

07/04/2025

Evening



Aakash

Medical | IIT-JEE | Foundations

Corporate Office : AESL, 3rd Floor, Incuspaze Campus-2, Plot-13, Sector-18, Udyog Vihar,
Gurugram, Haryana-122015

Answers & Solutions

Time : 3 hrs.

for

M.M. : 300

JEE (Main)-2025 (Online) Phase-2

(Mathematics, Physics and Chemistry)

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 Mathematics, **Part-B** is Physics and **Part-C** is Chemistry. 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 (MCQ). 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.

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(MPC)

1000+ 99
PERCENTILERS
IN CHEMISTRY

4000+ 95
PERCENTILERS
IN MATHS

100
Percentile
in
Maths



Shreyas Lohiya
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100
Percentile
in
Physics



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100
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in
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&
Chemistry



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2022
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INDIA
FEMALE
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Sanvi Jain
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2024
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INDIA
FEMALE
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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. The number of solutions of the equation

$$\cos 2\theta \cos \frac{\theta}{2} + \cos \frac{5\theta}{2} = 2 \cos^3 \frac{5\theta}{2} \text{ in } \left[-\frac{\pi}{2}, \frac{\pi}{2} \right] \text{ is:}$$

- (1) 9
- (2) 7
- (3) 6
- (4) 5

Answer (2)

Sol. $2(\cos 2\theta) \cdot \left(\cos \frac{\theta}{2} \right) + 2 \cos \frac{5\theta}{2} = 4 \cos^3 \left(\frac{5\theta}{2} \right)$

$$\Rightarrow \cos \left(\frac{5\theta}{2} \right) + \cos \frac{3\theta}{2} + 2 \cos \left(\frac{5\theta}{2} \right) = \left(\cos \frac{15\theta}{2} + 3 \cos \frac{5\theta}{2} \right)$$

$$\Rightarrow \cos \left(\frac{3\theta}{2} \right) + \cos \left(\frac{15\theta}{2} \right)$$

$$\Rightarrow \cos \left(\frac{3\theta}{2} \right) - \cos \frac{15\theta}{2} = 0$$

$$\Rightarrow 2 \sin \left(\frac{9\theta}{2} \right) \sin \left(\frac{6\theta}{2} \right) = 0, 3\theta = 2n\pi$$

$$\therefore \frac{9\theta}{2} = n\pi \rightarrow \theta = \frac{2n\pi}{9}$$

$$\Rightarrow \theta = \frac{2n\pi}{9}$$

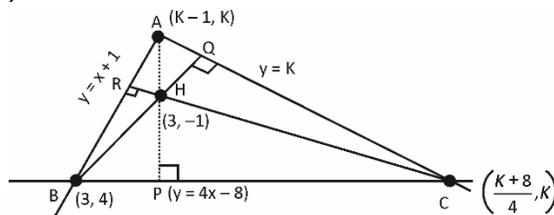
$$\therefore \theta = -\frac{4\pi}{9}, -\frac{3\pi}{9}, -\frac{2\pi}{9}, 0, \frac{2\pi}{9}, \frac{3\pi}{9}, \frac{4\pi}{9}$$

2. If the orthocenter of the triangle formed by the lines $y = x + 1$, $y = 4x - 8$ and $y = mx + c$ is at $(3, -1)$, then $m - c$ is:

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

Answer (2)

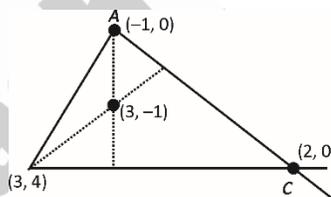
Sol. $y = x + 1$
 $y = 4x - 8$



$$CR \perp y = x + 1$$

$$\Rightarrow CR : x + y - 2 = 0$$

$$\frac{K+8}{4} + K - 2 = 0 \Rightarrow K = 0$$



$$\text{Line AC : } y = 0$$

3. If the equation of the line passing through the point $\left(0, -\frac{1}{2}, 0 \right)$ and perpendicular to the lines

$$\vec{r} = \lambda(\hat{i} + a\hat{j} + b\hat{k}) \quad \text{and} \quad \vec{r} = (\hat{i} - \hat{j} - 6\hat{k}) + \mu(-b\hat{i} + a\hat{j} + 5\hat{k})$$

is $\frac{x-1}{-2} = \frac{y+4}{d} = \frac{z-c}{-4}$, then $a + b + c + d$ is equal to:

- (1) 14
- (2) 10
- (3) 12
- (4) 13

Answer (1)

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Sol. Direction ratio of the given line are $-2, d$ and -4

$$\Rightarrow -2 + ad - 4b = 0 \quad \dots(i)$$

$$\text{and } 2b + ad - 20 = 0 \quad \dots(ii)$$

subtracting equation (i) and (ii)

$$6b - 18 = 0$$

$$b = 3$$

also, line passes through the point $(0, \frac{-1}{2}, 0)$

$$\Rightarrow \frac{0-1}{-2} = \frac{-\frac{1}{2}+4}{d} = \frac{0-c}{-4}$$

$$\Rightarrow d = 7, c = 2$$

From equation (i)

$$-2 + 7a - 12 = 0$$

$$\Rightarrow a = 2$$

$$a + b + c + d = 14$$

4. Let \vec{a} and \vec{b} be the vectors of the same magnitude

such that $\frac{|\vec{a} + \vec{b}| + |\vec{a} - \vec{b}|}{|\vec{a} + \vec{b}| - |\vec{a} - \vec{b}|} = \sqrt{2} + 1$. Then $\frac{|\vec{a} + \vec{b}|^2}{|\vec{a}|^2}$ is:

$$(1) 4 + 2\sqrt{2} \quad (2) 2 + 4\sqrt{2}$$

$$(3) 2 + \sqrt{2} \quad (4) 1 + \sqrt{2}$$

Answer (3)

Sol. $\frac{|\vec{a} + \vec{b}|}{|\vec{a} - \vec{b}|} = \frac{\sqrt{2} + 2}{\sqrt{2}}$ Let $|\vec{a}| = |\vec{b}| = k, \cos \theta = \vec{a} \cdot \vec{b}$

$$(\sqrt{2}|\vec{a} + \vec{b}|)^2 = (\sqrt{2} + 2)^2 |\vec{a} - \vec{b}|^2$$

$$2(k^2 + k^2 + 2k^2 \cos \theta) = (6 + 4\sqrt{2})$$

$$(k^2 + k^2 - \cos \theta)$$

$$(1 + \cos \theta) = (3 + 2\sqrt{2})(1 - \cos \theta)$$

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

$$\frac{1}{\cos \theta} = \frac{4 + 2\sqrt{2}}{2 + 2\sqrt{2}}$$

$$\cos \theta = \frac{1 + \sqrt{2}}{2 + \sqrt{2}}$$

$$\text{Now } \frac{|\vec{a} + \vec{b}|^2}{|\vec{a}|^2} = \frac{k^2 + k^2 + 2\cos \theta k^2}{k^2}$$

$$= 2 + 2\cos \theta = 2 + \frac{2 + 2\sqrt{2}}{2 + \sqrt{2}}$$

$$= \frac{6 + 4\sqrt{2}}{2 + \sqrt{2}}$$

$$= 2 + \sqrt{2}$$

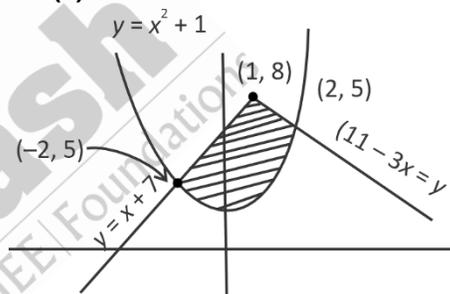
5. If the area of the region $\{(x, y) : 1 + x^2 \leq y \leq \min \{x + 7, 11 - 3x\}\}$ is A , then $3A$ is equal to

$$(1) 46 \quad (2) 49$$

$$(3) 50 \quad (4) 47$$

Answer (3)

Sol.



$$A = \int_{-2}^1 ((x+7) - (x^2 + 1)) dx + \int_1^2 ((11 - 3x) - (x^2 + 1)) dx$$

$$= \frac{50}{3}$$

$$\therefore 3A = 50$$

6. Let a random variable X take values $0, 1, 2, 3$ with $P(X = 0) = P(X = 1) = p, P(X = 2) = P(X = 3)$ and $E(X^2) = 2E(X)$. Then the value of $8p - 1$ is :

$$(1) 0 \quad (2) 3$$

$$(3) 2 \quad (4) 1$$

Answer (3)

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Sol. $P(X=0) = P(X=1) = p$ and $P(X=2) = P(X=3) = q$
 $2p + 2q = 1$

$$\Rightarrow p + q = \frac{1}{2} \quad \dots(1)$$

$$E(X^2) = 2E(x)$$

$$P(0^2) + p(1)^2 + q(2)^2 + q(3)^2$$

$$= 2(p(0) + p(1) + q(2) + q(3))$$

$$\Rightarrow \boxed{p = 3q} \quad \dots(2)$$

For (1) and (2)

$$q = \frac{1}{8} \text{ and } p = \frac{3}{8}$$

$$8p - 1 = 2$$

7. Let p be the number of all triangles that can be formed by joining the vertices of a regular polygon P of n sides and q be the number of all quadrilaterals that can be formed by joining the vertices of P . If $p + q = 126$, then the eccentricity of the ellipse $\frac{x^2}{16} + \frac{y^2}{n} = 1$ is :

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

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

Answer (2)

Sol. $P = {}^nC_3 = \frac{n(n-1)(n-2)}{6}$

$$q = {}^nC_4 = \frac{n(n-1)(n-2)(n-3)}{24}$$

$$p + q = 126$$

$$\therefore (n^2 - n)(n^2 - n - 2) = 3024$$

$$\text{Let } m = n^2 - n$$

$$m(m-2) = 3024$$

$$m^2 - 2m - 3024 = 0$$

$$m = 56$$

$$\text{or } n^2 - n = 56$$

$$n = 8$$

$$\therefore \text{Eqn. of ellipse, } \frac{x^2}{6} + \frac{y^2}{8} = 1$$

$$e = \sqrt{1 - \frac{b^2}{a^2}} = \frac{1}{\sqrt{2}}$$

8. If the range of the function $f(x) = \frac{5-x}{x^2-3x+2}$, $x \neq$

1, 2, is $(-\infty, \alpha] \cup [\beta, \infty)$, then $\alpha^2 + \beta^2$ is equal to :

- (1) 194 (2) 192
(3) 188 (4) 190

Answer (1)

Sol. $y = \frac{5-x}{x^2-3x+2}$

$$x^2y - 3xy + 2y = 5 - x$$

$$x^2y + x(1-3y) + 2y - 5 = 0$$

For x to be real

$$D > 0$$

$$(1-3y)^2 - 4y(2y-5) > 0$$

$$1 + 9y^2 - 6y - 8y^2 + 20y > 0$$

$$y^2 + 14y + 1 > 0$$

$$y \in (-\infty, \alpha) \cup (\beta, \infty)$$

$$\alpha + \beta = -14$$

$$\alpha^2 + \beta^2 = (\alpha + \beta)^2 - 2\alpha\beta = 194$$

9. If the locus of $z \in C$, such that $\text{Re}\left(\frac{z-1}{2z+i}\right) + \text{Re}\left(\frac{\bar{z}-1}{2\bar{z}-i}\right) = 2$, is a circle of radius r

and center (a, b) , then $\frac{15ab}{r^2}$ is equal to :

- (1) 12 (2) 24
(3) 18 (4) 16

Answer (3)

Sol. $\text{Re}(z) + \text{Re}(\bar{z}) = 2$

$$\Rightarrow \text{Re}(z) = 1$$

$$\Rightarrow \text{Re}\left(\frac{x+iy-1}{2x+i(2y+1)}\right) = 1$$

$$\Rightarrow \text{Re}\left(\frac{(x-1)+iy}{2x+i(2y+1)}\right) = 1$$

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$$F_1 F_2 = 2be = (2)(5) \left(\frac{4}{5} \right) = 8$$

$$F_3 F_4 = 2ae = 2(4) \cdot \left(\frac{5}{4} \right) = 10$$

$$\Rightarrow \text{eccentricity} = \sqrt{1 - \left(\frac{8}{10} \right)^2} = \frac{6}{10} = \frac{3}{5}$$

13. Let $A = \{(\alpha, \beta) \in \mathbb{R} \times \mathbb{R} : |\alpha - 1| \leq 4 \text{ and } |\beta - 5| \leq 6\}$
and $B = \{(\alpha, \beta) \in \mathbb{R} \times \mathbb{R} : 16(\alpha - 2)^2 + 9(\beta - 6)^2 \leq 144\}$.

Then

- (1) $B \subset A$
- (2) $A \cup B = \{(x, y) : -4 \leq x \leq 4, -1 \leq y \leq 11\}$
- (3) Neither $A \subset B$ nor $B \subset A$
- (4) $A \subset B$

Answer (1)

Sol. Set A : For α

$$-4 \leq \alpha - 1 \leq 4$$

$$\Rightarrow -3 \leq \alpha \leq 5$$

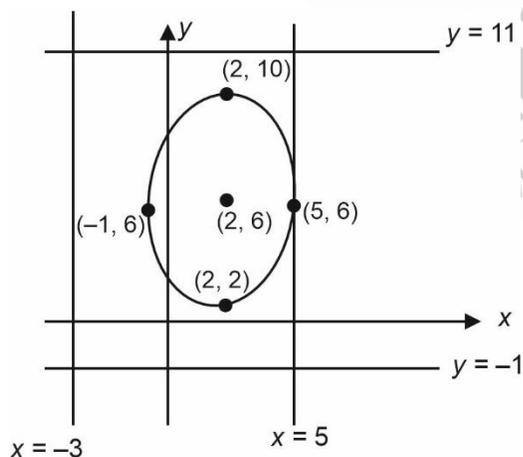
For β

$$-6 \leq \beta - 5 \leq 6$$

$$\Rightarrow -1 \leq \beta \leq 11$$

Set B :

$$\frac{(\alpha - 2)^2}{9} + \frac{(\beta - 6)^2}{16} \leq 1$$



Clearly $B \subset A$

14. If the sum of the second, fourth and sixth terms of a G.P. of positive terms is 21 and the sum of its eighth, tenth and twelfth terms is 15309, then the sum of its first nine terms is:

- (1) 755
- (2) 750
- (3) 760
- (4) 757

Answer (4)

$$\text{Sol. } ar + ar^3 + ar^5 = 21 \quad \dots(i)$$

$$ar^7 + ar^9 + ar^{11} = 15309 \quad \dots(ii)$$

(ii)/(i)

$$\frac{r^7}{r} = 729 \Rightarrow r = 3 \quad (r > 0)$$

Using (i)

$$a(3 + 27 + 243) = 21$$

$$\Rightarrow a = \frac{21}{273} = \frac{1}{13}$$

$$S_9 = \frac{1}{13} \frac{(3^9 - 1)}{3 - 1}$$

$$= \frac{1}{26} (3^9 - 1)$$

$$= \frac{1}{27} (3^3 - 1) (3^6 + 1 + 3^3)$$

$$= 3^6 + 3^3 + 1$$

$$= 757$$

15. Let the length of a latus rectum of an ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ be 10. If its eccentricity is the minimum

value of the function $f(t) = t^2 + t + \frac{11}{12}$, $t \in \mathbb{R}$, then

$a^2 + b^2$ is equal to

- (1) 125
- (2) 120
- (3) 126
- (4) 115

Answer (3)

$$\text{Sol. } \frac{2b^2}{a} = 10 \Rightarrow b^2 = 5a$$

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$$e = f(t)|_{\min} = t^2 + t + \frac{11}{12} \Big|_{t=\frac{1}{4}} = \frac{1}{4} - \frac{1}{2} + \frac{11}{12}$$

$$= \frac{3-6+11}{12} = \frac{8}{12} = \frac{2}{3}$$

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

$$\Rightarrow 1 - \frac{b^2}{a^2} = \frac{4}{9} \Rightarrow \frac{b^2}{a^2} = \frac{5}{9} \Rightarrow b^2 = \frac{5a^2}{9}$$

$$\Rightarrow 5a = \frac{5a^2}{9} \Rightarrow a = 9; \text{ So, } b^2 = 45$$

Hence, $a^2 + b^2 = 81 + 45 = 126$

16. Let $y = y(x)$ be the solution of the differential equation $(x^2 + 1)y' - 2xy = (x^4 + 2x^2 + 1)\cos x$,

$y(0) = 1$. Then $\int_{-3}^3 y(x)dx$ is :

- (1) 24
- (2) 18
- (3) 30
- (4) 36

Answer (1)

Sol. $(1+x^2)\frac{dy}{dx} - 2xy = (x^4 + 2x^2 + 1)\cos x$

$$\frac{dy}{dx} - \left(\frac{2x}{1+x^2}\right)y = \frac{(x^2+1)\cos x}{(x^2+1)}$$

$$IF = e^{-\int \frac{2x}{1+x^2} dx} = \frac{1}{1+x^2}$$

$$\frac{y}{1+x^2} = \int \cos x dx$$

$$\frac{y}{1+x^2} = \int \sin x + c$$

$\therefore y(0) = 1$

$\Rightarrow 1 = c$

$\therefore y = (1 + \sin x)(1 + x^2)$

$$\int_{-3}^3 y(x)dx = \int_{-3}^3 (1 + \sin x)(1 + x^2)dx$$

$$= \int_0^3 2(1+x^2)dx$$

$$= 2x + \frac{2x^3}{3} \Big|_0^3$$

$= 6 + 18 = 24$

17. Consider the lines $L_1 : x - 1 = y - 2 = z$ and $L_2 : x - 2 = y = z - 1$. Let the feet of the perpendiculars from the point $P(5, 1, -3)$ on the lines L_1 and L_2 be Q and R respectively. If the area of the triangle PQR is A , then $4A^2$ is equal to

- (1) 147
- (2) 143
- (3) 139
- (4) 151

Answer (1)

Sol. $P(5, 1, -3)$

$L_1 : x - 1 = y - 2 = z = \lambda$

$L_2 : x - 2 = y = z - 1 = \mu$

Any point of L_1 is $Q(\lambda + 1, \lambda + 2, \lambda)$

Any point of L_2 is $R(\mu + 2, \mu, \mu + 1)$

Now $PQ \cdot \langle \lambda - 4, \lambda + 1, \lambda + 3 \rangle \cdot \langle 1, 1, 1 \rangle = 0$

$\lambda - 4 + \lambda + 1 + \lambda + 3 = 0$

$3\lambda = 0$

$\Rightarrow \lambda = 0$

$\therefore Q(1, 2, 0)$

Also, $PR \cdot \langle \mu - 3, \mu - 1, \mu + 4 \rangle \cdot \langle 1, 1, 1 \rangle = 0$

$\mu - 3 + \mu - 1 + \mu + 4 = 0$

$\Rightarrow \mu = 0$

$R(2, 0, 1)$

$$\text{Area} = \frac{1}{2} |\overrightarrow{PQ} \times \overrightarrow{PR}| = \frac{1}{2} \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 4 & -1 & -3 \\ 3 & 1 & -4 \end{vmatrix}$$

$$= \frac{1}{2} |7\hat{i} + 7\hat{j} + 7\hat{k}| = \frac{1}{2} \times 7 \times \sqrt{3} = \frac{7\sqrt{3}}{2}$$

$\therefore A = \frac{7\sqrt{3}}{2}$

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$$\begin{aligned} \Rightarrow 4A^2 &= (7\sqrt{3})^2 \\ &= 49 \times 3 \\ &= 147 \end{aligned}$$

18. The number of real roots of the equation $x|x-2| + 3|x-3| + 1 = 0$ is

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

Answer (4)

Sol. $x|x-2| + 3|x-3| + 1 = 0$

Case I: $x < 2$

$$-x(x-2) - 3(x-3) + 1 = 0$$

$$-x^2 + 2x - 3x + 9 + 1 = 0$$

$$x^2 + x - 10 = 0$$

$$x = \frac{-1 - \sqrt{41}}{2} \text{ or } \frac{-1 + \sqrt{41}}{2} \text{ (rejected)}$$

1 solⁿ.

Case II: $2 \leq x < 3$

$$x(x-2) - 3(x-3) + 1 = 0$$

$$x^2 - 5x + 8 = 0$$

No solution

Case III: $x \geq 3$

$$x(x-2) + 3(x-3) + 1 = 0$$

$$x^2 + x - 8 = 0$$

$$x = \frac{-1 \pm \sqrt{33}}{2} \text{ (no solⁿ)}$$

$$\therefore x = \frac{-1 - \sqrt{41}}{2} \text{ is the only solution}$$

19. Let the system of equations

$$x + 5y - z = 1$$

$$4x + 3y - 3z = 7$$

$$24x + y + \lambda z = m$$

$\lambda, \mu \in \mathbf{R}$, have infinitely many solutions. Then the number of the solutions of this system, if x, y, z are integers and satisfy $7 \leq x + y + z \leq 77$, is

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

Answer (2)

$$\text{Sol. } \Delta = \begin{vmatrix} 1 & 5 & -1 \\ 4 & 3 & -3 \\ 24 & 1 & \lambda \end{vmatrix}$$

$$= (3\lambda + 3) - 5(4\lambda + 72) - (4 - 72)$$

$$= -17\lambda - 289 = 0$$

$$\Rightarrow \lambda = -17$$

$$\Delta_1 = \begin{vmatrix} 1 & 5 & -1 \\ 7 & 3 & -3 \\ \mu & 1 & -17 \end{vmatrix}$$

$$= (-51 + 3) - 5(-119 + 3\mu) - (7 - 3\mu)$$

$$= 540 - 12\mu$$

$$\mu = \frac{540}{12} = 45$$

$$\therefore x + 5y - z = 1$$

$$4x + 3y - 3z = 7$$

$$24x + y - 17z = 45$$

$$z = x + 5y - 1$$

$$\therefore 4x + 3y - 3x - 15y + 3 = 7$$

$$\Rightarrow x - 12y = 4$$

$$\Rightarrow x = 4 + 12y$$

$$\therefore z = 4 + 12y + 5y - 1$$

$$= 3 + 17y$$

$$\therefore (x, y, z) \equiv (4 + 12k, k, 3 + 17k) \text{ } (\because \text{Assume } y = k)$$

$$7 \leq 7 + 30k \leq 77$$

$$0 \leq 30k < 70$$

$$0 \leq k \leq 2.3$$

$$\Rightarrow k = 0, 1, 2 \text{ Three solutions possible}$$

20. Let $f: \mathbf{R} \rightarrow \mathbf{R}$ be a polynomial function of degree four having extreme values at $x = 4$ and $x = 5$. If

$$\lim_{x \rightarrow 0} \frac{f(x)}{x^2} = 5, \text{ then } f(2) \text{ is equal to}$$

- (1) 14 (2) 10
(3) 12 (4) 8

Answer (2)

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Sol. $f(x) = ax^4 + bx^3 + cx^2 + dx + e$

$f(4) = 0, f(5) = 0$

Also $\lim_{x \rightarrow 0} \frac{f(x)}{x^2} = 5$

$\Rightarrow \lim_{x \rightarrow 0} \left(\frac{ax^4 + bx^3 + cx^2 + dx + e}{x^2} \right) = 5$

$\Rightarrow d = e = 0$

and $c = 5$

$\therefore f(x) = ax^4 + bx^3 + 5x^2$

$f(x) = 4ax^3 + 3bx^2 + 10x$

$f(4) = 256a + 48b + 40 = 0 \dots(i)$

$f(5) = 500a + 75b + 50 = 0 \dots(ii)$

Solving equation (i) and (ii)

We get $a = \frac{1}{8}, b = \frac{-3}{2}$

$\therefore f(x) = \frac{1}{8}x^4 - \frac{3}{2}x^3 + 5x^2$

$f(2) = \frac{16}{8} - \frac{3}{2}(2)^3 + 5(2)^2$

$f(2) = 2 - 12 + 20$

$f(2) = 10$

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. For $t > -1$, let α_t and β_t be the roots of the equation

$\left((t+2)^{\frac{1}{7}} - 1 \right) x^2 + \left((t+2)^{\frac{1}{6}} - 1 \right) x + \left((t+2)^{\frac{1}{21}} - 1 \right) = 0.$

If $\lim_{t \rightarrow -1^+} \alpha_t = a$ and $\lim_{t \rightarrow -1^+} \beta_t = b$, then $72(a + b)^2$ is equal to ____.

Answer (98)

Sol. $\alpha + \beta = \frac{(t+2)^{\frac{1}{6}} - 1}{(t+2)^{\frac{1}{7}} - 1}$

$\alpha\beta = \frac{(t+2)^{\frac{1}{21}} - 1}{(t+2)^{\frac{1}{7}} - 1}$

$\lim_{t \rightarrow -1} (\alpha + \beta) = \frac{-\frac{1}{6}}{\frac{1}{7}} = \frac{-7}{6} = a + b$

$\lim_{t \rightarrow -1} (\alpha\beta) = \frac{\frac{1}{21}}{\frac{1}{7}} = \frac{7}{21} = \frac{1}{3} = ab$

$\Rightarrow (a + b)^2 = \frac{49}{36}$

$\Rightarrow 72(a + b)^2 = 98$

22. If $\int \left(\frac{1}{x} + \frac{1}{x^3} \right) \left(23\sqrt{3x^{-24} + x^{-26}} \right) dx$

$= -\frac{\alpha}{3(\alpha+1)} \left(3x^\beta + x^\gamma \right)^{\frac{\alpha+1}{\alpha}} + C, x > 0, (\alpha, \beta, \gamma \in Z),$

where C is the constant of integration, then $\alpha + \beta + \gamma$ is equal to ____.

Answer (19)

Sol. $I = \int \left(\frac{1}{x} + \frac{1}{x^3} \right) \left(\frac{3}{x^{24}} + \frac{1}{x^{26}} \right)^{\frac{1}{23}} dx$

$= \int \left(\frac{1}{x^2} + \frac{1}{x^4} \right) \left(\frac{3}{x} + \frac{1}{x^3} \right)^{\frac{1}{23}} dx$

Put $\frac{3}{x} + \frac{1}{x^3} = t \Rightarrow \left(-\frac{3}{x^2} - \frac{3}{x^4} \right) dx = dt$

$\Rightarrow I = -\frac{1}{3} \int t^{\frac{1}{23}} dt = -\frac{1}{3} \frac{t^{\frac{1}{23}+1}}{\frac{1}{23}+1} + C$

$= -\frac{1}{3} \times \frac{23}{24} \left(3x^{-1} + x^{-3} \right)^{\frac{24}{23}} + C$

$\Rightarrow \alpha = 23, \beta = -1, \gamma = -3$

$\Rightarrow \alpha + \beta + \gamma = 19$

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23. The sum of the series

$$2 \times 1 \times {}^{20}C_4 - 3 \times 2 \times {}^{20}C_5 + 4 \times 3 \times {}^{20}C_6 - 5 \times 4 \times {}^{20}C_7 + \dots + 18 \times 17 \times {}^{20}C_{20}, \text{ is equal to } \underline{\hspace{2cm}}.$$

Answer (34)

Sol. $(1+x)^{20} = {}^{20}C_0 + {}^{20}C_1x + {}^{20}C_2x^2 + {}^{20}C_3x^3 + {}^{20}C_4x^4 + {}^{20}C_5x^5 + \dots + {}^{20}C_{20}x^{20}$

$$\frac{(1+x)^{20}}{x^2} = \frac{1}{x^2} + \frac{20}{x} + {}^{20}C_2 + {}^{20}C_3x + {}^{20}C_4x^2 + {}^{20}C_5x^3 + \dots + {}^{20}C_{20}x^{18}$$

d.w.r. to x

$$\frac{x^2 \cdot 20(1+x)^{19} + (1+x)^{20} \cdot 2x}{x^4} = \frac{-2}{x^3} - \frac{20}{x^2} + {}^{20}C_3 + 2 \cdot {}^{20}C_4x + 3 \cdot {}^{20}C_5x^2 + \dots + 18 \cdot {}^{20}C_{20}x^{17}$$

$$\frac{2x(1+x)^{19}(11x+1)}{x^4} = \frac{-2}{x^3} - \frac{20}{x^2} + {}^{20}C_3 + 2 \cdot {}^{20}C_4x + 3 \cdot {}^{20}C_5x^2 + \dots + 18 \cdot {}^{20}C_{20}x^{17}$$

Differentiate w.r. to x

$$2 \left[\frac{x^3(1+x)^{19} \cdot 11 + x^3(11x+1) \cdot 19(1+x)^{18} - (1+x)^{19}(11x+1) \cdot 3x^2}{x^6} \right]$$

$$= \frac{6}{x^4} + \frac{40}{x^3} + 2 \cdot {}^{20}C_4 + 3 \cdot 2 \cdot {}^{20}C_5x + \dots + 18 \cdot 17 \cdot {}^{20}C_{20}x^{16}$$

Put $x = -1$ in above equation

$$\Rightarrow 0 = 6 - 40 + R \Rightarrow R = 34$$

24. Let the lengths of the transverse and conjugate axes of a hyperbola in standard form $2a$ and $2b$, respectively, and one focus and the corresponding directrix of this hyperbola be $(-5, 0)$ and $5x + 9 = 0$, respectively. If the product of the focal distances of a point $(\alpha, 2\sqrt{5})$ on the hyperbola is p , then $4p$ is equal to _____.

Answer (189)

Sol. Equation of hyperbola is $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$

Directrix: $x = \frac{-9}{5}$ and corresponding foci $(-5, 0)$

$$\Rightarrow -\frac{a}{e} = -\frac{9}{5} \text{ and } -ae = -5$$

$$\Rightarrow \frac{9e^2}{5} = 5 \Rightarrow e = \sqrt{\frac{25}{9}} = \frac{5}{3} \Rightarrow a = 3$$

$$\therefore b^2 = a^2(e^2 - 1) = 9 \left(\frac{25}{9} - 1 \right) = 16$$

Hyperbola $\frac{x^2}{9} - \frac{y^2}{16} = 1$

$(\alpha, 2\sqrt{5})$ lie on it

$$\Rightarrow \frac{\alpha^2}{9} - \frac{20}{16} = 1 \Rightarrow \alpha^2 = \frac{36}{16} \times 9 = \frac{81}{4}$$

Product for distance of (x_1, y_1) from the two foci

$$= (ex_1 + a) |ex_1 - a| = e^2 x_1^2 - a^2$$

For $(\alpha, 2\sqrt{5}) \Rightarrow P = \frac{25}{9} \cdot \frac{81}{4} - 9 = \frac{189}{4}$

$$4P = 189$$

25. If the function $f(x) = \frac{\tan(\tan x) - \sin(\sin x)}{\tan x - \sin x}$ is continuous at $x = 0$, then $f(0)$ is equal to _____.

Answer (2)

Sol. $\lim_{x \rightarrow 0} f(x) = \lim_{x \rightarrow 0} \frac{\tan(\tan x) - \sin(\sin x)}{\tan x - \sin x}$

$$= \lim_{x \rightarrow 0} \frac{\tan(\tan x) - \tan x + \sin x - \sin(\sin x) + (\tan x - \sin x)}{\tan x - \sin x}$$

$$= 1 + \lim_{x \rightarrow 0} \left(\left(\frac{\tan(\tan x) - \tan x}{\tan^3 x} \right) \frac{\tan^3 x}{x^3} + \left(\frac{\sin x - \sin(\sin x)}{\sin^3 x} \right) \frac{\sin^3 x}{x^3} \right) \frac{x^3}{\tan x - \sin x}$$

$$= 1 + \left(\frac{1}{6} + \frac{1}{3} \right) \times \lim_{x \rightarrow 0} \left(\frac{x^2}{1 - \cos x} \right) \cos x \cdot \left(\frac{x}{\sin x} \right) = 1 + \frac{1}{2} \cdot 2 = 2$$

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

Assertion (A) : Magnetic monopoles do not exist.

Reason (R) : Magnetic field lines are continuous and form closed loops.

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

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

Answer (4)

Sol. The magnet does not exist in form of monopole and magnetic lines never intersect, continuous and form a closed loop. Line initiates from north pole and end to south outside while inside vice versa.

30. Match **List-I** with **List-II**.

- | List-I | List-II |
|----------------------|---------------------|
| a. Mass density | (i) $[ML^2T^{-3}]$ |
| b. Impulse | (ii) $[MLT^{-1}]$ |
| c. Power | (iii) $[ML^2T^0]$ |
| d. Moment of inertia | (iv) $[ML^{-3}T^0]$ |

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

- (1) a(iv), b(ii), c(i), d(iii)
- (2) a(i), b(iii), c(iv), d(ii)
- (3) a(ii), b(iii), c(iv), d(i)
- (4) a(iv), b(ii), c(iii), d(i)

Answer (1)

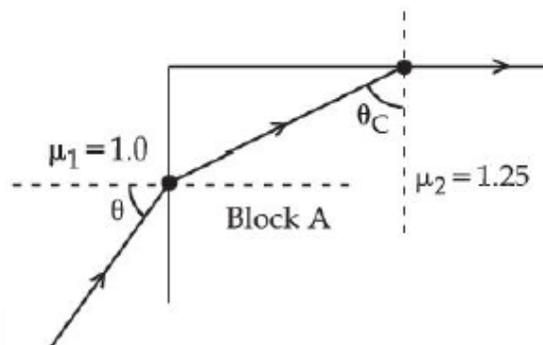
Sol. $\rho = \frac{kg}{m^3} \Rightarrow [ML^{-3}T^0]$... (iv)

$I = F \cdot \Delta t \Rightarrow [MLT^{-1}]$... (ii)

$P = \frac{W}{t} \Rightarrow [ML^2T^{-3}]$... (i)

$I = \frac{MR^2}{n} \Rightarrow [ML^2T^0]$... (iii)

31. A transparent block A having refractive index $\mu = 1.25$ is surrounded by another medium of refractive index $\mu = 1.0$ as shown in figure. A light ray is incident on the flat face of the block with incident angle θ as shown in figure. What is the maximum value of θ for which light suffers total internal reflection at the top surface of the block?



- (1) $\sin^{-1}(3/4)$
- (2) $\tan^{-1}(4/3)$
- (3) $\cos^{-1}(3/4)$
- (4) $\tan^{-1}(3/4)$

Answer (1)

Sol. At 1st refractions

$$1 \times \sin \theta = \frac{5}{4} \sin \alpha$$

$$\sin \alpha = \frac{4}{5} \sin \theta \quad \dots (i)$$

At point of TIR

$$\frac{5}{4} \sin(\theta_c) = 1$$

$$\sin(90 - \alpha) = \frac{4}{5}$$

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

$$\sin \alpha = \frac{3}{5} \quad \dots (ii)$$

From (i) and (ii)

$$\alpha = \sin^{-1}\left(\frac{3}{4}\right)$$

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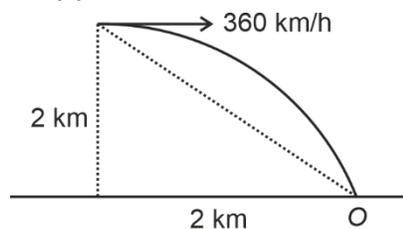
32. A helicopter flying horizontally with a speed of 360 km/h at an altitude of 2 km, drops an object at an instant. The object hits the ground at a point O, 20 s after it is dropped. Displacement of 'O' from the position of helicopter where the object was released is :

(use acceleration due to gravity $g = 10 \text{ m/s}^2$ and neglect air resistance)

- (1) $2\sqrt{2}$ km (2) 4 km
(3) $2\sqrt{5}$ km (4) 7.2 km

Answer (1)

Sol.



Displacement = $2\sqrt{2}$ km

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

Assertion (A) : The outer body of an air craft is made of metal which protects persons sitting inside from lightning-strikes.

Reason (R) : The electric field inside the cavity enclosed by a conductor 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 correct but **(R)** is **not** the correct explanation of **(A)**
(2) **(A)** is correct but **(R)** is not correct
(3) Both **(A)** and **(R)** are correct and **(R)** is the correct explanation of **(A)**
(4) **(A)** is not correct but **(R)** is correct

Answer (3)

Sol. The outer body of air craft made with metal to provide electrostatic shield, such that electric field inside craft remain zero for any charge on outer surface.

34. The dimension of $\sqrt{\frac{\mu_0}{\epsilon_0}}$ is equal to that of :

(μ_0 = Vacuum permeability and ϵ_0 = Vacuum permittivity)

- (1) Inductance (2) Resistance
(3) Capacitance (4) Voltage

Answer (2)

Sol. $[\mu_0] = [MLT^{-2}A^{-2}]$

$[\epsilon_0] = [M^{-1}L^{-3}T^4A^2]$

$$\left[\sqrt{\frac{\mu_0}{\epsilon_0}} \right] = [ML^2T^{-3}A^{-2}] = [R]$$

35. The helium and argon are put in the flask at the same room temperature (300 K). The ratio of average kinetic energies (per molecule) of helium and argon is (Give : Molar mass of helium = 4 g/mol, Molar mass of argon = 40 g/mol)

- (1) 1 : 10 (2) 10 : 1
(3) 1 : $\sqrt{10}$ (4) 1 : 1

Answer (4)

Sol. Average K.E. = $\frac{3}{2}RT$, is not depends on molar/molecular mass.

$$\text{so, } \frac{(\text{K.E.})_{\text{He}}}{(\text{K.E.})_{\text{Ar}}} = 1$$

36. A capillary tube of radius 0.1 mm is partly dipped in water (surface tension 70 dyn/cm and glass water contact angle $\approx 0^\circ$) with 30° inclined with the vertical. The length of water risen in the capillary is _____ cm. (Take $g = 9.8 \text{ m/s}^2$)

- (1) $\frac{82}{5}$ (2) $\frac{68}{5}$
(3) $\frac{71}{5}$ (4) $\frac{57}{2}$

Answer (1)

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Sol. $h = \frac{2T \cos \theta}{\rho g r}$
 $= \frac{100}{7}$

$h' = \frac{h}{\cos \theta} = \frac{100}{7 \cos 30^\circ}$

$h' = \frac{200}{7\sqrt{3}} \approx 16.49$

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

Assertion (A) : Refractive index of glass is higher than that of air.

Reason (R) : Optical density of a medium is directly proportionate to its mass density which results in a proportionate refractive index.

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

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

Answer (1)

Sol. Speed of light $v = \frac{c}{\mu}$

for air $v \approx c$

for glass $v < c$

so $\mu_g > \mu_a$

and opted density (μ) does not depends on density of medium

so A is correct but R is incorrect

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

Assertion (A) : The radius vector from the Sun to a planet sweeps out equal areas in equal intervals of time and thus areal velocity of planet is constant.

Reason (R) : For a central force field the angular momentum is a constant.

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

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

Answer (3)

Sol. From Kepler's 2nd law

$\frac{dA}{dt} = \frac{L}{2m} = \text{constant}$

and angular momentum for central force is constant.

so, both (A) and (R) are correct and (R) explain (A)

39. Match **List-I** with **List-II**.

List-I	List-II
(A) Isothermal	(I) ΔW (work done) = 0
(B) Adiabatic	(II) ΔQ (supplied heat) = 0
(C) Isobaric	(III) ΔU (change in internal energy) $\neq 0$
(D) Isochoric	(IV) $\Delta U = 0$

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

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

Answer (2)

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Sol. For isothermal,

$$T = \text{constant}, \Delta T = 0, \Delta U = nC_v \Delta T = 0 \quad \dots \text{(IV)}$$

For Adiabatic,

$$\Delta Q = 0, \Delta W = -\Delta U \quad \dots \text{(II)}$$

For Isobaric,

$$p = \text{constant}, \Delta U = nc, \Delta T \neq 0,$$

$$\Delta Q \neq 0, \Delta W \neq 0 \quad \dots \text{(III)}$$

For Isochoric,

$$v = \text{constant}, \Delta W = 0, \Delta Q = \Delta U \neq 0 \quad \dots \text{(I)}$$

40. A photoemissive substance is illuminated with a radiation of wavelength λ_i so that it releases electrons with de-Broglie wavelength λ_e . The longest wavelength of radiation that can emit photoelectron is λ_0 . Expression for de-Broglie wavelength is given by:

(m : mass of the electron, h : Planck's constant and c : speed of light)

$$(1) \lambda_e = \sqrt{\frac{h\lambda_i}{2mc}}$$

$$(2) \lambda_e = \sqrt{\frac{h}{2mc\left(\frac{1}{\lambda_i} - \frac{1}{\lambda_0}\right)}}$$

$$(3) \lambda_e = \sqrt{\frac{h\lambda_0}{2mc}}$$

$$(4) \lambda_e = \frac{h}{\sqrt{2mc\left(\frac{1}{\lambda_i} - \frac{1}{\lambda_0}\right)}}$$

Answer (2)

Sol. $\frac{hc}{\lambda_i} = \phi + KE$

$$\phi = \frac{hc}{\lambda_0}, KE = \left(\frac{h}{\lambda_e}\right)^2 \cdot \frac{1}{2m}$$

$$\frac{hc}{\lambda_i} = \frac{hc}{\lambda_0} + \left(\frac{h}{\lambda_e}\right)^2 \cdot \frac{1}{2m}$$

$$\left(\frac{\lambda_e}{h}\right)^2 = \frac{1}{2mhc\left(\frac{1}{\lambda_i} - \frac{1}{\lambda_0}\right)}$$

$$\lambda_e = \sqrt{\frac{h}{2mc\left(\frac{1}{\lambda_i} - \frac{1}{\lambda_0}\right)}}$$

41. An object with mass 500 g moves along x-axis with speed $v = 4\sqrt{x}$ m/s. The force acting on the object is:

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

Answer (2)

Sol. $\frac{dx}{dt} = 4\sqrt{x}$

$$x = 4t^2$$

$$v = \frac{dx}{dt} = 8t$$

$$a = 8 \text{ m/s}^2$$

$$F = ma = 4 \text{ N}$$

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

Assertion (A) : The density of the copper (${}^{64}_{29}\text{Cu}$) nucleus is greater than that of the carbon (${}^{12}_6\text{C}$) nucleus.

Reason (R) : The nucleus of mass number A has a radius proportional to $A^{1/3}$.

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

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

Answer (2)

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Sol. Density of nucleus independent on mass number (A) and radius is proportional to $A^{1/3}$ so Assertion (A) is incorrect but Reason (R) is correct.

43. Which one of the following forces cannot be expressed in terms of potential energy ?
 (1) Gravitational force (2) Restoring force
 (3) Frictional force (4) Coulomb's force

Answer (3)

Sol. Potential energy can be expressed for conservative force, so it can not be expressed for friction because it is non-conservative force

44. A mirror is used to produce an image with magnification of $\frac{1}{4}$. If the distance between object and its image is 40 cm, then the focal length of the mirror is _____.
 (1) 10.7 cm (2) 15 cm
 (3) 12.7 cm (4) 10 cm

Answer (1)

Sol. here $\left| \frac{v}{u} \right| = \frac{1}{4}$

$$u = 4v$$

$$\text{and } u + v = 40$$

$$\text{so } u = 32, v = 8$$

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

$$F = 10.66 \text{ cm} \approx 10.7 \text{ cm}$$

45. The equation of a wave travelling on a string is $y = \sin [20\pi x + 10\pi t]$, where x and t are distance and time in SI units. The minimum distance between two points having the same oscillating speed is :
 (1) 10 cm (2) 2.5 cm
 (3) 20 cm (4) 5.0 cm

Answer (4)

Sol. $k = 20\pi = \frac{2\pi}{\lambda}$

$$\lambda = 10 \text{ cm}$$

$$\text{Minimum distance} = \frac{\lambda}{2} = 5 \text{ cm}$$

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. The electric field in a region is given by $\vec{E} = (2\hat{i} + 4\hat{j} + 6\hat{k}) \times 10^3 \text{ N/C}$. The flux of the field through a rectangular surface parallel to x-z plane is $6.0 \text{ Nm}^2\text{C}^{-1}$. The area of the surface is _____ cm^2 .

Answer (15)

Sol. $\vec{E} = (2\hat{i} + 4\hat{j} + 6\hat{k}) \times 10^3 \text{ N/C}$

$$\phi = \vec{E} \cdot \vec{S}$$

$$= [(2\hat{i} + 4\hat{j} + 6\hat{k}) - (a\hat{j})] \times 10^3$$

$$6 = A \times 10^3$$

$$A = \frac{6}{4 \times 10^3} \text{ ms}$$

$$= 15 \text{ cm}$$

47. An inductor of reactance 100Ω , a capacitor of reactance 50Ω , and a resistor of resistance 50Ω are connected in series with an AC source of 10 V , 50 Hz . Average power dissipated by the circuit is _____ W .

Answer (1)

Sol. $P = \frac{I_0 V_0}{2} \cos \phi$

$$\cos \phi = \frac{R}{Z}, Z = \sqrt{R^2 + (X_L - X_C)^2} = 50\sqrt{2} \Omega$$

$$\cos \phi = \frac{1}{2}$$

$$P = 1 \text{ W}$$

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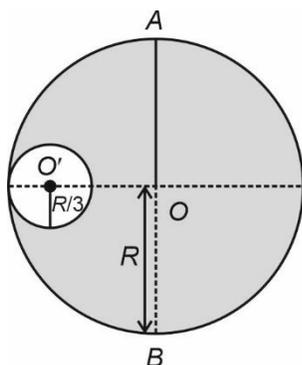


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48. M and R be the mass and radius of a disc. A small disc of radius $\frac{R}{3}$ is removed from the bigger disc as shown in figure. The moment of inertia of remaining part of bigger disc about an axis AB passing through the centre O and perpendicular to the plane of disc is $\frac{4}{x} MR^2$. The value of x is _____.



Answer (9)

Sol. $m_1 = M$

$$I_0 = \frac{MR^2}{2}$$

$$I_{O'} = \frac{m \left(\frac{R}{3}\right)^2}{2} = \frac{MR^2}{81 \times 2}$$

$$(I_{\text{net}})_O = \frac{MR^2}{2} \left\{ \frac{MR^2}{81 \times 2} + \frac{M}{9} \times \left(\frac{2R}{3}\right)^2 \right\}$$

$$= \frac{4}{9} MR^2$$

49. Two cylindrical rods A and B made of different materials, are joined in a straight line. The ratios of lengths, radii and thermal conductivities of these rods are:

$$\frac{L_A}{L_B} = \frac{1}{2}, \frac{r_A}{r_B} = 2 \text{ and } \frac{K_A}{K_B} = \frac{1}{2}.$$

The free ends of rods A and B are maintained at 400 K , 200 K , respectively. The temperature of rods interface is _____ K , when equilibrium is established.

Answer (360)

$$\text{Sol. } \frac{K_A \pi r_A^2 (400 - T)}{L_A} = \frac{K_B \pi r_B^2 (T - 200)}{L_B}$$

$$\frac{K_A \left(\frac{r_A}{r_B}\right)^2 (400 - T)}{L_B} = \frac{L_A}{L_B} (T - 200)$$

$$T = 360 \text{ K}$$

50. A parallel plate capacitor has charge $5 \times 10^{-6} \text{ C}$. A dielectric slab is inserted between the plates and almost fills the space between the plates. If the induced charge on one face of the slab is $4 \times 10^{-6} \text{ C}$ then the dielectric constant of the slab is _____.

Answer (5)

Sol. $E_{\text{net}} = E_0 - E_{\text{in}}$

$$E_{\text{in}} = E_0 \left(1 - \frac{1}{k}\right)$$

$$Q_{\text{in}} = Q_0 \left(1 - \frac{1}{k}\right)$$

$$4 \times 10^{-6} = 5 \times 10^{-6} \left(1 - \frac{1}{k}\right)$$

$$k = 5$$

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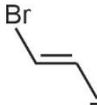
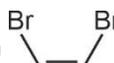
SECTION - A

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. Given below are two statements :

Statement I :  is more polar than .

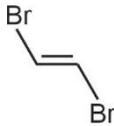
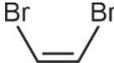
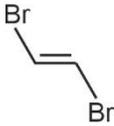
Statement II : Boiling point of  is lower than  but it is more polar than .

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

Answer (1)

Sol.  is more polar than  because C – Cl bond is more polar than C – Br bond.

Boiling point of  is less than that of  because of non-polar nature and hence lower intermolecular forces.  is non-polar.

52. Given below are two statements :

1 M aqueous solutions of each of $\text{Cu}(\text{NO}_3)_2$, AgNO_3 , $\text{Hg}_2(\text{NO}_3)_2$; $\text{Mg}(\text{NO}_3)_2$ are electrolysed using inert electrodes.

Given : $E_{\text{Ag}^+/\text{Ag}}^\circ = 0.80 \text{ V}$, $E_{\text{Hg}_2^{2+}/\text{Hg}}^\circ = 0.79 \text{ V}$,
 $E_{\text{Cu}^{2+}/\text{Cu}}^\circ = 0.24 \text{ V}$ and $E_{\text{Mg}^{2+}/\text{Mg}}^\circ = -2.37 \text{ V}$

Statement I : With increasing voltage, the sequence of deposition of metals on the cathode will be Ag, Hg and Cu.

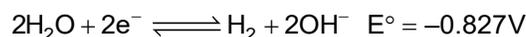
Statement II : Magnesium will not be deposited at cathode instead oxygen gas will be evolved at the cathode.

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

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

Answer (3)

Sol. Due to higher SRP, Ag will deposit first followed by Hg and Cu. Magnesium will not deposit, rather H_2O will get reduced due to higher SRP and H_2 gas will be produced.



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53. Mixture of 1 g each of chlorobenzene, aniline and benzoic acid is dissolved in 50 mL ethyl acetate and placed in a separating funnel. 5 M NaOH (30 mL) was added in the same funnel. The funnel was shaken vigorously and then kept aside. The ethyl acetate layer in the funnel contains

- (1) Benzoic acid
- (2) Benzoic acid and aniline
- (3) Chlorobenzene and aniline
- (4) Benzoic acid and chlorobenzene

Answer (3)

Sol. NaOH and benzoic acid will react to form salt. Aniline being a base and chlorobenzene will remain in ethyl acetate layer.

54. Match **List-I** with **List-II**.

List-I	List-II
(A) Solution of chloroform and acetone	(I) Minimum boiling azeotrope
(B) Solution of ethanol and water	(II) Dimerizes
(C) Solution of benzene and toluene	(III) Maximum boiling azeotrope
(D) Solution of acetic acid in benzene	(IV) $\Delta V_{\text{mix}} = 0$

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

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

Answer (4)

Sol. Acetone + chloroform shows negative deviation and form maximum boiling point azeotrope.

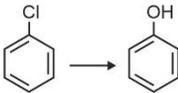
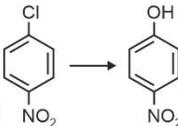
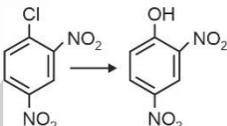
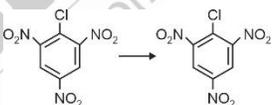
Ethanol and water shows positive deviation and form minimum boiling point azeotrope.

Benzene + toluene \Rightarrow Ideal solution

Hence, $\Delta V_{\text{mix}} = 0$

Acetic acid will dimerise in benzene.

55. Match List-I with List-II.

List-I (Conversion)	List-II (Reagents, Conditions used)
(A) 	(I) Warm, H ₂ O
(B) 	(II) (a) NaOH, 368 K; (b) H ₃ O ⁺
(C) 	(III) (a) NaOH, 443 K; (b) H ₃ O ⁺
(D) 	(IV) (a) NaOH, 623 K, 300 atm; (b) H ₃ O ⁺

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

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

Answer (2)

Sol. Presence of EWG at ortho and para-position of chlorobenzene will increase rate of aromatic nucleophilic substitution due to stable intermediate.

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

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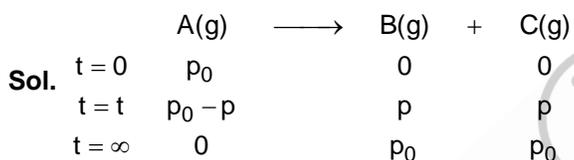
56. $A(g) \rightarrow B(g) + C(g)$ is a first order reaction.

Time	t	∞
P_{system}	p_t	p_{∞}

The reaction was started with reactant A only. Which of the following expression is correct for rate constant k?

- (1) $k = \frac{1}{t} \ln \frac{p_{\infty}}{p_t}$
- (2) $k = \frac{1}{t} \ln \frac{p_{\infty}}{(p_{\infty} - p_t)}$
- (3) $k = \frac{1}{t} \ln \frac{2(p_{\infty} - p_t)}{p_t}$
- (4) $k = \frac{1}{t} \ln \frac{p_{\infty}}{2(p_{\infty} - p_t)}$

Answer (4)



At t = t $p_t = p_0 + p \Rightarrow p = p_t - p_0$

t = ∞ $2p_0 = p_{\infty}$

For first order reaction

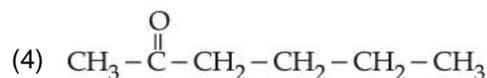
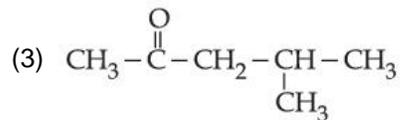
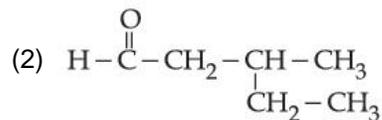
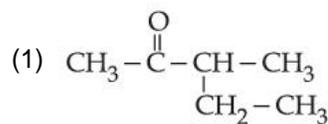
$$k = \frac{1}{t} \ln \frac{(p_0)_A}{(p_t)_A} \quad p_0 - p = \frac{p_{\infty}}{2} - p_t + \frac{p_{\infty}}{2}$$

$$= \frac{1}{t} \ln \frac{p_0}{p_0 - p} \quad = p_{\infty} - p_t$$

$$= \frac{1}{t} \ln \frac{p_{\infty}}{2(p_{\infty} - p_t)}$$

57. "P" is an optically active compound with molecular formula $C_6H_{12}O$. When "P" is treated with 2,4-dinitrophenylhydrazine, it gives a positive test. However, in presence of Tollens reagent, "P" gives a negative test.

Predict the structure of "P".

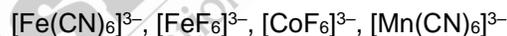


Answer (1)

Sol. P gives negative test with Tollen's reagent so it is not an aldehyde.

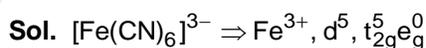
Also P is optically active so (1) is correct.

58. The number of unpaired electrons responsible for the paramagnetic nature of the following complex species are respectively:

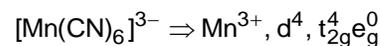
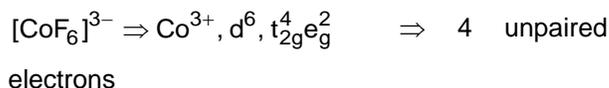
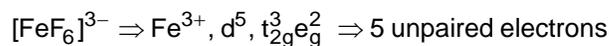


- (1) 1, 5, 4, 2
- (2) 1, 4, 4, 2
- (3) 1, 1, 4, 2
- (4) 1, 5, 5, 2

Answer (1)



\Rightarrow 1 unpaired electron



\Rightarrow 2 unpaired electrons

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59. The correct statements from the following are:

- (A) Tl^{3+} is a powerful oxidising agent
- (B) Al^{3+} does not get reduced easily
- (C) Both Al^{3+} and Tl^{3+} are very stable in solution
- (D) Tl^+ is more stable than Tl^{3+}
- (E) Al^{3+} and Tl^+ are highly stable

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

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

Answer (3)

Sol. Tl^{3+} is powerful oxidising agent as Tl^+ is more stable Tl^{3+} is not stable in solution due to inert pair effect.

60. Liquid A and B form an ideal solution. The vapour pressures of pure liquids A and B are 350 and 750 mm Hg respectively at the same temperature. If x_A and x_B are the mole fraction of A and B in solution while y_A and y_B are the mole fraction of A and B in vapour phase then,

- (1) $\frac{x_A}{x_B} = \frac{y_A}{y_B}$
- (2) $\frac{x_A}{x_B} < \frac{y_A}{y_B}$
- (3) $\frac{x_A}{x_B} > \frac{y_A}{y_B}$
- (4) $(x_A - y_A) < (x_B - y_B)$

Answer (3)

Sol. $P_A^0 = 350$ mm Hg

$P_B^0 = 750$ mm Hg

$$y_A = \frac{350x_A}{P_T}$$

$$y_B = \frac{350x_B}{P_T}$$

$$\frac{y_A}{y_B} = \frac{350x_A}{750x_B}$$

$$\Rightarrow \frac{y_A}{y_B} < \frac{x_A}{x_B}$$

61. The correct statement amongst the following is

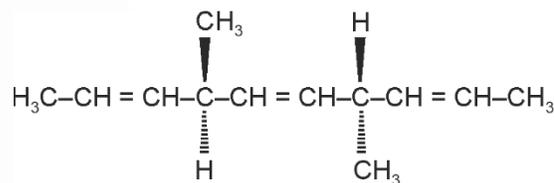
- (1) $\Delta_f H_{298}^0$ is zero for $O(g)$
- (2) $\Delta_f H_{500}^0$ is zero for $O_2(g)$
- (3) The term 'standard state' implies that the temperature is $0^\circ C$
- (4) The standard state of a pure gas is the pure gas at a pressure of 1 bar and temperature 273 K

Answer (3)

Sol. $\Delta_f H_{298}^0$ for O_2 is zero and not for O

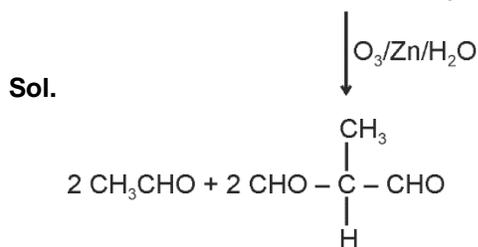
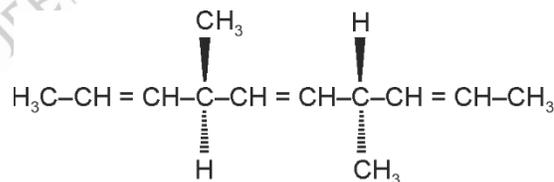
The term 'Standard state' does not necessarily means $0^\circ C$ temperature

62. The number of optically active products obtained from the complete ozonolysis of the given compound is



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

Answer (1)



Sol.

None is optically active.

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63. In SO_2 , NO_2^- and N_3^- the hybridization at the central atom are respectively

- (1) sp^2 , sp^2 and sp (2) sp^2 , sp^2 and sp^2
 (3) sp , sp^2 and sp (4) sp^2 , sp and sp

Answer (1)

Sol. $\text{SO}_2 \Rightarrow 2\sigma$ bond + 1 l.p. $\Rightarrow sp^2$ hybridisation

$\text{NO}_2^- \Rightarrow 2\sigma$ bond + 1 l.p. $\Rightarrow sp^2$ hybridisation

$\text{N}_3^- \Rightarrow 2\sigma$ bond $\Rightarrow sp$ hybridisation

64. Given below are two statements

Statement I: On hydrolysis, oligo peptides give rise to fewer number of α -amino acids while proteins give rise to a large number of β -amino acids.

Statement II: Natural proteins are denatured by acids which convert the water soluble form of fibrous proteins to their water insoluble form.

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

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

Answer (2)

Sol. Protein give rise to alpha amino acid, incorrect statement.

Natural protein are denatured by acid. Due to this, globules unfold and helix get uncoiled incorrect.

65. 'X' is the number of acidic oxides among VO_2 , V_2O_3 , CrO_3 , V_2O_5 and Mn_2O_7 . The primary valency of cobalt in $[\text{Co}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_3]_2(\text{SO}_4)_3$ is Y. The value of X + Y is _____.

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

Answer (4)

Sol. Among VO_2 , V_2O_3 , V_2O_5 , CrO_3 and Mn_2O_7 , only CrO_3 & Mn_2O_7 is acidic X = 2

Primary valency of cobalt in $[\text{Co}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_3]_2(\text{SO}_4)_3$ is 3 as cobalt have +3 charge

Y = 3

X + Y = 5

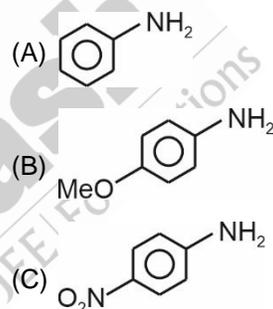
66. Choose the incorrect trend in the atomic radii (r) of the elements.

- (1) $r_{\text{Br}} < r_{\text{K}}$ (2) $r_{\text{Rb}} < r_{\text{Cs}}$
 (3) $r_{\text{Mg}} < r_{\text{Al}}$ (4) $r_{\text{At}} < r_{\text{Cs}}$

Answer (3)

Sol. $r_{\text{Mg}} > r_{\text{Al}}$ due to lower effective nuclear charge.

67. The descending order of basicity of following amines is :



- (D) CH_3NH_2
 (E) $(\text{CH}_3)_2\text{NH}$

Choose the correct answer from the options given below:

- (1) B > E > D > A > C
 (2) E > D > B > A > C
 (3) E > D > A > B > C
 (4) E > A > D > C > B

Answer (2)

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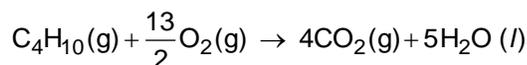


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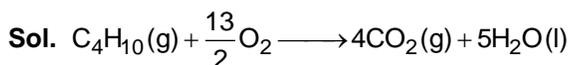
71. Butane reacts with oxygen to produce carbon dioxide and water following the equation given below.



If 174.0 kg of butane is mixed with 320.0 kg of O_2 , the volume of water formed in liters is _____. (Nearest integer)

[Given: (a) Molar mass of C, H, O are 12, 1, 16 g mol^{-1} respectively, (b) Density of water = 1 g mL^{-1}]

Answer (138)



$$\text{Moles of } \text{C}_4\text{H}_{10} = \frac{174\text{kg}}{50\text{g}} = 3 \times 10^3 \text{ moles}$$

$$\text{moles of } \text{O}_2 = \frac{320\text{ kg}}{32\text{g}}$$

$$= 10 \times 10^3 \text{ moles}$$

$$1 \text{ mole } \text{C}_4\text{H}_{10} \Rightarrow \frac{13}{2} \text{ moles } \text{O}_2$$

$$3 \times 10^3 \text{ moles } \text{C}_4\text{H}_{10} \Rightarrow \frac{13}{2} \times 3 \times 10^3 \text{ mole } \text{O}_2$$

O_2 is limiting reagent

$$\text{Moles of } \text{H}_2\text{O} \text{ formed} = \frac{10}{13} \times 5 \times 2 \times 10^3$$

$$\text{Volume of } \text{H}_2\text{O} \text{ formed} = \frac{10}{13} \times 5 \times 2 \times 18 \text{ L}$$

$$= 138.46 \text{ L}$$

72. One litre buffer solution was prepared by adding 0.10 mol each of NH_3 and NH_4Cl in deionised water.

The change in pH on addition of 0.05 mol of HCl to the above solution is _____ $\times 10^{-2}$. (Nearest integer)

Given: pK_b of $\text{NH}_3 = 4.745$ and $\log_{10} 3 = 0.477$

Answer (48)

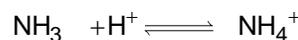
Sol. Initially

$$\text{pOH} = \text{pK}_b + \log \frac{[\text{NH}_4\text{Cl}]}{[\text{NH}_3]} = \text{pK}_b + \log \frac{0.1}{0.1}$$

$$\text{pOH} = \text{pK}_b$$

$$\text{pH} = 14 - \text{pOH} \Rightarrow \text{pH} = 9.255$$

When 0.05 mol HCl is added



$$0.1 \quad 0.05$$

$$0.05 \quad 0 \quad 0.15$$

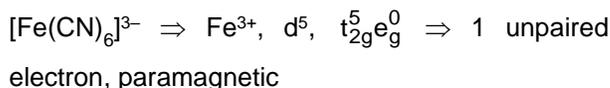
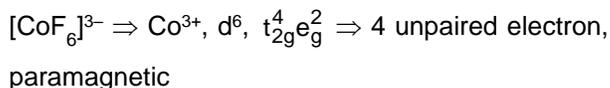
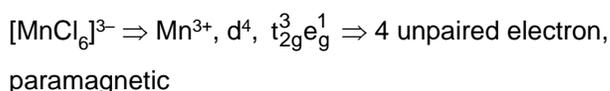
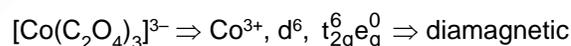
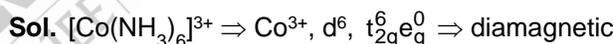
$$\text{pOH} = \text{pK}_b + \log \frac{0.15}{0.05} = 5.222$$

$$\text{pH} = 8.778$$

$$\text{Change in pH} = 0.477 \text{ or } 47.7 \times 10^{-2}$$

73. The number of paramagnetic metal complex species among $[\text{Co}(\text{NH}_3)_6]^{3+}$, $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$, $[\text{MnCl}_6]^{3-}$, $[\text{Mn}(\text{CN})_6]^{3-}$, $[\text{CoF}_6]^{3-}$, $[\text{Fe}(\text{CN})_6]^{3-}$ and $[\text{FeF}_6]^{3-}$ with same number of unpaired electrons is _____.

Answer (2)



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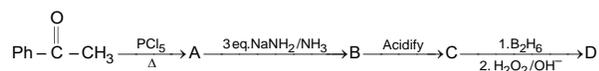


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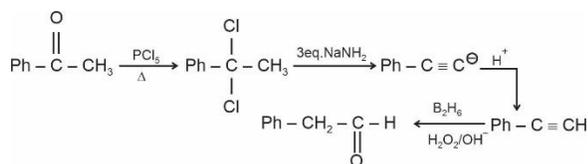


74. Identify the structure of the final product (D) in the following sequence of the reactions:



Total number of sp^2 hybridised carbon atoms in product D is _____.

Answer (7)



Sol.

Number of sp^2 hybridised carbon = 7

75. In Dumas' method 292 mg of an organic compound released 50 mL of nitrogen gas (N_2) at 300 K temperature and 715 mm Hg pressure. The percentage composition of 'N' in the organic compound is _____% (Nearest integer) (Aqueous tension at 300 K = 15 mm Hg)

Answer (18)

$$\text{Sol. } V_{\text{N}_2} \text{ at STP} = \frac{273 \times (715 - 15) \times 50}{300 \times 760}$$

$$= 41.9 \text{ mL}$$

$$M_{\text{N}_2} = \frac{41.9}{22400} \times 28 = 0.052 \text{ g}$$

$$\% \text{ N} = \frac{0.052 \text{ g}}{0.292} \times 100 = 17.94\%$$



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