



## JEE Main Online Exam 2026

Questions & Solution  
23<sup>rd</sup> January 2026 | Evening

### MATHEMATICS

#### SECTION-A

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

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

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

Ans. [2]

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

for continuity

$$\lim_{x \rightarrow 0^-} f(x) = \lim_{x \rightarrow 0^+} f(x) = f(0)$$

$$\lim_{x \rightarrow 0^+} \frac{ah + h^2 - 2(\sinh)\cosh}{-h}$$

$$= \lim_{x \rightarrow 0^+} \frac{ah + h^2 - 2(\sinh)\cosh}{h}$$

$$\text{or } -a + 2 = a - 2 = b$$

$$2a = 4$$

$$a = 2, b = 0$$

$$\therefore a + b = 2$$

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

$\sin\left(\frac{15\theta}{2}\right)(\cos 8\theta + \sin 8\theta) + \cos\left(\frac{15\theta}{2}\right)(\cos 8\theta - \sin 8\theta)$  is equal to :

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

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

Ans. [1]

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

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



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

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

5. Consider two sets  $A = \{x \in \mathbb{Z} : (|x - 3| - 3) \leq 1\}$  and

$$B = \left\{ x \in \mathbb{R} - \{1, 2\} : \frac{(x-2)(x-4)}{x-1} \log_e(|x-2|) = 0 \right\}$$

Then the number of onto functions  $f : A \rightarrow B$  is equal to :

- (1) 62                                      (2) 79                                      (3) 32                                      (4) 81

Ans. [1]

Sol.  $A : ||x - 3| - 3| \leq 1$

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

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

$$2 \leq (x - 3) \leq 4 \text{ or } -4 \leq (x - 3) \leq -2$$

$$5 \leq x \leq 7 \text{ or } -1 \leq x \leq 1$$

$$A = \{-1, 0, 1, 5, 6, 7\}$$

$$B \Rightarrow x = 4, |x - 2| = 1 \Rightarrow x = 3 \text{ or } 1 \text{ (reject)}$$

$$B = \{3, 4\}$$

$$\text{Number of onto functions from } A \text{ to } B = 2^6 - 2 = 62$$

6. The system of linear equations

$$x + y + z = 6$$

$$2x + 5y + az = 36$$

$$x + 2y + 3z = b$$

has

- (1) unique solution for  $a = 8$  and  $b = 16$   
(2) infinitely many solutions for  $a = 8$  and  $b = 14$   
(3) infinitely many solutions for  $a = 8$  and  $b = 16$   
(4) unique solution for  $a = 8$  and  $b = 14$

Ans. [2]

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

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

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

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

For  $a = 8$  &  $b = 14 \Rightarrow D_1$  &  $D_2$  are also zero

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

$\Rightarrow$  infinitely many solutions.

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

(1) 2

(2) 1

(3) 0

(4) 4

**Ans.** [3]

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

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

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

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

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

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

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

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

So sum of roots = 0

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

(1) 53

(2) 51

(3) 52

(4) 55

**Ans.** [4]

**Sol.** By family of curve, equation of circle will be

$$\Rightarrow S_1 + \lambda S_2 = 0$$

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

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

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

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

So equation of circle is

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

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

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

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

(1)  $2\sqrt{3}$

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

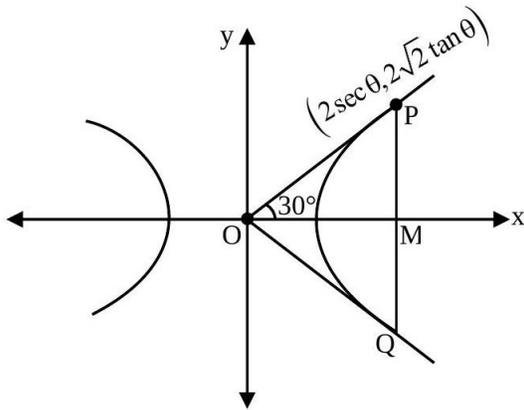
(3)  $\frac{11}{5}$

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

Ans. [2]

Sol.  $e = \sqrt{1 + \frac{b^2}{4}} = \sqrt{3} \Rightarrow b^2 = 8$

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



$$\frac{PM}{OM} = \tan 30^\circ$$

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

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

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

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

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

(1) 2

(2) 4

(3) 0

(4) 1

Ans. [4]

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

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

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

$$\lambda^2 = 16 + 16 - 4 \cdot 4 \cdot 2 \cdot \frac{1}{2}$$

$$\lambda^2 = 16$$

$$\lambda = \pm 4$$

$$\therefore \vec{b} - 2\vec{c} = \pm 4\vec{a}$$

$$\text{Dot with } \vec{c} \Rightarrow \vec{b} \cdot \vec{c} - 2|\vec{c}|^2 = \pm 4(\vec{a} \cdot \vec{c})$$

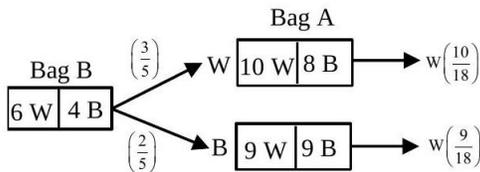
$$4.2. \frac{1}{2} - 2.4 = \pm 4(\vec{a} \cdot \vec{c})$$

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

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

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

Ans. [2]  
Sol.

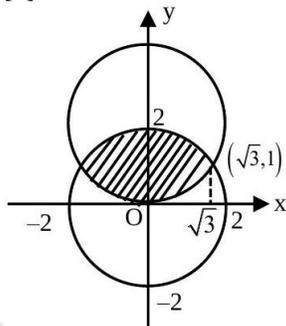


$$\begin{aligned} \therefore P(\text{ Drawn ball is white }) &= \frac{3}{5} \times \frac{10}{18} + \frac{2}{5} \times \frac{9}{18} \\ &= \frac{48}{90} = \frac{8}{15} = \frac{p}{q} \\ \therefore p + q &= 23 \end{aligned}$$

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

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

Ans. [4]



Sol.

$$\begin{aligned} A &= 2 \int_0^{\sqrt{3}} \left[ \sqrt{4-x^2} - \left( 2 - \sqrt{4-x^2} \right) \right] dx \\ &= 2 \int_0^{\sqrt{3}} \left( 2\sqrt{4-x^2} - 2 \right) dx \\ &= 4 \int_0^{\sqrt{3}} \left( \sqrt{4-x^2} - 1 \right) dx \\ &= \left[ 4 \left[ \frac{1}{2} \left( x\sqrt{4-x^2} + 4\sin^{-1} \frac{x}{2} \right) - x \right] \right]_0^{\sqrt{3}} \end{aligned}$$

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

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

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

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

Ans. [3]

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

$$f(\theta) = 4 - 3\sin 2\theta - \cos 2\theta$$

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

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

$\gcd(a, b) = 1$ , then  $a + b + c$  is equal to :

- (1) 29                                      (2) 28                                      (3) 31                                      (4) 30

Ans. [3]

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

(1) 429                                      (2) 384                                      (3) 403                                      (4) 455

Ans. [4]

Sol. Let oranges are identical then

$$x_1 + x_2 + x_3 + x_4 = 16$$

$$\text{and } x_1, x_2, x_3, x_4 \geq 1$$

$$\text{or } x_1' + x_2' + x_3' + x_4' = 12$$

so total number of solutions are

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

16. Let  $A = \{0, 1, 2, \dots, 9\}$ . Let  $R$  be a relation on  $A$  defined by  $(x, y) \in R$  if and only if  $|x - y|$  is a multiple of 3.

Given below are two statements:

Statement I:  $n(R) = 36$

Statement II:  $R$  is an equivalence relation.

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

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

Ans. [2]

Sol. Number of form  $3K = 4$   
Number of form  $3K + 1 = 3$   
Number of form  $3K + 2 = 3$   
 $4 \times 4 + 3 \times 3 + 3 \times 3 = 34$  elements in relation  
 $\Rightarrow xRy \Rightarrow yRx$   
 $\Rightarrow (x - y) = 3\lambda, (y - z) = 3\mu$   
 $\Rightarrow (x - z) = 3(\lambda + \mu)$

R is reflexive, symmetric and transitive  $S_2$  is true

Ans.  $S_1$  is false but  $S_2$  is true

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

(1) -1 (2) 0 (3) 1 (4) 256

Ans. [4]

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

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

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

18. If the mean and the variance of the data

| Class     | 4-8 | 8-12      | 12-16 | 16-20 |
|-----------|-----|-----------|-------|-------|
| Frequency | 3   | $\lambda$ | 4     | 7     |

are  $\mu$  and 19 respectively, then the value of  $\lambda + \mu$  is

(1) 18 (2) 21 (3) 20 (4) 19

Ans. [4]

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

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

$\lambda + 14$  is multiple of 60  $\Rightarrow \lambda = 1$  or 6 or 16.  $\therefore$  (assuming  $\mu$  is natural number)

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

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

$$\Rightarrow 19\lambda^2 - 28\lambda - 516 = 0$$

$$\Rightarrow \lambda = 6$$

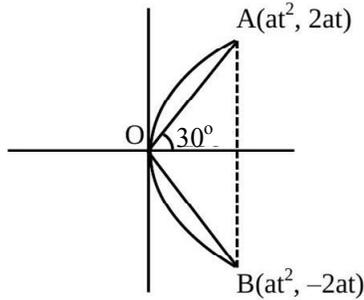
$$\text{for } \lambda = 6, \mu = 10 + 3 = 13$$

$$\lambda + \mu = 19$$

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

- (1)  $4(3 - \sqrt{3})$  (2)  $2(8 - 3\sqrt{3})$   
 (3)  $4(6 + \sqrt{3})$  (4)  $2(3 + \sqrt{3})$

**Ans.** [1]  
**Sol.**



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

$$\frac{2}{t} = \tan 30^\circ$$

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

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

$$\text{Least distance} = |\text{CP} - R|$$

$$= 12 - 4\sqrt{3} = 4(3 - \sqrt{3})$$

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

- (1) 12 (2) 3 (3) 5 (4) 7

**Ans.** [3]

**Sol.**  $a_n = S_n - S_{n-1}$   
 $= (\alpha n^2 + \beta n) - (\alpha(n-1)^2 + \beta(n-1))$

(1)  $a_{10} \Rightarrow 19\alpha + \beta = 59$

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

$$\Rightarrow 2\alpha = 3\beta$$

$$\alpha = 3, \beta = 2$$

$$\alpha + \beta = 5$$

### SECTION-B

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

**Ans.** [16]

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

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

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

$$\text{for } x = 3 \quad y = 15 \Rightarrow C = 12$$

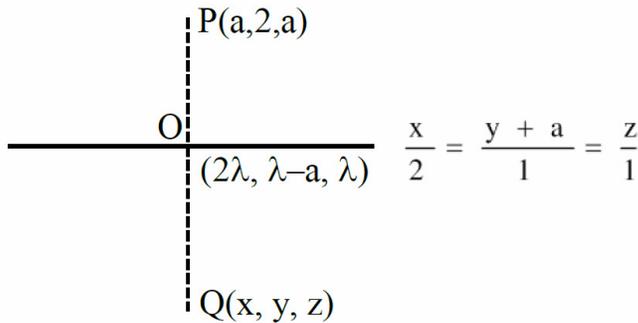
$$y = (-x^2 + 12)(x^2 - 4)$$

$$y' = 0 \Rightarrow x = 2\sqrt{2}$$

$$y_{\text{local maxi.}} = ((2\sqrt{2})^2 - 4)((-2\sqrt{2})^2 + 12) = 16$$

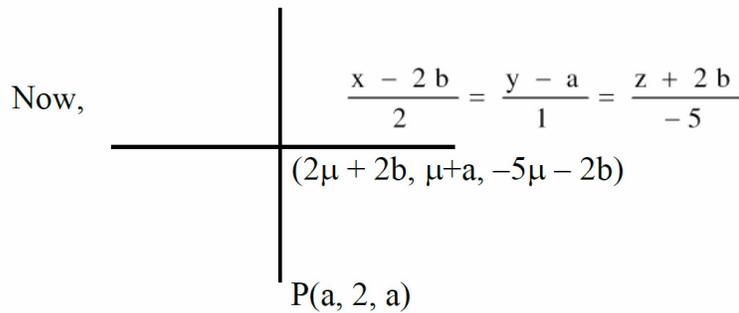
22. If the image of the point  $P(a, 2, a)$  in the line  $\frac{x}{2} = \frac{y+a}{1} = \frac{z}{1}$  is  $Q$  and the image of  $Q$  in the line  $\frac{x-2b}{2} = \frac{y-a}{1} = \frac{z+2b}{-5}$  is  $P$ , then  $a+b$  is equal to.

Ans. [3]



Sol.

$$Q. (4\lambda - a, 2\lambda - 2a - 2, 2\lambda - a)$$



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

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

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

$$\Rightarrow \lambda - \mu = b$$

$$\lambda - \mu = 2a$$

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

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

$$\begin{array}{c}
 P(a, 2, a) \\
 \left. \begin{array}{l} \frac{x}{2} = \frac{y+a}{1} = \frac{z}{1} \\ 2\hat{i} + \hat{j} + \hat{k} \end{array} \right\} \\
 (2\lambda, \lambda - a, \lambda) \\
 \text{For } \lambda = a \\
 (2a, 0, a)
 \end{array}$$

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

$$2a - 2 = 0$$

$$a = 1$$

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

$$a + b = 1 + 2 = 3$$

23. The number of elements in the set  $S = \{x : x \in [0, 100] \text{ and } \int_0^x t^2 \sin(x-t) dt = x^2\}$  is.....

Ans. [16]

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

Use by parts

$$\left[ t^2 \cos(x-t) \right]_0^x - \int_0^x 2t \cdot \cos(x-t) dt$$

$$x^2 - 2 \left[ -t \sin(x-t) \right]_0^x - \int_0^x 1 - \sin(x-t) dt$$

$$x^2 - 2[1 - \cos x]$$

we have,  $\int_0^x t^2 \sin(x-t) dt = x^2$

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

$$\Rightarrow \cos x = 1$$

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

$$\text{Total Elements} = 16$$

24. Let  $A = \begin{bmatrix} 0 & 2 & -3 \\ -2 & 0 & 1 \\ 3 & -1 & 0 \end{bmatrix}$  and B be a matrix such that

$B(I - A) = I + A$ . Then the sum of the diagonal elements of  $B^T B$  is equal to

Ans. [3]

Sol.  $A^T = -A$

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

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

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

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

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

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

$$= I$$

$$\text{tr}(B^T B) = 3$$

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

Ans. [260]

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

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

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

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



## JEE Main Online Exam 2026

### Questions & Solution

23<sup>rd</sup> January 2026 | Evening

#### PHYSICS

#### SECTION-A

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

(atmospheric pressure =  $10^5 \text{ Pa}$ )

- (1) 14.5                      (2) 1.55                      (3) 15.5                      (4) 1.45

Ans. [3]

Sol.

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

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

$$\Delta Q = 126$$

$$W = 26 = P\Delta V$$

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

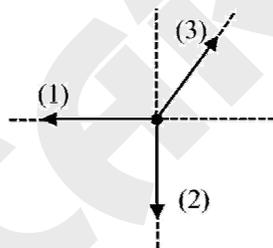
$$\Delta x = \frac{26}{170} = 15.3$$

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

- (1)  $10\sqrt{2}$                       (2)  $12\sqrt{2}$                       (3) 12                      (4)  $24\sqrt{2}$

Ans. [2]

Sol.



Apply C.O.M

$$M_1 V_1 + M_2 V_2 + M_3 V_3 = 0$$

$$2(-18\mathbf{i}) + 2(-18\mathbf{j}) + 3 V_3 = 0$$

$$V_3 = 12\mathbf{i} + 12\mathbf{j}$$

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

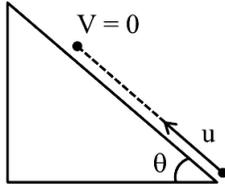
28. A block is sliding down on an inclined plane of slope  $\theta$  and at an instant  $t = 0$  this block is given an upward momentum so that it starts moving up on the inclined surface with velocity  $u$ . The distance ( $S$ ) travelled by the block before its velocity become zero, is \_\_\_\_ .

( $g =$  gravitational acceleration)

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

**Ans. [Dropped by JEE]**

**Sol.**



$$a = -g\sin\theta$$

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

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

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

**No options Matching.**

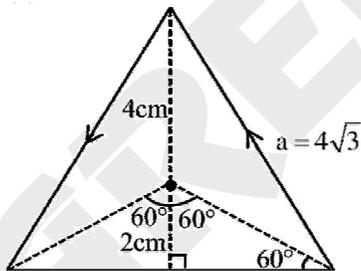
29. The current passing through a conducting loop in the form of equilateral triangle of side  $4\sqrt{3}$  cm is  $2A$ . The magnetic field at its centroid is  $\alpha \times 10^{-5}$  T. The value of  $\alpha$  is \_\_\_\_ .

(Given :  $\mu_0 = 4\pi \times 10^{-7}$  SI units)

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

**Ans. [3]**

**Sol.**



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

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

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

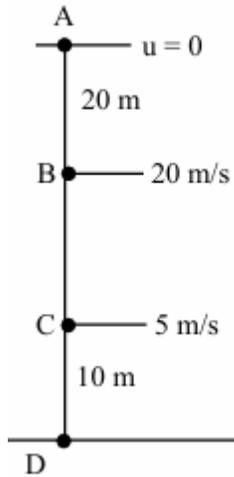
30. A paratrooper jumps from an aeroplane and opens a parachute after 2 s of free fall and starts decelerating with  $3 \text{ m/s}^2$ . At 10 m height from ground, while descending with the help of parachute, the speed of paratrooper is  $5 \text{ m/s}$ . The initial height of the aeroplane is \_\_\_\_ m. ( $g = 10 \text{ m/s}^2$ )

(1) 62.5

(2) 92.5

(3) 20

(4) 82.5

**Ans. [2]**
**Sol.**


A to B

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

$$V = 0 + 10 \times 2$$

B to C

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

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

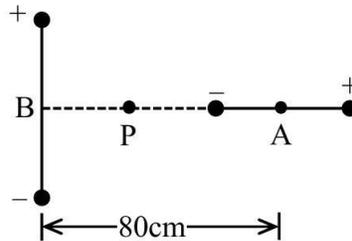
$$x_2 = 62.5$$

C to D

$$x_3 = 10 \text{ m}$$

$$H = x_1 + x_2 + x_3 = 92.5$$

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



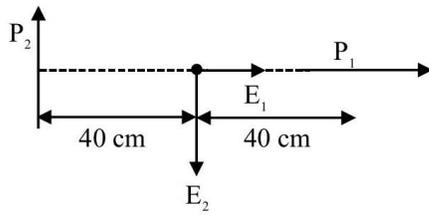
(1)  $\frac{9}{16}\sqrt{2} \times 10^5$

(2)  $4.5\sqrt{2} \times 10^4$

(3)  $9\sqrt{2} \times 10^4$

(4)  $\frac{9}{16}\sqrt{2} \times 10^4$

**Ans. [4]**
**Sol.**



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

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

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

$$\vec{E}_{\text{net}} = \frac{2 \times 9 \times 10^9 \times 2 \times 10^{-8}}{(0.4)^3} \hat{i} - \frac{9 \times 10^9 \times 4 \times 10^{-8}}{(0.4)^3} \hat{j}$$

$$\vec{E}_{\text{net}} = \frac{9 \times 10^9 \times 4 \times 10^{-8}}{(0.4)^3} [\hat{i} - \hat{j}]$$

$$|\vec{E}_{\text{net}}| = \frac{9 \times 10^4}{16} (\sqrt{2})$$

32. Two charges  $7\mu\text{C}$  and  $-2\mu\text{C}$  are placed at  $(-9,0,0)\text{cm}$  and  $(9,0,0)\text{cm}$  respectively in an external field  $E = \frac{A}{r^2} \hat{r}$ , where  $A = 9 \times 10^5 \text{ N/C.m}^2$ . Considering the potential at infinity is 0, the electrostatic energy of the configuration is \_\_\_\_ J.

- (1) 1.4                      (2) -90.7                      (3) 49.3                      (4) 24.3

Ans. [3]

Sol.  $q_1 = 7\mu\text{C}$        $r$                        $r$        $q_2 = -2\mu\text{C}$   
 $(-9,0,0)$        $(0,0,0)$                        $(9,0,0)$

$$dV = -\vec{E} \cdot d\vec{r}$$

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

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

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

$$= q_1 V_1 = q_2 V_2 + \frac{kq_1 q_2}{2r}$$

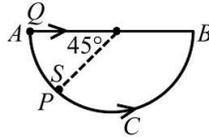
$$= 7 \times 10^{-6} \frac{A}{9 \times 10^{-2}} - 2 \times 10^{-6} \frac{A}{9 \times 10^{-2}} - \frac{9 \times 10^9 \times 14 \times 10^{-12}}{2 \times 9 \times 10^{-2}}$$

$$= \frac{5 \times 10^{-6} \times 9 \times 10^5}{9 \times 10^{-2}} - 7 \times 10^{-1}$$

$$= 50 - 0.7$$

$$= 49.3 \text{ J}$$

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



- (1)  $t_p > t_Q$                       (2)  $t_p < t_Q$                       (3)  $t_p > 1.25t_Q$                       (4)  $t_p = t_Q$

**Ans.**

[2]

**Sol.**

Horizontal displacement of Q is more than P.

$$X_Q > X_P$$

Horizontal component of velocity is same

$$\text{So } t_p = \frac{X_P}{v}$$

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

$$t_Q > t_p$$

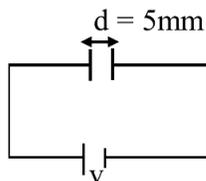
34. A parallel plate capacitor with plate separation 5 mm is charged by a battery. On introducing a mica sheet of 2 mm and maintaining the connections of the plates with the terminals of the battery, it is found that it draws 25% more charge from the battery. The dielectric constant of mica is \_\_\_\_\_.

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

**Ans.**

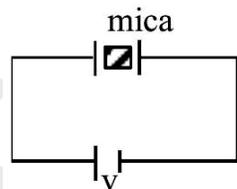
[2]

**Sol.**



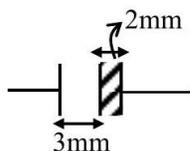
$$C = \frac{\epsilon_0 A}{d}$$

$$Q_1 = CV$$



$$Q_2 = (c_{eq})V$$

$$Q_2 = 1.25CV$$



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

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

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

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

35. To compare EMF of two cells using potentiometer the balancing lengths obtained are 200 cm and 150 cm. The least count of scale is 1 cm. The percentage error in the ratio of EMFs is \_\_\_\_\_
- (1) 1.45                      (2) 1.65                      (3) 1.75                      (4) 1.55

**Ans.** [Dropped by JEE]

**Sol.**

$$\epsilon = \lambda l$$

Potential gradient

$$\epsilon_1 = \lambda l_1$$

$$\epsilon_2 = \lambda l_2$$

$$y = \frac{\epsilon_1}{\epsilon_2} = \frac{l_1}{l_2}$$

$$\frac{\Delta y}{y} = \frac{\Delta l_1}{l_1} + \frac{\Delta l_2}{l_2}$$

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

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

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

**No options matching**

36. An air bubble of volume  $2.9 \text{ cm}^3$  rises from the bottom of a swimming pool of 5 m deep. At the bottom of the pool water temperature is  $17^\circ \text{C}$ . The volume of the bubble when it reaches the surface, where the water temperature is  $27^\circ \text{C}$ , is \_\_\_\_\_  $\text{cm}^3$ . ( $g = 10 \text{ m/s}^2$ , density of water =  $10^3 \text{ kg/m}^3$ , and 1 atm pressure is  $10^5 \text{ Pa}$ )
- (1) 4.2                      (2) 2.0                      (3) 3.0                      (4) 4.5

**Ans.** [4]

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

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

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

$$V_2 = 4.5 \text{ cm}^3$$



$$= 300R(0.693) \dots (1)$$

Now for adiabatic process,

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

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

$$(1) = (2)$$

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

$$T_{\text{Final}} = 216.84 \text{ K}$$

$$= -56.3^\circ \text{C}$$

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

( $\sin 15^\circ = 0.25$  and  $\sin 25^\circ = 0.43$ )

(1) between  $15^\circ$  and  $20^\circ$

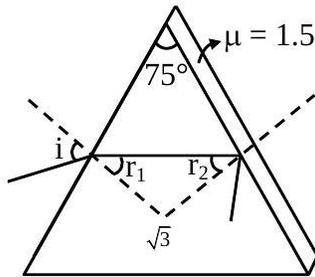
(2)  $15^\circ$

(3)  $> 25^\circ$

(4)  $< 15^\circ$

Ans. [1, 2, 4]

Sol.



$$r_1 + r_2 = 75^\circ$$

For TIR at back surface

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

$$r_2 \geq 60^\circ$$

$$r_1 \leq 15^\circ$$

$$\sin i = \sqrt{3} \sin 15^\circ$$

$$\sin i = 1.73 \times 0.25$$

$$\sin i = 0.433$$

$$i = 25^\circ \Rightarrow i < 25^\circ$$

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

(1) 6.6

(2) 13.2

(3) 8.25

(4) 1.32

Ans. [4]

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

circumference  $\approx 14\pi$

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

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

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

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

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

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

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

$EMF = 1.32 \text{ mV}$

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

[Resistance of the loop =  $10 \Omega$ ]

(1) 197                      (2) 80                      (3) 280                      (4) 100

Ans. [1]

Sol. Emf Induced  $\varepsilon = A \frac{dB}{dt} = A \mu_0 n \frac{di}{dt}$

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

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

So  $i = \frac{\pi r^2 \mu_0 n i_0 \omega}{\sqrt{2} R}$   
 $= \frac{\pi \times 10^{-4} \times 4\pi \times 10^{-7} \times 500 \times 10 \times 10^3}{\sqrt{2} \times 10}$   
 $= \frac{20\pi^2}{\sqrt{2}} \times 10^{-6}$   
 $\approx \frac{197}{\sqrt{2}} \mu \text{ A}$

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

(1) 36:1                      (2) 3:2                      (3) 6:1                      (4)  $\sqrt{6}:1$

Ans. [4]

**Sol.**  $\frac{C}{V} = \mu = \sqrt{\epsilon_r \mu_r}$   
 $\frac{C}{V} = \sqrt{\frac{3 \times 2}{1}} = \frac{\sqrt{6}}{1}$

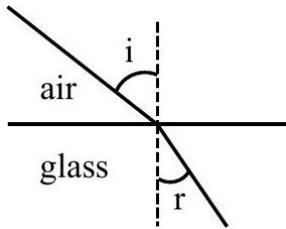
**44.** When an unpolarized light falls at a particular angle on a glass plate (placed in air), it is observed that the reflected beam is linearly polarized. The angle of refracted beam with respect to the normal is \_\_\_\_\_ .

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

- (1)  $39.6^\circ$                       (2)  $32.3^\circ$                       (3)  $42.6^\circ$                       (4)  $36.3^\circ$

**Ans.** [2]

**Sol.**



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

$$\tan i = 1.52$$

$$i = 57.7^\circ$$

$$r = 90^\circ - i$$

$$r = 32.3^\circ$$

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

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

- (1) 2.0                      (2) 1.0                      (3) 3.0                      (4) 1.5

**Ans.** [1]

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

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

$$V_T = 2 \text{ cm/sec.}$$

**SECTION - B**

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

(Avogadro Number =  $6 \times 10^{23}$  per mole)

**Ans.** [228]

**Sol.** Total numbers of U-235 atom is

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

$$\begin{aligned} \therefore \text{Total energy released} &= \frac{1}{5} \times 6 \times 10^{23} \times 190 \text{ MeV} \\ &= 228 \times 10^{23} \text{ MeV} \end{aligned}$$

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

Ans. [16]

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

$$m_1 = -m_2$$

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

$$f - 8 = 24 - f$$

$$2f = 32$$

$$f = 16 \text{ cm}$$

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

The value of  $\frac{b+c}{a+d}$  is \_\_\_\_\_ .

Ans. [1]

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

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

on comparing

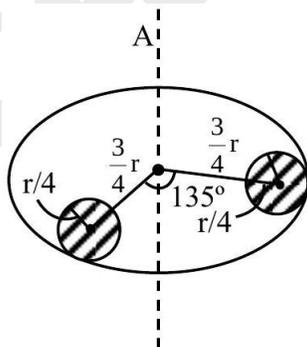
$$c = -1; a + c + d = 0; -3a - c - 3d + b = 0$$

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

$$b + c = 1$$

49. Suppose there is a uniform circular disc of mass  $M$  kg and radius  $r$  m shown in figure. The shaded regions are cut out from the disc. The moment of inertia of the remainder about the axis  $A$  of the disc is given by

$\frac{X}{256} Mr^2$ . The value of  $x$  is \_\_\_\_\_ .



Ans. [109]

Sol.  $M = \sigma\pi R^2$   
 $\sigma\pi R^2 = 16 m$   
 $m = \frac{\sigma\pi R^2}{16}$   
 $I_{\text{system}} = \frac{MR^2}{2} - 2\left(\frac{mR^2}{2 \times 16} + \frac{9mR^2}{16}\right)$   
 $= \frac{MR^2}{2} - 2 \times \frac{19mR^2}{32}$   
 $= \frac{MR^2}{2} - \frac{19}{16}mR^2$   
 $= \frac{MR^2}{2} - \frac{19}{256}MR^2$  becoz  $m = \frac{M}{16}$   
 $= \frac{(128-19)(MR^2)}{256}$   
 $= \frac{109MR^2}{256}$

50. The velocity of sound in air is doubled when the temperature is raised from  $0^\circ\text{C}$  to  $\alpha^\circ\text{C}$ . The value of  $\alpha$  is

Ans. [819]

Sol.  $V = \sqrt{\frac{\gamma RT}{M}}$   
 $\frac{V_1}{V_2} = \sqrt{\frac{T_1}{T_2}}$   
 $\frac{V_0}{2V_0} = \sqrt{\frac{273}{T_2}}$   
 $\frac{1}{4} = \frac{273}{T_2}$   
 $T_2 = 4 \times 273 = \alpha + 273$   
 $\alpha = 3 \times 273$   
 $\alpha = 819^\circ\text{C}$



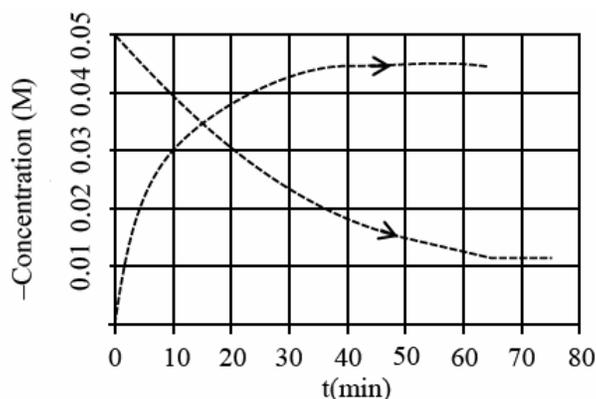
## JEE Main Online Exam 2026

Questions & Solution  
23<sup>rd</sup> January 2026 | Evening

### CHEMISTRY

### SECTION-A

51.



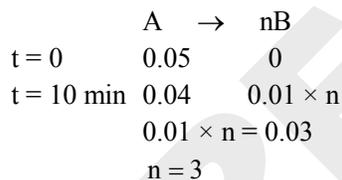
Given above is the concentration vs time plot for a dissociation reaction :  $A \rightarrow nB$  .

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

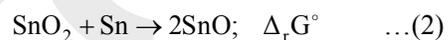
- (1) 4                                      (2) 3                                      (3) 2                                      (4) 5

Ans.[2]

Sol.



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



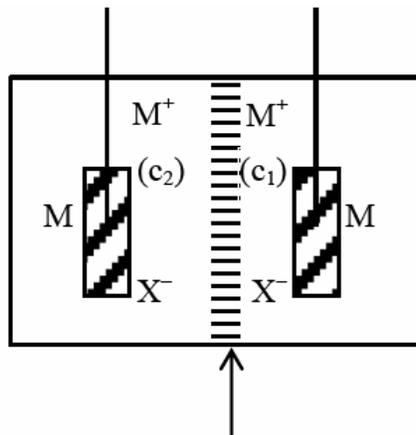
Identify the correct set from the following.

- (1)  $\Delta_r G^\circ(1) > 0; \Delta_r G^\circ(2) < 0$   
 (2)  $\Delta_r G^\circ(1) < 0; \Delta_r G^\circ(2) < 0$   
 (3)  $\Delta_r G^\circ(1) < 0; \Delta_r G^\circ(2) > 0$   
 (4)  $\Delta_r G^\circ(1) > 0; \Delta_r G^\circ(2) > 0$

Ans.[3]

- Sol.**  $\text{PbO}_2 + \text{Pb} \rightarrow 2\text{PbO}$   
 $\text{Pb}^{2+}$  is more stable hence reaction will be spontaneous. So  $\Delta G^\circ_r(1)$  is negative.  
 $\text{SnO}_2 + \text{Sn} \rightarrow 2\text{SnO}$   
 $\text{Sn}^{+2}$  is less stable, so reaction will be nonspontaneous hence  $\Delta G^\circ_r(2)$  is positive.

53.



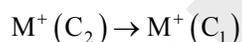
Semi permeable membrane

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

- (1) If  $c_1$  is present at anode, then  $c_1 = c_2$
- (2) If  $c_1$  is present at cathode, then  $c_1 < c_2$
- (3) If  $c_1$  is present at cathode, then  $c_1 > c_2$
- (4) If  $c_1$  is present at anode, then  $c_1 > c_2$

**Ans.[3]**

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



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

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

(2) If  $C_1$  is at cathode



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

$$C_2 < C_1$$

54. Both human DNA and RNA are chiral molecules. The chirality in DNA and RNA arises due to the presence of
- |                       |                           |
|-----------------------|---------------------------|
| (1) Base unit         | (2) Chiral phosphate unit |
| (3) D-sugar component | (4) L-sugar component     |

**Ans.[3]**

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

55. Identify the CORRECT set of details from the following :
- A.  $[\text{Co}(\text{NH}_3)_6]^{3+}$  : Inner orbital complex ;  $d^2sp^3$  hybridized
- B.  $[\text{MnCl}_6]^{3-}$  Outer orbital complex;  $sp^3d^2$  hybridized
- C.  $[\text{CoF}_6]^{3-}$  : Outer orbital complex ;  $d^2sp^3$  hybridized
- D.  $[\text{FeF}_6]^{3-}$  : Outer orbital complex:  $sp^3d^2$  hybridized
- E.  $[\text{Ni}(\text{CN})_4]^{2-}$  : Inner orbital complex ;  $sp^3$  hybridized

Choose the correct answer from the options given below:

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

Ans.[2]

- Sol. (A)  $\text{Co}^{3+}$  : -3  $d^6$   
 $\text{NH}_3 \Rightarrow$  S.F.L  
Hybridisation  $\Rightarrow d^2sp^3$ , Inner orbital complex
- (B)  $\text{Mn}^{3+}$  : -3  $d^4$   
 $\text{Cl}^- \Rightarrow$  W.F.L  
Hybridisation  $\Rightarrow sp^3d^2$ , Outer orbital complex
- (C)  $\text{Co}^{3+}$  : -3  $d^6$   
 $\text{F}^- \Rightarrow$  W.F.L  
Hybridisation  $\Rightarrow sp^3d^2$ , Outer orbital complex
- (D)  $\text{Fe}^{3+}$  : -3  $d^5$   
 $\text{F}^- \Rightarrow$  W.F.L  
Hybridisation  $\Rightarrow sp^3d^2$ , Outer orbital complex
- (E)  $\text{Ni}^{2+}$  : -3  $d^8$   
 $\text{CN}^- \Rightarrow$  S.F.L  
Hybridisation  $\Rightarrow dsp^2$ , Inner orbital complex

56. Elements X and Y belong to Group 15. The difference between the electronegativity values of ' X ' and phosphorus is higher than that of the difference between phosphorus and ' Y '. ' X ' & ' Y ' are respectively
- (1) N & As                      (2) As & Bi                      (3) Bi & N                      (4) As & Sb

Ans.[1]

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

X = Nitrogen (N)  
Y = Arsenic (As)

57. Given below are two statements:

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

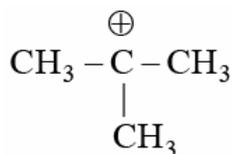
**Statement II:**  $\overset{\oplus}{\text{C}}\text{H}_3$  is less stable than  $(\text{CH}_3)_3\overset{\oplus}{\text{C}}$  as only three hyperconjugation interactions are possible in  $\overset{\oplus}{\text{C}}\text{H}_3$ .

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

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

Ans.[1]

Sol. S-1:  $(\text{CH}_3)_3\overset{\oplus}{\text{C}} > \overset{\oplus}{\text{C}}\text{H}_3$ ; due to hyperconjugation interaction



S-2 : False

58. Iodoform test can differentiate between

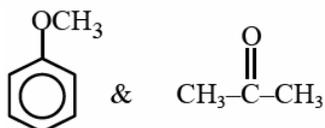
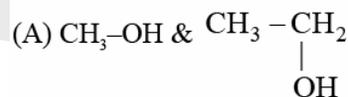
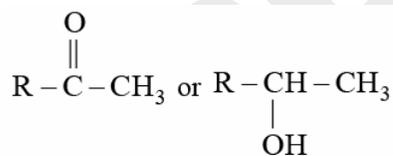
- A. Methanol and Ethanol
- B.  $\text{CH}_3\text{COOH}$  and  $\text{CH}_3\text{CH}_2\text{COOH}$
- C. Cyclohexene and cyclohexanone
- D. Diethyl ether and Pentan-3-one
- E. Anisole and acetone

Choose the correct answer from the options given below:

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

Ans.[1]

Sol.



59. Given below are two statements :

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

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

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

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

Ans.[1]

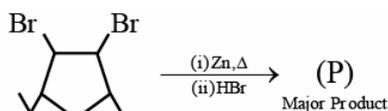
Sol.  $Na^+ : -1s^2 2s^2 2p^6$  (fully filled electronic configuration)

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

$IE_2$  of Na  $>$   $IE_2$  of Mg

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

60.

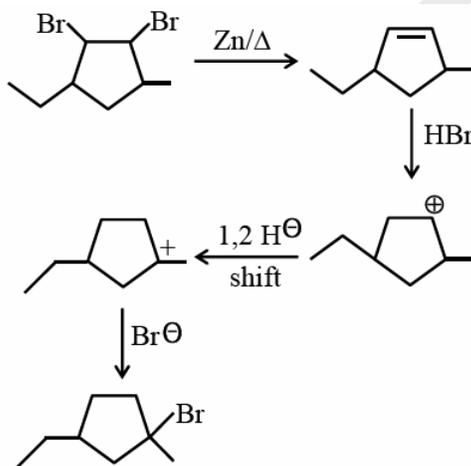


Identify (P)



Ans.[2]

Sol.



61. Observe the following reactions at T(K)

I.  $A \rightarrow$  products.

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

Both the reactions are started at 10.00 am . The rates of these reactions at 10.10 am are same. The value of

$-\frac{\Delta[Br^-]}{\Delta t}$  at 10.10 am is  $2 \times 10^{-4} \text{ mol L}^{-1} \text{Min}^{-1}$  . The concentration of A at 10.10 am is  $10^{-2} \text{ mol L}^{-1}$  . What

is the first order rate constant (in  $\text{min}^{-1}$  ) of reaction I?

- (1)  $2 \times 10^{-3}$
- (2)  $10^{-3}$
- (3)  $10^{-2}$
- (4)  $4 \times 10^{-3}$

**Ans.[4]**
**Sol.** At  $t = 10$  minutes

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

 For reaction  $A \rightarrow P$ 

 at  $t = 10$  minutes

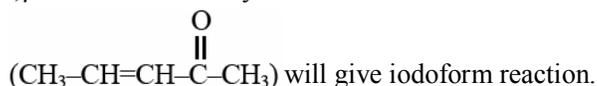
$$\text{Rate of reaction} = 4 \times 10^{-5} = k[A]$$

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

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

A. Sodium hypochlorite reacts with KI to give KOI.

B. KOI is a reducing agent.

 C.  $\alpha, \beta$ -unsaturated methylketone


D. Isopropyl alcohol will not give iodoform test.

E. Methanoic acid will give positive iodoform test.

Choose the correct answer from the options given below:

(1) A, C &amp; E only

(2) A, B &amp; C only

(3) A &amp; C only

(4) B, D &amp; E only

**Ans.[3]**
**Sol.** (A)  $\text{NaOCl} + \text{KI} \rightarrow \text{NaCl} + \text{KOI}$ 

(B) Incorrect statement

 (C)  $\text{CH}_3 - \text{CH} = \overset{\text{O}}{\parallel}{\text{C}} - \text{CH}_3$  gives iodoform reaction.

(D) Incorrect statement

(E) Incorrect statement

**63.** Which statements are NOT TRUE about  $\text{XeO}_2 \text{F}_2$  ?

A. It has a see-saw shape.

 B. Xe has 5 electron pairs in its valence shell in  $\text{XeO}_2 \text{F}_2$  .

 C. The  $\text{O} - \text{Xe} - \text{O}$  bond angle is close to  $180^\circ$  .

 D. The  $\text{F} - \text{Xe} - \text{F}$  bond angle is close to  $180^\circ$ 

 E. Xe has 16 valence electrons in  $\text{XeO}_2 \text{F}_2$  .

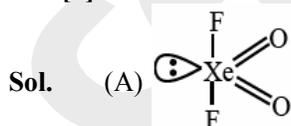
Choose the correct answer from the options given below.

(1) B, C and E only

(2) B and D only

(3) A and D only

(4) B, D and E only

**Ans.[1]**


See-saw

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

 (C)  $\text{O} - \text{Xe} - \text{O}$  Bond angle is close to  $120^\circ$ 

 (D)  $\text{F} - \text{Xe} - \text{F}$  Bond angle is close to  $180^\circ$ 

 (E) Xe has 14 valence electron in  $\text{XeO}_2 \text{F}_2$

64. Identify the INCORRECT statements from the following:

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

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

C. One radiation has wavelength  $= \lambda_1$  (900 nm) and energy  $= E_1$ .

Other radiation has wavelength  $= \lambda_2$  (300 nm) and energy  $= E_2$ ,  $E_1 : E_2 = 3 : 1$ .

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

Choose the correct answer from the options given below:

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

Ans.[2]

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

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

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

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

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

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

(1) 53.58%      (2) 87.65%      (3) 37.57%      (4) 34.79%

Ans.[1]

Sol. Organic compound : 0.2425 gm

AgCl obtained : 0.5253 gm

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

Hence percentage of Cl.

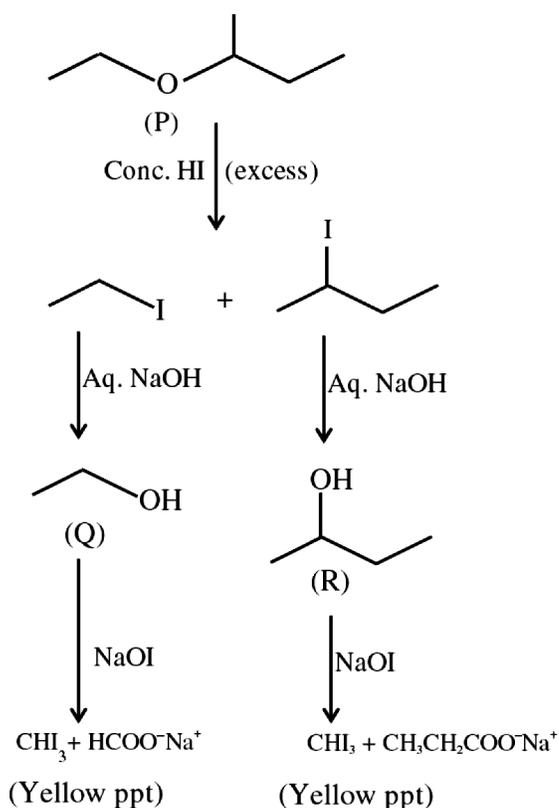
$$\text{Percentage of Cl} = \frac{35.5}{143.5} \times \frac{0.5253}{0.2425} \times 100 = 53.58\%$$

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



Ans.[1]

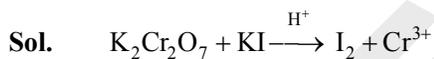
Sol.



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

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

Ans.[2]



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

- (1) 3.1, 6.2                      (2) 2.3, 4.6                      (3) 1.4, 2.8                      (4) 1.5, 3.0

Ans.[2]

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

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

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

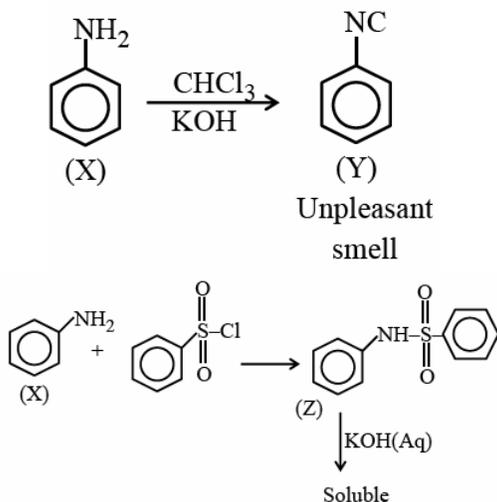
By eq. (1) divide eq. (2)

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

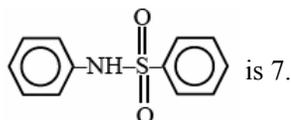
$$\frac{2.642}{1} = \frac{6 - \phi_1}{6 - 2\phi_1}$$



Sol.

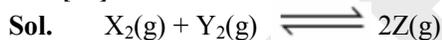


Number of different H atom in



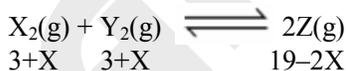
### SECTION-B

71.  $\text{X}_2(\text{g}) + \text{Y}_2(\text{g}) \rightleftharpoons 2\text{Z}(\text{g})$   
 $\text{X}_2(\text{g})$  and  $\text{Y}_2(\text{g})$  are added to a 1 L flask and it is found that the system attains the above equilibrium at  $T(\text{K})$  with the number of moles of  $\text{X}_2(\text{g})$ ,  $\text{Y}_2(\text{g})$  and  $\text{Z}(\text{g})$  being 3, 3 and 9 mol respectively (equilibrium moles). Under this conditions of equilibrium, 10 mol of  $\text{Z}(\text{g})$  is added to the flask and the temperature is maintained at  $T(\text{K})$ . Then the number of moles of  $\text{Z}(\text{g})$  in the flask when the new equilibrium is established is \_\_\_\_\_. (Nearest integer).

**Ans.[15]**


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

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



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

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

$$19-2X = 9+3X$$

$$10 = 5X$$

$$X = 2$$

 At equilibrium  $\Rightarrow$  moles of Z =  $19 - 2 \times 2 = 15$  moles

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

Ans. [200]

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

$$P_s = P_A^0 X_A + P_B^0 X_B$$

$$500 = P_A^0 \times \frac{3}{4} + P_B^0 \times \frac{1}{4}$$

$$3P_A^0 + P_B^0 = 2000 \quad \dots(1)$$

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

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

$$P_s = 520 = P_A^0 \times \frac{4}{5} + P_B^0 \times \frac{1}{5}$$

$$4P_A^0 + P_B^0 = 2600 \quad \dots(2)$$

By equation (2) - equation (1)

$$P_A^0 = 600 \text{ mmHg}$$

$$P_B^0 = 200 \text{ mmHg}$$

73. 200 cc of  $x \times 10^{-3} M$  potassium dichromate is required to oxidise 750 cc of 0.6 M Mohr's salt solution in acidic medium.  
Here  $x =$

Ans. [375]

74. Total number of unpaired electrons present in the central metal atoms/ions of  $[\text{Ni}(\text{CO})_4]$ ,  $[\text{NiCl}_4]^{2-}$ ,  $[\text{PtCl}_2(\text{NH}_3)_2]$ ,  $[\text{Ni}(\text{CN})_4]^{2-}$  and  $[\text{Pt}(\text{CN})_4]^{2-}$  is \_\_\_\_\_.

Ans. [2]

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

Hybridisation state:  $sp^3$

Unpaired electron = 0

In  $[\text{NiCl}_4]^{2-}$ ,  $\text{Ni}^{2+} : 3 d^8$

Hybridisation state:  $sp^3$

Unpaired electron = 2

In  $[\text{PtCl}_4]^{2-}$ ,  $\text{Pt}^{2+} : 5 d^8$

Hybridisation state:  $dsp^2$

Unpaired electron = 0

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

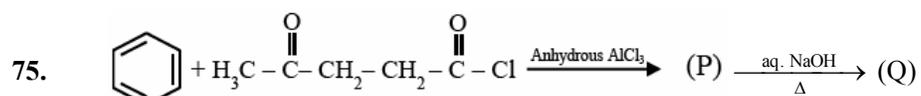
Hybridisation state:  $dsp^2$

Unpaired electron = 0

In  $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ ,  $\text{Pt}^{2+} : 5 d^8$

Hybridisation state:  $dsp^2$

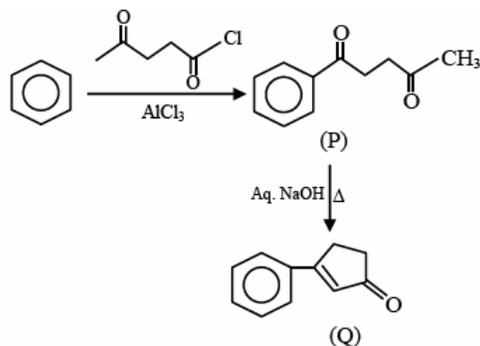
Unpaired electron = 0



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

Ans.[10]

Sol.



Molecular mass of Q is = 158

% of oxygen in product 'Q' is =  $10.12\% \approx 10\%$