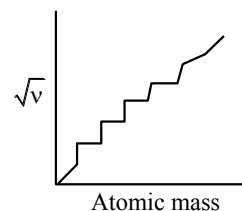
Statement (II) : A plot of ν (ν = frequency of X-rays emitted) vs atomic number is a straight line.

In the light of the above statements choose the **correct** answer from the options given below :

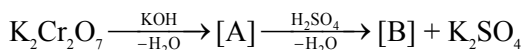
- (1) **Statement I** is true but **Statement II** is false
- (2) Both **Statement I** and **Statement II** are true
- (3) Both **Statement I** and **Statement II** are false
- (4) **Statement I** is false but **Statement II** is true

Ans. (3)

Sol.



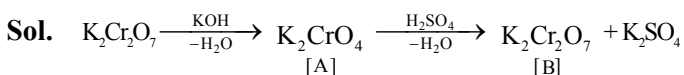
70. Consider the following reactions



The products [A] and [B], respectively are :

- (1) $\text{K}_2\text{Cr}(\text{OH})_6$ and Cr_2O_3
- (2) K_2CrO_4 and Cr_2O_3
- (3) K_2CrO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$
- (4) K_2CrO_4 and CrO

Ans. (3)



SECTION-B

71. 0.01 mole of an organic compound (X) containing 10% hydrogen, on complete combustion produced 0.9 g H_2O . Molar mass of (X) is _____ g mol^{-1} .

Ans. (100)



$$\therefore \text{mole of H}_2\text{O} = \frac{0.9}{18} = 0.05 \text{ mole}$$

$$\therefore \text{mole of H in H}_2\text{O} = 0.05 \times 2 = 0.1 \text{ mole}$$

= mole of H in 0.01 mole
Organic compound

$$\therefore \text{wt of H atom in 0.01 mole compound} = 0.1 \times 1 = 0.1 \text{ gm}$$

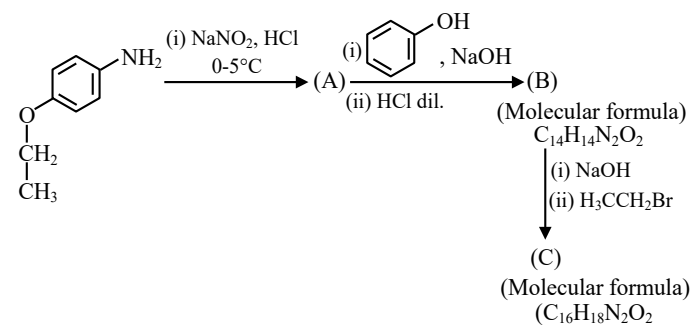
$$\therefore \text{wt of H atom in one mole compound} = \frac{0.1}{0.01} = 10 \text{ gm}$$

$$\therefore \text{wt. \% of H} = \frac{\text{wt. of H in one mole compound}}{\text{Molar mass of compound}} \times 100$$

$$10 = \frac{10}{M} \times 100$$

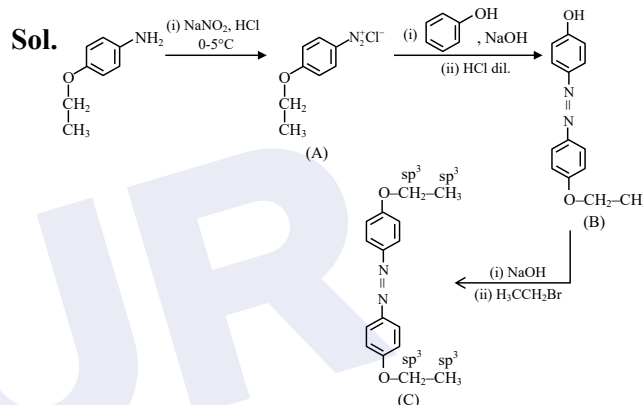
$$\therefore \boxed{M=100}$$

72. Consider the following sequence of reactions.



Total number of sp^3 hybridised carbon atoms in the major product C formed is _____.

Ans. (4)

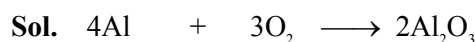


73. When 81.0 g of aluminium is allowed to react with 128.0 g of oxygen gas, the mass of aluminium oxide produced in grams is _____. (Nearest integer)
Given :

Molar mass of Al is 27.0 g mol^{-1}

Molar mass of O is 16.0 g mol^{-1}

Ans. (153)



$$\frac{81}{27} = 3 \text{ mole} \quad \frac{128}{32} = 4 \text{ mole}$$

Limiting reagent

$$\therefore \text{mole of Al}_2\text{O}_3 \text{ formed} = \frac{1}{2} \times 3 \text{ mole}$$

$$\therefore \text{wt. of Al}_2\text{O}_3 \text{ formed} = \frac{3}{2} \times 102$$

$$= 153 \text{ gm}$$

