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JEE ADVANCED 2026

17 MAY 2026 - Paper 2

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JEE MAIN 2025



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JEE ADV 2025



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NEET 2025



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CLASSROOM STUDENT

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APPL. NO. 260310064705

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**27 RANKS
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ALL INDIA
OPEN CATEGORY**

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23 RANK
SHREYAS MISHRA
APPL. NO. 260310038861*

30 RANK
SHRESTH JASORIA
APPL. NO. 260310117626*

32 RANK
AARUSH GOEL
APPL. NO. 260310032423*

46 RANK
NISKARSH VERMA
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46 RANK
KATA HIMAKAR
APPL. NO. 260310178198

48 RANK
RUCHIT AGRAWAL
APPL. NO. 260310175846*

52 RANK
T JASHWANTH REDDY
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GANNI SAI SATHVIK
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58 RANK
P BHARGAV NAIDU
APPL. NO. 260310428312

60 RANK
PANAKA RAM SUBHASH
APPL. NO. 260310301035

62 RANK
M RAMA SANTHOSH
APPL. NO. 260310178289

70 RANK
S NIKHILESH KESANI
APPL. NO. 260311019556

73 RANK
LAKSHIT SINSINWAR
APPL. NO. 26031877889*

79 RANK
B SAMEERAJ REDDY
APPL. NO. 260310704062

80 RANK
MUKKARA SAKETH
APPL. NO. 260310180924

83 RANK
P CHENNA KESAV
APPL. NO. 260310184531

85 RANK
M NAGA SAHARSHA
APPL. NO. 260310177318

87 RANK
ADITYA SINGH
APPL. NO. 260310087528

100 RANK
YAJAT SHINGHAL
APPL. NO. 260310228683

*T.S. Copy | *Note: Any information provided in this advertisement could be brought to our notice. *Note: The information is as per students' feedback.

*CIP-ATIS Information so far.

BELOW 100
ALL INDIA OPEN
CATEGORY RANKS

27

BELOW 1000
ALL INDIA OPEN
CATEGORY RANKS

172

BELOW 100
ALL INDIA CATEGORY
RANKS COUNT

95

BELOW 1000
ALL INDIA CATEGORY
RANKS COUNT

640

TOTAL QUALIFIED RANKS
FOR JEE ADVANCED - 2026
24,700





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JEE-ADVANCED-2026-P2-Model

Time:3Hr's

IMPORTANT INSTRUCTIONS

Max Marks: 180

MATHEMATICS:

Section	Question Type	+Ve Marks	- Ve Marks	No.of Qs	Total marks
Sec – I(Q.N : 1 – 4)	Questions with Single Correct Choice	+3	-1	4	12
Sec – II(Q.N : 5 – 9)	Questions with Multiple Correct Choice with partial mark	+4	-1	5	20
Sec – III(Q.N : 10 – 14)	Questions with Numerical Value Answer Type	+4	0	5	20
Sec – IV(Q.N : 15 – 18)	Paragraph Questions with Numerical Value Answer Type	+4	-1	4	8
Total				18	60

PHYSICS:

Section	Question Type	+Ve Marks	- Ve Marks	No.of Qs	Total marks
Sec – I(Q.N : 19 – 22)	Questions with Single Correct Choice	+3	-1	4	12
Sec – II(Q.N : 23 – 27)	Questions with Multiple Correct Choice with partial mark	+4	-1	5	20
Sec – III(Q.N : 28 – 32)	Questions with Numerical Value Answer Type	+4	0	5	20
Sec – IV(Q.N : 33 – 36)	Paragraph Questions with Numerical Value Answer Type	+4	-1	4	8
Total				18	60

CHEMISTRY:

Section	Question Type	+Ve Marks	- Ve Marks	No.of Qs	Total marks
Sec – I(Q.N : 37 – 40)	Questions with Single Correct Choice	+3	-1	4	12
Sec – II(Q.N : 41 – 45)	Questions with Multiple Correct Choice with partial mark	+4	-1	5	20
Sec – III(Q.N : 46 – 50)	Questions with Numerical Value Answer Type	+4	0	5	20
Sec – IV(Q.N : 51 – 54)	Paragraph Questions with Numerical Value Answer Type	+4	-1	4	8
Total				18	60

**HISTORY CREATED 300/300 IN JEE MAIN
4TH YEAR IN A ROW**

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MATHEMATICS

Max Marks: 60

SECTION – I
(SINGLE CORRECT ANSWER TYPE)This section contains **FOUR (04)** questions.

- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +3 If **ONLY** the correct option is chosen;**Zero Marks** : 0 If none of the options is chosen (i.e. the question is unanswered);**Negative Marks** : -1 In all other cases

1. Let \vec{a}, \vec{b} be two vectors and let P, Q and R be the points with position vectors \vec{a}, \vec{b} and $\vec{a} + \vec{b}$, respectively, with respect to the origin O . If $|\vec{a} + \vec{b}| = \sqrt{21}$, $|\vec{a} - \vec{b}| = 3$ and \vec{a} and $(\vec{a} - \vec{b})$ are perpendicular to each other, then the area of the triangle OPR is

- A) $\sqrt{3}$ B) $\frac{\sqrt{3}}{2}$ C) $\frac{3\sqrt{3}}{2}$ D) $\frac{3}{2}$

Ans: C

Sol: $|\vec{a} + \vec{b}| = \sqrt{21}, |\vec{a} - \vec{b}| = 3$

$$\Rightarrow 2(|\vec{a}|^2 + |\vec{b}|^2) = 30, 4\vec{a} \cdot \vec{b} = 12$$

$$\Rightarrow (|\vec{a}|^2 + |\vec{b}|^2) = 15, \vec{a} \cdot \vec{b} = 3$$

$$\vec{a} \cdot (\vec{a} - \vec{b}) = 0 \Rightarrow |\vec{a}|^2 = 3, |\vec{b}|^2 = 12$$

$$\text{Area} = \frac{1}{2} |\vec{a} \times (\vec{a} + \vec{b})| = \frac{1}{2} |\vec{a} \times \vec{b}| = \frac{1}{2} \sqrt{36 - 9} = \frac{3\sqrt{3}}{2}$$

2. Let T be the tangent to the parabola $y^2 = 16x$ at the point $(64, 32)$. Let L be the tangent to the same parabola at another point (x_1, y_1) on the parabola. If L and T are perpendicular to each other, then the distance between the point (x_1, y_1) and the focus of the parabola, is

- A) $\frac{15}{4}$ B) 4 C) $\frac{17}{4}$ D) 5

Ans: C



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2026



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Sol: $y^2 = 16x, A(t_1) = (64, 32) \Rightarrow t_1 = 4$

$B(t_2) = (x_1, y_1)$

Tangents at A, B are $\perp ar \Rightarrow t_1 t_2 = -1 \Rightarrow t_2 = \frac{-1}{4}$

$B\left(\frac{1}{4}, -2\right), F(4, 0)$

$BF = \sqrt{\left(\frac{15}{4}\right)^2 + 4} = \frac{17}{4}$

3. Let $y: (-\infty, \infty) \rightarrow (0, \infty)$ be the solution of the differential equation $\frac{dy}{dx} = \frac{e^{5x}y^3 + y^3}{e^x + e^xy^4}$,

Satisfying $y(0) = \frac{1}{\sqrt{2}}$. Then the value of $y(\log_e 2)$ is

- A) $\sqrt{\frac{5+\sqrt{35}}{2}}$ B) $\sqrt{\frac{7+\sqrt{53}}{2}}$ C) $\frac{7+\sqrt{53}}{2}$ D) $\frac{5+\sqrt{35}}{2}$

Ans: B

Sol: $\left(\frac{1+y^4}{y^3}\right)dy = \left(\frac{e^{5x}+1}{e^x}\right)dx \quad \int \frac{dy}{y^3} + \int ydy = \int e^{4x}dx + \int e^{-x}dx$

$\Rightarrow -\frac{1}{2y^2} + \frac{y^2}{2} = \frac{e^{4x}}{4} - e^{-x} + C$

$y(0) = \frac{1}{\sqrt{2}} \Rightarrow -1 + \frac{1}{4} = \frac{1}{4} - 1 + C \Rightarrow C = 0 \quad \therefore$ Solution is $\frac{y^2}{2} - \frac{1}{2y^2} = \frac{e^{4x}}{4} - e^{-x}$

$x = \ln 2 \Rightarrow \frac{y^2}{2} - \frac{1}{2y^2} = 4 - \frac{1}{2} \Rightarrow y^4 - 1 = 7y^2 \Rightarrow y^4 - 7y^2 - 1 = 0$

$\Rightarrow y^2 = \frac{7 \pm \sqrt{53}}{2} \quad \because y \in (0, \infty), y = \sqrt{\frac{7 + \sqrt{53}}{2}}$

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4. The value of the definite integral $\int_0^2 \frac{1}{3^x + 3} dx$ is

- A) $\frac{1}{2}$ B) $\frac{1}{3}$ C) $\frac{\log_e 3}{3}$ D) $\frac{\log_e 3}{2}$

Ans: B

Sol:
$$I = \int_0^2 \frac{dx}{3^x + 3} = \int_0^2 \frac{dx}{3^{2-x} + 3}$$

$$\Rightarrow 2I = \int_0^2 \left(\frac{1}{3^x + 3} + \frac{3^x}{3(3 + 3^x)} \right) dx$$

$$\Rightarrow 2I = \int_0^2 \frac{dx}{3} = \frac{2}{3} \Rightarrow I = 1/3$$

SECTION – II
(ONE OR MORE CORRECT ANSWER TYPE)

This section contains FIVE (05) questions.

- Each question has FOUR options (A), (B), (C) and (D). ONE OR MORE THAN ONE of these four option(s) is(are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks :+4 ONLY if (all) the correct option(s) is(are) chosen;

Partial Marks: +3 If all the four options are correct but ONLY three options are chosen;

Partial Marks: +2 If three or more options are correct but ONLY two options are chosen, both of which are correct;

Partial Marks: +1 If two or more options are correct but ONLY two options are chosen, and it is a correct option;

Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);

Negative Marks : -2 In all other cases.

For example, in a question, if (A), (B) and (D) are the ONLY three options corresponding to correct answers, then choosing ONLY (A), (B) and (D) will get +4 marks; choosing ONLY (A) and (B) will get +2 marks; choosing ONLY (A) and (D) will get +2 marks; choosing ONLY (B) and (D) will get +2 marks; choosing ONLY (A) will get +1 mark; choosing ONLY (B) will get +1 mark; choosing ONLY (D) will get +1 mark; choosing no option (i.e. the question is unanswered) will get 0 marks; and choosing any other combination of options will get -2 marks.

5. Let \mathbb{R} denote the set of all real numbers. Consider the polynomials function $f : \mathbb{R} \rightarrow \mathbb{R}$

defined by $f(x) = \frac{d^{10}}{dx^{10}} ((x^2 - 1)^{10})$, for all $x \in \mathbb{R}$.

Here $\frac{d^{10}}{dx^{10}} ((x^2 - 1)^{10})$ is the 10th order derivative of the function $(x^2 - 1)^{10}$.

Then which of the following statements is (are) TRUE?

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- A) The coefficient of x^8 in the polynomial $f(x)$ is $(-10) \binom{18!}{8!}$
- B) The value of $f(1) + f(-1)$ is equal to $10! 2^{11}$
- C) The degree of the polynomial $f(x)$ is 10
- D) The constant term of the polynomial $f(x)$ is $-\left(\frac{10!}{5!}\right)$

Ans: ABC

SOL: $[x^2 - 1]^{10} = {}^{10}C_0(-1)^{10} + {}^{10}C_1x^2(-1)^9 + \dots + {}^{10}C_{10}x^{20}$

Differentiate 10 times

$$f(x) = \left[{}^{-10}C_5 \right] 10! + {}^{10}C_6 \frac{[12]!}{2!} x^2 - {}^{10}C_7 \frac{14!}{4!} x^4$$

$$+ {}^{10}C_8 \frac{16!}{6!} x^6 - {}^{10}C_9 \frac{18!}{8!} x^8 + {}^{10}C_{10} \frac{20!}{10!} x^{10}$$

B) given $(x-1)^{10} (x+1)^{10}$

Where $(x+1)$ term exist & if $(x-1)$ exist it gives zero

$$f(1) = \left({}^{10}C_{10} \right) (10!) 2^{10}$$

$$f(1) + f(-1) = 2f(1) = 10! 2^{11}$$

6. Let a, b, c be positive integers in arithmetic progression such that the equation

$$ax^2 + bx + c = 0$$

has only integer solutions.

Then which of the following statements is (are) TRUE?

- A) $c - b$ is an integer multiple of a
- B) Both the roots of the equation $ax^2 + bx + c = 0$ are odd integers
- C) If $c = 15$, then $ab = 8$
- D) If $b = 8$, then $x = 3$ is a root of the equation $ax^2 + bx + c = 0$

Ans: ABC









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SOL: $a, b, c \in N$ & $2b = a + c$

$ax^2 + bx + c = 0$ has integral solutions

$$\Rightarrow \frac{b}{a}, \frac{c}{a} \in N \text{ and } \frac{b^2 - 4ac}{a^2} = \text{perfect square}$$

$$\Rightarrow \frac{c-b}{a} \in \text{integers} \quad \therefore \text{option (A) is correct}$$

$$2\frac{b}{a} = 1 + \frac{c}{a}$$

LHS is even \Rightarrow RHS is even

$$\Rightarrow \frac{c}{a} \text{ is odd}$$

\therefore option (B) is correct

If $c = 15$, then $a = 1$ (or) 3 (or) 5 (or) 15

a	$\frac{c}{a}$	$\frac{b}{a}$	$\frac{b^2 - 4ac}{a^2}$
1	15	8	4 \rightarrow perfect square
3	5	3	-11
5	3	2	-8
15	1	1	-3

$$\Rightarrow a=1, b=8$$

\therefore option (C) is correct

$$x=3 \text{ is a root } \Rightarrow 9a + 3b + c = 0$$

$$+ve = 0 \text{ (ABSURD)}$$

\therefore option (D) is incorrect










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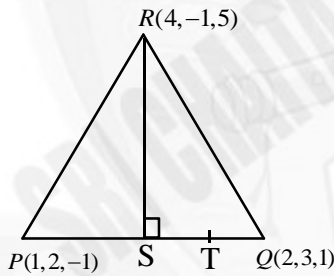
7. Let L be the straight line joining the points $P(1,2,-1)$ and $Q(2,3,1)$. Let S be the foot of the perpendicular drawn from the point $R(4,-1,5)$ to the line L. Another line passing through R intersects L at the point T such that the point S divides the line segment PT internally in the ratio $|PS|:|ST|=1:2$, where $|PS|$ and $|ST|$ are the lengths of the line segments PS and ST, respectively.

Then which of the following statements is (are) TRUE?

- A) The orthocentre of the triangle PRT is $(\frac{23}{5}, -4, \frac{31}{5})$
- B) The orthocentre of the triangle PRT is $(4,3,5)$
- C) The area of the triangle PRT is $6\sqrt{5}$
- D) The area of the triangle PRT is $18\sqrt{5}$

Ans: AD

SOL:



$$\frac{PS}{ST} = \frac{1}{2}$$

Find S, $\overrightarrow{PQ} = \hat{i} + \hat{j} + 2\hat{k}$

$$S(1+k, 2+k, -1+2k)$$

$$\overrightarrow{OS} \perp \overrightarrow{RS} \Rightarrow k - 3 + k + 3 + 4k - 2 = 0$$

$$\Rightarrow k = 2 \ \& \ S(3, 4, 3)$$

$$\overrightarrow{PS} = (2, 2, 4),$$

$$\overrightarrow{PR} = (3, -3, 6)$$









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$$\text{Area} = \frac{1}{2} \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 2 & 4 \\ 3 & -3 & 6 \end{vmatrix} = \frac{|24\hat{i} - 12\hat{k}|}{2}$$

$$\text{PRT area} = 18\sqrt{5}$$

$$\text{Orthocentre} \rightarrow \left(\frac{23}{5}, -4, \frac{31}{5} \right)$$

8. Let $y=f(x)$ be the real valued function defined on the interval $(0, \infty)$, satisfying $y(1)=0$

and the differential equation $x \frac{dy}{dx} = y - x^3$

Then which of the following statements is (are) TRUE?

- A) The function f has a local minimum at $x = \frac{1}{\sqrt{3}}$
- B) The function f has a local maximum at $x = \frac{1}{\sqrt{3}}$
- C) The function f is increasing in the interval $(1, 2)$
- D) If $g(x) = 4x^3 - 5x^2 + \frac{3}{2}x$ for $x > 0$, then the number of elements in the set $\{x \in (0, \infty) : f(x) = g(x)\}$ is 2

Ans: BD

SOL: $f : (0, \infty) \rightarrow R, \quad y(1)=0,$

$$\begin{aligned} \frac{xdy}{dx} - y = -x^3 &\Rightarrow \frac{xdy - y}{dx} = -x^3 \\ \Rightarrow d\left(\frac{y}{x}\right) &= -x dx \Rightarrow \frac{y}{x} = \frac{-x^2}{2} + C \end{aligned}$$







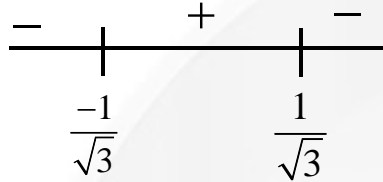



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$$y(1) = 0 \Rightarrow C = \frac{1}{2} \quad \frac{y}{x} = \frac{-x^2}{2} + \frac{1}{2} \Rightarrow y = \frac{x(1-x^2)}{2}$$

$$\frac{dy}{dx} = \frac{1}{2} [1 - 3x^2]$$



\therefore 'f' has local maximum at $x = \frac{1}{\sqrt{3}}$ and 'f' is decreasing in $(1, 2)$

$$f(x) = \frac{x}{2} - \frac{x^3}{2} \quad g(x) = 4x^3 - 5x^2 + \frac{3x}{2}$$

$$x > 0, f(x) = g(x)$$

$$\Rightarrow 4x^3 - 5x^2 + \frac{3x}{2} - \frac{x}{2} + \frac{x^3}{2} = 0$$

$$\Rightarrow \frac{9x^3}{2} - 5x^2 + x = 0 \Rightarrow x = 0 \quad (\text{or}) \quad 9x^2 - 10x + 2 = 0$$

\therefore number of solutions will be 2

9. Let \mathbb{R} denote the set of all real numbers and let $i = \sqrt{-1}$. Consider the matrices

$$S = \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix} \text{ and } T = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}.$$

Let a, b, c, d be real numbers such that $ST = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$.

Let $H = \{x + iy : x, y \in \mathbb{R} \text{ and } y > 0\}$.

Then which of the following statements is (are) TRUE?

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A) $\frac{b+ia}{d+ic} = i$

B) If $\omega = \frac{-1+i\sqrt{3}}{2}$, then $\frac{a\omega+b}{c\omega+d} = \omega$

C) If m is an integer greater than 2 such that $(ST)^2 = (ST)^m$, then m is an integer multiple of 8

D) If $z \in H$, then $\frac{az+b}{cz+d} \in H$

Ans: BD

SOL: $S = \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}, T = \begin{pmatrix} 1 & 1 \\ 0 & 1 \end{pmatrix} \Rightarrow ST = \begin{pmatrix} 0 & -1 \\ 1 & 1 \end{pmatrix} \Rightarrow a=0, b=-1, c=1, d=1$

A) $\frac{b+ia}{d+ic} = \frac{-1}{1+i} \neq i \quad \therefore$ Option (A) is incorrect

B) $\frac{a\omega+b}{c\omega+d} = \frac{-1}{1+\omega} = \omega \quad \therefore$ Option (B) is correct

C) $(ST)^2 = \begin{pmatrix} 0 & -1 \\ 1 & 1 \end{pmatrix} \begin{pmatrix} 0 & -1 \\ 1 & 1 \end{pmatrix} = \begin{pmatrix} -1 & -1 \\ 1 & 0 \end{pmatrix}$

$(ST)^4 = \begin{pmatrix} -1 & -1 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} -1 & -1 \\ 1 & 0 \end{pmatrix} = \begin{pmatrix} 0 & 1 \\ -1 & -1 \end{pmatrix}$

$(ST)^8 = \begin{pmatrix} 0 & 1 \\ -1 & -1 \end{pmatrix} \begin{pmatrix} 0 & 1 \\ -1 & -1 \end{pmatrix} = \begin{pmatrix} -1 & -1 \\ 1 & 0 \end{pmatrix}$

$(ST)^6 = I \Rightarrow m = 2 + 6n \quad \therefore$ Option (C) is incorrect

D) $H = \{x+iy, x, y \in R, y > 0\}$

$Z \in H$ i.e., $y > 0$

$\frac{az+b}{cz+d} = \frac{-1}{z+1} = \frac{-1}{x+1+iy} = \frac{-(x+1)+iy}{(x+1)^2+y^2} \in H \quad \therefore$ Option (D) is correct



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SECTION-III
(NUMERICAL VALUE)

This section contains **FIVE (05)** questions.

- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value corresponding to the answer in the designated place using the mouse and the on-screen virtual numeric keypad.
- If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places.
- Answer to each question will be evaluated **according to the following marking scheme:**

Full Marks : +4 If **ONLY** the correct numerical value is entered in the designated place;

Zero Marks : 0 In all other cases.

10. Let \mathbb{N} denotes the set of all positive integers. Consider the sets

$$A = \{1, 2, 3, 4, 5\} \text{ and } B = \{1, 2, 3, 4, 5, 6, 7\}.$$

Let S be the set of all functions $f: A \rightarrow B$ such that $f(2) \neq 2$ and $f(4) \neq 4$. Consider the

$$\text{set } T = \left\{ f \in S : \text{there exists a function } g: B \rightarrow \mathbb{N} \text{ such that } g(f(x)) = 2^x \text{ for all } x \in A \right\}.$$

Then the number of elements in the set T is _____.

Ans: 1860

SOL: $A = \{1, 2, 3, 4, 5\}, \quad B = \{1, 2, 3, 4, 5, 6, 7\}$

$$f(2) \neq 2, \quad f(4) \neq 4$$

$$g(f(x)) = 2^x \forall x \in A$$

$f(x)$ to be one-one mapping

$$f(2) \neq 2, f(4) \neq 4 \quad f(2) = 4, f(4) = 2$$

$${}^6C_1 \times {}^5C_1 \times {}^5C_3 \times 3! + {}^5C_3 \times 3! = 1800 + 60 = 1860$$

11. A bookshelf contains 6 distinct books of Mathematics and 5 distinct books of Physics. From these 11 books, 6 books are chosen at random. Let X be the absolute value of the difference between the number of Mathematics books chosen and the number of Physics books chosen. If α is the mean of the random variable X , then the value of 77α is _____.

ANS:100










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SOL: 6 maths BOOKS, 5 physics books Number of ways of selecting 6 books = ${}^{11}C_6$

$X = x_i$	6	4	2	0
$P(X = x_i)$	$\frac{1}{{}^{11}C_6}$	$\frac{{}^6C_5 \cdot {}^5C_1 + {}^5C_5 \cdot {}^6C_1}{{}^{11}C_6}$	$\frac{{}^6C_4 \cdot {}^5C_2 + {}^5C_4 \cdot {}^6C_2}{{}^{11}C_6}$	$\frac{{}^6C_3 \cdot {}^5C_3}{{}^{11}C_6}$

$$\alpha = \frac{6 + 4({}^6C_5 \cdot {}^5C_1 + {}^5C_5 \cdot {}^6C_1) + 2({}^6C_4 \cdot {}^5C_2 + {}^5C_4 \cdot {}^6C_2) + 0}{{}^{11}C_6}$$

$$\alpha = \frac{600}{462} \Rightarrow 77\alpha = 100$$

12. Consider a data consisting of 10 observations x_1, x_2, \dots, x_{10} , whose mean is 5 and variance is 7. If the mean and the variance of the first 8 observations x_1, x_2, \dots, x_8 are 4 and 3.5, respectively, and $x_9 < x_{10}$, then the value of $3x_9 + 2x_{10}$ is _____.

Ans: 44

Sol: $\frac{x_1 + x_2 + \dots + x_{10}}{10} = 5, \frac{x_1^2 + x_2^2 + \dots + x_{10}^2}{10} - 25 = 7$

$$\frac{x_1 + x_2 + \dots + x_8}{8} = 4, \frac{x_1^2 + x_2^2 + \dots + x_8^2}{8} - 16 = \frac{7}{2}$$

$$\Rightarrow x_9 + x_{10} = 18 \text{ and } x_9^2 + x_{10}^2 = 164$$

$$\therefore x_9 < x_{10}, x_9 = 8, x_{10} = 10 \quad 3x_9 + 2x_{10} = 44$$

13. Consider the ellipse E given by $\frac{x^2}{18} + \frac{y^2}{12} = 1$. Let H be the hyperbola whose eccentricity is the reciprocal of the eccentricity of E and whose foci are the same as that of E. Let P and Q be the points of intersection of H and the parabola $\sqrt{5}y = x^2$ in the first quadrant. Let d be the distance between P and Q.

If a and b are the integers such that $d^2 = a + b\sqrt{5}$, then the value of $a - b$ is _____.

Ans: 18










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SOL: e of ellipse $= \sqrt{1 - \frac{12}{18}} = \frac{1}{\sqrt{3}}$

Foci of ellipse: $ae = \sqrt{6} \Rightarrow F(\pm\sqrt{6}, 0)$

Hyperbola: foci: $\Rightarrow (\pm\sqrt{6}, 0)$

$e = \sqrt{3} \Rightarrow A = \sqrt{2}, B = 2 \quad \frac{x^2}{2} - \frac{y^2}{4} = 1$

$\sqrt{5}y = x^2$ solve with hyperbola

$\frac{\sqrt{5}y}{2} - \frac{y^2}{4} = 1 \Rightarrow y = \sqrt{5} + 1$ or $\sqrt{5} - 1$

$P \& Q: (\sqrt{5 + \sqrt{5}}, \sqrt{5} + 1) \& (\sqrt{5 - \sqrt{5}}, \sqrt{5} - 1)$

$d^2 = (x_1 - x_2)^2 + (y_1 - y_2)^2$
 $= 5 + \sqrt{5} + 5 - \sqrt{5} - 225 - 5 + 4 = 10 - 2\sqrt{20} + 4 = 14 - 4\sqrt{5}$

$a = 14, b = -4, (a - b) = 18$

14. For a real number α , let $[\alpha]$ denote the greatest integer less than or equal to α . For a finite set S , let $|S|$ denote the number of elements in the set S .

Consider the function $f: (-3, 3) \rightarrow (-\infty, \infty)$ and $g: (-3, 3) \rightarrow (-\infty, \infty)$ defined by

$f(x) = [x^3] \log_e (1 + \sin^2(\pi(x - [x])))$ and $g(x) = x^3 \sin^2(\pi \log_e (1 + x - [x]))$.

Let $A = \{x \in (-3, 3) : f \text{ is discontinuous at } x\}$

and $B = \{x \in (-3, 3) : g \text{ is discontinuous at } x\}$.

Then the value of $|A| + 2|B| - |A \cap B|$ is _____.

Ans: 56










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Sol: $f(x) = [x^3] \log_e (1 + \sin^2 \pi (x - [x]))$

$[x^3]$ discontinuous at all integers in $[-26, 26] = 53$ points

But continuous at $-2, -1, +1, +2, 0$

$|A| = 48$ points

$g(x) = x^3 \sin^2 (\pi \log_e (1 + x - [x]))$

$g(x)$ discontinuous at $-2, -1, 1, 2$

$|B| = 4$

$\Rightarrow |A| + 2|B| - |A \cap B| = 48 + 2(4) - 0 = 56$

SECTION – IV
(PARAGRAPH WITH NUMERICAL VALUE TYPE)

- This section contains **TWO (02)** question stems.
- There are **TWO (02)** questions corresponding to each question stem.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value corresponding to the answer in the designated place using the mouse and the on-screen virtual numeric keypad.
- If the numerical value has more than two decimal places, truncate/round-off the value to **TWO** decimal places.
- Answer to each question will be evaluated according to the following marking scheme:
Full Marks : +2 If **ONLY** the correct numerical value is entered at the designated place;
Zero Marks : 0 In all other cases.

Question Stem for Question Nos. 15 and 16

Consider the curve C_1 given by

$y = e^{-x}$ for $x \in [0, 10\pi]$,

and the curve C_2 given by

$y = e^{-x} (\sin x + \cos x)$ for $x \in [0, 10\pi]$.

Let n be the total number of points of intersection of the curves C_1 and C_2 .

Suppose that $\alpha_1, \alpha_2, \dots, \alpha_n \in [0, 10\pi]$ are the x-coordinates of the points of intersection of the curve C_1 and C_2 such that

$\alpha_1 < \alpha_2 < \dots < \alpha_n$.

15. The value of n is _____.

Ans: 11









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SOL:

$$C_1 : y = e^{-x}$$

$$C_2 : y = e^{-x}(\sin x + \cos x), x \in [0, 10\pi]$$

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

$$\Rightarrow \sin x + \cos x = 1 \Rightarrow \sqrt{2} \sin x \left(x + \frac{\pi}{4} \right) = 1$$

$$\Rightarrow \sin \left(x + \frac{\pi}{4} \right) = \frac{1}{\sqrt{2}}, x + \frac{\pi}{4} \in \left[\frac{\pi}{4}, 10\pi + \frac{\pi}{4} \right]$$

$$\Rightarrow x + \frac{\pi}{4} = \frac{\pi}{4}, \pi - \frac{\pi}{4}, 2\pi + \frac{\pi}{4}, \dots, 10\pi + \frac{\pi}{4}$$

16. Let β be the area of the region enclosed between the curves C_1, C_2 , and the lines

$$x = \alpha_1 \text{ and } x = \alpha_4. \text{ Then the value of } -\frac{1}{\pi} \log_e \left(\beta - 2e^{-\frac{\pi}{2}} \right) \text{ is } \underline{\hspace{2cm}}.$$

Ans: 2.50

Sol: $\alpha_1 = 0, \alpha_4 = \frac{5\pi}{2}$

$$\beta = \int_0^{\frac{5\pi}{2}} e^{-x} |\sin x + \cos x - 1| dx$$

$$= \int_0^{\frac{\pi}{2}} e^{-x} (\sin x + \cos x - 1) dx + \int_{\frac{\pi}{2}}^{2\pi} e^{-x} (1 - \sin x - \cos x) dx + \int_{2\pi}^{\frac{5\pi}{2}} e^{-x} (\sin x + \cos x - 1) dx$$

$$= \left[e^{-x} (1 - \cos x) \right]_0^{\frac{\pi}{2}} + \left[e^{-x} (\cos x - 1) \right]_{\frac{\pi}{2}}^{2\pi} + \left[e^{-x} (1 - \cos x) \right]_{2\pi}^{\frac{5\pi}{2}}$$

$$= e^{-\frac{\pi}{2}} + \left(e^{-\frac{\pi}{2}} \right) + e^{-\frac{5\pi}{2}} \Rightarrow -\frac{1}{\pi} \ln \left(\beta - 2e^{-\frac{\pi}{2}} \right) = \frac{5}{2}$$









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Question Stem for Question Nos. 17 and 18

Consider the ellipses given by $x^2 + 4y^2 = 1$ and $4x^2 + y^2 = 1$.

17. Let P be the point in the first quadrant where the given ellipses intersect. If θ is the acute angle between the tangents to the given ellipses at the point P, then the value of $4 \tan \theta$ is _____.

Ans:7.50

Sol: $x^2 + 4y^2 = 1, 4x^2 + y^2 = 1$

$$\Rightarrow x_1^2 = y_1^2 = \frac{1}{5}$$

$P(x_1, y_1)$ is point of intersection

$$P \text{ is } \left(\frac{1}{\sqrt{5}}, \frac{1}{\sqrt{5}} \right)$$

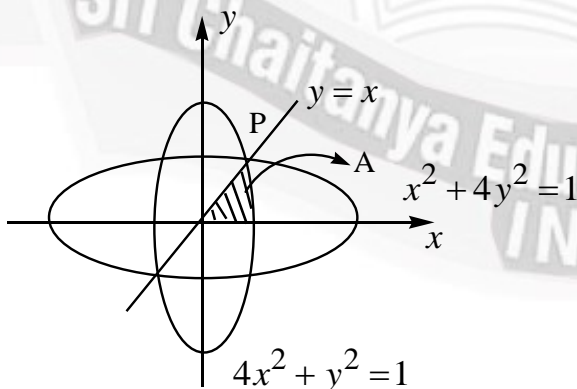
Tangents will be $\frac{1}{\sqrt{5}}x + \frac{4y}{\sqrt{5}} = 1, \frac{4x}{\sqrt{5}} + \frac{y}{\sqrt{5}} = 1$

$$\Rightarrow \text{Slopes are } \frac{-1}{4}, -4 \Rightarrow \tan \theta = \frac{\left| \frac{-1}{4} - (-4) \right|}{1+1} = \frac{15}{8} \Rightarrow 4 \tan \theta = 7.50$$

18. If α is the area of the common region that lies inside both the given ellipses, then the value of $\cot \alpha$ is _____.

Ans:0.75

Sol:











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$$\text{Required Area} = 8A = 8 \left[\frac{1}{2} \left(\frac{1}{\sqrt{5}} \right) \left(\frac{1}{\sqrt{5}} \right) + \int_{\frac{1}{\sqrt{5}}}^{\frac{1}{2}} \sqrt{1-4x^2} dx \right]$$

$$\int_{\frac{1}{\sqrt{5}}}^{\frac{1}{2}} \sqrt{\frac{1}{4} - x^2} dx = \left[\frac{x}{2} \sqrt{\frac{1}{4} - x^2} + \frac{1}{8} \sin^{-1}(2x) \right]_{\frac{1}{\sqrt{5}}}^{\frac{1}{2}}$$

$$= 0 + \frac{\pi}{16} - \frac{1}{20} - \frac{1}{8} \sin^{-1} \left(\frac{2}{\sqrt{5}} \right)$$

$$\therefore 8A = 8 \left[\frac{1}{10} + \frac{\pi}{8} - \frac{1}{10} - \frac{1}{4} \sin^{-1} \left(\frac{2}{\sqrt{5}} \right) \right]$$

$$= \pi - 2 \sin^{-1} \left(\frac{2}{\sqrt{5}} \right) = \alpha = \pi - 2 \tan^{-1}(2)$$

$$\Rightarrow \cot \alpha = \cot \left(\pi - 2 \tan^{-1} 2 \right) = -\cot \left(2 \tan^{-1} 2 \right) = \frac{3}{4}$$



PHYSICS

Max Marks: 60

SECTION – I
(SINGLE CORRECT ANSWER TYPE)This section contains **FOUR (04)** questions.

- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +3 If **ONLY** the correct option is chosen;**Zero Marks** : 0 If none of the options is chosen (i.e. the question is unanswered);**Negative Marks** : -1 In all other cases.

19. A metal wire of cross-sectional area 0.5 mm^2 and length 100 m is connected across a battery of e.m.f. 2 V and internal resistance 1Ω . The density, atomic mass and electrical conductivity of the metal are $6.35 \times 10^3 \text{ kg m}^{-3}$, and $2 \times 10^8 \text{ mho m}^{-1}$, respectively. Assuming one conduction electron per atom of the metal, the drift velocity (in mm s^{-1}) of the electrons in the wire is:

[Take Avogadro's number as 6×10^{23} and charge of the electron as $1.6 \times 10^{-19} \text{ C}$.]

- A) 0.052 B) 0.104 C) 0.208 D) 0.156

Ans: C

Sol: Resistance of wire is $R = \frac{L}{\sigma A} = \frac{100}{2 \times 10^8 \times .5 \times 10^{-6}} = 1\Omega$

Current in the wire $I = nAV_d e = \frac{2V}{1\Omega + 1\Omega} = 1A$

Here n = no of electrons/volume = no of atoms/volume

$$= \frac{6.35 \times 10^3 \times 10^3 \times 6 \times 10^{23}}{63.5} = 6 \times 10^{28}$$

So $1A = (6 \times 10^{28} \times .5 \times 10^{-6} \times V_d \times 1.6 \times 10^{-19}) A$

$$\Rightarrow V_d = 2.08 \times 10^{-4} \text{ m / sec}$$

$$= 0.208 \text{ mm / sec}$$









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20. A nuclear reactor starts producing a radioactive nuclide X from $t = 0$, at a constant rate of α per second. Each decay of X produces energy E_0 , which is utilized to heat a liquid of mass m and specific heat s . Assuming no heat loss from the liquid and taking λ as the decay constant of X, the rate of increase in the temperature of the liquid is:

- A) $\frac{\alpha E_0}{ms} (1 - e^{-\lambda t})$ B) $\frac{\alpha E_0}{ms} (e^{\lambda t} - t)$
 C) $\frac{\lambda E_0}{ms} (1 - e^{-\lambda t})$ D) $\frac{E_0}{ms} (\alpha - \lambda e^{-\lambda t})$

Ans: a

Sol:

Rate of production is α .

Say concentration of x at same time $t = N$.

Then $dN = \alpha dt - \lambda N dt$

$$\Rightarrow \int_0^N \frac{dN}{\alpha - \lambda N} = \int_0^t dt \qquad \Rightarrow N = \frac{\alpha}{\lambda} (1 - e^{-\lambda t})$$

$$\begin{aligned} \text{No of nuclei decaying in time } dt &= \lambda N dt = \lambda \frac{\alpha}{\lambda} (1 - e^{-\lambda t}) dt \\ &= \alpha (1 - e^{-\lambda t}) dt \end{aligned}$$

$$\text{So energy released} = E_0 \alpha (1 - e^{-\lambda t}) dt = ms d\theta \qquad \Rightarrow \frac{d\theta}{dt} = \frac{E_0 \alpha}{ms} (1 - e^{-\lambda t})$$

21. A beam of polychromatic light passes through a thin prism of prism angle β° . The refractive index of the metal of the prism varies with wavelength (λ) as $n(\lambda) = \alpha \lambda + \frac{\beta}{\lambda^2}$, where $\alpha = 3 \mu\text{m}^{-1}$ and $\beta = 0.096 \mu\text{m}^2$. If λ_{\min} is the wavelength at which the angle of minimum deviation D_m is smallest, then the correct value of D_m at λ_{\min} is

- A) 6.4° B) 4.8° C) 3.2° D) 2.4°

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Ans: B

Sol:

As angle of prism is small

$$D_m = (n-1)A$$

$$= \left(\alpha\lambda + \frac{\beta}{\lambda^2} - 1 \right) A$$

Where δ_m is smallest $\frac{d}{d\lambda}(D_m) = 0 \Rightarrow \alpha - \frac{2\beta}{\lambda^3} = 0$

$$\Rightarrow \lambda^3 = \frac{2\beta}{\alpha} = \frac{2 \times 0.096 \mu m^2}{3 \mu m^{-1}} \Rightarrow \lambda = 0.4 \mu m$$

Value of n for $\lambda = 0.4 \mu m = 3 \times 0.4 + \frac{0.96}{(4)^2} = 1.8$

Hence $D_m = (1.8 - 1)6^\circ = 4.8^\circ$

22. The particle of mass m , and angular momentum ℓ is moving in a circular orbit of radius r_0 under the influence of an attractive force $\vec{F}(r) = -\frac{k}{r^2} \hat{r}$. Keeping its angular momentum unchanged, the particle is displaced radially by a small distance $\delta r \ll r_0$, due to which its radial distance varies periodically. The corresponding time period is:

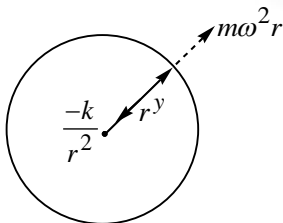
- A) $\frac{2\pi\ell^3}{mk^2}$ B) $2\pi\sqrt{\frac{m}{k}}$ C) $\frac{2\pi\ell^3}{3mk^2}$ D) $\frac{2\pi\ell^3}{5mk^2}$

Ans: A

Sol:

Solving in rotating frame fixed to axis of rotation.

$$\text{Total force} = \vec{F} = \left(m\omega^2 r - \frac{k}{r^2} \right) \hat{r}$$





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When $F = 0$; equilibrium radius is r_0 . $m\omega^2 r_0 - \frac{k}{r_0^2} = 0 \Rightarrow r_0 = \frac{\ell^2}{mk}$.

As $l = mr^2\omega \Rightarrow \omega = \frac{\ell}{mr^2}$

So $F = \frac{m\ell^2}{m^2r^4}r - \frac{k}{r^2} = \frac{\ell^2}{mr^3} - \frac{k}{r^2} \Rightarrow \frac{\partial F}{\partial r} = \frac{-3\ell^2}{mr^4} + \frac{2k}{r^3}$

Putting $r = r_0$ we will get $\frac{\partial F}{\partial r} = \left(\frac{-3\ell^2}{3\left(\frac{\ell}{mk}\right)^4} + \frac{2k}{\left(\frac{\ell^2}{mk}\right)^3} \right) dr = \frac{-m^2k^4}{\ell^6} dr$

So angular frequency $\omega = \frac{m^2k^4}{\ell^6}$

Time period = $\frac{2\pi\ell^3}{mk^2}$

SECTION – II
(ONE OR MORE CORRECT ANSWER TYPE)

This section contains **FIVE (05)** questions.

- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks :+4 ONLY if (all) the correct option(s) is(are) chosen;

Partial Marks: +3 If all the four options are correct but **ONLY** three options are chosen;

Partial Marks: +2 If three or more options are correct but **ONLY** two options are chosen, both of which are correct;

Partial Marks: +1 If two or more options are correct but **ONLY** two options are chosen, and it is a correct option;

Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);

Negative Marks : -2 In all other cases.

For example, in a question, if (A), (B) and (D) are the **ONLY** three options corresponding to correct answers, then choosing **ONLY** (A), (B) and (D) will get +4 marks; choosing **ONLY** (A) and (B) will get +2 marks; choosing **ONLY** (A) and (D) will get +2 marks; choosing **ONLY** (B) and (D) will get +2 marks; choosing **ONLY** (A) will get +1 mark; choosing **ONLY** (B) will get +1 mark; choosing **ONLY** (D) will get +1 mark; choosing no option (i.e. the question is unanswered) will get 0 marks; and choosing any other combination of options will get -2 marks.

23. Consider two isosceles prisms 1 and 1 with prism angles A_1 and A_2 and refractive indices n_1 and n_2 , respectively, as shown in the figure. The faces a_1b_1 and a_2b_2 are parallel to each other and perpendicular to the mirror M. If a ray of light is incident on the face a_1c_1 and emerges from the face a_2c_2 , then the correct statement(s) is/are:



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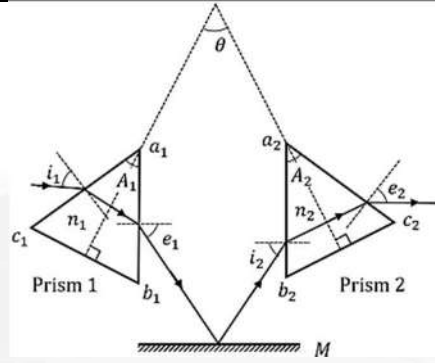
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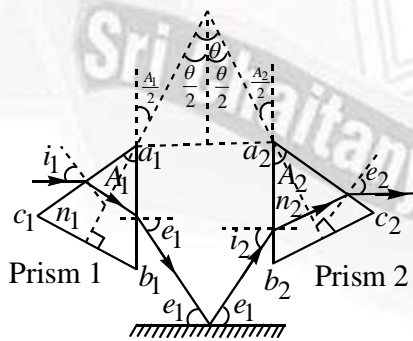
- A) If both the prisms are at minimum deviation condition, then $\frac{n_2}{n_1} = \sin\left(\frac{A_1}{2}\right) / \sin\left(\frac{A_2}{2}\right)$.
- B) If prism 2 is at minimum deviation condition then is $i_1 = n_2 \sin\left(\frac{A_2}{2}\right)$ always true.
- C) If both the prisms 1 and 2 are thin and are at minimum deviation condition with angles of deviation δ_{m1} and δ_{m2} , respectively, then $\theta = \frac{\delta_{m1}}{2(n_1 - 1)} + \frac{\delta_{m2}}{2(n_2 - 1)}$.
- D) If prism 1 is at minimum deviation condition, then $i_2 = n_1 \sin\left(\frac{A_1}{2}\right)$ is always true.

Ans: ACD

Sol: From geometry $i_1 = e_1 = i_2 = e_2$

$$\frac{\theta}{2} = \frac{A_1}{2} = \frac{A_2}{2} \Rightarrow \theta = \frac{A_1}{2} + \frac{A_2}{2}$$

$$\frac{\sin i_1}{\sin \frac{A_1}{2}} = n_1 \text{ and } \frac{\sin i_2}{\sin \frac{A_2}{2}} = n_2 \Rightarrow \frac{n_2}{n_1} = \frac{\sin \frac{A_1}{2}}{\sin \frac{A_2}{2}}$$



If prisms are thin, then $\delta_1 = (n_1 - 1)A_1$ and $\delta_2 = (n_2 - 1)A_2$

$$\text{So } \theta = \frac{A_1}{2} + \frac{A_2}{2} = \frac{\delta_1}{2(n_1 - 1)} + \frac{\delta_2}{2(n_2 - 1)}$$



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24. In a vacuum chamber, a particle of charge $1\mu C$ and mass 1 mg is projected with a velocity $(\hat{i} + 2\hat{j})ms^{-1}$ from the XZ plane at time $t = 0$ in an electric field of $1\hat{i}Vm^{-1}$. At $t = 0.2\text{ s}$, the electric field is switched off and a magnetic field of $6\hat{j}T$ is switched on. The acceleration due to gravity is $-10\hat{j}ms^{-2}$. Correct option(s) is/are:
- A) The vertical distance of the particle from the XZ plane at $t = 0.3\text{ s}$ is 15 cm .
 - B) The vertical distance of the particle from the XZ plane at $t = 0.4\text{ s}$ is 10 cm .
 - C) The radius of the trajectory of the particle for $t > 0.2\text{ s}$ is 20 cm .
 - D) The particle will be in the XZ plane at $t = 0.35\text{ s}$.

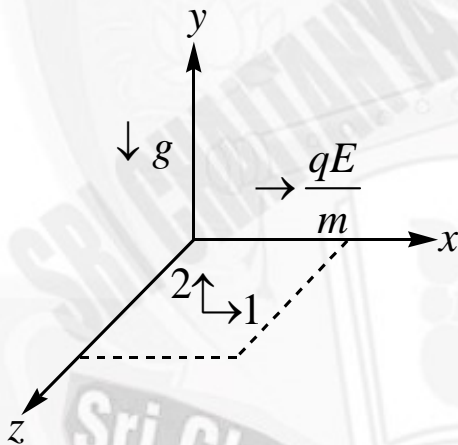
Ans: A

Sol: Initial velocity of particle $= (\hat{i} + 2\hat{j})m/\text{sec}$

Acceleration of particle till 0.2 sec in $a_x = \frac{qE}{m} = \frac{10^{-6} \times 1}{10^{-6}} = 1m/\text{sec}^2$

$a_y = -10m/\text{sec}^2$

After 0.2 sec particle will move in helical path with varying pitch.



Along y-axis is always $-10m/\text{sec}^2$

So $y = 2t - \frac{1}{2} \times 10 \times t^2 = 2t - 5t^2$

Putting $t = 0.3\text{ sec}$, $y = 15\text{m} = 15\text{cm}$

$t = 0.4\text{ sec}$, $y = 0$

After 0.2sec path is a helical path with variable pitch. Radius of curvature is variable with time. So option "C" is wrong.









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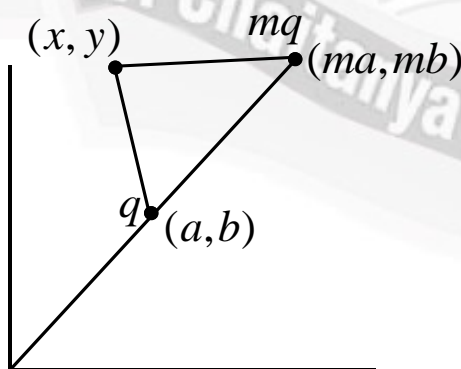
25. Two charges $Q_1 = q$ and $Q_2 = mq$ are placed at the points $P_1(a, b)$ and $P_2(ma, mb)$, respectively, in the XY plane, where $a, b \neq 0$ and $m \neq 0$. If V_1 is the potential at a point in the XY plane due to charge Q_1 and V_2 is the potential at that point due to charge Q_2 . Correct statement(s) for the points at which $|V_1| = |V_2|$ is/are:
- A) For $m = -1$, locus of these points is $ax + by = 0$.
 - B) For $m = 2$, the locus of these points is a circle of radius $\frac{2}{3}\sqrt{a^2 + b^2}$ centred at $(\frac{2}{3}a, \frac{2}{3}b)$.
 - C) For $m = -2$, the locus of these points is a circle of radius $2\sqrt{a^2 + b^2}$ centred at $(2a, 2b)$.
 - D) For $m = -3$, locus of these points is $3bx + 3ay = 0$.

Ans: ABC

Sol: $V_1 = \frac{kq}{\sqrt{(x-a)^2 + (y-b)^2}}$ and $V_2 = \frac{kmq}{\sqrt{(x-ma)^2 + (y-mb)^2}}$

If $|V_1| = |V_2|$

$$\frac{1}{(x-a)^2 + (y-b)^2} = \frac{m^2}{(x-ma)^2 + (y-mb)^2}$$



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$$\Rightarrow (x - ma)^2 + (y - mb)^2 = m^2 \{ (x - a)^2 + (y - b)^2 \}$$

Putting $m = -1$, we get $ax + by = 0$

Putting $m = 2$, we get $x^2 + y^2 - \frac{4a}{3}x - \frac{4b}{3}y = 0$

So $g = \frac{-2a}{3}, f = \frac{-2b}{3}, c = 0$

Hence centre in at $\left(\frac{2a}{3}, \frac{2b}{3}\right)$ and $r = \frac{2}{3}\sqrt{a^2 + b^2}$

Putting $m = -2$, we get $x^2 + y^2 - 4ax - 4by = 0$

Hence centre is at $(2a, 2b)$ and $r = 2\sqrt{a^2 + b^2}$

26. Consider an electric dipole comprising two charges $+q$ and $-q$ each with mass m , separated by a fixed distance d and initially at rest with its dipole moment pointing along \hat{i} . A uniform electric field $E\hat{J}$ is turned on at time $t = 0$ and it is turned off at $t = t_f$, when the dipole moment makes an angle θ_f with \hat{i} . Neglecting any sources of energy loss, correct option(s) is/are:

A) The center of mass of the dipole is deflected towards \hat{J} in the presence of the field.

B) If the magnitude of the final angular velocity $\omega_f = \sqrt{\frac{2qE}{md}}$, then $\theta_f = \frac{\pi}{6}$.

C) If $\theta_f = \pi/3$, then the change in kinetic energy of the dipole is given by $2\sqrt{3}qEd$.

D) For $\theta_f = \pi/4$, the dipole rotates around its center of mass with a constant angular velocity after $t < t_f$.

Ans: BD

Sol: As field in uniform, net force is zero.

Hence centre of mass will not deflect.

$$P.E = -\vec{P} \cdot \vec{E} = U$$

$$V_i = 0, V_f = -PE \cos(90 - \theta) = -PE \sin \theta_f$$

For $\theta_f = \pi/6$, loss in $P.E = \frac{PE}{2}$





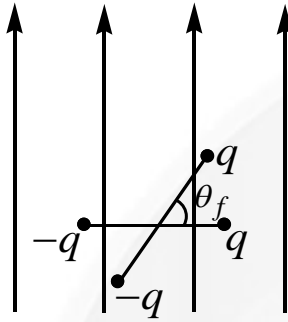





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Hence $\frac{1}{2} \times \frac{md^2}{2} \times \omega^2 = \frac{PE}{2} = \frac{qdE}{2} \Rightarrow \omega = \sqrt{\frac{2qe}{md}}$



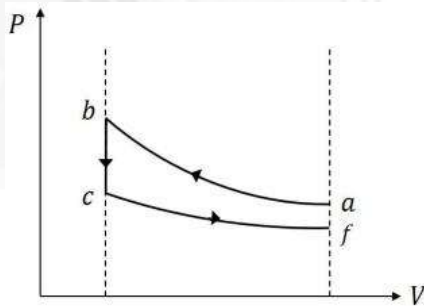
For $\theta_f = \pi / 6$, charge in $K.E = PE \frac{\sqrt{3}}{2} = \frac{\sqrt{3}}{2} qEd$

For $\theta_f = \pi / 4$ dipole has an angular velocity with remain constant.

27. Ten moles of an ideal monoatomic gas, initially in state a at atmospheric pressure and temperature $T_a = 27^\circ C$, is enclosed in a metal cylinder of volume V_0 fitted with a frictionless piston. The gas is suddenly compressed to state b with volume $V_0 / 3$. Now, keeping the piston stationary, the cylinder is submerged in a water bath of temperature $11^\circ C$ until the gas reaches the temperature of the water bath, which is denoted as state c. Finally, while in the water bath, the piston is brought slowly to its initial position, which is denoted as state f. If R is universal gas constant, then the correct option(s) is/are:

[Given: $9^{1/3} = 2.08$]

A) The schematic P-V diagram of the processes described above is:



- B) The change in internal energy in going from state a to b is $4860R$.
 C) The net change in the internal energy in the whole process is $-240R$.
 D) The pressure and temperature of the state b are 2.08 times the atmospheric pressure and 624 K, respectively.

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Ans: ABC

Sol: $a \rightarrow b$ is adiabatic process (suddenly compressed)

$b \rightarrow c$ is isochoric process (held)

$c \rightarrow f$ is isothermal process (slow process with conducting vessel)

$$\text{For } a \rightarrow b \quad P_b = P_0 \left(\frac{V_0}{V_0/3} \right)^r = P_0(3)^x = P_0 3^{5/3}$$

$$T_b = T_0(3)^{r-1} = T_0(3)^{2/3} = T_0(9)^{1/3} = 2.08 \times 300 = 624 \text{ K}$$

$$(\Delta V)_{ab} = 10 \times \frac{3R}{2} \times 324 = 4860R$$

Final temp is 11°C

$$\text{So total change in internal energy} = 10 \times \frac{3R}{2} \times (-16) = -240R$$

SECTION-III (NUMERICAL VALUE)

This section contains **FIVE (05)** questions.

- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value corresponding to the answer in the designated place using the mouse and the on-screen virtual numeric keypad.
- If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places.
- Answer to each question will be evaluated **according to the following marking scheme**:

Full Marks : +4 If **ONLY** the correct numerical value is entered in the designated place;

Zero Marks : 0 In all other cases.

28. Two thin wires, Wire-1 of diameter 0.650 mm and Wire-2 of unknown diameter d are given. To obtain the value of d , the diameter of the two wires are measured with a screw gauge. The screw gauge has a pitch of 0.5 mm and there are 100 divisions on the circular scale (CS). The smallest division on the linear scale (LS) is 0.5 mm. The table shows the readings of LS and CS for the measurements. The value of d (in μm) is:

	Readings	
	LS (mm)	CS
Wire-1	0.5	42
Wire-2	1.5	95









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Ans: 1915**Sol:** For wire 1, diameter $= 0.5 + 42 \times .005 = 0.71 \text{ mm}$

Hence instrument has +Ve zero error of $(0.71 - .650) \text{ mm}$
 $= .060 \text{ mm}$

For wire 2, diameter $= 1.5 + (95 \times .005) - .060 = 1.915 \text{ mm}$
 $= 1915 \mu\text{m}$

- 29.** In a single slit diffraction experiment, a slit of width $(0.016 \pm 0.002) \text{ mm}$ is used to measure the wavelength of a monochromatic light source. In the diffraction pattern, the angular distance between the central maximum and first minimum is measured to be $(2^\circ \pm 40')$. The value of the fractional error in the measurement of wavelength is:

[Given: $\sin(2^\circ) = 0.035$]

Ans: 0.46

Sol: $\sin \theta = \frac{\lambda}{a} \Rightarrow \lambda = a \sin \theta$

$$\Rightarrow d\lambda = a \cos \theta d\theta + \sin \theta \cdot da \Rightarrow \frac{d\lambda}{\lambda} = \cot \theta \cdot d\theta + \frac{da}{a}$$

$$= \frac{\sqrt{1 - (.035)^2}}{.035} \times \frac{2}{3} \times \frac{\pi}{180} + \frac{.002}{.016}$$

$$= .457 \approx .46$$

- 30.** As shown in the figure, a ray AB of unpolarized light enters from water of refractive index $n_w = 4/3$ into a medium of refractive index $n_p = 4/\sqrt{3}$ after passing through a glass plate of refractive index $n_g = 1.5$ and a layer of water. At a particular incident angle i the reflected ray CD is polarized in the direction as shown in the figure. The value of i (in degrees) is:





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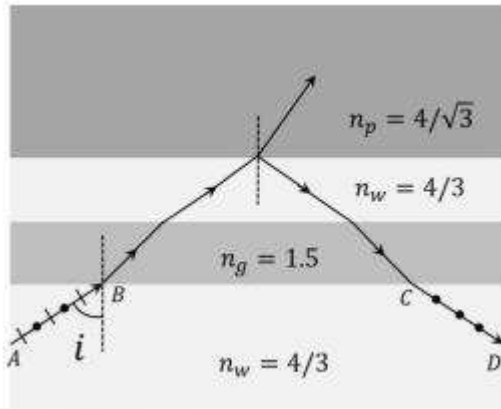
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Ans: 60

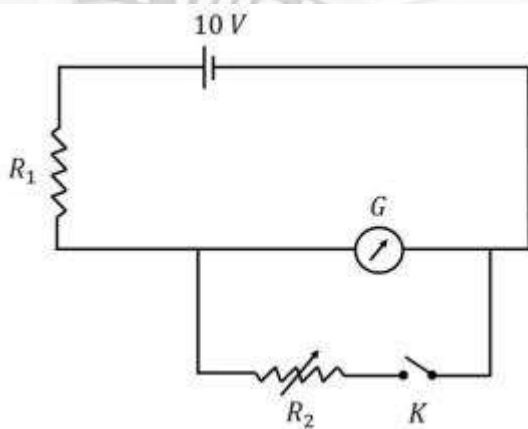
Sol: For polarization by reflection $\frac{\sin \theta}{\cos \theta} = \frac{4 / \sqrt{3}}{4 / 3}$

$$\Rightarrow \tan \theta = \sqrt{3} \quad \Rightarrow \theta = 60^\circ$$

Again $n \sin \theta = \text{const}$

$$\frac{4}{3} \sin \theta = \frac{4}{3} \sin i \quad \Rightarrow i = 60^\circ$$

31. As shown in the figure, the resistance of a galvanometer G can be found by the half-deflection method. Here the resistance R_2 is adjusted such that when the key K is closed the deflection in the galvanometer becomes half of the value as compared to when K is open. Half-deflection is obtained at $R_2 = 4\Omega$ and thus the galvanometer resistance is found to be 6Ω . In this half-deflection condition the current (in mA) through the resistor R_1 is:





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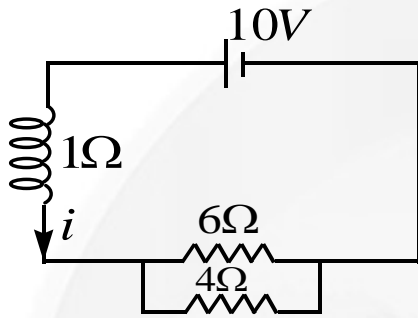
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Ans: 694.44

Sol: For half deflection method $G = \frac{RS}{R-S}$

Here $G = 6\Omega, R = R_1, S = R_2 = 4\Omega$



$$\Rightarrow 6 = \frac{R_1 \times 4}{R_1 - 4} \Rightarrow 6R_1 - 4R_1 = 24 \quad \Rightarrow R_1 = 12\Omega$$

$$i = \frac{10}{12 + \frac{6 \times 4}{6 + 4}} A = \frac{10}{14.4} A = 0.69444 A = 694.44 mA$$

32. In a new system of units, the units of mass, length, time and current are 5 kg, 5m, 5s and 5A, respectively. If μ_0 and ϵ_0 are the permeability and permittivity of free space, respectively, then in this new system of units, the magnitude of one SI unit of $\sqrt{\mu_0/\epsilon_0}$, is:

Ans: 25

Sol: $X = \sqrt{\frac{\mu_0}{\epsilon_0}} = \mu_0 \frac{1}{\sqrt{\epsilon_0 \mu_0}} = \mu_0 C$

Dimension of μ_0 is $MLT^{-2}A^{-2}$

Hence dimension of X is $ML^2T^{-3}A^{-2}$

Hence $1(kgm^2s^{-3}A^{-2}) = x(5kg)(25m^2)\left(\frac{1}{125}s^{-3}\right)\left(\frac{1}{25}A^{-2}\right) \Rightarrow x = 25$



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SECTION – IV
(PARAGRAPH WITH NUMERICAL VALUE TYPE)

- This section contains **TWO (02)** question stems.
- There are **TWO (02)** questions corresponding to each question stem.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value corresponding to the answer in the designated place using the mouse and the on-screen virtual numeric keypad.
- If the numerical value has more than two decimal places, truncate/round-off the value to **TWO** decimal places.
- Answer to each question will be evaluated according to the following marking scheme:

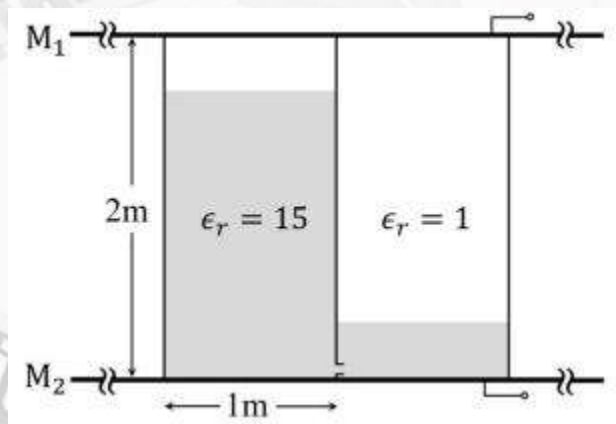
Full Marks : +2 If **ONLY** the correct numerical value is entered at the designated place;

Zero Marks : 0 In all other cases.

Question Stem for Question Nos. 33 and 34

A container of height 2m, length 2m and breadth 1m is made of insulating vertical walls and two large area horizontal metal plates (M_1 and M_2) which extend far beyond the vertical walls in all directions. The container is partitioned into two equal chambers with a thin insulating vertical wall. The partition wall contains a small hole of cross-sectional area $\sqrt{10} \text{ cm}^2$ near its bottom edge. Initially the hole is closed and left chamber of the container is completely filled with a liquid of dielectric constant $\epsilon_r = 15$ and the chamber to the right chamber. In both the chambers, the space above the liquid has $\epsilon_r = 1$ and is maintained at atmospheric pressure. The schematic of the container at a time $t > 0$ is shown in the figure.

[Given: acceleration due to gravity is 10 ms^{-2} .]



33. The height (in m) of the liquid in left chamber at $t = 500 \text{ s}$ is:

Ans: 1.25

34. The difference in the capacitance (in F) between the metal plates at $t = 0$ and that at $t = 500 \text{ s}$ is $(8-n)\epsilon_0$, where ϵ_0 is the permittivity of free space. The value of n is:

Ans: 1.97









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Sol: 33 & 34

Velocity of flow $(2 - y)pg - ypg = \frac{1}{2}pv^2$

$\Rightarrow v = \sqrt{4g(1 - y)}$

Now $avdt = dy \times 1$ (a is hole area)

$\Rightarrow \sqrt{10} \times 10^{-4} \times \sqrt{4g(1 - y)} = dy \quad \Rightarrow \int_0^y \frac{dy}{\sqrt{1 - y}} = 2 \times 10^{-3}t$

$\Rightarrow 1 - \sqrt{1 - y} = 10^{-3} \times \frac{10^3}{2} \quad \Rightarrow \sqrt{1 - y} = \frac{1}{2}m \Rightarrow y = 3/4m$

So height of liquid in left chamber is $(2 - \frac{3}{4})m = \frac{5}{4}m$.

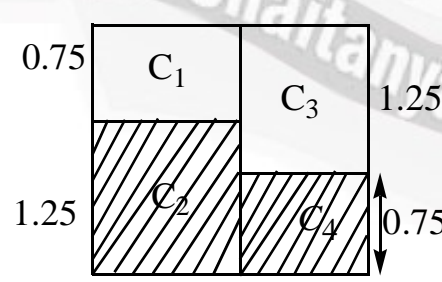
Finding capacitance

Take $\epsilon_0 A = a$

$C_0 = \frac{\epsilon_r a}{2} + \frac{a}{2} = 8a$

$C = \frac{C_1 C_2}{C_1 + C_2} + \frac{C_3 C_4}{C_3 + C_4}$

$= \frac{a}{.75} \times \frac{15a}{1.25} + \frac{a}{1.25} \times \frac{15a}{.75}$
 $= \frac{.75}{a} \times \frac{15a}{1.25} + \frac{1.25}{a} \times \frac{15a}{.75}$



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$$= a \left[\frac{\frac{4}{3} \times 12}{\frac{4}{3} + 12} + \frac{\frac{4}{5} \times 20}{\frac{4}{5} + 20} \right] = a \left[\frac{16 \times 3}{40} + \frac{16 \times 5}{104} \right]$$

$$= a [1.2 + .769] = 1.97a$$

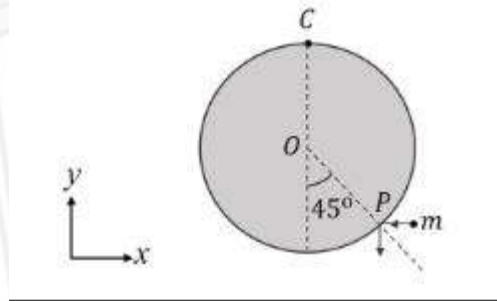
Hence charge in capacitance $= (8 - 1.97)a = (8 - 1.97) \epsilon_0 \times 1$

Hence $n = 1.97$

Question Stem for Question Nos. 35 and 36

A uniform circular disk of radius 0.2m and mass 1 kg is pivoted at its top point C such that it can rotate freely around C in the XY plane, as shown in the figure. Initially, when the disk is at rest, a particle of mass 20g, travelling along negative x direction in the XY plane with speed $100ms^{-1}$, hits the circumference of the disk at a point P. After collision the particle moves along negative y direction at a speed of $90ms^{-1}$.

[Given: the acceleration due to gravity (g) = $-10 \text{ } jm^{-2}$]



35. After the collision the disk starts to rotate around point C in the XY plane. The maximum change in the height (in m) of its centre O is:

Ans: 0.15

36. Amount of energy loss (in J) in the collision is:

Ans: 17.48 TO 17.49









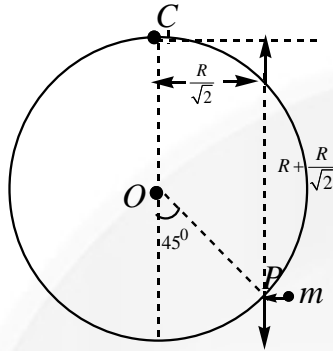




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35 & 36

Applying conservation of angular momentum



$$mv_0R = \left(1 + \frac{1}{\sqrt{2}}\right) = \frac{3}{2}MR^2\omega + mv\frac{R}{\sqrt{2}}$$

$$\Rightarrow \omega = \frac{mv_0R\left(1 + \frac{1}{\sqrt{2}}\right) - \frac{mvR}{\sqrt{2}}}{\frac{3}{2}MR^2}$$

$$\Rightarrow \omega = \frac{20 \times 10^{-3} \times 100 \times 0.2 \times 2.41 - 20 \times 10^{-3} \times 90 \times 0.2}{\frac{3}{2} \times 1 \times 0.04}$$

$$= \frac{(0.964 - 0.36) \times 1.41}{0.12} = \frac{0.851}{0.12} = 7.097 \approx 7.1 \text{ rad / sec}$$

Applying conservation of energy

$$\frac{1}{2} \times \frac{3}{2}MR^2\omega^2 = Mgh \Rightarrow h = \frac{3}{4g}R^2\omega^2$$

$$= \frac{0.75}{10} \times 0.4 \times (7.1)^2$$

$$= 0.1512m$$

$$\text{Loss in energy} = \frac{1}{2}mv_0^2 - \left(\frac{1}{2}mv^2 + \frac{3}{4}mR^2\omega^2\right)$$

$$= \frac{1}{2} \times 20 \times 10^{-3} \times 10^4 - \frac{1}{2} \times 20 \times 10^{-3} \times 81 \times 10^2 - \frac{3}{4} \times 1 \times 0.04 \times (7.1)^2$$

$$= 100 - 81 - 1.513 = 17.487 \text{ J}$$



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CHEMISTRY

Max Marks: 60

SECTION – I
(SINGLE CORRECT ANSWER TYPE)This section contains **FOUR (04)** questions.

- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +3 If **ONLY** the correct option is chosen;

Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);

Negative Marks : -1 In all other cases.

37. At 300K, the molar conductivities of the aqueous solutions of three salts at two different concentrations are given below:

Salt	Concentration (M)	Molar conductivity ($S\text{ cm}^2\text{ mol}^{-1}$)
NaNO_3	0.01	111
	0.04	101
NaCl	0.01	117
	0.04	107
AgNO_3	0.01	125
	0.04	116

The conductivity of a saturated aq solution of AgCl is $1.40 \times 10^{-6} S\text{ cm}^{-1}$ at 300K. If the solubility of AgCl in water at 300K is $X\text{ mol L}^{-1}$, then $\log_{10}(X^{-1})$ is:

(Assume that AgCl dissolved in water ionizes completely and that the molar conductivity of saturated AgCl solution is equal to its limiting conductivity)

- A) 3 B) 4 C) 5 D) 6

Ans: C

Sol: $\lambda_m = \lambda_m^\infty - A\sqrt{C}$

For NaNO_3 :

$$111 = \lambda_m^\infty - A\sqrt{10^{-2}}$$

$$101 = \lambda_m^\infty - A\sqrt{4 \times 10^{-2}}$$










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On solving

$$\lambda_m^\infty = 121$$

For NaCl :

$$117 = \lambda_m^\infty - A\sqrt{10^{-2}}$$

$$107 = \lambda_m^\infty - A\sqrt{4 \times 10^{-2}}$$

On solving

$$\lambda_m^\infty = 127$$

For AgNO_3 :

$$125 = \lambda_m^\infty - A\sqrt{10^{-2}}$$

$$116 = \lambda_m^\infty - A\sqrt{4 \times 10^{-2}}$$

$$\lambda_m^\infty = 134$$

$$\lambda_m^\infty [\text{AgCl}] = \lambda_m^\infty [\text{AgNO}_3] + \lambda_m^\infty (\text{NaCl}) - \lambda_m^\infty (\text{NaNO}_3)$$

$$= 134 + 127 - 121$$

$$= 140$$

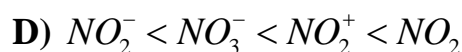
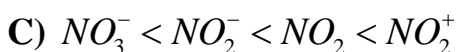
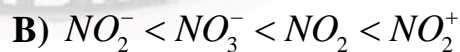
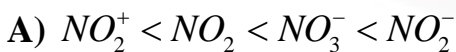
$$\lambda_m^\infty [\text{AgCl}] = \frac{k \times 1000}{X}$$

$$140 = \frac{1.4 \times 10^{-6} \times 1000}{X}$$

$$X = 10^{-5} \quad \frac{1}{X} = 10^5$$

$$\log \frac{1}{X} = 5$$

38. The correct order of ONO bond angle in the given species is:



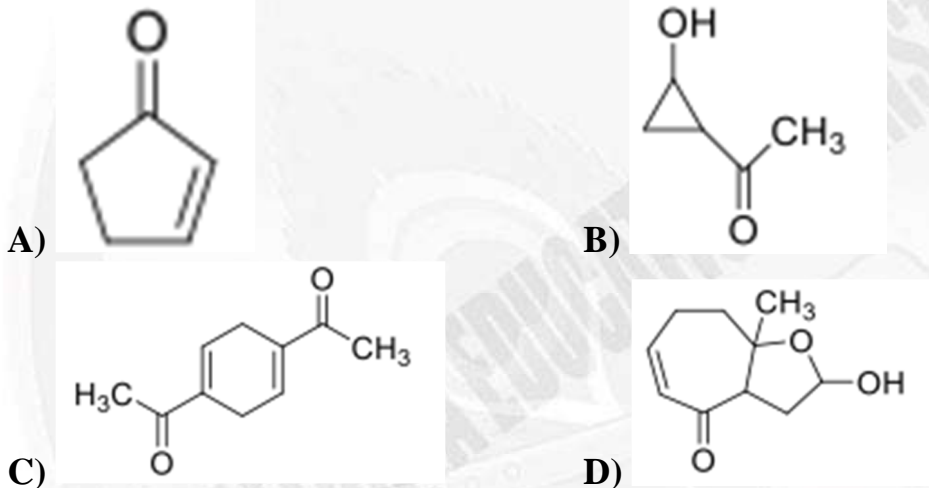
Ans: B



Sol:

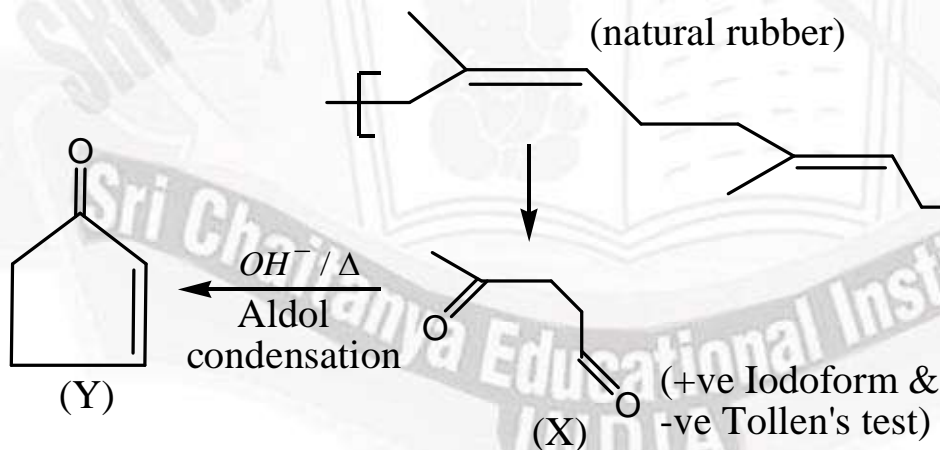
NO_2^-	$<120^\circ$
NO_3^-	120°
NO_2^+	180°
NO_2	134°

39. Natural rubber on complete ozonolysis ($O_3 / Zn - H_2O$) gives compound X as the major product. X gives positive iodoform and Tollen's tests. X on heating with aqueous NaOH gives Y as the major product. Y is _____



Ans:A

Sol:





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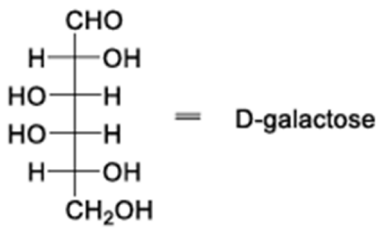


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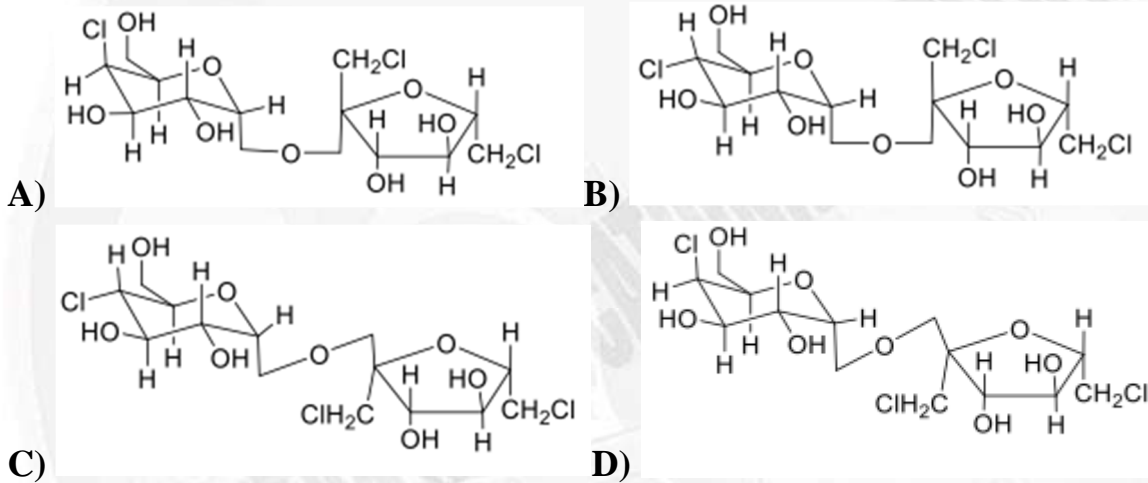
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40. A known artificial sweetener X is composed of 4-chloro-4-deoxy- α -D-galactose and 1,6-dichloro-1,6-dideoxy- β -D-fructose joined by a glycosidic linkage. Structure of D-galactose is given below:

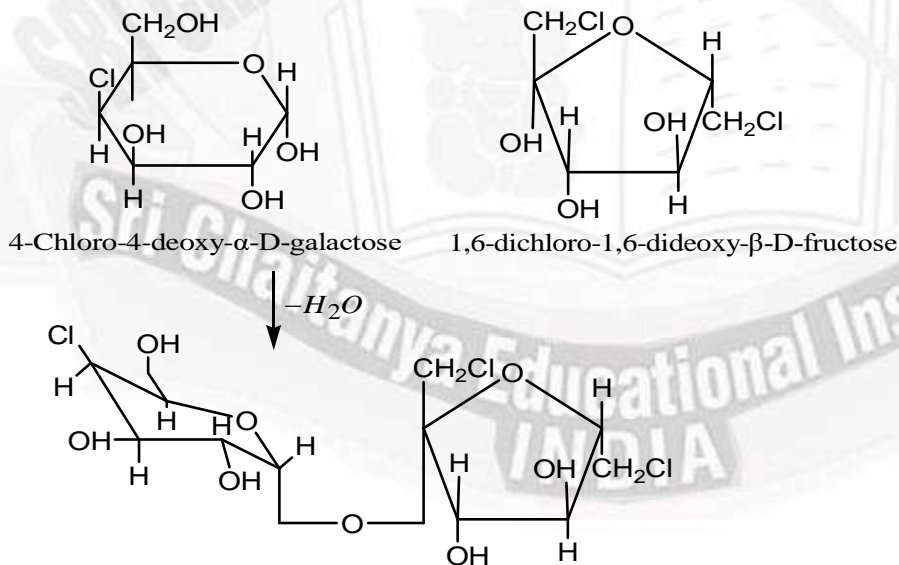


The correct structure of X is



Ans:A

Sol:











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SECTION – II
(ONE OR MORE CORRECT ANSWER TYPE)

This section contains **FIVE (05)** questions.

- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +4 ONLY if (all) the correct option(s) is(are) chosen;

Partial Marks: +3 If all the four options are correct but **ONLY** three options are chosen;

Partial Marks: +2 If three or more options are correct but **ONLY** two options are chosen, both of which are correct;

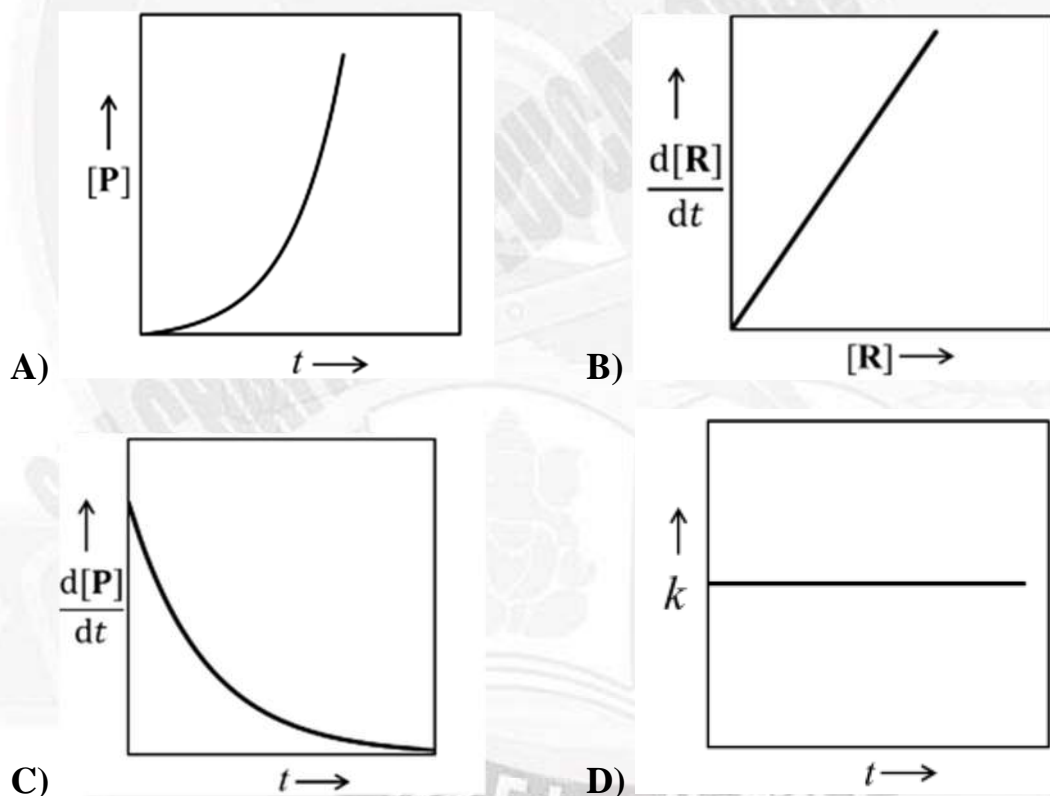
Partial Marks: +1 If two or more options are correct but **ONLY** two options are chosen, and it is a correct option;

Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);

Negative Marks : -2 In all other cases.

For example, in a question, if (A), (B) and (D) are the **ONLY** three options corresponding to correct answers, then choosing **ONLY** (A), (B) and (D) will get +4 marks; choosing **ONLY** (A) and (B) will get +2 marks; choosing **ONLY** (A) and (D) will get +2 marks; choosing **ONLY** (B) and (D) will get +2 marks; choosing **ONLY** (A) will get +1 mark; choosing **ONLY** (B) will get +1 mark; choosing **ONLY** (D) will get +1 mark; choosing no option (i.e. the question is unanswered) will get 0 marks; and choosing any other combination of options will get -2 marks.

41. For a first-order reaction $R \rightarrow P$ at a given temperature, k is the rate constant. For this reaction, at the given temperature, the concentrations of R and P at a time t are $[R]$ and $[P]$, respectively. The correct graphical representation(s) for this reaction is (are)



Ans: CD



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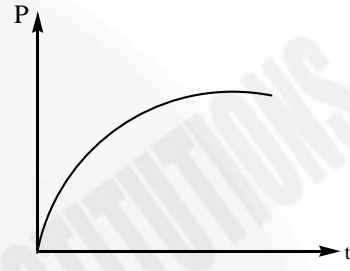


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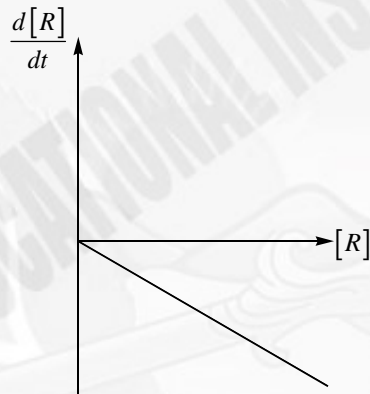
Sol: A) $R \longrightarrow P$

A 0

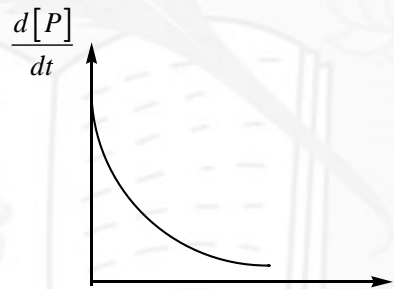
(a - x) x



$$\Rightarrow R = [R]_0 e^{-kt} \quad \Rightarrow a - x = a e^{-kt} \quad \Rightarrow x = a(1 - e^{-kt})$$



B) $\Rightarrow \frac{-d[R]}{DT} = k[R]$



C) $\Rightarrow \frac{d[P]}{dt} = k[R] = k[R]_0 e^{-kt}$



D) $\Rightarrow k$ does not depend upon time



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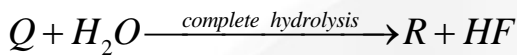
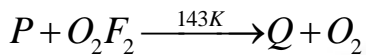
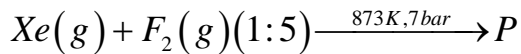


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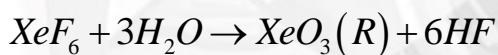
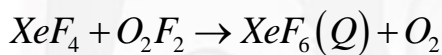
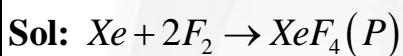
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42. Correct statement(s) about the compounds P, Q and R is(are):



- A) P has two lone pairs of electrons on the central atom
 B) Q has a perfect octahedral geometry
 C) Q can act as a fluorinating agent
 D) The molecular structure of R is trigonal pyramidal

Ans: ACD



XeF_4 : sp^3d^2 : AB_4E_2 type: 2 lone pairs near central atom

XeF_6 : distorted octahedral

XeF_6 : fluorinating reagent

XeO_3 : sp^3 : one lone pair near central atom: trigonal pyramidal

43. The correct statement(s) regarding the periodic properties of elements is(are):

- A) Second ionization enthalpy of carbon atom is less than that of boron atom
 B) Increasing order of ionic radii : $\text{Al}^{3+} < \text{Mg}^{2+} < \text{Na}^+$
 C) Under identical conditions, in solid state, the density of potassium metal is more than density of sodium metal
 D) The H – H bond is weaker than F – F bond

Ans: AB









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Sol: (i) B: $1s^2 2s^2 2p^1$ and C: $1s^2 2s^2 2p^2$

(ii) $B^+ : 1s^2 2s^2$ and $C^+ : 1s^2 2s^2 2p^1$

Therefore, $\Delta_f H$ of $B^+ > C^+$

(iii) Na^+, Mg^{2+}, Al^{3+} : isoelectronic species

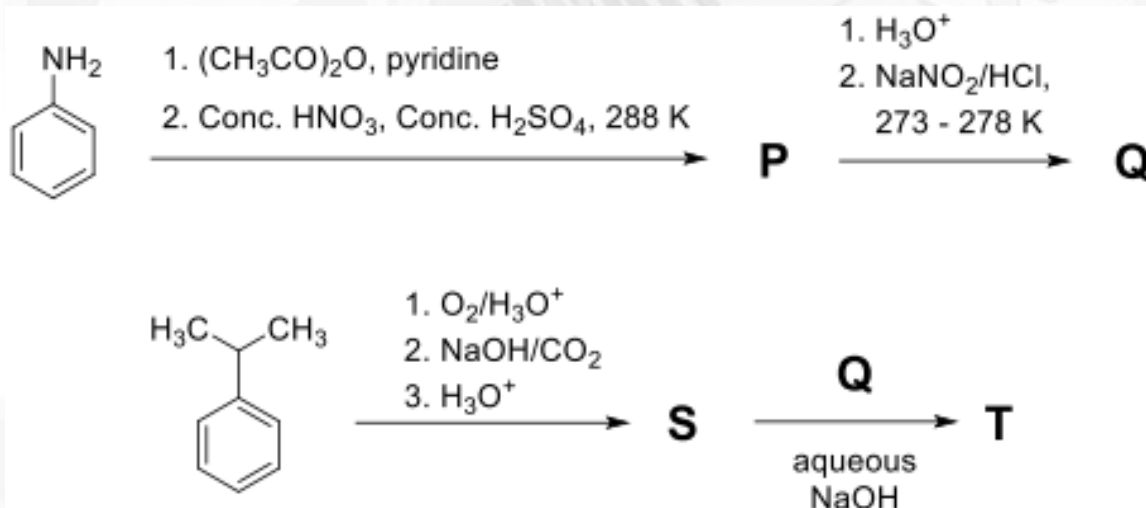
As $\frac{Z}{e}$ increases, size decreases

Therefore: $Al^{3+} < Mg^{2+} < Na^+$: ionic size

(iv) $Li < K < Na < Rb < Cs$: order of density

(v) $H_2 (438 \text{ kJ/mol}) > F_2 (159 \text{ kJ/mol})$: BDE

44. In the following reactions sequence, P, Q, S and T are the major products.



The correct statement(s) about P, Q, S and T is(are)

- A) Q on treatment with ethanol generates an aromatic aldehyde.
- B) S gives positive phthalein dye test.
- C) P is a dinitro compound.
- D) T is a coloured compound.

Ans: BD









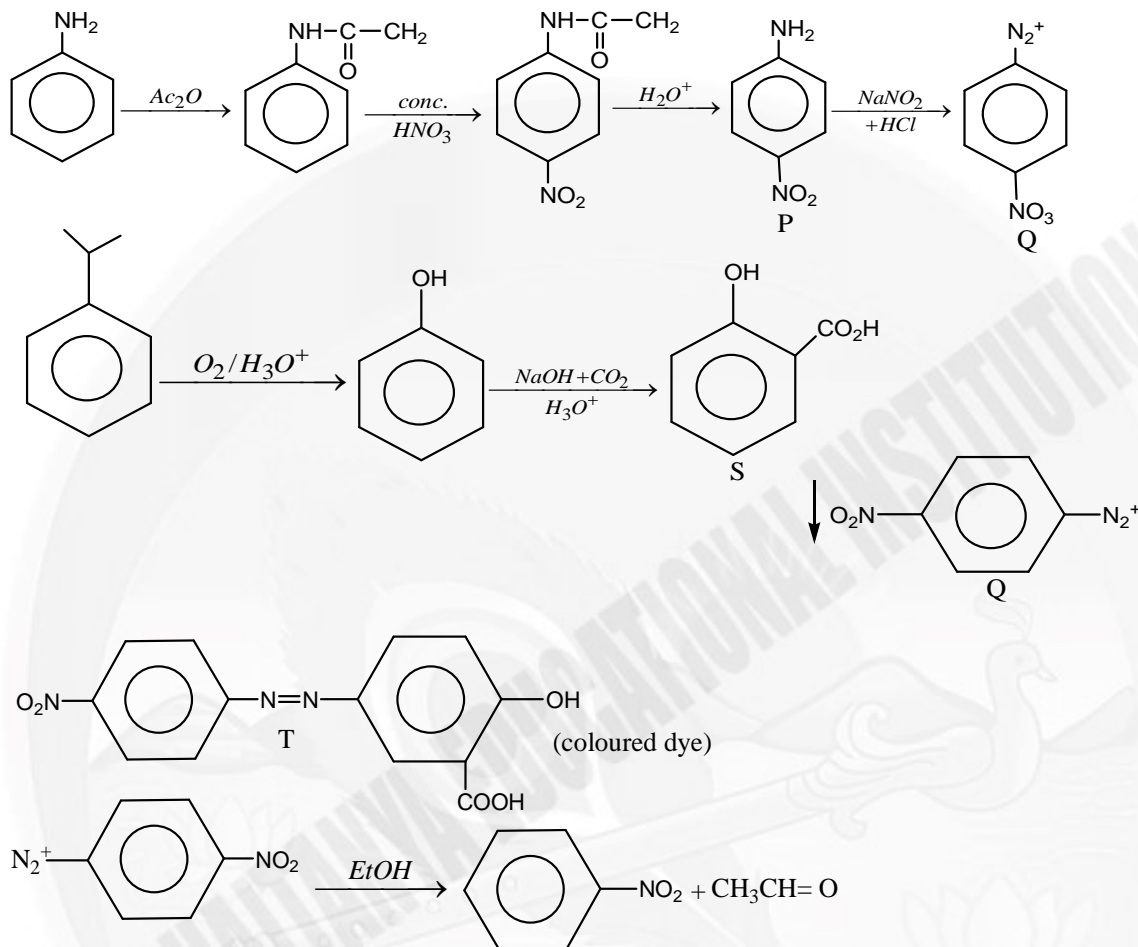




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Sol:



S gives positive phthalein dye test because it is phenol derivative

P is mononitro product

T is coloured dye compound.

45. The correct statement(s) regarding sugars is(are)

Given: Specific rotation of L - (-) glucose and L -(+) - fructose are -52.5^0 and $+92.5^0$, respectively

- A) On treatment with HNO_3 , gluconic acid is oxidised to saccharic acid, whereas glucose is not oxidised to saccharic acid
- B) Fructose gives a positive Fehling's test because it isomerises to glucose and another aldohexose in the presence of Fehling's reagent
- C) Invert sugar is an equimolar mixture of D - glucose and D - fructose formed after hydrolysis of the corresponding disaccharide
- D) Specific rotation of invert sugar is -40^0

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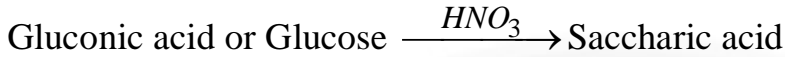
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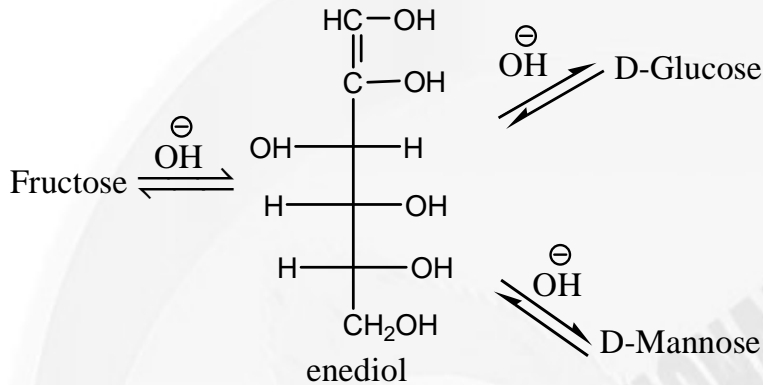
Ans:BC

Sol: Option (A)



Both gluconic acid & glucose oxidized to saccharic acid.

Option (B)



Fructose tautomerise in D-glucose & D-mannose in basic medium.

So fructose gives +ve Fehling test because Fehling solution has basic medium (dil NaOH)

Option (C)

Acidic hydrolysis of sucrose gives D-glucose & D-fructose (i.e Invert sugar) in 1: 1 ratio

Option (D)

Specific rotation of invert sugar is -20^0

SECTION-III (NUMERICAL VALUE)

This section contains **FIVE (05)** questions.

- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value corresponding to the answer in the designated place using the mouse and the on-screen virtual numeric keypad.
- If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places.
- Answer to each question will be evaluated **according to the following marking scheme:**

Full Marks : +4 If **ONLY** the correct numerical value is entered in the designated place;

Zero Marks : 0 In all other cases.

46. X^{a+} and Y^{b+} are hydrogen-like species. The wavelength of light absorbed during the transition between the states with principal quantum numbers $n = 1$ and $n = 2$ of X^{a+} is λ . The wavelength of light absorbed during the transition between the states with principal quantum numbers $n = 2$ and $n = 4$ of Y^{b+} is 9λ . The lowest possible value of $(a+b)$ is _____.

Ans:3









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Sol: For X^{a+} $Z = (a + 1)$

For Y^{b+} $Z = (b + 1)$

For X^{a+}

$$\Delta E = \frac{-13.6(a+1)^2}{(2)^2} + \frac{13.6(a+1)^2}{(1)^2}$$

For Y^{b+}
$$\Delta E = \frac{-13.6(b+1)^2}{(4)^2} + \frac{13.6(b+1)^2}{(2)^2}$$

$$\frac{\Delta E \text{ for } X^{a+}}{\Delta E \text{ for } Y^{b+}} = 9 \quad 9 = \frac{(a+1)^2}{(b+1)^2} \times 4$$

$$\frac{9}{4} = \frac{(a+1)^2}{(b+1)^2} \quad \frac{3}{2} = \frac{a+1}{b+1}$$

$$3b - 2a = -1 \quad \Rightarrow b = 1$$

$$a = 2 \quad a + b = 2 + 1 \Rightarrow 3$$

47. At a given temperature, 0.45 g of acetic acid in 50 mL of water is shaken with 1.0 g of charcoal and the pH of the resulting solution is 3.0. Assume, the adsorption of acetic acid from the aqueous solution by charcoal follows Freundlich isotherm, $\frac{x}{m} = kC^{1/n}$

If the plot of $\log_{10}(x/m)$ against $\log_{10}C$ gives a straight line with slope 1, the value of k in $Lmol^{-1}$ is _____.

Given: The molar mass of acetic acid is $60 g mol^{-1}$.

The acid dissociation constant of acetic acid is 1.0×10^{-5} at the given temperature.

x is the mass (in grams) of acetic acid adsorbed.

m is the mass (in grams) of charcoal.

C is the equilibrium concentration of acetic acid in the solution after the adsorption is complete.

k and n are constants for acetic acid-charcoal system at the given temperature.



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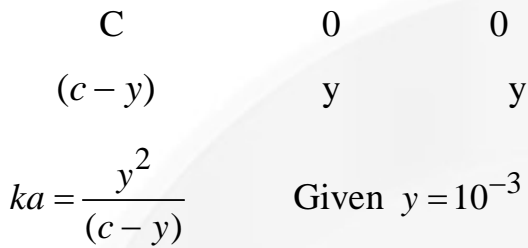
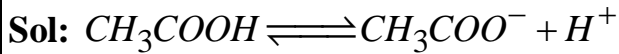


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Ans:1.5



$(c - y) = \frac{10^{-6}}{10^{-5}} = 0.1 \text{ mole / l}$

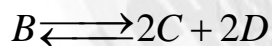
At equilibrium the amount of acetic acid present in 50ml solution = 0.3 gram

$\Rightarrow x = 0.45 - 0.3 = 0.15 \text{ gram}$

$\frac{x}{m} = k \cdot (C)^n$ $\frac{x}{m} = k \cdot C$ $n = 1$

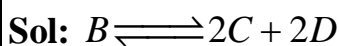
$0.15 = k \times 0.1$ $k = 1.5$

48. In a solvent S, a compound B is partially dissociated into C and D as given below:



B, C and **D** are non-volatile in nature. The molar mass of **B** is 10 times the molar mass of **S**. The standard boiling point and the standard enthalpy of vaporization of **S** are 400K and $10R \text{ J mol}^{-1}$, respectively (R is the gas constant in $\text{J K}^{-1} \text{ mol}^{-1}$). A solution of **B** in **S** with an initial concentration of **B** as 0.25% (mass/mass) has a boiling point of 408K at 1 bar pressure. In this solution, the mole percent of **B** that has been dissociated is _____.

Ans: 33.16 TO 33.34



$(1 - \alpha) \quad 2\alpha \quad 2\alpha$

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$$\alpha = \frac{i-1}{4-1} \quad i = 1 + 3\alpha$$

Let molar mass of B = M ∴ Molar mass of S = $\frac{M}{10}$

$$\text{molality} = \frac{0.25 \times 1000}{M \times 99.75} \approx \frac{2.5}{M}$$

$$k_b = \frac{RTb^2 \cdot M_{\text{solvent}}}{1000 \Delta H_{\text{vap}}}$$

$$k_b = \frac{R \times 400 \times 400 \times M / 10}{1000 \times 10R}$$

$$k_b = 1.6M$$

$$\Delta T_b = 408 - 400 = 8$$

$$\Delta T_b = i k_b \cdot \text{molality}$$

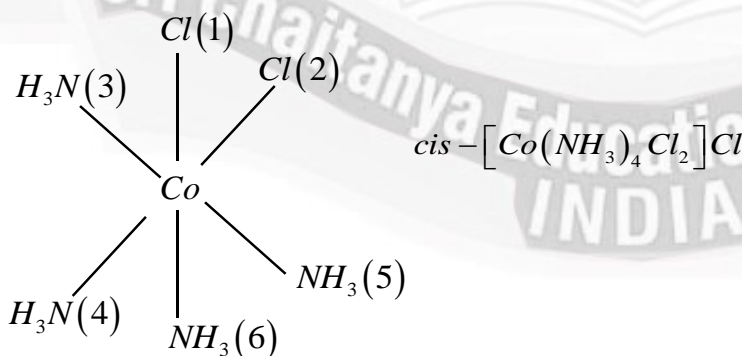
$$8 = i \times 1.6M \times \frac{2.5}{M} \quad i = 2 \quad 1 + 3\alpha = 2$$

$$\alpha = 0.333$$

49. Consider that the coordinating atoms of the ligands in cis - $[Co(NH_3)_4Cl_2]Cl$ and mer - $[Co(NH_3)_3Cl_3]$ octahedral complexes are at the vertices of an octahedron. The sum of total number of the triangular faces in both the complexes having one N atom and two Cl atoms at their corners is__

Ans:6

Sol:













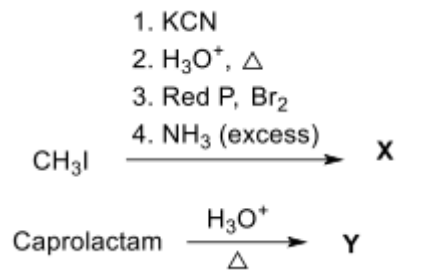


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Number of trigonal faces having one N atom and two Cl atoms = 2 (132), (152)

50. In the following reaction sequence, major products X and Y are acyclic monomers. 500 mol of X completely reacts with 500 mol of Y to give 1 mol of a single biodegradable acyclic copolymer Z as the only product. The amount of Z formed in grams is _____.

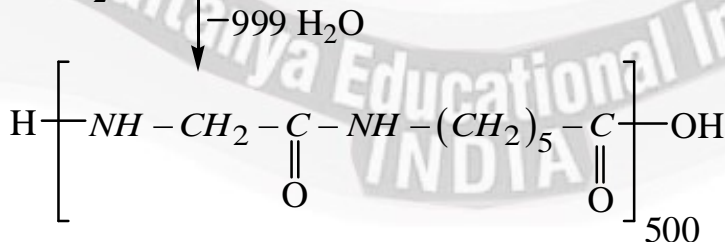
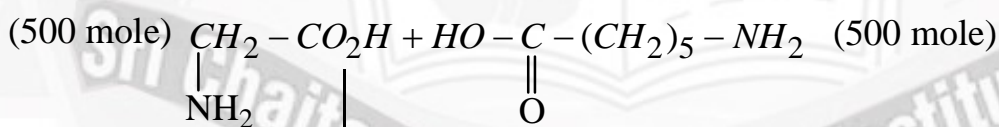
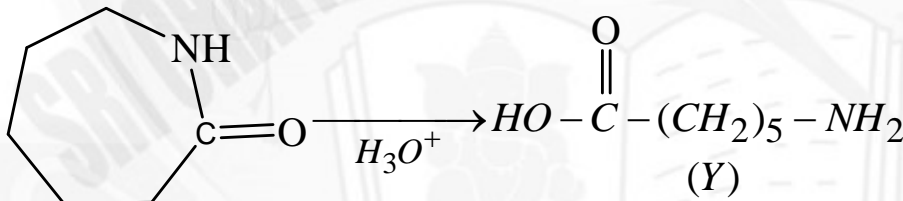
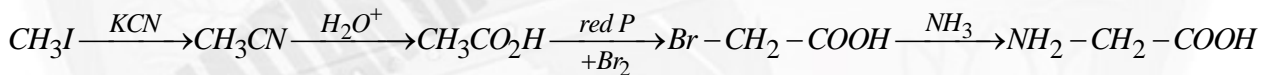


Given:

Atomic mass (in amu): $H:1, C:12, N:14, O:16, Br:80$

Ans: 85018

Sol:



$$170 \times 500 + 18$$

$$= 85000 + 18 = 85018$$









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SECTION – IV
(PARAGRAPH WITH NUMERICAL VALUE TYPE)

- This section contains **TWO (02)** question stems.
- There are **TWO (02)** questions corresponding to each question stem.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value corresponding to the answer in the designated place using the mouse and the on-screen virtual numeric keypad.
- If the numerical value has more than two decimal places, truncate/round-off the value to **TWO** decimal places.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +2 If **ONLY** the correct numerical value is entered at the designated place;

Zero Marks : 0 In all other cases.

Question Stem for Question Nos. 51 and 52

Two volatile liquids A and B form an ideal solution. Consider a 5 molal solution of B in A inside a closed container having a total vapour pressure of 100mm Hg at 300K. The vapour pressure of pure A at 300K is 105mm Hg. Assume that A and B behave as ideal gases in the vapour phase.

Given:

The gas constant $R = 0.08 \text{ L atm K}^{-1} \text{ mol}^{-1}$

Molar mass of A is 50 g mol^{-1}

Molar mass of B is 57 g mol^{-1}

Density of liquid B at 300K is 0.5 g/mL

$1 \text{ atm} = 760 \text{ mm Hg}$

- 51.** At 300K, the ratio of the molar volume of pure B in vapour phase to its molar volume in liquid phase is _____.

Ans:2000

Sol: 5 mole B is present in 1000 gram (A)

Mole of A = 20

$$X_A = \frac{4}{5} \quad X_B = \frac{1}{5}$$

$$P = X_A \cdot P_A^0 + X_B P_B^0$$

$$100 = \frac{4}{5} \times 105 + \frac{1}{5} \times P_B^0$$









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$$P_B^0 = 80$$

$$\text{Molar volume of B in the liquid} = \frac{57}{0.5}$$

$$= 114 \text{ ml} = 114 \times 10^{-3} \text{ litre}$$

In the vapours

$$V = \frac{nRT}{P_B^0} = \frac{1 \times 0.08 \times 300}{\left(\frac{80}{760}\right)} \text{ litre} = 228 \text{ litre}$$

$$\text{Ratio} = \frac{228}{114 \times 10^{-3}} = 2000$$

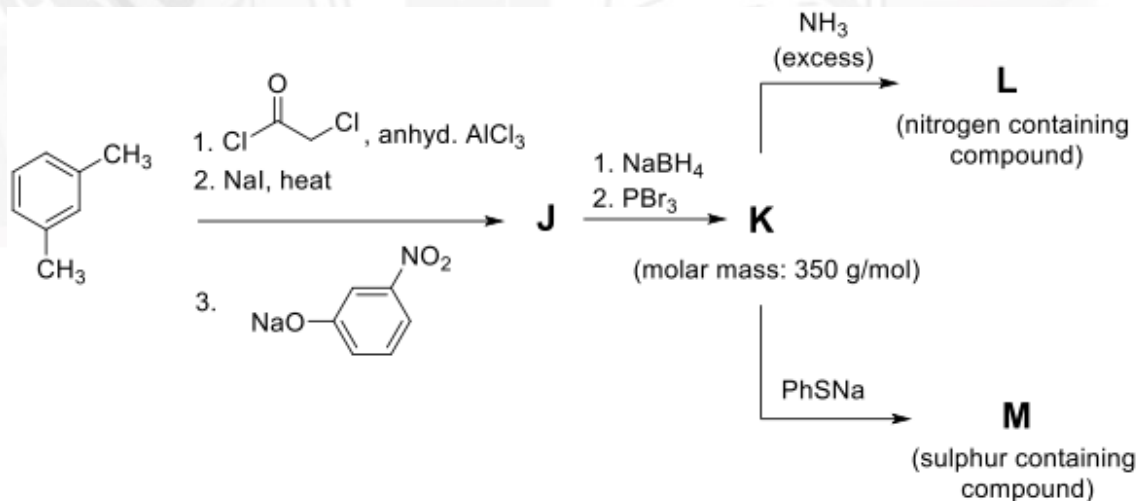
52. The mole fraction of B in vapour phase which is in equilibrium with this solution is _____.

Ans: 0.16

$$\text{Sol: } y_B = \frac{X_B \cdot P_B^0}{P} = \frac{1}{5} \times \frac{80}{100} = 0.16$$

Question Stem for Question Nos. 53 and 54

Consider the following reaction sequence in which J, K, L and M are the products.



Given :

Atomic mass (in amu): H:1, C:12, N:14, O:16, S:32, Br:80, Ba:137



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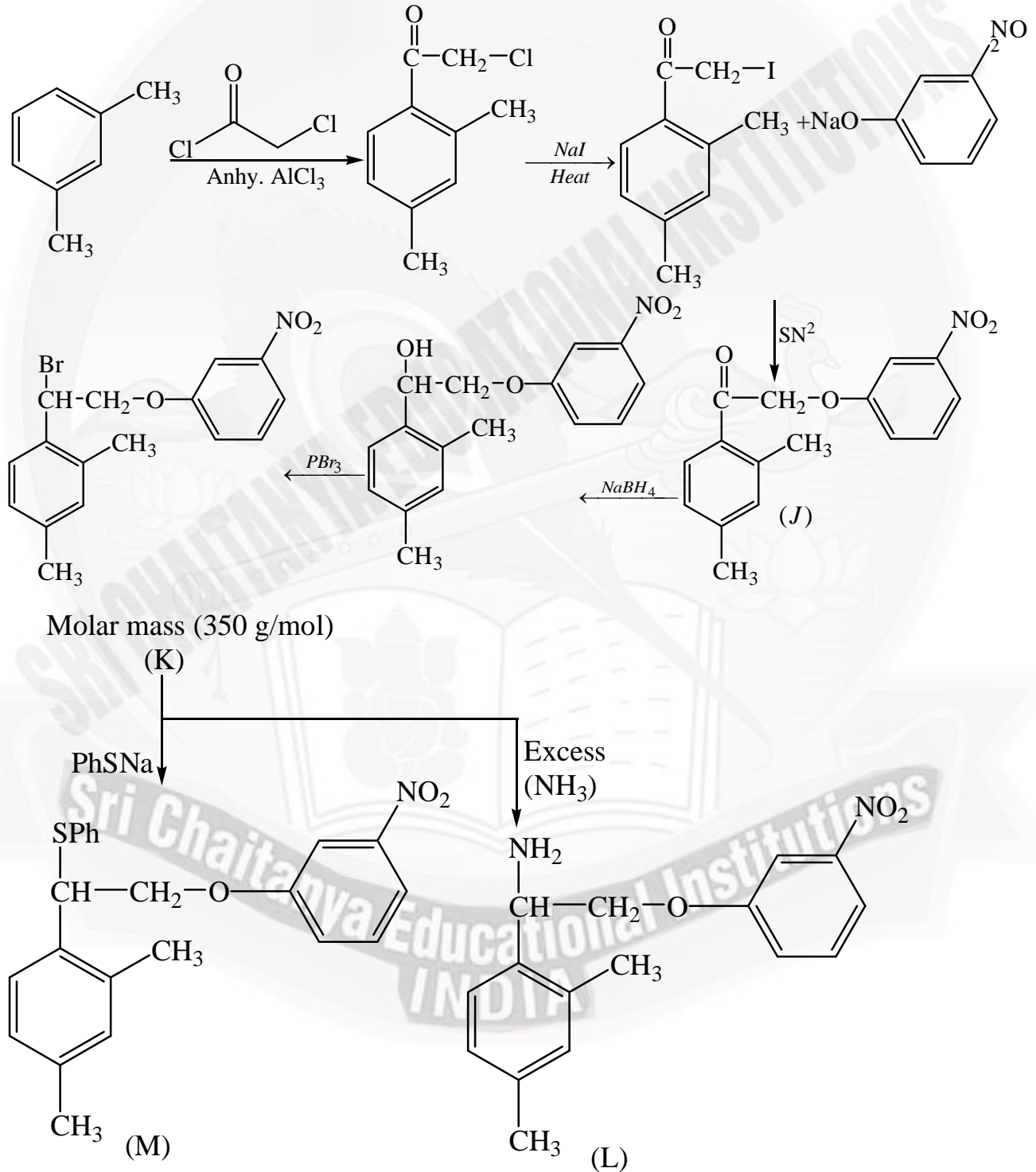
**HISTORY CREATED 300/300 IN JEE MAIN
4TH YEAR IN A ROW**

CONSISTENCY ISN'T LUCK. IT'S CULTURE.

53. The volume of 1M aqueous H_2SO_4 required to completely neutralize the ammonia evolved from 5.72g of L in Kjeldhal's method of nitrogen estimation is ____ mL.

Ans:10

Sol:















**HISTORY CREATED 300/300 IN JEE MAIN
4TH YEAR IN A ROW**

CONSISTENCY ISN'T LUCK. IT'S CULTURE.

286 gm L requires = $\frac{1}{2}$ mole H_2SO_4

5372 gm L requires = 1 mole H_2SO_4

Hence 5.72 gm of L = 0.02 mole of compound L

0.02 mol L requires = 0.01 mole H_2SO_4

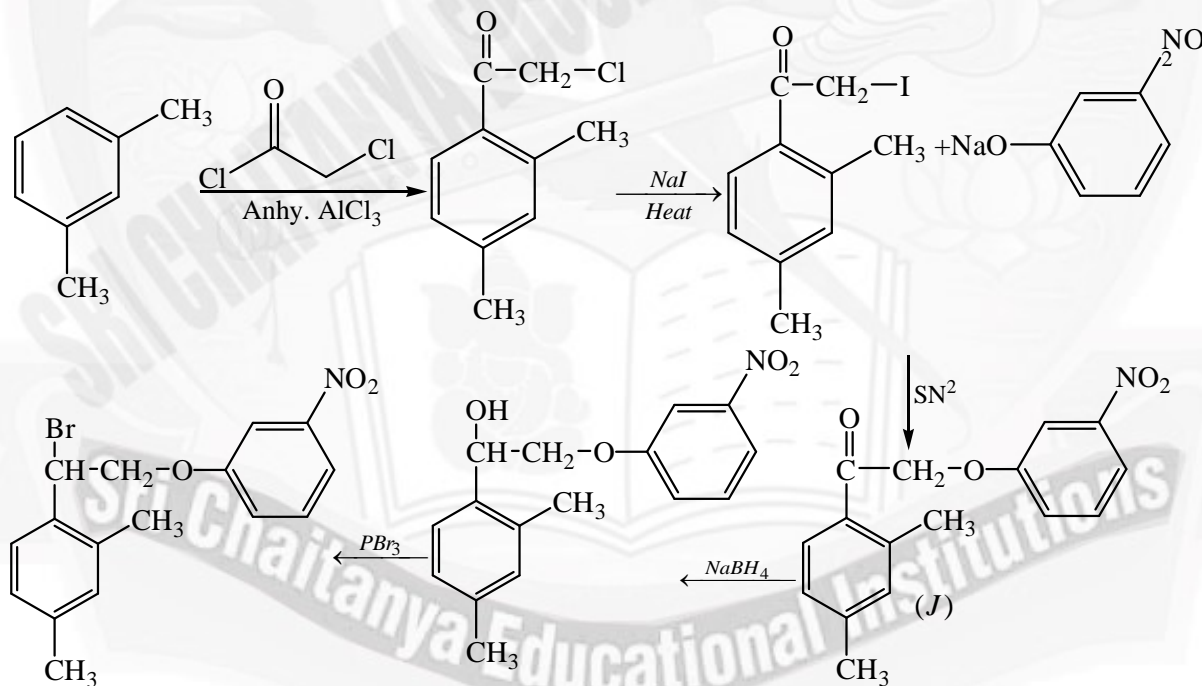
$$\frac{\text{Molarity} \times V(\text{ml})}{1000} = 0.01$$

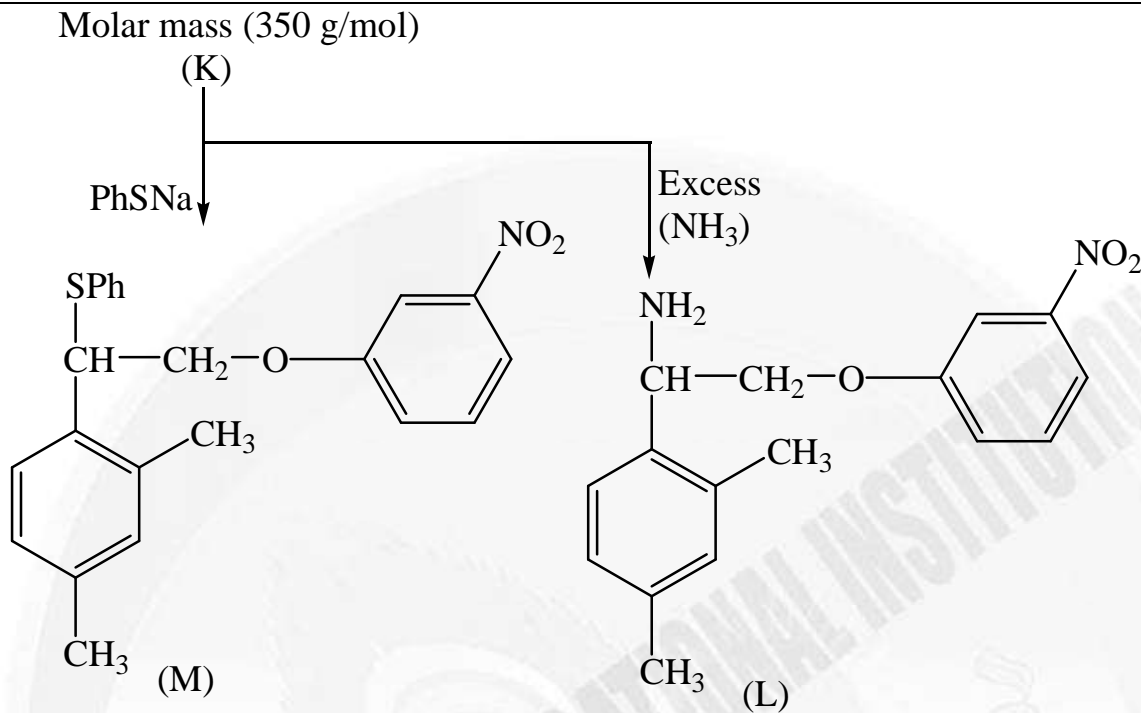
$$V(\text{ml}) = 10$$

54. In Sulphur estimation by Carius method, the amount of $BaSO_4$ formed from 3.79 g of M is ____g.

Ans:2.33

Sol:





Molecular formula of $M = C_{22}H_{21}NO_3S$

Molar mass of $M = 379$ gm/mol

Given mass of $M = 3.79$

Hence Moles of $M = \frac{3.79}{379} = 0.01$

Molecule of M contains 1 sulphur atom so 0.01 mole of $BaSO_4$ is formed

Mass of $BaSO_4 = 0.01 \times 233 = 2.33$ g



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LEADING BY MILES **SRI CHAITANYA** DOMINATES JEE ADVANCED 2025

29 Ranks in Top 100 in All-India Open Category



4 Students in Top 11 in JEE-Advanced 2025, All India Open Category

16 RANK DEVDUTTA MAJHI HT. No. 253053116*	18 RANK DHARMANA GNANA RUTVIK SAI HT. No. 256055278	19 RANK VANGALA AJAY REDDY HT. No. 256131009	23 RANK AKSH GOGI HT. No. 252071075*	26 RANK P HEMA SAI SURYA KARTHIK HT. No. 256033006	27 RANK SARKARSAMUDRA HT. No. 252071105*
30 RANK OM PRAKASH BEHERA HT. No. 252021018*	32 RANK SUNKARA SAI RISHANTH REDDY HT. No. 256165327	34 RANK DHRUBA JYOTHI PANJA HT. No. 252048246*	35 RANK BHAVESH JAYANTHI HT. No. 251043080	36 RANK ADVAY MAYANK HT. No. 252104113*	37 RANK KARMANYA GUPTA HT. No. 252081477*
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63 RANK SAMAJYOTI BISWAS HT. No. 253058456*	64 RANK AARUSH ANAND HT. No. 251008176*	72 RANK RUSHMITH BANDARI HT. No. 256168048	78 RANK KORIKANA RASAGNYA HT. No. 256057045	87 RANK LAKSHYA SHARMA HT. No. 252070079*	91 RANK AVANEESH BANSAL HT. No. 251113130*
95 RANK KAVYA AGGARWAL HT. No. 252079121*					

BELOW 100 > **29** |
 BELOW 500 > **113** |
 BELOW 1000 > **205** |
 BELOW 1000 > **745** |
 NUMBER OF QUALIFIED RANKS **4,212**