

JEE-MAIN EXAMINATION – JANUARY 2025

(HELD ON TUESDAY 28th JANUARY 2025)

TIME : 9:00 AM TO 12:00 NOON

$$AC = \sqrt{1+4+4} = 3$$

$$BC = \sqrt{1+16+1} = \sqrt{18}$$

$$AB = AC$$

$$\text{isosceles } \Delta \text{ & } AB^2 + AC^2 = BC^2$$

right angle Δ

$$\text{Area of } \Delta ABC = \frac{1}{2} \times \text{base.height}$$

$$\frac{1}{2} \times 3 \times 3 = \frac{9}{2}$$

So only S₁ is true

7. The relation $R = \{(x, y) : x, y \in z \text{ and } x + y \text{ is even}\}$ is :

- (1) reflexive and transitive but not symmetric
- (2) reflexive and symmetric but not transitive
- (3) an equivalence relation
- (4) symmetric and transitive but not reflexive

Ans. (3)

Sol. $R = \{(x, y) : x, y \in z \text{ and } x + y \text{ is even}\}$

reflexive $x + x = 2x$ even

symmetric of $x + y$ is even, then $(y + x)$ is also even

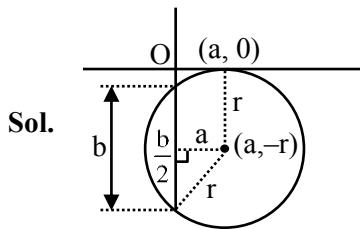
transitive of $x + y$ is even & $y + z$ is even then $x + z$ is also even

So, relation is an equivalence relation.

8. Let the equation of the circle, which touches x-axis at the point $(a, 0)$, $a > 0$ and cuts off an intercept of length b on y-axis be $x^2 + y^2 - \alpha x + \beta y + \gamma = 0$. If the circle lies below x-axis, then the ordered pair $(2a, b^2)$ is equal to :

- (1) $(\alpha, \beta^2 + 4\gamma)$ (2) $(\gamma, \beta^2 - 4\alpha)$
- (3) $(\gamma, \beta^2 + 4\alpha)$ (4) $(\alpha, \beta^2 - 4\gamma)$

Ans. (4)



$$\text{By pythagoras } r^2 = a^2 + \frac{b^2}{4} = P^2$$

$$r = \sqrt{\frac{4a^2 + b^2}{4}}$$

$$\text{Equation of circle is } (x - a)^2 + (y - \beta)^2 = r^2$$

$$x^2 + y^2 - 2ax - 2py + a^2 + p^2 - r^2 = 0$$

$$\text{comparision } x^2 + y^2 - \alpha x + \beta y + r = 0$$

$$-\alpha = -2a, \beta = -2p, r = a^2$$

$$\Rightarrow 2a = \alpha, 4a^2 + b^2 = 4p^2$$

$$\alpha^2 + b^2 = 4p^2$$

$$\alpha^2 + b^2 = \beta^2$$

$$\text{So, } (2a, b^2) = (\alpha, \beta^2 - 4r)$$

9. Let $\langle a_n \rangle$ be a sequence such that $a_0 = 0, a_1 = \frac{1}{2}$ and

$$2a_{n+2} = 5a_{n+1} - 3a_n, n = 0, 1, 2, 3, \dots \text{ Then } \sum_{k=1}^{100} a_k$$

is equal to :

$$(1) 3a_{99} - 100 \quad (2) 3a_{100} - 100$$

$$(3) 3a_{100} + 100 \quad (4) 3a_{99} + 100$$

Ans. (2)

$$\text{Sol. } a_0 = 0, a_1 = \frac{1}{2}$$

$$2a_{n+2} = 5a_{n+1} - 3a_n$$

$$2x^2 - 5x + 3 = 0 \Rightarrow x = 1, 3/2$$

$$\therefore a_n = A(1)^n + B\left(\frac{3}{2}\right)^n$$

$$n=0 \quad 0 = A + B \quad \boxed{A = -1}$$

$$n=1 \quad \frac{1}{2} = A + \frac{3}{2}B \quad \boxed{B = 1}$$

$$\Rightarrow a_n = -1 + \left(\frac{3}{2}\right)^n$$

$$\sum_{k=1}^{100} a_k = \sum_{k=1}^{100} (-1) + \left(\frac{3}{2}\right)^k$$

$$= -100 + \frac{\left(\frac{3}{2}\right) \left(\left(\frac{3}{2}\right)^{100} - 1 \right)}{\frac{3}{2} - 1}$$

$$= -100 + 3 \left(\left(\frac{3}{2}\right)^{100} - 1 \right)$$

$$= 3.(a_{100}) - 100$$

10. $\cos\left(\sin^{-1}\frac{3}{5} + \sin^{-1}\frac{5}{13} + \sin^{-1}\frac{33}{65}\right)$ is equal to :

(1) 1

(2) 0

(3) $\frac{33}{65}$

(4) $\frac{32}{65}$

Ans. (2)

$$\text{Sol. } \cos\left(\sin^{-1}\frac{3}{5} + \sin^{-1}\frac{5}{13} + \sin^{-1}\frac{33}{65}\right)$$

$$\cos\left(\tan^{-1}\frac{3}{4} + \tan^{-1}\frac{5}{12} + \tan^{-1}\frac{33}{56}\right)$$

$$\cos\left(\tan^{-1}\frac{3}{4} + \tan^{-1}\frac{5}{12} + \tan^{-1}\frac{33}{56}\right)$$

$$\cos\left(\tan^{-1}\frac{56}{33} + \cot^{-1}\frac{56}{33}\right)$$

$$\cos\left(\frac{\pi}{2}\right) = 0$$

11. Let T_r be the r^{th} term of an A.P. If for some m ,

$$T_m = \frac{1}{25}, T_{25} = \frac{1}{20} \text{ and } 20 \sum_{r=1}^{25} T_r = 13, \text{ then}$$

$$5m \sum_{r=m}^{2m} T_r \text{ is equal to :}$$

(1) 112

(2) 126

(3) 98

(4) 142

Ans. (2)

$$\text{Sol. } T_m = \frac{1}{25}, T_{25} = \frac{1}{20}, 20 \sum_{r=1}^{25} T_r = 13$$

$$T_m = a + (m-1)d = \frac{1}{25} \quad \dots \dots (1)$$

$$T_{25} = a + 24d = \frac{1}{20}$$

$$20 \cdot \frac{25}{2} \left[a + \frac{1}{20} \right] = 13 \Rightarrow a = \frac{1}{500}$$

$$\text{also, } 20S_{25} = 20 \cdot \frac{25}{2} [2a + 24d] = 13 \Rightarrow d = \frac{1}{500}$$

$$\text{from (1) } \frac{1}{500} + \frac{m-1}{500} = \frac{1}{25} \Rightarrow m = 20$$

Now,

$$5m \sum_{r=m}^{2m} T_r = 100 \sum_{r=20}^{40} T_r = 126$$

12. If the image of the point $(4, 4, 3)$ in the line

$$\frac{x-1}{2} = \frac{y-2}{1} = \frac{z-1}{3} \text{ is } (\alpha, \beta, \gamma), \text{ then } \alpha + \beta + \gamma \text{ is}$$

equal to

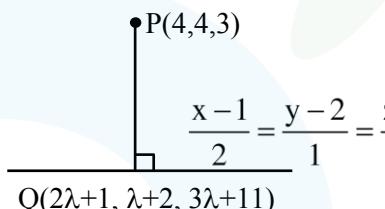
(1) 9

(2) 12

(3) 8

(4) 7

Ans. (1)



$$\overrightarrow{PQ} \perp (2\hat{i} + \hat{j} + 3\hat{k})$$

$$\Rightarrow 2(2\lambda - 3) + 1(\lambda - 2) + 3(3\lambda - 2) = 0$$

$$\Rightarrow 14\lambda - 14 = 0, \lambda = 1$$

So, Q(3,3,4)

Let image in R(α,β,γ)

$$\frac{\alpha+4}{2} = 3, \frac{\beta+4}{2} = 3, \frac{\gamma+3}{2} = 4$$

$$(\alpha, \beta, \gamma) = (2, 2, 5)$$

$$\Rightarrow \alpha + \beta + \gamma = 9$$

13. If $\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \frac{96x^2 \cos^2 x}{(1+e^x)} dx = \pi(\alpha\pi^2 + \beta)$, $\alpha, \beta \in \mathbb{Z}$, then

$(\alpha + \beta)^2$ equals :

(1) 144

(2) 196

(3) 100

(4) 64

Ans. (3)

$$\text{Sol. } \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \frac{96x^2 \cos^2 x}{(1+e^x)} dx \text{ (Apply King Property)}$$

$$\int_0^{\frac{\pi}{2}} 96x^2 \cos^2 x \, dx = 48 \int_0^{\frac{\pi}{2}} x^2 (1 + \cos 2x) \, dx$$

$$48 \left[\left(\frac{x^3}{3} \right)_{0}^{\pi/2} + \int_0^{\frac{\pi}{2}} x^2 \cos 2x \, dx \right]$$

\Rightarrow On solving $\pi(2\pi^2 - 12)$

$\Rightarrow \alpha = 2, \beta = -12$

$\Rightarrow (\alpha + \beta)^2 = 100$

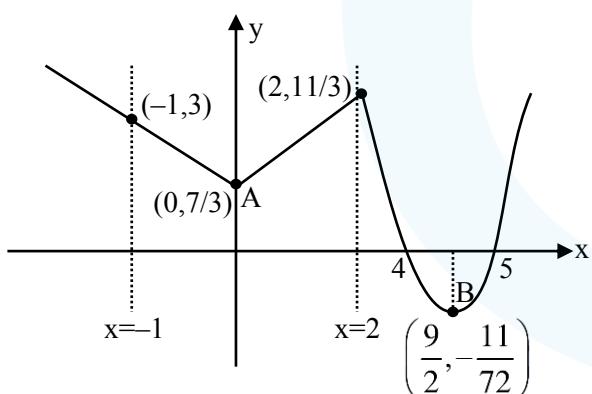
14. The sum of all local minimum values of the

$$\text{function } f(x) = \begin{cases} 1-2x, & x < -1 \\ \frac{1}{3}(7+2|x|), & -1 \leq x \leq 2 \\ \frac{11}{18}(x-4)(x-5), & x > 2 \end{cases}$$

- (1) $\frac{171}{72}$ (2) $\frac{131}{72}$
 (3) $\frac{157}{72}$ (4) $\frac{167}{72}$

Ans. (3)

$$\text{Sol. } f(x) = \begin{cases} 1-2x, & x < -1 \\ \frac{1}{3}(7-2x), & -1 \leq x \leq 2 \\ \frac{1}{3}(7+2x), & 0 \leq x < 2 \\ \frac{11}{18}(x-4)(x-5), & x > 2 \end{cases}$$



\therefore Local minimum values at A & B

$$\begin{aligned} & \frac{7}{3} - \frac{11}{72} \\ & \Rightarrow \frac{168 - 11}{72} \Rightarrow \frac{157}{72} \end{aligned}$$

15. The sum of the squares of all the roots of the equation $x^2 + |2x - 3| - 4 = 0$, is :

- (1) $3(3 - \sqrt{2})$ (2) $6(3 - \sqrt{2})$
 (3) $6(2 - \sqrt{2})$ (4) $3(2 - \sqrt{2})$

Ans. (3)

$$\text{Sol. } x^2 + |2x - 3| - 4 = 0$$

$$\text{Case I : } x \geq \frac{3}{2}$$

$$x^2 + 2x - 3 - 4 = 0$$

$$x^2 + 2x - 7 = 0$$

$$x = 2\sqrt{2} - 1$$

$$\text{Case II : } x < \frac{3}{2}$$

$$x^2 + 3 - 2x - 4 = 0$$

$$x^2 - 2x - 1 = 0$$

$$x = 1 - \sqrt{2}$$

$$\begin{aligned} \text{Sum of squares} &= (2\sqrt{2} - 1)^2 + (1 - \sqrt{2})^2 \\ &= 8 - 4\sqrt{2} + 1 + 1 - 2\sqrt{2} + 2 \\ &= 6(2 - \sqrt{2}) \quad \therefore (3) \end{aligned}$$

16. Let for some function $y = f(x)$, $\int_0^x t f(t) dt = x^2 f(x)$,

$x > 0$ and $f(2) = 3$. Then $f(6)$ is equal to :

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

Ans. (1)

$$\text{Sol. } \int_0^x t f(t) dt = x^2 f(x), x > 0$$

Diff. both side w.r. to x

$$x f(x) = x^2 f'(x) + 2x f(x)$$

$$-x f(x) = x^2 f'(x)$$

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

$$\log f(x) = -\log x + \log c$$

$$f(x) = \frac{c}{x}$$

$$f(2) = 3 \Rightarrow 3 = \frac{c}{2} \Rightarrow c = 6$$

$$f(x) = \frac{6}{x}$$

$$f(6) = 1 \quad \therefore (1)$$

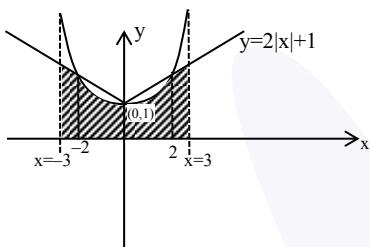
20. The area (in sq. units) of the region

$$\{(x, y) : 0 \leq y \leq 2|x| + 1, 0 \leq y \leq x^2 + 1, |x| \leq 3\}$$

is

- (1) $\frac{80}{3}$ (2) $\frac{64}{3}$
 (3) $\frac{17}{3}$ (4) $\frac{32}{3}$

Ans. (2)



Sol.

$$\text{Area} = 2 \left[\int_0^2 (x^2 + 1) dx + \int_2^3 (2x + 1) dx \right]$$

$$\Rightarrow \frac{64}{3} \quad \therefore (2)$$

SECTION-B

21. Let M denote the set of all real matrices of order 3×3 and let $S = \{-3, -2, -1, 1, 2\}$. Let

$$S_1 = \{A = [a_{ij}] \in M : A = A^T \text{ and } a_{ij} \in S, \forall i, j\}$$

$$S_2 = \{A = [a_{ij}] \in M : A = -A^T \text{ and } a_{ij} \in S, \forall i, j\}$$

$$S_3 = \{A = [a_{ij}] \in M : a_{11} + a_{22} + a_{33} = 0 \text{ and } a_{ij} \in S, \forall i, j\}$$

If $n(S_1 \cup S_2 \cup S_3) = 125\alpha$, then α equals.

Ans. (1613)

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$

No. of elements in S_1 : $A = A^T \Rightarrow 5^3 \times 5^3$

No. of elements in S_2 : $A = -A^T \Rightarrow 0$

since no zero in S_2

No. of elements in $S_3 \Rightarrow$

$$a_{11} + a_{22} + a_{33} = 0 \Rightarrow (1, 2, -3) \Rightarrow 3! \quad \left. \begin{array}{c} \text{or} \\ (1, 1, -2) \Rightarrow 3 \\ \text{or} \\ (-1, -1, 2) \Rightarrow 3 \end{array} \right\} \Rightarrow 12 \times 5^6$$

$$n(S_1 \cap S_3) = 12 \times 5^3$$

$$n(S_1 \cup S_2 \cup S_3) = 5^6(1+12) - 12 \times 5^3$$

$$\Rightarrow 5^3 \times [13 \times 5^3 - 12] = 125\alpha$$

$$\alpha = 1613$$

22. If $\alpha = 1 + \sum_{r=1}^6 (-3)^{r-1} {}^{12}C_{2r-1}$, then the distance of the point $(12, \sqrt{3})$ from the line $\alpha x - \sqrt{3}y + 1 = 0$ is

Ans. (5)

$$\text{Sol. } \alpha = 1 + \sum_{r=1}^6 (-1)^{r-1} {}^{12}C_{2r-1} 3^{r-1}$$

$$\alpha = 1 + \sum_{r=1}^6 {}^{12}C_{2r-1} \frac{(\sqrt{3}i)^{2t-1}}{\sqrt{3}i} \quad i = \text{iota, let } \sqrt{3}i = x$$

$$\alpha = 1 + \frac{1}{\sqrt{3}i} \left({}^{12}C_1 x + {}^{12}C_3 x^3 + \dots + {}^{12}C_{11} x^{11} \right)$$

$$= 1 + \frac{1}{\sqrt{3}i} \left(\frac{(1+\sqrt{3}i)^{12} - (1-\sqrt{3}i)^{12}}{2} \right)$$

$$= 1 + \frac{1}{\sqrt{3}i} \left(\frac{(-2\omega^2)^{12} - (2\omega)^{12}}{2} \right) = 1$$

so distance of $(12, \sqrt{3})$ from $x - \sqrt{3}y + 1 = 0$ is

$$\frac{12 - 3 + 1}{2} = 5$$

23. Let $\vec{a} = \hat{i} + \hat{j} + \hat{k}$, $\vec{b} = 2\hat{i} + 2\hat{j} + \hat{k}$ and $\vec{d} = \vec{a} \times \vec{b}$. If \vec{c} is a vector such that $\vec{a} \cdot \vec{c} = |\vec{c}|$, $|\vec{c} - 2\vec{a}|^2 = 8$ and the angle between \vec{d} and \vec{c} is $\frac{\pi}{4}$, then $|10 - 3\vec{b} \cdot \vec{c}| + |\vec{d} \times \vec{c}|^2$ is equal to

Ans. (6)

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

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

$$\vec{d} = \vec{a} \times \vec{b}$$

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

$$|\vec{c} - 2\vec{a}|^2 = 8$$

$$|\vec{c}|^2 + 4|\vec{a}|^2 - 4(\vec{a} \cdot \vec{c}) = 8$$

$$c^2 + 12 - 4c = 8$$

$$c^2 - 4c + 4 = 0$$

$$|c| = 2$$

$$\vec{d} = \vec{a} \times \vec{b}$$

$$\vec{d} \times \vec{c} = (\vec{a} \times \vec{b}) \times \vec{c}$$

$$\left(|\vec{d}| |\vec{c}| \sin \frac{\pi}{4} \right)^2 = ((\vec{a} \cdot \vec{c}) \cdot \vec{b} - (\vec{b} \cdot \vec{c}) \cdot \vec{a})^2$$

$$4 = 4b^2 + (b \cdot c)^2 - 2(a \cdot b)(a \cdot c)$$

Let b.c = x

$$4 = 36 + 3x^2 - 20x$$

$$3x^2 - 20x + 32 = 0$$

$$3x^2 - 12x - 8x + 32 = 0$$

$$x = \frac{8}{3}, 4$$

$$b.c = \frac{8}{3}, 4$$

$$b.c = \frac{8}{3}$$

$$\text{Now } |10 - 3b.c| + |d \times c|^2$$

$$|10 - 8| + (2)^2$$

$$\Rightarrow 6 \text{ Ans.}$$

24. Let

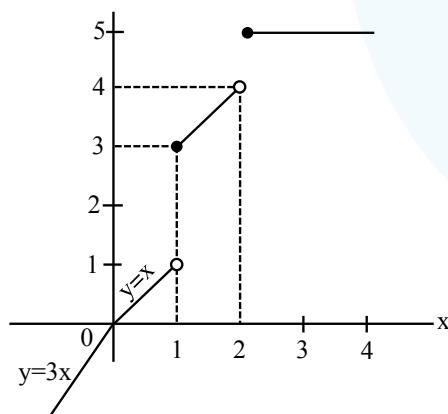
$$f(x) = \begin{cases} 3x, & x < 0 \\ \min\{1+x+[x], x+2[x]\}, & 0 \leq x \leq 2 \\ 5, & x > 2 \end{cases}$$

where $[.]$ denotes greatest integer function. If α and β are the number of points, where f is not continuous and is not differentiable, respectively, then $\alpha + \beta$ equals.....

Ans. (5)

$$\text{Sol. } f(x) = \begin{cases} 3x & ; \quad x < 0 \\ \min\{1+x, x\} & ; \quad 0 \leq x < 1 \\ \min\{2+x, x+2\} & ; \quad 1 \leq x < 2 \\ 5 & ; \quad x > 2 \end{cases}$$

$$f(x) = \begin{cases} 3x & ; \quad x < 0 \\ x & ; \quad 0 \leq x < 1 \\ x+2 & ; \quad 1 \leq x < 2 \\ 5 & ; \quad x > 2 \end{cases}$$



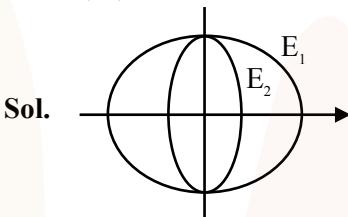
Not continuous at $x \in \{1, 2\} \Rightarrow \alpha = 2$

Not diff. at $x \in \{0, 1, 2\} \Rightarrow \beta = 3$

$$\alpha + \beta = 5$$

25. Let $E_1 : \frac{x^2}{9} + \frac{y^2}{4} = 1$ be an ellipse. Ellipses E_i 's are constructed such that their centres and eccentricities are same as that of E_1 , and the length of minor axis of E_i is the length of major axis of E_{i+1} ($i \geq 1$). If A_i is the area of the ellipse E_i , then $\frac{5}{\pi} \left(\sum_{i=1}^{\infty} A_i \right)$, is equal to

Ans. (54)



$$E_1 : \frac{x^2}{9} + \frac{y^2}{4} = 1 \Rightarrow e = \sqrt{1 - \frac{4}{9}} = \frac{\sqrt{5}}{3}$$

$$E_2 : \frac{x^2}{a^2} + \frac{y^2}{4} = 1$$

$$e = \frac{\sqrt{5}}{3} = \sqrt{1 - \frac{a^2}{4}} \Rightarrow \frac{5}{9} = 1 - \frac{a^2}{4}$$

$$a^2 = \frac{16}{9}$$

$$E_2 : \frac{x^2}{\frac{16}{9}} + \frac{y^2}{4} = 1$$

$$E_3 : \frac{x^2}{\frac{16}{9}} + \frac{y^2}{b^2} = 1$$

$$e = \frac{\sqrt{5}}{3} = \sqrt{1 - \frac{b^2}{\frac{16}{9}}} \Rightarrow b^2 = \frac{64}{81}$$

$$E_3 : \frac{x^2}{\frac{16}{9}} + \frac{y^2}{\frac{64}{81}} = 1$$

$$A_1 = \pi \times 3 \times 2 \Rightarrow 6\pi$$

$$A_2 = \pi \times \frac{4}{3} \times 2 = \frac{8\pi}{3}$$

$$A_3 = \pi \times \frac{4}{3} \times \frac{8}{9} = \frac{32\pi}{81}$$

$$\sum_{i=1}^{\infty} A_i = 6\pi + \frac{8\pi}{3} + \frac{32\pi}{81} + \dots \infty \Rightarrow \frac{6\pi}{1 - \frac{4}{9}} \Rightarrow \frac{54\pi}{5}$$

$$\therefore \frac{5}{\pi} \sum_{i=1}^{\infty} A_i \Rightarrow \frac{5}{\pi} \times \frac{54\pi}{5} = 54$$

JEE-MAIN EXAMINATION – JANUARY 2025
(HELD ON TUESDAY 28th JANUARY 2025)
TIME : 9 : 00 AM TO 12 : 00 NOON

PHYSICS	TEST PAPER WITH SOLUTION
SECTION-A	
<p>26. Two capacitors C_1 and C_2 are connected in parallel to a battery. Charge-time graph is shown below for the two capacitors. The energy stored with them are U_1 and U_2, respectively. Which of the given statements is true ?</p> <p>(1) $C_1 > C_2$, $U_1 > U_2$ (2) $C_2 > C_1$, $U_2 < U_1$ (3) $C_1 > C_2$, $U_1 < U_2$ (4) $C_2 > C_1$, $U_2 > U_1$</p>	<p>(1) B, D and E only (2) A, C and D only (3) C, D and E only (4) A, B and E only</p> <p>Ans. (2)</p> <p>Sol. $V_T = \frac{2}{9} R^2 \frac{g}{\eta} (d - \rho)$</p>
<p>27. In the experiment for measurement of viscosity 'η' of given liquid with a ball having radius R, consider following statements.</p> <p>A. Graph between terminal velocity V and R will be a parabola B. The terminal velocities of different diameter balls are constant for a given liquid. C. Measurement of terminal velocity is dependent on the temperature. D. This experiment can be utilized to assess the density of a given liquid. E. If balls are dropped with some initial speed, the value of η will change.</p> <p>Choose the correct answer from the options given below:</p>	<p>28. Consider following statements:</p> <p>A. Surface tension arises due to extra energy of the molecules at the interior as compared to the molecules at the surface, of a liquid. B. As the temperature of liquid rises, the coefficient of viscosity increases. C. As the temperature of gas increases, the coefficient of viscosity increases. D. The onset of turbulence is determined by Reynold's number. E. In a steady flow two stream lines never intersect.</p> <p>Choose the correct answer from the options given below :</p> <p>(1) A, D, E only (2) C, D, E only (3) B, C, D only (4) A, B, C only</p> <p>Ans. (2)</p> <p>29. Three infinitely long wires with linear charge density λ are placed along the x-axis, y-axis and z-axis respectively. Which of the following denotes an equipotential surface ?</p> <p>(1) $xy + yz + zx = \text{constant}$ (2) $(x + y)(y + z)(z + x) = \text{constant}$ (3) $(x^2 + y^2)(y^2 + z^2)(z^2 + x^2) = \text{constant}$ (4) $xyz = \text{constant}$</p>

Ans. (3)

$$\text{Sol. } v = -\int \vec{E} \cdot d\vec{r} = \int \frac{2k\lambda}{r} dr = 2k\lambda \ln r + c$$

Net potential due to all wire

$$v = 2k\lambda \ln \sqrt{x^2 + y^2} + 2k\lambda \ln \sqrt{y^2 + z^2} + 2k\lambda \ln \sqrt{z^2 + x^2} + c$$

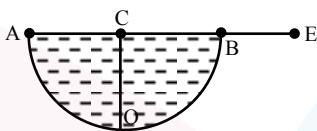
 for $v = c$

$$\sqrt{(x^2 + y^2)(y^2 + z^2)(z^2 + x^2)} = c$$

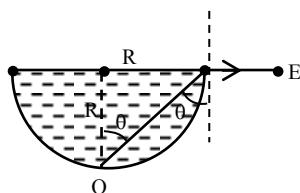
$$\therefore (x^2 + y^2)(y^2 + z^2)(z^2 + x^2) = c$$

 where $c = \text{constant}$

- 30.** A hemispherical vessel is completely filled with a liquid of refractive index μ . A small coin is kept at the lowest point (O) of the vessel as shown in figure. The minimum value of the refractive index of the liquid so that a person can see the coin from point E (at the level of the vessel) is _____.



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

Ans. (3)
Sol.


$$\sin c = \frac{1}{\mu}$$

 for $\mu \rightarrow \text{least}$, $c \rightarrow \text{maximum}$

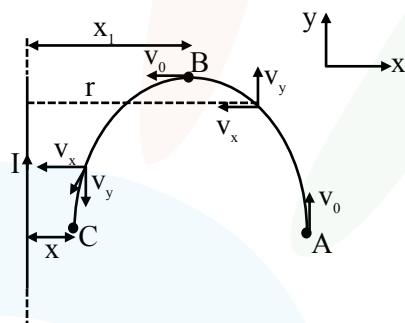
$$\theta = c = 45^\circ$$

$$\mu = \frac{1}{\sin 45^\circ} = \sqrt{2}$$

- 31.** Consider a long thin conducting wire carrying a uniform current I. A particle having mass "M" and charge "q" is released at a distance "a" from the wire with a speed v_0 along the direction of current in the wire. The particle gets attracted to the wire due to magnetic force. The particle turns round when it is at distance x from the wire. The value of x is [μ_0 is vacuum permeability]

$$(1) a \left[1 - \frac{mv_0}{2q\mu_0 I} \right] \quad (2) \frac{a}{2}$$

$$(3) a \left[1 - \frac{mv_0}{q\mu_0 I} \right] \quad (4) ae^{-\frac{4\pi m v_0}{q\mu_0 I}}$$

Ans. (4)

 $A \rightarrow B$

$$\vec{V} = -v_x \hat{i} + v_y \hat{j}$$

$$\vec{B} = \frac{\mu_0 I}{2\pi r} (-\hat{k})$$

$$\vec{F} = q(\vec{v} \times \vec{B}) = \frac{\mu_0 I q}{2\pi r} [-v_x \hat{j} - v_y \hat{i}]$$

$$a_x = -\frac{\mu_0 I q}{2\pi m} \cdot \frac{v_y}{r}$$

$$a_y = -\frac{\mu_0 I q}{2\pi m} \cdot \frac{v_x}{r}$$

$$\frac{v_x dv_x}{dr} = -\frac{\mu_0 I q}{2\pi m} \frac{v_y}{r}$$

$$\frac{v_x dv_x}{v_y} = -\frac{\mu_0 I q}{2\pi m} \frac{dr}{r}$$

$$\int_0^{v_0} \frac{v_x dv_x}{\sqrt{v_0^2 - v_x^2}} = -\frac{\mu_0 I q}{2\pi m} \int_a^{x_1} \frac{dr}{r}$$

$$\text{Let, } z^2 = v_0^2 - v_x^2$$

$$2z dz = -2v_x dv_x$$

$$zdz = -v_x dv_x$$

$$\frac{v_x dv_x}{\sqrt{v_0^2 - v_x^2}} = \frac{-zdz}{z} = -dz$$

then integral becomes

$$-\int_{v_0}^0 dz = -\frac{\mu_0 I q}{2\pi m} \ln \frac{x_1}{a}$$

$$v_0 = -\frac{\mu_0 I q}{2\pi m} \ln \frac{x_1}{a}$$

$$x_1 = a e^{-\frac{2\pi m v_0}{\mu_0 I q}} \dots\dots(1)$$

For B → C

$$\vec{v} = -v_x \hat{i} - v_y \hat{j}$$

$$\vec{B} = \frac{\mu_0 I}{2\pi r} (-\hat{k})$$

$$\vec{F} = q(\vec{v} \times \vec{B}) = \frac{\mu_0 I q}{2\pi r} (-v_x \hat{j} + v_y \hat{i})$$

$$a_x = +\frac{\mu_0 I q}{2\pi m} \frac{v_y}{r} \quad a_y = -\frac{\mu_0 I q}{2\pi m} \cdot \frac{v_x}{r}$$

$$\frac{v_x dv_x}{dr} = \frac{\mu_0 I q}{2\pi m} \frac{v_y}{r}$$

$$\int_{v_0}^0 \frac{v_x dv_x}{\sqrt{v_0^2 - v_x^2}} = \frac{\mu_0 I q}{2\pi m} \int_{x_1}^x \frac{dr}{r}$$

$$\frac{\mu_0 I q}{2\pi m} \ln \frac{x}{x_1} = -\int_0^{v_0} dz = -v_0$$

$$x = x_1 e^{-\frac{2\pi m v_0}{\mu_0 I q}} \dots\dots(2)$$

From equation 1 and 2

$$X = a e^{-\frac{4\pi m v_0}{\mu_0 I q}}$$

32. A Carnot engine (E) is working between two temperatures 473K and 273K. In a new system two engines – engine E₁ works between 473K to 373K and engine E₂ works between 373K to 273K. If η₁₂, η₁ and η₂ are the efficiencies of the engines E, E₁ and E₂, respectively, then

- (1) η₁₂ < η₁ + η₂ (2) η₁₂ = η₁ η₂
 (3) η₁₂ = η₁ + η₂ (4) η₁₂ ≥ η₁ + η₂

Ans. (1)

$$\text{Sol. } \eta_{12} = 1 - \frac{273}{473} = \frac{200}{473} = 0.423$$

$$\eta_1 = 1 - \frac{373}{473} = \frac{100}{473} = 0.211$$

$$\eta_2 = 1 - \frac{273}{373} = \frac{100}{373} = 0.268$$

33. Given below are two statements: one is labelled as **Assertion A** and the other is labelled as **Reason R**
Assertion A: A sound wave has higher speed in solids than gases.

Reason R: Gases have higher value of Bulk modulus than solids.

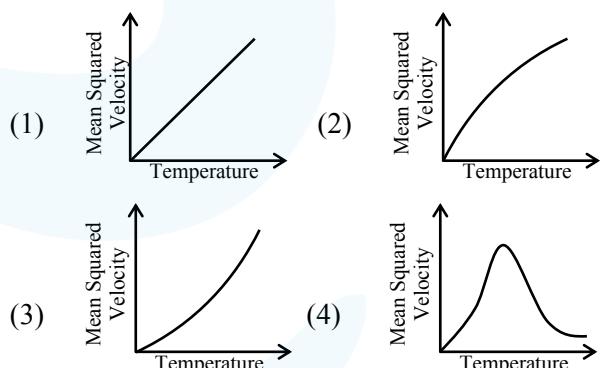
In the light of the above statements, choose the **correct** answer from the options given below

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

Ans. (4)

Sol. Solids have higher value of bulk modulus than gases.

34. For a particular ideal gas which of the following graphs represents the variation of mean squared velocity of the gas molecules with temperature?



Ans. (1)

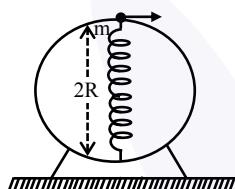
$$\text{Sol. } V_{rms} = \sqrt{\frac{3RT}{M}}$$

$$V_{rms}^2 = 3RT/M$$

Hence we can conclude that V_{rms}² is directly proportional to temperature
 $y = mx$

⇒ Graph will be straight line

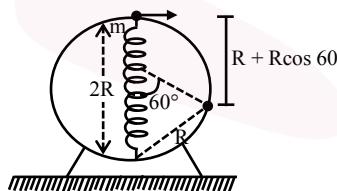
35. A bead of mass 'm' slides without friction on the wall of a vertical circular hoop of radius 'R' as shown in figure. The bead moves under the combined action of gravity and a massless spring (k) attached to the bottom of the hoop. The equilibrium length of the spring is 'R'. If the bead is released from top of the hoop with (negligible) zero initial speed, velocity of bead, when the length of spring becomes 'R', would be (spring constant is 'k', g is acceleration due to gravity)



$$\begin{array}{ll}
 (1) 2\sqrt{gR + \frac{kR^2}{m}} & (2) \sqrt{2Rg + \frac{4kR^2}{m}} \\
 (3) \sqrt{2Rg + \frac{kR^2}{m}} & (4) \sqrt{3Rg + \frac{kR^2}{m}}
 \end{array}$$

Ans. (4)

Sol.



Work energy theorem

$$Mg(R + R\cos 60^\circ) + \frac{1}{2}k(R^2 - 0^2) = \frac{1}{2}mv^2$$

$$Mg \frac{3R}{2} + \frac{KR^2}{2} = \frac{1}{2}mv^2$$

$$V = \sqrt{3gR + \frac{KR^2}{m}}$$

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

Assertion A: In a central force field, the work done is independent of the path chosen

Reason R: Every force encountered in mechanics does not have an associated potential energy.

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

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

Ans. (2)

Sol. Both statement are correct but Reason is not the correct explanation of Assertion.

37. Choose the correct nuclear process from the below options

[p: proton, n: neutron, e^- : electron, e^+ : positron, ν : neutrino, $\bar{\nu}$: antineutrino]

- (1) $n \rightarrow p + e^- + \bar{\nu}$
- (2) $n \rightarrow p + e^- + \nu$
- (3) $n \rightarrow p + e^+ + \bar{\nu}$
- (4) $n \rightarrow p + e^+ + \nu$

Ans. (1)

Sol. Theoretical equation for β^- decay

$$n_0^1 \rightarrow p_1^1 + e_{-1}^{-0} + \bar{\nu}$$

38. Which of the following circuits has the same output as that of the given circuit?



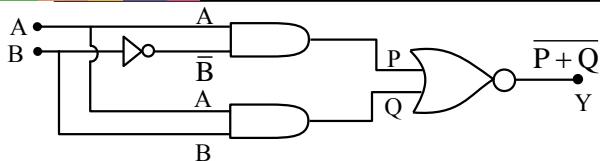
$$(1) A \rightarrow \text{NOT} \rightarrow Y$$

$$(2) A \oplus B \rightarrow Y$$

$$(3) A \oplus B \rightarrow \text{NOT} \rightarrow Y$$

$$(4) A \oplus B \rightarrow Y$$

Ans. (1)

Sol.


$$P = A \cdot \bar{B}$$

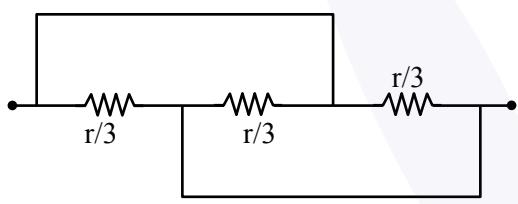
$$Q = A \cdot B$$

$$Y = \overline{P+Q} = \overline{A \cdot \bar{B} + A \cdot B}$$

$$= \overline{A \cdot (B + \bar{B})} = \overline{A \cdot I}$$

$$Y = \overline{A}$$

- 39.** Find the equivalent resistance between two ends of the following circuit.

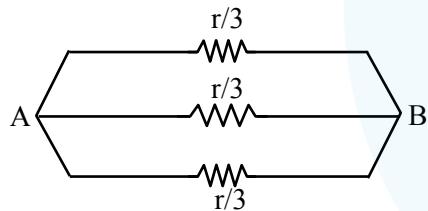
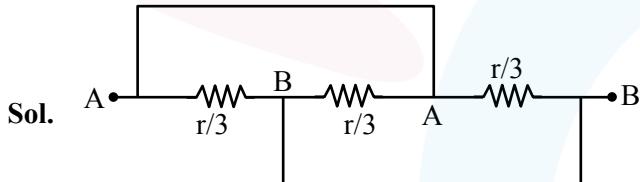


$$(1) r$$

$$(2) \frac{r}{6}$$

$$(3) \frac{r}{9}$$

$$(4) \frac{r}{3}$$

Ans. (3)


All are in parallel

$$R_{eq} = \frac{r/3}{3} = r/9$$

- 40.** A wire of resistance R is bent into an equilateral triangle and an identical wire is bent into a square. The ratio of resistance between the two end points of an edge of the triangle to that of the square is

$$(1) 9/8$$

$$(2) 8/9$$

$$(3) 27/32$$

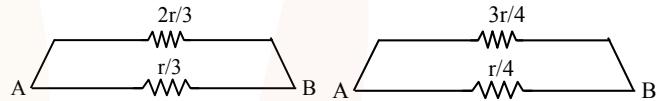
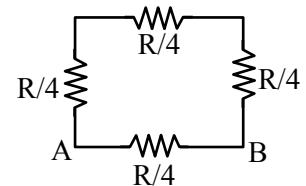
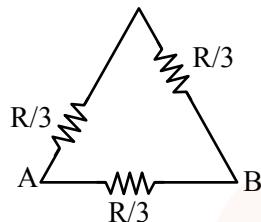
$$(4) 32/27$$

Ans. (4)

$$\text{Sol. } R = \frac{\rho \ell}{A}$$

 So, $R \propto \ell$

Side length of triangle is 1/3 of total length.



$$(R_{eq})_1 = \frac{2r/3 \times r/3}{2r/3 + r/3} \quad (R_{eq})_2 = \frac{3r/4 \times r/4}{3r/4 + r/4}$$

$$(R_{eq})_1 = 2r/9$$

$$(R_{eq})_2 = 3r/16$$

$$\frac{(R_{eq})_1}{(R_{eq})_2} = \frac{2r/9}{3r/16} = \frac{32}{27}$$

- 41.** Due to presence of an em-wave whose electric component is given by $E = 100 \sin(\omega t - kx) \text{ NC}^{-1}$, a cylinder of length 200 cm holds certain amount of em-energy inside it. If another cylinder of same length but half diameter than previous one holds same amount of em-energy, the magnitude of the electric field of the corresponding em-wave should be modified as

$$(1) 25 \sin(\omega t - kx) \text{ NC}^{-1}$$

$$(2) 200 \sin(\omega t - kx) \text{ NC}^{-1}$$

$$(3) 400 \sin(\omega t - kx) \text{ NC}^{-1}$$

$$(4) 50 \sin(\omega t - kx) \text{ NC}^{-1}$$

Ans. (2)

$$\text{Sol. Energy density} = \frac{1}{2} \epsilon_0 E^2 \times c$$

$$\text{Energy} = \frac{1}{2} \epsilon_0 E^2 \times c \times \text{volume}$$

$$(Energy)_1 = (Energy)_2 \quad (\text{Given})$$

$$\frac{1}{2} \epsilon_0 E_1^2 c \pi R_1^2 \times L_1 = \frac{1}{2} \epsilon_0 E_2^2 c \pi R_2^2 \times L_2$$

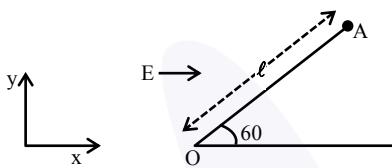
$$E_1^2 R_1^2 = E_2^2 R_2^2$$

$$E_1 R_1 = E_2 R_2$$

$$100 \times R_1 = E_2 \times \frac{R_1}{2}$$

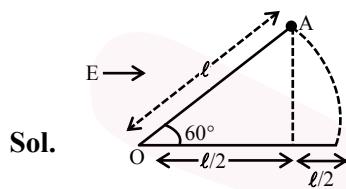
$$E_2 = 200 \text{ N/C}$$

42. A particle of mass ‘m’ and charge ‘q’ is fastened to one end ‘A’ of a massless string having equilibrium length ℓ , whose other end is fixed at point ‘O’. The whole system is placed on a frictionless horizontal plane and is initially at rest. If uniform electric field is switched on along the direction as shown in figure, then the speed of the particle when it crosses the x-axis is



- (1) $\sqrt{\frac{2qE\ell}{m}}$ (2) $\sqrt{\frac{qE\ell}{4m}}$
 (3) $\sqrt{\frac{qE\ell}{m}}$ (4) $\sqrt{\frac{qE\ell}{2m}}$

Ans. (3)



Sol.

$$W_{\text{all}} = \Delta k$$

$$W_e = k_f - k_i$$

$$qE \frac{\ell}{2} = \frac{1}{2} mv^2 - 0$$

$$v = \sqrt{\frac{qE\ell}{m}}$$

43. A proton of mass ‘ m_p ’ has same energy as that of a photon of wavelength ‘ λ ’. If the proton is moving at non-relativistic speed, then ratio of its de Broglie wavelength to the wavelength of photon is.

- (1) $\frac{1}{c} \sqrt{\frac{2E}{m_p}}$ (2) $\frac{1}{c} \sqrt{\frac{E}{m_p}}$
 (3) $\frac{1}{c} \sqrt{\frac{E}{2m_p}}$ (4) $\frac{1}{2c} \sqrt{\frac{E}{m_p}}$

Ans. (3)

Sol. E is missing in the question but considering E as energy, the solution will be

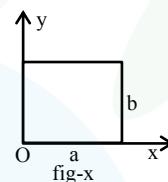
$$E_{\text{photon}} = \frac{hc}{\lambda} = E ; E_{\text{proton}} = \frac{1}{2} m_p v^2 = E$$

$$\frac{\lambda_{\text{proton}}}{\lambda_{\text{photon}}} = \frac{h/p}{hc/E} = \frac{h/\sqrt{2m_p E}}{hc/E}$$

$$= \frac{E}{c\sqrt{2m_p E}}$$

$$\frac{\lambda_{\text{proton}}}{\lambda_{\text{photon}}} = \frac{1}{c} \sqrt{\frac{E}{2m_p}}$$

44. The centre of mass of a thin rectangular plate (fig - x) with sides of length a and b, whose mass per unit area (σ) varies as $\sigma = \frac{\sigma_0 x}{ab}$ (where σ_0 is a constant), would be _____

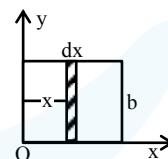


- (1) $\left(\frac{2}{3}a, \frac{b}{2}\right)$ (2) $\left(\frac{2}{3}a, \frac{2}{3}b\right)$
 (3) $\left(\frac{a}{2}, \frac{b}{2}\right)$ (4) $\left(\frac{1}{3}a, \frac{b}{2}\right)$

Ans. (1)

Sol. σ is constant in y-direction

$$\text{So, } y_{\text{cm}} = b/2$$



$$x_{\text{cm}} = \frac{\int_0^a x dm}{\int_0^a dm}$$

$$\frac{I_1}{I_2} = 2.5 \Rightarrow \frac{\frac{MR_1^2}{4}}{\frac{MR_2^2}{2}} = \frac{5}{2} \Rightarrow \frac{R_1^2}{R_2^2} = 5 \dots(1)$$

Now we are provided with information that

$$\frac{I_3}{I_2} = n$$

$$\Rightarrow \frac{\frac{2MR_1^2}{5}}{\frac{MR_2^2}{2}} = n \Rightarrow \frac{4R_1^2}{5R_2^2} = n \dots\dots(2)$$

From Eq', (1) and (2)

$$\Rightarrow n = 4$$

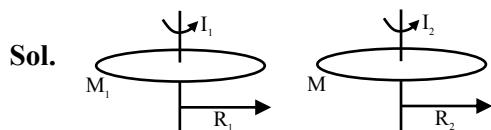
- 48.** In a measurement, it is asked to find modulus of elasticity per unit torque applied on the system. The measured quantity has dimension of $[M^a L^b T^c]$. If $b = 3$, the value of c is _____

NTA Ans. (4)

$$\begin{aligned} \text{Sol. } \frac{\text{modulus of elasticity}}{\text{Torque}} &= \frac{\text{Stress}}{\text{strain} \times \text{torque}} \\ &= \frac{[\text{Force}]}{[\text{Area}] \times [\text{Force} \times \text{length}]} \\ &= \frac{1}{[\text{Area} \times \text{length}]} = [L^{-3}] \end{aligned}$$

- 49.** Two iron solid discs of negligible thickness have radii R_1 and R_2 and moment of inertia I_1 and I_2 , respectively. For $R_2 = 2R_1$, the ratio of I_1 and I_2 would be $1/x$, where $x =$ _____

Ans. (16)



Given $R_2 = 2R_1$

$$M_1 = \sigma \times \pi R_1^2 = M_o$$

$$M_2 = \sigma \times \pi R_2^2 = M_o$$

$$M_2 = \sigma \times \pi R_2^2 = \sigma \times \pi [2R_1]^2 = \sigma \times 4\pi R_1^2 = 4M_o$$

$$\frac{I_1}{I_2} = \frac{\frac{M_1 R_1^2}{2}}{\frac{M_2 R_2^2}{2}} = \frac{M_1 R_1^2}{M_2 R_2^2} = \frac{1}{4} \times \frac{1}{4} = \frac{1}{16}$$

- 50.** A double slit interference experiment performed with a light of wavelength 600 nm forms an interference fringe pattern on a screen with 10th bright fringe having its centre at a distance of 10 mm from the central maximum. Distance of the centre of the same 10th bright fringe from the central maximum when the source of light is replaced by another source of wavelength 660 nm would be _____ mm.

Ans. (11)

Sol. In case of YDSE the distance of n^{th} maxima from central maxima is given by

$$Y = \frac{n\lambda D}{d}$$

Here n , D & d are same

So, $y \propto \lambda$

$$\Rightarrow \frac{y_2}{y_1} = \frac{\lambda_2}{\lambda_1} \Rightarrow \frac{y_2}{10 \text{ mm}} = \frac{660 \text{ nm}}{600 \text{ nm}}$$

$$\Rightarrow y_2 = 11 \text{ mm}$$

JEE-MAIN EXAMINATION – JANUARY 2025

(HELD ON TUESDAY 28th JANUARY 2025)

TIME : 9 : 00 AM TO 12 : 00 NOON

CHEMISTRY	TEST PAPER WITH SOLUTIONS		
SECTION-A			
51. The incorrect decreasing order of atomic radii is : (1) Mg > Al > C > O (2) Al > B > N > F (3) Be > Mg > Al > Si (4) Si > P > Cl > F	The titration of FAS v/s KMnO ₄ do not require heating because at higher temperature the oxidation of Fe ²⁺ to Fe ³⁺ by atmospheric O ₂ will be prominent.		
Ans. (3)	53. Match the List-I with List-II		
	List-I (Redox Reaction)	List-II (Type of Redox Reaction)	
A	$\text{CH}_{4(\text{g})} + 2\text{O}_{2(\text{g})} \xrightarrow{\Delta} \text{CO}_{2(\text{g})} + 2\text{H}_2\text{O}_{(\text{l})}$	(I)	Disproportionation reaction
B	$2\text{NaH}_{(\text{s})} \xrightarrow{\Delta} 2\text{Na}_{(\text{s})} + \text{H}_{2(\text{g})}$	(II)	Combination reaction
C	$\text{V}_{2\text{O}}_{5(\text{s})} + 5\text{Ca}_{(\text{s})} \xrightarrow{\Delta} 2\text{V}_{(\text{s})} + 5\text{CaO}_{(\text{s})}$	(III)	Decomposition reaction
D	$2\text{H}_2\text{O}_{2(\text{aq})} \xrightarrow{\Delta} 2\text{H}_2\text{O}_{(\text{l})} + \text{O}_{2(\text{g})}$	(IV)	Displacement reaction
	Choose the correct answer from the options given below :		
	(1) A-II, B-III, C-IV, D-I (2) A-II, B-III, C-I, D-IV (3) A-III, B-IV, C-I, D-II (4) A-IV, B-I, C-II, D-III		
Ans. (2)	Sol. For the titration : Oxalic acid v/s KMnO ₄ $2\text{MnO}_4^- + 5(\text{COO})_2^{2-} + 16\text{H}^+ \rightarrow 10\text{CO}_2 + 2\text{Mn}^{2+} + 8\text{H}_2\text{O}$ This reaction is slow at room temperature, but becomes fast at 60°C. Manganese(II) ions catalyse the reaction; thus, the reaction is autocatalytic; once manganese(II) ions are formed, it becomes faster and faster.		
Ans. (1)	Sol. (A) Combustion of hydrocarbon (B) Decomposition into gaseous product. (C) Displacement of 'V' by 'Ca' atom. (D) Disproportionation of H ₂ O ₂ ⁻¹ into O ⁻² and O ⁰ oxidation states.		

54. Given below are two statements :

Statement I : will undergo alkaline hydrolysis at a faster rate than .

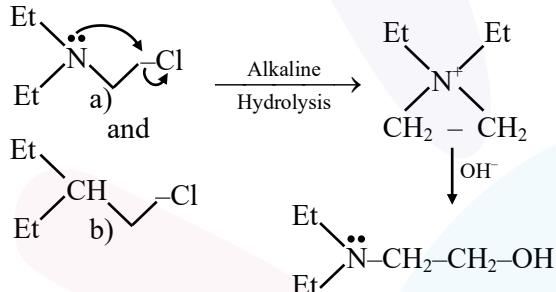
Statement II : , intramolecular substitution takes place first by involving lone pair of electrons on nitrogen.

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

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

Ans. (3)

Sol.



Rate of (a) is faster than rate of (b) because it is a intramolecular substitution.

55. A weak acid HA has degree of dissociation x. Which option gives the correct expression of $\text{pH} = \text{pK}_a$?

- (1) $\log(1 + 2x)$
- (2) $\log\left(\frac{1-x}{x}\right)$
- (3) 0
- (4) $\log\left(\frac{x}{1-x}\right)$

Ans. (4)

Sol. $\text{HA} \rightleftharpoons \text{H}^+ + \text{A}^-$

$$t=0 \quad a$$

$$t=t \quad a(1-x) \quad ax \quad ax$$

$$K_a = (ax) \frac{(x)}{1-x}; [\text{H}^+] = ax$$

$$-\log(K_a) = -\log(ax) - \log\left(\frac{x}{1-x}\right)$$

$$\text{pK}_a = \text{pH} - \log\left(\frac{x}{1-x}\right)$$

$$\text{pH} - \text{pK}_a = \log\left(\frac{x}{1-x}\right)$$

56. Consider 'n' is the number of lone pair of electrons present in the equatorial position of the most stable structure of ClF_3 . The ions from the following with 'n' number of unpaired electrons are :

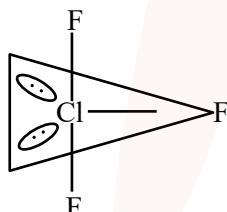
- A. V^{3+}
 B. Ti^{3+}
 C. Cu^{2+}
 D. Ni^{2+}
 E. Ti^{2+}

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

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

Ans. (2)

Sol. ClF_3



$n = 2$ (No of lone pair present in equitorial plane)
 (Unpaired e^-)

- | | |
|--|---|
| (A) $\text{V}^{3+} : [\text{Ar}]3d^2$ | 2 |
| (B) $\text{Ti}^{3+} : [\text{Ar}]3d^1$ | 1 |
| (C) $\text{Cu}^{2+} : [\text{Ar}]3d^9$ | 1 |
| (D) $\text{Ni}^{2+} : [\text{Ar}]3d^8$ | 2 |
| (E) $\text{Ti}^{2+} : [\text{Ar}]3d^2$ | 2 |

$[\text{A}]_0 / \text{mol L}^{-1}$	$t_{1/2} / \text{min}$
0.100	200
0.025	100

For a given reaction $\text{R} \rightarrow \text{P}$, $t_{1/2}$ is related to $[\text{A}]_0$ as given in table :

Given : $\log 2 = 0.30$

Which of the following is *true* ?

- A. The order of the reaction is $\frac{1}{2}$.
- B. If $[\text{A}]_0$ is 1M, then $t_{1/2}$ is $200\sqrt{10}$ min
- C. The order of the reaction changes to 1 if the concentration of reactant changes from 0.100 M to 0.500 M.
- D. $t_{1/2}$ is 800 min for $[\text{A}]_0 = 1.6$ M

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

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

Ans. (3)

Sol. $t_{1/2} \propto \frac{1}{A_0^{n-1}}$

$$\frac{(t_{1/2})_1}{(t_{1/2})_2} = \frac{(A_0)_2^{n-1}}{(A_0)_1^{n-1}}$$

$$\frac{200}{100} = \left(\frac{0.025}{0.100}\right)^{n-1}$$

$$2 = \left(\frac{1}{4}\right)^{n-1}$$

$$n - 1 = -\frac{1}{2}$$

$$n = \frac{1}{2} (\text{order})$$

$$\Rightarrow t_{1/2} \propto \sqrt{A_0}$$

$$\frac{200}{t_{1/2}} = \frac{(0.1)^{1/2}}{(1)^{1/2}}$$

when $A_0 = 1\text{M}$

$$t_{1/2} = 200\sqrt{10} \text{ min}$$

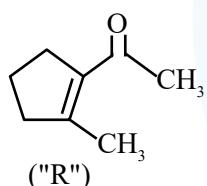
* Ist order kinetics have $t_{1/2}$ independent of their concentration. So upon changing the concentration $t_{1/2}$ should not change for first order reaction.

$$\frac{200}{t_{1/2}} = \frac{(0.1)^{1/2}}{(1.6)^{1/2}}$$

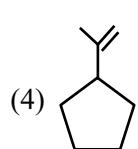
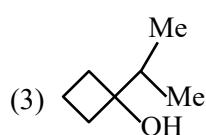
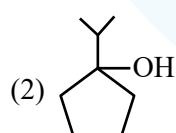
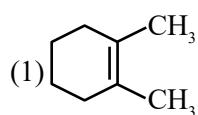
when $A_0 = 1.6\text{ M}$

$$t_{1/2} = 800 \text{ min}$$

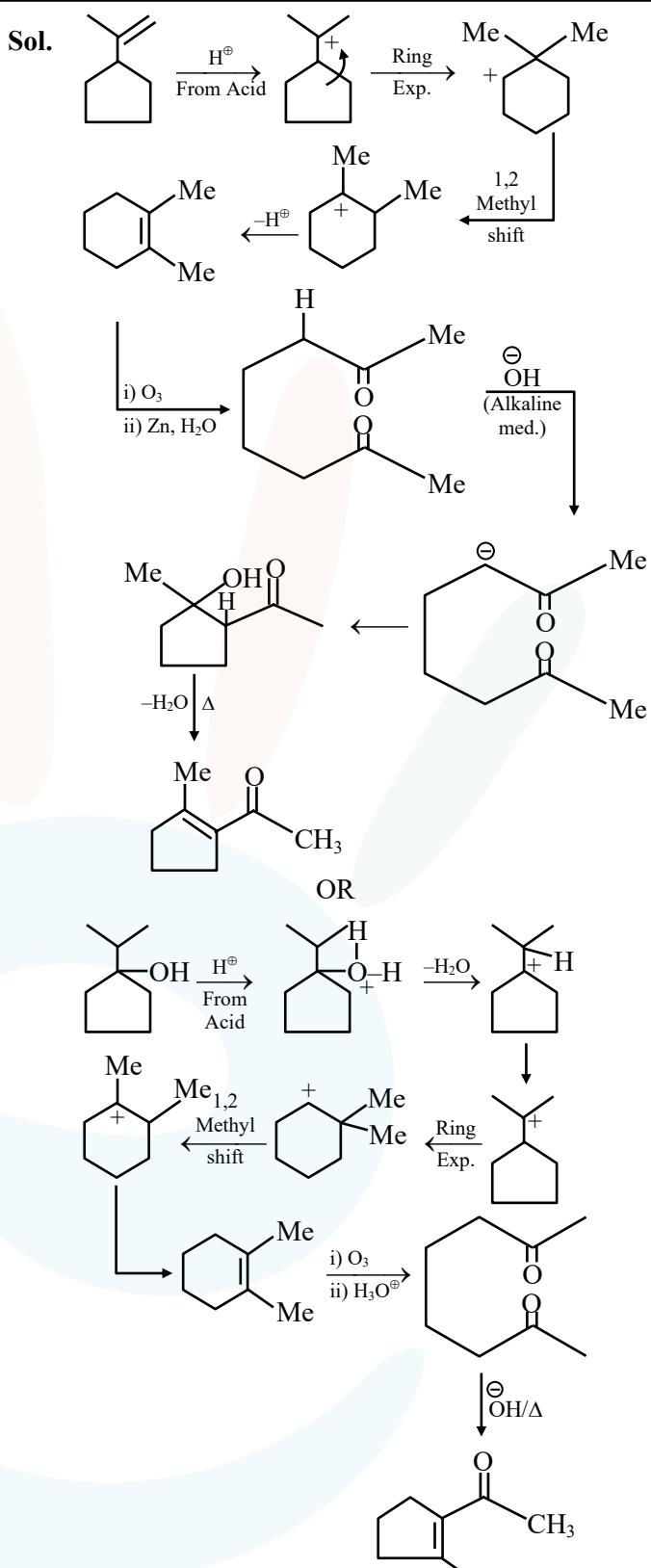
58. A molecule ("P") on treatment with acid undergoes rearrangement and gives ("Q") ("Q") on ozonolysis followed by reflux under alkaline condition gives ("R"). The structure of ("R") is given below :



The structure of ("P") is



NTA Ans. (2)

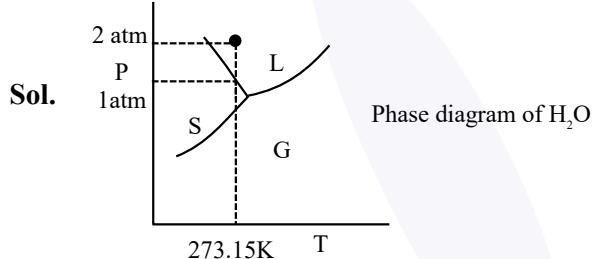


Note : In question about molecule "P" is not clarified, whether it is alcohol or alkene and as in question language rearrangement product is asking hence according to question language ans. is either (2) or (4). As alkene also undergoes rearrangement in presence of acid but option (2) also fulfil all conditions.

59. Ice and water are placed in a closed container at a pressure of 1 atm and temperature 273.15 K. If pressure of the system is increased 2 times, keeping temperature constant, then identify correct observation from following :

- (1) Volume of system increases.
- (2) Liquid phase disappears completely.
- (3) The amount of ice decreases.
- (4) The solid phase (ice) disappears completely.

Ans. (4)

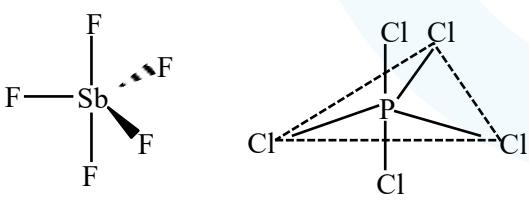
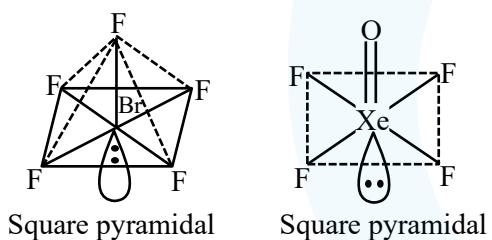


If pressure is made two time then mixture of ice and water will completely convert into water (liquid) form.

60. The molecules having square pyramidal geometry are

- (1) BrF_5 & XeOF_4
- (2) SbF_5 & XeOF_4
- (3) SbF_5 & PCl_5
- (4) BrF_5 & PCl_5

Ans. (1)

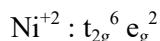


- Sol.**
- BrF_5 : Square pyramidal
 - XeOF_4 : Square pyramidal
 - SbF_5 : Trigonal bipyramidal
 - PCl_5 : Trigonal bipyramidal

61. The metal ion whose electronic configuration is not affected by the nature of the ligand and which gives a violet colour in non-luminous flame under hot condition in borax bead test is
- (1) Ti^{3+}
 - (2) Ni^{2+}
 - (3) Mn^{2+}
 - (4) Cr^{3+}

Ans. (2)

Sol. Ni^{2+} gives violet coloured bead in non-luminous flame under hot conditions. Ni^{2+} has d^8 configuration which does not depend on nature of ligand present in octahedral complex.



62. Both acetaldehyde and acetone (individually) undergo which of the following reactions?

- A. Iodoform Reaction
- B. Cannizaro Reaction
- C. Aldol condensation
- D. Tollen's Test
- E. Clemmensen Reduction

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

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

Ans. (2)

Sol.

S.No.	Name of Reaction	Acetaldehyde $\text{CH}_3-\overset{\text{C}}{\underset{\text{O}}{\text{=}}}-\text{H}$	Acetone $\text{CH}_3-\overset{\text{C}}{\underset{\text{O}}{\text{=}}}-\text{CH}_3$
1	Iodoform reaction	⊕ve	⊕ve
2	Cannizaro	⊖ve	⊖ve
3	Aldol reaction	⊕ve	⊕ve
4	Tollen's test	⊕ve	⊖ve
5	Clemmensen reduction	⊕ve	⊕ve

Ans. (2) A, C and E only

63. In a multielectron atom, which of the following orbitals described by three quantum numbers with have same energy in absence of electric and magnetic fields?

- A. $n = 1, l = 0, m_l = 0$
- B. $n = 2, l = 0, m_l = 0$
- C. $n = 2, l = 1, m_l = 1$
- D. $n = 3, l = 2, m_l = 1$
- E. $n = 3, l = 2, m_l = 0$

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

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

Ans. (4)

Sol.

orbital

$$A : n = 1, l = 0, m_l = 0$$

1s

$$B : n = 2, l = 0, m_l = 0$$

2s

$$C : n = 3, l = 1, m_l = 1$$

3p

$$D : n = 3, l = 2, m_l = 1$$

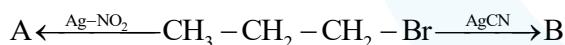
3d

$$E : n = 3, l = 2, m_l = 0$$

3d

In absence of electric and magnetic fields, all orbitals of 3d are degenerate

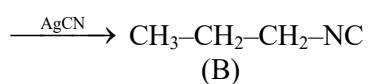
64. The products A and B in the following reactions, respectively are



- (1) $\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{ONO}$, $\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{NC}$
- (2) $\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{ONO}$, $\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CN}$
- (3) $\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{NO}_2$, $\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CN}$
- (4) $\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{NO}_2$, $\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{NC}$

Ans. (4)

Sol. $\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{NO}_2 \xleftarrow{\text{Ag-NO}_2} \text{CH}_3-\text{CH}_2-\text{CH}_2-\text{Br}$
(A)



65. What is the freezing point depression constant of a solvent, 50 g of which contain 1 g non volatile solute (molar mass 256 g mol⁻¹) and the decrease in freezing point is 0.40 K?

- (1) 5.12 K kg mol⁻¹
- (2) 4.43 K kg mol⁻¹
- (3) 1.86 K kg mol⁻¹
- (4) 3.72 K kg mol⁻¹

Ans. (1)

Sol. $\Delta T_f = K_b \cdot m$

$$0.4 = K_b \frac{1}{\frac{256}{50 \times 10^{-3}}}$$

$$K_b = 5.12 \text{ K kg / mol}$$

66. Consider the following elements In, Tl, Al, Pb, Sn and Ge.

The most stable oxidation states of elements with highest and lowest first ionisation enthalpies, respectively, are

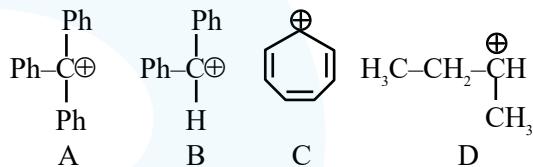
- (1) +2 and +3
- (2) +4 and +3
- (3) +4 and +1
- (4) +1 and +4

NTA Ans. (3)

Sol. Among Al, In, Tl, Ge, Sn, Pb, the metal having highest IE₁ is Ge and lowest IE₁ is In.

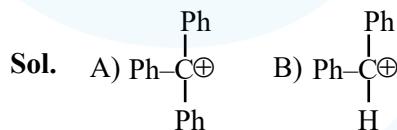
Most stable oxidation state of Ge is +4 and In is +3.

67. The correct order of stability of following carbocations is :



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

Ans. (4)



Solution :-

C is aromatic due to \oplus ve charge hence it is most stable

A have more resonance structure

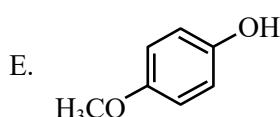
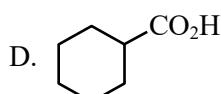
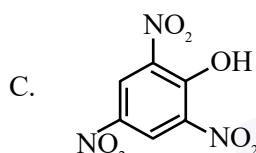
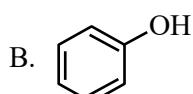
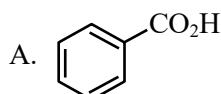
B have less resonance structure

D have only hyper conjugation

Consider First Aromaticity > Resonance > Hyper conjugation

Ans. D < B < A < C

68. The compounds that produce CO_2 with aqueous NaHCO_3 solution are :



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

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

Ans. (3)

Sol. A, C, D produce CO_2 with aqueous NaHCO_3 solution.

A, C, D acids are stronger acid than H_2CO_3 (Carbonic acid)

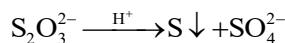
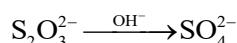
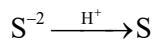
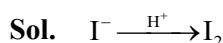
69. Which of the following oxidation reactions are carried out by both $\text{K}_2\text{Cr}_2\text{O}_7$ and KMnO_4 in acidic medium ?

- A. $\text{I}^- \rightarrow \text{I}_2$
 B. $\text{S}^{2-} \rightarrow \text{S}$
 C. $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+}$
 D. $\text{I}^- \rightarrow \text{IO}_3^-$
 E. $\text{S}_2\text{O}_3^{2-} \rightarrow \text{SO}_4^{2-}$

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

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

Ans. (3)



70. Given below are two statements :

Statement I : D-glucose pentaacetate reacts with 2, 4-dinitrophenylhydrazine.

Statement II : Starch, on heating with concentrated sulfuric acid at 100°C and 2-3 atmosphere pressure produces glucose.

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

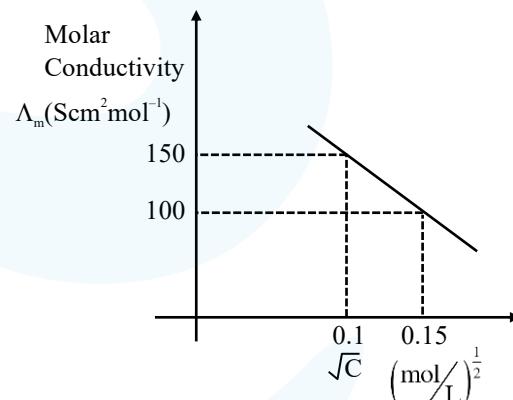
- (1) Both Statement I and Statement II are false
 (2) Statement I is false but Statement II is true
 (3) Statement I is true but Statement II is false
 (4) Both Statement I and Statement II are true

Ans. (2)

Sol.

SECTION-B

71. Given below is the plot of the molar conductivity vs $\sqrt{\text{concentration}}$ for KCl in aqueous solution.



If, for the higher concentration of KCl solution, the resistance of the conductivity cell is 100Ω , then the resistance of the same cell with the dilute solution is ' x ' Ω .

The value of x is _____ (Nearest integer)

Ans. 150

