

**JEE-MAIN EXAMINATION – APRIL 2025**

**(HELD ON TUESDAY 08<sup>th</sup> APRIL 2025)**

**TIME : 3:00 PM TO 6:00 PM**

**MATHEMATICS**

**TEST PAPER WITH SOLUTION**

**SECTION-A**

1. Let the values of  $\lambda$  for which the shortest distance between the lines  $\frac{x-1}{2} = \frac{y-2}{3} = \frac{z-3}{4}$  and  $\frac{x-\lambda}{3} = \frac{y-4}{4} = \frac{z-5}{5}$  is  $\frac{1}{\sqrt{6}}$  be  $\lambda_1$  and  $\lambda_2$ . Then

the radius of the circle passing through the points  $(0, 0)$ ,  $(\lambda_1, \lambda_2)$  and  $(\lambda_2, \lambda_1)$  is

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

**Ans. (1)**

**Sol.**  $\vec{p} = 2\hat{i} + 3\hat{j} + 4\hat{k}, \vec{q} = 3\hat{i} + 4\hat{j} + 5\hat{k}$

$$\Rightarrow \vec{p} \times \vec{q} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 3 & 4 \\ 3 & 4 & 5 \end{vmatrix} = -\hat{i} + 2\hat{j} - \hat{k}$$

$A \equiv (1, 2, 3)$   $B \equiv (\lambda, 4, 5)$

Shortest Distance =  $\frac{|\vec{AB} \cdot (\vec{p} \times \vec{q})|}{|\vec{p} \times \vec{q}|}$

$$\frac{1}{\sqrt{6}} = \frac{|((\lambda-1)\hat{i} + 2\hat{j} + 2\hat{k}) \cdot (-\hat{i} + 2\hat{j} - \hat{k})|}{\sqrt{6}}$$

$\Rightarrow |-\lambda + 1 + 4 - 2| = 1 \Rightarrow |\lambda - 3| = 1$

$\Rightarrow \lambda = 3 \pm 1 = 4, 2$

Radius of circle passing through points  $(0, 0)$ ,  $(4, 2)$  &  $(2, 4)$

$$= \frac{abc}{4\Delta} = \frac{\sqrt{20} \times \sqrt{20} \times \sqrt{8}}{2 \times 12} = \frac{20 \times 2\sqrt{2}}{2 \times 12}$$

$$4 \times \frac{1}{2} \begin{vmatrix} 1 & 1 & 1 \\ 0 & 4 & 2 \\ 0 & 2 & 4 \end{vmatrix}$$

$$= \frac{5\sqrt{2}}{3}$$

2. Let  $\alpha$  be a solution of  $x^2 + x + 1 = 0$ , and for some a and b in

$$\mathbb{R}, [4 \ a \ b] \begin{bmatrix} 1 & 16 & 13 \\ -1 & -1 & 2 \\ -2 & -14 & -8 \end{bmatrix} = [0 \ 0 \ 0]. \text{ If } \frac{4}{\alpha^4}$$

$+\frac{m}{\alpha^a} + \frac{n}{\alpha^b} = 3$ , then  $m + n$  is equal to \_\_\_\_

- (1) 3 (2) 11  
(3) 7 (4) 8

**Ans. (2)**

**Sol.**  $x^2 + x + 1 = 0$

$\alpha$  is root

$\therefore \alpha^2 + \alpha + 1 = 0$

$\Rightarrow \alpha = \omega$  as  $\omega^2$  [cube root of unity]

also

$$[4 - a - 2b \quad 64 - a - 14b \quad 52 + 2a - 8b] = [0 \ 0 \ 0]$$

$\therefore a + 2b = 4$

$a + 14b = 64$

$\Rightarrow 12b = 60 \Rightarrow \boxed{b = 5}$

$\Rightarrow \boxed{a = -6}$

$\therefore \frac{4}{\alpha^4} + \frac{m}{\alpha^{-6}} + \frac{n}{\alpha^5} = 3$

$\Rightarrow \frac{4}{\omega} + \frac{m}{1} + \frac{n}{\omega^2} = 3$

$\Rightarrow 4\omega^2 + m + n\omega = 3$

$\Rightarrow 4\left(-\frac{1}{2} - \frac{\sqrt{3}}{2}i\right) + m + n\left(-\frac{1}{2} + \frac{\sqrt{3}}{2}i\right) = 3$

$\therefore -2 + m - \frac{n}{2} = 3 \quad \dots(1)$

&  $\frac{-4\sqrt{3}}{2} + \frac{n\sqrt{3}}{2} = 0$

$\therefore \boxed{n = 4}$

$\boxed{m = 7}$

$\therefore \boxed{m + n = 11}$

3. Let the function  $f(x) = \frac{x}{3} + \frac{3}{x} + 3$ ,  $x \neq 0$  be strictly increasing in  $(-\infty, \alpha_1) \cup (\alpha_2, \infty)$  and strictly decreasing

in  $(\alpha_3, \alpha_4) \cup (\alpha_4, \alpha_5)$ . Then  $\sum_{i=1}^5 \alpha_i^2$  is equal to :-

- (1) 48 (2) 28  
(3) 40 (4) 36

**Ans. (4)**

**Sol.**  $f(x) = \frac{x}{3} + \frac{3}{x} + 3$ ,  $x \neq 0$

$$f'(x) = \frac{1}{3} - \frac{3}{x^2} = 0 \Rightarrow x = \pm 3$$

$$f'(x) = \frac{x^2 - 3}{3x^2}$$

$f'(x) > 0 \forall (-\infty, -3) \cup (3, \infty) \rightarrow$  increasing

$f'(x) < 0 \forall (-3, 0) \cup (0, 3) \rightarrow$  decreasing

$$\sum_{i=1}^5 \alpha_i^2 = (-3)^2 + (3)^2 + (-3)^2 + (0)^2 + (3)^2 = 36$$

4. If A and B are two events such that  $P(A) = 0.7$ ,  $P(B) = 0.4$  and  $P(A \cap \bar{B}) = 0.5$ , where  $\bar{B}$  denotes the complement of B, then  $P(B | (A \cup \bar{B}))$  is equal:-

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

**Ans. (1)**

**Sol.**  $P(A) = \frac{7}{10}$ ,  $P(B) = \frac{4}{10}$

$$P(A \cup \bar{B}) = \frac{5}{10}$$

$$P\left(\frac{B}{A \cup \bar{B}}\right) = \frac{P(B \cap (A \cup \bar{B}))}{P(A \cup \bar{B})}$$

$$= \frac{P((B \cap \bar{B}) \cup (B \cap A))}{P(A \cup \bar{B})} = \frac{P(A \cap B)}{P(A \cup \bar{B})}$$

$$= \frac{P(A) - P(A \cap \bar{B})}{P(A) + P(\bar{B}) - P(A \cap \bar{B})} = \frac{\frac{7}{10} - \frac{5}{10}}{\frac{7}{10} + \left(1 - \frac{4}{10}\right) - \frac{5}{10}}$$

$$= \frac{2}{8} = \frac{1}{4}$$

5. If  $\frac{1}{1^4} + \frac{1}{2^4} + \frac{1}{3^4} + \dots = \frac{\pi^4}{90}$ ,

$$\frac{1}{1^4} + \frac{1}{3^4} + \frac{1}{5^4} + \dots = \alpha,$$

$$\frac{1}{2^4} + \frac{1}{4^4} + \frac{1}{6^4} + \dots = \beta,$$

then  $\frac{\alpha}{\beta}$  is equal to

- (1) 23 (2) 18  
(3) 15 (4) 14

**Ans. (3)**

**Sol.** If  $\frac{1}{1^4} + \frac{1}{2^4} + \frac{1}{3^4} + \dots = \frac{\pi^4}{90}$  .....(i)

$$\beta = \frac{1}{2^4} + \frac{1}{4^4} + \frac{1}{6^4} + \dots,$$

$$= \frac{1}{16} \left[ \frac{1}{1^4} + \frac{1}{2^4} + \frac{1}{3^4} + \dots \right],$$

$$= \frac{1}{16} \times \frac{\pi^4}{90} \quad \text{using (i) .....(ii)}$$

$$\alpha = \frac{1}{1^4} + \frac{1}{3^4} + \frac{1}{5^4} + \dots$$

$$\left( \frac{1}{1^4} + \frac{1}{2^4} + \frac{1}{3^4} + \frac{1}{4^4} + \frac{1}{5^4} + \dots \right)$$

$$- \left( \frac{1}{2^4} + \frac{1}{4^4} + \frac{1}{6^4} + \dots \right)$$

$$\alpha = \frac{\pi^4}{90} - \frac{1}{16} \times \frac{\pi^4}{90} \quad \text{[using (i) and (ii)]}$$

$$\alpha = \frac{16-1}{16 \times 90} \times \pi^4 = \frac{15}{16 \times 90} \pi^4 = \frac{\pi^4}{96}$$

$$\therefore \frac{\alpha}{\beta} = \frac{\frac{\pi^4}{96}}{\frac{\pi^4}{16 \times 90}} = \frac{16 \times 90}{96} = 15$$

6. The sum of the squares of the roots of  $|x+2|^2 + |x-2| - 2 = 0$  and the squares of the roots of  $x^2 - 2|x-3| - 5 = 0$ , is

- (1) 26 (2) 36  
(3) 30 (4) 24

**Ans. (2)**

**Sol.**  $|x - 2|^2 + 2|x - 2| - |x - 2| - 2 = 0$

$\Rightarrow (|x - 2| + 2)(|x - 2| - 1) = 0$

$\Rightarrow |x - 2| = 1$

$\Rightarrow x = 2 \pm 1 = 3, 1$

$\Rightarrow$  sum of square of roots  $= 9 + 1 = 10$

$x^2 - 2|x - 3| - 5 = 0$

Case-I  $x - 3 \geq 0$

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

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

$\Rightarrow x = 1$

But  $x \geq 3$

$\Rightarrow x \in \phi$

Case-II  $x - 3 < 0$

$x^2 + 2x - 11 = 0, D > 0 \Rightarrow$  Real & distinct roots

$f(x) = x^2 + 2x - 11$

$f(3) > 0, \frac{-p}{2a} = -1 < 3$

$\Rightarrow$  both roots  $< 3$ , both roots acceptable

Sum of square of roots  $= (\alpha + \beta)^2 - 2\alpha\beta$

$= 4 + 22 = 26$

$\Rightarrow$  Final sum  $= 10 + 26 = 36$

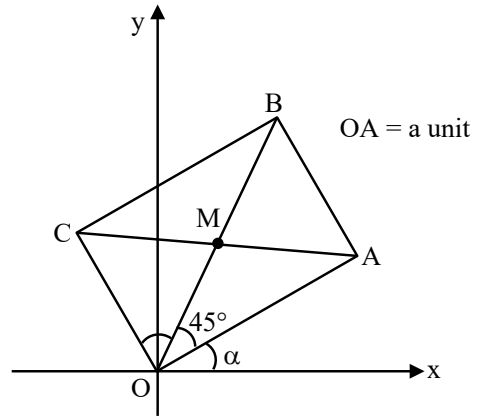
7. Let  $a$  be the length of a side of a square OABC with O being the origin. Its side OA makes an acute angle  $\alpha$  with the positive x-axis and the equations of its diagonals are  $(\sqrt{3} + 1)x + (\sqrt{3} - 1)y = 0$

and  $(\sqrt{3} - 1)x - (\sqrt{3} + 1)y + 8\sqrt{3} = 0$ . Then  $a^2$  is equal to

- (1) 48
- (2) 32
- (3) 16
- (4) 24

Ans. (1)

**Sol.**



Slope of diagonal OB  $= \frac{\sqrt{3} + 1}{1 - \sqrt{3}}$   
 $= \tan 105^\circ$

$\therefore \alpha = 60^\circ$

$\therefore A(\cos 60^\circ, \sin 60^\circ)$

$\therefore A\left(\frac{a}{2}, \frac{\sqrt{3}a}{2}\right)$

A Lies on other diagonal

$\therefore \left(\frac{\sqrt{3}-1}{2}\right)a - \left(\frac{\sqrt{3}+1}{2}\right) \cdot \frac{\sqrt{3}a}{2} + 8\sqrt{3} = 0$

$a \left[ \frac{\sqrt{3}-1-3-\sqrt{3}}{2} \right] = -8\sqrt{3}$

$a = 4\sqrt{3}$

$\therefore a^2 = 48$

8. Let  $f(x)$  be a positive function and

$I_1 = \int_{-\frac{1}{2}}^1 2xf(2x(1-2x)) dx$  and  $I_2 = \int_{-1}^2 f(x(1-x)) dx$ .

Then the value of  $\frac{I_2}{I_1}$  is equal to \_\_\_\_\_

- (1) 9
- (2) 6
- (3) 12
- (4) 4

Ans. (4)

**Sol.**  $I_1 = \int_{-\frac{1}{2}}^1 2xf(2x(1-2x))dx$

$\Rightarrow 2x = t \Rightarrow 2dx = dt \Rightarrow I_1 = \frac{1}{2} \int_{-1}^2 tf(t(1-t))dt$

$\Rightarrow 2I_1 = \int_{-1}^2 (1-t)f(1-t)(1-(1-t))dt$

$\Rightarrow 2I_1 = \int_{-1}^2 f(t(1-t))dt - \int_{-1}^2 tf(t(1-t))dt$

$\Rightarrow 2I_1 = I_2 - 2I_1$

$\Rightarrow 4I_1 = I_2$

$\Rightarrow \frac{I_2}{I_1} = 4$

9. Let  $\vec{a} = \hat{i} + 2\hat{j} + \hat{k}$  and  $\vec{b} = 2\hat{i} + \hat{j} - \hat{k}$ . Let  $\hat{c}$  be a unit vector in the plane of the vectors  $\vec{a}$  and  $\vec{b}$  and be perpendicular to  $\vec{a}$ . Then such a vector  $\hat{c}$  is :

- (1)  $\frac{1}{\sqrt{5}} (\hat{j} - 2\hat{k})$       (2)  $\frac{1}{\sqrt{3}} (-\hat{i} + \hat{j} - \hat{k})$   
(3)  $\frac{1}{\sqrt{3}} (\hat{i} - \hat{j} + \hat{k})$       (4)  $\frac{1}{\sqrt{2}} (-\hat{i} + \hat{k})$

**Ans. (4)**

**Sol.** Let vector  $\vec{p}$  in plane of  $\vec{a}$  &  $\vec{b} = K(\vec{a} + \lambda\vec{b})$

$\vec{p} \perp \vec{a} = \vec{p} \cdot \vec{a} = 0$

$\Rightarrow K(\vec{a} + \lambda\vec{b}) \cdot \vec{a} = 0$

$\Rightarrow \vec{a} \cdot \vec{a} + \lambda\vec{b} \cdot \vec{a} = 0$

$\Rightarrow 6 + \lambda(3) = 0$

$\Rightarrow \lambda = -2$

$\Rightarrow \vec{p} = (-3\hat{i} + 3\hat{k})$

Unit vector  $\rightarrow \pm \frac{(-\hat{i} + \hat{k})}{\sqrt{2}}$

10. Let the ellipse  $3x^2 + py^2 = 4$  pass through the centre C of the circle  $x^2 + y^2 - 2x - 4y - 11 = 0$  of radius r. Let  $f_1, f_2$  be the focal distances of the point C on the ellipse. Then  $6f_1f_2 - r$  is equal to

(1) 74      (2) 68

(3) 70      (4) 78

**Ans. (3)**

**Sol.** E :  $\frac{x^2}{4/3} + \frac{y^2}{4/P} = 1$

Centre of circle (1, 2), radius

$r = \sqrt{1+4+11}$

$r = 4$

$\therefore$  E pass from centre (1, 2)

$\therefore \frac{3}{4} + P = 1$

$P = \frac{1}{4} \therefore$  vertical ellipse

$e = \sqrt{1 - \frac{4/3}{16}} = \sqrt{1 - \frac{1}{12}} = \sqrt{\frac{11}{12}}$

$\therefore$  Focal distance of C (h, k)

$= b \pm ek$

$F_1 = 4 + \sqrt{\frac{11}{12}} \times 2$

$F_2 = 4 - \sqrt{\frac{11}{12}} \times 2$

$\therefore F_1F_2 = 16 - \frac{11}{3} = \frac{37}{3}$

$\therefore 6F_1F_2 - r = 74 - 4 = 70$

11. The integral  $\int_{-1}^{\frac{3}{2}} (|\pi^2 x \sin(\pi x)|) dx$  is equal to :

(1)  $3 + 2\pi$

(2)  $4 + \pi$

(3)  $1 + 3\pi$

(4)  $2 + 3\pi$

**Ans. (3)**



14. Let A =

$$\left\{ \theta \in [0, 2\pi] : 1 + 10 \operatorname{Re} \left( \frac{2 \cos \theta + i \sin \theta}{\cos \theta - 3i \sin \theta} \right) = 0 \right\}.$$

Then  $\sum_{\theta \in A} \theta^2$  is equal to

- (1)  $\frac{21}{4} \pi^2$                       (2)  $8\pi^2$   
(3)  $\frac{27}{4} \pi^2$                       (4)  $6\pi^2$

Ans. (1)

Sol.  $1 + 10 \operatorname{Re} \left( \frac{2 \cos \theta + i \sin \theta}{\cos \theta - 3i \sin \theta} \right) = 0$

$\therefore z + \bar{z} = 2 \operatorname{Re}(z)$

$$\frac{2 \cos \theta + i \sin \theta}{\cos \theta - 3i \sin \theta} + \frac{2 \cos \theta - i \sin \theta}{\cos \theta + 3i \sin \theta} = 2 \times \left( \frac{-1}{10} \right)$$

$$\frac{(2 \cos^2 \theta - 3 \sin^2 \theta) + (2 \cos^2 \theta) - (3 \sin^2 \theta)}{\cos^2 \theta + 9 \sin^2 \theta} = \frac{-2}{10}$$

$$\Rightarrow \frac{2 \cos^2 \theta - 3 \sin^2 \theta}{\cos^2 \theta + 9 \sin^2 \theta} = \frac{-1}{10}$$

$$\Rightarrow 20 \cos^2 \theta - 30 \sin^2 \theta = -\cos^2 \theta - 9 \sin^2 \theta$$

$$21 \cos^2 \theta - 21 \sin^2 \theta = 0$$

$$\Rightarrow \cos 2\theta = 0$$

$$2\theta = \frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{2}, \frac{7\pi}{2}$$

$$\Rightarrow \sum \theta^2 = \frac{\pi^2}{16} + \frac{9\pi^2}{16} + \frac{25\pi^2}{16} + \frac{49\pi^2}{16} = \frac{84\pi^2}{16} = \frac{21\pi^2}{4}$$

15. Let A = {0, 1, 2, 3, 4, 5}. Let R be a relation on A defined by (x, y) ∈ R if and only if max {x, y} ∈ {3, 4}. Then among the statements (S<sub>1</sub>) : The number of elements in R is 18, and (S<sub>2</sub>) : The relation R is symmetric but neither reflexive nor transitive

- (1) both are true                      (2) both are false  
(3) only (S<sub>2</sub>) is true                      (4) only (S<sub>1</sub>) is true

Ans. (3)

Sol. A = {0, 1, 2, 3, 4, 5}

R ≡ {(0,3), (3,0), (0,4), (4,0), (1,3), (3,1), (1,4), (4,1), (2,3), (3,2), (2,4), (4,2), (3,3), (3,4), (4,3), (4,4)}

Total 16 elements

Not reflexive as (0,0), ..., (2,2) ∉ R

Symmetric ∴ ∀ all a, b

(a, b) & (b, a) ∈ R

Not transitive ∴ (0,3), (3,1) ∈ R

but (0,1) ∉ R

⇒ Only S<sub>2</sub> correct

16. The number of integral terms in the expansion of

$$\left( 5^{\frac{1}{2}} + 7^{\frac{1}{8}} \right)^{1016}$$

- (1) 127                                      (2) 130  
(3) 129                                      (4) 128

Ans. (4)

Sol.  $T_r = {}^{1016}C_r (5)^{\frac{1016-r}{2}} (7^{\frac{1}{8}})^r$

⇒ r = 0, 8, 16, 24, ..., 1016

1016 = 0 + (n - 1)8

⇒ n - 1 =  $\frac{1016}{8} = 127$

So, n = 128.

17. Let f(x) = x - 1 and g(x) = e<sup>x</sup> for x ∈ ℝ. If

$\frac{dy}{dx} = \left( e^{-2\sqrt{x}} g(f(f(x))) - \frac{y}{\sqrt{x}} \right)$ , y(0) = 0, then y(1)

is :-

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

Ans. (3)

Sol. f(x) = x - 1

f(f(x)) = f(x) - 1 = x - 1 - 1 = x - 2

g(f(f(x))) = e<sup>x-2</sup>

∴  $\frac{dy}{dx} = e^{-2\sqrt{x}} \times e^{x-2} - \frac{1}{\sqrt{x}} y$

$\frac{dy}{dx} + \frac{1}{\sqrt{x}} y = e^{x-2\sqrt{x}-2}$  which is L.D.E

I.F. =  $e^{\int \frac{1}{\sqrt{x}} dx} = e^{2\sqrt{x}}$

Its solution is

$y \times e^{2\sqrt{x}} = \int e^{2\sqrt{x}} \times e^{x-2\sqrt{x}-2} dx + c$

$y \times e^{2\sqrt{x}} = \int e^{x-2} dx + c$

$y \times e^{2\sqrt{x}} = e^{x-2} + c$

Given x = 0, y = 0 ⇒ 0 = e<sup>-2</sup> + c ; c = -e<sup>-2</sup>

∴  $y \times e^{2\sqrt{x}} = e^{x-2} - e^{-2}$

when x = 1,  $y \times e^2 = e^{-1} - e^{-2}$

$$y = \frac{e^{-1} - e^{-2}}{e^2} = \frac{\frac{1}{e} - \frac{1}{e^2}}{e^2} = \frac{e^2 - e}{e^5} = \frac{e-1}{e^4}$$

Option (1) is correct



**Sol.** 
$$\lim_{x \rightarrow 0} \frac{\tan^{-1} x + \frac{1}{2} [\ln(1+x) - \ln(1-x)] - 2x}{x^5}$$

$$= \lim_{x \rightarrow 0} \frac{\left(x - \frac{x^3}{3} + \frac{x^5}{5} \dots\right) + \frac{1}{2} \left[x - \frac{x^2}{2} + \frac{x^3}{3} \dots - \left(-x - \frac{x^2}{2} - \frac{x^3}{3} \dots\right)\right] - 2x}{x^5}$$

$$= \lim_{x \rightarrow 0} \frac{2x + \frac{2x^5}{5} \dots - 2x}{x^5} = \frac{2}{5}$$

$$\lim_{x \rightarrow 1} x^{\frac{2}{1-x}} = e^{\lim_{x \rightarrow 1} \left(\frac{2}{1-x}\right)(x-1)} = e^{-2}$$

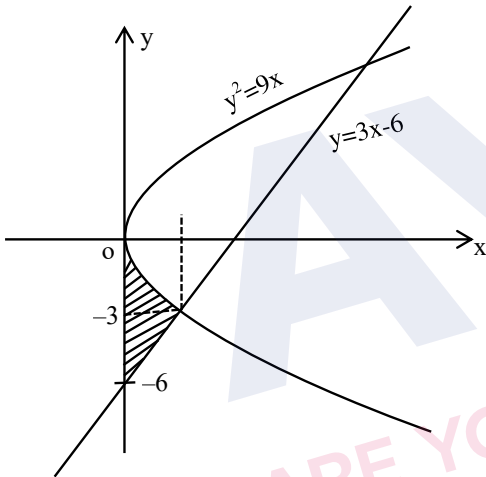
⇒ Both statements correct

**SECTION-B**

**21.** Let the area of the bounded region  $\{(x, y) : 0 \leq 9x \leq y^2, y \geq 3x - 6\}$  be A. Then 6A is equal to \_\_\_\_\_

**Ans. (15)**

**Sol.**  $0 \leq 9x \leq y^2$  &  $y \geq 3x - 6$



A = Required Area =  $\left[ \int_0^1 (-3\sqrt{x}) dx - \int_0^1 (3x - 6) dx \right]$

$$A = -3 \left[ \frac{x^{\frac{3}{2}}}{\frac{3}{2}} \right]_0^1 - \left[ \frac{3x^2}{2} - 6x \right]_0^1$$

$$A = -2[1 - 0] \left[ \frac{3}{2} - 6 \right]$$

$$A = -2 - \frac{3}{2} + 6 = \frac{5}{2} \text{ Sq. unit}$$

$$\therefore 6A = 6 \times \frac{5}{2} = 15$$

**22.** Let the domain of the function  $f(x) = \cos^{-1}\left(\frac{4x+5}{3x-7}\right)$  be  $[\alpha, \beta]$  and the domain of  $g(x) = \log_2(2 - 6\log_{27}(2x+5))$  be  $(\gamma, \delta)$ . Then  $|7(\alpha + \beta) + 4(\gamma + \delta)|$  is equal to \_\_\_\_\_

**Ans. (96)**

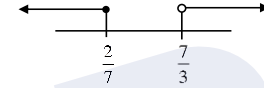
**Sol.**  $f(x) = \cos^{-1}\left(\frac{4x+5}{3x-7}\right)$

$$\Rightarrow -1 \leq \left(\frac{4x+5}{3x-7}\right) \leq 1$$

$$\left(\frac{4x+5}{3x-7}\right) \geq -1$$

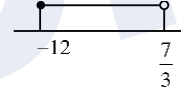
$$\frac{4x+5+3x-7}{3x-7} \geq 0$$

$$\Rightarrow \frac{7x-2}{3x-7} \geq 0$$



$$x \in \left(-\infty, \frac{2}{7}\right] \cup \left(\frac{7}{3}, \infty\right)$$

$$\& \frac{4x+5}{3x-7} \leq 1 \Rightarrow \frac{x+12}{3x-7} \leq 0$$



∴ Domain of f(x) is

$$\left[-12, \frac{2}{7}\right] \quad \alpha = -12, \beta = \frac{2}{7}$$

$$g(x) = \log_2(2 - 6\log_{27}(2x+5))$$

Domain

$$2 - 6\log_{27}(2x+5) > 0$$

$$\Rightarrow 6\log_{27}(2x+5) < 2$$

$$\Rightarrow \log_{27}(2x+5) < \frac{1}{3}$$

$$\Rightarrow 2x+5 < 3$$

$$\Rightarrow x < -1$$

$$\& 2x+5 > 0 \Rightarrow x > -\frac{5}{2}$$

$$\text{Domain is } x \in \left(-\frac{5}{2}, -1\right)$$

$$\gamma = -\frac{5}{2}, \delta = -1$$

$$|7(\alpha + \beta) + 4(\gamma + \delta)| = |7(-12 + \frac{2}{7}) + 4(-\frac{5}{2} - 1)|$$

$$|-82 - 14| = 96$$

23. Let the area of the triangle formed by the lines  $x + 2 = y - 1 = z$ ,  $\frac{x-3}{5} = \frac{y}{-1} = \frac{z-1}{1}$  and  $\frac{x}{-3} = \frac{y-3}{3} = \frac{z-2}{1}$  be A. Then  $A^2$  is equal to \_\_\_\_\_

Ans. (56)

Sol.  $L_1 : x + 2 = y - 1 = z = \ell$

$$L_2 : \frac{x-3}{5} = \frac{y}{-1} = \frac{z-1}{1} = m$$

$$L_3 : \frac{x}{-3} = \frac{y-3}{3} = \frac{z-2}{1} = n$$

Point of intersection of  $L_1$  and  $L_2$

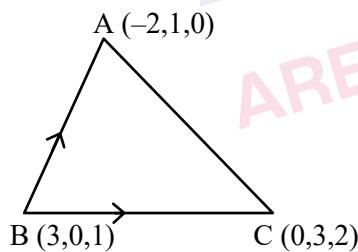
$$\left. \begin{aligned} \ell - 2 &= 5m + 3 \\ \ell + 1 &= -m \\ \ell &= m + 1 \end{aligned} \right\} \ell = 0, m = -1 \quad A(-2, 1, 0)$$

Point of intersection of  $L_2$  and  $L_3$

$$\left. \begin{aligned} 5m + 3 &= -3n \\ -m &= 3n + 3 \\ m + 1 &= n + 2 \end{aligned} \right\} m = 0, n = -1, B(3, 0, 1)$$

Point of intersection  $L_3$  and  $L_4$

$$\left. \begin{aligned} -3n &= \ell - 2 \\ 3n + 3 &= \ell + 1 \\ n + 2 &= \ell \end{aligned} \right\} \ell = 2, n = 0, C(0, 3, 2)$$



$$Ar(\Delta ABC) = \frac{1}{2} \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -2 & 1 & -1 \\ 3 & 0 & 1 \end{vmatrix}$$

$$A = \frac{1}{2} |\hat{i}(4) - \hat{j}(-8) + \hat{k}(-12)|$$

$$A = \frac{1}{2} \sqrt{16 + 64 + 144} = \sqrt{56}$$

$$A^2 = 56$$

24. The product of the last two digits of  $(1919)^{1919}$  is \_\_\_\_\_

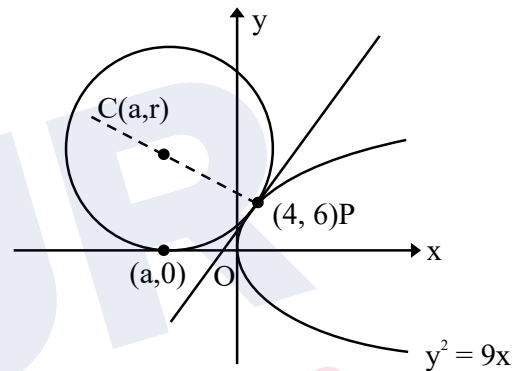
Ans. (63)

Sol.  $(1919)^{1919} = (1920 - 1)^{1919}$   
 $= {}^{1919}C_0(1920)^{1919} - {}^{1919}C_1(1920)^{1918} + \dots$   
 $+ {}^{1919}C_{1918}(1920)^1 - {}^{1919}C_{1919}$   
 $= 100\lambda + 1919 \times 1920 - 1$   
 $= 100\lambda + 3684480 - 1$   
 $= 100\lambda + \dots\dots\dots 79$  (last two digit)  
 $\Rightarrow$  Number having last two digit 79  
 $\therefore$  Product of last two digit 63

25. Let r be the radius of the circle, which touches x-axis at point (a, 0),  $a < 0$  and the parabola  $y^2 = 9x$  at the point (4, 6). Then r is equal to \_\_\_\_\_

Ans. (30)

Sol.



$$\begin{aligned} (x - a)^2 + (y - r)^2 &= r^2 \\ (4 - a)^2 + (6 - r)^2 &= r^2 \\ 16 + a^2 - 8a + 36 + r^2 - 12r &= r^2 \\ a^2 - 8a - 12r + 52 &= 0 \end{aligned}$$

Tangent to parabola at (4, 6) is

$$6.4 = 9 \cdot \left( \frac{x+4}{2} \right) \quad \text{i.e. } 3x - 4y + 12 = 0$$

This is also tangent to the circle

$$\therefore CP = r$$

$$\frac{3a - 4r + 12}{5} = \pm r$$

$$3a + 12 = 4r \pm 5r \quad \dots\dots(1)$$

equation of circle is

$$(x - a)^2 + (y - r)^2 = r^2$$

$$\text{satisfy } P(4, 6) \Rightarrow a^2 - 8a - 12r + 52 = 0 \quad \dots\dots(2)$$

From equation (1)

If  $a + 4 = 3r$  then  $a = +6$  (rejected)

If  $3a + 12 = -r$  then  $a = -14$  and  $r = 30$

**JEE-MAIN EXAMINATION – APRIL 2025**

**(HELD ON TUESDAY 08<sup>th</sup> APRIL 2025)**

**TIME : 3:00 PM TO 6:00 PM**

**PHYSICS**

**TEST PAPER WITH SOLUTION**

**SECTION-A**

26. Given below are two statements : one is labelled as **Assertion A** and the other is labelled as **Reason R**  
**Assertion A** : Work done in moving a test charge between two points inside a uniformly charged spherical shell is zero, no matter which path is chosen.

**Reason R** : Electrostatic potential inside a uniformly charged spherical shell is constant and is same as that on the surface of the shell.

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

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

**Ans. (2)**

**Sol. Conceptual**

27. A rod of linear mass density ' $\lambda$ ' and length ' $L$ ' is bent to form a ring of radius ' $R$ '. Moment of inertia of ring about any of its diameter is :

- (1)  $\frac{\lambda L^3}{16\pi^2}$
- (2)  $\frac{\lambda L^3}{12}$
- (3)  $\frac{\lambda L^3}{4\pi^2}$
- (4)  $\frac{\lambda L^3}{8\pi^2}$

**Ans. (4)**

**Sol.**  $L = 2\pi R$

$$I = \frac{MR^2}{2} = \frac{\lambda \times L}{2} \times \left(\frac{L}{2\pi}\right)^2 = \frac{\lambda L^3}{8\pi^2}$$

28. A 3 m long wire of radius 3 mm shows an extension of 0.1 mm when loaded vertically by a mass of 50 kg in an experiment to determine Young's modulus. The value of Young's modulus of the wire as per this experiment is  $P \times 10^{11} \text{ Nm}^{-2}$ , where the value of P is : (Take  $g = 3\pi \text{ m/s}^2$ )

- (1) 5
- (2) 10
- (3) 25
- (4) 2.5

**Ans. (1)**

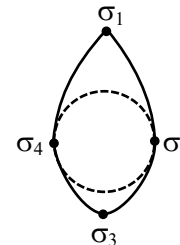
**Sol.**  $\frac{50g}{\pi r^2} = y \cdot \frac{\Delta l}{l}$

$$\frac{50 \times 3\pi}{\pi \times (3 \times 10^{-3})^2} = P \times 10^{11} \times \frac{0.1 \times 10^{-3}}{3}$$

$$\Rightarrow P = \frac{50 \times 3 \times 3}{3^2 \times 10^{-6} \times 10^{11} \times 0.1 \times 10^{-3}}$$

$P = 5$

29. Electric charge is transferred to an irregular metallic disk as shown in figure. If  $\sigma_1, \sigma_2, \sigma_3$  and  $\sigma_4$  are charge densities at given points then, choose the correct answer from the options given below:



- (A)  $\sigma_1 > \sigma_3 ; \sigma_2 = \sigma_4$
- (B)  $\sigma_1 > \sigma_2 ; \sigma_3 > \sigma_4$
- (C)  $\sigma_1 > \sigma_3 > \sigma_2 = \sigma_4$
- (D)  $\sigma_1 < \sigma_3 < \sigma_2 = \sigma_4$
- (E)  $\sigma_1 = \sigma_2 = \sigma_3 = \sigma_4$
- (1) A, B and C Only
- (2) A and C Only
- (3) D and E Only
- (4) B and C Only

**Ans. (1)**

**Sol.**  $\sigma \propto \frac{1}{ROC}$

$(ROC)_1 < (ROC)_3 < (ROC)_2 = (ROC)_4$

$\sigma_1 > \sigma_3 > \sigma_2 = \sigma_4$

**30.** Water falls from a height of 200 m into a pool. Calculate the rise in temperature of the water assuming no heat dissipation from the water in the pool.

(Take  $g = 10 \text{ m/s}^2$ , specific heat of water =  $4200 \text{ J/(kg K)}$ )

- (1) 0.23 K                      (2) 0.36 K  
(3) 0.14 K                      (4) 0.48 K

**Ans. (4)**

**Sol.**  $mgh = ms\Delta T$

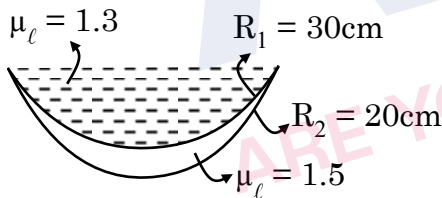
$$\Delta T = \frac{gh}{s} = \frac{10 \times 200}{4200} \text{ K} = \frac{10}{21} \text{ K}$$

**31.** A concave-convex lens of refractive index 1.5 and the radii of curvature of its surfaces are 30 cm and 20 cm, respectively. The concave surface is upwards and is filled with a liquid of refractive index 1.3. The focal length of the liquid-glass combination will be

- (1)  $\frac{500}{11} \text{ cm}$                       (2)  $\frac{800}{11} \text{ cm}$   
(3)  $\frac{700}{11} \text{ cm}$                       (4)  $\frac{600}{11} \text{ cm}$

**Ans. (4)**

**Sol.**



$$\begin{aligned} \frac{1}{f} &= \left(\frac{1.3-1}{1}\right) \left(\frac{1}{\infty} - \frac{1}{-30}\right) \\ &= \left(\frac{1.5-1}{1}\right) \left(\frac{1}{-30} - \frac{1}{-30}\right) \\ &= \frac{0.3}{30} + \frac{0.5}{60} = \frac{1}{100} + \frac{1}{120} \\ &= \frac{6+5}{600} = \frac{11}{600} \\ f &= \frac{600}{11} \text{ cm} \end{aligned}$$

**32.** An infinitely long wire has uniform linear charge density  $\lambda = 2 \text{ nC/m}$ . The net flux through a Gaussian cube of side length  $\sqrt{3} \text{ cm}$ , if the wire passes through any two corners of the cube, that are maximally displaced from each other, would be  $x \text{ Nm}^2 \text{ C}^{-1}$ , where x is :

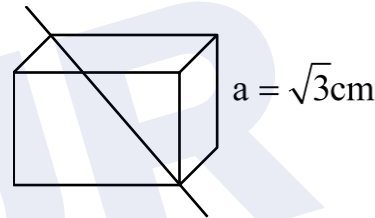
[Neglect any edge effects and use  $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9$

SI units]

- (1)  $0.72 \pi$                       (2)  $1.44 \pi$   
(3)  $6.48 \pi$                       (4)  $2.16 \pi$

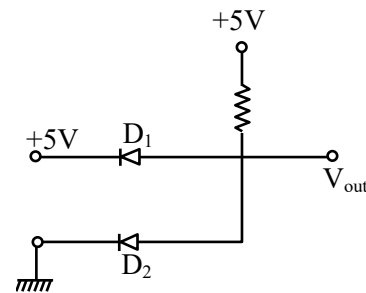
**Ans. (4)**

**Sol.**



$$\begin{aligned} \phi &= \frac{q_{\text{enc}}}{\epsilon_0} = \frac{\lambda \cdot \sqrt{3}a}{\epsilon_0} \\ &= 2 \times 10^{-9} \times \sqrt{3} \times \sqrt{3} \times 10^{-2} \times 36\pi \times 10^9 \text{ Nm}^2 \text{ C}^{-1} \\ &= 2.16 \pi \text{ Nm}^2 \text{ C}^{-1} \end{aligned}$$

**33.** The output voltage in the following circuit is (Consider ideal diode case)



- (1) 10 V                      (2) 0 V  
(3) + 5 V                      (4) - 5 V

**Ans. (2)**

**Sol.** Here  $D_1$  is reverse biased and  $D_2$  is forward biased. Therefore current flow through  $D_Q$  and 5V drop on resistor.

So,  $V_{out} = 0$

**34.** Two metal spheres of radius  $R$  and  $3R$  have same surface charge density  $\sigma$ . If they are brought in contact and then separated, the surface charge density on smaller and bigger sphere becomes  $\sigma_1$  and  $\sigma_2$ , respectively. The ratio  $\frac{\sigma_1}{\sigma_2}$  is.

(1)  $\frac{1}{9}$  (2) 9

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

**Ans. (4)**

**Sol.** For conducting sphere,  $V = \frac{\sigma r}{\epsilon_0}$

After contact,  $V_1 = V_2$

$\sigma_1 r_1 = \sigma_2 r_2$

$\frac{\sigma_1}{\sigma_2} = \frac{r_2}{r_1}$

$\frac{\sigma_1}{\sigma_2} = 3$

**35.** A quantity  $Q$  is formulated as  $X^{-2}Y^{+\frac{3}{2}}Z^{\frac{2}{5}}$ .  $X$ ,  $Y$  and  $Z$  are independent parameters which have fractional errors of 0.1, 0.2 and 0.5, respectively in measurement. The maximum fractional error of  $Q$  is

(1) 0.1 (2) 0.8

(3) 0.7 (4) 0.6

**Ans. (3)**

**Sol.** Fractional error  $= 2 \frac{\Delta X}{X} + \frac{3}{2} \frac{\Delta Y}{Y} + \frac{2}{5} \frac{\Delta Z}{Z}$

$= 2(0.1) + \frac{3}{2}(0.2) + \frac{2}{5}(0.5)$

$= 0.2 + 0.3 + 0.2 = 0.7$

**36.** A monoatomic gas having  $\gamma = \frac{5}{3}$  is stored in a thermally insulated container and the gas is suddenly compressed to  $\left(\frac{1}{8}\right)^{th}$  of its initial volume.

The ratio of final pressure and initial pressure is: ( $\gamma$  is the ratio of specific heats of the gas at constant pressure and at constant volume)

(1) 16 (2) 40

(3) 32 (4) 28

**Ans. (3)**

**Sol.**  $P_i V_i^\gamma = P_f V_f^\gamma$

$\frac{P_f}{P_i} = \left(\frac{V_i}{V_f}\right)^\gamma = (8)^{5/3}$

$\frac{P_f}{P_i} = 32$

**37.** A convex lens of focal length 30 cm is placed in contact with a concave lens of focal length 20 cm. An object is placed at 20 cm to the left of this lens system. The distance of the image from the lens in cm is \_\_\_\_\_

(1) 30 (2) 45

(3)  $\frac{60}{7}$  (4) 15

**Ans. (4)**

**Sol.** Equivalent focal length

$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$

$= \frac{1}{30} + \frac{1}{-20} = \frac{2-3}{60} = -\frac{1}{60}$

$f = -60$  cm

Lens formula

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

$\frac{1}{v} - \frac{1}{-20} = \frac{1}{-60}$

$v = -15$  cm

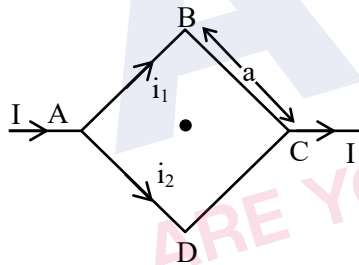
38. Two strings with circular cross section and made of same material, are stretched to have same amount of tension. A transverse wave is then made to pass through both the strings. The velocity of the wave in the first string having the radius of cross section R is  $v_1$ , and that in the other string having radius of cross section R/2 is  $v_2$ . Then  $\frac{v_2}{v_1} =$

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

Ans. (2)

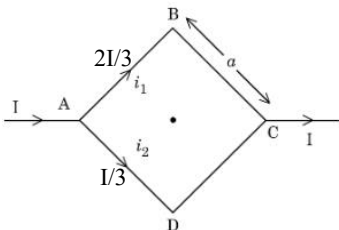
Sol.  $v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{T}{f\pi R^2}}$   
 $\frac{v_2}{v_1} = \frac{R_1}{R_2} = 2$

39. Figure shows a current carrying square loop ABCD of edge length is 'a' lying in a plane. If the resistance of the ABC part is r and that of ADC part is 2r, then the magnitude of the resultant magnetic field at centre of the square loop is



- (1)  $\frac{3\pi\mu_0 I}{\sqrt{2}a}$  (2)  $\frac{\mu_0 I}{2\pi a}$   
(3)  $\frac{\sqrt{2}\mu_0 I}{3\pi a}$  (4)  $\frac{2\mu_0 I}{3\pi a}$

Ans. (3)



Sol.

$\vec{B} = \vec{B}_{AB} + \vec{B}_{BC} + \vec{B}_{CD} + \vec{B}_{DA}$

$$\vec{B} = \left[ \frac{-\mu_0(2I/3)}{4\pi(a/2)}\sqrt{2} - \frac{\mu_0(2I/3)}{4\pi(a/2)}\sqrt{2} + \frac{\mu_0(I/3)}{4\pi(a/2)}\sqrt{2} + \frac{\mu_0(I/3)}{4\pi(a/2)}\sqrt{2} \right] \hat{k}$$

$$\vec{B} = \left[ \frac{-2\sqrt{2}\mu_0 I}{3\pi a} + \frac{\sqrt{2}\mu_0 I}{3\pi a} \right] \hat{k}$$

$$\vec{B} = \frac{-\sqrt{2}\mu_0 I}{3\pi a} \hat{k}$$

40. A body of mass 2 kg moving with velocity of  $\vec{v}_{in} = 3\hat{i} + 4\hat{j} \text{ms}^{-1}$  enters into a constant force field of 6N directed along positive z-axis. If the body remains in the field for a period of  $\frac{5}{3}$  seconds, then velocity of the body when it emerges from force field is

- (1)  $4\hat{i} + 3\hat{j} + 5\hat{k}$  (2)  $3\hat{i} + 4\hat{j} + 5\hat{k}$   
(3)  $3\hat{i} + 4\hat{j} - 5\hat{k}$  (4)  $3\hat{i} + 4\hat{j} + \sqrt{5}\hat{k}$

Ans. (2)

Sol.  $\vec{a} = \frac{B}{m} \hat{k} = 3\hat{k}$ ,  $t = \frac{5}{3} \text{s}$

$\vec{u} = 3\hat{i} + 4\hat{j}$

$\vec{v} = \vec{u} + \vec{a}t = 3\hat{i} + 4\hat{j} + 5\hat{k}$

41. Two balls with same mass and initial velocity, are projected at different angles in such a way that maximum height reached by first ball is 8 times higher than that of the second ball.  $T_1$  and  $T_2$  are the total flying times of first and second ball, respectively, then the ratio of  $T_1$  and  $T_2$  is :

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

Ans. (1)

**Sol.** Given,  $(H_{\max})_1 = 8 \times (H_{\max})_2$

$$\frac{u^2 \sin^2 \theta_1}{2g} = 8 \times \frac{u^2 \sin^2 \theta_2}{2g}$$

$$\Rightarrow \sin \theta_1 = 2\sqrt{2} \sin \theta_2$$

$$\frac{T_1}{T_2} = \frac{2u \sin \theta_1 / g}{2u \sin \theta_2 / g} = \frac{\sin \theta_1}{\sin \theta_2} = 2\sqrt{2}$$

**42.** The amplitude and phase of a wave that is formed by the superposition of two harmonic travelling waves,  $y_1(x, t) = 4 \sin(kx - \omega t)$  and

$$y_2(x, t) = 2 \sin(kx - \omega t + \frac{2\pi}{3}), \text{ are :}$$

(Take the angular frequency of initial waves same as  $\omega$ )

(1)  $[6, \frac{2\pi}{3}]$

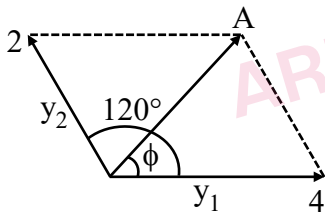
(2)  $[6, \frac{\pi}{3}]$

(3)  $[\sqrt{3}, \frac{\pi}{6}]$

(4)  $[2\sqrt{3}, \frac{\pi}{6}]$

**Ans. (4)**

**Sol.**



$$A = \sqrt{2^2 + 4^2 + 2 \times 2 \times 4 \times \cos 120^\circ}$$

$$= \sqrt{12} = 2\sqrt{3}$$

$$\tan \phi = \frac{2 \sin 120^\circ}{4 + 2 \cos 120^\circ} = \frac{\sqrt{3}}{3} = \frac{1}{\sqrt{3}}$$

$$\phi = \frac{\pi}{6}$$

**43.** In a Young's double slit experiment, the source is white light. One of the slits is covered by red filter and another by a green filter. In this case

(1) There shall be an interference pattern for red distinct from that for green.

(2) There shall be no interference fringes.

(3) There shall be alternate interference fringes of red and green.

(4) There shall be an interference pattern, where each fringe's pattern center is green and outer edges is red.

**Ans. (2)**

**Sol.** Different colours will have different fringe width. Within a few fringes of red, there will be several fringes of violet.

Also, there will be overlapping of colours.

**44.** For a nucleus of mass number A and radius R, the mass density of nucleus can be represented as

(1)  $A^3$

(2)  $A^{\frac{1}{3}}$

(3)  $A^{\frac{2}{3}}$

(4) Independent of A

**Ans. (4)**

**Sol.** Conceptual

**45.** A block of mass 2 kg is attached to one end of a massless spring whose other end is fixed at a wall. The spring-mass system moves on a frictionless horizontal table. The spring's natural length is 2 m and spring constant is 200 N/m. The block is pushed such that the length of the spring becomes 1 m and then released. At distance x m ( $x < 2$ ) from the wall. the speed of the block will be :

(1)  $10[1-(2-x)]^{3/2}$  m/s

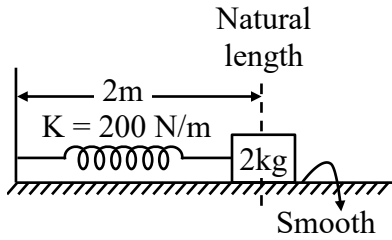
(2)  $10[1-(2-x)^2]^{1/2}$  m/s

(3)  $10[1-(2-x)^2]$  m/s

(4)  $10[1-(2-x)^2]^{2/3}$  m/s

**Ans. (2)**

Sol.



Given, Natural length of spring = 2m  
Initial compression in spring ( $x_i$ ) = 1m  
Final compression in spring ( $x_f$ ) = (2 - x)m

Using energy conservation

$$K_i + U_i = K_f + U_f$$

$$0 + \frac{1}{2} K x_i^2 = \frac{1}{2} m v^2 + \frac{1}{2} K x_f^2$$

$$\frac{1}{2} m v^2 = \frac{1}{2} K (x_i^2 - x_f^2)$$

$$\frac{1}{2} \times 2 \times v^2 = \frac{1}{2} \times 200 \times (1^2 - (2 - x)^2)$$

$$v^2 = 100[1 - (2 - x)^2]$$

$$v = 10[1 - (2 - x)^2]^{1/2}$$

### SECTION-B

46. An electron is released from rest near an infinite non-conducting sheet of uniform charge density ' $-\sigma$ '. The rate of change of de-Broglie wave length associated with the electron varies inversely as  $n^{\text{th}}$  power of time. The numerical value of  $n$  is \_\_\_\_\_.

Ans. (2)

Sol. Let the momentum of  $e^-$  at any time  $t$  is  $p$  and its de-broglie wavelength is  $\lambda$ .

$$\text{Then, } p = \frac{h}{\lambda}$$

$$\frac{dp}{dt} = \frac{-h}{\lambda^2} \frac{d\lambda}{dt}$$

$$m a = F = -\frac{h}{\lambda} \frac{d\lambda}{dt} \quad [m = \text{mass of } e^-]$$

Where, -ve sign represents decrease in  $\lambda$  with time

$$m a = \frac{-h}{(h/p)^2} \frac{d\lambda}{dt}$$

$$a = -\frac{p^2}{mh} \frac{d\lambda}{dt}$$

$$a = -\frac{m v^2}{h} \frac{d\lambda}{dt}$$

$$\frac{d\lambda}{dt} = -\frac{ah}{m v^2} \quad \dots(1)$$

$$\text{here, } a = \frac{qE}{m} = \frac{e}{m} \frac{\sigma}{2\epsilon_0}$$

$$a = \frac{\sigma e}{2m\epsilon_0}$$

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

$$v = at$$

Substituting values of  $a$  &  $v$  in equation (1)

$$\frac{d\lambda}{dt} = -\frac{2h\epsilon_0}{\sigma e t^2}$$

$$\Rightarrow \frac{d\lambda}{dt} \propto \frac{1}{t^2}$$

$$\Rightarrow n = 2$$

47. A sample of a liquid is kept at 1 atm. It is compressed to 5 atm which leads to change of volume of  $0.8 \text{ cm}^3$ . If the bulk modulus of the liquid is 2 GPa, the initial volume of the liquid was \_\_\_\_\_ litre. (Take 1 atm =  $10^5 \text{ Pa}$ )

Ans. (4)

Sol. Given, Initial pressure of liquid ( $P_i$ ) = 1 atm

Final pressure of liquid ( $P_f$ ) = 5 atm

Change in pressure ( $dP$ ) =  $P_f - P_i = 4 \text{ atm}$

$$= 4 \times 10^5 \text{ Pa}$$

Change in volume ( $dV$ ) =  $-0.8 \text{ cm}^3$

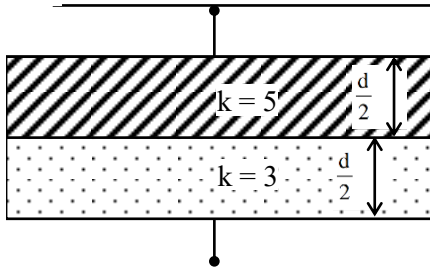
Bulk modulus ( $B$ ) =  $2 \times 10^9 \text{ Pa}$

$$\text{Now, } B = \frac{-dP}{(dV/V)} \Rightarrow V = -B \left( \frac{dV}{dP} \right)$$

$$\Rightarrow V = -2 \times 10^9 \times \frac{(-0.8 \times 10^{-6})}{4 \times 10^5}$$

$$= 4 \times 10^{-3} \text{ m}^3 = 4 \text{ litre}$$

48.

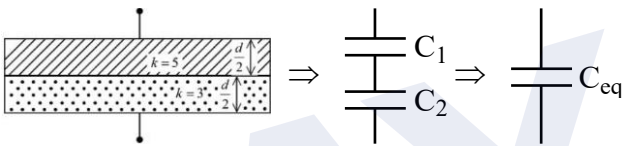


Space between the plates of a parallel plate capacitor of plate area  $4 \text{ cm}^2$  and separation of  $(d)$   $1.77 \text{ mm}$ , is filled with uniform dielectric materials with dielectric constants  $(3 \text{ and } 5)$  as shown in figure. Another capacitor of capacitance  $7.5 \text{ pF}$  is connected in parallel with it. The effective capacitance of this combination is \_\_\_\_\_ pF.

(Given  $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$ )

Ans. (15)

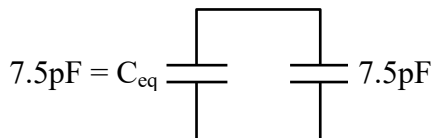
Sol.



$$C_1 = \frac{5 \times 4 \times 10^{-4} \times 8.85 \times 10^{-12}}{\frac{1.77}{2} \times 10^{-3}} = 20 \text{ pF}$$

$$C_2 = \frac{3 \times 4 \times 10^{-4} \times 8.85 \times 10^{-12}}{\frac{1.77}{2} \times 10^{-3}} = 12 \text{ pF}$$

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = \frac{12 \times 20}{12 + 20} = 7.5 \text{ pF}$$



Finally equivalent capacitance

$$(C_{eq})_{final} = 7.5 + 7.5 = 15 \text{ pF}$$

49. A thin solid disk of  $1 \text{ kg}$  is rotating along its diameter axis at the speed of  $1800 \text{ rpm}$ . By applying an external torque of  $25 \pi \text{ Nm}$  for  $40 \text{ s}$ , the speed increases to  $2100 \text{ rpm}$ . The diameter of the disk is \_\_\_\_\_ m.

Ans. (40)

Sol. Given,  $m = 1 \text{ kg}$

$$\omega_i = 1800 \text{ rpm} = 1800 \times \frac{2\pi}{60} = 60\pi \frac{\text{rad}}{\text{sec}}$$

$$\omega_f = 2100 \text{ rpm} = 2100 \times \frac{2\pi}{60} = 70\pi \frac{\text{rad}}{\text{sec}}$$

$$\tau_{ext} = 25\pi \text{ Nm}$$

$$t = 40 \text{ sec}$$

Using equation of motion

$$\omega_f = \omega_i + \alpha t$$

$$70\pi = 60\pi + \alpha(40)$$

$$\alpha = \frac{\pi}{4} \text{ rad/sec}^2$$

$$\text{Also, } \tau = I\alpha$$

$$\tau = \frac{mR^2}{4} \alpha$$

$$25\pi = \frac{1 \times R^2}{4} \times \frac{\pi}{4}$$

$$R = 20 \text{ m}$$

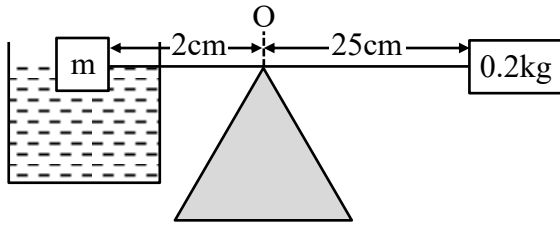
$$\text{Hence, diameter of disk} = 2R = 2 \times 20 = 40 \text{ m}$$

50. A cube having a side of  $10 \text{ cm}$  with unknown mass and  $200 \text{ gm}$  mass were hung at two ends of an uniform rigid rod of  $27 \text{ cm}$  long. The rod along with masses was placed on a wedge keeping the distance between wedge point and  $200 \text{ gm}$  weight as  $25 \text{ cm}$ . Initially the masses were not at balance. A beaker is placed beneath the unknown mass and water is added slowly to it. At given point the masses were in balance and half volume of the unknown mass was inside the water.

(Take the density of unknown mass is more than that of the water, the mass did not absorb water and water density is  $1 \text{ gm/cm}^3$ .) The unknown mass is \_\_\_\_\_ kg.

Ans. (3)

Sol.



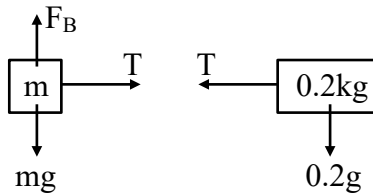
Given, volume of block =  $(10 \times 10^{-2})^3 = 10^{-3} \text{ m}^3$

Let density of block =  $\rho \text{ kg/m}^3$

mass of block =  $\rho \times 10^{-3} \text{ kg}$

Buoyant Force ( $F_B$ ) =  $1000 \times \frac{10^{-3}}{2} \times 10 = 5 \text{ N}$

F.B.D. of blocks



Balancing torque about point O, we get

$$mg(2 \times 10^{-2}) - F_B(2 \times 10^{-2}) = 0.2g(25 \times 10^{-2})$$

$$\rho \times 10^{-3} \times 10 \times 2 - 10 = 50$$

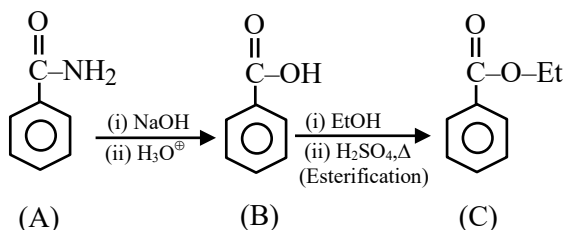
$$\rho = 3000 \text{ kg/m}^3$$

Hence, mass of block =  $\rho \times 10^{-3}$

$$= 3000 \times 10^{-3} = 3 \text{ kg}$$



Sol.



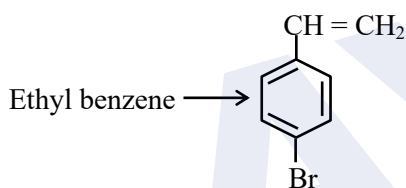
Molar mass = 121

A  $\rightarrow$  Benzamide Shows positive Lassaigh's test.

B  $\rightarrow$  Benzoic acid gives effervescence with aq.  $\text{NaHCO}_3$ .

C  $\rightarrow$  Ester gives fruity smell.

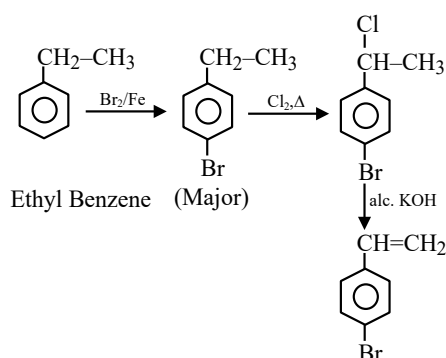
54. Choose the correct set of reagents for the following conversion.



- (1)  $\text{Br}_2/\text{Fe}$  ;  $\text{Cl}_2, \Delta$  ; alc. KOH
- (2)  $\text{Cl}_2/\text{Fe}$  ;  $\text{Br}_2/\text{anhy. AlCl}_3$  ; aq. KOH
- (3)  $\text{Br}_2/\text{anhy. AlCl}_3$  ;  $\text{Cl}_2, \Delta$  ; aq. KOH
- (4)  $\text{Cl}_2/\text{anhy. AlCl}_3$  ;  $\text{Br}_2/\text{Fe}$  ; alc. KOH

Ans. (1)

Sol.

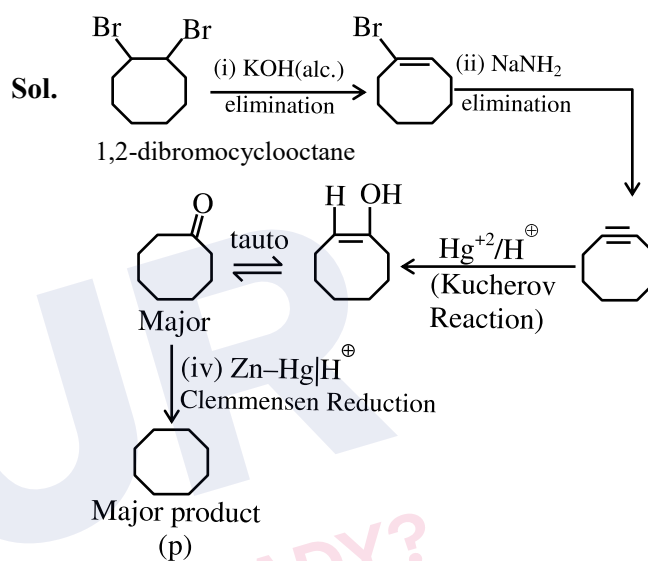


55. 1, 2-dibromocyclooctane  $\xrightarrow[\text{(iii) Hg}^{2+}/\text{H}^+]{\text{(i) KOH (alc.)}}$   $\xrightarrow[\text{(iv) Zn-Hg/H}^+]{\text{(ii) NaNH}_2}$  P (Major product)

'P' is

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

Ans. (2)



56. Given below are two statements :

**Statement I** : A homoleptic octahedral complex, formed using monodentate ligands, will not show stereoisomerism.

**Statement II** : cis- and trans- platin are heteroleptic complexes of Pd.

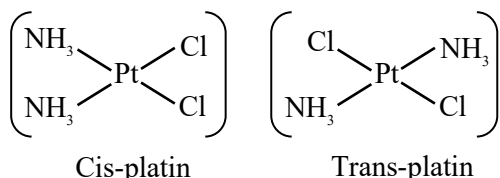
In the light of the above statements, choose the **correct** answer from the options given below.

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

Ans. (4)

**Sol.** Homoleptic complex of type  $[Ma_6]$  (Where  $a \Rightarrow$  monodentate ligand) cannot show geometrical as well as optical isomerism.

Cis-platin and trans-platin has formula  $[Pt(NH_3)_2Cl_2]$  which is a heteroleptic complex of platinum.



**57.** The atomic number of the element from the following with lowest 1<sup>st</sup> ionisation enthalpy is :

- (1) 32                                      (2) 35  
(3) 87                                        (4) 19

**Ans. (3)**

**Sol.** Atomic no. 32  $\Rightarrow$  Ge

Atomic no. 35  $\Rightarrow$  Br

Atomic no. 87  $\Rightarrow$  Fr

Atomic no. 19  $\Rightarrow$  K

Lowest first I.E. among the given element will be of Fr [87].

Fr -  $[Rn] 7s^1$

**58.** Which of the following binary mixture does not show the behaviour of minimum boiling azeotropes ?

- (1)  $H_2O + CH_3COCH_3$   
(2)  $C_6H_5OH + C_6H_5NH_2$   
(3)  $CS_2 + CH_3COCH_3$   
(4)  $CH_3OH + CHCl_3$

**Ans. (2)**

**Sol.** Binary mixture of  $C_6H_5OH$  and  $C_6H_5NH_2$  shows negative deviation from Raoult's law

So vapour pressure of solution is less than V.P of pure  $C_6H_5OH$  &  $C_6H_5NH_2$

So B.P. of solution is greater than boiling point of pure  $C_6H_5OH$  &  $C_6H_5NH_2$

So shows maximum Boiling azeotrope

**59.**  $HA(aq) \rightleftharpoons H^+(aq) + A^-(aq)$

The freezing point depression of a 0.1 m aqueous solution of a monobasic weak acid HA is  $0.20^\circ C$ .

The dissociation constant for the acid is

Given :

$K_f(H_2O) = 1.8 \text{ K kg mol}^{-1}$ , molality  $\equiv$  molarity

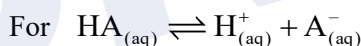
- (1)  $1.38 \times 10^{-3}$   
(2)  $1.1 \times 10^{-2}$   
(3)  $1.90 \times 10^{-3}$   
(4)  $1.89 \times 10^{-1}$

**Ans. (1)**

**Sol.**  $\Delta T_f = i k_f m$

$$0.2 = i \times 1.8 \times 0.1$$

$$i = \frac{20}{18} = \frac{10}{9}$$



$$t=0 \quad 1$$

$$t=t_{eq} \quad 1-\alpha \quad \alpha \quad \alpha$$

$$i = 1 + \alpha$$

$$\frac{10}{9} = 1 + \alpha$$

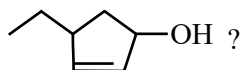
$$\alpha = \frac{1}{9}$$

$$K_{eq} = \frac{[H^+][A^-]}{[HA]} = \frac{C\alpha^2}{1-\alpha}$$

$$= \frac{0.1 \left( \frac{1}{9} \right)^2}{1 - \frac{1}{9}} = \frac{1}{720}$$

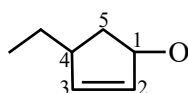
$$K_{eq} = 1.38 \times 10^{-3}$$

60. What is the correct IUPAC name of



- (1) 4-Ethyl-1-hydroxycyclopent-2-ene
- (2) 1-Ethyl-3-hydroxycyclopent-2-ene
- (3) 1-Ethylcyclopent-2-en-3-ol
- (4) 4-Ethylcyclopent-2-en-1-ol

Ans. (4)



Sol.

4-Ethylcyclopent-2-en-1-ol

61. The correct decreasing order of spin only magnetic moment values (BM) of  $\text{Cu}^+$ ,  $\text{Cu}^{2+}$ ,  $\text{Cr}^{2+}$  and  $\text{Cr}^{3+}$  ions is :

- (1)  $\text{Cu}^+ > \text{Cu}^{2+} > \text{Cr}^{3+} > \text{Cr}^{2+}$
- (2)  $\text{Cu}^{2+} > \text{Cu}^+ > \text{Cr}^{2+} > \text{Cr}^{3+}$
- (3)  $\text{Cr}^{2+} > \text{Cr}^{3+} > \text{Cu}^{2+} > \text{Cu}^+$
- (4)  $\text{Cr}^{3+} > \text{Cr}^{2+} > \text{Cu}^+ > \text{Cu}^{2+}$

Ans. (3)

Sol.  $\text{Cu}^+$  :  $[\text{Ar}] 3d^{10}$ , Spin only magnetic moment = 0 B.M.

$\text{Cu}^{2+}$  :  $[\text{Ar}] 3d^9$ , Spin only magnetic moment =  $\sqrt{3}$  B.M.

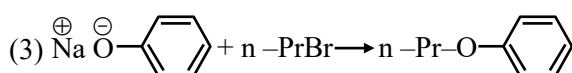
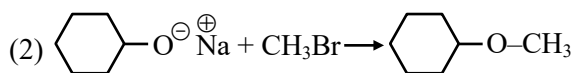
$\text{Cr}^{2+}$  :  $[\text{Ar}] 3d^4$ , Spin only magnetic moment =  $\sqrt{24}$  B.M.

$\text{Cr}^{3+}$  :  $[\text{Ar}] 3d^3$ , Spin only magnetic moment =  $\sqrt{15}$  B.M.

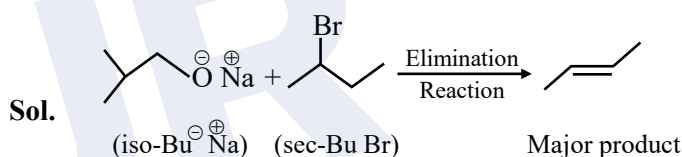
Order of  $\mu$  :  $\text{Cr}^{2+} > \text{Cr}^{3+} > \text{Cu}^{2+} > \text{Cu}^+$

62. Which one of the following reactions will not lead to the desired ether formation in major proportion?

(iso-Bu  $\Rightarrow$  isobutyl, sec-Bu  $\Rightarrow$  sec-butyl, nPr  $\Rightarrow$  n-propyl,  $^t\text{Bu}$   $\Rightarrow$  tert-butyl, Et  $\Rightarrow$  ethyl)



Ans. (4)

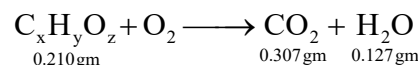


63. On combustion 0.210 g of an organic compound containing C, H and O gave 0.127 g  $\text{H}_2\text{O}$  and 0.307 g  $\text{CO}_2$ . The percentages of hydrogen and oxygen in the given organic compound respectively are:

- (1) 53.41, 39.6
- (2) 6.72, 53.41
- (3) 7.55, 43.85
- (4) 6.72, 39.87

Ans. (2)

Sol. In the combustion of organic compound, all "C" in  $\text{CO}_2$  and all "H" in  $\text{H}_2\text{O}$  comes from organic compound



$$\text{Weight of "C" in } \text{CO}_2 = \frac{12}{44} \times 0.307$$

$$= 0.0837 \text{ gm}$$

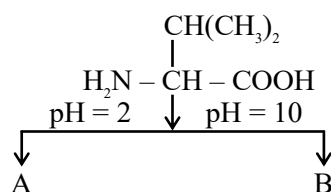
$$\text{Weight of "H" in } \text{H}_2\text{O} = \frac{2}{18} \times 0.127 = 0.0141 \text{ g}$$

$$\begin{aligned} \% \text{ 'H' in compound} &= \frac{0.0141}{0.21} \times 100 = 6.719 \% \\ &= 6.72 \% \end{aligned}$$

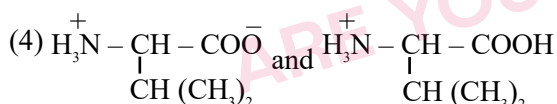
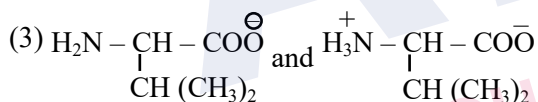
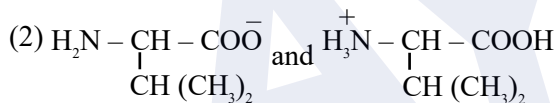
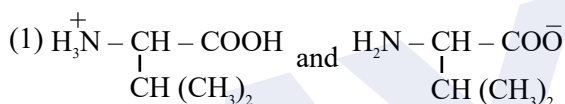
$$\begin{aligned} \text{Weight of "O" in compound} &= 0.210 - (0.0837 + 0.0141) \\ &= 0.1122 \end{aligned}$$

$$\begin{aligned} \% \text{ of "O" in compound} &= \frac{0.1122}{0.21} \times 100 \\ &= 53.41 \% \end{aligned}$$

64.

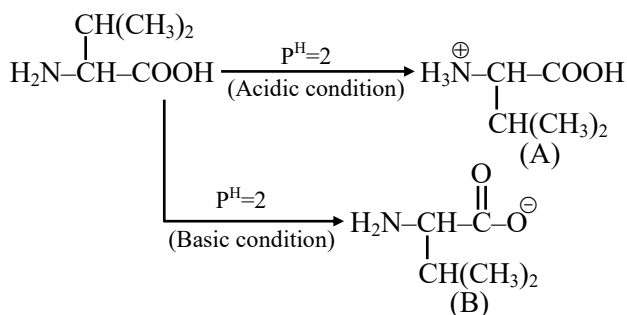


Choose the correct option for structures of A and B, respectively.



Ans. (1)

Sol.



65. Correct statements for an element with atomic number 9 are

A. There can be 5 electrons for which  $m_s = +\frac{1}{2}$  and

4 electrons for which  $m_s = -\frac{1}{2}$

B. There is only one electron in  $p_z$  orbital

C. The last electron goes to orbital with  $n = 2$  and  $l = 1$

4. The sum of angular nodes of all the atomic orbitals is 1.

Choose the correct answer from the options given below:

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

(3) A, C and D Only (4) A and B Only

Ans. (2)

Sol. Element with atomic number 9 is Fluorine

$$F(9) = 1s^2 2s^2 2p^5$$



(A) 5 electrons can be up-spin  $\left[ m_s = +\frac{1}{2} \right]$  and

4 electrons can be down spin  $\left[ m_s = -\frac{1}{2} \right]$

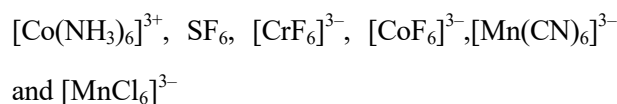
(B) Unpaired electron can be in anyone of  $p_x$ ,  $p_y$  or  $p_z$  orbital

(C) Last electron is in 2p subshell with  $n = 2$ ,  $l = 1$

(D) Angular node for s-orbital = 0 while of each p-orbital = 1

Sum of all angular node = 3

66. The number of species from the following that are involved in  $sp^3d^2$  hybridization is



(1) 5 (2) 6

(3) 4 (4) 3

Allen Ans. (4)

NTA Ans. (3)

**Sol.** In  $[\text{Co}(\text{NH}_3)_6]^{3+}$ ,  $\text{Co}^{+3} : [\text{Ar}]3d^6$ ,  $\text{NH}_3$  is S.F.L  
Hybridisation state of  $\text{Co}^{3+}$  is  $d^2sp^3$   
In  $\text{SF}_6$ , Hybridisation state of sulphur is  $sp^3d^2$   
In  $[\text{CrF}_6]^{3-}$ ,  $\text{Cr}^{+3} : [\text{Ar}]3d^3$   
Hybridisation state of  $\text{Cr}^{3+}$  is  $d^2sp^3$   
 $[\text{CoF}_6]^{3-}$ ,  $\text{Co}^{+3} : [\text{Ar}]3d^6$  F is W.F.L  
Hybridisation state of  $\text{Co}^{3+}$  is  $sp^3d^2$   
 $[\text{Mn}(\text{CN})_6]^{3-}$ ,  $\text{Mn}^{+3} : [\text{Ar}]3d^4$   $\text{CN}^-$  is S.F.L  
Hybridisation state of  $\text{Mn}^{3+}$  is  $d^2sp^3$   
 $[\text{MnCl}_6]^{3-}$ ,  $\text{Mn}^{+3} : [\text{Ar}]3d^4$   $\text{Cl}^-$  is W.F.L  
Hybridisation state of  $\text{Cl}^-$  is  $sp^3d^2$   
Total number of  $sp^3d^2$  hybridized molecules is 3

67. Match the LIST-I with LIST-II


LIST-I (Reagent)		LIST-II (Functional Group detected)	
A.	Sodium bicarbonate solution	I.	double bond/unsaturation
B.	Neutral ferric chloride	II.	carboxylic acid
C.	ceric ammonium nitrate	III.	phenolic - OH
D.	alkaline $\text{KMnO}_4$	IV.	alcoholic - OH

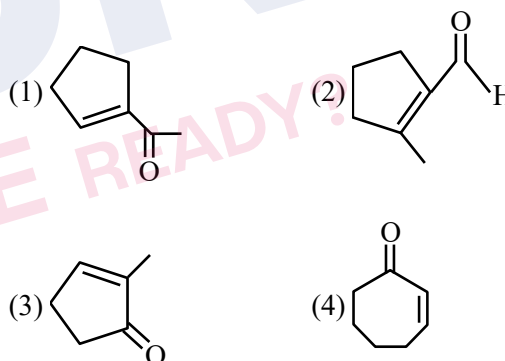
Choose the **correct** answer from the options given below :

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

**Ans. (1)**

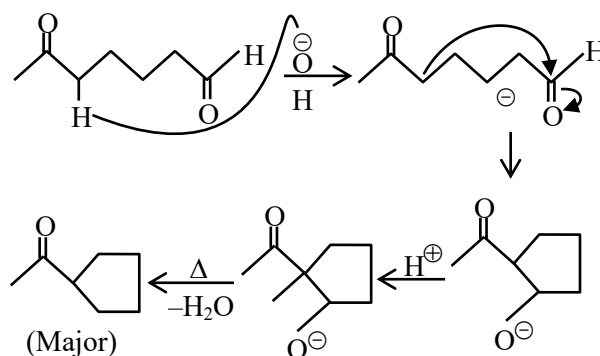
**Sol.** (1) Carboxylic acid gives efferve scence with sodium bicarbonate solution  
(2) Phenolic-OH gives violet coloured complex with Neutral  $\text{FeCl}_3$ .  
(3) Alcoholic-OH gives Red colour with ceric ammonium Nitrate.  
(4) When alkaline  $\text{KMnO}_4$  reacts with an unsaturated compound (Alkene or alkyne) the purple colour of  $\text{KMnO}_4$  solution disappears, indicating positive test for unsaturation.

68. When  undergoes intramolecular aldol condensation, the major product formed is :



**Ans. (1)**

**Sol.** Aldol condensation reaction



69. Match the LIST-I with LIST-II

LIST-I (Complex/Species)		LIST-II (Shape & magnetic moment)	
A.	[Ni(CO) <sub>4</sub> ]	I.	Tetrahedral, 2.8 BM
B.	[Ni(CN) <sub>4</sub> ] <sup>2-</sup>	II.	Square planar, 0 BM
C.	[NiCl <sub>4</sub> ] <sup>2-</sup>	III.	Tetrahedral, 0 BM
D.	[MnBr <sub>4</sub> ] <sup>2-</sup>	IV.	Tetrahedral, 5.9 BM

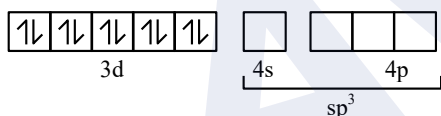
Choose the **correct** answer from the options given below :

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

Ans. (3)

Sol. (A) [Ni(CO)<sub>4</sub>], Ni<sup>0</sup>: [Ar]3d<sup>8</sup> 4s<sup>2</sup>

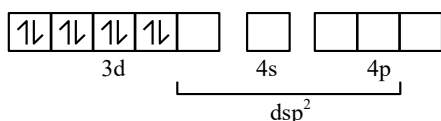
Valence orbitals of Ni<sup>0</sup> in pre-hybridisation state :



Tetrahedral, Diamagnetic,  $\mu = 0$  B.M.

(B) [Ni(CN)<sub>4</sub>]<sup>2-</sup>, Ni<sup>+2</sup>: [Ar]3d<sup>8</sup> 4s<sup>0</sup>

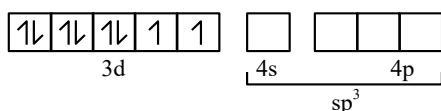
Valence orbitals of Ni<sup>+2</sup> in pre-hybridisation state :



Square planar, Diamagnetic,  $\mu = 0$  B.M.

(C) [NiCl<sub>4</sub>]<sup>2-</sup>, Ni<sup>+2</sup>: [Ar]3d<sup>8</sup> 4s<sup>0</sup>

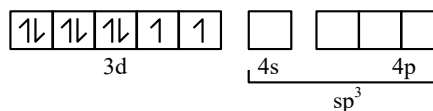
Valence orbitals of Ni<sup>+2</sup> in ground state :



Tetrahedral, paramagnetic,  $\mu = \sqrt{8} = 2.8$  B.M.

(D) [MnBr<sub>4</sub>]<sup>2-</sup>, Mn<sup>+2</sup>: [Ar]3d<sup>5</sup>

Valence orbitals of Mn<sup>+2</sup> in ground state :



Tetrahedral, paramagnetic,  $\mu = \sqrt{35} = 5.9$  B.M.

70. Given below are two statements :

**Statement I** : H<sub>2</sub>Se is more acidic than H<sub>2</sub>Te.

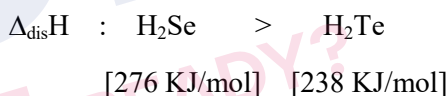
**Statement II** : H<sub>2</sub>Se has higher bond enthalpy for dissociation than H<sub>2</sub>Te.

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) Both statement I and Statement II are true.
- (3) Statement I is true but Statement II is false.
- (4) Statement I is false but Statement II is true.

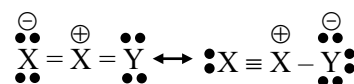
Ans. (4)

Sol. Acidic strength : H<sub>2</sub>Se < H<sub>2</sub>Te

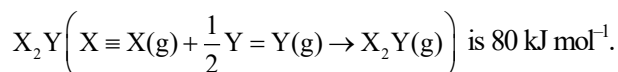


### SECTION-B

71. Resonance in X<sub>2</sub>Y can be represented as



The enthalpy of formation of



The magnitude of resonance energy of X<sub>2</sub>Y is \_\_\_\_\_ kJ mol<sup>-1</sup> (nearest integer value)

Given : Bond energies of X ≡ X, X = X, Y = Y and X = Y are 940, 410, 500 and 602 kJ mol<sup>-1</sup> respectively.

valence X : 3, Y : 2

Ans. (98)

**Sol.**  $\Delta H_{R,E} = \Delta H_{f(\text{exp})} - \Delta H_{f(\text{Theo})}$   
 $\Delta H_{f(\text{exp})}$  for  $X_2Y_{(g)} = 80 \text{ kJ/mole}$   
 for  $\Delta H_{f(\text{Theo})}$   
 $X_{2(g)} + \frac{1}{2} Y_{2(g)} \rightarrow X_2Y_{(g)} \Delta H_f = ?$

$$\Delta H_{f(\text{Theo})} = \left( BE_{X=X} + \frac{1}{2} BE_{Y=Y} \right) - (BE_{X=X} + BE_{X=Y})$$

$$= \left( 940 + \frac{1}{2} \times 500 \right) - (410 + 602)$$

$$= 178 \text{ kJ/mole}$$

$$\Delta H_{R,E} = 80 - 178$$

$$= -98 \text{ kJ/mol}$$

$$|\Delta H_{R,E}| = 98$$

**72.** The energy of an electron in first Bohr orbit of H-atom is  $-13.6 \text{ eV}$ . The magnitude of energy value of electron in the first excited state of  $\text{Be}^{3+}$  is \_\_\_\_\_ eV. (nearest integer value)

**Ans. (54)**

**Sol.**  $E_T = -13.6 \frac{z^2}{n^2} \text{ eV}$

For energy of H-atom, energy of 1<sup>st</sup> Bohr orbit  
 $E_1 = -13.6 \text{ eV} [z = 1, n = 1]$

For  $\text{Be}^{+3}$  ion, energy of 1<sup>st</sup> E.S.  $[z = 4, n = 2]$

$$\frac{E_H}{E_{\text{Be}^{+3}}} = \frac{z_1^2}{n_1^2} \times \frac{n_2^2}{z_2^2}$$

$$\frac{E_H}{E_{\text{Be}^{+3}}} = \frac{1}{1} \times \frac{4}{16}$$

$$E_{\text{Be}^{+3}} = -13.6 \times 4 = -54.4 \text{ eV}$$

$$|E_{\text{Be}^{+3}}| = 54.4 \text{ eV}$$

**73.** 20 mL of sodium iodide solution gave 4.74 g silver iodide when treated with excess of silver nitrate solution. The molarity of the sodium iodide solution is \_\_\_\_\_ M. (Nearest Integer value)  
 (Given : Na = 23, I = 127, Ag = 108, N = 14, O = 16 g mol<sup>-1</sup>)

**Ans. (1)**

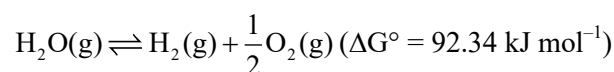
**Sol.**  $\text{NaI}_{(\text{aq})} + \text{AgNO}_{3(\text{aq})} \rightarrow \text{AgI}_{(\text{s})} + \text{NaNO}_{3(\text{aq})}$   
 M, 20 ml excess 4.74g

$$\text{Moles of } I^- \text{ in NaI} = \text{Moles of } (I^-) \text{ in AgI} = \frac{4.74}{235}$$

$$\text{Moles of NaI} = \frac{4.74}{235}$$

$$\text{Molarity [NaI]} = \frac{4.74}{235 \times 0.02} = 1.008$$

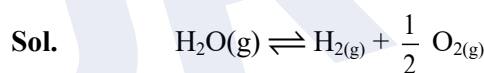
**74.** The equilibrium constant for decomposition of  $\text{H}_2\text{O}(\text{g})$



is  $8.0 \times 10^{-3}$  at 2300 K and total pressure at equilibrium is 1 bar. Under this condition, the degree of dissociation ( $\alpha$ ) of water is \_\_\_\_\_  $\times 10^{-2}$  (nearest integer value).

[Assume  $\alpha$  is negligible with respect to 1]

**Ans. (5)**



$$t = 0 \quad 1 \text{ mole}$$

$$t = t_{\text{eq}} \quad 1-\alpha \quad \alpha \quad \frac{\alpha}{2}$$

$$n_T = 1 + \frac{\alpha}{2} \approx 1 \quad (\alpha \ll 1)$$

$$K_p = \frac{P_{\text{H}_2} \cdot P_{\text{O}_2}^{1/2}}{P_{\text{H}_2\text{O}}} = \frac{(\alpha \cdot P) \left( \frac{\alpha}{2} P \right)^{1/2}}{(1-\alpha)P}$$

$$P = 1$$

$$8 \times 10^{-3} = \frac{\alpha^{3/2}}{\sqrt{2}}$$

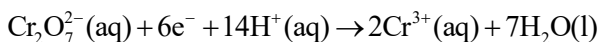
$$\alpha^{3/2} = 8\sqrt{2} \times 10^{-3}$$

$$\alpha^3 = 128 \times 10^{-6}$$

$$\alpha = \sqrt[3]{128} \times 10^{-2}$$

$$= 5.03 \times 10^{-2}$$

75. Consider the following half cell reaction



The reaction was conducted with the ratio of

$$\frac{[\text{Cr}^{3+}]^2}{[\text{Cr}_2\text{O}_7^{2-}]} = 10^{-6}. \text{ The pH value at which the EMF}$$

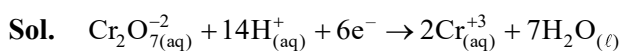
of the half cell will become zero is \_\_\_\_\_ .

(nearest integer value)

[Given : standard half cell reduction potential

$$E_{\text{Cr}_2\text{O}_7^{2-}, \text{H}^+/\text{Cr}^{3+}}^{\circ} = 1.33\text{V}, \frac{2.303RT}{F} = 0.059\text{V}]$$

**Ans. (10)**



$$E_{\text{R}} = E_{\text{R}}^{\circ} - \frac{0.059}{6} \log \frac{[\text{Cr}^{3+}]^2}{[\text{Cr}_2\text{O}_7^{2-}][\text{H}^+]^{14}}$$

$$0 = 1.33 - \frac{0.059}{6} \log \frac{10^{-6}}{[\text{H}^+]^{14}}$$

$$\frac{1.33 \times 6}{0.059} = \log \frac{10^{-6}}{[\text{H}^+]^{14}}$$

$$135.254 = -6 - 14 \log [\text{H}^+]$$

$$141.254 = 14 \text{ pH}$$

$$\text{pH} = \frac{141.254}{14} = 10.08$$