



**SANTOSH**  
*Academia*  
IIT-JEE | NEET | Foundation

## Answers & Solutions

Time : 3 hrs.

M.M. : 300

*for*  
**JEE (Main)-2025 Phase-1**  
**[Computer Based Test (CBT) mode]**  
**(Mathematics, Physics and Chemistry)**

29/01/2025

Morning

### IMPORTANT INSTRUCTIONS:

- (1) The test is of **3 hours** duration.
- (2) This test paper consists of 75 questions. Each subject (MPC) has 25 questions. The maximum marks are 300.
- (3) This question paper contains **Three** Parts. **Part-A** is Physics, **Part-B** is Chemistry and **Part-C** is **Mathematics**. Each part has only two sections: **Section-A** and **Section-B**.
- (4) **Section - A** : Attempt all questions.
- (5) **Section - B** : Attempt all questions.
- (6) **Section - A (01 – 20)** contains 20 multiple choice questions which have **only one correct answer**. Each question carries **+4 marks** for correct answer and **-1 mark** for wrong answer.
- (7) **Section - B (21 – 25)** contains 5 **Numerical value** based questions. The answer to each question should be rounded off to the **nearest integer**. Each question carries **+4 marks** for correct answer and **-1 mark** for wrong answer.



**SANTOSH**  
Deemed to be University

Head Office: Santosh University, No 1, Santosh Nagar, Pratap Vihar, Ghaziabad

Ghaziabad Branch : J-10, Aniket Arcade, RDC Ghaziabad ☎ +91 93114 41940, +91 93114 42359



**MATHEMATICS**

**SECTION - A**

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. Define a relation  $R$  on the interval  $\left[0, \frac{\pi}{2}\right]$  by  $x R y$  if and only if  $\sec^2 x - \tan^2 y = 1$ . Then  $R$  is:
- (1) both reflexive and transitive but not symmetric
  - (2) an equivalence relation
  - (3) reflexive but neither symmetric nor transitive
  - (4) both reflexive and symmetric but not transitive

**Answer (2)**

**Sol.**  $x R y : \sec^2 x - \tan^2 y = 1$

Check reflexive:

$$x R x = \sec^2 x - \tan^2 x = 1$$

$$\forall x \in \left[0, \frac{\pi}{2}\right]$$

Check symmetric:

$$x R y \Rightarrow y R x$$

$$\sec^2 x - \tan^2 y = 1$$

$$= \sec^2 y - \tan^2 x = (1 + \tan^2 y) - (\sec^2 x - 1)$$

$$= 2 - (\sec^2 x - \tan^2 y)$$

$$= 2 - 1 = 1$$

$$\Rightarrow y R x$$

Check transitive

$$x R y \text{ and } y R z$$

$$\Rightarrow \sec^2 x - \tan^2 y = 1$$

$$\sec^2 y - \tan^2 z = 1$$

$$\text{Add } \Rightarrow \sec^2 x - \tan^2 z + (\sec^2 y - \tan^2 y) = 2$$

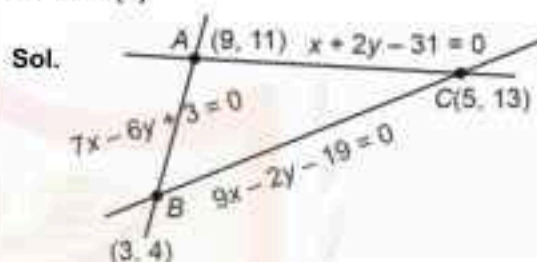
$$\Rightarrow \sec^2 x - \tan^2 z + 1 = 2 \Rightarrow x R z$$

$$\Rightarrow R \text{ is an equivalence relation.}$$

2. Let  $ABC$  be a triangle formed by the lines  $7x - 6y + 3 = 0$ ,  $x + 2y - 31 = 0$  and  $9x - 2y - 19 = 0$ . Let the point  $(h, k)$  be the image of the centroid of  $\triangle ABC$  in the line  $3x + 6y - 53 = 0$ . Then  $h^2 + k^2 + hk$  is equal to:

- (1) 40
- (2) 36
- (3) 47
- (4) 37

**Answer (4)**

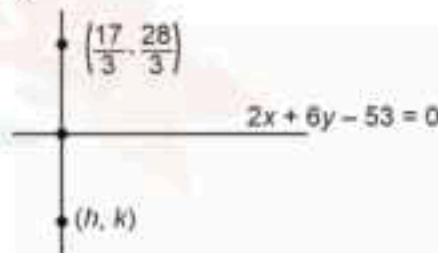


Points of intersections are  $(9, 11)$ ,  $(3, 4)$ ,  $(5, 13)$

$$\text{Centroid of } \triangle ABC = \left(\frac{17}{3}, \frac{28}{3}\right)$$

Since during image of  $\triangle ABC$  about line will reflect the whole triangle including centroid, reflected centroid will be image of  $\left(\frac{17}{3}, \frac{28}{3}\right)$  about  $2x + 6y - 53 = 0$

$$53 = 0$$



$$\frac{x - \frac{17}{3}}{2} = \frac{y - \frac{28}{3}}{6} = \frac{-2\left(2\left(\frac{17}{3}\right) + 6\left(\frac{28}{3}\right) - 53\right)}{2^2 + 6^2}$$

$$\Rightarrow h = 3, k = 4$$

$$\Rightarrow h^2 + k^2 + hk = (h + k)^2 - hk$$

$$= 49 - 12 = 37$$

3. Let  $\vec{a} = 2\hat{i} - \hat{j} + 3\hat{k}$ ,  $\vec{b} = 3\hat{i} - 5\hat{j} + \hat{k}$  and  $\vec{c}$  be a vector such that  $\vec{a} \times \vec{c} = \vec{c} \times \vec{b}$  and  $(\vec{a} + \vec{c}) \cdot (\vec{b} + \vec{c}) = 168$ . Then the maximum value of  $|\vec{c}|^2$  is
- (1) 308 (2) 462  
 (3) 154 (4) 77

**Answer (1)**

**Sol.**  $\vec{a} \times \vec{c} = \vec{c} \times \vec{b} = -(\vec{b} \times \vec{c})$

$$\Rightarrow (\vec{a} \times \vec{c} + \vec{b} \times \vec{c}) = (\vec{a} + \vec{b}) \times \vec{c} = 0$$

$$\Rightarrow \vec{c} \text{ is parallel to } \vec{a} + \vec{b}$$

$$\vec{c} = \lambda(5\hat{i} + (-6)\hat{j} + 4\hat{k}) \Rightarrow |\vec{c}|^2 = \lambda^2(25)$$

$$(\vec{a} + \vec{c}) \cdot (\vec{b} + \vec{c}) = \vec{a} \cdot \vec{b} + |\vec{c}|^2 + \vec{c} \cdot (\vec{a} + \vec{b})$$

$$= (6 + 5 + 3) + |\vec{c}|^2 + \lambda(25 + 36 + 16) = 168$$

$$\Rightarrow |\vec{c}|^2 + \lambda(77) = 154$$

$$\Rightarrow 77\lambda^2 + 77\lambda - 152 = 0$$

$$\Rightarrow \lambda^2 + \lambda - 2 = 0$$

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

$$|\vec{c}|_{\text{max}}^2 = (-2)^2(77) = 308$$

4. Let  $y = y(x)$  be the solution of the differential equation  $\cos x (\log_e (\cos x))^2 dy + (\sin x - 3y \sin x \log_e (\cos x)) dx = 0$ ,  $x \in \left(0, \frac{\pi}{2}\right)$ . If

$$y\left(\frac{\pi}{4}\right) = \frac{-1}{\log_e 2}, \text{ then } y\left(\frac{\pi}{6}\right) \text{ is equal to:}$$

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

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

**Answer (2)**

**Sol.**  $\frac{dy}{dx} \frac{3 \sin x}{\cos x \ln \cos x} y = \frac{\sin x}{\cos x (\ln \cos x)^2}$

$$\text{I.F.} = e^{\int \frac{3 \sin x}{\ln \cos x} dx}$$

$$\text{Let } \ln \cos x = t$$

$$-\tan x dx = dt$$

$$e^{3 \int \frac{dt}{t}} = e^{3 \ln t} = t^3 = (\ln \cos x)^3$$

$\therefore$  Solution will be

$$y(\ln \cos x)^3 = -\int (\tan x)(\ln \cos x) dx$$

$$y(\ln \cos x)^3 = \frac{(\ln \cos x)^2}{2} + c$$

$$\therefore y\left(\frac{\pi}{4}\right) = \frac{1}{\ln 2}$$

$$\Rightarrow c = 0$$

$$\therefore y = \frac{1}{2(\ln \cos x)}$$

$$y\left(\frac{\pi}{6}\right) = \frac{1}{2} \times \frac{1}{\ln\left(\cos \frac{\pi}{6}\right)}$$

$$= \frac{1}{2} \left[ \frac{1}{\ln\left(\frac{\sqrt{3}}{2}\right)} \right]$$

$$= \frac{1}{2} \times \frac{1}{\ln \sqrt{3} - \ln 2}$$

$$= \frac{1}{\ln 3 - \ln 4}$$

5. The value of  $\lim_{n \rightarrow \infty} \left( \sum_{k=1}^n \frac{k^3 + 6k^2 + 11k + 5}{(k+3)!} \right)$  is

(1)  $\frac{7}{3}$  (2)  $\frac{4}{3}$

(3)  $\frac{5}{3}$  (4) 2

**Answer (3)**

Sol.  $\lim_{n \rightarrow \infty} \left( \sum_{k=1}^n \frac{k^3 + 6k^2 + 11k + 5}{(k+3)!} \right)$

$$\lim_{n \rightarrow \infty} \left( \sum_{k=1}^n \frac{k^3 + 6k^2 + 11k + 6 - 1}{(k+3)!} \right)$$

$$\lim_{n \rightarrow \infty} \left( \sum_{k=1}^n \frac{(k+1)(k+2)(k+3) - 1}{(k+3)!} \right)$$

$$\lim_{n \rightarrow \infty} \left( \sum_{k=1}^n \frac{1}{k!} - \frac{1}{(k+3)!} \right)$$

$$= \left( \frac{1}{1!} + \frac{1}{2!} + \frac{1}{3!} + \dots - \infty \right) - \left( \frac{1}{4!} + \frac{1}{5!} + \frac{1}{6!} + \dots - \infty \right)$$

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

$$= 1 + \frac{1}{2} + \frac{1}{6} = \frac{10}{6} = \frac{5}{3}$$

6. Let  $P$  be the set of seven digit numbers with sum of their digits equal to 11. If the numbers  $P_n$  are formed by using the digits 1, 2 and 3 only, then the number of elements in the set  $P$  is:

- (1) 173 (2) 161  
(3) 164 (4) 158

**Answer (2)**

Sol. Case I: 3 2 2 1 1 1 1

$$n_1 = \frac{7!}{4!2!} = 105$$

Case II: 2 2 2 2 1 1 1

$$n_2 = \frac{7!}{4!3!} = 35$$

Case III: 3 3 1 1 1 1 1

$$n_3 = \frac{7!}{2!4!} = 21$$

$$\text{Total numbers} = 105 + 35 + 21 = 161$$

7. Let  $M$  and  $m$  respectively be the maximum and the minimum values of

$$f(x) = \begin{vmatrix} 1 + \sin^2 x & \cos^2 x & 4 \sin 4x \\ \sin^2 x & 1 + \cos^2 x & 4 \sin 4x \\ \sin^2 x & \cos^2 x & 1 + 4 \sin 4x \end{vmatrix}, x \in R$$

Then  $M^4 - m^4$  is equal to

- (1) 1295 (2) 1040  
(3) 1280 (4) 1215

**Answer (3)**

Sol.  $R_1 \rightarrow R_1 - R_2, R_2 \rightarrow R_2 - R_3$

$$\begin{vmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ \sin^2 x & \cos^2 x & 1 + 4 \sin 4x \end{vmatrix} = f(x)$$

$C_2 \rightarrow C_1 + C_2$

$$\begin{vmatrix} 1 & 0 & 0 \\ 0 & 1 & -1 \\ \sin^2 x & 1 + 4 \sin 4x & \end{vmatrix} = f(x)$$

$$f(x) = 1 + 4 \sin 4x + 1 = 2 + 4 \sin 4x$$

$$M = 6, m = -2$$

$$M^4 - m^4 = 1280$$

8. The integral  $80 \int_0^{\pi/4} \left( \frac{\sin \theta + \cos \theta}{9 + 16 \sin 2\theta} \right) d\theta$  is equal to

- (1)  $4 \log_e 3$  (2)  $6 \log_e 4$   
(3)  $2 \log_e 3$  (4)  $3 \log_e 4$

**Answer (1)**

Sol.  $I = \int_0^{\pi/4} \left( \frac{\sin \theta + \cos \theta}{9 - 16 \sin 2\theta} \right) d\theta$

Take  $\sin \theta - \cos \theta = t$

$$(\cos \theta + \sin \theta) d\theta = dt$$

$$(\sin \theta - \cos \theta)^2 = t^2$$

$$\Rightarrow \sin 2\theta = 1 - t^2$$

$$\theta = 0 \rightarrow t = -1$$

$$\theta = \frac{\pi}{4} \rightarrow t = 0$$

$$I = \int_{-1}^0 \frac{dt}{9 + 16(1 - t^2)}$$

$$= \frac{1}{16} \int_{-1}^0 \frac{dt}{\frac{25}{16} - t^2}$$

$$= \frac{1}{4} \left[ \frac{1}{10} \log \left| \frac{5+4t}{5-4t} \right| \right]_{-1}^0$$

$$= \frac{1}{40} [0 + \log_e 9]$$

$$I = \frac{\log_e 9}{40}$$

$$80I = 2 \log_e 9$$

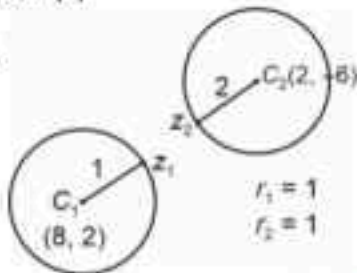
$$80I = 4 \log_e 3$$



9. Let  $|z_1 - 8 - 2j| \leq 1$  and  $|z_2 - 2 + 6j| \leq 2$ ,  $z_1, z_2 \in \mathbb{C}$ .  
Then the minimum value of  $|z_1 - z_2|$  is  
(1) 13 (2) 10  
(3) 7 (4) 3

**Answer (3)**

**Sol.**



$$\begin{aligned} |z_1 - z_2| &= C_1 C_2 - (r_1 + r_2) \\ &= \sqrt{6^2 + 8^2} - (1 + 2) \\ &= 10 - 3 = 7 \end{aligned}$$

10. Let  $A = [a_{ij}] = \begin{bmatrix} \log_5 128 & \log_4 5 \\ \log_5 8 & \log_4 25 \end{bmatrix}$

If  $A_{ij}$  is the cofactor of  $a_{ij}$ ,  $C_{ij} = \sum_{k=1}^2 a_{ik} A_{jk}$ ,  $1 \leq i, j \leq 2$

and  $C = [C_{ij}]$ , then  $8|C|$  is equal to

- (1) 222 (2) 242  
(3) 288 (4) 262

**Answer (2)**

**Sol.**  $[a_{ij}] = \begin{bmatrix} 7 \log_5 2 & \frac{1}{2} \log_2 5 \\ 3 \log_5 2 & \log_2 5 \end{bmatrix}$

$$[A_{ij}] = \begin{bmatrix} \log_2 5 & -3 \log_5 2 \\ -\frac{1}{2} \log_2 5 & 7 \log_5 2 \end{bmatrix}$$

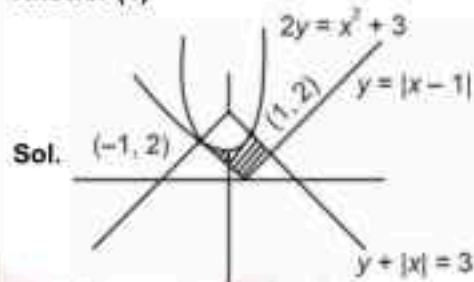
$$C_{ij} = \sum_{k=1}^2 a_{ik} A_{jk}, \quad 1 \leq i, j \leq 2$$

$$C = \begin{bmatrix} \frac{11}{2} & 0 \\ 0 & \frac{11}{2} \end{bmatrix}$$

$$8|C| = \frac{121}{4} \cdot 8 = 242$$

11. Let the area of the region  $\{(x, y) : 2y \leq x^2 + 3, y + |x| \leq 3, y \geq |x - 1|\}$  be  $A$ .  
Then  $6A$  is equal to  
(1) 18 (2) 12  
(3) 16 (4) 14

**Answer (4)**



$$\int_{-1}^1 \left( \frac{x^2 + 3}{2} + (x - 1) \right) dx + \int_1^2 \left( (3 - x) - (x - 1) \right) dx$$

$$\Rightarrow \left[ \frac{x^3}{6} + \frac{3x}{2} + \frac{x^2}{2} - x \right]_{-1}^1 + \left[ 3x - \frac{x^2}{2} - \frac{x^2}{2} + x \right]_1^2$$

$$A = \frac{7}{3} \Rightarrow 6A = 14$$

12. Let  $L_1 : \frac{x-1}{1} = \frac{y-2}{-1} = \frac{z-1}{2}$  and

$$L_2 : \frac{x+1}{-1} = \frac{y-2}{2} = \frac{z}{1}$$

be two lines. Let  $L_3$  be a line passing through the point  $(\alpha, \beta, \gamma)$  and be perpendicular to both  $L_1$  and  $L_2$ . If  $L_3$  intersects  $L_1$ , then  $|5\alpha - 11\beta - 8\gamma|$  equals

- (1) 18 (2) 25  
(3) 16 (4) 20

**Answer (2)**

**Sol.**  $\frac{x-\alpha}{a} = \frac{y-\beta}{b} = \frac{z-\gamma}{c} = L_3$

$$(a\hat{i} + b\hat{j} + c\hat{k}) \parallel (\hat{i} - \hat{j} + 2\hat{k}) \times (-\hat{i} + 2\hat{j} + \hat{k})$$

$$(a, b, c) = (5, 3, -1)$$

$$\Rightarrow \frac{x-\alpha}{5} = \frac{y-\beta}{3} = \frac{z-\gamma}{-1} = \lambda$$

Point of intersection

$$\alpha = p + 1 - 5\lambda, \beta = -p + 2 - 3\lambda$$

$$\gamma = 2p + 1 + \lambda$$

$$\Rightarrow |5\alpha - 11\beta - 8\gamma| = 25$$





$$9t^2 - 9t + 2 = 0$$

$$\Rightarrow t = \frac{9 \pm \sqrt{81 - 72}}{18}$$

$$\Rightarrow t = \frac{9 \pm 3}{18}$$

$$\Rightarrow t = \frac{2}{3}, \frac{1}{3}$$

$$\Rightarrow 2t^2 - 7t + 3 = 0$$

$$\Rightarrow 2t^2 - 6t - t + 3 = 0$$

$$\Rightarrow 2t(t-3) - 1(t-3) = 0$$

$$t = \frac{1}{2}, 3$$

$$\Rightarrow \sqrt{x} = \frac{3}{2}, 3, 2, \frac{1}{3}$$

$$\Rightarrow x = \frac{9}{4}, 9, 4, \frac{1}{9}$$

Hence, number of solutions = 4

16. Consider an A.P. of positive integers, whose sum of the first three terms is 54 and the sum of the first twenty terms lies between 1600 and 1800. Then its 11<sup>th</sup> term is:

- (1) 84                                      (2) 122  
 (3) 90                                        (4) 108

**Answer (3)**

**Sol.** Let A.P. be  $a, a + d, a + 2d$

$$3a + 3d = 54$$

$$a + d = 18 \quad \dots (1)$$

$$1600 < \frac{20}{2}[2a + 19d] < 1800$$

$$160 < 2a + 19d < 180$$

$$160 < 18 \times 2 + 17d < 180$$

$$\frac{124}{7} < d < \frac{144}{17}$$

$$\therefore d \in \text{integer} \Rightarrow d = 8$$

$$a + d = 18$$

$$\Rightarrow a = 10$$

$$a_{11} = a + 10d$$

$$= 10 + 10 \times 8 = 90$$

17. Let the ellipse  $E_1: \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ ,  $a > b$  and

$E_2: \frac{x^2}{A^2} + \frac{y^2}{B^2} = 1$ ,  $A < B$  have same eccentricity  $\frac{1}{\sqrt{3}}$ . Let the product of their lengths of latus

rectums be  $\frac{32}{\sqrt{3}}$ , and the distance between the foci

of  $E_1$  be 4. If  $E_1$  and  $E_2$  meet at A, B, C and D, then the area of the quadrilateral ABCD equals

- (1)  $6\sqrt{6}$                                       (2)  $\frac{24\sqrt{6}}{5}$   
 (3)  $\frac{12\sqrt{6}}{5}$                                         (4)  $\frac{18\sqrt{6}}{5}$

**Answer (2)**

**Sol.**  $2ae = 4$

$$\Rightarrow a = 2\sqrt{3}$$

$$\Rightarrow 1 - \frac{b^2}{12} = \frac{1}{3} \Rightarrow b^2 = 8$$

$$\frac{2b^2}{a} \times \frac{2A^2}{B} = \frac{32}{\sqrt{3}}$$

$$\Rightarrow \frac{2 \times 8}{2\sqrt{3}} \times \frac{2A^2}{B} = \frac{32}{\sqrt{3}}$$

$$\Rightarrow \frac{A^2}{B} = 2 \Rightarrow A^2 = 2B$$

$$1 - \frac{A^2}{B} = \frac{1}{3}$$

$$\Rightarrow B = 3 \Rightarrow A^2 = 6$$

$$E_1: \frac{x^2}{12} + \frac{y^2}{8} = 1 \quad \dots (i)$$

$$E_2: \frac{x^2}{6} + \frac{y^2}{9} = 1 \quad \dots (ii)$$

On solving (i) & (ii)

$$(x, y) = \left( \frac{\sqrt{6}}{\sqrt{5}}, \frac{6}{\sqrt{5}} \right), \left( \frac{-\sqrt{6}}{\sqrt{5}}, \frac{6}{\sqrt{5}} \right), \left( \frac{\sqrt{6}}{\sqrt{5}}, \frac{-6}{\sqrt{5}} \right),$$

$$\left( \frac{-\sqrt{6}}{\sqrt{5}}, \frac{-6}{\sqrt{5}} \right)$$

Four points are vertices of rectangle area =  $\frac{24\sqrt{6}}{5}$



18. Let  $\vec{a} = \hat{i} + 2\hat{j} + \hat{k}$  and  $\vec{b} = 2\hat{i} + 7\hat{j} + 3\hat{k}$  Let

$$L_1: \vec{r} = (-\hat{i} + 2\hat{j} + \hat{k}) + \lambda\vec{a}, \lambda \in \mathbf{R} \quad \text{and}$$

$$L_2: \vec{r} = (\hat{j} + \hat{k}) + \mu\vec{b}, \mu \in \mathbf{R}$$

be two lines. If the line  $L_3$  passes through the point of intersection of  $L_1$  and  $L_2$  and is parallel to  $\vec{a} + \vec{b}$ , then  $L_3$  passes through the point

(1) (8, 26, 12)                      (2) (2, 8, 5)

(3) (5, 17, 4)                        (4) (-1, -1, 1)

**Answer (1)**

**Sol.**  $\vec{a} = \hat{i} + 2\hat{j} + \hat{k}$

$$\vec{b} = 2\hat{i} + 7\hat{j} + 3\hat{k}$$

$$L_1: \vec{r} = (-\hat{i} + 2\hat{j} + \hat{k}) + \lambda\vec{a}, \lambda \in \mathbf{R}$$

and  $L_2 = (\hat{j} + \hat{k}) + \mu\vec{b}, \mu \in \mathbf{R}$

$$\vec{a} + \vec{b} = 3\hat{i} + 9\hat{j} + 4\hat{k}$$

$$L_1: \vec{r} = (\lambda - 1)\hat{i} + 2(\lambda + 1)\hat{j} + (\lambda + 1)\hat{k}$$

$$L_2: \vec{r} = 2\mu\hat{i} + (7\mu + 1)\hat{j} + (1 + 3\mu)\hat{k}$$

For point of intersection of  $L_1$  &  $L_2$

$$\lambda - 1 = 2\mu \quad \text{and} \quad 2(\lambda + 1) = 7\mu + 1$$

$$\Rightarrow \lambda = 3 \quad \text{and} \quad \mu = 1$$

$$L_3: \vec{r} = 2\hat{i} + 8\hat{j} + 4\hat{k} + \alpha(3\hat{i} + 9\hat{j} + 4\hat{k})$$

For  $\alpha = 2$

$$\vec{r} = 8\hat{i} + 26\hat{j} + 12\hat{k}$$

19. Two parabolas have the same focus (4, 3) and their directrices are the x-axis and the y-axis, respectively. If these parabolas intersect at the points A and B, then  $(AB)^2$  is equal to :

(1) 392                                  (2) 192

(3) 384                                  (4) 96

**Answer (2)**

**Sol.** The parabolas are

$$(x - 4)^2 + (y - 3)^2 = x^2 \quad \dots (i)$$

$$\text{and } (x - 4)^2 + (y - 3)^2 = y^2 \quad \dots (ii)$$

If point of intersection are A( $x_1, y_1$ ) and B( $x_2, y_2$ )

By solving (i) and (ii), we get

$$x_1 + x_2 = 14 \quad \text{and} \quad x_1 x_2 = 25$$

$$(AB)^2 = 2((x_1 + x_2)^2 - 4 x_1 x_2) = 192$$

20. Let the line  $x + y = 1$  meet the circle  $x^2 + y^2 = 4$  at the points A and B. If the line perpendicular to AB and passing through the mid-point of the chord AB intersects the circle at C and D, then the area of the quadrilateral ADBC is equal to:

(1)  $2\sqrt{14}$

(2)  $3\sqrt{7}$

(3)  $5\sqrt{7}$

(4)  $\sqrt{14}$

**Answer (1)**

**Sol.** Solving  $x = y$  &  $x^2 + y^2 = 4$  gives

$$C(\sqrt{2}, \sqrt{2}) \quad \text{and} \quad D(-\sqrt{2}, -\sqrt{2})$$

Solving  $x + y = 1$  &  $x^2 + y^2 = 4$  gives

$$A\left(\frac{1 + \sqrt{7}}{2}, \frac{1 - \sqrt{7}}{2}\right) \quad \text{and} \quad B\left(\frac{1 - \sqrt{7}}{2}, \frac{1 + \sqrt{7}}{2}\right)$$

$$\text{Required area} = 2 \times \frac{1}{2} \begin{vmatrix} \sqrt{2} & \sqrt{2} & 1 \\ \frac{1 - \sqrt{7}}{2} & \frac{1 + \sqrt{7}}{2} & 1 \\ -\sqrt{2} & -\sqrt{2} & 1 \end{vmatrix}$$

$$= 2\sqrt{14} \text{ sq. units}$$





SECTION - B

**Numerical Value Type Questions:** This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. Let  $[t]$  be the greatest integer less than or equal to  $t$ . Then the least value of  $p \in \mathbb{N}$  for which

$$\lim_{x \rightarrow 0^+} \left( x \left( \left[ \frac{1}{x} \right] + \left[ \frac{2}{x} \right] + \dots + \left[ \frac{p}{x} \right] \right) - x^2 \left( \left[ \frac{1}{x^2} \right] + \left[ \frac{2^2}{x^2} \right] + \dots + \left[ \frac{p^2}{x^2} \right] \right) \right) \geq 1$$

is equal to \_\_\_\_\_.

**Answer (24)**

**Sol.**  $\lim_{x \rightarrow 0^+} \left( x \left( \left[ \frac{1}{x} \right] + \left[ \frac{2}{x} \right] + \dots + \left[ \frac{p}{x} \right] \right) - x^2 \left( \left[ \frac{1}{x^2} \right] + \left[ \frac{2^2}{x^2} \right] + \dots + \left[ \frac{p^2}{x^2} \right] \right) \right) \geq 1$

$$\Rightarrow (1 + 2 + 3 + \dots + p) - (1^2 + 2^2 + \dots + p^2) \geq 1$$

$$\Rightarrow \frac{p(p+1)}{2} - \frac{9(10)(19)}{6} \geq 1$$

$$\Rightarrow p(p+1) \geq 572$$

$\Rightarrow$  Least natural values of  $p$  is 24

22. Let  $f : (0, \infty) \rightarrow \mathbb{R}$  be a twice differentiable function.

If for some  $a \neq 0$ ,  $\int_0^1 f(\lambda x) d\lambda = af(x)$ ,  $f(1) = 1$  and

$f(16) = \frac{1}{8}$ , then  $16 - f'\left(\frac{1}{16}\right)$  is equal to \_\_\_\_\_.

**Answer (112)**

**Sol.** Given,  $\int_0^1 f(\lambda x) d\lambda = af(x) \dots (1)$

Let  $\lambda x = u$

$$d\lambda = \frac{1}{x} du$$

$$\therefore \text{From (1)} \quad \frac{1}{x} \int_0^x f(u) du = af(x)$$

$$\Rightarrow \int_0^x f(u) du = axf(x)$$

Differentiate both sides

$$f(x) = a(xf'(x) + f(x))$$

$$\Rightarrow f(x) = axf'(x) + af(x)$$

$$\Rightarrow (1-a)f(x) = axf'(x)$$

$$\Rightarrow \frac{f'(x)}{f(x)} = \frac{(1-a)}{a} \cdot \frac{1}{x}$$

Integrate both side w.r.t. (x)

$$\Rightarrow \int \frac{f'(x)}{f(x)} dx = \frac{(1-a)}{a} \int \frac{1}{x} dx$$

$$\Rightarrow \ln f(x) = \left( \frac{1-a}{a} \right) \ln x + c$$

Now at  $x = 1$   $f(1) = 1$

$$\Rightarrow c = 0$$

Also given  $f(16) = \frac{1}{8}$

$$\therefore \frac{1}{8} = (16)^{\frac{1-a}{a}}$$

$$\Rightarrow 2^{-3} = 2^{\frac{1-4a}{a}}$$

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

$$\Rightarrow -3a = 4 - 4a$$

$$\Rightarrow a = 4$$

$$\therefore f(x) = x^{-3/4}$$

$$f(x) = \frac{-3}{4} x^{-7/4}$$

Put  $x = \frac{1}{16}$

$$f'\left(\frac{1}{16}\right) = \frac{-3}{4} \left(\frac{1}{16}\right)^{-7/4} = \frac{-3}{4} \cdot 2^{-4} \cdot \left(\frac{7}{4}\right) = -96$$

$$\therefore 16 - f'\left(\frac{1}{16}\right) \Rightarrow 16 - (-96) = 112$$





23. Let  $S = \{x : \cos^{-1} x = \pi + \sin^{-1} x + \sin^{-1}(2x+1)\}$ .

Then  $\sum_{x \in S} (2x-1)^2$  is equal to \_\_\_\_\_.

**Answer (5)**

**Sol.**  $\cos^{-1} x = \pi + \sin^{-1} x + \sin^{-1}(2x+1)$ .

$$\frac{\pi}{2} - \sin^{-1} x = \pi + \sin^{-1} x + \sin^{-1}(2x+1)$$

$$-\frac{\pi}{2} - 2\sin^{-1} x = \sin^{-1}(2x+1)$$

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

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

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

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

$$2x^2 - 2x - 2 = 0$$

$$x = \frac{2 \pm \sqrt{4+16}}{4}$$

$$x = \frac{2 \pm 2\sqrt{5}}{4} = \frac{1 \pm \sqrt{5}}{2} \left\{ x = \frac{1 + \sqrt{5}}{2} \text{ rejected} \right\}$$

$$\text{So, } \sum_{x \in S} (2x-1)^2 = 5$$

24. The number of 6 letter words, with or without meaning, that can be formed using the letters of the word MATHS such that any letter that appears in the word must appear at least twice is

**Answer (1405)**

$$\text{Sol. } {}^3C_3 \times \frac{6!}{2!2!2!} + {}^5C_2 \left( \frac{6!}{2!4!} \times 2 + \frac{6!}{3!3!} \right) + {}^5C_1 \cdot 1$$

$$= 10 \times 90 + 10(15 \times 2 + 20) + 5$$

$$= 900 + 500 + 5$$

$$= 1405$$

25. Let  $S = \{m \in \mathbf{Z} : A^{m^2} + A^m = 3I - A^{-6}\}$ , where

$$A = \begin{bmatrix} 2 & -1 \\ 1 & 0 \end{bmatrix}. \text{ Then } n(S) \text{ is equal to } \underline{\hspace{2cm}}$$

**Answer (2)**

$$\text{Sol. } A = \begin{bmatrix} 2 & -1 \\ 1 & 0 \end{bmatrix}$$

Now finding characteristic equation

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

$$\Rightarrow (2-\lambda)(-\lambda) - (-1)(1) = -2\lambda + \lambda^2 + 1 = 0$$

$$\Rightarrow \lambda^2 - 2\lambda + 1 = 0$$

$$\Rightarrow (\lambda - 1)^2 = 0$$

$$\Rightarrow \lambda = 1$$

Since  $A$  satisfies  $(A - I)^2 = 0$

$\therefore A = I + N$  where

$$N = A - I$$

$$N = \begin{bmatrix} 1 & -1 \\ 1 & -1 \end{bmatrix}$$

$$N^2 = 0$$

$$A^m = (I + N)^m = I + mN$$

$$A^m \cdot A^m = (I + mN)(I + mN) = I + 2mN + m^2N^2$$

$$\text{Since } N^2 = 0$$

$$\Rightarrow A^{m^2} = I + 2mN$$

Now putting in given condition

$$I + m^2N + I + mN = 3I - A^{-6} \quad \dots (i)$$

$$A^{-1} = \begin{bmatrix} 0 & 1 \\ -1 & 2 \end{bmatrix}$$

$$A^{-6} = (A^{-1})^6 = I + (-6)N$$

$\therefore$  Putting in (i)

$$(m^2 + m)N = I - (I - 6N)$$

$$(m^2 + m)N = 6N$$

$$\text{Since } N \neq 0$$

$$\Rightarrow m^2 + m = 6$$

$$\Rightarrow m^2 + m - 6 = 0$$

$$\Rightarrow (m-2)(m+3) = 0$$

$$\Rightarrow m = 2, -3$$

$\therefore$  Number of elements in  $S$  is 2



## PHYSICS

### SECTION - A

**Multiple Choice Questions:** This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

**Choose the correct answer :**

26. The workdone in an adiabatic change in an ideal gas depends upon only :
- (1) Change in its volume
  - (2) Change in its temperature
  - (3) Change in its pressure
  - (4) Change in its specific heat

**Answer (2)**

**Sol.** Work done in adiabatic process =  $\frac{nR\Delta T}{1-\gamma}$

So, depends upon change in temperature.

27. Two projectiles are fired with same initial speed from same point on ground at angles of  $(45^\circ - \alpha)$  and  $(45^\circ + \alpha)$ , respectively, with the horizontal direction. The ratio of their maximum heights attained is :

- |   |   |
|---|---|
| (1) $\frac{1 + \sin 2\alpha}{1 - \sin 2\alpha}$ | (2) $\frac{1 + \sin \alpha}{1 - \sin \alpha}$   |
| (3) $\frac{1 - \tan \alpha}{1 + \tan \alpha}$   | (4) $\frac{1 - \sin 2\alpha}{1 + \sin 2\alpha}$ |

**Answer (4)**

**Sol.**  $H_{\max} = \frac{u^2 \sin^2 \theta}{2g}$

$$\frac{H_1}{H_2} = \frac{\sin^2(45^\circ - \alpha)}{\sin^2(45^\circ + \alpha)}$$

$$= \frac{(\cos \alpha - \sin \alpha)^2}{(\cos \alpha + \sin \alpha)^2}$$

$$\frac{H_1}{H_2} = \frac{1 - \sin 2\alpha}{1 + \sin 2\alpha}$$

28. Consider a long straight wire of a circular cross-section (radius  $a$ ) carrying a steady current  $I$ . The current is uniformly distributed across this cross-section. The distances from the centre of the wire's cross-section at which the magnetic field [inside the wire, outside the wire] is half of the maximum possible magnetic field, anywhere due to the wire, will be

- |                   |                     |
|-------------------|---------------------|
| (1) $\{a/2, 2a\}$ | (2) $\{a/2, 3a\}$   |
| (3) $\{a/4, 2a\}$ | (4) $\{a/4, 3a/2\}$ |

**Answer (1)**

**Sol.** Magnetic field inside cylinder at distance  $r$  from axis

$$= \frac{\mu_0 I}{2\pi R^2} r$$

$$B_{\max} = \frac{\mu_0 I}{2\pi R}$$

$$\frac{\mu_0 I}{2\pi R^2} r = \frac{\mu_0 I}{2\pi R} \left( \frac{1}{2} \right)$$

$$r = \frac{R}{2} = \frac{a}{2}$$

Magnetic field outside cylinder at distance  $r$  from axis

$$= \frac{\mu_0 I}{2\pi r}$$

$$\frac{\mu_0 I}{2\pi r_2} = \frac{\mu_0 I}{2\pi R} \left( \frac{1}{2} \right)$$

$$r_2 = 2R = 2a$$

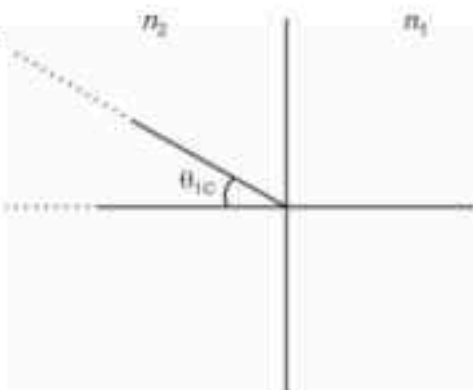
29. At the interface between two materials having refractive indices  $n_1$  and  $n_2$ , the critical angle for reflection of an em wave is  $\theta_{1c}$ . The  $n_2$  material is replaced by another material having refractive index  $n_3$  such that the critical angle at the interface between  $n_1$  and  $n_3$  materials is  $\theta_{2c}$ . If  $n_3 > n_2 > n_1$ ,

$$\frac{n_2}{n_3} = \frac{2}{5} \text{ and } \sin \theta_{2c} - \sin \theta_{1c} = \frac{1}{2}, \text{ then } \theta_{1c} \text{ is}$$

- |   |   |
|---|---|
| (1) $\sin^{-1} \left( \frac{1}{3n_1} \right)$ | (2) $\sin^{-1} \left( \frac{1}{6n_1} \right)$ |
| (3) $\sin^{-1} \left( \frac{5}{6n_1} \right)$ | (4) $\sin^{-1} \left( \frac{2}{3n_1} \right)$ |

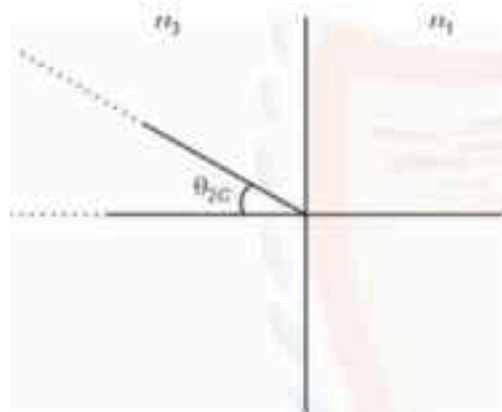
**Answer (\*)**

Sol.



$$n_2 \sin(\theta_{1c}) = 1$$

$$\sin(\theta_{1c}) = \frac{n_1}{n_2}$$



$$n_3 \sin(\theta_{2c}) = 1$$

$$\Rightarrow \sin(\theta_{2c}) = \frac{n_1}{n_3}$$

$$\text{Also, } n_3 = \frac{5n_2}{2} \Rightarrow \frac{2n_1}{5} \sin(\theta_{1c}) = \frac{1}{n_3}$$

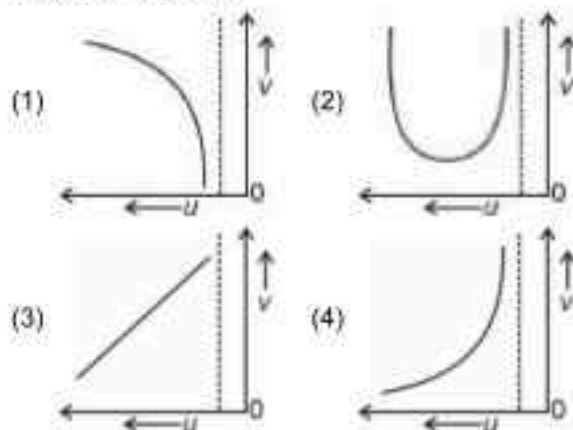
$$\Rightarrow \frac{n_1}{n_2} = \frac{5}{2} \cdot \sin(\theta_{1c}) \Rightarrow \sin(\theta_{2c}) - \sin(\theta_{1c}) = -$$

$$\text{Given, } \frac{2n_1}{5n_2} - \frac{n_1}{n_2} = \frac{1}{2} \Rightarrow \frac{n_1}{n_2} \left( \frac{2}{5} - 1 \right) = \frac{1}{2}$$

Coming out to be (-ve)

\* None of the answer is matching

30. Let  $u$  and  $v$  be the distances of the object and the image from a lens of focal length  $f$ . The correct graphical representation of  $u$  and  $v$  for a convex lens when  $|u| > f$ , is



Answer (4)

Sol. Lens formula  $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u}$$

Since  $|u| > f$

So, RHS is positive.

31. The pair of physical quantities not having same dimensions is :

- (1) Angular momentum and Planck's constant
- (2) Torque and energy
- (3) Surface tension and impulse
- (4) Pressure and Young's modulus

Answer (3)

Sol. [Angular momentum] =  $ML^2T^{-1}$

[Planck's Constant] =  $ML^2T^{-1}$

[Torque] =  $ML^2T^{-2}$

[Energy] =  $ML^2T^{-2}$

[Surface tension] =  $MT^{-2}$

[Impulse] =  $MLT^{-1}$

[Pressure] =  $ML^{-1}T^{-2}$

[Young's modulus] =  $ML^{-1}T^{-2}$

32. The expression given below shows the variation of velocity ( $v$ ) with time ( $t$ ),  $v = At^2 + \frac{Bt}{Ct}$ . The

dimension of  $ABC$  is :

- (1)  $[M^0L^1T^{-2}]$                       (2)  $[M^0L^1T^{-3}]$   
(3)  $[M^0L^2T^{-2}]$                       (4)  $[M^0L^2T^{-3}]$

**Answer (3)**

**Sol.**  $v = At^2 + \frac{Bt}{Ct}$

$$[v] = [A] t^2 = \left[ \frac{Bt}{Ct} \right]$$

$$[A] = LT^{-2}$$

$$[C] = T$$

$$[B] = LT^{-1}$$

$$[ABC] = L^2T^{-2}$$

33. Given below are two statements: one is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**.

**Assertion (A)** : Choke coil is simply a coil having a large inductance but a small resistance. Choke coils are used with fluorescent mercury-tube fittings. If household electric power is directly connected to a mercury tube, the tube will be damaged.

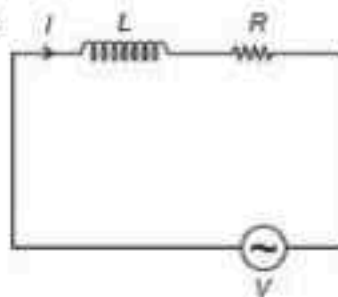
**Reason (R)** : By using the choke coil, the voltage across the tube is reduced by a factor  $\left( \frac{R}{\sqrt{R^2 + \omega^2 L^2}} \right)$ , where  $\omega$  is frequency of the supply across resistor  $R$  and inductor  $L$ . If the choke coil were not used, the voltage across the resistor would be the same as the applied voltage.

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

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

**Answer (1)**

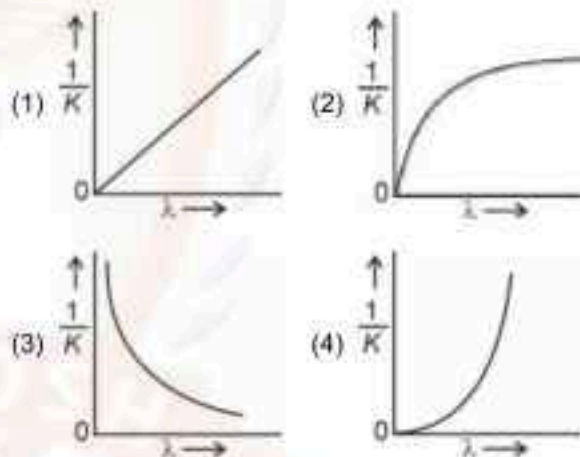
**Sol.**



$$I = \frac{V}{\sqrt{R^2 + \omega^2 L^2}}$$

$$V_R = \frac{V R}{\sqrt{R^2 + \omega^2 L^2}}$$

34. If  $\lambda$  and  $K$  are de Broglie wavelength and kinetic energy, respectively, of a particle with constant mass. The correct graphical representation for the particle will be



**Answer (4)**

**Sol.**  $\lambda = \frac{h}{\sqrt{2mK}}$

$$\lambda^2 = \frac{h^2}{2mK}$$

$$\frac{1}{K} = \frac{2}{h^2} \frac{m}{\lambda^2}$$

35. Consider  $I_1$  and  $I_2$  are the currents flowing simultaneously in two nearby coils 1 & 2, respectively. If  $L_1 =$  self inductance of coil 1,  $M_{12} =$  mutual inductance of coil 1 with respect to coil 2, then the value of induced emf in coil 1 will be

(1)  $\varepsilon_1 = -L_1 \frac{dI_1}{dt} - 2 M_{12} \frac{dI_2}{dt}$

(2)  $\varepsilon_1 = -L_1 \frac{dI_1}{dt} - M_{12} \frac{dI_2}{dt}$

(3)  $\varepsilon_1 = -L_1 \frac{dI_1}{dt} + 2 M_{12} \frac{dI_2}{dt}$

(4)  $\varepsilon_1 = -L_1 \frac{dI_1}{dt} + M_{12} \frac{dI_2}{dt}$

**Answer (1)**

**Sol.** Magnitude of induced emf due to self inductance

$$= \frac{L dI_1}{dt}$$

Magnitude of induced emf due to mutual inductance

$$= \frac{M dI_2}{dt}$$

36. Given below are two statements : one is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**.

**Assertion (A) :** Electromagnetic waves carry energy but not momentum.

**Reason (R) :** Mass of a photon is zero.

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

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

**Answer (2)**

**Sol.** EM wave carry both energy and momentum. Rest mass of photon is zero.

37. An electric dipole of mass  $m$ , charge  $q$ , and length  $l$  is placed in a uniform electric field  $E = E_0 \hat{j}$ . When the dipole is rotated slightly from its equilibrium position and released, the time period of its oscillations will be :

(1)  $2\pi \sqrt{\frac{ml}{2qE_0}}$

(2)  $\frac{1}{2\pi} \sqrt{\frac{ml}{qE_0}}$

(3)  $2\pi \sqrt{\frac{ml}{qE_0}}$

(4)  $\frac{1}{2\pi} \sqrt{\frac{2ml}{qE_0}}$

**Answer (1)**

**Sol.**  $\rightarrow E_0$



$$\tau = PE_0 \sin \theta$$

If  $\theta$  is small

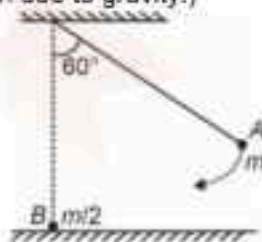
$$\tau = -(PE_0)\theta$$

$$I \alpha = \left(\frac{l}{2}\right)^2 \frac{2}{2} \frac{ml^2}{2}$$

$$T = 2\pi \sqrt{\frac{I}{2PE_0}} = 2\pi \sqrt{\frac{ml^2}{2qEl}}$$

$$T = 2\pi \sqrt{\frac{ml}{2qE_0}}$$

38. As shown below, bob A of a pendulum having massless string of length 'R' is released from  $60^\circ$  to the vertical. It hits another bob B of half the mass that is at rest on a frictionless table in the center. Assuming elastic collision, the magnitude of the velocity of bob A after the collision will be (take  $g$  as acceleration due to gravity.)



(1)  $\frac{1}{3} \sqrt{Rg}$

(2)  $\sqrt{Rg}$


(3)  $\frac{4}{3} \sqrt{Rg}$

(4)  $\frac{2}{3} \sqrt{Rg}$

**Answer (1)**

Sol. Velocity of A before collision =  $\sqrt{2gh}$

$$= \sqrt{2g \times \frac{R}{2}} = \sqrt{Rg}$$

After collision 

COM

$$mu = \frac{m}{2}v_1 + mv_2$$

$$2u = v_1 + 2v_2 \quad \dots(i)$$

$$e = 1, u = v_1 - v_2 \quad \dots(ii)$$

$$u = 3v_2$$

$$v_2 = \frac{u}{3} = \frac{1}{3}\sqrt{Rg}$$

39. Match List-I with List-II.

	List-I		List-II
(A)	Electric field inside (distance $r > 0$ from center) of a uniformly charged spherical shell with surface charge density $\sigma$ , and radius $R$ .	(I)	$\sigma / \epsilon_0$
(B)	Electric field at distance $r > 0$ from a uniformly charged infinite plane sheet with surface charge density $\sigma$ .	(II)	$\sigma / 2 \epsilon_0$
(C)	Electric field outside (distance $r > 0$ from center) of a uniformly charged spherical shell with surface charge density $\sigma$ , and radius $R$ .	(III)	0
(D)	Electric field between 2 oppositely charged infinite plane parallel sheets with uniform surface charge density $\sigma$ .	(IV)	$\frac{\sigma}{\epsilon_0 r^2}$

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

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

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

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

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

Answer (\*)

Sol. Inside uniformly charged spherical shell,  $E = 0$

$\therefore A \rightarrow \text{III}$

For uniformly charged infinite plate

$$E = \frac{\sigma}{2\epsilon_0}$$

$B \rightarrow \text{II}$

Outside of spherical shell

$$E = \frac{Q}{4\pi\epsilon_0 r^2} = \frac{R\sigma}{\epsilon_0 r^2}$$

None of the option is matching for C.

Between two plates  $E = \frac{\sigma}{\epsilon_0}$

$D \rightarrow \text{I}$

**None of the option is correct**

40. The fractional compression  $\left(\frac{\Delta V}{V}\right)$  of water at the depth of 2.5 km below the sea level is \_\_\_\_\_ %. Given, the Bulk modulus of water =  $2 \times 10^9 \text{ Nm}^{-2}$ , density of water =  $10^3 \text{ kg m}^{-3}$ , acceleration due to gravity =  $g = 10 \text{ ms}^{-2}$ .

(1) 1.25

(2) 1.5

(3) 1.0

(4) 1.75

Answer (1)

$$\text{Sol. } B = \frac{\Delta P}{-\left(\frac{\Delta V}{V}\right)}$$

$$-\left(\frac{\Delta V}{V}\right) = \frac{\Delta P}{B} = \frac{\rho gh}{B}$$

$$= \frac{10^3 \times 10 \times 2.5 \times 10}{2 \times 10^9} = 1.25\%$$

41. Given below are two statements : one is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**.

**Assertion (A)** : Emission of electrons in photoelectric effect can be suppressed by applying a sufficiently negative electron potential to the photoemissive substance.

**Reason (R)** : A negative electric potential, which stops the emission of electrons from the surface of a photoemissive substance, varies linearly with frequency of incident radiation.

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

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

**Answer (4)**

- Sol.** Negative potential will slow the electrons and if it is sufficient, it will make the photocurrent zero.

$$eVs = hf - \phi_0$$

42. Given below are two statements : one is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**.

**Assertion (A)** : Time period of a simple pendulum is longer at the top of a mountain than that at the base of the mountain.

**Reason (R)** : Time period of a simple pendulum decreases with increasing value of acceleration due to gravity and vice-versa.

In the light of the above statements, choose the **most appropriate 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 but (R) is not the correct explanation of (A)
- (4) Both (A) and (R) are true and (R) is the correct explanation of (A)

**Answer (4)**

**Sol.**  $T = 2\pi \sqrt{\frac{l}{g}}$

At top of mountain  $g \downarrow, \therefore T \uparrow$

43. A coil of area  $A$  and  $N$  turns is rotating with angular velocity  $\omega$  in a uniform magnetic field  $B$  about an axis perpendicular to  $B$ . Magnetic flux  $\phi$  and induced emf  $\varepsilon$  across it, at an instant when  $B$  is parallel to the plane of coil, are :

- (1)  $\phi = 0, \varepsilon = 0$
- (2)  $\phi = AB, \varepsilon = 0$
- (3)  $\phi = AB, \varepsilon = NAB\omega$
- (4)  $\phi = 0, \varepsilon = NAB\omega$

**Answer (3)**

**Sol.**  $\phi = NBA \cos \theta$

$$\varepsilon = -\frac{d\phi}{dt} = -NBA \frac{d \cos \theta}{dt}$$

$$\theta = \omega t$$

$$\varepsilon = -NBA\omega \sin \omega t$$

If  $B$  is parallel to plane of coil

$$\theta = 90^\circ$$

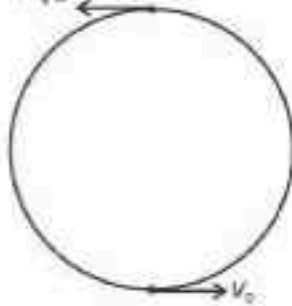
$$\phi = 0, \varepsilon = BA\omega N$$

44. A body of mass ' $m$ ' connected to a massless and unstretchable string goes in vertical circle of radius ' $R$ ' under gravity  $g$ . The other end of the string is fixed at the center of circle. If velocity at top of circular path is  $n\sqrt{gR}$ , where,  $n \geq 1$ , then ratio of kinetic energy of the body at bottom to that at top of the circle is

- |                           |                           |
|---------------------------|---------------------------|
| (1) $\frac{n^2 + 4}{n^2}$ | (2) $\frac{n}{n + 4}$     |
| (3) $\frac{n + 4}{n}$     | (4) $\frac{n^2}{n^2 + 4}$ |

**Answer (1)**

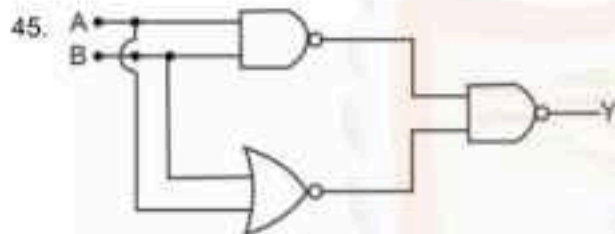
Sol.  $v = n\sqrt{gR}$



$$v_0 = \sqrt{v^2 - 2gR}$$

$$v_0 = \sqrt{n^2 gR - 4gR}$$

$$\therefore \frac{k_{\text{trans}} X_0}{k_{\text{top}}} = \frac{2}{v^2} \frac{n^2 + 4}{n^2}$$



For the circuit shown above, equivalent GATE is :

- (1) AND gate
- (2) OR gate
- (3) NOT gate
- (4) NAND gate

**Answer (2)**

Sol.  $Y = \overline{AB(A+B)}$

$$= AB + A + B$$

$$= A(B+1) + B$$

$$= A + B$$

or GATE

**SECTION - B**

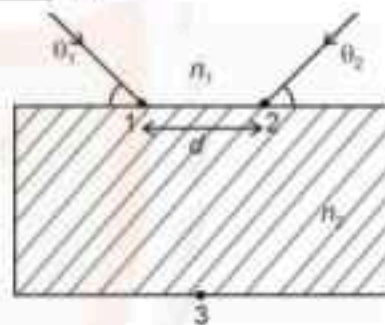
**Numerical Value Type Questions:** This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

46. Two light beams fall on a transparent material block at point 1 and 2 with angle  $\theta_1$  and  $\theta_2$ , respectively, as shown in figure. After refraction, the beams intersect at point 3 which is exactly on the interface at other end of the block. Given : the distance between 1 and 2,  $d = 4\sqrt{3}$  cm and

$$\theta_1 - \theta_2 = \cos^{-1} \left( \frac{n_2}{2n_1} \right),$$

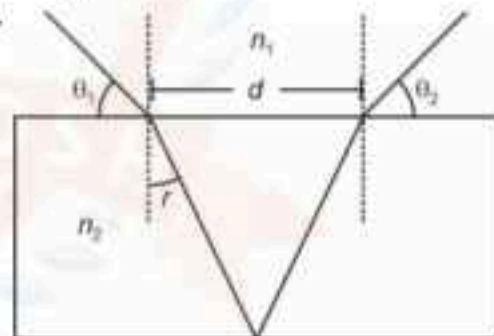
where refractive index of

the block  $n_2 >$  refractive index of the outside medium  $n_1$ , then the thickness of the block is \_\_\_\_\_ cm.



**Answer (6)**

Sol.



$$n_1 \sin(90 - \theta_1) = n_2 \sin r$$

$$n_1 \times \frac{n_2}{2n_1} = n_2 \sin r$$

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

$$r = 30^\circ$$

$$\tan r = \left( \frac{d/2}{t} \right)$$

$$t = \frac{d}{2 \tan r} = \frac{\sqrt{3}}{2} = \frac{(4\sqrt{3})\sqrt{3}}{2}$$

$$= 6 \text{ cm}$$

47. A container of fixed volume contains a gas at  $27^\circ \text{C}$ . To double the pressure of the gas, the temperature of gas should be raised to \_\_\_\_\_  $^\circ\text{C}$ .

**Answer (327)**

**Sol.**  $V = \text{constant}$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$P_2 = 2P_1$$

$$T_2 = 2T_1$$

$$= 2 \times 300 = 600 \text{ K}$$

$$\therefore = 327^\circ\text{C}$$

48. The maximum speed of a boat in still water is  $27 \text{ km/h}$ . Now this boat is moving downstream in a river flowing at  $9 \text{ km/h}$ . A man in the boat throws a ball vertically upwards with speed of  $10 \text{ m/s}$ . Range of the ball as observed by an observer at rest on the river bank, is \_\_\_\_\_  $\text{cm}$ . (Take  $g = 10 \text{ m/s}^2$ )

**Answer (2000)**

**Sol.**  $v_y = 10 \text{ m/s}$

$$v_x = v_{\text{river}} + v_{\text{boat}} = 27 + 9$$

$$= 36 \text{ km/h} = 10 \text{ m/s}$$

$$R = \left( \frac{2v_y}{g} \right) \times v_x = \frac{2 \times 10}{10} \times 10 = 20 \text{ m}$$

$$= 2000 \text{ cm}$$

49. In a hydraulic lift, the surface area of the input piston is  $6 \text{ cm}^2$  and that of the output piston is  $1500 \text{ cm}^2$ . If  $100 \text{ N}$  force is applied to the input piston to raise the output piston by  $20 \text{ cm}$ , then the work done is \_\_\_\_\_  $\text{kJ}$ .

**Answer (5)**

**Sol.** According to Pascal's law

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$F_2 = F_1 \left( \frac{A_2}{A_1} \right) = \frac{1500}{6} \times 100 \text{ N}$$

$$W = F_2 d = \frac{1500}{6} \times 100 \times \frac{20}{100}$$

$$= 5 \text{ kJ}$$

50. The coordinates of a particle with respect to origin in a given reference frame is  $(1, 1, 1)$  meters. If a force of  $F = \hat{i} - \hat{j} + \hat{k}$  acts on the particle, then the magnitude of torque (with respect to origin) in  $z$ -direction is \_\_\_\_\_.

**Answer (2)**

**Sol.**  $\tau = r \times F$

$$\tau = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 1 & 1 \\ 1 & -1 & 1 \end{vmatrix}$$

Along  $\hat{k}$

$$\tau_z = -2\hat{k}$$

## CHEMISTRY

### SECTION - A

**Multiple Choice Questions:** This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

**Choose the correct answer :**

51. For a  $Mg|Mg^{2+}(aq)||Ag^+(aq)|Ag$  the correct Nernst equation is :

(1)  $E_{cell} = E_{cell}^{\circ} - \frac{RT}{2F} \ln \frac{[Ag^+]^2}{[Mg^{2+}]}$

(2)  $E_{cell} = E_{cell}^{\circ} - \frac{RT}{2F} \ln \frac{[Ag^+]}{[Mg^{2+}]}$

(3)  $E_{cell} = E_{cell}^{\circ} - \frac{RT}{2F} \ln \frac{[Ag^+]}{[Mg^{2+}]}$

(4)  $E_{cell} = E_{cell}^{\circ} - \frac{RT}{2F} \ln \frac{[Mg^{2+}]}{[Ag^+]}$

**Answer (1)**

**Sol.** Cathode  $(Ag^+(aq) + e^- \rightarrow Ag) \times 2$

Anode  $Mg \rightarrow Mg^{2+}(aq) + 2e^-$

Cell reaction  $2Ag^+ + Mg \rightarrow 2Ag + Mg^{2+}$

$$Q = \frac{[Mg^{2+}]}{[Ag^+]^2}$$

By Nernst equation:

$$E_{cell} = E_{cell}^{\circ} - \frac{RT}{nF} \ln Q$$

$$E_{cell} = E_{cell}^{\circ} - \frac{RT}{nF} \ln \frac{[Mg^{2+}]}{[Ag^+]^2}$$

$$= E_{cell}^{\circ} - \frac{RT}{2F} \ln \frac{[Mg^{2+}]}{[Ag^+]^2}$$

52. 1.24 g of  $AX_2$  (molar mass  $124 \text{ g mol}^{-1}$ ) is dissolved in 1 kg of water to form a solution with boiling point of  $100.0156^\circ\text{C}$ , while 25.4 g of  $AY_2$  (molar mass  $250 \text{ g mol}^{-1}$ ) in 2 kg of water constitutes a solution with a boiling point of  $100.0260^\circ\text{C}$ .

$$K_b(\text{H}_2\text{O}) = 0.52 \text{ K kg mol}^{-1}$$

Which of the following is **correct** ?

(1)  $AX_2$  and  $AY_2$  (both) are fully ionised

(2)  $AX_2$  is fully ionised while  $AY_2$  is completely unionised

(3)  $AX_2$  and  $AY_2$  (both) are completely unionised

(4)  $AX_2$  is completely unionised while  $AY_2$  is fully ionised

**Answer (2)**

**Sol.** For  $AX_2$

$$\Delta T_b = iK_b m$$

$$0.0156 = i \times 0.52 \times \frac{1.24}{124 \times 1}$$

$$3 = i$$

$$3 = 1 + 2\alpha$$

$$1 = \alpha$$

For  $AY_2$

$$\Delta T_b = iK_b m$$

$$0.0260 = i \times 0.52 \times \frac{25.4}{250 \times 2}$$

$$i = 1$$

$\therefore AX_2$  is completely ionised &  $AY_2$  is completely unionised

53. The standard reduction potential values of some of the p-block ions are given below. Predict the one with the strongest oxidising capacity.

(1)  $E_{Al^{3+}/Al} = -1.66 V$

(2)  $E_{Sn^{4+}/Sn} = +1.15 V$

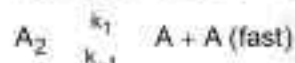
(3)  $E_{Ti^{3+}/Ti} = +1.26 V$

(4)  $E_{Pb^{4+}/Pb} = +1.67 V$

**Answer (4)**

**Sol.** The element having strongest oxidising capacity will have highest value of standard reduction potential

54. The reaction  $A_2 + B_2 \rightarrow 2AB$  follows the mechanism



The overall order of the reaction is :

(1) 1.5 (2) 2.5

(3) 3 (4) 2

**Answer (1)**

**Sol.** Since, second step is slow step

$$r = k_2[A][B_2] \quad \dots(i)$$

$$\text{Also, } \frac{k_1}{k_{-1}} = \frac{[A]^2}{[A_2]}$$

$$[A] = \left( \frac{[A_2] k_1}{k_{-1}} \right)^{\frac{1}{2}} \quad \dots(ii)$$

$$r = k_2 \left( \frac{k_1}{k_{-1}} \right)^{\frac{1}{2}} [A_2]^{\frac{1}{2}} [B_2]$$

$$\text{order} = \frac{1}{2} + \frac{1}{2} = 1$$

55. The molar conductivity of a weak electrolyte when plotted against the square root of its concentration, which of the following is expected to be observed?

(1) A small increase in molar conductivity is observed at infinite dilution

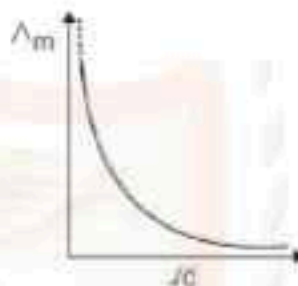
(2) Molar conductivity increases sharply with increase in concentration

(3) A small decrease in molar conductivity is observed at infinite dilution

(4) Molar conductivity decreases sharply with increase in concentration.

**Answer (4)**

**Sol.** For weak electrolyte, variation of  $\Lambda_m$  with  $\sqrt{c}$  is



56. At temperature T, compound  $AB_2(g)$  dissociates as

$AB_2(g) \rightleftharpoons AB(g) + \frac{1}{2}B(g)$  having degree of dissociation  $x$  (small compared to unity). The correct expression for  $x$  in terms of  $K_p$  and  $p$  is

(1)  $\sqrt[3]{\frac{2K_p}{p}}$  (2)  $\sqrt[3]{\frac{2K_p}{p}}$

(3)  $\sqrt[4]{\frac{2K_p}{p}}$  (4)  $\sqrt{K_p}$

**Answer (1)**



$t = 0 \quad p_0$

$t = t_{eq} \quad p_0(1-x) \quad p_0x \quad \frac{p_0x}{2}$

$$p = p_0x - p_0x + p_0x + \frac{p_0x}{2}$$

$$p = p_0 \left(1 + \frac{x}{2}\right)^2$$

$$p_0 = \frac{p}{\left(1 + \frac{x}{2}\right)^2}$$

$$K_p = \frac{(P_{AB})^2 (P_{B_2})^{1/2}}{(P_{AB_2})}$$

$$K_p = \frac{(P_0 x)^2 \left(\frac{P_0 x}{2}\right)^{1/2}}{P_0 (1-x)}$$

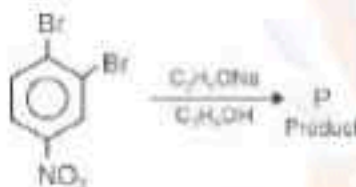
$$K_p = \frac{px \left(\frac{p}{1 + \frac{x}{2}}\right)^2 \left(\frac{x}{2}\right)^{1/2}}{p(1-x) \left(1 + \frac{x}{2}\right)^2}$$

Since  $x \ll 1$

$$K_p = \frac{p^{1/2} x^{3/2}}{2^{1/2}}$$

$$x = \sqrt[3]{\frac{2K_p^2}{p}}$$

57. In the following substitution reaction :

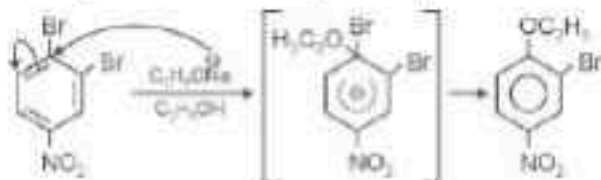


Product 'P' formed is

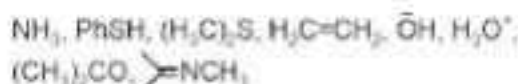
- (1)
- (2)
- (3)
- (4)

**Answer (2)**

**Sol.** Br at the para of  $\text{NO}_2$  will undergo aromatic nucleophilic substitution by nucleophile  $\text{C}_2\text{H}_5\text{ONa}$ .



58. Total number of nucleophiles from the following is



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

**Answer (3)**

**Sol.** Any specie having electrons available for donation can act as nucleophile.

Total 5 are present.

59. Choose the **correct** statements :

- (A) Weight of a substance is the amount of matter present in it.  
(B) Mass is the force exerted by gravity on an object.  
(C) Volume is the amount of space occupied by a substance.  
(D) Temperatures below  $0^\circ\text{C}$  are possible in Celsius scale, but in Kelvin scale negative temperature is not possible.  
(E) Precision refers to the closeness of various measurements for the same quantity.

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

- (1) (A), (B) and (C) only (2) (A), (D) and (E) only  
(3) (C), (D) and (E) only (4) (B), (C) and (D) only

**Answer (3)**

**Sol.** Mass of substance is amount of matter present in it. Weight is force exerted by gravity on object.

60. Match List-I with List-II.

List-I (Carbohydrate)	List-II (Linkage Source)
(A) Amylose	(I) $\beta$ -C <sub>1</sub> -C <sub>4</sub> , plant
(B) Cellulose	(II) $\alpha$ -C <sub>1</sub> -C <sub>4</sub> , animal
(C) Glycogen	(III) $\alpha$ -C <sub>1</sub> -C <sub>4</sub> , $\alpha$ -C <sub>1</sub> -C <sub>6</sub> , plant
(D) Amylopectin	(IV) $\alpha$ -C <sub>1</sub> -C <sub>4</sub> , plant

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

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

**Answer (4)**

**Sol.** Amylose  $\Rightarrow$  It is a plant based starch it has  $\alpha$ -C<sub>1</sub>-C<sub>4</sub> glycosidic linkage.

Cellulose  $\Rightarrow$  It has  $\beta$ -C<sub>1</sub>-C<sub>4</sub> glycosidic linkage

Glycogen  $\Rightarrow$  It has  $\alpha$ -C<sub>1</sub>-C<sub>4</sub> and glycosidic linkage (animal starch)

Amylopectin  $\Rightarrow$  It is a plant based with  $\alpha$ -C<sub>1</sub>-C<sub>4</sub> and C<sub>1</sub>-C<sub>6</sub> glycosidic linkage

61. If  $a_0$  is denoted as the Bohr radius of hydrogen atom, then what is the de-Broglie wavelength ( $\lambda$ ) of the electron present in the second orbit of hydrogen atom? [ $n$  : any integer]

- |                          |                          |
|--------------------------|--------------------------|
| (1) $\frac{2a_0}{n\pi}$  | (2) $\frac{4n}{\pi a_0}$ |
| (3) $\frac{4\pi a_0}{n}$ | (4) $\frac{8\pi a_0}{n}$ |

**Answer (4)**

**Sol.**  $r_n = \frac{a_0 n^2}{z}$

Also,  $2\pi r_n = n\lambda$ .

Where  $\lambda$  is de-Broglie wavelength

$$\frac{2\pi a_0 n^2}{z} = n\lambda$$

For second orbit of H-atom

$$\lambda = \frac{8\pi a_0}{n}$$

62. Match List - I with List - II.

List - I (Complex)	List - II (Hybridisation & Magnetic characters)
(A) $[\text{MnBr}_4]^{2-}$	(I) $d^2sp^3$ & diamagnetic
(B) $[\text{FeF}_6]^{3-}$	(II) $sp^3d^2$ & paramagnetic
(C) $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$	(III) $sp^3$ & diamagnetic
(D) $[\text{Ni}(\text{CO})_4]$	(IV) $sp^3$ & paramagnetic

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

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

**Answer (1)**

**Sol.**  $[\text{MnBr}_4]^{2-}$

$\text{Mn}^{2+}$ ,  $\text{Br}^-$  is WFL

$d^5$ , so it is  $sp^3$  and paramagnetic.

$[\text{FeF}_6]^{3-}$

$\text{Fe}^{3+}$ ,  $\text{F}^-$  is WFL

$d^5$ , so it is  $sp^3d^2$  and paramagnetic.



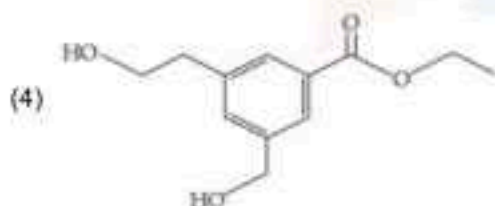
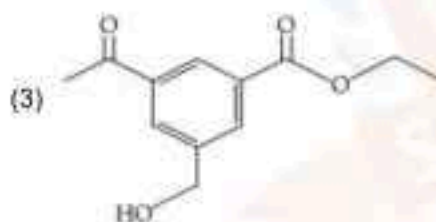
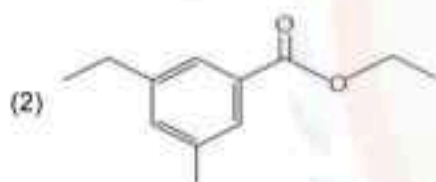
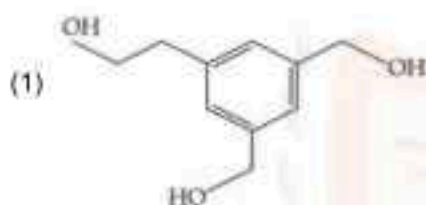
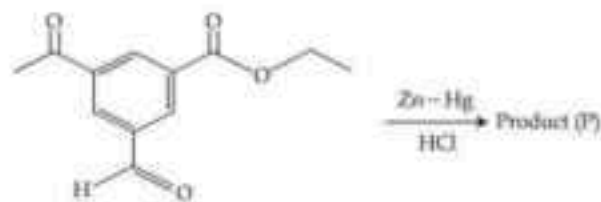
$\text{Co}^{3+}$ ,  $\text{C}_2\text{O}_4^{2-}$  is a SFL

$d^6$ , so it is  $d^2sp^3$  and diamagnetic.

$[\text{Ni}(\text{CO})_4]$ , CO is a SFL

$d^{10}$ , it is  $sp^3$  and diamagnetic.

63. The product (P) formed in the following reaction is:



**Answer (2)**

**Sol.** It is Clemmensen reduction, it will not reduce ester.



Ester cannot be reduced by clemmensen reduction

64. The correct increasing order of stability of the complexes based on  $\Delta_0$  value is:

- I.  $[\text{Mn}(\text{CN})_6]^{3-}$       II.  $[\text{Co}(\text{CN})_6]^{4-}$   
 III.  $[\text{Fe}(\text{CN})_6]^{4-}$       IV.  $[\text{Fe}(\text{CN})_6]^{3-}$   
 (1) III < II < IV < I      (2) II < III < I < IV  
 (3) IV < III < II < I      (4) I < II < IV < III

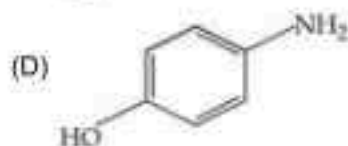
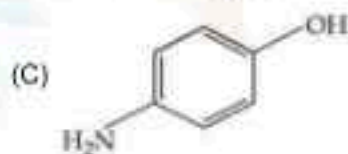
**Answer (4)**

**Sol.** Neglecting pairing energy

- I.  $[\text{Mn}(\text{CN})_6]^{3-} \Rightarrow \text{Mn}^{3+}$ ,  $t_{2g}^4$ ,  $\text{CFSE} = -0.4 \times 4 \Delta_0 = -1.6\Delta_0$   
 II.  $[\text{Co}(\text{CN})_6]^{4-} \Rightarrow \text{Co}^{2+}$ ,  $t_{2g}^6 e_g^1$ ,  $\text{CFSE} = -0.4 \times 6 + 0.6 \times 1 = -1.8\Delta_0$   
 III.  $[\text{Fe}(\text{CN})_6]^{4-} \Rightarrow \text{Fe}^{2+}$ ,  $t_{2g}^6 e_g^0$ ,  $\text{CFSE} = -0.4 \times 6 = -2.4\Delta_0$   
 IV.  $[\text{Fe}(\text{CN})_6]^{3-} \Rightarrow \text{Fe}^{3+}$ ,  $t_{2g}^5 e_g^0$ ,  $\text{CFSE} = -0.4 \times 5 = -2\Delta_0$

Order of stability III > IV > II > I

65. The steam volatile compounds among the following are :



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

- (1) (B) and (D) Only
- (2) (A) and (C) Only
- (3) (A), (B) and (C) Only
- (4) (A) and (B) Only

**Answer (4)**

**Sol.** Ortho nitro phenol and ortho nitro aniline will be steam volatile as they will show intra molecular H-bonding.

66. Match List I with List-II

List-I (Structure)	List-II (IUPAC Name)
(A)	(I) 4-Methylpent-1-ene
(B) $(CH_3)_2C(C_2H_5)_2$	(II) 3-Ethyl-5-methylheptane
(C)	(III) 4, 4-Dimethylheptane
(D)	(IV) 2-Methyl-1, 3-pentadiene

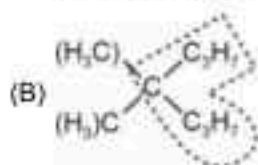
Choose the correct answer from the options given below

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

**Answer (2)**

**Sol.** (A)  $\text{CH}_3-\text{CH}_2-\underset{\text{C}_2\text{H}_5}{\text{CH}}-\text{CH}_2-\underset{\text{CH}_3}{\text{CH}}-\text{C}_2\text{H}_5$

3-Ethyl-5-methylheptane



4,4-Dimethylheptane



2-Methyl-1,3-pentadiene



4-Methylpent-1-ene

67. 500 J of energy is transferred as heat to 0.5 mol of Argon gas at 298 K and 1.00 atm. The final temperature and the change in internal energy respectively are: Given:  $R = 8.3 \text{ JK}^{-1} \text{ mol}^{-1}$

- (1) 378 K and 500 J
- (2) 368 K and 500 J
- (3) 378 K and 300 J
- (4) 348 K and 300 J

**Answer (4)**

**Sol.** At const. P

$$Q = nC_P \Delta T$$

$$500 = 0.5 \times \frac{5}{2} \times 8.3 (T_f - 298)$$

$$346.2 \text{ K} = T_f$$

$$\Delta U = nC_V \Delta T$$

$$= \frac{13}{2} \times 0.5 \times 8.3 \times (346.2 - 298)$$

$$= 300 \text{ J}$$

68. The correct option with order of melting points of the pairs (Mn, Fe), (Tc, Ru) and (Re, Os) is:

- (1)  $\text{Fe} < \text{Mn}$ ,  $\text{Ru} < \text{Tc}$  and  $\text{Re} < \text{Os}$
- (2)  $\text{Mn} < \text{Fe}$ ,  $\text{Tc} < \text{Ru}$  and  $\text{Os} < \text{Re}$
- (3)  $\text{Fe} < \text{Mn}$ ,  $\text{Ru} < \text{Tc}$  and  $\text{Os} < \text{Re}$
- (4)  $\text{Mn} < \text{Fe}$ ,  $\text{Tc} < \text{Ru}$  and  $\text{Re} < \text{Os}$

**Answer (2)**

**Sol.** Melting point order

$$\text{Fe} > \text{Mn}$$

$$\text{Ru} > \text{Tc}$$

$$\text{Re} > \text{Os}$$

69. An element 'E' has the ionisation enthalpy value of  $374 \text{ kJ mol}^{-1}$ . 'E' reacts with elements A, B, C and D with electron gain enthalpy values of  $-328$ ,  $-349$ ,  $-325$  and  $-295 \text{ kJ mol}^{-1}$ , respectively. The correct order of the products EA, EB, EC and ED in terms of ionic character is:
- (1)  $ED > EC > EA > EB$  (2)  $EA > EB > EC > ED$   
 (3)  $EB > EA > EC > ED$  (4)  $ED > EC > EB > EA$

**Answer (3)**

**Sol.** The element having high value of Electron gain enthalpy (magnitude) will form a compound having higher ionic character so order of ionic character



70. Given below are two statements :

**Statement (I) :** The radii of isoelectronic species increases in the order.



**Statement (II) :** The magnitude of electron gain enthalpy of halogen decreases in the order.



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

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

**Answer (2)**

**Sol.**  $r \propto q^-$  (for isoelectronic species)

$$\propto \frac{1}{q^+}$$

∴ **Statement I** is correct

Magnitude of electron gain enthalpy

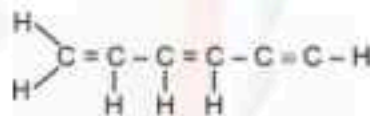

**SECTION - B**

**Numerical Value Type Questions:** This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

71. The sum of sigma ( $\sigma$ ) and pi ( $\pi$ ) bonds in Hex-1, 3-dien-5-yne is \_\_\_\_\_.

**Answer (15)**

**Sol.**



Hex-1, 3-dien-5-yne

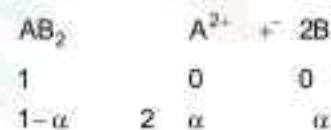
No. of  $\pi$  bond = 4

No. of  $\sigma$  bond = 11

72. If  $\text{A}_2\text{B}$  is 30% ionised in an aqueous solution, then the value of van't Hoff factor ( $i$ ) is \_\_\_\_\_  $\times 10^{-1}$ .

**Answer (16)**

**Sol.**



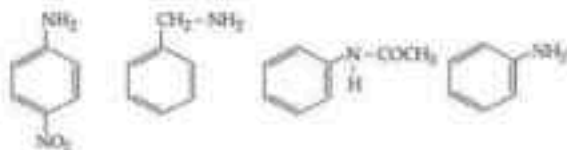
$$i = 1 + 2\alpha$$

$$= 1 + 2 \times (0.3)$$

$$= 1.6$$

$$= 16 \times 10^{-1}$$

73. Given below are some nitrogen containing compounds

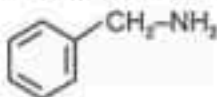


Each of them is treated with HCl separately, 1.0 g of the most basic compound will consume \_\_\_\_\_ mg of HCl.

(Given molar mass in  $\text{g mol}^{-1}$  C : 12, H : 1, O : 16, Cl : 35.5)

**Answer (341)**

**Sol.** The most basic compound will be aliphatic amine due to localised electrons



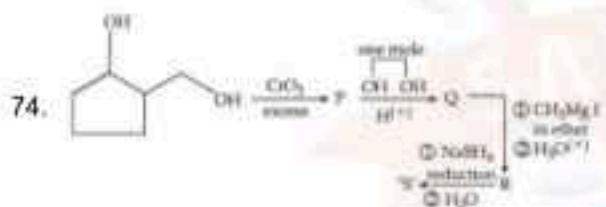
1 mole of this will consume 1 mole HCl

So mass of HCl consumed for 1 g of this compound

$$= \frac{1}{107} \times 36.5$$

$$= 0.341 \text{ gm}$$

$$= 341 \text{ mg}$$

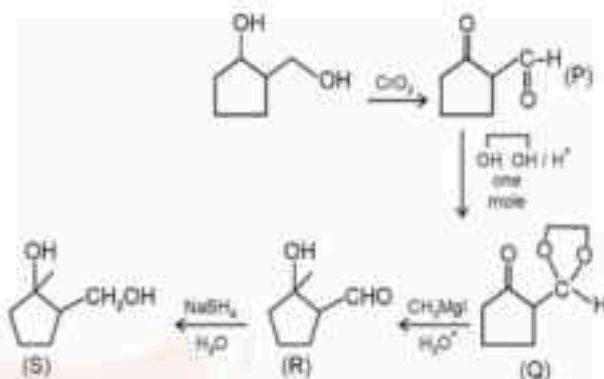


0.1 mole of compound 'S' will weight \_\_\_\_\_ g.

(Given molar mass in  $\text{g mol}^{-1}$  C : 12, H : 1, O : 16)

**Answer (13)**

**Sol.**



$$\text{mass of 0.1 mole (S)} = 0.1(84 + 32 + 14)$$

$$= 13 \text{ g}$$

75. The molar mass of the water insoluble product formed from the fusion of chromite ore ( $\text{FeCr}_2\text{O}_4$ ), with  $\text{Na}_2\text{CO}_3$  in presence of  $\text{O}_2$  is \_\_\_\_\_  $\text{g mol}^{-1}$ .

**Answer (160)**

**Sol.**  $\text{FeCr}_2\text{O}_4 + \text{Na}_2\text{CO}_3 + \text{O}_2 \rightarrow \text{Na}_2\text{CrO}_2 + \text{Fe}_2\text{O}_3 + \text{CO}_2$

Insoluble product will be  $\text{Fe}_2\text{O}_3$

$$\text{molar mass} = 56 \times 2 + 16 \times 3$$

$$= 112 + 48$$

$$= 160$$