

03/04/2025

Evening



# Aakash

Medical | IIT-JEE | Foundations

Corporate Office : AESL, 3rd Floor, Incuspaze Campus-2, Plot-13, Sector-18, Udyog Vihar,  
Gurugram, Haryana-122015

## Answers & Solutions

Time : 3 hrs.

for

M.M. : 300

## JEE (Main)-2025 (Online) Phase-2

(Mathematics, Physics and Chemistry)

### IMPORTANT INSTRUCTIONS:

- (1) The test is of **3 hours** duration.
- (2) This test paper consists of **75** questions. Each subject (MPC) has 25 questions. The maximum marks are 300.
- (3) This question paper contains **Three Parts**. **Part-A** is Mathematics, **Part-B** is Physics and **Part-C** is Chemistry. Each part has only two sections: **Section-A** and **Section-B**.
- (4) **Section - A** : Attempt all questions.
- (5) **Section - B** : Attempt all questions.
- (6) **Section - A (01 - 20)** contains 20 multiple choice questions which have **only one correct answer**. Each question carries **+4 marks** for correct answer and **-1 mark** for wrong answer.
- (7) **Section - B (21 - 25)** contains 5 **Numerical value** based questions (MCQ). The answer to each question should be rounded-off to the **nearest integer**. Each question carries **+4 marks** for correct answer and **-1 mark** for wrong answer.

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4 STATE  
TOPPERS

70+

100  
PERCENTILERS  
IN PHYSICS,  
CHEMISTRY & MATHS

1000+

99  
PERCENTILERS  
& ABOVE

4000+

95  
PERCENTILERS  
& ABOVE

100  
Percentile  
in Physics  
& Maths



**Shreyas Lohiya**  
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100  
Percentile  
in Physics



**Harsh Jha**  
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100  
Percentile  
in Physics  
& Chemistry



**99.99**  
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**Devya Rustagi**  
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Percentile



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Percentile  
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4 Year Classroom  
**1** AIR  
JEE (Adv.)  
2020



**Tanishka Kabra**  
4 Year Classroom  
**1** AIR-16 CRL  
JEE (Adv.)  
2022  
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FEMALE  
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**Sanvi Jain**  
4 Year Classroom  
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JEE (Main)  
2024  
ALL INDIA  
FEMALE  
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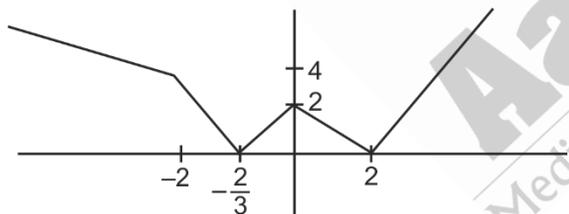
$$\text{Sol. } f(x) = \begin{cases} |-x-2+2x| & x \leq -2 \\ |x+2+2x| & -2 \leq x \leq 0 \\ |x+2-2x| & x \geq 0 \end{cases}$$

$$f(x) = \begin{cases} |-x-2+2x| & x \leq -2 \\ |x+2+2x| & -2 \leq x \leq 0 \\ |x+2-2x| & x \geq 0 \end{cases}$$

$$f(x) = \begin{cases} |x-2| & x \leq -2 \\ |3x+2| & -2 < x \leq 0 \\ |2-x| & x > 0 \end{cases}$$

$$f(x) = \begin{cases} 2-x & x \leq -2 \\ -3x-2 & -2 < x \leq -\frac{2}{3} \\ 3x+2 & -\frac{2}{3} < x \leq 0 \end{cases}$$

$$f(x) = \begin{cases} 2-x & x \leq -2 \\ -3x-2 & -2 < x \leq -\frac{2}{3} \\ 3x+2 & -\frac{2}{3} < x \leq 0 \\ 2-x & 0 < x < 2 \\ x-2 & x \geq 2 \end{cases}$$



No. of maxima = 1

No. of minima = 2

$m = 2$

$n = 1$

$m + n = 3$

7. If the probability that the random variable  $X$  takes the value  $x$  is given by

$P(X = x) = k(x + 1)3^{-x}$ ,  $x = 0, 1, 2, 3, \dots$ , where  $k$  is a constant, then  $P(X \geq 3)$  is equal to

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

(2)  $\frac{7}{27}$

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

(4)  $\frac{8}{27}$

Answer (3)

$$\text{Sol. } s = \frac{k}{3^0} + \frac{2k}{3} + \frac{3k}{3^2} + \dots$$

$$\frac{s}{3} = \frac{k}{3} + \frac{2k}{3^2} + \dots$$

$$s - \frac{s}{3} = k + \frac{k}{3} + \frac{k}{3^2} + \dots$$

$$\frac{2s}{3} = k \left( 1 + \frac{1}{3} + \frac{1}{3^2} + \dots \right)$$

$$\frac{2s}{3} = k \times \frac{1}{1 - \frac{1}{3}} = \frac{3k}{2}$$

$$s = \frac{9k}{4} = 1 \quad (\text{Total probability})$$

$$k = \frac{4}{9}$$

$$P(x \geq 3) = 1 - (P(x=0) + P(x=1) + P(x=2))$$

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

$$= 1 - 2k$$

$$= 1 - 2 \times \frac{4}{9}$$

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

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8. Each of the angles  $\beta$  and  $\gamma$  that a given line makes with the positive  $y$ - and  $z$ -axes, respectively, is half of the angle that this line makes with the positive  $x$ -axis. Then the sum of all possible values of the angle  $\beta$  is

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

**Answer (2)**

**Sol.**  $\beta = \gamma = \frac{\alpha}{2}$

$$\begin{aligned} \cos^2\alpha + \cos^2\beta + \cos^2\gamma &= 1 \\ \cos^2 2\beta + \cos^2\beta + \cos^2\beta &= 1 \\ (2\cos^2\beta - 1)^2 + (2\cos^2\beta - 1) &= 0 \\ (2\cos^2\beta - 1) [(2\cos^2\beta - 1) + 1] &= 0 \\ \cos^2\beta = \frac{1}{2} \text{ or } \cos^2\beta &= 0 \end{aligned}$$

$$\therefore \beta = \frac{\pi}{4}, \frac{\pi}{2}$$

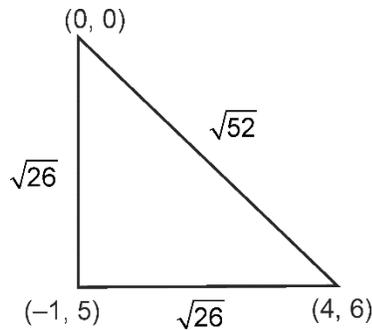
$$\therefore \text{sum} = \frac{\pi}{4} + \frac{\pi}{2} = \frac{3\pi}{4}$$

9. If the four distinct points  $(4, 6)$ ,  $(-1, 5)$ ,  $(0, 0)$  and  $(k, 3k)$  lie on a circle of radius  $r$ , then  $10k + r^2$  is equal to

- (1) 33 (2) 32  
 (3) 34 (4) 35

**Answer (4)**

**Sol.**



$$\begin{aligned} 2r &= \sqrt{52} \\ 4r^2 &= 52 \end{aligned}$$

$$\begin{aligned} 2r^2 &= 26 \\ r^2 &= 13 \\ \text{Eq}^n \text{ of circle is} \\ x(x-4) + y(y-6) &= 0 \\ k(k-4) + 3k(3k-6) &= 0 \\ k^2 - 4k + 9k^2 - 18k &= 0 \\ 10k^2 &= 22k \\ 10k &= 22 \\ \therefore 10k + r^2 &= 35 \end{aligned}$$

10. The sum  $1 + \frac{1+3}{2!} + \frac{1+3+5}{3!} + \frac{1+3+5+7}{4!} + \dots$

- upto  $\infty$  terms, is equal to  
 (1)  $6e$  (2)  $2e$   
 (3)  $3e$  (4)  $4e$

**Answer (2)**

**Sol.**  $T_r = \frac{r^2}{r!} = \frac{r}{(r-1)!} = \frac{(r-1)+1}{(r-1)!} = \frac{1}{(r-2)!} + \frac{1}{(r-1)!}$

$$\sum_{r=1}^{\infty} T_r = \sum_{r=1}^{\infty} \frac{1}{(r-2)!} + \frac{1}{(r-1)!} = e + e = 2e$$

11. Let  $f$  be a function such that  $f(x) + 3f\left(\frac{24}{x}\right) = 4x$ ,

- $x \neq 0$ . Then  $f(3) + f(8)$  is equal to  
 (1) 10 (2) 12  
 (3) 13 (4) 11

**Answer (4)**

**Sol.**  $f(x) + 3f\left(\frac{24}{x}\right) = 4x, x \neq 0 \dots(1)$

replace  $x$  by  $\frac{24}{x}$

$$f\left(\frac{24}{x}\right) + 3f\left(\frac{24}{\frac{24}{x}}\right) = 4\left(\frac{24}{x}\right) = \frac{96}{x} \dots(2)$$

$$3 \times (2) - (1)$$

$$\Rightarrow 8f(x) = \frac{96.3}{x} - 4x \Rightarrow f(x) = \frac{36}{x} - \frac{x}{2}$$

$$f(3) + f(8) = \left(12 - \frac{3}{2}\right) + \left(\frac{36}{8} - 4\right)$$

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$$= 8 + \frac{36}{8} - \frac{12}{8} = 11$$

12. The number of solutions of the equation  $(4 - \sqrt{3})\sin x - 2\sqrt{3}\cos^2 x = -\frac{4}{1 + \sqrt{3}}$ ,  $x \in \left[-2\pi, \frac{5\pi}{2}\right]$

is

- (1) 6 (2) 4  
(3) 3 (4) 5

**Answer (4)**

**Sol.**  $(4 - \sqrt{3})\sin x - 2\sqrt{3}\cos^2 x = \frac{-4}{(1 + \sqrt{3})}$

Let  $\sin x = t \Rightarrow \cos^2 x = 1 - t^2$

$$(4 - \sqrt{3})t - 2\sqrt{3}(1 - t^2) = \frac{-4}{(1 + \sqrt{3})}$$

$$\Rightarrow 2\sqrt{3}t^2 + (4 - \sqrt{3})t - 2\sqrt{3} + \frac{4}{1 + \sqrt{3}} = 0$$

$$2\sqrt{3}t^2 + (4 - \sqrt{3})t + \frac{(-2\sqrt{3} - 2)}{(1 + \sqrt{3})} = 0$$

$$2\sqrt{3}t^2 + (4 - \sqrt{3})t - 2 = 0$$

$$\Rightarrow t = \frac{(\sqrt{3} - 4) \pm \sqrt{19 - 8\sqrt{3} + 8(2\sqrt{3})}}{4\sqrt{3}}$$

$$t = \frac{(\sqrt{3} - 4) \pm \sqrt{19 + 8\sqrt{3}}}{4\sqrt{3}} = \frac{(\sqrt{3} - 4) \pm (\sqrt{3} + 4)}{4\sqrt{3}} = \left(\frac{2\sqrt{3}}{4\sqrt{3}}\right) \text{ or } \frac{-8}{4\sqrt{3}}$$

$$\Rightarrow \sin x = \frac{1}{2} \text{ or } \frac{-2}{\sqrt{3}} < -1 \Rightarrow \text{only } \sin x = \frac{1}{2}$$

$$\Rightarrow 5 \text{ solutions in } x \in \left[-2\pi, \frac{5\pi}{2}\right]$$

13. The shortest distance between the curves  $y^2 = 8x$  and  $x^2 + y^2 + 12y + 35 = 0$  is:

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

**Answer (3)**

**Sol.** Equation of normal:  $y = mx - 2am - am^3$  ( $a = 2$ )  
 $y = mx - 4m - 2m^3$

centre of circle:  $c(0, -6)$ , radius = 1

$$-6 = -4m - 2m^3$$

$$\Rightarrow m = 1$$

$$P(am^2, -2am)$$

$$= P(2, -4)$$

Shortest distance:  $CP - r$

$$= \sqrt{4 + 4} - 1$$

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

14. Let  $A = \{-2, -1, 0, 1, 2, 3\}$ . Let  $R$  be a relation on  $A$  defined by  $xRy$  if and only if  $y = \max\{x, 1\}$ . Let  $l$  be the number of elements in  $R$ . Let  $m$  and  $n$  be the minimum number of elements required to be added in  $R$  to make it reflexive and symmetric relations, respectively. Then  $l + m + n$  is equal to

- (1) 12 (2) 11  
(3) 14 (4) 13

**Answer (1)**

**Sol.**  $A = \{-2, -1, 0, 1, 2, 3\}$

$$xRy \Leftrightarrow y = \max\{x, 1\}$$

$$\therefore R = \{(-2, 1), (-1, 1), (0, 1), (1, 1), (2, 2), (3, 3)\}$$

$$l = 6$$

Elements to be added to make it reflexive:

$$\{-2, -2\}, \{-1, -1\}, \{0, 0\}$$

$$\therefore m = 3$$

Elements to be added to make it symmetric:

$$\{1, -2\}, \{1, -1\}, \{1, 0\}$$

$$\therefore n = 3$$

$$l + m + n = 12$$

15. The distance of the point  $(7, 10, 11)$  from the line

$$\frac{x-4}{1} = \frac{y-4}{0} = \frac{z-2}{3} \text{ along the line}$$

$$\frac{x-9}{2} = \frac{y-13}{3} = \frac{z-17}{6} \text{ is}$$

- (1) 16 (2) 18  
(3) 14 (4) 12

**Answer (3)**

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**Sol.** Equation of line passing through  $P(7, 10, 11)$  along the line  $\frac{x-9}{2} = \frac{y-13}{3} = \frac{z-17}{6}$  is

$$\frac{x-7}{2} = \frac{y-10}{3} = \frac{z-11}{6} = \lambda$$

Let the point on the line is

$$Q(2\lambda + 7, 3\lambda + 10, 6\lambda + 11)$$

$$Q \text{ lies on line } \frac{x-4}{1} = \frac{y-4}{0} = \frac{z-2}{3}$$

$$3\lambda + 10 = 4 \Rightarrow \lambda = -2$$

$$\therefore Q(3, 4, -1)$$

$$PQ = \sqrt{16 + 36 + 144} = 14$$

16. Consider the lines  $x(3\lambda + 1) + y(7\lambda + 2) = 17\lambda + 5$ ,  $\lambda$  being a parameter, all passing through a point  $P$ . One of these lines (say  $L$ ) is farthest from the origin. If the distance of  $L$  from the point  $(3, 6)$  is  $d$ , then the value of  $d^2$  is

- (1) 10 (2) 20  
(3) 15 (4) 30

**Answer (2)**

**Sol.**  $x(3\lambda + 1) + y(7\lambda + 2) = 17\lambda + 5$

$$(x + 2y - 5) + \lambda(3x + 7y - 17) = 0$$

$$L_1 + \lambda L_2 = 0$$

$\Rightarrow P$  is intersection of  $L_1$  &  $L_2$  i.e.  $(1, 2)$

$$y - 2 = m(x - 1)$$

$$mx - y + 2 - m = 0$$

$$\text{Distance from origin} = \frac{|2 - m|}{\sqrt{1 + m^2}} = \max$$

$$2y - 4 = -x + 1$$

$$\text{For } m = -\frac{1}{2}$$

$$\therefore L = y - 2 = -\frac{1}{2}(x - 1)$$

$$L: x + 2y - 5 = 0$$

$$\text{Now, } d = \left| \frac{3 + 12 - 5}{\sqrt{5}} \right| = \left| \frac{10}{\sqrt{5}} \right|$$

$$d^2 = \frac{100}{5} = 20$$

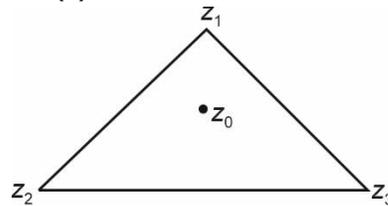
17. If  $z_1, z_2, z_3 \in \mathbb{C}$  are the vertices of an equilateral triangle, whose centroid is  $z_0$ , then  $\sum_{k=1}^3 (z_k - z_0)^2$  is

equal to

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

**Answer (1)**

**Sol.**



$$z_0 = z_1 + z_2 + z_3$$

$$\sum_{k=1}^3 (z_k - z_0)^2 = (z_1 - z_0)^2 + (z_2 - z_0)^2 + (z_3 - z_0)^2$$

Let  $z_0$  is origin  $\Rightarrow z_1, z_2, z_3$  lies on a circle

having  $|z_0 - z| = R$

$$\therefore z_1 = Re^{2\pi/3} \quad z_2 = Re^{4\pi/3} \quad z_3 = Re^{6\pi/3}$$

$$\Rightarrow z_1^2 + z_2^2 + z_3^2 = R^2 [e^{i4\pi/3} + e^{i8\pi/3} + e^{i12\pi/3}]$$

$$= 0$$

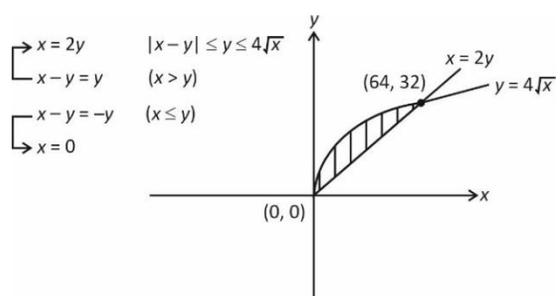
$$\therefore \sum_{k=1}^3 (z_k - z_0)^2 = 0$$

18. The area of the region  $\{(x, y) : |x - y| \leq y \leq 4\sqrt{x}\}$  is

- (1)  $\frac{512}{3}$  (2)  $\frac{1024}{3}$   
(3)  $\frac{2048}{3}$  (4) 512

**Answer (2)**

**Sol.**  $|x - y| \leq y \leq 4\sqrt{x}$



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$$\begin{aligned} \text{Area} &= \int_0^{64} \left( 4\sqrt{x} - \frac{x}{2} \right) dx \\ &= \left[ \frac{4x^{3/2}}{\frac{3}{2}} - \frac{x^2}{4} \right]_0^{64} \end{aligned}$$

19. Let  $y = y(x)$  be the solution of the differential equation  $\frac{dy}{dx} + 3(\tan^2 x)y + 3y = \sec^2 x, y(0) = \frac{1}{3} + e^3$ .

Then  $y\left(\frac{\pi}{4}\right)$  is equal to

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

**Answer (2)**

**Sol.**  $\frac{dy}{dx} + 3(\tan^2 x)y + 3y = \sec^2 x$

$$\Rightarrow \frac{dy}{dx} + 3\sec^2 x y = \sec^2 x$$

$$\begin{aligned} \text{I.F} &= e^{\int 3\sec^2 x dx} \\ &= e^{3\tan x} \end{aligned}$$

$$y \cdot e^{3\tan x} = \int e^{3\tan x} \cdot \sec^2 x dx + c$$

$$y \cdot e^{3\tan x} = \frac{e^{3\tan x}}{3} + c$$

$$\text{Also } f(0) = \frac{1}{3} + e^3$$

$$\Rightarrow \left( \frac{1}{3} + e^3 \right) = \frac{1}{3} + c$$

$$\Rightarrow c = e^3$$

$$\therefore y \cdot e^{3\tan x} = \frac{e^{3\tan x}}{3} + e^3$$

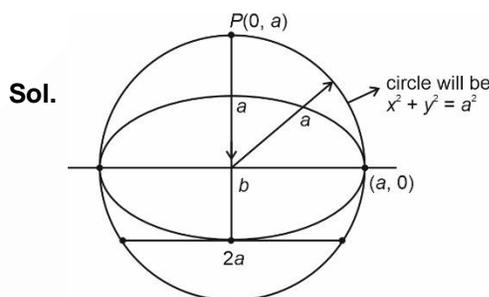
$$\text{Put } x = \frac{\pi}{4}$$

$$ye^3 = \frac{e^3}{3} + e^3 \Rightarrow \boxed{y = \frac{4}{3}}$$

20. Let  $C$  be the circle of minimum area enclosing the ellipse  $E: \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$  with eccentricity  $\frac{1}{2}$  and foci  $(\pm 2, 0)$ . Let  $PQR$  be a variable triangle, whose vertex  $P$  is on the circle  $C$  and the side  $QR$  of length  $2a$  is parallel to the major axis of  $E$  and contains the point of intersection of  $E$  with the negative  $y$ -axis. Then the maximum area of the triangle  $PQR$  is:

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

**Answer (1)**



$$\text{Area} = \frac{1}{2} \times (a + b) \cdot 2a = a(a + b)$$

$$\text{Since, } e = \frac{1}{2} \Rightarrow ae = 2 \Rightarrow a = 4, b = 2\sqrt{3}$$

$$\Rightarrow \text{Area} = 4(4 + 2\sqrt{3}) = 8(2 + \sqrt{3})$$

**SECTION - B**

**Numerical Value Type Questions:** This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. If the equation of the hyperbola with foci  $(4, 2)$  and  $(8, 2)$  is  $3x^2 - y^2 - \alpha x + \beta y + \gamma = 0$ , then  $\alpha + \beta + \gamma$  is equal to \_\_\_\_\_.

**Answer (141)**

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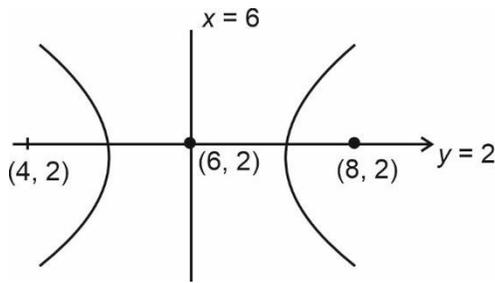
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Given  $\frac{(x-6)^2}{a^2} - \frac{(y-2)^2}{b^2} = 1$   
 $\Rightarrow b^2x^2 - a^2y^2 - 12xb^2 + 4ya^2 + 36b^2 - 4a^2 - a^2b^2 = 0$

Comparing  $\frac{b^2}{a^2} = 3 \Rightarrow e^2 = 1 + \frac{b^2}{a^2}$   
 $\Rightarrow e^2 = 4$   
 $\Rightarrow \boxed{e = 2}$

Similarly,  $2ae = 4$

$\Rightarrow a = 1 \Rightarrow b = \sqrt{3}$   
 $\frac{(x-6)^2}{1} - \frac{(y-2)^2}{3} = 1$   
 $\Rightarrow 3x^2 - y^2 - 36x + 4y + 108 - 4 - 3 = 0$   
 $\Rightarrow 3x^2 - y^2 - 36x + 4y + 101 = 0$   
 $\Rightarrow \alpha = 36, \beta = 4, \gamma = 101$   
 $\Rightarrow \alpha + \beta + \gamma = 141$

22. Let  $I$  be the identity matrix of order  $3 \times 3$  and for the

matrix  $A = \begin{bmatrix} \lambda & 2 & 3 \\ 4 & 5 & 6 \\ 7 & -1 & 2 \end{bmatrix}$ ,  $|A| = -1$ . Let  $B$  be the

inverse of the matrix  $\text{adj}(A \text{adj}(A^2))$ . Then  $|\lambda(B + I)|$  is equal to \_\_\_\_\_.

**Answer (38)**

**Sol.**  $B = [\text{adj}(A \text{adj}(A^2))]^{-1}$

$\text{Adj}(A^2) = (\text{adj}A)^2 \Rightarrow A \text{adj}(A^2) = A \text{adj}(A) \cdot (\text{adj} A)$   
 $= A(|A|A^{-1})^2 = |A|^2(A^{-1}) = A^{-1}$

$\Rightarrow B = (\text{adj}(A^{-1}))^{-1} = (|A^{-1}| A)^{-1} = \frac{A^{-1}}{-1} = -A^{-1}$

$\Rightarrow B = -A^{-1}$

$|A| = -1 = \begin{vmatrix} \lambda & 2 & 3 \\ 4 & 5 & 6 \\ 7 & -1 & 2 \end{vmatrix} = -1 \Rightarrow \lambda = 3$

$|3B + I| = |I - 3A^{-1}| = \frac{|A||I - 3A^{-1}|}{|A|} = \frac{|A - 3I|}{|A|}$

$= \frac{|A - 3I|}{-1} = \begin{vmatrix} 0 & 2 & 3 \\ 4 & 2 & 6 \\ 7 & -1 & -1 \end{vmatrix} = 38$

$\Rightarrow |3B + I| = 38$

23. If  $\lim_{x \rightarrow 0} \left( \frac{\tan x}{x} \right)^{\frac{1}{x^2}} = p$ , then  $96 \log_e p$  is equal to \_\_\_\_\_.

**Answer (32)**

**Sol.**  $\lim_{x \rightarrow 0} \left( \frac{\tan x}{x} \right)^{\frac{1}{x^2}} = p$

$\therefore$  Form:  $1^\infty$

$\Rightarrow p = e^{\lim_{x \rightarrow 0} \left( \frac{\tan x}{x} - 1 \right) \frac{1}{x^2}}$

$= e^{\lim_{x \rightarrow 0} \left( \frac{\tan x - x}{x^3} \right)}$

$= e^{\lim_{x \rightarrow 0} \left( \frac{x + \frac{x^3}{3} + \frac{2}{15}x^5 + \dots - x}{x^3} \right)} = e^{\frac{1}{3}}$

$\Rightarrow \log_e p = \frac{1}{3}$

$\Rightarrow 96 \log_e p = 32$

24. Let  $\vec{a} = \hat{i} + 2\hat{j} + \hat{k}$ ,  $\vec{b} = 3\hat{i} - 3\hat{j} + 3\hat{k}$ ,  $\vec{c} = 2\hat{i} - \hat{j} + 2\hat{k}$  and  $\vec{d}$  be a vector such that  $\vec{b} \times \vec{d} = \vec{c} \times \vec{d}$  and  $\vec{a} \cdot \vec{d} = 4$ . Then  $|(\vec{a} \times \vec{d})|^2$  is equal to \_\_\_\_\_.

**Answer (128)**

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**Sol.**  $\vec{b} \times \vec{d} = \vec{c} \times \vec{d} \Rightarrow (\vec{b} - \vec{c}) \times \vec{d} = 0$

$\Rightarrow (\vec{b} - \vec{c})$  is parallel to  $\vec{d}$

$\Rightarrow \vec{d} = \lambda(\hat{i} - 2\hat{j} + \hat{k})$

$\therefore \vec{a} \cdot \vec{d} = 4$

$\Rightarrow \lambda - 4\lambda + \lambda = 4$

$\Rightarrow \lambda = -2 \Rightarrow \vec{d} = -2\hat{i} + 4\hat{j} - 2\hat{k}$

$$\vec{a} \times \vec{d} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 2 & 1 \\ -2 & 4 & -2 \end{vmatrix} = -8\hat{i} + 0\hat{j} + 8\hat{k}$$

$|\vec{a} \times \vec{d}|^2 = 128$

25. Let  $(1 + x + x^2)^{10} = a_0 + a_1x + a_2x^2 + \dots + a_{20}x^{20}$ . If  $(a_1 + a_3 + a_5 + \dots + a_{19}) - 11a_2 = 121k$ , then  $k$  is equal to \_\_\_\_\_.

**Answer (239)**

**Sol.** Let  $f(x) = (1 + x + x^2)^{10} = \sum_{r=0}^{20} a_r x^r$

The sum of odd coefficients:  $S_{\text{odd}} = a_1 + a_3 + a_5 + \dots + a_{19}$

Subtracting  $11a_2$  from above will give the answer

$$S_{\text{odd}} = \frac{f(1) - f(-1)}{2}$$

$f(1) = (1 + 1 + 1)^{10} = 3^{10}$

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

$$S_{\text{odd}} = \sum_{\text{odd } r} a_r = \frac{3^{10} - 1}{2}$$

Now for  $a_2$

$$1 + x + x^2 = \frac{1 - x^3}{1 - x} \Rightarrow f(x) = \left( \frac{1 - x^3}{1 - x} \right)^{10} = \frac{(1 - x^3)^{10}}{(1 - x)^{10}}$$

Now use:

$$(1 - x^3)^{10} = \sum_{k=0}^{10} (-1)^k \binom{10}{k} x^{3k}$$

$$(1 - x)^{-10} = \sum_{r=0}^{\infty} \binom{r+9}{9} x^r$$

So

$$f(x) = \left( \sum_{k=0}^{10} (-1)^k \binom{10}{k} x^{3k} \right) \cdot \left( \sum_{r=0}^{\infty} \binom{r+9}{9} x^r \right)$$

Only the term with  $x^0$  from the first sum (i.e.,  $k = 0$ ) can contribute to  $x^2$ , since all other  $k \geq 1$  gives  $x^{3k} \geq x^3$

From  $(1 - x^3)^{10}$ : the  $x^0$  term is  $\binom{10}{0} = 1$

From  $(1 - x)^{-10}$ : the coefficient of  $x^2$  is

$$\binom{2+9}{9} = \binom{11}{9} = 55$$

Hence,  $a_2 = 1 \cdot 55 = 55$

Now,  $S_{\text{odd}} - 11a_2 = \frac{3^{10} - 1}{2} - 11 \cdot 55 = 121k$

$3^{10} = 59049$

So:

$$S = \frac{59049 - 1}{2} - 605 = \frac{59048}{2} - 605$$

$= 29524 - 605 = 28919$

So:

$121k = 28919 \Rightarrow k = \frac{28919}{121} = 239$

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**PHYSICS**

**SECTION - A**

**Multiple Choice Questions:** This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

**Choose the correct answers :**

26. A magnetic dipole experiences a torque of  $80\sqrt{3}$  N m when placed in uniform magnetic field in such a way that dipole moment makes angle of  $60^\circ$  with magnetic field. The potential energy of the dipole is :

- (1)  $-80$  J
- (2)  $-40\sqrt{3}$  J
- (3)  $-60$  J
- (4)  $80$  J

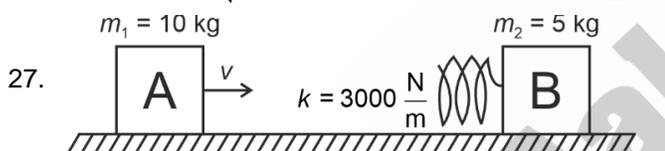
**Answer (1)**

**Sol.**  $\tau = MB \sin\theta$

$$U = -MB \cos\theta$$

$$\frac{U}{\tau} = -\cot\theta$$

$$U = -80\sqrt{3} \times \frac{1}{\sqrt{3}} = -80$$



27.

Consider two blocks A and B of masses  $m_1 = 10$  kg and  $m_2 = 5$  kg that are placed on a frictionless table. The block A moves with a constant speed  $v = 3$  m/s towards the block B kept at rest. A spring with spring constant  $k = 3000$  N/m is attached with the block B as shown in the figure. After the collision, suppose that the blocks A and B, along with the spring in constant compression state, move together, then the compression in the spring is, (Neglect the mass of the spring)

- (1)  $0.2$  m
- (2)  $0.3$  m
- (3)  $0.4$  m
- (4)  $0.1$  m

**Answer (4)**

**Sol.** COLM

$$10 \times 3 + 50 \times 0 = 15V_C$$

$$V_C = 2 \text{ m/s}$$

COME

$$\frac{1}{2} kx^2 = \left| \frac{1}{2} (m + m) V_C^2 - \frac{1}{2} m v_0^2 \right|$$

$$1500x^2 = \left| \frac{1}{2} \times 15 \times 2^2 - \frac{1}{2} \times 10 \times 3^2 \right|$$

$$1500x^2 = |30 - 45|$$

$$x^2 = \frac{15}{1500}$$

$$x = \frac{1}{10} = 0.1 \text{ m}$$

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

**Assertion A :** The Bohr model is applicable to hydrogen and hydrogen-like atoms only

**Reason R :** The formulation of Bohr model does not include repulsive force between electrons.

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

**Answer (4)**

**Sol.** Assertion is correct as a fact, Reason is correct as there are no two electrons for repulsion.

Therefore (4) is most appropriate response

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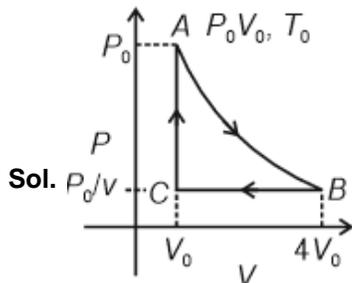
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29. An ideal gas exists in a state with pressure  $P_0$ , volume  $V_0$ . It is isothermally expanded to 4 times of its initial volume ( $V_0$ ), then isobarically compressed to its original volume. Finally the system is heated isochorically to bring it to its initial state. The amount of heat exchanged in this process is

- (1)  $P_0 V_0 (\ln 2 - 0.25)$       (2)  $P_0 V_0 (2 \ln 2 - 0.75)$   
(3)  $P_0 V_0 (2 \ln 2 - 0.25)$       (4)  $P_0 V_0 (\ln 2 - 0.75)$

**Answer (2)**



$$\Delta Q = \Delta v + \Delta W$$

For cyclic process  $\Delta Q = \Delta W$

$$W = W_{AB} + W_{BC} + W_{CA}$$

$$= P_0 V_0 \ln \frac{4V_0}{V_0} + \frac{P_0}{4} (V_0 - 4V_0) + 0$$

$$= P_0 V_0 \ln 4 - \frac{3}{4} P_0 V_0$$

$$= P_0 V_0 (2 \ln 2 - 0.75)$$

30. A particle is projected with velocity  $u$  so that its horizontal range is three times the maximum height attained by it. The horizontal range of the projectile

is given as  $\frac{nu^2}{25g}$ , where value of  $n$  is :

(Given, 'g' is the acceleration due to gravity.)

- (1) 18                                      (2) 6  
(3) 12                                      (4) 24

**Answer (4)**

**Sol.**  $R = 3H$

$$\frac{u^2 \sin 2\theta}{g} = \frac{3u^2 \sin^2 \theta}{2g}$$

$$2 \sin \theta \cos \theta = \frac{3}{2} \sin \theta \sin \theta$$

$$\frac{4}{3} = \tan \theta$$

$$\theta = 53^\circ$$

$$R = \frac{u^2}{g} \times 2 \times \frac{4}{5} \times \frac{3}{5} = \frac{24}{25} \frac{u^2}{g}$$

31. A monochromatic light of frequency  $5 \times 10^{14}$  Hz travelling through air, is incident on a medium of refractive index '2'. Wavelength of the refracted light will be :

- (1) 400 nm                                      (2) 300 nm  
(3) 600 nm                                      (4) 500 nm

**Answer (2)**

**Sol.**  $v = \nu \lambda$

As  $\mu = 2$  therefore; speed  $c \rightarrow \frac{C}{2}$

$$\lambda_r = \frac{C}{2\nu} = \frac{3 \times 10^8}{2 \times 5 \times 10^{14}} = 3 \times 10^{-8} \text{ m}$$

$$= 3 \times 10^{-7} \times 10^9 \text{ nm} = 300 \text{ nm}$$

32. A block of mass 1 kg, moving along x with speed  $v_i = 10$  m/s enters a rough region ranging from  $x = 0.1$  m to  $x = 1.9$  m. The retarding force acting on the block in this range is  $F_r = -kx$  N, with  $k = 10$  N/m. Then the final speed of the block as it crosses rough region is.

- (1) 6 m/s                                      (2) 10 m/s  
(3) 4 m/s                                      (4) 8 m/s

**Answer (4)**

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Sol.  $W = \Delta k$  so  $|W_f| = \text{loss in KE}$

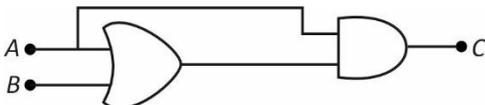
$$\frac{1}{2} k((1.9)^2 - (0.1)^2) = \frac{1}{2} \times 1 \{10^2 - v^2\}$$

$$10 \times 1.8 \times 2 = 100 - v^2$$

$$v^2 = 64$$

$$v = 8 \text{ m/s}$$

33. The truth table corresponding to the circuit given below is :



(1)

A	B	C
0	0	1
0	1	0
1	0	0
1	1	0

(2)

A	B	C
0	0	0
0	1	0
1	0	1
1	1	1

(3)

A	B	C
0	0	1
1	0	0
0	1	0
1	1	0

(4)

A	B	C
0	0	0
1	0	0
0	1	0
1	1	1

Answer (2)

Sol. Logic :  $C = (A + B) \cdot A$   
 $A = A \cdot A + A \cdot B$   
 $= A + A \cdot B$   
 $= A(1 + B)$   
 $C = A$

34. Two monochromatic light beams have intensities in the ratio 1 : 9. An interference pattern is obtained by these beams. The ratio of the intensities of maximum to minimum is

- (1) 3 : 1                      (2) 9 : 1  
 (3) 8 : 1                      (4) 4 : 1

Answer (4)

Sol.  $\frac{I_{\max}}{I_{\min}} = \frac{(\sqrt{I_1} + \sqrt{I_2})^2}{(\sqrt{I_1} - \sqrt{I_2})^2} = \frac{(1+3)^2}{(1-3)^2} = \frac{16}{4} = 4$

35. In the resonance experiment, two air columns (closed at one end) of 100 cm and 120 cm long, give 15 beats per second when each one is sounding in the respective fundamental modes. The velocity of sound in the air column is

- (1) 370 m/s  
 (2) 340 m/s  
 (3) 360 m/s  
 (4) 335 m/s

Answer (3)

Sol.  $f_0 = \frac{v}{4L}$   
 $\Delta f = \frac{v}{4} \left\{ \frac{1}{1} - \frac{1}{1.2} \right\}$   
 $\frac{15 \times 4 \times 1.2}{0.2} = v$

$$360 = v$$

36. Width of one of the two slits in a Young's double slit interference experiment is half of the other slit. The ratio of the maximum to the minimum intensity in the interference pattern is

- (1)  $(2\sqrt{2} + 1) : (2\sqrt{2} - 1)$     (2) 3 : 1  
 (3) 9 : 1                              (4)  $(3 + 2\sqrt{2}) : (3 - 2\sqrt{2})$

Answer (3)

Sol. Amplitude  $\propto$  width

$$\Rightarrow \text{Intensity} \propto \text{width}^2$$

$$I_1 = I, I_2 = 4I; \text{ ratio } \left( \frac{\sqrt{I_1} + \sqrt{I_2}}{\sqrt{I_1} - \sqrt{I_2}} \right)^2$$

$$\text{Ratio} = \left( \frac{1+2}{1-2} \right)^2 = 9$$

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

**Assertion A** : If Oxygen ion ( $O^{2-}$ ) and Hydrogen ion ( $H^+$ ) enter normal to the magnetic field with equal momentum, then the path of  $O^{2-}$  ion has a smaller curvature than that of  $H^+$ .

**Reason R** : A proton with same linear momentum as an electron will form a path of smaller radius of curvature on entering a uniform magnetic field perpendicularly.

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

**Answer (1)**

**Sol.**  $R = \frac{mv}{qB}$

(A)  $mv$ ,  $B$  are same for  $O^{2-}$  &  $H^+$  therefore  $R \propto \frac{1}{|q|}$   
therefore (A) is correct

(B)  $R = \frac{mv}{qB}$ ;  $mv$ ,  $q$ ,  $B$  are same both therefore (R) is incorrect

38. An electric bulb rated as 100W – 220 V is connected to an ac source of rms voltage 220 V. The peak value of current through the bulb is

- (1) 0.64 A
- (2) 0.32 A
- (3) 0.45 A
- (4) 2.2 A

**Answer (1)**

**Sol.**  $R_B = \frac{V^2}{P} = \frac{220 \times 220}{100} = 484$

$$I_{rms} = \frac{V_{rms}}{R} = \frac{220}{484} = \frac{10}{22} = \frac{5}{11}$$

$$I_0 = \frac{5\sqrt{2}}{11} \approx \frac{7.07}{11} \approx 0.64$$

39. Match the **LIST-I** with **LIST-II**.

	LIST-I		LIST-II
A.	Boltzmann constant	I.	$ML^2T^{-1}$
B.	Coefficient of viscosity	II.	$MLT^{-3}K^{-1}$
C.	Planck's constant	III.	$ML^2T^{-2}K^{-1}$
D.	Thermal conductivity	IV.	$ML^{-1}T^{-1}$

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

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

**Answer (1)**

**Sol.**  $kt = \text{Energy} \Rightarrow k = ML^2T^{-2}K^{-1}$

A → III

$$F = 6\pi\eta ru \Rightarrow \eta = \frac{MLT^{-2}}{LLT^{-1}}$$

$$\eta = ML^{-1}T^{-1}$$

B → IV

$$E = hv = h = ML^2T^{-1}$$

C → I

$$H = \frac{kA\Delta T}{l} = k = \frac{ML^2T^{-3}}{LK} = MLT^{-3}K^{-1}$$

D → II

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40. Using a battery, a 100 pF capacitor is charged to 60 V and then the battery is removed. After that, a second uncharged capacitor is connected to the first capacitor in parallel. If the final voltage across the second capacitor is 20 V, its capacitance is: (in pF)

- (1) 100
- (2) 400
- (3) 200
- (4) 600

**Answer (3)**

Sol. 

i.e.  $Q = 60 \times 100 \text{ pC}$

When new capacitance  $C'$  is connected

Then  $Q = (C + C')V$

$60 \times 100 = (100 + C') \times 20$

$200 = C'$

41. A particle moves along the  $x$ -axis and has its displacement  $x$  varying with time  $t$  according to the equation:

$x = c_0(t - 2) + c(t - 2)^2$

Where  $c_0$  and  $c$  are constants of appropriate dimensions. Then, which of the following statements is correct?

- (1) The acceleration of the particle is  $2c_0$
- (2) The initial velocity of the particle is  $4c$
- (3) The acceleration of the particle is  $2c$
- (4) The acceleration of the particle is  $2(c + c_0)$

**Answer (4)**

Sol.  $x = C_0(t - 2) + C(t^2 + 4 - 2t)$

$V = C_0(2t) + C(2t - 2)$

at  $t = 0$

$v = -2C$

$a = 2C_0 + 2C$

42. A motor operating on 100 V draws a current of 1 A. If the efficiency of the motor is 91.6%, then the loss of power in units of cal/s is

- (1) 4
- (2) 6.2
- (3) 8.4
- (4) 2

**Answer (4)**

Sol.  $P_0 = 100 \times 1 = 100 \text{ W}$

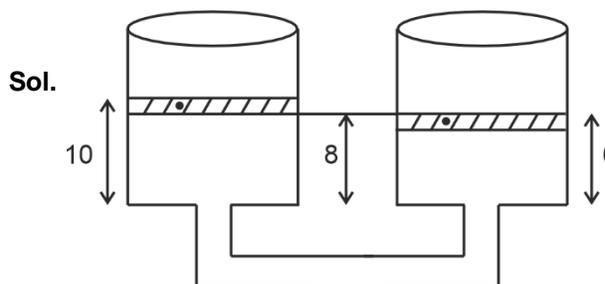
Loss =  $(1 - \eta) P_0 = \frac{8.4}{100} \times 100 = 8.4 \text{ J}$

Loss =  $\frac{8.4}{4.2} \text{ cal} = 2$

43. Two cylindrical vessels of equal cross sectional area of  $2\text{m}^2$  contain water upto heights 10m and 6m, respectively. If the vessels are connected at their bottom then the work done by the force of gravity is (Density of water is  $10^3 \text{ kg/m}^3$  and  $g = 10 \text{ m/s}^2$ )

- (1)  $4 \times 10^4 \text{ J}$
- (2)  $8 \times 10^4 \text{ J}$
- (3)  $6 \times 10^4 \text{ J}$
- (4)  $1 \times 10^5 \text{ J}$

**Answer (2)**



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100  
Percentile  
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Physics



**Harsh Jha**  
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100  
Percentile  
in  
Physics  
& Chemistry



**Devya Rustagi**  
PSID: 00014768785

99.99  
Percentile



**Amogh Bansal**  
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Effectively shaded portion has descended

$$|w| = \Delta mg \Delta h$$

$$= (\rho 2A)g \times 2$$

$$= 10^3 \times 2 \times 40$$

$$= 8 \times 10^4 \text{ J}$$

44. A solid steel ball of diameter 3.6 mm acquired terminal velocity  $2.45 \times 10^{-2}$  m/s while falling under gravity through an oil of density  $925 \text{ kg m}^{-3}$ . Take density of steel as  $7825 \text{ kg m}^{-3}$  and  $g$  as  $9.8 \text{ m/s}^2$ . The viscosity of the oil in SI unit is

- (1) 2.18  
(2) 1.68  
(3) 2.38  
(4) 1.99

**Answer (2)**

**Sol.**  $v = \frac{2}{9} \frac{r^2 g (\sigma - \rho)}{\eta}$

$$\eta = \frac{2}{9} \times \frac{1.8 \times 1.8 \times 10^{-6} \times 10}{2.45 \times 10^{-2}} \{7825 - 925\}$$

$$\approx 2$$

45. Pressure of an ideal gas, contained in a closed vessel, is increased by 0.4% when heated by  $1^\circ\text{C}$ .

Its initial temperature must be:

- (1)  $25^\circ\text{C}$   
(2)  $250^\circ\text{C}$   
(3)  $250 \text{ K}$   
(4)  $2500 \text{ K}$

**Answer (3)**

**Sol.** For constant volume

$$\frac{P}{T} = \text{constant}$$

$$\frac{\Delta P}{P} = \frac{\Delta T}{T}$$

$$\frac{0.4}{100} = \frac{1}{T}$$

$$T = \frac{100}{0.4} = 250 \text{ K}$$

**SECTION - B**

**Numerical Value Type Questions:** This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

46. Two cells of emfs 1 V and 2 V and internal resistances  $2 \Omega$  and  $1 \Omega$ , respectively, are connected in series with an external resistance of  $6 \Omega$ . The total current in the circuit is  $I_1$ . Now the same two cells in parallel configuration are connected to same external resistance. In this case, the total current drawn is  $I_2$ .

The value of  $\left(\frac{I_1}{I_2}\right)$  is  $\frac{x}{3}$ . The value of  $x$  is

**Answer (4)**

**Sol.**  $I_1 = \frac{\varepsilon_1 + \varepsilon_2}{r_1 + r_2 + R} = \frac{1+2}{2+1+6} = \frac{3}{9} = \frac{1}{3}$

$$I_2 = \frac{\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{R}} = \frac{\frac{1}{2} + \frac{2}{1}}{\frac{1}{2} + \frac{1}{1} + \frac{1}{6}} = \frac{5 \times 2 \times 3}{2 \times 3 \times 20}$$

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

$$\frac{I_1}{I_2} = \frac{1}{3} \times \frac{4}{1} = \frac{4}{3}$$

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5 above

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in  
**100**  
Percentile



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**100**  
Percentile  
in  
**100**  
Percentile



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**99.99**  
Percentile  
in  
**99.99**  
Percentile



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47. An electron in the hydrogen atom initially in the fourth excited state makes a transition to  $n^{\text{th}}$  energy state by emitting a photon of energy 2.86 eV. The integer value of  $n$  will be \_\_\_\_\_.

**Answer (2)**

**Sol.**  $E_n = 13.6 \left( \frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$

$$2.86 = 13.6 \left[ \frac{1}{25} - \frac{1}{n^2} \right]$$

$$\Rightarrow \frac{2.86}{13.6} + \frac{1}{25} = \frac{1}{n^2}$$

$$\frac{1}{n^2} = 0.25$$

$$n^2 = 4$$

$$\Rightarrow \boxed{n = 2}$$

48. A physical quantity  $C$  is related to four other quantities

$$p, q, r \text{ and } s \text{ as follows } C = \frac{pq^2}{r^3 \sqrt{s}}$$

The percentage errors in the measurement of  $p, q, r$  and  $s$  are 1%, 2%, 3% and 2%, respectively. The percentage error in the measurement of  $C$  will be \_\_\_\_\_ %.

**Answer (15)**

**Sol.**  $\frac{\Delta C}{C} = \frac{\Delta p}{p} + 2 \frac{\Delta q}{q} + \frac{3\Delta r}{r} + \frac{1}{2} \frac{\Delta s}{s}$

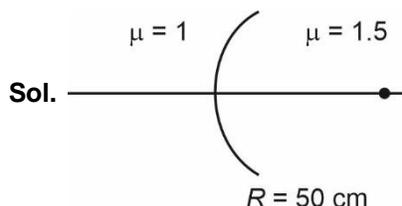
$$\% \text{ error} = 1 + 2 \times 2 + 3 \times 3 + \frac{1}{2} \times 2$$

$$= 1 + 4 + 9 + 1$$

$$= 15$$

49. Light from a point source in air falls on a spherical glass surface (refractive index,  $\mu = 1.5$  and radius of curvature = 50 cm). The image is formed at a distance of 200 cm from the glass surface inside the glass. The magnitude of distance of the light source from the glass surface is \_\_\_\_\_ m.

**Answer (4)**



**Sol.**

$$v = 200 \text{ cm}$$

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

$$\frac{1.5}{200} - \frac{1}{u} = \frac{1.5 - 1}{50} = \frac{1}{100}$$

$$\frac{1}{u} = \frac{15}{2000} - \frac{1}{100} = \frac{15 - 20}{2000} = \frac{-5}{2000}$$

$$u = -400 \text{ cm} = -4 \text{ m}$$

50. The excess pressure inside a soap bubble  $A$  in air is half the excess pressure inside another soap bubble  $B$  in air. If the volume of the bubble  $A$  is  $n$  times the volume of the bubble  $B$ , then, the value of  $n$  is \_\_\_\_\_.

**Answer (8)**

**Sol.**  $\frac{2s}{r_1} = \frac{12s}{r_2}$

$$r_1 = 2r_2$$

$$\text{Ratio} = \frac{\frac{4}{3} \pi r_1^3}{\frac{4}{3} \pi r_2^3} = 8$$

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in  
Physics



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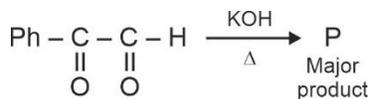
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**SECTION - A**

**Multiple Choice Questions:** This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

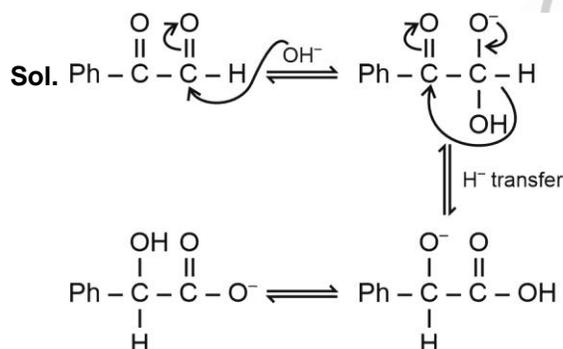
**Choose the correct answer :**

51. The major product (P) in the following reaction is



- (1)  $\text{Ph}-\underset{\text{O}}{\underset{\parallel}{\text{C}}}-\text{CH}_2\text{OH}$       (2)  $\text{Ph}-\underset{\text{OH}}{\text{CH}}-\text{COO}^-\text{K}^+$
- (3)  $\text{Ph}-\underset{\text{OH}}{\text{CH}}-\text{CH}_2\text{OH}$       (4)  $\text{Ph}-\underset{\text{O}}{\underset{\parallel}{\text{C}}}-\text{COO}^-\text{K}^+$

**Answer (2)**



52. Given below are two statements:

**Statement I :** Hyperconjugation is not a permanent effect.

**Statement II :** In general, greater the number of alkyl groups attached to a positively charged C-atom, greater is the hyperconjugation interaction and stabilization of the cation.

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) **Statement I** is false but **Statement II** is true  
 (3) Both **Statement I** and **Statement II** are false  
 (4) **Statement I** is true but **Statement II** is false

**Answer (2)**

**Sol.** Hyperconjugation is a permanent effect.

With increase in number of  $\alpha$ -H which increases with number of alkyl groups attached to positively charged C, hyperconjugation increases.

53. Identify the diamagnetic octahedral complex ions from below :

- A.  $[\text{Mn}(\text{CN})_6]^{3-}$   
 B.  $[\text{Co}(\text{NH}_3)_6]^{3+}$   
 C.  $[\text{Fe}(\text{CN})_6]^{4-}$   
 D.  $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$

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

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

**Answer (2)**

**Sol.**  $[\text{Mn}(\text{CN})_6]^{3-} : \text{Mn}^{3+} : [\text{Ar}]4s^03d^4 : t_{2g}^4e_g^0$

Octahedral, paramagnetic

$[\text{Co}(\text{NH}_3)_6]^{3+} : \text{Co}^{3+} : [\text{Ar}]4s^03d^6 : t_{2g}^6e_g^0$

Octahedral, diamagnetic

$[\text{Fe}(\text{CN})_6]^{4-} : \text{Fe}^{2+} : [\text{Ar}]4s^03d^6 : t_{2g}^6e_g^0$

Octahedral, diamagnetic

$[\text{Co}(\text{H}_2\text{O})_6]^{3+} : \text{Co}^{3+} : [\text{Ar}]4s^03d^6 : t_{2g}^4e_g^2$

Octahedral, paramagnetic

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54. Given below are two statements:

**Statement I :** When a system containing ice in equilibrium with water (liquid) is heated, heat is absorbed by the system and there is no change in the temperature of the system until whole ice gets melted.

**Statement II :** At melting point of ice, there is absorption of heat in order to overcome intermolecular forces of attraction within the molecules of water in ice and kinetic energy of molecules is not increased at melting point.

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) **Statement I** is true but **Statement II** is false
- (3) Both **Statement I** and **Statement II** is false
- (4) **Statement I** is false but **Statement II** is true

**Answer (1)**

**Sol.**  $\text{H}_2\text{O}(s) \rightleftharpoons \text{H}_2\text{O}(l)$

In phase transition, heat provided is used to change solid ice to liquid water at constant temperature, hence there is no change in temperature and kinetic energy.

55. Given below are two statements:

**Statement I :** Wet cotton clothes made of cellulose based carbohydrate takes comparatively longer time to get dried than wet nylon polymer based clothes.

**Statement II :** Intermolecular hydrogen bonding with water molecule is more in nylon-based clothes than in the case of cotton clothes.

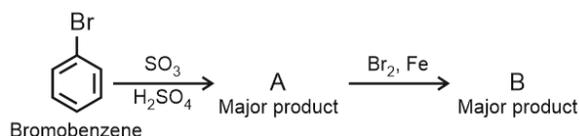
In the light of above statements, choose the **correct** answer from the options given below.

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

**Answer (2)**

**Sol.** Wet cellulose-based cotton clothes take longer time to dry than wet nylon-based clothes due to more number of H-bonds between cellulose and water molecules. So, Statement-I is correct, Statement-II is incorrect.

56. In the following series of reactions identify the major products A & B respectively



- |     |   |
|-----|---|
| A   | B |
|     |   |
| (1) |   |
| A   | B |
|     |   |
| (2) |   |
| A   | B |
|     |   |
| (3) |   |
| A   | B |
|     |   |
| (4) |   |

**Answer (1)**

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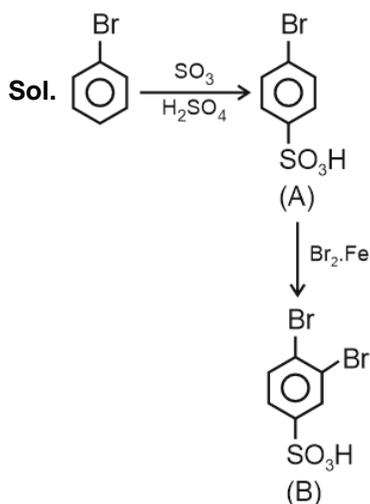
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57. Given below are two statements:

**Statement I:**  $\text{CrO}_3$  is a stronger oxidizing agent than  $\text{MoO}_3$

**Statement II:**  $\text{Cr(VI)}$  is more stable than  $\text{Mo(VI)}$

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

**Answer (1)**

Sol. Oxidising strength :  $\text{CrO}_3 > \text{MoO}_3$

Stability :  $\text{Cr}^{6+} < \text{Mo}^{6+}$

58. Mass of magnesium required to produce 220 mL of hydrogen gas at STP on reaction with excess of dil. HCl is

Given: Molar mass of Mg is  $24 \text{ g mol}^{-1}$ .

- (1) 235.7 g
- (2) 0.24 mg
- (3) 2.444 g
- (4) 236 mg

**Answer (4)**



$$\text{Moles of H}_2 = \frac{220}{22400} \text{ moles}$$

$$\text{Mass of Mg} = \frac{220}{22400} \times 24 = 0.236 \text{ g} = 236 \text{ mg}$$

59. Compounds that should not be used as primary standards in titrimetric analysis are :

- A.  $\text{Na}_2\text{Cr}_2\text{O}_7$
- B. Oxalic acid
- C. NaOH
- D.  $\text{FeSO}_4 \cdot 6\text{H}_2\text{O}$
- E. Sodium tetraborate

Choose the **most appropriate** answer from the options given below:

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

**Answer (2)**

Sol. Compounds like NaOH,  $\text{FeSO}_4 \cdot 6\text{H}_2\text{O}$ ,  $\text{Na}_2\text{Cr}_2\text{O}_7$  are not suitable as primary standards in titrimetric analysis because they are hygroscopic, unstable or difficult to obtain in a pure state.

60. Consider the following statements related to temperature dependence of rate constants.

Identify the correct statements.

- A. The Arrhenius equation holds true only for an elementary homogenous reaction.
- B. The unit of A is same as that of k in Arrhenius equation.
- C. At a given temperature, a low activation energy means a fast reaction.
- D. A and  $E_a$  as used in Arrhenius equation depend on temperature.
- E. When  $E_a \gg RT$ , A and  $E_a$  become interdependent.

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1 AIR-34 CBZ  
JEE (Main) 2024

Choose the correct answer from the options given below.

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

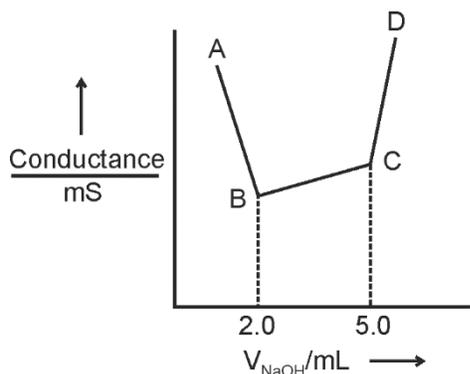
**Answer (1)**

**Sol.**  $k = Ae^{-E_a/RT}$

If  $E_a \downarrow : k \uparrow$

$k$  and  $A$  has same units.

61. 40 mL of a mixture of  $\text{CH}_3\text{COOH}$  and  $\text{HCl}$  (aqueous solution) is titrated against 0.1 M  $\text{NaOH}$  solution conductometrically. Which of the following statement is **correct**?



- (1) The concentration of  $\text{HCl}$  in the original mixture is 0.005 M  
(2) Point 'C' indicates the complete neutralisation of  $\text{HCl}$   
(3)  $\text{CH}_3\text{COOH}$  is neutralised first followed by neutralisation of  $\text{HCl}$   
(4) The concentration of  $\text{CH}_3\text{COOH}$  in the original mixture is 0.005 M

**Answer (1)**

**Sol.**  $\text{CH}_3\text{COOH} + \text{NaOH} \rightarrow \text{CH}_3\text{COONa} + \text{H}_2\text{O}$

$\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}$

At first  $\text{NaOH}$  reacts with  $\text{HCl}$ , replacing fast moving  $\text{H}^+$  ions by slow moving  $\text{Na}^+$  ions, hence conductivity decreases.

At point B, eq. of  $\text{HCl} = \text{eq. of NaOH}$

Hence,  $[\text{HCl}] = \frac{2 \times 0.1}{42} = 0.005 \text{ M}$

62. In Dumas' method for estimation of nitrogen 0.4 g of an organic compound gave 60 mL of nitrogen collected at 300 K temperature and 715 mm Hg pressure. The percentage composition of nitrogen in the compound is

(Given : Aqueous tension at 300 K = 15 mm Hg)

- (1) 7.85%                                      (2) 20.95%  
(3) 17.46%                                      (4) 15.71%

**Answer (4)**

**Sol.**  $P_{\text{N}_2} = 715 - 15 = 700 \text{ mm Hg}$

$$n_{\text{N}_2} = \frac{PV}{RT} = \frac{700 \times 60}{760 \times 1000 \times 0.0821 \times 300}$$

$$n_{\text{N}_2} = 2.24 \times 10^{-3}$$

$$\% \text{N}_2 = \frac{2.24 \times 10^{-3} \times 28}{0.4} \times 100$$

$$= 15.71\%$$

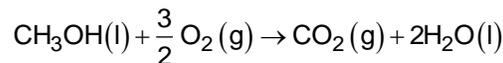
63. The standard cell potential ( $E_{\text{cell}}^\ominus$ ) of a fuel cell based on the oxidation of methanol in air that has been used to power television relay station is measured as 1.21 V. The standard half cell reduction potential for  $\text{O}_2$  ( $E_{\text{O}_2/\text{H}_2\text{O}}^\ominus$ ) is 1.229 V.

Choose the correct statement :

- (1) The standard half cell reduction potential for the reduction of  $\text{CO}_2$  ( $E_{\text{CO}_2/\text{CH}_3\text{OH}}^\ominus$ ) is 19 mV  
(2) Reduction of methanol takes place at the cathode  
(3) Reactants are fed at one go to each electrode  
(4) Oxygen is formed at the anode

**Answer (1)**

**Sol.** Fuel cell reaction



Here  $\text{O}_2$  reduces to  $\text{H}_2\text{O}$  and  $\text{CH}_3\text{OH}$  oxidises to  $\text{CO}_2$ .

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**Sanvi Jain**  
4 Year Classroom  
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Hence,

$$E_{\text{cell}}^{\circ} = E_{\text{O}_2/\text{H}_2\text{O}}^{\circ} - E_{\text{CO}_2/\text{CH}_3\text{OH}}^{\circ}$$

$$1.21 = 1.229 - E_{\text{CO}_2/\text{CH}_3\text{OH}}^{\circ}$$

$$E_{\text{CO}_2/\text{CH}_3\text{OH}}^{\circ} = 0.019 \text{ V}$$

64. The correct orders among the following are

Atomic radius :  $\text{B} < \text{Al} < \text{Ga} < \text{In} < \text{Tl}$

Electronegativity :  $\text{Al} < \text{Ga} < \text{In} < \text{Tl} < \text{B}$

Density :  $\text{Tl} < \text{In} < \text{Ga} < \text{Al} < \text{B}$

1<sup>st</sup> Ionisation energy :  $\text{In} < \text{Al} < \text{Ga} < \text{Tl} < \text{B}$

Choose the correct answer from the options given below :

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

**Answer (3)**

**Sol.** EN :  $\text{B} > \text{Tl} > \text{In} > \text{Ga} > \text{Al}$

(2.0) (1.8) (1.7) (1.6) (1.5)

IE<sub>1</sub> :  $\text{B} > \text{Tl} > \text{Ga} > \text{Al} > \text{In}$

(801) (589) (579) (577) (558) (in kJ/mol)

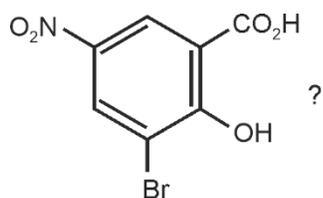
Density :  $\text{Tl} > \text{In} > \text{Ga} > \text{Al} > \text{B}$

(11.85) (7.31) (5.9) (2.7) (2.35) (in g/ml)

Atomic radius:  $\text{B} < \text{Ga} < \text{Al} < \text{In} < \text{Tl}$

(85) (135) (143) (167) (170) (in pm)

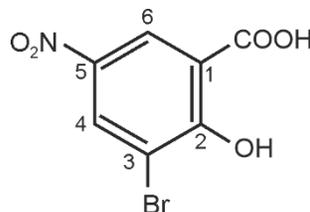
65. What is the correct IUPAC name of



- (1) 3-Bromo-4-hydroxy-1-nitrobenzoic acid  
(2) 3-Bromo-2-hydroxy-5-nitrobenzoic acid  
(3) 2-Hydroxy-3-bromo-5-nitrobenzoic acid  
(4) 5-Nitro-3-bromo-2-hydroxybenzoic acid

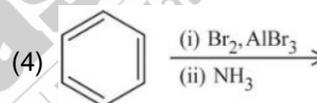
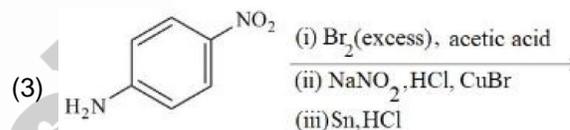
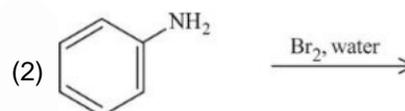
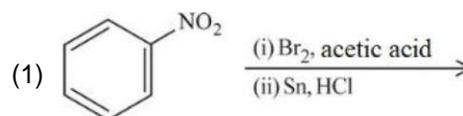
**Answer (2)**

**Sol.**



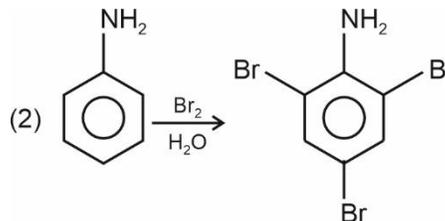
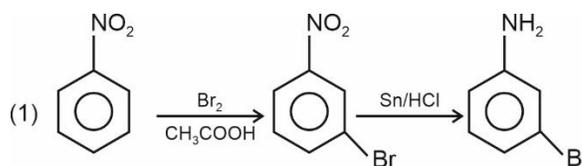
3-Bromo-2-hydroxy-5-nitrobenzoic acid

66. The sequence from the following that would result in giving predominantly 3, 4, 5-Tribromoaniline is



**Answer (3)**

**Sol.**



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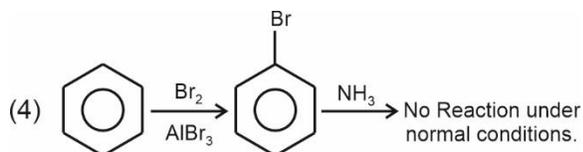
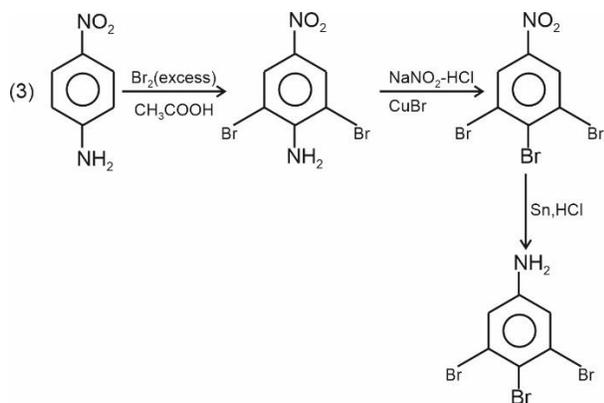
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67. Fast soluble vitamins are:

- (A) Vitamin B<sub>1</sub>                      (B) Vitamin C  
(C) Vitamin E                        (D) Vitamin B<sub>12</sub>  
(E) Vitamin K

Choose the correct answer from the options given below:

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

**Answer (4)**

**Sol.** Fat soluble vitamins are : A, D, E and K.

68. Match the List-I with List-II.

	List-I (Family)		List-II (Symbol of Element)
A.	Pnictogen (group 15)	I.	Ts
B.	Chalcogen	II.	Og
C.	Halogen	III.	Lv
D.	Noble gas	IV.	Mc

Choose the correct answer from the options given below.

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

**Answer (1)**

**Sol.**

A.	Pnictogen (group 15)	IV.	Mc
B.	Chalcogen	III.	Lv
C.	Halogen	I.	Ts
D.	Noble gas	II.	Og

69. 10 mL of 2 M NaOH solution is added to 20 mL of 1 M HCl solution kept in a beaker. Now, 10 mL of this mixture is poured into a volumetric flask of 100 mL containing 2 moles of HCl and made the volume upto the mark with distilled water. The solution in this flask.

- (1) 10 M HCl solution  
(2) 20 M HCl solution  
(3) Neutral solution  
(4) 0.2 M NaCl solution

**Answer (2)**

**Sol.** 10 mL of 2 M NaOH reacts with 20 mL of 1 M HCl to give completely neutralised 30 mL of NaCl (20 mmole) solution.

10 mL of this solution has  $\frac{20}{30} \times 10 = \frac{20}{3}$  mmol of NaCl

In Final 100 mL solution :

$$[\text{HCl}] = \frac{2}{100} \times 1000 = 20\text{M}$$

$$[\text{NaCl}] = \frac{20}{3 \times 100} = \frac{1}{15}\text{M}$$

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70. For electrons in '2s' and '2p' orbitals, the orbital angular momentum values, respectively are

(1) 0 and  $\sqrt{2} \frac{h}{2\pi}$       (2) 0 and  $\sqrt{6} \frac{h}{2\pi}$

(3)  $\sqrt{2} \frac{h}{2\pi}$  and 0      (4)  $\frac{h}{2\pi}$  and  $\sqrt{2} \frac{h}{2\pi}$

**Answer (1)**

**Sol.** Orbital angular momentum =  $\frac{h}{2\pi} \sqrt{l(l+1)}$

For 2s;

$l = 0$

Orbital angular momentum = 0

For 2p;

$l = 1 \Rightarrow \frac{h}{2\pi} \sqrt{l(l+1)} = \frac{\sqrt{2}h}{2\pi} = \frac{h}{(\sqrt{2})\pi}$

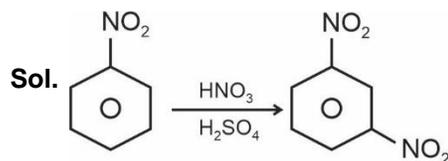
**SECTION - B**

**Numerical Value Type Questions:** This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

71. X g of nitrobenzene on nitration gave 4.2 g of m-dinitrobenzene. X = \_\_\_\_\_ g. (nearest integer)

[Given: molar mass (in g mol<sup>-1</sup>) C: 12, H: 1, O: 16, N: 14]

**Answer (3)**



$\frac{X}{123} = \frac{4.2}{168}$

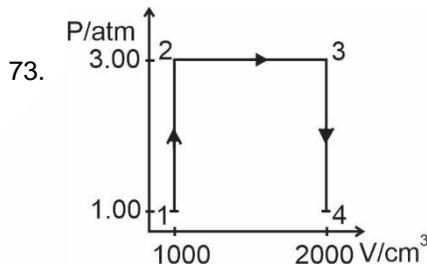
X = 3.075 g

72. A sample of n-octane (1.14 g) was completely burnt in excess of oxygen in a bomb calorimeter, whose heat capacity is 5 kJ K<sup>-1</sup>. As a result of combustion reaction, the temperature of the calorimeter is increased by 5 K. The magnitude of the heat of combustion of octane at constant volume is \_\_\_\_\_ kJ mol<sup>-1</sup> (nearest integer).

**Answer (2500)**

**Sol.** Q = CΔT = 5 × 5 = 25 kJ

$Q_v = \frac{25}{1.14} \times 114 = 2500 \text{ kJ mol}^{-1}$



A perfect gas (0.1 mol) having  $\bar{C}_v = 1.50R$  (independent of temperature) undergoes the above transformation from point 1 to point 4. If each step is reversible, the total work done (w) while going from point 1 to point 4 is (–) \_\_\_\_\_ J (nearest integer)

[Given: R = 0.082 L atm K<sup>-1</sup> mol<sup>-1</sup>]

**Answer (304)**

**Sol.** |w| = area under the curve

$|w| = 3 \times (2000 - 1000)$

= 3000 mL atm

= 3 L atm

$|w| = 3 \times 101.3 \text{ J}$

= 303.9 J

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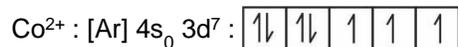
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74. Among, Sc, Mn, Co and Cu, identify the element with highest enthalpy of atomisation. The spin only magnetic moment value of that element in its +2 oxidation state is \_\_\_\_\_ BM (in nearest integer).

**Answer (4)**

**Sol.** Enthalpy of atomisation of : Sc = 326 kJ/mol, Mn = 281 kJ/mol, Co = 425 kJ/mol, Cu = 338 kJ/mol

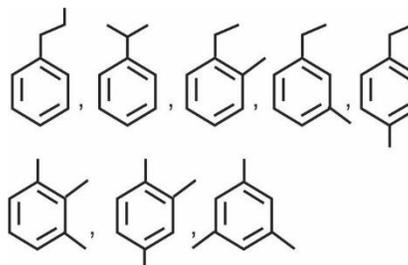


$$\mu = \sqrt{3(3+2)} = \sqrt{15} = 3.87$$

75. The total number of structural isomers possible for the substituted benzene derivatives with the molecular formula  $\text{C}_9\text{H}_{12}$  is \_\_\_\_\_.

**Answer (8)**

**Sol.** Degree of unsaturation =  $\frac{2 \times 9 + 2 - 12}{2} = 4$



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