JEE (Main)-2026 Session-1

Question Paper with Solutions

(Mathematics, Physics, And Chemistry)

23 January 2026 Shift – 2

Time: 3 hrs. **M.M: 300**

IMPORTANT INSTRUCTIONS:

(1) The test is of 3 hours duration.

(2) This test paper consists of 75 questions. Each subject (PCM) has 25 questions. The maximum marks are 300.

(3) This question paper contains Three Parts. Part-A is Physics, Part-B is Chemistry and Part-C is Mathematics. Each part has only two sections: Section-A and Section-B.

(4) Section - A: Attempt all questions.

(5) Section - B: Attempt all questions.

(6) Section - A (01 - 20) contains 20 multiple choice questions which have only one correct answer. Each question carries +4 marks for correct answer and -1 mark for wrong answer.

(7) Section - B (21 - 25) contains 5 Numerical value-based questions. The answer to each question should be rounded off to the nearest integer. Each question carries +4 marks for correct answer and -1 mark for wrong answer.

MATHEMATICS

SECTION-A

1. If $f(x)=\begin{cases}\dfrac{a|x|+x^2-2(\sin|x|)(\cos|x|)}{x} & , x\neq 0\\ b & , x=0\end{cases}$

is continuous at x = 0, then a + b is equal to :

(1) 1 (2) 2

(3) 0 (4) 4

Ans. (2)

Sol. $f(x)=\begin{cases}\dfrac{a|x|+x^2-2\sin|x|\cos|x|}{x} & ; \quad x\neq 0\\ b & ; \quad x=0\end{cases}$

for continuity

$\lim\limits_{x\to 0^-} f(x)=\lim\limits_{x\to 0^+} f(x)=f(0)$

$\lim\limits_{x\to 0^-}\dfrac{ah+h^2-2(\sinh)\cosh}{-h}$

$=\lim\limits_{x\to 0^+}\dfrac{ah+h^2-2(\sinh)\cosh}{h}$

or –a + 2 = a – 2 = b

2a = 4

a = 2, b = 0

$\therefore$ a + b = 2

2. Let $\dfrac{\pi}{2}<\theta<\pi$ and $\cot\theta=-\dfrac{1}{2\sqrt{2}}$. Then the value of

$\sin\left(\dfrac{15\theta}{2}\right)(\cos 8\theta+\sin 8\theta)+\cos\left(\dfrac{15\theta}{2}\right)(\cos 8-\sin 8\theta)$

is equal to :

(1) $\dfrac{1-\sqrt{2}}{\sqrt{3}}$ (2) $-\dfrac{\sqrt{2}}{\sqrt{3}}$

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

Ans. (1)

Sol. $\dfrac{\pi}{2}<\theta<\pi$ and $\cot\theta=-\dfrac{1}{2\sqrt{2}}$

$\Rightarrow \sin\left(\dfrac{15\theta}{2}\right)(\cos 8\theta+\sin 8\theta)$

$+\cos\left(\dfrac{15\theta}{2}\right)(\cos 8\theta-\sin 8\theta)$

$\Rightarrow \sin\left(\dfrac{15\theta}{2}\right)\cos 8\theta-\cos\left(\dfrac{15\theta}{2}\right)\sin 8\theta$

$+\sin\dfrac{15\theta}{2}\sin 8\theta+\cos\dfrac{15\theta}{2}\cos 8\theta$

$\Rightarrow \sin\left(\dfrac{15\theta}{2}-8\theta\right)+\cos\left(\dfrac{15\theta}{2}-8\theta\right)$

$\Rightarrow \cos\dfrac{\theta}{2}-\sin\dfrac{\theta}{2}=-\sqrt{1-\sin\theta} \quad \left(\dfrac{\pi}{4}<\dfrac{\theta}{2}<\dfrac{\pi}{2}\right)$

$\Rightarrow$ given $\cot\theta=-\dfrac{1}{2\sqrt{2}}$, $\sin\theta=\dfrac{2\sqrt{2}}{3}$

$\Rightarrow -\sqrt{1-\sin\theta}=\sqrt{\dfrac{3-2\sqrt{2}}{3}}=-\dfrac{\left(\sqrt{2}-1\right)}{3}$

$=\dfrac{1-\sqrt{2}}{\sqrt{3}}$

3. Let $\vec{a}=\hat{i}-2\hat{j}+3\hat{k}$, $\vec{b}=2\hat{i}+\hat{j}-\hat{k}$, $\vec{c}=\lambda\hat{i}+\hat{j}+\hat{k}$ and $\vec{v}=\vec{a}\times\vec{b}$. If $\vec{v}.\vec{c}=11$ and the length of the projection of $\vec{b}$ on $\vec{c}$ is p, then $9p^2$ is equal to :

(1) 9 (2) 6

(3) 4 (4) 12

Ans. (4)

Sol. $\vec{a}=\hat{i}-2\hat{j}+3\hat{k}$, $b=2\hat{i}+\hat{j}-\hat{k}$, $\vec{c}=\lambda\hat{i}+\hat{j}+\hat{k}$, and $\vec{v}=\vec{a}\times\vec{b}$. If $\vec{v}.\vec{c}=11$

$\vec{v}=(\vec{a}\times\vec{b})=(-\hat{i}+7\hat{j}+5\hat{k})$

$\vec{v}.\vec{c}=11 = (-\hat{i}+7\hat{j}+5\hat{k}).(\lambda\hat{i}+\hat{j}+\hat{k})=11$

$\Rightarrow -\lambda + 7 + 5 = 11$

$\Rightarrow \lambda = 1$

Length of projection of $\vec{b}$ on $\vec{c}$ = $\vec{b}.\hat{c}$

$\Rightarrow \left|(2\hat{i}+\hat{j}-\hat{k}).\frac{(\hat{i}+\hat{j}+\hat{k})}{\sqrt{3}}\right| = \frac{2+1-1}{\sqrt{3}} = P=\frac{2}{\sqrt{3}}$

$\Rightarrow 9p^2 = 9\left(\frac{4}{3}\right)=12$

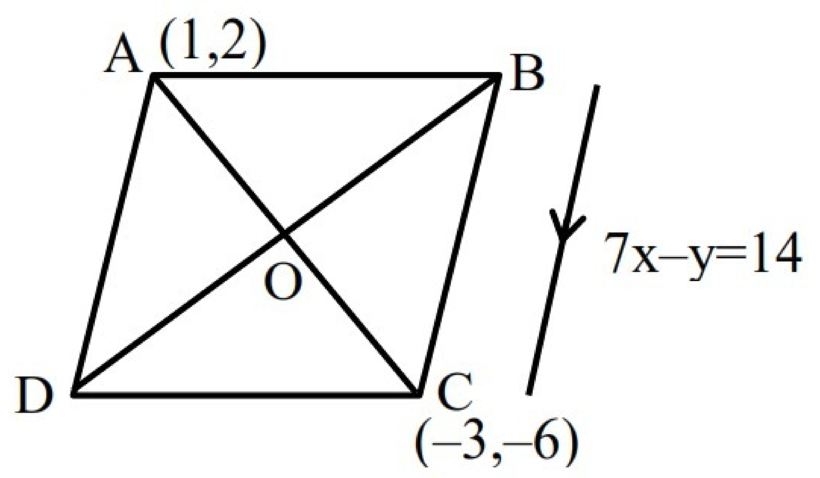
4. Let A(1, 2) and C(–3, –6) be two diagonally opposite vertices of a rhombus, whose sides AD an BC are parallel to the line 7x – y = 14. If B (α, β) and D(γ, δ) are the other two vertices, then |α + β + γ + δ| is equal to :

(1) 9 (2) 3

(3) 6 (4) 1

Ans. (3)

Sol.



Given the points of B and D are (α, β) and (γ, δ) and mid point of A and C is (–1, –2)

So $\frac{\alpha+\gamma}{2}=-1$ and $\frac{\beta+\delta}{2}=-2$

$|\alpha + \gamma + \beta + \delta| = 6$

5. Consider two sets A = {x∈z : |(|x – 3| – 3)|≤1} and $B=\left\{x\in\mathbb{R}-\{1,2\}:\frac{(x-2)(x-4)}{x-1}\log_e(|x-2|)=0\right\}$. Then the number of onto functions f : A→B is equal to :

(1) 62 (2) 79

(3) 32 (4) 81

Ans. (1)

Sol. A : ||x – 3| – 3| ≤ 1

$\Rightarrow -1 \le |x-3|-3 \le 1$

$2 \le |x-3| \le 4$

$2 \le (x-3) \le 4$ or $-4 \le (x-3) \le -2$

$5 \le x \le 7$ or $-1 \le x \le 1$

A = {–1, 0, 1, 5, 6, 7}

B ⇒ x = 4, |x – 2| = 1 ⇒ x = 3 or 1(reject) +

B = {3, 4}

Number of onto functions from A to B = $2^6 - 2 = 62$

6. The system of linear equations

x + y + z = 6

2x + 5y + az = 36

x + 2y + 3z = b

has

(1) unique solution for a = 8 and b = 16

(2) infinitely many solutions for a = 8 and b = 14

(3) infinitely many solutions for a = 8 and b = 16

(4) unique solution for a = 8 and b = 14

Ans. (2)

Sol. If $D=\begin{vmatrix}1&1&1\\2&5&a\\1&2&3\end{vmatrix}=0\Rightarrow a=8$

If $D_1=\begin{vmatrix}6&1&1\\36&5&a\\b&2&3\end{vmatrix}=0\Rightarrow ab-5b-12a+54=0$

If $D_2=\begin{vmatrix}1&6&1\\2&36&a\\1&b&3\end{vmatrix}=0\Rightarrow ab-6a-2b-36=0$

If $D_3=\begin{vmatrix}1&1&6\\2&5&36\\1&2&b\end{vmatrix}=0\Rightarrow b=14$

For a = 8 & b= 14 ⇒ D_1 & D_2 are also zero

For a = 8 & b = 14 ⇒ $D = D_1 = D_2 = D_3 = 0$

⇒ infinitely many solutions.

7. The sum of all the real solutions of the equation $\log_{(x+3)}(6x^2 + 28x + 30) = 5 - 2\log_{(6x+10)}(x^2 + 6x + 9)$ is equal to :

(1) 2 (2) 1

(3) 0 (4) 4

Ans. (3)

Sol. $\log_{x+3}[(x + 3)(6x + 10)] = 5 - 2\log_{6x+10}(x + 3)^2$

$1 + \log_{x+3}(6x + 10) = 5 - 4\log_{6x+10}(x + 3)$

Let $\log_{(x+3)}(6x + 10) = A$

$\Rightarrow A + \frac{4}{A} = 4$ or $A = 2$

$\Rightarrow \log_{(x+3)}(6x + 10) = 2$

$\Rightarrow 6x + 10 = (x + 3)^2$

$\Rightarrow 6x + 10 = x^2 + 9 + 6x$

$\Rightarrow x^2 = 1, x = \pm 1$

So sum of roots = 0

8. If the points of intersection of the ellipses $x^2 + 2y^2 - 6x - 12y + 23 = 0$ and $4x + 2y^2 - 20x - 12y + 35 = 0$ lie on a circle of radius r and centre (a, b), then the value of $ab + 18r^2$ is

(1) 53 (2) 51

(3) 52 (4) 55

Ans. (4)

Sol. By family of curve equation of circle will be

$\Rightarrow S_1 + \lambda S_2 = 0$

$\Rightarrow (x^2 + 2y^2 - 6x - 12y + 23)$

$+ \lambda(4x^2 + 2y^2 - 20x - 12y + 35) = 0$

$\Rightarrow$ for circle coeff of x^2 = coeff. of y^2

$\Rightarrow \lambda = \frac{1}{2}$

So equation of circle is

$\Rightarrow x^2 + y^2 - \frac{16}{3}x - 6y + \frac{27}{2} = 0$

Centre $\left(\frac{8}{3}, 3\right)$: Radius $r = \sqrt{\frac{47}{18}} = r$

$\therefore ab + 18r^2 = 8 + 47 = 55$

9. Let PQ be a chord of the hyperbola $\frac{x^2}{4} - \frac{y^2}{b^2} = 1$, perpendicular to the x-axis such that OPQ is an equilateral triangle, O being the centre of the hyperbola. If the eccentricity of the hyperbola is $\sqrt{3}$, then the area of the triangle OPQ is :

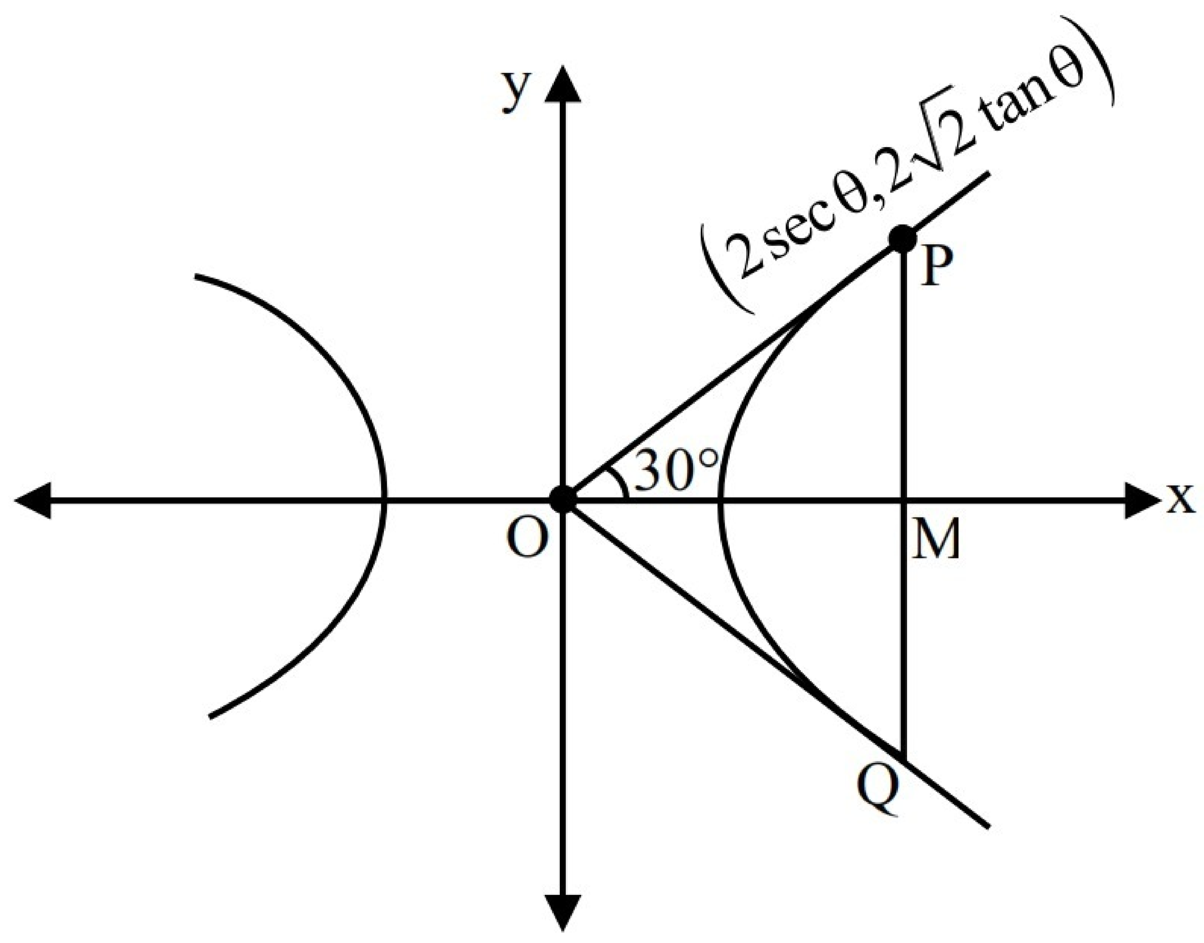
(1) $2\sqrt{3}$ (2) $\frac{8\sqrt{3}}{5}$

(3) $\frac{11}{5}$ (4) $\frac{9}{5}$

Ans. (2)

Sol. $e = \sqrt{1 + \frac{b}{4}} = \sqrt{3}$ $\Rightarrow b = 8$

$\therefore$ Hyperbola $\frac{x^2}{4} - \frac{y^2}{8} = 1$



$\frac{PM}{OM} = \tan 30°$

$\Rightarrow \frac{2\sqrt{2}\tan\theta}{2\sec\theta} = \frac{1}{\sqrt{3}} \Rightarrow \sin\theta = \frac{1}{\sqrt{6}}$

Area $= 2 \times \frac{1}{2} \times OM \times MP$

$= 2\sec\theta \times 2\sqrt{2}\tan\theta$

$= 4\sqrt{2}\frac{\sin\theta}{\cos^2\theta} = 4\sqrt{2} \times \frac{1}{\sqrt{6} \times \left(1 - \frac{1}{6}\right)} = \frac{8\sqrt{3}}{5}$

10. Let $\vec{a},\vec{b},\vec{c}$ be three vectors such that $\vec{a}\times\vec{b}=2(\vec{a}\times\vec{c})$. If $|\vec{a}|=1, |\vec{b}|=4$, $|\vec{c}|=2$, and the angle between $\vec{b}$ and $\vec{c}$ is 60°, then $|\vec{a}.\vec{c}|$ is :

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

Ans. (4)

Sol. $\vec{a}\times\vec{b}-2(\vec{a}\times\vec{c})=0$

$\vec{a}\times(\vec{b}-2\vec{c})=0 \Rightarrow \vec{b}-2\vec{c}=\lambda\vec{a}$ ...(1)

$|\lambda a|^2=|\vec{b}-2\vec{c}|^2 \Rightarrow \lambda^2|\vec{a}|^2=b^2+4c^2-4\vec{b}.\vec{c}$

$\lambda^2=16+16-4.4.2\cdot\frac{1}{2}$

$\lambda^2=16$

$\lambda=\pm4$

$\because$ $\vec{b}-2\vec{c}=\pm4\vec{a}$

Dot with $\vec{c} \Rightarrow \vec{b}.\vec{c}-2|\vec{c}|^2=\pm4(\vec{a}.\vec{c})$

$4.2.\frac{1}{2}-2.4=\pm4(\vec{a}.\vec{c})$

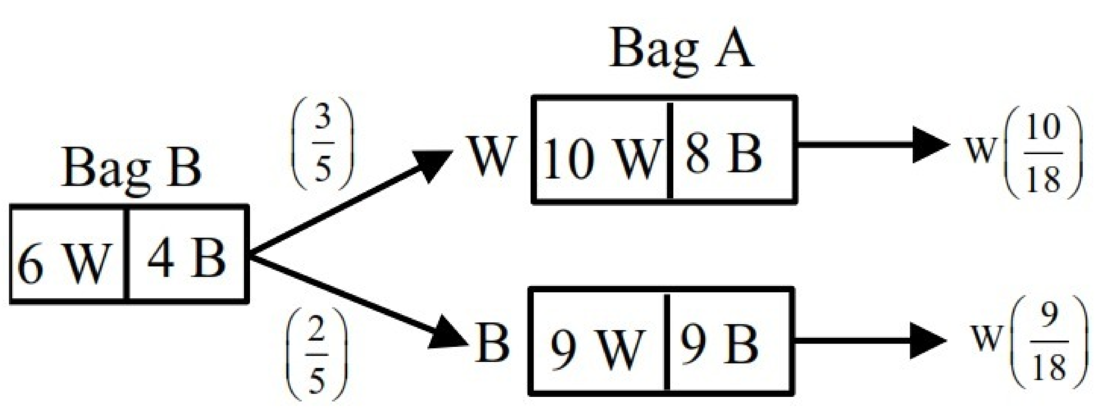
$|\vec{a}.\vec{c}|=1$

11. Bag A contains 9 white and 8 black balls, while bag B contains 6 white and 4 black balls. One ball is randomly picked up from the bag B and mixed up with the balls in the bag A. Then a ball is randomly drawn from the bag A. If the probability, that the ball drawn is white, is $\frac{p}{q}$, gcd(p, q) = 1, then p + q is equal to

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

Ans. (2)

Sol.



$\therefore$ P(Drawn ball is white) $=\frac{3}{5}\times\frac{10}{18}+\frac{2}{5}\times\frac{9}{18}$

$=\frac{48}{90}=\frac{8}{15}=\frac{p}{q}$

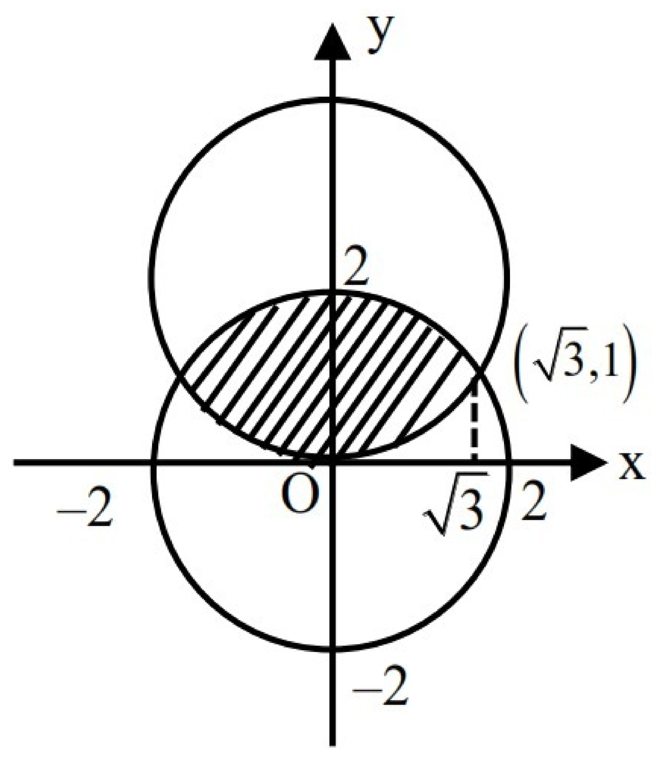
$\therefore$ p + q = 23

12. The area of the region enclosed between the circles $x^2+y^2=4$ and $x^2+(y-2)^2=4$ is :

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

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

Ans. (4)



Sol.

$$A=2\int_0^{\sqrt{3}}\left[\sqrt{4-x^2}-\left(2-\sqrt{4-x^2}\right)\right]dx$$

$$=2\int_0^{\sqrt{3}}\left(2\sqrt{4-x^2}-2\right)dx$$

$$=4\int_0^{\sqrt{3}}\left(\sqrt{4-x^2}-1\right)dx$$

$$=\left[4\left[\frac{1}{2}\left(x\sqrt{4-x^2}+4\sin^{-1}\frac{x}{2}\right)-x\right]\right]_0^{\sqrt{3}}$$

$$=4\left[\frac{1}{2}\left(\sqrt{3}+4\times\frac{\pi}{3}\right)-\sqrt{3}\right]=4\left[\frac{2\pi}{3}-\frac{\sqrt{3}}{2}\right]$$

$$=\frac{8\pi}{3}-2\sqrt{3} \text{ (Sq. units)}$$

13. The least value of $(\cos^2\theta-6\sin\theta\cos\theta+3\sin^2\theta+2)$ is

(1) –1 (2) $4+\sqrt{10}$

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

Ans. (3)

Sol. $f(\theta)=\frac{1+\cos2\theta}{2}-3\sin2\theta+3\left(\frac{1-\cos2\theta}{2}\right)+2$

$f(\theta)=4-3\sin2\theta-\cos2\theta$

$f(\theta)\in[4-\sqrt{10},4+\sqrt{10}]$

14. Let $I(x) = \int \frac{3dx}{(4x+6)(\sqrt{4x^2+8x+3})}$ and $I(0) = \frac{\sqrt{3}}{4} + 20$. If $I\left(\frac{1}{2}\right) = \frac{a\sqrt{2}}{b} + c$, where a, b, c $\in$ N, gcd(a,b) = 1, then a + b + c is equal to :

(1) 29 (2) 28

(3) 31 (4) 30

Ans. (3)

Sol. Let $4x + 6 = \frac{1}{t} \Rightarrow x = \frac{\frac{1}{t}-6}{4}$

$$4dx = -\frac{dt}{t^2} \quad \left\{ x+1 = \frac{\frac{1}{t}-2}{4} \right.$$

$$\int \frac{3dx}{(4x+6)\sqrt{4(x+1)^2-1}}$$

$$\int \frac{3(-dt)}{4t^2 \times \frac{1}{t}\sqrt{4\left(\frac{\frac{1}{t}-2}{4}\right)^2-1}}$$

$$-\frac{3}{4}\int \frac{dt}{t\sqrt{\frac{(1-2t)^2}{4t^2}-1}}$$

$$-\frac{3}{4}\int \frac{dt(2t)}{t\sqrt{1-4t}}$$

$$-\frac{3}{2}\int \frac{dt}{\sqrt{1-4t}} = -\frac{3}{2}\left(\frac{\sqrt{1-4t}}{\frac{1}{2}\times -4}\right) + c$$

$$= \frac{3}{4}\sqrt{1-4t} + c \qquad \because t = \frac{1}{4x+6}$$

$$= \frac{3}{4}\sqrt{1-4\left(\frac{1}{4x+6}\right)} + c$$

$$= \frac{3}{4}\sqrt{\frac{4x+6-4}{4x+6}} + c$$

$$I(x) = \frac{3}{4}\sqrt{\frac{4x+2}{4x+6}} + c$$

$$I(0) = \frac{3}{4}\sqrt{\frac{2}{6}} + c$$

$$I(0) = \frac{\sqrt{3}}{4} + c \Rightarrow c = 20$$

Hence $I(x) = \frac{3}{4}\sqrt{\frac{4x+2}{4x+6}} + 20$

$$I\left(\frac{1}{2}\right) = \frac{3}{4}\sqrt{\frac{4}{8}} + 20$$

$$= \frac{3}{4\sqrt{2}} + 20$$

$$= \frac{3\sqrt{2}}{8} + 20$$

a + b + c = 3 + 8 + 20 = 31

15. The number of ways, in which 16 oranges can be distributed to four children such that each child gets at least one orange, is

(1) 429 (2) 384

(3) 403 (4) 455

Ans. (4)

Sol. Let oranges are identical then

$x_1 + x_2 + x_3 + x_4 = 16$

and $x_1, x_2, x_3, x_4 \geq 1$

or $x'_1 + x'_2 + x'_3 + x'_4 = 12$

so total number of solutions are

$= {}^{12+3}C_3 = {}^{15}C_3 = 455$

16. Let A = {0, 1, 2,....9). Let R be a relation on A defined by (x, y) ∈ R if and only if |x–y| is a multiple of 3.

Given below are two statements:

Statement I: n(R) = 36

Statement II: R is an equivalence relation.

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

(1) Both Statement I and Statement II are correct

(2) Statement I is incorrect but Statement II is correct

(3) Statement I is correct but Statement II is incorrect

(4) Both Statement I and Statement II are incorrect

Ans. (2)

Sol. Number of form 3K = 4

Number of form 3K + 1 = 3

Number of form 3K + 2 = 4

4 × 4 + 3 × 3 + 3 × 3 = 34 relations

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

$\Rightarrow (x - y) = 3\lambda, (y - z) = 3\mu$

$\Rightarrow (x - z) = 3(\lambda + \mu)$

R is reflexive, symmetric and transitive S_2 is ture

Ans. S_1 is false but S_2 is ture

17. If $z = \frac{\sqrt{3}}{2} + \frac{i}{2}, i = \sqrt{-1}$, then $(z^{201} - i)^8$ is equal to

(1) –1 (2) 0

(3) 1 (4) 256

Ans. **(4)**

Sol. $z = \cos\frac{\pi}{6} + i\sin\frac{\pi}{6}$

$$z^{201} = \cos\left(201\frac{\pi}{6}\right) + i\sin\left(201\frac{\pi}{6}\right) = -i$$

$(z^{201} - i)^8 = (-2i)^8 = 256$

18. If the mean and the variance of the data

Class	4–8	8–12	12–16	16–20
Frequency	3	λ	4	7

are μ and 19 respectively, then the value of λ + μ is

(1) 18 (2) 21

(3) 20 (4) 19

Ans. **(4)**

Sol. $\mu = \frac{\sum f_i x_i}{\sum f_i} = \frac{18 + 10\lambda + 56 + 126}{14 + \lambda}$

$= \frac{200 + 10\lambda}{\lambda + 14} = 10 + \left(\frac{60}{\lambda + 14}\right)$

λ + 14 is multiply of 60 $\Rightarrow$ λ = 1 or 6 or 16.

$$\sigma^2 = \frac{\sum x_1^2}{\lambda + 14} - (\mu)^2$$

$$\sigma^2 = \frac{6^2(3) + 10^2(\lambda) + 14^2(4) + (18)^2(7)}{\pi + 14} - \mu^2$$

for λ = 6, μ = 10 + 3 = 13

λ + μ = 19

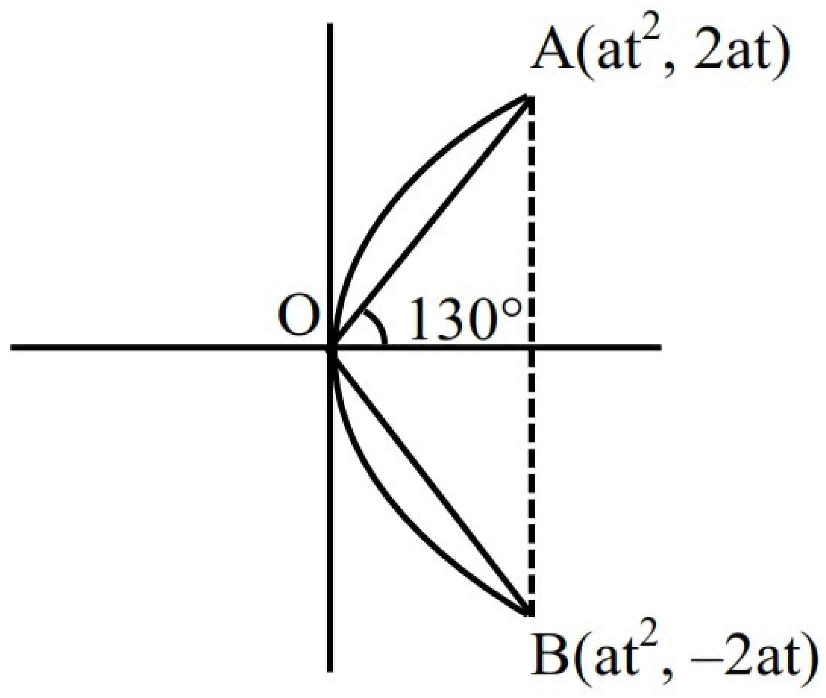
19. An equilateral triangle OAB is inscribed in the parabola $y^2 = 4x$ with the vertex O at the vertex of the parabola. Then the minimum distance of the circle having AB as a diameter from the origin is

(1) $4(3 - \sqrt{3})$ (2) $2(8 - 3\sqrt{3})$

(3) $4(6 + \sqrt{3})$ (4) $2(3 + \sqrt{3})$

Ans. **(1)**

Sol.



$$M_{OA} = \frac{2t - 0}{t^2 - 0} = \frac{2}{f}$$

$\frac{2}{t} = \tan 30°$

$t = 2\sqrt{3}$

Req. Circle : $(x-12)^2 + y^2 = (4\sqrt{3})^2$

Least distance = |CP – R|

$= \left|2 - 4\sqrt{3} = 4\left(3 - \sqrt{3}\right)\right.$

20. Let $\sum_{k=1}^{n} a_k = \alpha n^2 + \beta n$. If $a_{10} = 59$ and $a_6 = 7a_1$ then α + β is equal to

(1) 12 (2) 3

(3) 5 (4) 7

Ans. **(3)**

Sol. $a_n = S_n - S_{n-1}$

$= (\alpha n^2 + \beta n) - (\alpha(n-1)^2 + \beta(n-1))$

(1) $a_{59} \Rightarrow 19\alpha + \beta = 59$

(2) $a_6 = 7a_1 \Rightarrow 11\alpha + \beta = 7(\alpha + \beta)$

$\Rightarrow 2\alpha = 3\beta$

a = 3, β = 2

$\boxed{\alpha + \beta = 5}$

SECTION-B

21. If the solution curve $y = f(x)$ of the differential equation $(x^2 - 4)\, y' - 2xy + 2x(4 - x^2)^2 = 0$ $x > 2$, passes through the point (3, 15), then the local maximum value of f is ………

Ans. (16)

Sol. $(x^2 - 4)y^1 - 2xy = -2x(x^2-4)^2$

$$d\left(\frac{y}{x^2-4}\right) = -2x$$

$y = (-x^2 + C)\,(x^2 - 4)$

for $x = 3$ $y = 15 \Rightarrow C = 12$

$y = (-x^2 + 12)\,(x^2 - 4)$

$y^1 = 0 \Rightarrow x = 2\sqrt{2}$

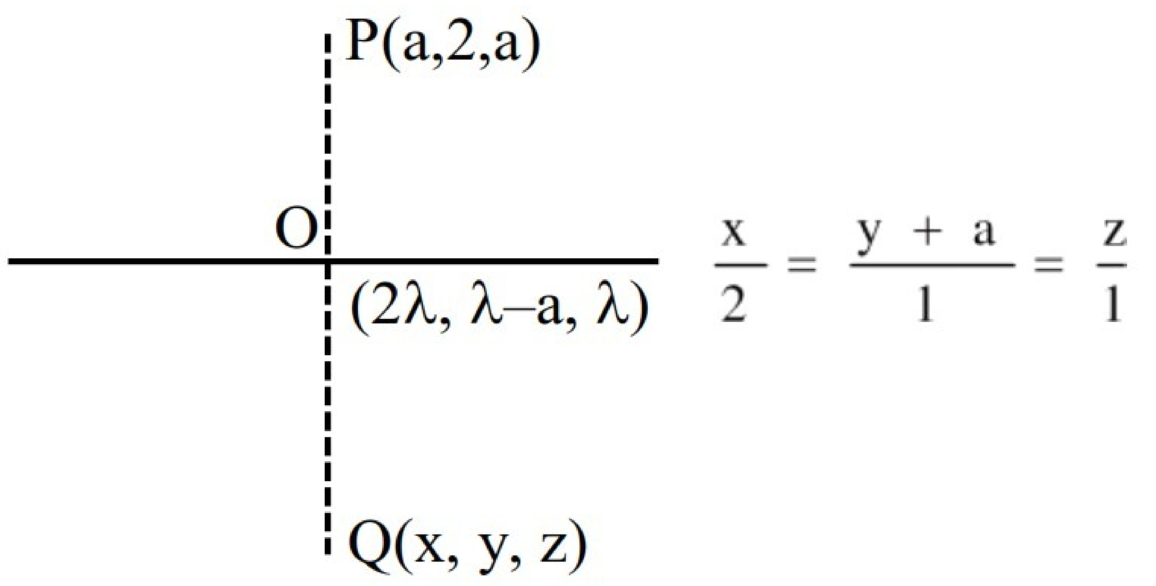
$$y_{\text{local maxi.}} = \left(\left(2\sqrt{2}\right)^2 - 4\right)\left(-\left(2\sqrt{2}\right)^2 + 12\right)$$

$= 16$

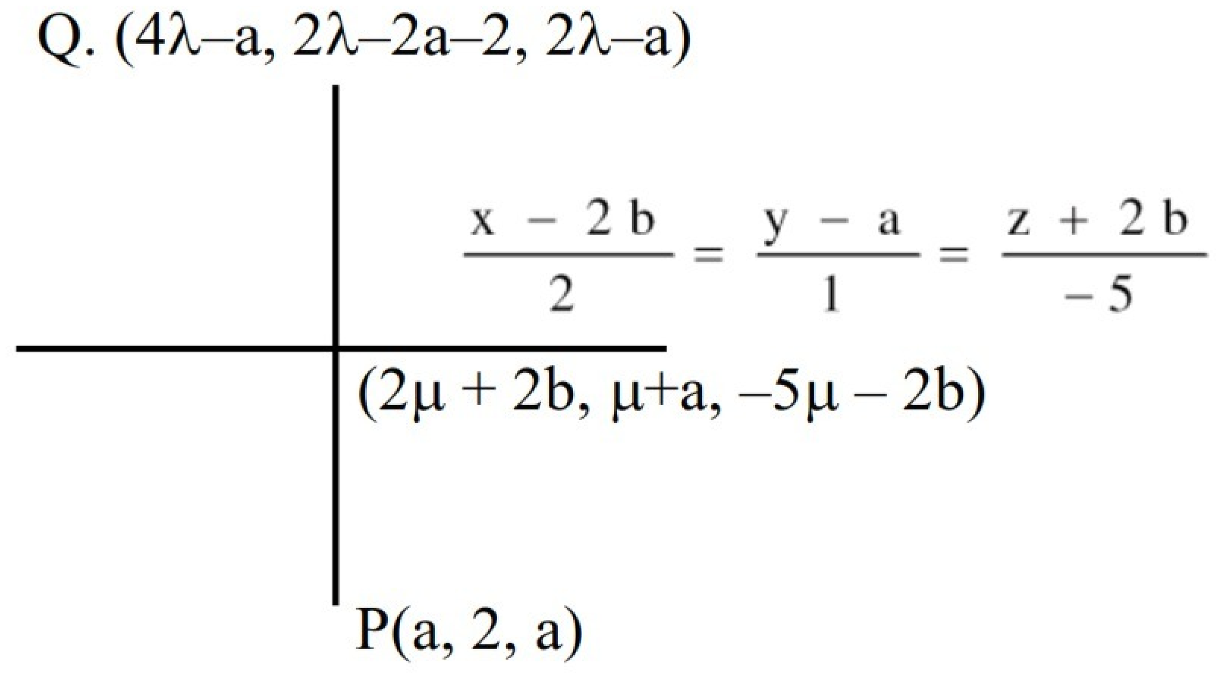
22. If the image of the point P(a, 2, a) in the line $\frac{x}{2} = \frac{y+a}{1} = \frac{z}{1}$ is Q and the of image of Q in the line $\frac{x-2b}{2} = \frac{y-a}{1} = \frac{z+2b}{-5}$ is P, then a + b is equal to………..

Ans. (3)

Sol.



Now,



$$\frac{2\lambda - a + a}{2} = -5\mu - 2b$$

and $\frac{a + 4\lambda - a}{2} = 2\mu + 2b$

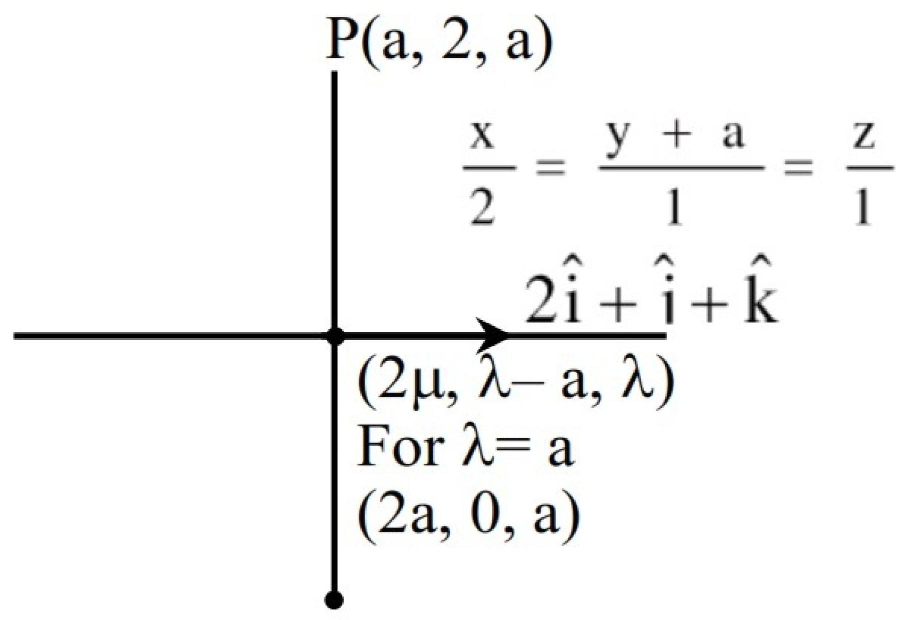
and $\frac{2\lambda - 2a - 2 + 2}{2} = \mu + a$

$\Rightarrow \lambda - \mu = b$

$\lambda - \mu = 2a$

$\lambda + 5\mu = -2b$

$\Rightarrow b = 2a$ and $\lambda = a$, $\mu = -a$



$$\left(a\hat{i} - 2\hat{j} + 0\hat{k}\right).\left(2\hat{i} + \hat{j} + \hat{k}\right) = 0$$

$2a - 2 = 0$

$a = 1$

$b = 2a = 2 \times 1 = 2$

$a + b = 1 + 2 = 3$

23. The number of elements in the

$$\text{set } S = \left\{x : x \in [0,100] \text{ and } \int_0^x t^2 \sin(x - t)dt = x^2\right\} \text{is.....}$$

Ans. (16)

Sol. $\int_0^x t^2 \sin(x-t)dt = x^2$

Use by parts

$-x^2\cos x + x^2 + 2x^2\cos x - 2x \sin x$

$-x^2\cos x + 2x \sin x + 2\cos x - 2 = x$

$\cos x = 1$

$x = 0, 2\pi, 4\pi, \ldots\ldots, 30\pi$

Total Elements = 16

24. Let A = $\begin{bmatrix} 0 & 2 & -3 \\ -2 & 0 & 1 \\ 3 & -1 & 0 \end{bmatrix}$ and B be a matrix such that $B(I - A) = I + A$. Then the sum of the diagonal elements of B^TB is equal to______.

Ans. **(3)**

Sol. $A^T = -A$

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

$B^T = ((I-A)^{-1})^T (I + A)^T$

$B^T = (I-A^T)^{-1} (I + A^T)$

$B^T = (I+A)^{-1} (I + A)$

$B^TB = (I+A)^{-1} (I - A)(I+A)(I-A)^{-1}$

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

$= I$

$tr(B^TB) = 3$

25. Let S denote the set of 4-digit numbers abcd such that a > b > c > d and P denote the set of 5-digit numbers having product of its digits equal to 20. Then n(S) + n(P) is equal to…………

Ans. **(260)**

Sol. For $n(s) = {}^{10}C_4 = 210$

(5, 4, 1, 1, 1) (5, 2, 2, 1, 1)

For $n(p) = \frac{5!}{3!} + \frac{5!}{2!2!} = 50$

$n(s) + n(p) = 210 + 50 = 260$

PHYSICS

26. The internal energy of a monoatomic gas is 3nRT. One mole of helium is kept in a cylinder having internal cross section area of 17 cm^2 and fitted with a light movable frictionless piston. The gas is heated slowly by suppling 126 J heat. If the temperature rises by 4 °C, then the piston will move______cm.

(atmospheric pressure = 10^5 Pa)

(1) 14.5 (2) 1.55

(3) 15.5 (4) 1.45

Ans. (3)

Sol. $\Delta U = 3nR\Delta T$

$$\Delta U = 3 \times 1 \times \frac{25}{3} \times 4 = 100 \text{ Joule}$$

$\Delta Q = 126$

$W = 26 = P\Delta V$

$26 = 10^5 \times 17 \times 10^{-4}\ \Delta x$

$$\Delta x = \frac{26}{170} = 15.3$$

27. A body of mass 14 kg initially at rest explodes and breaks into three fragments of masses in the ratio 2 : 2 : 3. The two pieces of equal masses fly off perpendicular to each other with a speed of 18 m/s each. The velocity of the heavier fragment is ____m/s.

(1) $10\sqrt{2}$

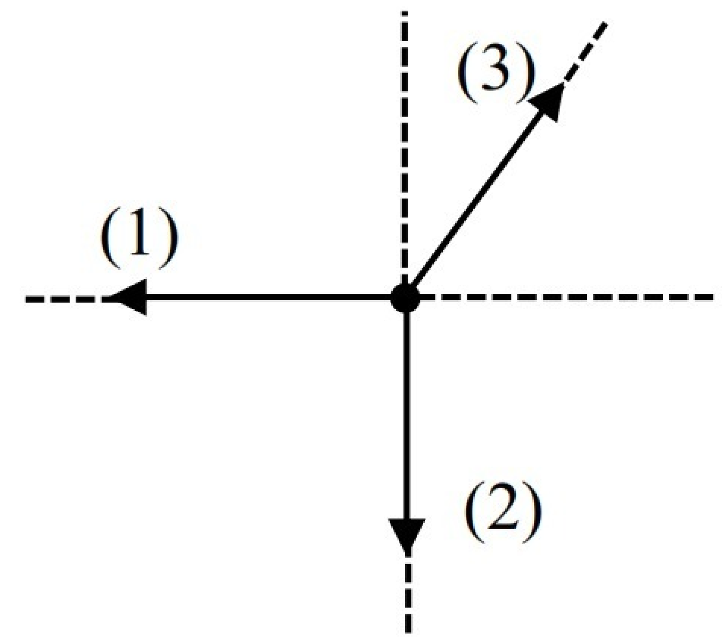
(2) $12\sqrt{2}$

(3) 12

(4) $24\sqrt{2}$

Ans. (2)

Sol.



Apply C.O.M

$M_1V_1 + M_2V_2 + M_3V_3 = 0$

$2(-18i) + 2(-18j) + 3V_3 = 0$

$V_3 = 12i + 12j$

$|V_3| = 12\sqrt{2}$ m/s

28. A block is sliding down on an inclined plane of slope θ and at an instant $t = 0$ this block is given an upward momentum so that it starts moving up on the inclined surface with velocity u. The distance (S) travelled by the block before its velocity become zero, is______.

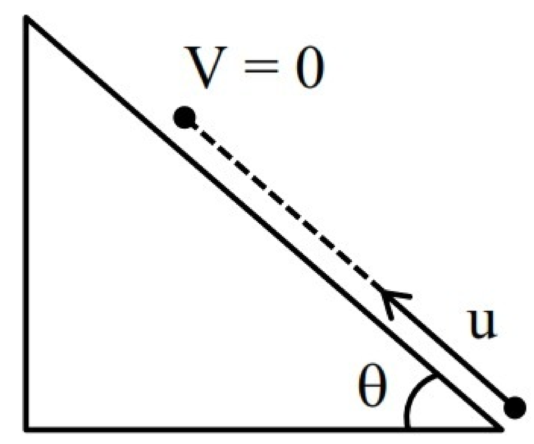
(g = gravitational acceleration)

(1) $\frac{u^2}{4g\sin\theta}$ (2) $\frac{2u^2}{g\cos\theta}$

(3) $\frac{u^2}{\sqrt{2}g\cos\theta}$ (4) $\frac{u^2}{2g\cos\theta}$

Ans. (4)

Sol.



$a = -g\sin\theta$

$V^2 = U^2 + 2as$

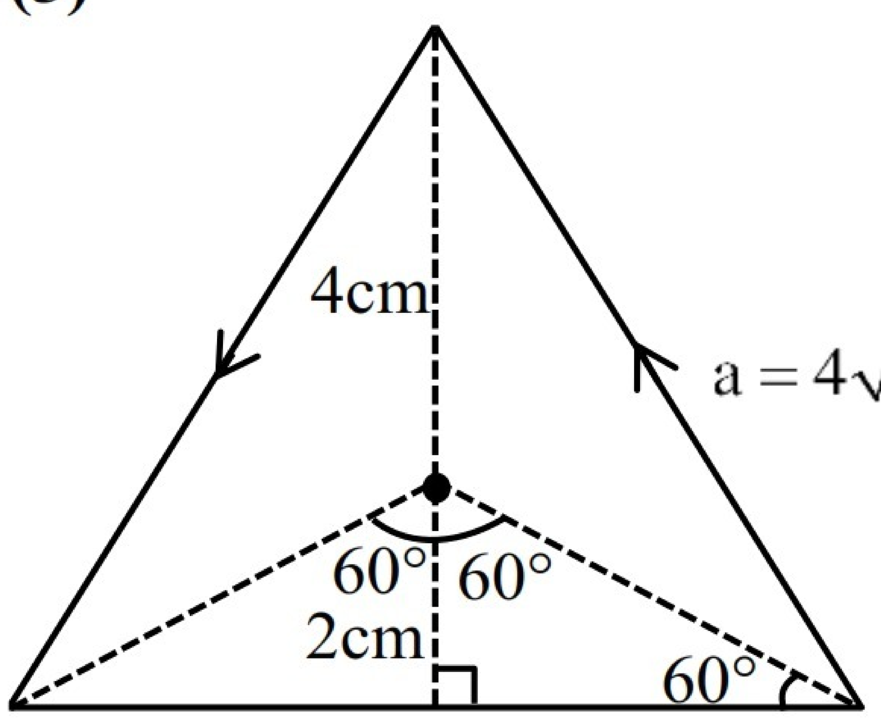
$0 = u^2 - 2g\sin\theta \cdot s$

$$s = \frac{u^2}{2g\sin\theta}$$

29. The current passing through a conducting loop in the form of equilateral triangle of side $4\sqrt{3}$ cm is 2A. The magnetic field at its centroid is $\alpha \times 10^{-5}$ T. The value of α is ______.
(Given : $\mu_o = 4\pi \times 10^{-7}$ SI units)
(1) $2\sqrt{3}$ (2) $\sqrt{3}$
(3) $3\sqrt{3}$ (4) $\frac{\sqrt{3}}{2}$

Ans. **(3)**

Sol.



$$B = \frac{\mu_0}{4\pi} \times \frac{I}{d} \ [\sin 60° + \sin 60°] \times 3$$

$$B = 10^{-7} \times \frac{2}{2\times10^{-2}}\left(\frac{\sqrt{3}}{2}+\frac{\sqrt{3}}{2}\right)\times 3$$

$$= \sqrt{3} \times 10^{-5} \times 3 = 3\sqrt{3}\times10^{-5}$$

30. A paratrooper jumps from an aeroplane and opens a parachute after 2 s of free fall and starts deaccelerating with 3 m/s^2. At 10 m height from ground, while descending with the help of parachute, the speed of paratrooper is 5 m/s. The initial height of the aeroplane is _____m.
($g = 10$ m/s^2)
(1) 62.5 (2) 92.5
(3) 20 (4) 82.5

Ans. **(2)**

Sol. A to B

$x_1 = \frac{1}{2} \times 10 \times 2^2 = 20$ m

$V = 0 + 10 \times 2$

B to C

$5^2 = 20^2 - 2(3)x_2$

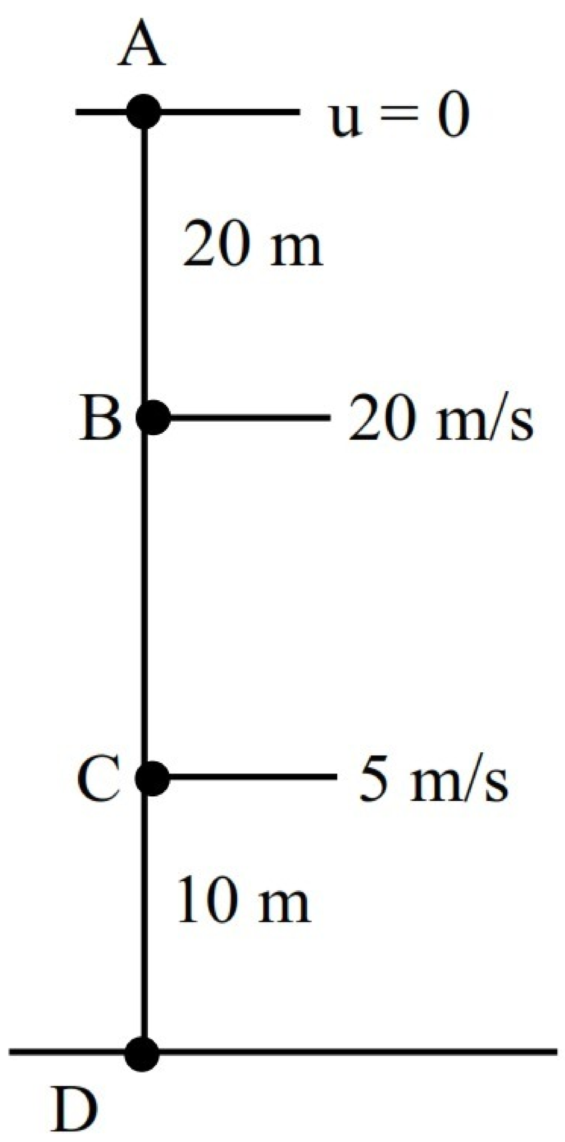
$x_2 = \frac{375}{6}$

$x_2 = 62.5$

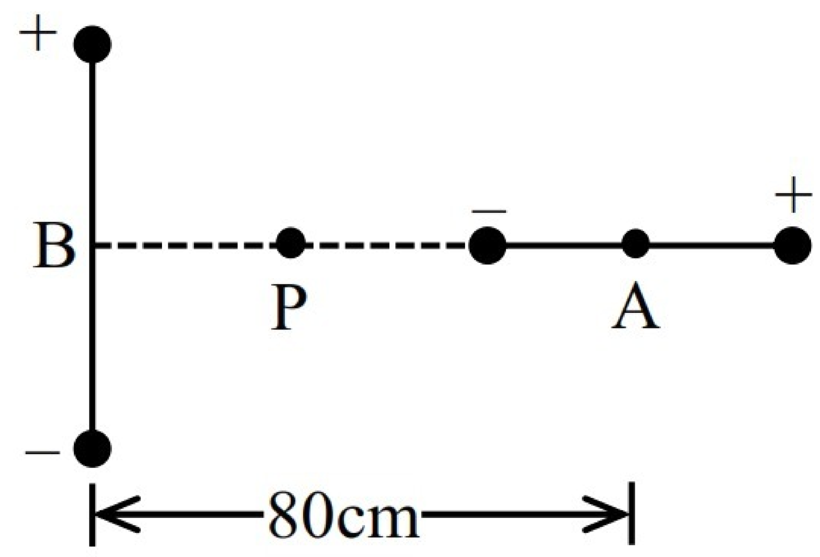
C to D

$x_3 = 10$m

$H = x_1 + x_2 + x_3 = 92.5$



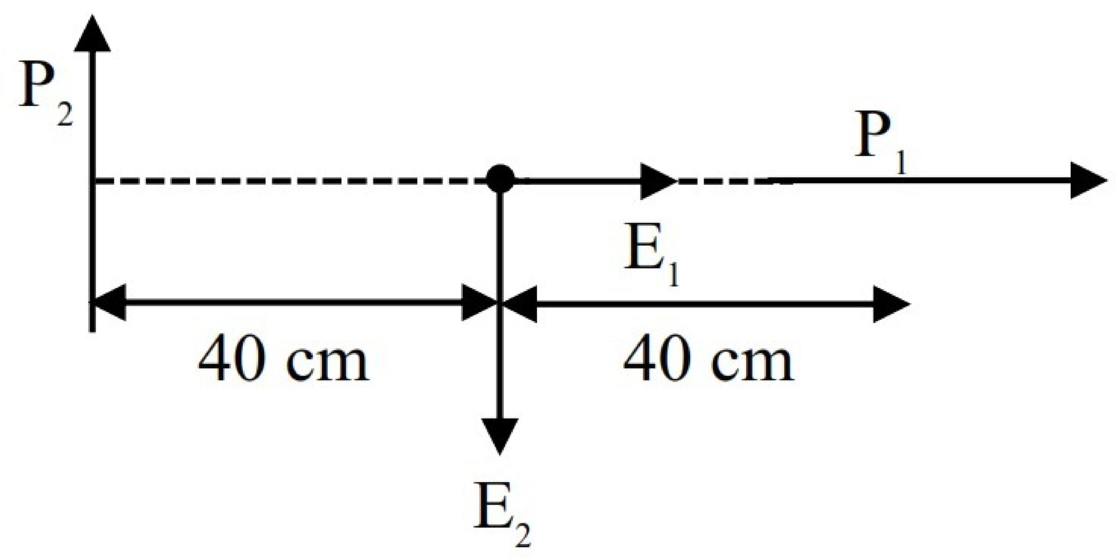
31. Two shorts dipoles (A, B), A having charges $\pm$ 2μC and length 1 cm and B having charges $\pm$ 4μC and length 1 cm are placed with their centres 80 cm apart as shown in the figure. The electric field at a point P, equi-distant from the centres of both dipoles is_____N/C.



(1) $\frac{9}{16}\sqrt{2}\times10^5$ (2) $4.5\ \sqrt{2}\times10^4$
(3) $9\sqrt{2}\times10^4$ (4) $\frac{9}{16}\sqrt{2}\times10^4$

Ans. **(4)**

Sol.



$$\vec{E}_2 = -\frac{KP_2}{r^3} \ ; \ \vec{E}_1 = -\frac{2KP_1}{r^3}$$

$P_1 = 2 \times 10^{-6} \times 10^{-2} = 2 \times 10^{-8}$

$P_2 = 4 \times 10^{-6} \times 10^{-2} = 4 \times 10^{-8}$

$$\vec{E}_{net} \ \frac{2\times9\times10^9\times2\times10^{-8}}{(0.4)^3}\ \hat{i} - \frac{9\times10^9\times4\times10^{-8}}{(0.4)^3}\hat{j}$$

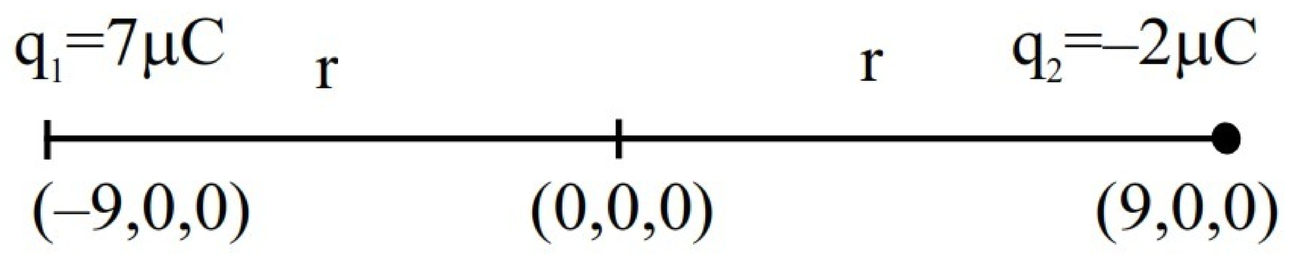
$$\vec{E}_{net} = \frac{9\times10^9\times4\times10^{-8}}{(0.4)^3}[\hat{i}-\hat{j}]$$

$$\left|\vec{E}_{net}\right| = \frac{9\times10^4}{16}(\sqrt{2})$$

32. Two charges 7μC and –2 μC are placed at (–9, 0, 0) cm and (9, 0, 0) cm respectively in an external field $E = \frac{A}{r^2}\hat{r}$, where $A = 9 \times 10^5$ N/C.m^2.
Considering the potential at infinity is 0, the electrostatic energy of the configuration is_____J.
(1) 1.4 (2) –90.7
(3) 49.3 (4) 24.3

Ans. **(3)**

Sol.



$$dV = -\vec{E}.\vec{dr}$$

$$\int_0^v dV = -\int_\infty^r \frac{A}{r^2}dr$$

$$V = -\left[\frac{-A}{r^2}\right]_\infty^r \Rightarrow \boxed{V = \frac{A}{r}}$$

$$U = U_{self} + U_{interaction}$$

$$= q_1v_1 = q_2v_2 + \frac{kq_1q_2}{2r}$$

$$= 7\times10^{-6}\frac{A}{9\times10^{-2}} - 2\times10^{-6}\frac{A}{9\times10^{-2}}$$

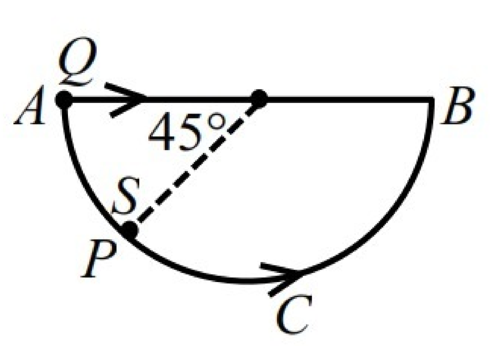
$$-\frac{9\times10^9\times14\times10^{-12}}{2\times9\times10^{-2}}$$

$$= \frac{5\times10^{-6}\times9\times10^5}{9\times10^{-2}} - 7\times10^{-1}$$

$= 50 - 0.7$

$= 49.3$ J

33. A bead P sliding on a frictionless semi-circular string (ACB) and it is at point S at t = 0 and at this instant the horizontal component of its velocity is v. Another bead Q of the same mass as P is ejected from point A at t = 0 along the horizontal string AB, with the speed v, friction between the beads and the respective strings may be neglected in both cases. Let t_p and t_Q be the respective times taken by beads P and Q to reach the point B, then the relation between t_p and t_Q is



(1) $t_P > t_Q$

(2) $t_p < t_Q$

(3) $t_p > 1.25t_Q$

(4) $t_p = t_Q$

Ans. **(2)**

Sol. Horizontal displacement of Q is more then P.

$$X_Q > X_P$$

Horizontal component of velocity is same

So $t_p = \frac{x_p}{v}$

$$t_Q = \frac{x_Q}{v}$$

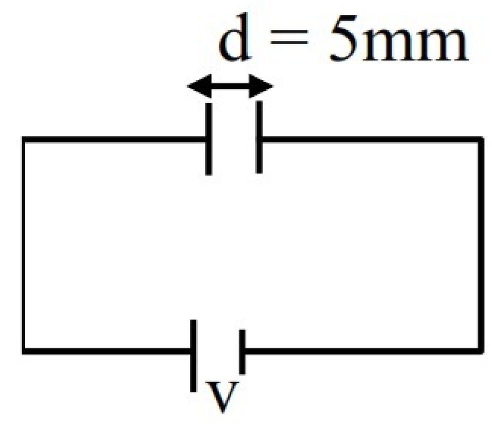
$t_Q > t_p$

34. A parallel plate capacitor with plate separation 5 mm is charged by a battery. On introducing a mica sheet of 2 mm and maintaining the connections of the plates with the terminals of the battery, it is found that it draws 25% more charge from the battery. The dielectric constant of mica is____.

(1) 2.5
(2) 2.0
(3) 1.5
(4) 1.0

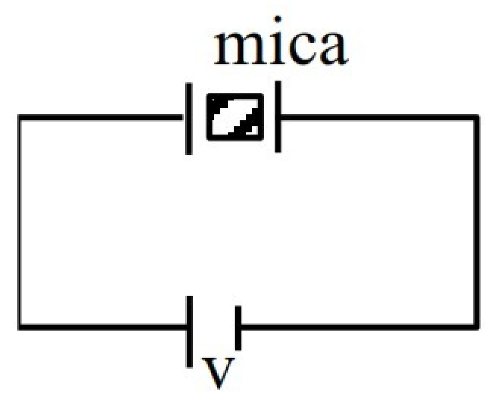
Ans. **(2)**

Sol.



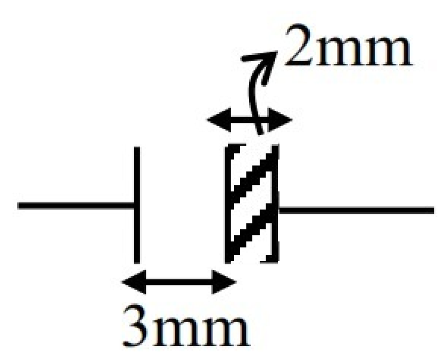
$$C = \frac{\epsilon_0 A}{d}$$

$Q_1 = CV$



$Q_2 = (c_{eq})$ v

$Q_2 = 1.25$ cv



$$c_{eq} = \frac{C_1C_2}{C_1+C_2} = \frac{\frac{\epsilon_0 A}{3}\times\frac{K\epsilon_0 A}{2}}{\frac{\epsilon_0 A}{3}+\frac{K\epsilon_0 A}{2}}$$

$$c_{eq} = \frac{(\epsilon_0 A)^2\left(\frac{K}{6}\right)}{\epsilon_0 A\left(\frac{2+3K}{6}\right)} \Rightarrow C_{eq} = \frac{K\epsilon_0 A}{2+3K}$$

$$1.25 \times \frac{\epsilon_0 A}{5} = \frac{K\epsilon_0 A}{2+3K} \Rightarrow 0.25\,(2+3K) = K$$

$$2 + 3K = 4K \Rightarrow K = 2$$

35. To compare EMF of two cells using potentiometer the balancing lengths obtained are 200 cm and 150 cm. The least count of scale is 1 cm. The percentage error in the ratio of EMFs is____

(1) 1.45 (2) 1.65

(3) 1.75 (4) 1.55

Ans. (2)

Sol. $\epsilon = \lambda \ell$

Potential gradient

$\epsilon_1 = \lambda \ell_1$

$\epsilon_2 = \lambda \ell_2$

$$y = \frac{\epsilon_1}{\epsilon_2} = \frac{\ell_1}{\ell_2}$$

$$\frac{\Delta y}{y} = \frac{\Delta \ell_1}{\ell_1} + \frac{\Delta \ell_2}{\ell_2}$$

$$\frac{\Delta y}{y} = \frac{1}{200} + \frac{1}{150}$$

$$\frac{\Delta y}{y} \times 100\left(\frac{1}{200} + \frac{1}{150}\right) \times 100$$

$$= \left(\frac{3+4}{600}\right) \times 100 \Rightarrow \frac{7}{6} = 1.16\%$$

No options matching

36. An air bubble of volume 2.9 cm^3 rises from the bottom of a swimming pool of 5 m deep. At the bottom of the pool water temperature is 17 °C. The volume of the bubble when it reaches the surface, where the water temperature is 27 °C, is____ cm^3.
($g = 10\ m/s^2$, density of water $= 10^3\ kg/m^3$, and 1 atm pressure is 10^5 Pa)

(1) 4.2 (2) 2.0

(3) 3.0 (4) 4.5

Ans. (4)

Sol. For an air bubble rising in water, the no. of moles remain constant

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{(P_{atm} + \rho g h)2.9cm^3}{290K} = \frac{(P_{atm})V_2}{300}$$

$V_2 = 4.5\ cm^3$

37. Which of the following pair of nuclei are isobars of the element ?

(1) ${}_1^2H$ and ${}_1^3H$

(2) ${}_{92}^{236}U$ and ${}_{92}^{238}U$

(3) ${}_{80}^{198}Hg$ and ${}_{79}^{197}Au$

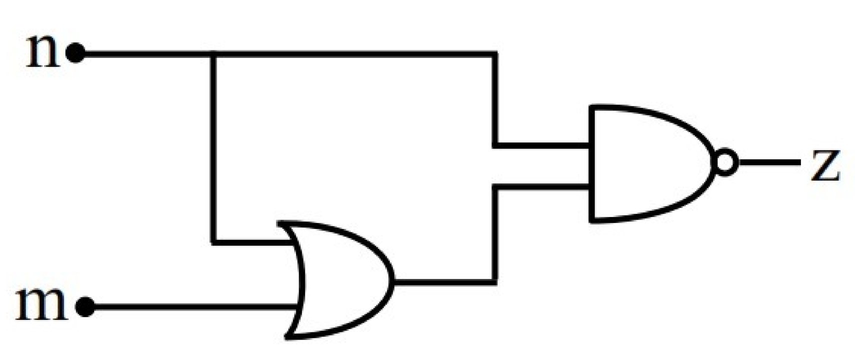
(4) ${}_1^3H$ and ${}_2^3H$

Ans. (4)

Sol. Isobars are nuclei that have the same mass number

${}_1^3H$ & ${}_2^3He$ have same mass number.

38. For the given logic gate circuit, which of the following is the correct truth table?



(1)

n	m	z
0	0	1
0	1	0
1	1	0
1	0	0

(2)

n	m	z
0	0	0
0	1	1
1	1	0
1	0	1

(3)

n	m	z
0	0	1
0	1	0
1	1	1
1	0	0

(4)

n	m	z
0	0	1
0	1	1
1	1	0
1	0	0

Ans. (4)

Sol. **Gate 1 :** At bottom there is an OR gate with inputs n & m

out put = n + m

Gate 2 : A NAND gate, its Input are direct n & the output of OR gate (n + m)

out put $z = \overline{n.(n+m)}$

since n.(n + m) = (n.n) + (n.m)

= n + n.m = n(1 + m) = n

$\therefore$ output $z = \overline{n.(n+m)} = \bar{n}$

n	m	$z = \bar{n}$
0	0	1
0	1	1
1	1	0
1	0	0

39. One mole of an ideal diatomic gas expands from volume V to 2V isothermally at a temperature 27°C and does W joule of work. If the gas undergoes same magnitude of expansion adiabatically from 27°C doing the same amount of work W, then its final temperature will be (close to) __________ °C.

(1) –189 (2) –56

(3) –30 (4) –117

Ans. **(2)**

Sol. For Isothermal process

$$W_{isothermal} = nRT\ell n\left(\frac{V_2}{V_1}\right)$$

$= 1.R\ 300.\ \ell n(2)$

$= 300\ R\ (0.693)$…………..(1)

Now for adiabatic process,

It is given work done in Isothermal = work done in adiabatic

$$W_{adiabatic} = \frac{nR(T_1 - T_2)}{\gamma - 1} \text{…………..(2)}$$

(1) = (2)

$$\frac{nR(300 - T_{final})}{1.4 - 1} = 300R(0.693)$$

$T_{Final} = 216.84$ K

= –56.3°C

40. A prism of angle 75° and refractive index $\sqrt{3}$ is coated with thin film of refractive index 1.5 only at the back exit surface. To have total internal reflection at the back exit surface the incident angle must be _______.

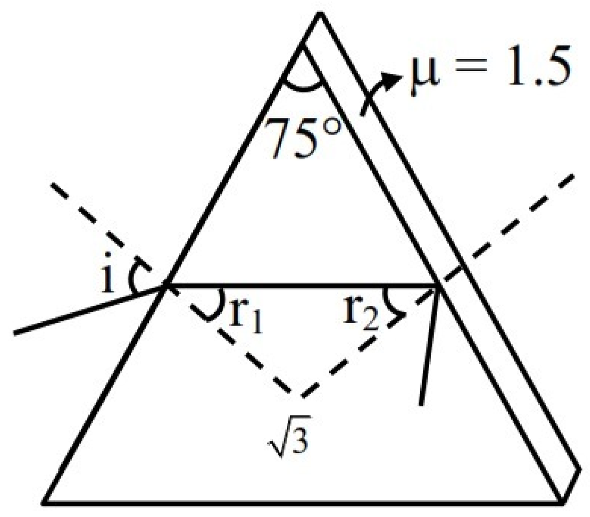
(sin 15° = 0.25 and sin 25° = 0.43)

(1) between 15° and 20° (2) 15°

(3) > 25° (4) < 15°

Ans. **(1, 2, 4)**

Sol.



$r_1 + r_2 = 75°$

For T I R at back surface

$$\sqrt{3}\sin r_2 = \frac{3}{2}\sin 90°$$

$r_2 \geq 60°$

$r_1 \leq 15°$

$1\sin i = \sqrt{3}\sin 15°$

$\sin i = 1.73 \times .25$

$\sin i = .433$

$i = 25° \Rightarrow i < 25°$

41. A circular loop of radius 7 cm is placed in uniform magnetic field of 0.2 T directed perpendicular to plane of loop. The loop is converted into a square loop in 0.5 s. The EMF induced in the loop is ___________ mV.

(1) 6.6 (2) 13.2

(3) 8.25 (4) 1.32

Ans. **(4)**

Sol. induced EMF $= \frac{d\phi}{dt}$

circumference $\simeq 14\pi$

side length of square loop $= \frac{14\pi}{4} = \frac{7\pi}{2}$

$\Delta\phi = B\ (A_1 - A_2)$

$$= (.2)\left(\left(\frac{7\pi}{2}\right) \times \frac{7\pi}{2} - 49\pi\right) \times 10^{-4}$$

$$= .2\left(\frac{49\pi^2}{4} - 49\pi\right)\times 10^{-4}$$

$\Delta\phi = .2 \times 33.07 \times 10^{-4}$

$\Delta\phi = 6.614 \times 10^{-4}$

$$\text{EMF} = \frac{6.614\times 10^{-4}}{\frac{1}{2}}\text{V} = 13.23 \times 10^{-4}\ \text{V}$$

EMF = 1.32 mV

42. Suppose a long solenoid of 100 cm length, radius 2 cm having 500 turns per unit length, carries a current I = 10 sin (ωt) A, where ω = 1000 rad./s. A circular conducting loop (B) of radius 1 cm coaxially slided through the solenoid at a speed v = 1 cm/s. The r.m.s. current through the loop when the coil B is inserted 10 cm inside the solenoid is $\alpha/\sqrt{2}$ μA. The value of α is __________.

[Resistance of the loop = 10 Ω]

(1) 197 (2) 80

(3) 280 (4) 100

Ans. **(1)**

Sol. EMF induced $\varepsilon = A\dfrac{dB}{dt} = A\mu_0 n\dfrac{di}{dt}$

$\varepsilon = A\mu_0 n\, i_0 \omega \cos\omega t$

current induced $i = \dfrac{\varepsilon}{R} = \dfrac{\pi r^2\mu_0 n i_0\omega}{R}\cos\omega t$

So $i = \dfrac{\pi r^2\mu_0 n i_0\omega}{\sqrt{2}R}$

$$= \frac{\pi\times 10^{-4}\times 4\pi\times 10^{-7}\times 500\times 10\times 10^3}{\sqrt{2}\times 10}$$

$$= \frac{20\pi^2}{\sqrt{2}}\times 10^{-6}$$

$$\simeq \frac{197}{\sqrt{2}}\mu\text{A}$$

43. The ratio of speeds of electromagnetic waves in vacuum and a medium, having dielectric constant k = 3 and permeability of $\mu = 2\mu_0$, is

(μ_0 = permeability of vacuum)

(1) 36 : 1

(2) 3 : 2

(3) 6 : 1

(4) $\sqrt{6}$: 1

Ans. **(4)**

Sol. $\dfrac{C}{V} = \mu = \sqrt{\varepsilon_r\mu_r}$

$$\frac{C}{V} = \sqrt{\frac{3\times 2}{1}} = \frac{\sqrt{6}}{1}$$

44. When an unpolarized light falls at a particular angle on a glass plate (placed in air), it is observed that the reflected beam is linearly polarized. The angle of refracted beam with respect to the normal is ________.

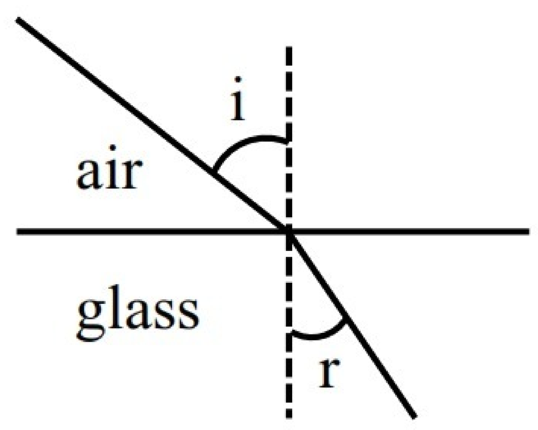
($\tan^{-1}$ (1.52) = 57.7°, refractive indices of air and glass are 1.00 and 1.52, respectively)

(1) 39.6° (2) 32.3°

(3) 42.6° (4) 36.3°

Ans. **(2)**

Sol.



$$\tan i = \frac{\mu_2}{\mu_1} = \frac{\mu_g}{\mu_a}$$

tan i = 1.52

i = 57.7°

r = 90° – i

r = 32.3°

45. A small metallic sphere of diameter 2 mm and density 10.5 g/cm^3 is dropped in glycerine having viscosity 10 Poise and density 1.5 g/cm^3 respectively. The terminal velocity attained by the sphere is ________ cm/s.

($\pi = \frac{22}{7}$ and $g = 10\ m/s^2$)

(1) 2.0 (2) 1.0

(3) 3.0 (4) 1.5

Ans. (1)

Sol. $V_T = \frac{2r^2g}{9\eta}(\rho_b - \rho_\ell)$

$V_T = \frac{2}{9}\frac{(.1)^2 \times 10}{(10)}(10.5 - 1.5)$

$V_T = 2$ cm/sec.

SECTION - B

46. The average energy released per fission for the nucleus of ${}^{235}_{92}U$ is 190 MeV. When all the atoms of 47 g pure ${}^{235}_{92}U$ undergo fission process, the energy released is $\alpha \times 10^{23}$ MeV. The value of α is _______.

(Avogadro Number = 6×10^{23} per mole)

Ans. (228)

Sol. Total numbers of U-235 atom is

$47\ g = \frac{47}{235}$ moles $= \frac{1}{5}$ moles

$\therefore$ Total energy released $= \frac{1}{5} \times 6 \times 10^{23} \times 190$ MeV

$= 228 \times 10^{23}$ MeV

47. The size of the images of an object, formed by a thin lens are equal when the object is placed at two different positions 8 cm and 24 cm from the lens. The focal length of the lens is ________ cm.

Ans. (16)

Sol. $m = \frac{f}{f+u}$

$m_1 = -m_2$

$\frac{f}{f-8} = -\frac{f}{f-24}$

$f - 8 = 24 - f$

$2f = 32$

$f = 16$ cm

48. A ball of radius r and density ρ dropped through a viscous liquid of density σ and viscosity η attains its terminal velocity at time t, given by $t = A\ \rho^a\ r^b\ \eta^c\ \sigma^d$, where A is a constant and a, b c and d are integers. The value of $\frac{b+c}{a+d}$ is ______.

Ans. (1)

Sol. $T = (ML^{-3})^a L^b (ML^{-1}T^{-1})^c (ML^{-3})^d$

$T = M^{a+c+d}\ L^{-3a-c-3d+b}\ T^{-c}$

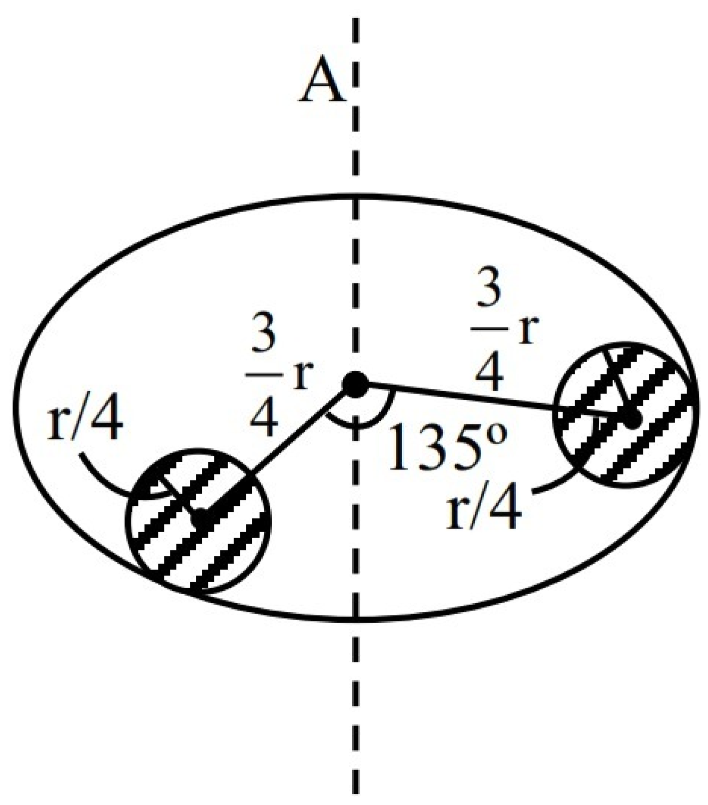
on comparing

$c = -1;\ a + c + d = 0;\ -3a - c - 3d + b = 0$

$b = 2;\ a + d = 1$

$b + c = 1$

49. Suppose there is a uniform circular disc of mass M kg and radius r m shown in figure. The shaded regions are cut out from the disc. The moment of inertia of the remainder about the axis A of the disc is given by $\frac{x}{256}\ Mr^2$. The value of x is _________.



Ans. (109)

Sol. $M = \sigma\pi R^2$

$\sigma\pi R^2 = 16\ m$

$m = \frac{\sigma\pi R^2}{16}$

$I_{system} = \frac{MR^2}{2} - 2\left(\frac{mR^2}{2\times 16} + \frac{9mR^2}{16}\right)$

$= \frac{MR^2}{2} - 2 \times \frac{19mR^2}{32}$

$= \frac{MR^2}{2} - \frac{19}{16}mR^2$

$= \frac{MR^2}{2} - \frac{19}{256}MR^2$ becoz $m = \frac{M}{16}$

$= \frac{(128-19)(MR^2)}{256}$

$= \frac{109MR^2}{256}$

50. The velocity of sound in air is doubled when the temperature is raised from 0°C to α°C. The value of α is ________.

Ans. (819)

Sol. $V = \sqrt{\frac{\gamma RT}{M}}$

$$\frac{V_1}{V_2} = \frac{\sqrt{T_1}}{\sqrt{T_2}}$$

$$\frac{V_0}{2V_0} = \sqrt{\frac{273}{T_2}}$$

$$\frac{1}{4} = \frac{273}{T_2}$$

$T_2 = 4 \times 273 = \alpha + 273$

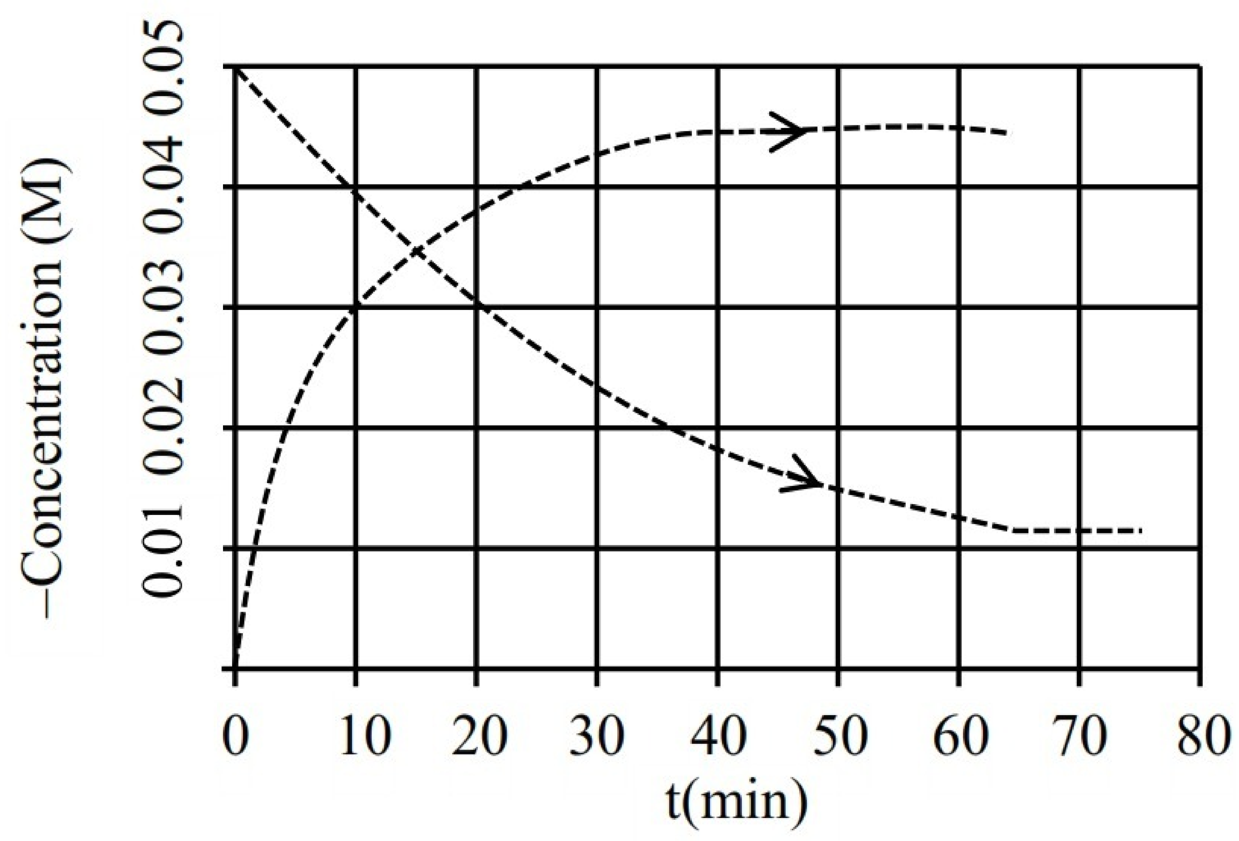
$\alpha = 3 \times 273$

$\alpha = 819°C$

CHEMISTRY

SECTION-A

51.



Given above is the concentration vs time plot for a dissociation reaction : $A \rightarrow nB$.

Based on the data of the initial phase of the reaction (initial 10 min), the value of n is ________.

(1) 4 (2) 3

(3) 2 (4) 5

Ans. (2)

Sol. $A \rightarrow nB$

$0.05 \quad 0$

$0.04 \quad 0.01 \times n$

$0.01 \times n = 0.03$

$n = 3$

52. It is noticed that Pb^{2+} is more stable than Pb^{2+} but Sn^{2+} is less stable than Sn^{4+}. Observe the following reactions

$PbO_2 + Pb \rightarrow 2PbO; \Delta_rG° (1)$

$SnO_2 + Sn \rightarrow 2SnO; \Delta_rG° (2)$

Identify the correct set from the following.

(1) $\Delta_rG°(1) > 0 ; \Delta_rG°(2) < 0$

(2) $\Delta_rG°(1) < 0 ; \Delta_rG°(2) < 0$

(3) $\Delta_rG°(1) < 0 ; \Delta_rG°(2) > 0$

(4) $\Delta_rG°(1) > 0 ; \Delta_rG°(2) > 0$

Ans. (3)

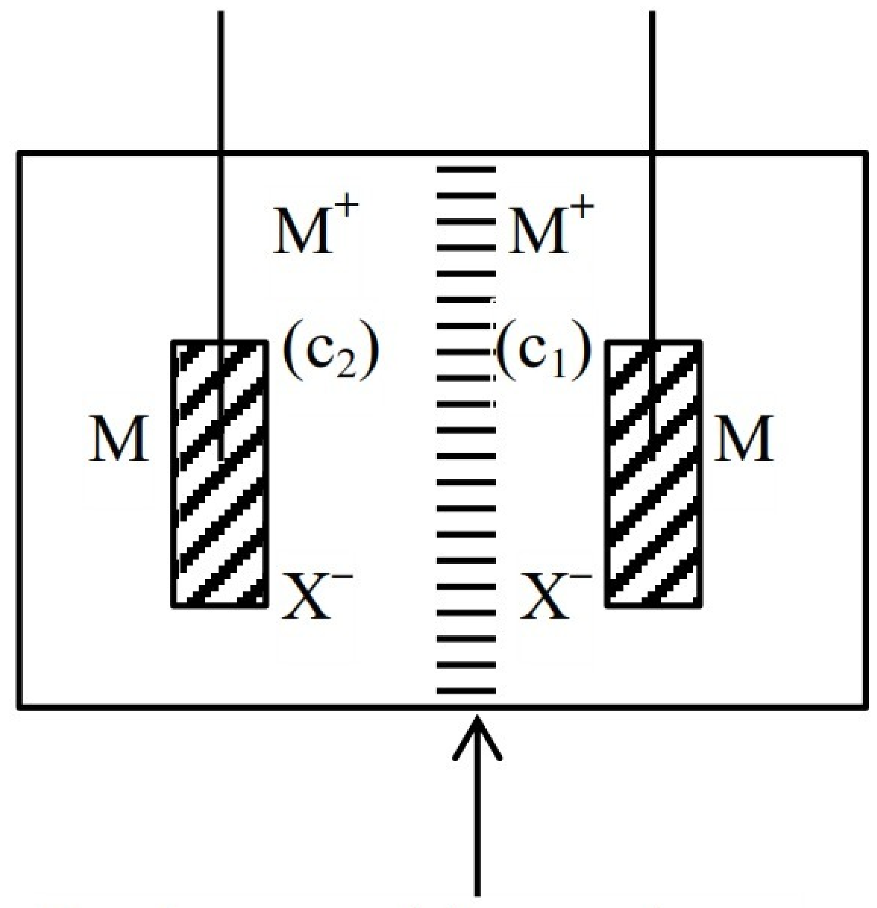
Sol. $PbO_2 + Pb \rightarrow 2PbO$

Pb^{2+} is more stable hence reaction will be spontaneous. So $\Delta G°_r(1)$ is negative.

$SnO_2 + Sn \rightarrow 2SnO$

Sn^{+2} is less stable, so reaction will be non-spontaneous hance $\Delta G°_r(2)$ is positive.

53.



Semi permeable membrane

Consider the above electrochemical cell where a metal electrode (M) is undergoing redox reaction by forming M^+ ($M \rightarrow M^+ + e$). The cation M^+ is present in two different concentrations c_1 and c_2 as shown above. Which of the following statement is correct for generating a positive cell potential?

(1) If c_1 is present at anode, then $c_1 = c_2$

(2) If c_1 is present at cathode, then $c_1 < c_2$

(3) If c_1 is present at cathode, then $c_1 > c_2$

(4) If c_1 is present at anode, then $c_1 > c_2$

Ans. (3)

Sol. (1) If C_1 is at anode $\Rightarrow$ cell reaction

$M^+(C_2) \rightarrow M^+(C_1)$

$$E_{cell} = -0.059 \log \frac{C_1}{C_2}$$

$\therefore E_{cell} > 0 \Rightarrow C_1 < C_2$

(2) If C_1 is at cathode

$M^+(C_1) \rightarrow M^+(C_2)$

$$E_{cell} = -0.059 \log \frac{C_2}{C_1} > 0$$

$C_2 < C_1$

54. Both human DNA and RNA are chiral molecules. The chirality in DNA and RNA arises due to the presence of

(1) Base unit (2) Chiral phosphate unit

(3) D-sugar component (4) L-sugar component

Ans. (3)

Sol. DNA & RNA are chiral molecules due to presence of chiral 2-deoxy-Ribose & Ribose sugar unit respectively.

55. Identify the **CORRECT** set of details from the following :

A. $[Co(NH_3)_6]^{3+}$: Inner orbital complex ; d^2sp^3 hybridized

B. $[MnCl_6]^{3-}$ Outer orbital complex; sp^3d^2 hybridized

C. $[CoF_6]^{3-}$: Outer orbital complex ; d^2sp^3 hybridized

D. $[FeF_6]^{3-}$: Outer orbital complex: sp^3d^2 hybridized

E. $[Ni(CN)_4]^{2-}$: Inner orbital complex ; sp^3 hybridized

Choose the correct answer from the options given below:

(1) C & D only (2) A, B & D only

(3) A, C & E only (4) A, B, C, D & E

Ans. (2)

Sol. (A) Co^{3+} :- $3d^6$

$NH_3 \Rightarrow$ S.F.L

Hybridisation $\Rightarrow$ d^2sp^3, Inner orbital complex

(B) Mn^{3+} :- $3d^4$

$Cl^- \Rightarrow$ W.F.L

Hybridisation $\Rightarrow$ sp^3d^2, Outer orbital complex

(C) Co^{3+} :- $3d^6$

$F^- \Rightarrow$ W.F.L

Hybridisation $\Rightarrow$ sp^3d^2, Outer orbital complex

(D) Fe^{3+} :- $3d^5$

$F^- \Rightarrow$ W.F.L

Hybridisation $\Rightarrow$ sp^3d^2, Outer orbital complex

(E) Ni^{2+} :- $3d^8$

$CN^- \Rightarrow$ S.F.L

Hybridisation $\Rightarrow$ dsp^2, Inner orbital complex

56. Elements X and Y belong to Group 15. The difference between the electronegativity values of 'X' and phosphorus is higher than that of the difference between phosphorus and 'Y'. 'X' & 'Y' are respectively

(1) N & As (2) As & Bi

(3) Bi & N (4) As & Sb

Ans. (1)

Sol.

Element	EN
N	3.0
P	2.1
As	2.0
Sb	1.9
Bi	1.9

X = Nitrogen (N)

Y = Arsenic (As)

57. Given below are two statements:

Statement I: $(CH_3)_3\overset{\oplus}{C}$ is more stable than $\overset{\oplus}{C}H_3$ as nine hyperconjugation interactions are possible in $(CH_3)_3\overset{\oplus}{C}$.

Statement II: $\overset{\oplus}{C}H_3$ is less stable than $(CH_3)_3\overset{\oplus}{C}$ as only three hyperconjugation interactions are possible in $\overset{\oplus}{C}H_3$.

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

(1) **Statement I** is true but **Statement II** is false

(2) Both **Statement I** and **Statement II** are true

(3) Both **Statement I** and **Statement II** are false

(4) **Statement I** is false but **Statement II** is true

Ans. (1)

Sol. S-1 : $(CH_3)_3C^+ > \overset{+}{C}H_3$; due to hyperconjugation interaction $CH_3-\overset{\oplus}{C}(CH_3)-CH_3$.

S-2 : False

58. Iodoform test can differentiate between

A. Methanol and Ethanol

B. CH_3COOH and CH_3CH_2COOH

C. Cyclohexene and cyclohexanone

D. Diethyl ether and Pentan-3-one

E. Anisole and acetone

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

(1) A & E only (2) A & D only

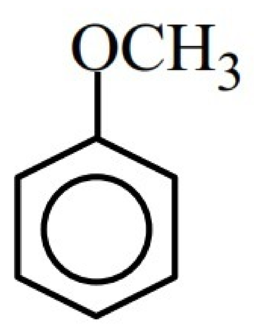
(3) A, B & E only (4) B, C & E only

Ans. (1)

Sol. $R-\overset{O}{\overset{\|}{C}}-CH_3$ or $R-\underset{OH}{\underset{|}{CH}}-CH_3$

$\xrightarrow[+I_2]{NaOH} R-CO\overset{\ominus}{O}\overset{\oplus}{Na} + \underset{\text{Yellow ppt}}{CHI_3 \downarrow}$

(A) CH_3-OH & $CH_3-\underset{OH}{\underset{|}{CH_2}}$



& $CH_3-\overset{O}{\overset{\|}{C}}-CH_3$

59. Given below are two statements :

Statement I : The second ionisation enthalpy of Na is larger than the corresponding ionisation enthalpy of Mg.

Statement II : The ionic radius of O^{2-} is larger than that of F^-.

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

(1) Both statement I and statement II are true

(2) Both statement I and statement II are false

(3) Statement I is false but statement II is true

(4) Statement I is true but statement II is false

Ans. (1)

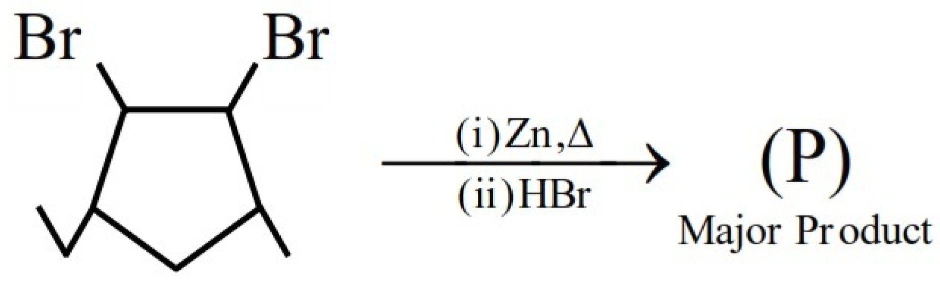
Sol. **Na^+ :-** $1s^2 2s^2 2p^6$ (fully filled electronic configuration)

Mg^+ :- $1s^2 2s^2 2p^6 3s^1$

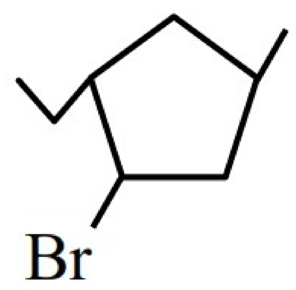
IE_2 of Na > IE_2 of Mg

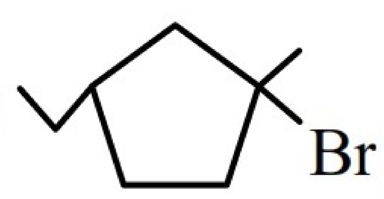
Size of $O^{2-} > F^-$

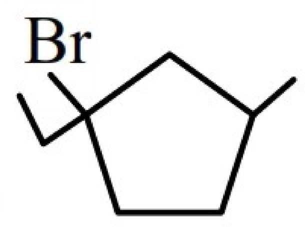
60.

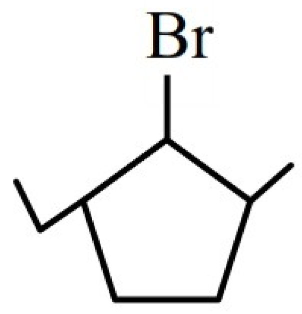


Identify (P)

(1) 

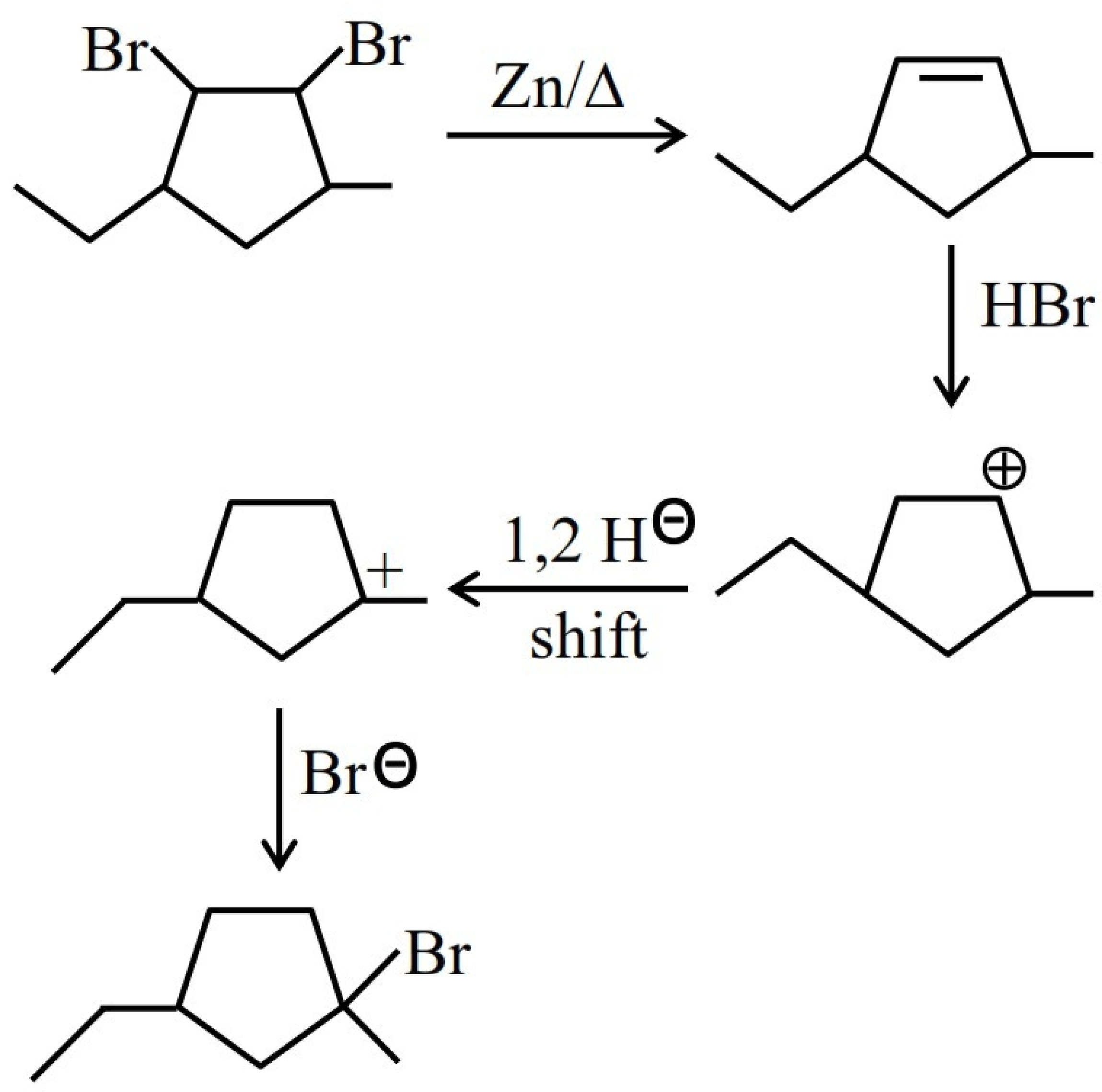
(2) 

(3) 

(4) 

Ans. (2)

Sol.



61. Observe the following reactions at T(K)

I. A $\rightarrow$ products.

II. $5Br^-(aq) + BrO_3^-(aq) + 6H^+(aq) \rightarrow 3Br_2(aq) + 3H_2O(l)$

Both the reactions are started at 10.00 am. The rates of these reactions at 10.10 am are same. The value of $-\frac{\Delta[Br^-]}{\Delta t}$ at 10.10 am is 2×10^{-4} mol L^{-1} Min^{-1}. The concentration of A at 10.10 am is 10^{-2} mol L^{-1}. What is the first order rate constant (in min^{-1}) of reaction I?

(1) 2×10^{-3}

(2) 10^{-3}

(3) 10^{-2}

(4) 4×10^{-3}

Ans. (4)

Sol. At t = 10 minutes

Rate of reaction $= -\frac{1}{5}\frac{\Delta[Br^-]}{\Delta t} = \frac{1}{5} \times (2 \times 10^{-4})$

$= 4 \times 10^{-5}$

For reaction $A \rightarrow P$

at t = 10 minutes

Rate of reaction $= 4 \times 10^{-5} = k[A]$

$k = 4 \times 10^{-3}\ min^{-1}$.

62. Which of the following statements are **TRUE** about Haloform reaction?

A. Sodium hypochlorite reacts with KI to give KOI.

B. KOI is a reducing agent.

C. α, β-unsaturated methylketone $(CH_3{-}CH{=}CH{-}\overset{\overset{\large O}{||}}{C}{-}CH_3)$ will give iodoform reaction.

D. Isopropyl alcohol will not give iodoform test.

E. Methanoic acid will give positive iodoform test.

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

(1) A, C & E only (2) A, B & C only

(3) A & C only (4) B, D & E only

Ans. (3)

Sol. (A) $NaOCl + KI \rightarrow NaCl + KOI$

(B) Incorrect statement

(C) $CH_3 - CH = CH - \overset{\overset{O}{||}}{C} - CH_3$ gives iodoform reaction.

(D) Incorrect statement

(E) Incorrect statement

63. Which statements are **NOT TRUE** about XeO_2F_2?

A. It has a see-saw shape.

B. Xe has 5 electron pairs in its valence shell in XeO_2F_2.

C. The O–Xe–O bond angle is close to 180°.

D. The F–Xe–F bond angle is close to 180°

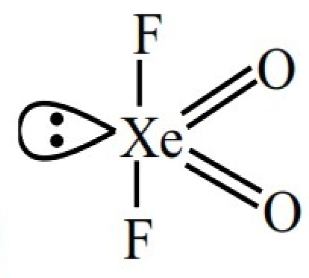
E. Xe has 16 valence electrons in XeO_2F_2.

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

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

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

Ans. (1)

Sol. **(A)** 

See-saw

(B) Xe has 7 electron pair in its valence shell

(C) O–Xe–O Bond angle is close to 120°

(D) F–Xe–F Bond angle is close to 180°

(E) Xe has 14 valence electron in XeO_2F_2

64. Identify the **INCORRECT** statements from the following:

A. Notation $^{24}_{12}Mg$ represents 24 protons and 12 neutrons.

B. Wavelength of a radiation of frequency $4.5 \times 10^{15}\ s^{-1}$ is 6.7×10^{-8} m.

C. One radiation has wavelength = λ_1(900 nm) and energy = E_1. Other radiation has wavelength = λ_2(300 nm) and energy = E_2.$E_1 : E_2 = 3 : 1$.

D. Number of photons of light of wavelength 2000 pm that provides 1 J of energy is 1.006×10^{16}.

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

(1) A and D only (2) A and C only

(3) A and B only (4) B and C only

Ans. (2)

Sol. (A) $_{12}Mg^{24}$ represents 12 protons and 12 neutrons.

(B) $\lambda = \frac{C}{\nu} = \frac{3\times10^8}{4.5\times10^{15}} = 6.67 \times 10^{-8}$ m.

(C) $\frac{E_1}{E_2} = \frac{hC/\lambda_1}{hC/\lambda_2} = \frac{\lambda_2}{\lambda_1}$

$\frac{E_1}{E_2} = \frac{300}{900} = \frac{1}{3}$ (false)

(D) No. of photons $= \frac{\text{Energy}}{hC/\lambda} = 10^{16}$ (True)

65. In Carius method 0.2425 g of an organic compounds gave 0.5253 g silver chloride. The percentage of chlorine in the organic compound is

(1) 53.58% (2) 87.65%

(3) 37.57% (4) 34.79%

Ans. (1)

Sol. Organic compound : 0.2425 gm

AgCl obtained : 0.5253 gm

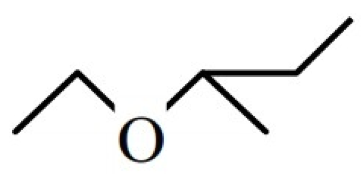
In carius method for estimation of halogen amount of AgCl obtained is 0.5253 gm from 0.2425 gm of organic compound.

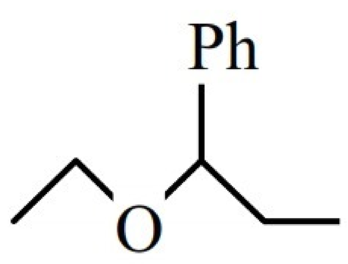
Hence percentage of Cl.

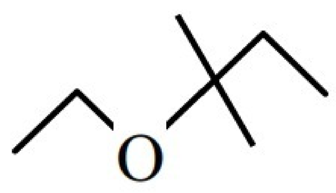
Percentage of Cl = $\frac{35.5}{143.5} \times \frac{0.5253}{0.2425} \times 100$

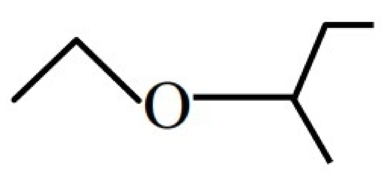
= 53.58%

66. A mixed ether (P), when heated with excess of hot concentrated hydrogen iodide produces two different alkyl iodides which when treated with aq. NaOH give compounds (Q) and (R). Both (Q) and (R) give yellow precipitate with NaOI. Identify the mixed ether (P):

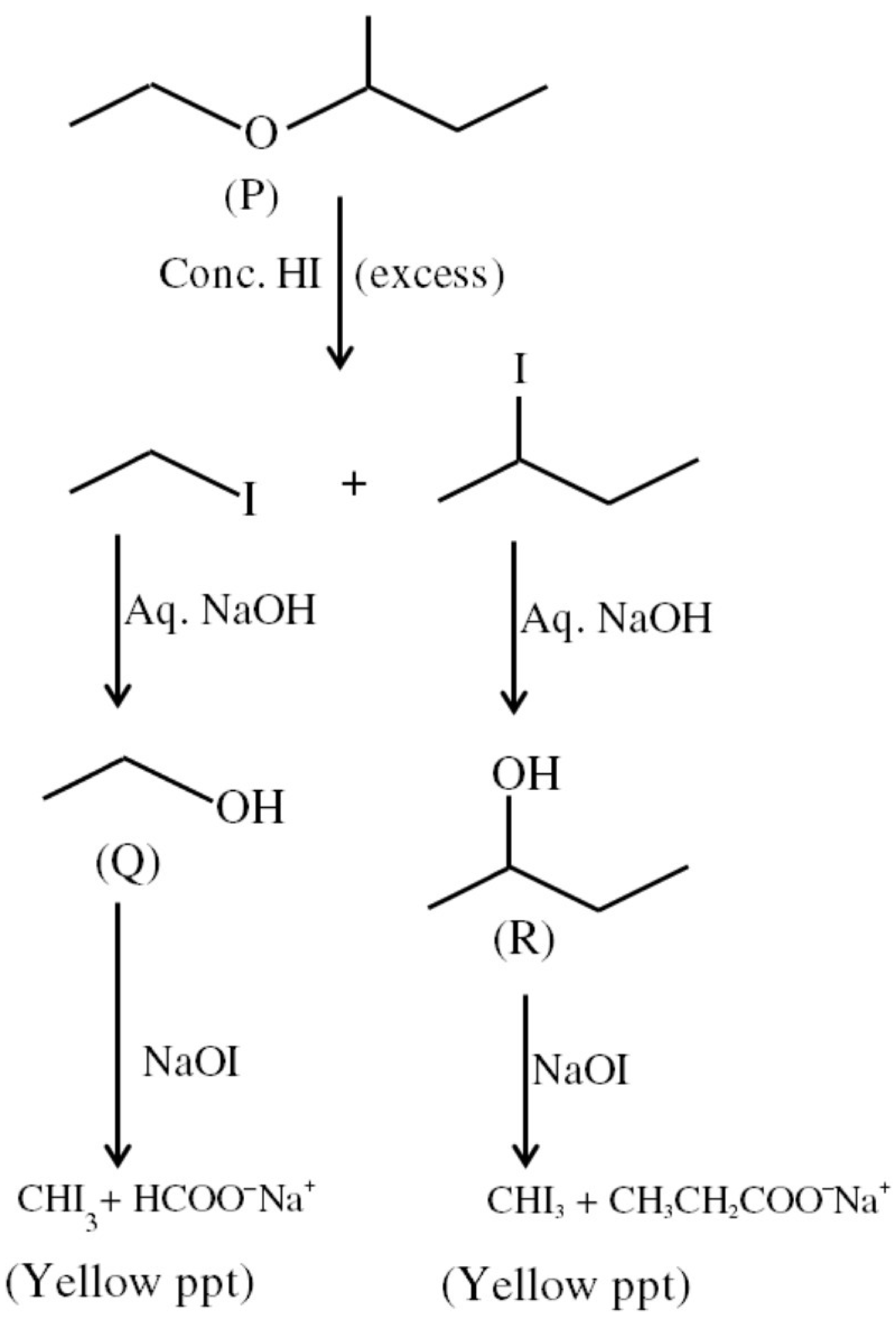
(1) 

(2) 

(3) 

(4) 

Ans. (1)



67. The oxidation state of chromium in the final product formed in the reaction between KI and acidified $K_2Cr_2O_7$ solution is:

(1) +4 (2) +3

(3) +2 (4) +6

Ans. (2)

Sol. $K_2Cr_2O_7 + KI \xrightarrow{H^+} I_2 + Cr^{3+}$

68. The work functions of two metals (M_A and M_B) are in the 1 : 2 ratio. When these metals are exposed to photons of energy 6 eV, the kinetic energy of liberated electrons of M_A : M_B is in the ratio of 2.642 : 1. The work functions (in eV) of M_A and M_B are respectively.

(1) 3.1, 6.2 (2) 2.3, 4.6

(3) 1.4, 2.8 (4) 1.5, 3.0

Ans. (2)

Sol. $KE_{max} = E - \phi$

$(KE_{max})_1 = 6 - \phi_1$ ...... (1)

$(KE_{max})_2 = 6 - \phi_2$ ...... (2)

By eq. (1) divide eq. (2)

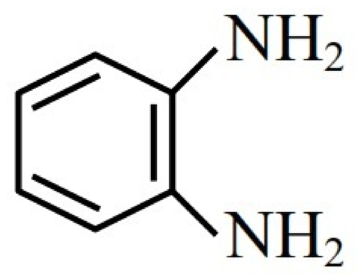
$$\frac{(KE_{max})_1}{(KE_{max})_2} = \frac{2.642}{1} = \frac{6-\phi_1}{6-\phi_2}$$

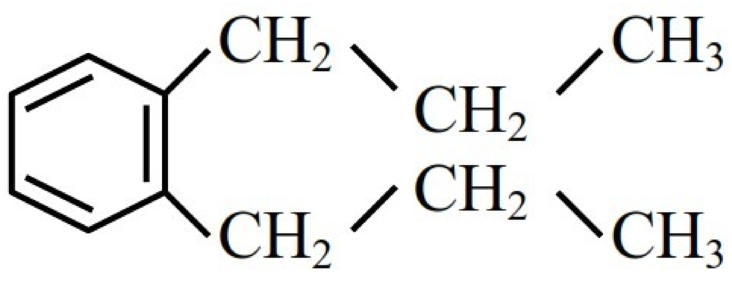
$$\frac{2.642}{1} = \frac{6-\phi_1}{6-2\phi_1}$$

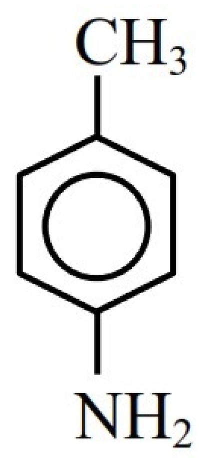
$\phi_1 = 2.3$ eV

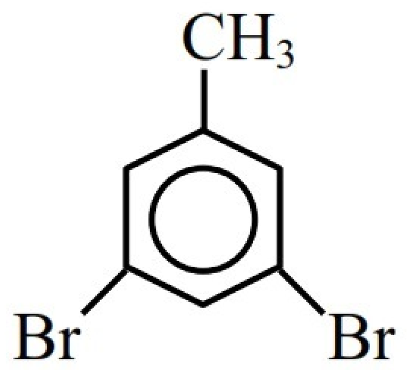
$\phi_2 = 4.6$ eV.

69. Given below are two statements:

Statement I:  can be synthesized from

 using simpler reagents in the order i) Acidic $KMnO_4$, ii) Ammonia, iii) Bromine and alkali

Statement II :  can be converted into

 using reagents in the order (i) Bromine-H_2O (ii) $NaNO_2$/HCl (0-5 °C) (iii) aq. H_3PO_2.

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

(1) Both **Statement I** and **Statement II** are false

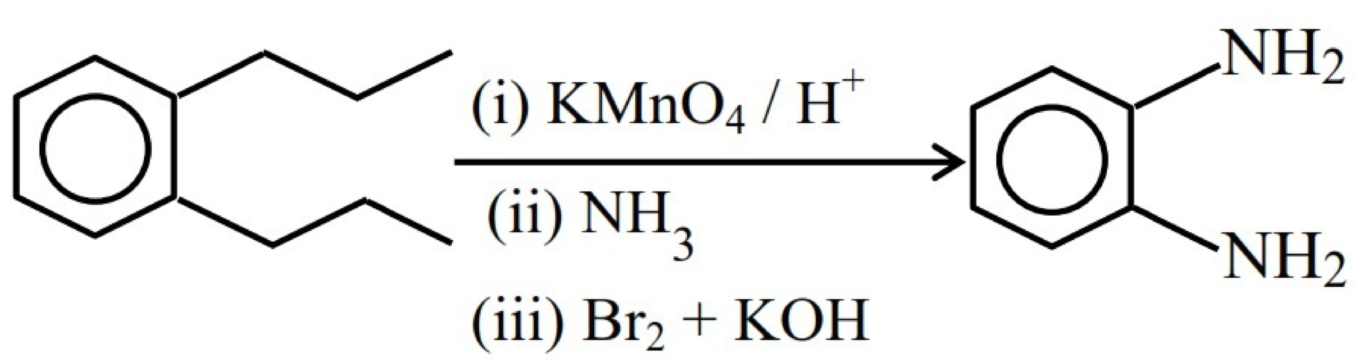
(2) **Statement I** is true but **Statement II** is false

(3) Both **Statement I** and **Statement II** are true

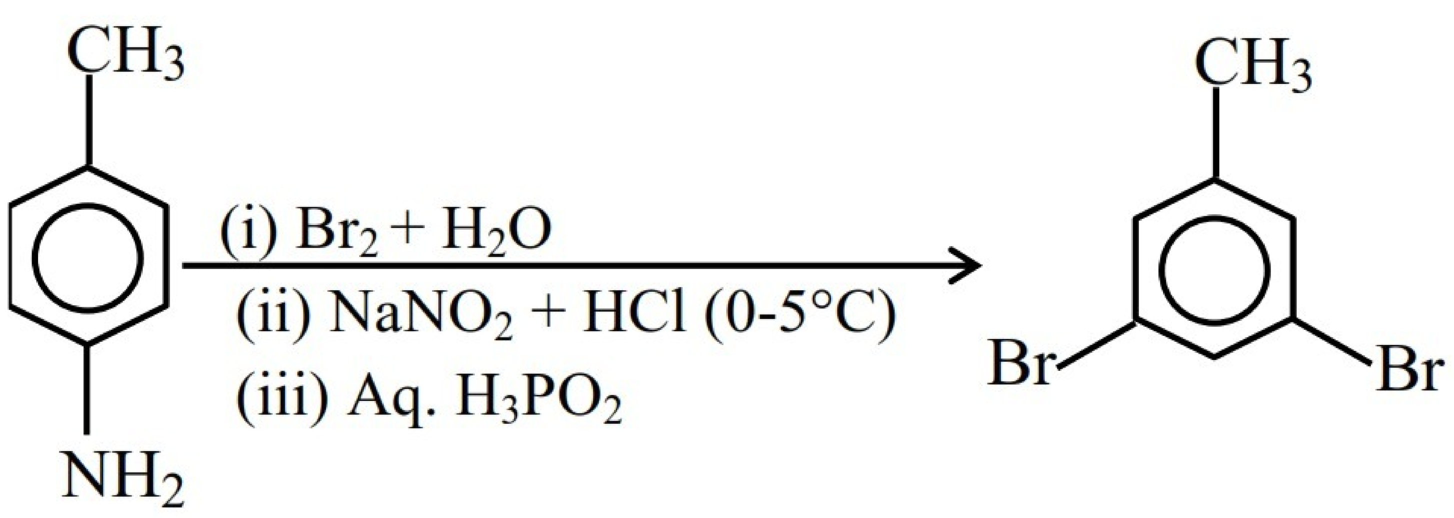
(4) **Statement I** is false but **Statement II** is true

Ans. **(3)**

Sol. Statement-**I**



Statement-**II**



Both statement (I) and (II) are true.

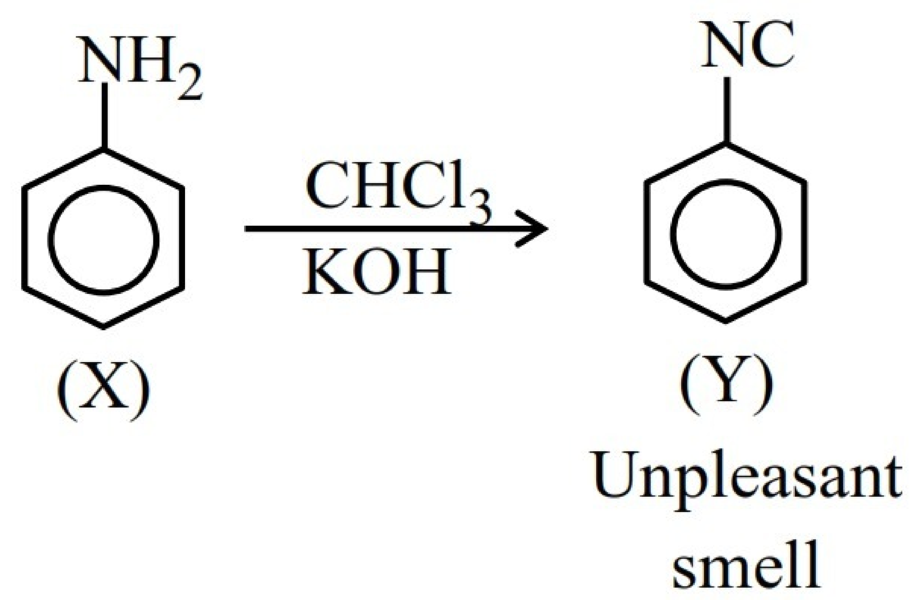
70. A student has been given a compound "x" of molecular formula – C_6H_7N. 'x' is sparingly soluble in water. However, on addition of dilute mineral acid , 'x' becomes soluble in water. 'x' when treated with $CHCl_3$ and KOH (alc.) 'y' is produced. 'y' has a specific unpleasant smell. On treatment with benzenesulphonyl chloride, 'x' gives a compound 'z' which is soluble in alkali. The number of different "H" atoms present in 'z' is:-

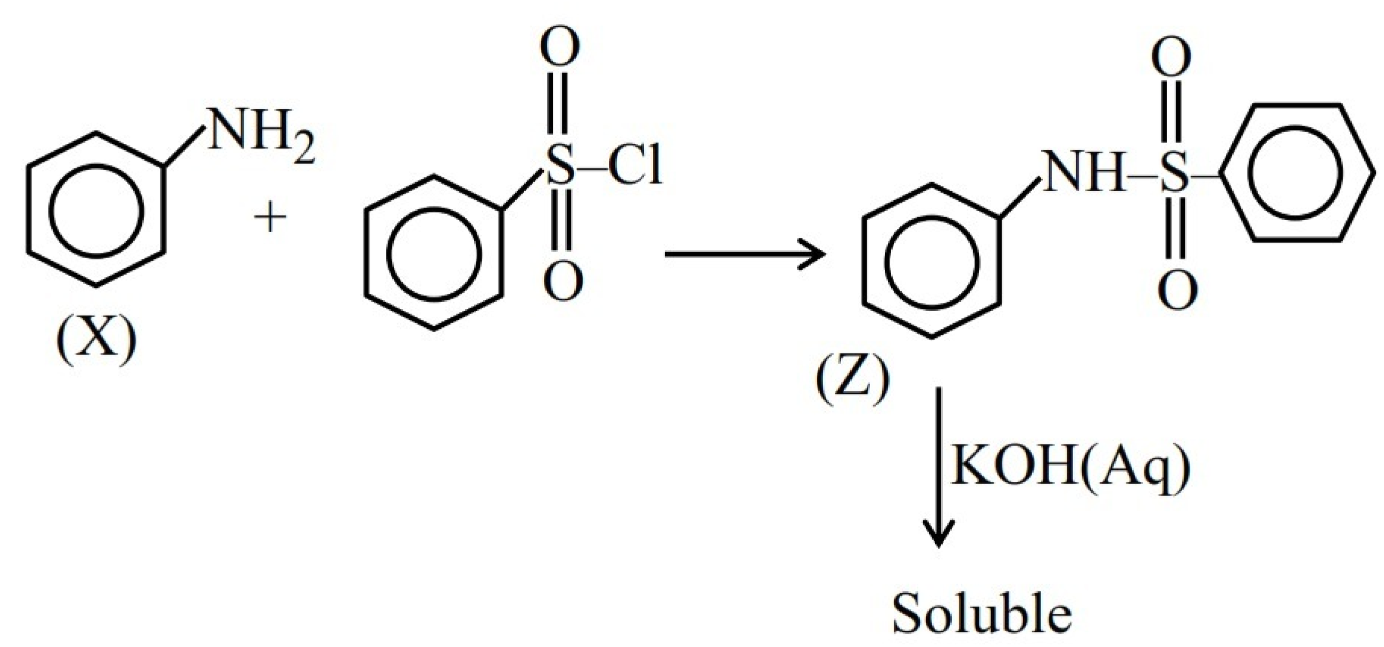
(1) 5 (2) 8

(3) 4 (4) 7

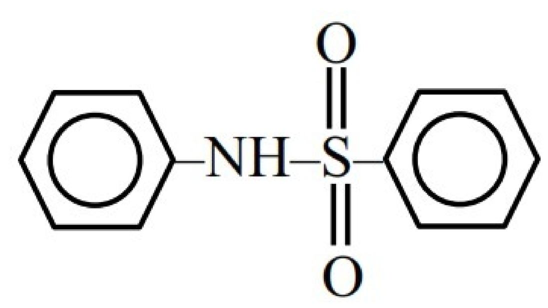
Ans. (4)

Sol.





Number of different H atom in

 is 7.

SECTION-B

71. $X_2(g) + Y_2(g) \rightleftharpoons 2Z(g)$

$X_2(g)$ and $Y_2(g)$ are added to a 1 L flask and it is found that the system attains the above equilibrium at T(K) with the number of moles of $X_2(g)$, $Y_2(g)$ and Z(g) being 3, 3 and 9 mol respectively (equilibrium moles). Under this conditions of equilibrium, 10 mol of Z(g) is added to the flask and the temperature is maintained at T(K). Then the number of moles of Z(g) in the flask when the new equilibrium is established is _______. (Nearest integer).

Ans. (15)

Sol. $X_2(g) + Y_2(g) \rightleftharpoons 2Z(g)$

$$K_C = \frac{(9)^2}{3 \times 3} = 9$$

Now 10 moles of Z are added then reaction will move in backward direction.

$X_2(g) + Y_2(g) \rightleftharpoons 2Z(g)$

$3 + X \quad 3 + X \qquad 19–2X$

$$K_C = \frac{(19-2X)^2}{(3+X)(3+X)} = 9$$

$$\frac{19-2X}{3+X} = 3$$

$19 – 2X = 9 + 3X$

$10 = 5X$

$X = 2$

At equilibrium ⇒ moles of Z = 19 – 2 × 2

= 15 moles

72. Two liquids A and B form an ideal solution. At 320 K, the vapour pressure of the solution, containing 3 mol of A and 1 mol of B is 500mm Hg. At the same temperature, if 1 mol of A is further added to this solution, vapour pressure of the solution increases by 20 mm Hg. Vapour pressure (in mm Hg) of B in the pure state is ________. (Nearest integer)

72. Ans. (200)

Sol. $X_A = \frac{3}{4}, \; X_B = \frac{1}{4}$

$$P_S = P_A^o X_A + P_B^o X_B$$

$$500 = P_A^o \times \frac{3}{4} + P_B^o \times \frac{1}{4}$$

$3P_A^o + P_B^o = 2000 \quad$ ….. (1)

Now 1 moles of A is further added so n_A = 4 mole, n_B = 1 mole

$X'_A = \frac{4}{5}, \; X'_B = \frac{1}{5}$

$$P_s = 520 = P_A^o \times \frac{4}{5} + P_B^o \times \frac{1}{5}$$

$4P_A^o + P_B^o = 2600 \quad$ ….. (2)

By equation (2) – equation (1)

P_A^o = 600 mm Hg

P_B^o = 200 mm Hg

73. 200 cc of x × 10^{-3}M potassium dichromate is required to oxidise 750 cc of 0.6 M

Mohr's salt solution in acidic medium.

Here x =

Ans. (375)

74. Total number of unpaired electrons present in the central metal atoms/ions of

$[Ni(CO)_4]$, $[NiCl_4]^{2-}$, $[PtCl_2(NH_3)_2]$, $[Ni(CN_4)]^{2-}$ and $[Pt(CN_4)]^{2-}$ is____.

Ans. **(2)**

Sol. In $[Ni(CO)_4]$, $Ni^0 : 3d^8 4s^2$

Hybridisation state : sp^3

Unpaired electron = 0

In $[NiCl_4]^{2-}$, $Ni^{2+} : 3d^8$

Hybridisation state : sp^3

Unpaired electron = 2

In $[PtCl_4]^{2-}$, $Pt^{2+} : 5d^8$

Hybridisation state : dsp^2

Unpaired electron = 0

In $[Ni(CN)_4]^{2-}$, $Ni^{2+} : 3d^8$

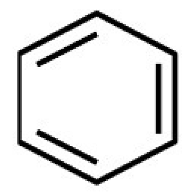
Hybridisation state : dsp^2

Unpaired electron = 0

In $[Pt(NH_3)_2Cl_2]$, $Pt^{2+} : 5d^8$

Hybridisation state : dsp^2

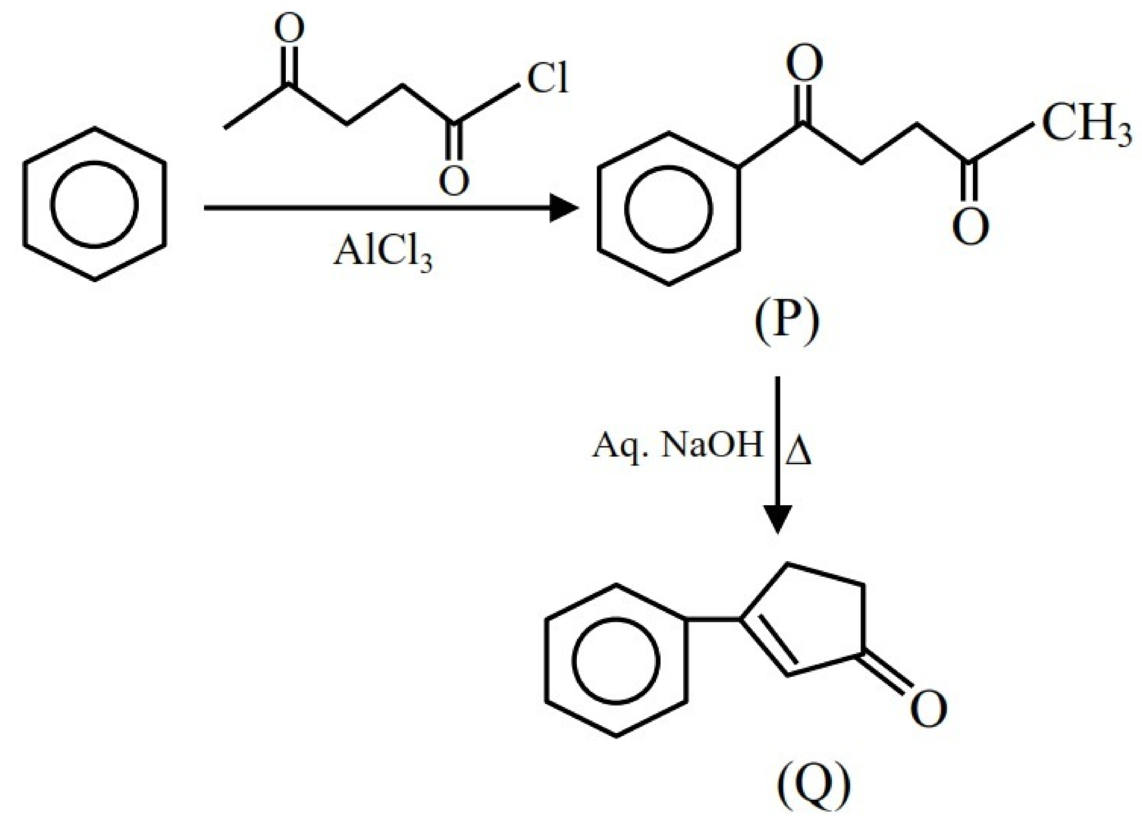
Unpaired electron = 0

75.  $+ H_3C-\overset{O}{\overset{\|}{C}}-CH_2-CH_2-\overset{O}{\overset{\|}{C}}-Cl \xrightarrow{\text{Anhydrous } AlCl_3} (P)$

$\xrightarrow[\Delta]{aq.\,NaOH} (Q)$

In compound (Q) , the percentage of oxygen is _____%. (Nearest integer)

Sol.



Molecular mass of Q is = 157

% of oxygen in product 'Q' is = $\frac{16}{157} \times 100 = 10.19\%$