# FIITJEE

# Solutions to JEE(Main) -2024

## Test Date: 5th April 2024 (First Shift)

# MATHEMATICS, PHYSICS & CHEMISTRY

## Paper – 1

**Time Allotted: 3 Hours** **Maximum Marks: 300**

- Please read the instructions carefully. You are allotted 5 minutes specifically for this purpose.

***Important Instructions:***

1. The test is of 3 hours duration.
2. This test paper consists of 90 questions. Each subject (MPC) has 30 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 :** Do any 5 questions out of 10 Questions.
6. **Section-A (01 – 20, 31 – 50, 61 – 80)** contains 60 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 – 30, 51 – 60, 81 – 90)** contains 30 Numerical based questions. The answer to each question is rounded off to the nearest integer value. Each question carries **+4 marks** for correct answer and **–1 mark** for wrong answer.

***Note: For the benefit of the students, specially the aspiring ones, the question of JEE(Main), 2024 are also given in this booklet. Keeping the interest of students studying in class XI, the questions based on topics from class XI have been marked with '*', which can be attempted as a test.***

# PART – A (MATHEMATICS)

## SECTION - A

**(One Options Correct Type)**

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

**Q1.** Suppose $\theta \in \left[0, \frac{\pi}{4}\right]$ is a solution of $4\cos\theta - 3\sin\theta = 1$. Then $\cos\theta$ is equal to:

(A) $\frac{4}{(3\sqrt{6}+2)}$ (B) $\frac{6-\sqrt{6}}{(3\sqrt{6}-2)}$

(C) $\frac{4}{(3\sqrt{6}-2)}$ (D) $\frac{6+\sqrt{6}}{(3\sqrt{6}+2)}$.

**Ans.** **C**

**Sol.** $4\cos\theta - 3\sin\theta = 1$

$\Rightarrow \quad 4\cos\theta - 1 = 3\sin\theta$

Squaring both side, we get

$\Rightarrow (4\cos\theta - 1)^2 = (3\sin\theta)^2$

$\Rightarrow 16\cos^2\theta + 1 - 8\cos\theta = 9\left(1 - \cos^2\theta\right)$

$\Rightarrow 25\cos^2\theta - 8\cos\theta - 8 = 0$

$\cos\theta = \frac{4 \pm 6\sqrt{6}}{25}$

As, $\theta \in \left[0, \frac{\pi}{4}\right] \Rightarrow \cos\theta = \frac{4+6\sqrt{6}}{25}$

$\Rightarrow \cos\theta = \frac{(4+6\sqrt{6})(4-6\sqrt{6})}{25(4-6\sqrt{6})}$

$\Rightarrow \cos\theta = \frac{4}{3\sqrt{6}-2}$

**Q2.** If $\frac{1}{\sqrt{1}+\sqrt{2}} + \frac{1}{\sqrt{2}+\sqrt{3}} + \ldots + \frac{1}{\sqrt{99}+\sqrt{100}} = m$ and $\frac{1}{1.2} + \frac{1}{2.3} + \ldots + \frac{1}{99.100} = n$, then the point (m, n) lies on the line

(A) 11 (x – 2) – 100 (y – 1) = 0 (B) 11 (x – 1) – 100 (y – 2) = 0

(C) 11 (x – 1) – 100y = 0 (D) 11x – 100y = 0

**Ans.** **D**

**Sol.** $m = \frac{1}{\sqrt{1}+\sqrt{2}} + \frac{1}{\sqrt{2}+\sqrt{3}} + \cdots - \frac{1}{\sqrt{99}+\sqrt{100}}$

$\Rightarrow M = \frac{2-1}{\sqrt{1}+\sqrt{2}} + \frac{3-2}{\sqrt{2}+\sqrt{3}} + \cdots + \frac{(100-99)}{\sqrt{99}+\sqrt{100}}$

$\Rightarrow M = \frac{(\sqrt{2}+1)(\sqrt{2}-1)}{(\sqrt{2}+\sqrt{1})} + \frac{(\sqrt{3}+\sqrt{2})(\sqrt{3}-\sqrt{2})}{(\sqrt{3}+\sqrt{2})} + \cdots \frac{(\sqrt{100}+\sqrt{99})(\sqrt{100}-\sqrt{99})}{(\sqrt{99}+\sqrt{100})}$

$\Rightarrow M = \sqrt{2} - 1 + \sqrt{3} - \sqrt{2} + \cdots \sqrt{100} - \sqrt{99}$

$\Rightarrow M = \sqrt{100} - 1$

$\Rightarrow M = 10 - 1 = 9$

$n = \frac{1}{1.2} + \frac{1}{2.3} + \frac{1}{3.4} + \cdots + \frac{1}{99.100}$

$\Rightarrow n = \frac{2-1}{1.2} + \frac{3-2}{2.3} + \cdots - \cdots + \frac{100-99}{99.100}$

$\Rightarrow n = \left(1 - \frac{1}{2}\right) + \left(\frac{1}{2} - \frac{1}{3}\right) + \cdots + \left(\frac{1}{99} - \frac{1}{100}\right)$

$\Rightarrow n = 1 - \frac{1}{100} = \frac{99}{100}$

$\left(9, \frac{99}{100}\right)$ lies on line: $11x - 100y = 0$

**Q3.** The integral $\int_0^{\pi/4} \frac{136\sin x}{3\sin x + 5\cos x}\,dx$ is equal to :

(A) $3\pi - 25\log_e 2 + 10\log_e 5$

(B) $3\pi - 30\log_e 2 + 20\log_e 5$

(C) $3\pi - 50\log_e 2 + 20\log_e 5$

(D) $3\pi - 10\log_e(2\sqrt{2}) + 10\log_e 5$

**Ans.** **C**

**Sol.** $I = \int_0^{\frac{\pi}{4}} \frac{136\sin x}{3\sin x + 5\cos x}dx$

$136\sin x = A(3\sin x + 5\cos x) + Bd(3\sin x + 5\cos x)$

$\Rightarrow 136\sin x = A(3\sin x + 5\cos x) + B(3\cos x - 5\sin x)$

$\Rightarrow 136\sin x = (3A - 5B)\sin x + (5A + 3B)\cos x$

$136 = 3A - 5B$ .....(1)

$0 = 5A + 3B$ .....(2)

$\Rightarrow 3B = -5A$

$\Rightarrow B = \frac{-5}{3}A$

Putting the value of B in equation (1), we get

$136 = 3A - 5\left(\frac{-5}{3}A\right)$

$\Rightarrow 136 = 3A + \frac{25A}{3}$

$\Rightarrow A = 12$

$\Rightarrow B = \frac{-5}{3} \times A = \frac{-5}{3} \times 12 = -20$

$I = \int_0^{\frac{\pi}{4}} \frac{12(3\sin x + 5\cos x)}{3\sin x + 5\cos x} + \int_0^{\frac{\pi}{4}} \frac{-20(3\cos x - 5\sin x)}{3\sin x + 5\cos x}$

$= 12(x)_0^{\frac{\pi}{4}} + (-20)\int_0^{\frac{\pi}{4}} \frac{dt}{t} \quad \begin{bmatrix} 3\sin x + 5\cos x = t \\ dt = 3\cos x - 5\sin x \end{bmatrix}$

$= 12.\frac{\pi}{4} - 20[\ell n(3\sin x + 5\cos x)]_0^{\pi/4}$

$= 3\pi - 20\left[\ell n\left(\frac{3}{\sqrt{2}} + \frac{5}{\sqrt{2}}\right) - \ell n(0+5)\right]$

$= 3\pi - 20\ell n(4\sqrt{2}) + 20\ell n 5$

$= 3\pi - 20 \times \frac{5}{2} \ell n 2 + 20 \ell n 5$

$= 3\pi - 50 \log_e 2 + 20 \log_e 5$

**Q4.** Let two straight lines drawn from the origin O intersect the line 3x + 4y = 12 at the points P and Q such that $\Delta OPQ$ is an isosceles triangle and $\angle POQ = 90°$. If $l = OP^2 + PQ^2 + QO^2$, then the greatest integer less than or equal to l is :

(A) 42 (B) 44

(C) 48 (D) 46

**Ans.** **D**

**Sol.** $3x + 4y = 12$

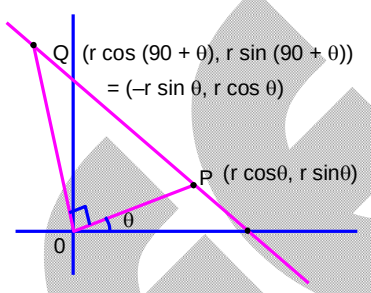
$\Rightarrow 3(r\cos\theta) + 4(r\sin\theta) = 12$

$\Rightarrow r(3\cos\theta + 4\sin\theta) = 12$

$3(-r\sin\theta) + 4(r\cos\theta) = 12$

$\Rightarrow r(-3\sin\theta + 4\cos\theta) = 12$

Squaring (1) and (2), we get




$\left(\frac{12}{r}\right)^2 + \left(\frac{12}{r}\right)^2 = (3\cos\theta + 4\sin\theta)^2 + (-3\sin\theta + 4\cos\theta)^2$

$\Rightarrow 2\left(\frac{12}{r}\right)^2 = 9 + 16$

$\Rightarrow 2 \times \frac{144}{r^2} = 25$

$\Rightarrow r^2 = \frac{288}{25}$

$\Rightarrow r = \sqrt{2}\left(\frac{12}{5}\right)$

$\ell = OP^2 + PQ^2 + QO^2$

$= \left[(r\cos\theta)^2 + (r\sin\theta)^2\right] + \left[(-r\sin\theta)^2 + (r\cos\theta)^2\right] + \left[(-r\sin\theta - r\cos\theta)^2 + (r\cos\theta - r\sin\theta)^2\right]$

$= r^2 + r^2 + r^2\sin^2\theta + r^2\cos^2\theta + 2r^2\sin\theta\cos\theta + r^2\cos^2\theta + r^2\sin^2 - 2r^2\sin\theta\cos\theta$

$= 4r^2 = 4\left(\frac{288}{25}\right) = \frac{1152}{25}$

$\Rightarrow \ell = 46.08$

$\Rightarrow [\ell] = 46$

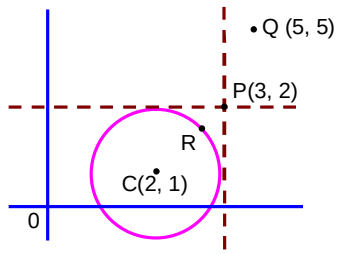
**Q5.** Let a circle C of radius 1 and closer to the origin be such that the lines passing through the point (3, 2) and parallel to the coordinate axes touch it. Then the shortest distance of the circle C from the point (5, 5) is:

(A) 5 (B) 4

(C) $4\sqrt{2}$ (D) $2\sqrt{2}$

**Ans.** **B**

**Sol.** As radius = 1 and circle touches the line passing through the point (3, 2) and parallel to coordinate exes.




So, Coordinates of centre will be (2, 1)

Equation of circle $\square$ $(x - 2)^2 + (y - 1)^2 = 1$

$QC = \sqrt{(5-2)^2 + (5-1)^2}$

$= \sqrt{3^2 + 4^2}$

$= 5$

Shortest distance of Q (5, 5) from circle is

$RQ = CQ - CR$

$RQ = 5 - 1$

$RQ = 4$

**Q6.** If the function $f(x) = \dfrac{\sin 3x + \alpha \sin x - \beta \cos 3x}{x^3}$, $x \in R$, is continuous at x = 0, then f(0) is equal to :

(A) 4 (B) –2

(C) –4 (D) 2

**Ans.** **C**

**Sol.** $\lim\limits_{x\to 0} \dfrac{\sin 3x + \alpha \sin x + \beta \cos 3x}{x^3}$

$= \lim\limits_{x\to 0} \dfrac{\left(3x - \dfrac{27x^3}{3!} + \cdots\right) + \alpha\left(x - \dfrac{x^3}{3!} + \cdots\right) + \beta\left(1 - \dfrac{9x^2}{2!} + \dfrac{81x^4}{4!} + \cdots\right)}{x^3}$

$\therefore \ \beta = 0$ and $\alpha = -3$

$\therefore f(0) = \lim\limits_{x\to 0} \dfrac{\left[-\dfrac{27}{3!} + \dfrac{3}{3!}\right]x^3 + \cdots}{x^3}$

$= \dfrac{-27+3}{3!} = \dfrac{-24}{6} = -4$

**Q7.** If y = y(x) is the solution of the differential equation $\dfrac{dy}{dx} + 2y = \sin(2x), y(0) = \dfrac{3}{4}$, then $y\left(\dfrac{\pi}{8}\right)$ is equal to :

(A) $e^{-\pi/8}$ (B) $e^{\pi/8}$

(C) $e^{-\pi/4}$ (D) $e^{\pi/4}$

**Ans.** **C**

**Sol.** $\dfrac{dy}{dx} + 2y = \sin(2x)$

I.F. $= e^{\int 2\cdot dx}$

$\Rightarrow$ I.F. $= e^{2x}$

$ye^{2x} = \int e^{2x} \sin 2x \, dx$

Let $2x = t$

$dx = \dfrac{dt}{2}$

$\Rightarrow ye^{2x} = \int e^t \sin t \cdot \dfrac{dt}{2}$

$\Rightarrow ye^{2x} = \dfrac{1}{2}\int e^t \cdot \sin t$

$$\Rightarrow ye^{2x} = \frac{1}{4}\left[e^t[\sin t - \cos t]\right] + c$$

$$\Rightarrow ye^{2x} = \frac{e^{2x}}{4}(\sin 2x - \cos 2x) + c$$

$$y(0) = \frac{3}{4}$$

$$\Rightarrow \frac{3}{4} = \frac{e^0}{4}(\sin 0 - \cos 0) + c$$

$$\Rightarrow \frac{3}{4} = \frac{-1}{4} + c$$

$c = 1$

$$\therefore y = \frac{\sin 2x - \cos 2x}{4} + \frac{1}{e^{2x}}$$

$$\therefore y\left(\frac{\pi}{8}\right) = \frac{\sin\frac{\pi}{4} - \cos\frac{\pi}{4}}{4} + \frac{1}{e^{\frac{\pi}{4}}}$$

$$\Rightarrow y\left(\frac{\pi}{8}\right) = e^{-\frac{\pi}{4}}$$

**Q8.** Let A and B be two square matrices of order 3 such that |A| = 3 and |B| = 2. Then $|A^TA(\text{adj}(2A))^{-1}(\text{adj}(4B))(\text{adj}(AB))^{-1}AA^T|$ is equal to:

(A) 108 (B) 81

(C) 32 (D) 64

**Ans.** **D**

**Sol.** $= \left|A^TA(\text{adj}(2A))^{-1}(\text{adj}(4B))(\text{adj}(AB))^{-1}AA^T\right|$

$$= 3\times 3\times\left|(\text{adj}(2A))^{-1}\right|\times|\text{adj}(4B)|\times\left|(\text{adj}(AB))^{-1}\right|\times 3\times 3$$

$$= 3^4\times\frac{1}{|\text{adj}(2A)|}\times 2^{12}\times 2^2\times\frac{1}{|\text{adj}(AB)|}$$

$$= 3^4\times 2^{14}\times\frac{1}{2^6|\text{adj}(A)|}\times\frac{1}{|\text{adjB}\cdot\text{adj}A|}$$

$$= 3^4\times 2^{14}\times\frac{1}{2^6\cdot 3^2}\times\frac{1}{2^2\cdot 3^2}$$

$= 64$

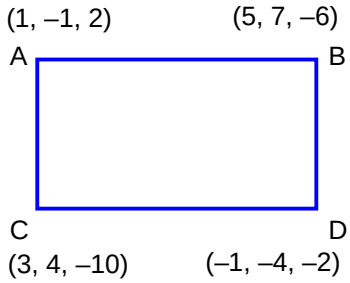
**Q9.** If A(1, –1, 2), B(5, 7, – 6), C(3, 4, –10) and D(–1, –4, –2) are the vertices of a quadrilateral ABCD, then its area is

(A) $24\sqrt{29}$ (B) $48\sqrt{7}$

(C) $24\sqrt{7}$ (D) $12\sqrt{29}$

**Ans.** **D**

**Sol.** $\text{Area} = \frac{1}{2}|\overrightarrow{AC} \times \overrightarrow{BD}|$




$$= \frac{1}{2}|(2\hat{i} + 5\hat{j} - 12\hat{k}) \times (6\hat{i} + 11\hat{j} - 4\hat{k})|$$

$$\frac{1}{2}\begin{Vmatrix} i & \hat{j} & \hat{k} \\ 2 & 5 & -12 \\ 6 & 11 & -4 \end{Vmatrix}$$

$$= \frac{1}{2}|\hat{i}(-20 + 132) - \hat{j}(-8 + 72) + \hat{k}(22 - 30)|$$

$$= \frac{1}{2}|112\hat{i} - 64\hat{j} - 8\hat{k}|$$

$$= 4|14\hat{i} - 8\hat{j} - \hat{k}|$$

$$= 4\sqrt{(14)^2 + (8)^2 + (1)^2}$$

$$= 4\sqrt{261} = 12\sqrt{29}$$

**Q10.** For the function

$f(x) = \sin x + 3x - \frac{2}{\pi}(x^2 + x)$, where $x \in \left[0, \frac{\pi}{2}\right]$,

consider the following two statement

(I) f is increasing in $\left(0, \frac{\pi}{2}\right)$

(II) f' is decreasing in $\left(0, \frac{\pi}{2}\right)$

Between the above two statements,

(A) only (II) is true
(B) neither (I) nor (II) are true
(C) both (I) and (II) are true
(D) only (I) is true

**Ans.** **C**

**Sol.** $f'(x) = \cos x + 3 - \frac{2}{\pi}(2x + 1)$

For $x \in \left(0, \frac{\pi}{2}\right)$

$f'(x) = +ve \Rightarrow f(x)$ is increasing

$f''(x) = -\sin x - \frac{4}{\pi}$

For $x \in \left(0, \frac{\pi}{2}\right)$

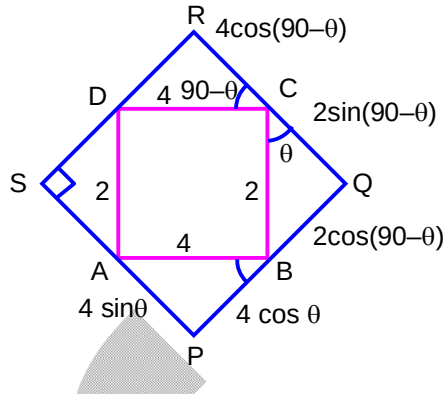
$f''(x) = -ve \Rightarrow f'(x)$ is decreasing

**Q11.** Let a rectangle ABCD of sides 2 and 4 be inscribed in another rectangle PQRS such that the vertices of the rectangle ABCD lie on the sides of the rectangle PQRS. Let a and b be the sides of the rectangle PQRS when its area is maximum. Then $(a + b)^2$ is equal to

(A) 64
(B) 80
(C) 60
(D) 72

**Ans.** **D**

**Sol.** Area = PQ × RQ




$$\text{Area} = (4\cos\theta + 2\sin\theta)(2\cos\theta + 4\sin\theta) + 8\cos^2\theta$$

$$= 8 + 20\sin\theta\cos\theta$$

$$= 8 + 10\sin 2\theta$$

$$= 8 + 10 = 18\left(\sin 2\theta = 1, \theta = 45^\circ\right)$$

$$(a+b)^2 = (4\cos\theta + 2\sin\theta + 2\cos\theta + 4\sin\theta)^2$$

$$= (6\cos\theta + 6\sin\theta)^2$$

$$= 36(\sin\theta + \cos\theta)^2$$

$$= 36\left(\sin 45^\circ + \cos 45^\circ\right)^2$$

$$= 36(\sqrt{2})^2$$

$$= 72$$

**Q12.** If the line $\frac{2-x}{3} = \frac{3y-2}{4\lambda+1} = 4-z$ makes a right angle with the line $\frac{x+3}{3\mu} = \frac{1-2y}{6} = \frac{5-z}{7}$, then $4\lambda + 9\mu$ is equal to :

(A) 4 (B) 6

(C) 13 (D) 5

**Ans.** **B**

**Sol.** $\frac{2-x}{3} = \frac{3y-2}{4\lambda+1} = 4-z$ .....(1)

$$\Rightarrow \frac{x-2}{(-3)} = \frac{y-\frac{2}{3}}{\left(\frac{4\lambda+1}{3}\right)} = \frac{z-4}{(-1)}$$

$\frac{x+3}{3\mu} = \frac{1-2y}{6} = \frac{5-z}{7}$ .....(2)

$$\Rightarrow \frac{x+3}{3\mu} = \frac{y-\frac{1}{2}}{(-3)} = \frac{z-5}{-7}$$

Both are perpendicular to each other, so,

$$\Rightarrow (-3)(3\mu) + \left(\frac{4\lambda+1}{3}\right)(-3) + (-1)(-7) = 0$$

$$\Rightarrow -9\mu - 4\lambda - 1 + 7 = 0$$

$$\Rightarrow 4\lambda + 9\mu = 6$$

**Q13.** Let the line $2x + 3y - k = 0$, $k > 0$, intersect the x-axis and y-axis at the points A and B, respectively. If the equation of the circle having the line segment AB as a diameter is $x^2 + y^2 - 3x - 2y = 0$ and the length of the latus rectum of the ellipse $x^2 + 9y^2 = k^2$ is $\frac{m}{n}$, where m and n are coprime, then $2m + n$ is equal to

(A) 12 (B) 10

(C) 13 (D) 11

**Ans.** **D**

**Sol.** equation of circle $\Rightarrow x^2 + y^2 - 3x - 2y = 0$

Centre of circle $= \left(\frac{3}{2}, 1\right)$

Equation of diameter $\Rightarrow 2x + 3y - k = 0$

$2\left(\frac{3}{2}\right)+3(1)-k=0$

$\Rightarrow k=6$

Now, Equation of ellipse becomes

$x^2+9y^2=36$

$\Rightarrow \frac{x^2}{36}+\frac{y^2}{4}=1$

a = 6, b = 2

Length of L.R. $=\frac{2b^2}{a}=\frac{2\cdot 2^2}{6}=\frac{4}{3}=\frac{m}{n}$

$\therefore 2m+n=2(4)+3=11$

**Q14.** Let A = {1, 3, 7, 9, 11} and B = {2, 4, 5, 7, 8, 10, 12}. Then the total number of one-one maps $f: A \to B$, such that f(1) + f(3) = 14, is

(A) 120 (B) 240

(C) 180 (D) 480

**Ans.** **B**

**Sol.** $A=\{1,3,7,9,11\}$

$B=\{2,4,5,7,8,10,12\}$

$f(1)+f(3)=14$

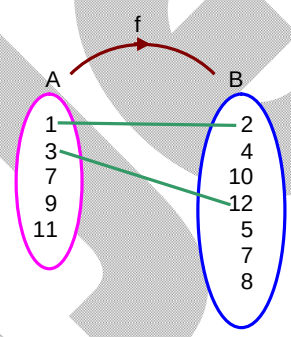
There are only 2 cases,

(2, 12) and (4, 10)

So, total no. of one-one function

= (5 × 4 × 3) × 2 × 2!

= 240




**Q15.** Consider the following two statements :

**Statement I :** For any two non-zero complex number $z_1$, $z_2$,

$(|z_1|+|z_2|)\left|\frac{z_1}{|z_1|}+\frac{z_2}{|z_2|}\right| \le 2(|z_1|+|z_2|)$ and

**Statement II :** if x, y, z are three distinct complex numbers and a, b, c are three positive real numbers such that $\frac{a}{|y-z|}=\frac{b}{|z-x|}=\frac{c}{|x-y|}$, then $\frac{a^2}{y-z}+\frac{b^2}{z-x}+\frac{c^2}{x-y}=1$

Between the above two statements,

(A) both Statement I and Statement II are incorrect

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

(C) both Statement I and Statement II are correct

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

**Ans.** **B**

**Sol.** Statement I :

$\left|\frac{z_1}{|z_1|}+\frac{z_2}{|z_2|}\right| \le \left|\frac{z_1}{|z_1|}\right|+\left|\frac{z_2}{|z_2|}\right|$

$\left|\frac{z_1}{|z_2|}+\frac{z_2}{|z_2|}\right| \le \frac{|z_1|}{|z_1|}+\frac{|z_2|}{|z_2|}$

$\left|\frac{z_1}{|z_2|}+\frac{z_2}{|z_2|}\right| \le 2$

$\therefore$ Statement I is correct

Statement II :

$$\frac{a}{|y-z|}=\frac{b}{|z-x|}=\frac{c}{|x-y|}$$

$$\frac{a^2}{|y-z|^2}=\frac{b^2}{|z-x|^2}=\frac{c^2}{|x-y|^2}=\lambda$$

$$a^2=\lambda\left(|y-z|^2\right)=\lambda(y-z)(\bar{y}-\bar{z})$$

$$b^2=\lambda(z-x)(\bar{z}-\bar{x})$$

$$c^2=\lambda(x-y)(\bar{x}-\bar{y})$$

$$\frac{a^8}{y-z}+\frac{b^2}{z-x}+\frac{c^2}{x-y}=\lambda(\bar{y}-\bar{z}+\bar{z}-\bar{x}+\bar{x}-\bar{y})=0$$

$\therefore$ Statement II is incorrect

**Q16.** The value of $\int_{-\pi}^{\pi}\frac{2y(1+\sin y)}{1+\cos^2 y}dy$ is

(A) $2\pi^2$ (B) $\pi^2$

(C) $\frac{\pi}{2}$ (D) $\frac{\pi^2}{2}$

**Ans.** **B**

**Sol.** $\int_{-\pi}^{\pi}\frac{2y(1+\sin y)}{1+\cos^2 y}dy$

$$=\int_{-\pi}^{\pi}\frac{2y}{1+\cos^2 y}dy+\int_{-\pi}^{\pi}\frac{2y\sin y}{1+\cos^2 y}dy.$$

(odd) (even)

$$=0+2.2\int_0^{\pi}y\left(\frac{\sin y}{1+\cos^2 y}\right)dy$$

$$I=4\int_0^{\pi}\frac{y\sin y}{1+\cos^2 y}dy$$

$$I=4\int_0^{\pi}\frac{(\pi-y)\sin y}{1+\cos^2 y}dy$$

$$2I=4\int_0^{\pi}\frac{\pi\sin y}{1+\cos^2 y}dy$$

Let $\cos y=t,\ dt=-\sin y.dy$

$$I=2\pi\int_0^{\pi}\frac{-dt}{1+t^2}$$

$$=2\pi\left(-\tan^{-1}(t)\right)_0^{\pi}$$

$$=2\pi\left(-\tan^{-1}(\cos y)\right)_0^{\pi}$$

$$=-2\pi\left[\left(-\frac{\pi}{4}\right)-\left(\frac{\pi}{4}\right)\right]$$

$$=-2\pi\left[-\frac{2\pi}{4}\right]=\pi^2$$

**Q17.** If the system of equations
$11x + y + \lambda z = -5$
$2x + 3y + 5z = 3$
$8x - 19y - 39z = \mu$
has infinitely many solutions, then $\lambda^4 - \mu$ is equal to
(A) 45 (B) 49
(C) 51 (D) 47

**Ans.** **D**

**Sol.** $11x + y + \lambda z = -5$

$2x + 3y + 5z = 3$

$8x - 19y - 39z = \mu$

For Infinitely many solutions,

$\Delta = 0$

$$\Rightarrow \begin{vmatrix} 11 & 1 & \lambda \\ 2 & 3 & 5 \\ 8 & -19 & -39 \end{vmatrix} \Rightarrow 11(3\times -39 + 5\times 19) - 1(-39\times 2 - 40) + \lambda(2\times -19 - 24) = 0$$

$\Rightarrow -242 + 118 + 62\lambda = 0$

$\Rightarrow 62\lambda = 124$

$\Rightarrow \lambda = \frac{124}{62}2 \Rightarrow \lambda = 2$

For Infinitely many solutions.

$\Delta_z = 0$

$$\begin{vmatrix} 11 & 1 & -5 \\ 2 & 3 & 3 \\ 8 & -19 & r \end{vmatrix} = 0$$

$\Rightarrow 11(3\mu + 3\times 19) - 1(2\mu - 24) - 5(2x - 19 - 8\times 3) = 0$

$\Rightarrow 33\mu + 33\times 19 - 2\mu + 24 - 5(-38 - 24) = 0$

$\Rightarrow 31\mu + 310 + 651 = 0$

$\Rightarrow 31\mu = -961$

$\Rightarrow \mu = -31$

$\lambda^4 - \mu = (2)^4 - (-31)$

$= 16 + 31 = 47$

**Q18.** Let d be the distance of the point of intersection of the lines $\frac{x+6}{3} = \frac{y}{2} = \frac{z+1}{1}$ and $\frac{x-7}{4} = \frac{y-9}{3} = \frac{z-4}{2}$ from the point (7, 8, 9). Then $d^2 + 6$ is equal to
(A) 72 (B) 69
(C) 75 (D) 78

**Ans.** **C**

**Sol.** Let $\frac{x+6}{3} = \frac{y}{2} = \frac{z+1}{1} = \lambda$,

$\frac{x-7}{4} = \frac{y-9}{3} = \frac{z-4}{2} = \mu$,

$x = 3\lambda - 6 \qquad x = 4\mu + 7$

$y = 2\lambda \qquad y = 3\mu + 9$

$z = \lambda - 1 \qquad z = 2\mu + 4$

We have to equate the x coordinate ad y-coordinate to find out the value of $\lambda$ and $\mu$.

$3\lambda - 6 = 4\mu + 7$

$\Rightarrow 3\lambda - 4\mu = 13$ .....(1)

$2\lambda - 3\mu + 9$

$\Rightarrow 2\lambda - 3\mu = 9$ .....(2)

Solving equation (1) and (2), we get

$67 - 8\mu = 26$

$67 - 9\mu = 27$

(-) (+) –

$\mu = -1$

By putting the value of $\mu = -1$, in equation (1), we get value of $\lambda$

$3\lambda - 4x - 1 = 13$

$\Rightarrow 3\lambda = 13 - 4$

$\Rightarrow 3\lambda = 9 \Rightarrow \lambda = 3$

$P(3\lambda - 6, 2\lambda, \lambda - 1)$

P (3, 6, 2)

The distance 'd' from P(3, 6, 2) to Q (7, 8, 9) is

$d = \sqrt{(7-3)^2 + (8-6)^2 + (9-2)^2}$

$= \sqrt{4^2 + 2^2 + 7^2} = \sqrt{16 + 4 + 49}$

$= \sqrt{69}$

$d^2 + 6 = 69 + 6$

$= 75$

**Q19.** Let $f(x) = x^5 + 2x^3 + 3x + 1$, $x \in R$, and g(x) be a function such that $f(f(x)) = x$ for all $x \in R$. Then $\frac{g(7)}{g'(7)}$ is equal to :

(A) 1 (B) 14

(C) 7 (D) 42

**Ans.** **B**

**Sol.** $f(x) = x^5 + 2x^3 + 3x + 1$

$f'(x) = 5x^4 + 6x^2 + 3$

$f'(1) = 5 + 6 + 3 = 14$

$g(f(x)) = x$

$g'(f(x))\ \ f'(x) = 1$

For f(x) = 7

$\Rightarrow x^5 + 2x^3 + 3x + 1 = 7$

$\Rightarrow \quad x = 1$

$g'(7)f'(1) = 1$

$g'(7) = \frac{1}{f'(1)} = \frac{1}{14}$

x = 1, f(x) = 7

So, g(7) =1

$\frac{g(7)}{g'(7)} = \frac{1}{\frac{1}{14}} = 14$

**Q20.** The coefficients a, b, c, in the quadratic equation $ax^2 + bx + c = 0$ are chosen from the set {1, 2, 3, 4, 5, 6, 7, 8}. The probability of this equation having repeated roots is

(A) $\frac{1}{64}$ (B) $\frac{3}{256}$

(C) $\frac{1}{128}$ (D) $\frac{3}{128}$

**Ans.** **A**

**Sol.** $ax^2 + bx + c = 0$

$a,b,c \in \{1,2,3,4,5,6,7,8\}$

For Repeated roots,

D = 0

$\Rightarrow \quad b^2 - 4ac = 0$

$\Rightarrow b^2 = 4ac$

So, (a, b, c) are :

(1, 2, 1), (2, 4, 2), (1, 4, 4), (4, 4, 1), (3, 6, 3), (2, 8, 8), (8, 8, 2), (4, 8, 4) = 8 cases

Total cases = 8 × 8 × 8

So, Probability of repeated roots = $= \frac{8}{8\times8\times8} = \frac{1}{64}$

## SECTION - B

**(Numerical Answer Type)**

This section contains **10** Numerical based questions. The answer to each question is rounded off to the nearest integer value.

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**Q21.** If the constant term in the expansion of $(1+2x-3x^3)\left(\frac{3}{2}x^2 - \frac{1}{3x}\right)^9$ is p, then 108p is equal to_____.

**Ans.** **54**

**Sol.** General term $\left(\frac{3}{2}x^2 - \frac{1}{3x}\right)^9$

$^9C_r \times \frac{3^{9-2r}}{2^{9-r}}(-1)^r \cdot x^{18-3r}$

Put r = 6 to get coeff. of $x^0$

$^9C_6 \cdot \frac{1}{6^3} \times x^0 = \frac{7}{18}x^0$

$= -9c_7 \times \frac{1}{3^5 \times 2^2} \times x^{-3} = \frac{-1}{27}x^{-3}$

$\left(1+2x-3x^3\right)\left(\frac{7}{18}x^0 - \frac{1}{27}x^{-3}\right)$

$\frac{7}{18} + \frac{3}{27} = \frac{1}{2}$

$\therefore 108 \times \frac{1}{2} = 54$

**Q22.** From a lot of 10 items, which include 3 defective items, a sample of 5 items is drawn at random. Let the random variable X denote the number of defective items in the sample. If the variance of X is $\sigma^2$, then $96\sigma^2$ is equal to_____.

**Ans.** **56**

**Sol.**

| x | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| P(x) | $\frac{7}{15}$ | $\frac{5}{12}$ | $\frac{5}{12}$ | $\frac{1}{12}$ |
| $x_i^2$ | 0 | 1 | 4 | 9 |
| $P_ix_i^2$ | 0 | $\frac{5}{12}$ | $\frac{20}{12}$ | $\frac{9}{12}$ |
| $P_ix$ | 0 | $\frac{5}{12}$ | $\frac{10}{12}$ | $\frac{3}{12}$ |

x = denotes number of defective

$$\mu = \sum p_i x_i = \frac{18}{12}$$

$$\sum p_i x_i^2 = \frac{34}{12}$$

$$r^2 = \sum p_i x_i^2 - (\mu)^2$$

$$= \frac{34}{12} - \left(\frac{18}{12}\right)^2 = \frac{7}{12}$$

$$96\sigma^2 = 56$$

**Q23.** Let $a_1, a_2, a_3, \ldots$ be in an arithmetic progression of positive terms.

Let $A_k = a_1^2 - a_2^2 + a_3^2 - a_3^2 + \ldots + a_{2k-1}^2 - a_{2k}^2$.

If $A_3 = -153$, $A_5 = -435$ and $a_1^2 + a_2^2 + a_3^2 = 66$, then $a_{17} - A_7$ is equal to_____.

$$a_1^2 + a_2^2 + a_3^2 = 64$$

$$\Rightarrow a_1^2 + (a_1 + d)^2 + (a_1 + 2d)^2 = 66$$

$$\Rightarrow a_1^2 + 16a_1^2 + 49a_1^2 = 66$$

$$\Rightarrow a_1^2 = 1 \Rightarrow a_1 = 1, d = 3$$

$$a_{17} = 49$$

$$A_7 = -861$$

**Ans.** **910**

**Sol.** $a_2 - a_1 = a_3 - a_2 = \ldots = +d$

$$(a_1 - a_2)(a + a_2) + (a_3 - a_4)(a_3 + a_4) \cdots (a_{2k-1} - a_{2k})(a_{2k-1} + a_{2k}) = A_k$$

$$A_k = (-d)\left[a_1 + a_2 + \ldots a_{2k}\right]$$

$$= -d\left[\frac{2k}{2}(2a_1 + (2k-1)d\right]$$

$$A_3 = -153 = (-d)\left[3(2a_1 + 5d)\right] \quad \ldots(1)$$

$$A_5 = -435 = (-d)\left[5(2a_1 + 9d)\right] \quad \ldots(2)$$

(2) / (1)

$$\frac{29}{17} = \frac{2a_1 + 9d}{2a_1 + 5d}$$

$\Rightarrow d = 3a_1$

$a_1^2 + a_2^2 + a_3^2 = 64$

$\Rightarrow a_1^2 + (a_1 + d)^2 + (a_1 + 2d)^2 = 66$

$\Rightarrow a_1^2 + 16a_1^2 + 49a_1^2 = 66$

$\Rightarrow a_1^2 = 1 \Rightarrow a_1 = 1, d = 3$

$a_{17} = 49$

$A_7 = -861$

**Q24.** The area of the region enclosed by the parabolas $y = x^2 - 5x$ and $y = 7x - x^2$ is _____.

**Ans.** **72**

**Sol.** $y = x^2 - 5x$

$y = 7x - x^2$

$\text{Area} = \int_0^6 (g(x) - f(x)) \cdot dx$

$= \int_0^6 \left( (7x - x^2) - (x^2 - 5x) \right) \cdot dx$

$= \int_0^6 (12x - 2x^2) \cdot dx$

$= \left[ 12\frac{x^2}{2} - \frac{2x^3}{6} \right]_0^6$

$= 6(6)^2 - \frac{2}{3}(6)^3$

$= 72 \text{ Unit}^2$

**Q25.** Let f be a differentiable function in the interval $(0, \infty)$ such that f(1) = 1 and $\lim\limits_{t \to x} \frac{t^2 f(x) - x^2 f(t)}{t - x} = 1$ for each $x > 0$. Then $2f(2) + 3f(3)$ is equal to_____.

**Ans.** **24**

**Sol.** $\lim\limits_{t \to x} \frac{t^2 f(x) - x^2 f(t)}{t - x} = 1$

Applying L'Hospital rule

$L = \lim\limits_{t \to x} \frac{2t\, f(x) - x^2 f'(x)}{1} = 1$

$\Rightarrow 2xf(x) - x^2 f'(x) = 1$

Solving above differential equation we get

$f(x) = \frac{2}{3}x^2 + \frac{1}{3x}$

**Q26.** Let $\vec{a} = \hat{i} - 3\hat{j} + 7\hat{k}, \vec{b} = 2\hat{i} - \hat{j} + \hat{k}$ and $\vec{c}$ be a vector such that $(\vec{a} + 2\vec{b}) \times \vec{c} = 3(\vec{c} \times \vec{a})$. If $\vec{a} \cdot \vec{c} = 130$, then $\vec{b} \cdot \vec{c}$ is equal to _____.

**Ans.** **30**

**Sol.** $(\vec{a} + 2\vec{b}) \times \vec{c} - 3(\vec{c} \times \vec{a}) = 0$

$(\vec{a} + 2\vec{b} + 3\vec{a}) \times \vec{c} = 0$

$(4\vec{a} + 2\vec{b}) \times \vec{c} = 0$

$\vec{c} = \lambda(2\vec{a} + \vec{b})$

$\vec{a}\cdot\vec{c} = 130.$

$\Rightarrow \quad \lambda\left(2|\vec{a}|^2 + \vec{a}\cdot\vec{b}\right) = 130$

$\Rightarrow \quad \lambda(2\times 59 + 12) = 130$

$\Rightarrow \quad \lambda = 1$

$\vec{c} = 2\vec{a} + \vec{b}$

$\vec{b}\cdot\vec{c} = (2\times 12 + 6) = 30$

**Q27.** The number of ways of getting a sum 16 on throwing a dice four times is_____.

**Ans.** **125**

**Sol.** Coeff of $x^{16}$ in $\left(x + x^2 + x^3 \ldots x^6\right)^4$

$= x^4 \cdot \left(\frac{1-x^6}{1-x}\right)^4$

$= x^4\left[1 - 4x^6 + 6x^{12} \ldots\right]\left[1 + {}^{15}c_{12}x^{12} + {}^{9}C_2x^6 \ldots\right]$

$= \left({}^{15}c_{12} - 4.{}^{9}c_6 + 6\right)x^{16}$

$= {}^{15}C_3 - 4.\ {}^{9}C_6 + 6$

$= 455 - 336 + 6$

$= 125$

**Q28.** Suppose AB is a focal chord of the parabola $y^2 = 12x$ of length l and slope $m < \sqrt{3}$. If the distance of the chord AB from the origin is d, then $\ell d^2$ is equal to _____.

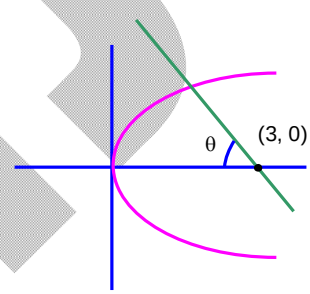
**Ans.** **108**

**Sol.** Length of focal chord = $4a\,\text{cosec}^2$

$\ell = 4.3.\text{cosec}^2\theta$

Eq$^n$ of line $\Rightarrow y = \tan\theta\,(y - 3)$

$d = 8\left|\frac{-3\tan\theta}{\sqrt{1+\tan^2\theta}}\right|$




$\ell d^2 = \frac{9\tan^2\theta}{1+\tan^2\theta}.4.3.\text{cosec}^2\theta$

$= 108$

**Q29.** If $S = \{a \in R : |2a - 1| = 3[a] + 2[a]\}$, where [t] denotes the greatest integer less than or equal to t and {t} represents the fractional part of t, then $72\sum_{a\in S} a$ is equal to_____.

**Ans.** **18**

**Sol.** $|2a - 1| = 3[a] + 2\{a\}$

$|2a - 1| = [a] + 2a$

$\Rightarrow$ Case-1: $a > \frac{1}{2}$

$2a - 1 = [a] + 2a$

$[a] = -1 \Rightarrow a \in [-1, 0)$ Reject

$\rightarrow$ case $-$ 2 : $a < \frac{1}{2}$

$-2a + 1 = [a] + 2a$

A = I + f

$-2(I + f) + 1 = I + 2I + 2f$

$I = 0, f = \frac{1}{4},\ \therefore a = \frac{1}{4}$

$72\sum_{a\in S} a = 72 \times \frac{1}{4} = 18$

**Q30.** The number of distinct real roots of the equation $|x|\,|x+2| - 5|x+1| - 1 = 0$ is_____.

**Ans.** **3**

**Sol.** (I) $x \geqslant 0$

$x^2 + 2x - 5x - 5 - 1 = 0$

$x^2 - 3x - 6 = 0 \rightarrow 1$ root +ve

(II) $-1 \leq x < 0$

$-x^2 - 2x - 5x - 5 - 1 = 0$

$x^2 + 7x + 6 = 0 \rightarrow x = -1$ is a root

(III) $-1 < x \leqslant -2$

$x^2 - 2x + 5x + 5 - 1 = 0$

$x^2 - 3x - 4 = 0 \rightarrow$ No root in given range

(IV) $x < -2$

$x^2 + 2x + 5x + 5 - 1 = 0$

$x^2 + 7x + 4 = 0 \rightarrow$ one root less than-2

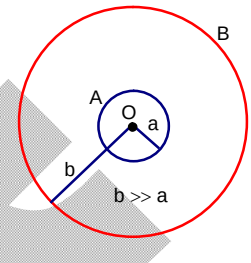
# PART – B (PHYSICS)

## SECTION - A

**(One Options Correct Type)**

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

**Q31.** Two conducting circular loops A and B are placed in the same plane with their centres coinciding as shown in figure. The mutual inductance between them is:




(A) $\frac{\mu_0 \pi b^2}{2a}$

(B) $\frac{\mu_0}{2\pi} \cdot \frac{b^2}{a}$

(C) $\frac{\mu_0 \pi a^2}{2b}$

(D) $\frac{\mu_0}{2\pi} \cdot \frac{a^2}{b}$

**Ans.** **C**

**Sol.** $M_{AB} = \frac{\phi_A}{i_B} = \frac{BA}{i} = \frac{\mu_0 i}{2b} \times \frac{\pi a^2}{i}$

$M_{AB} = \frac{\mu_0 \pi a^2}{2b}$

**Q32.** An electron rotates in a circle around a nucleus having positive charge Ze. Correct relation between total energy (E) of electron to its potential energy (U) is:

(A) 2E = 3U

(B) E = 2U

(C) E = U

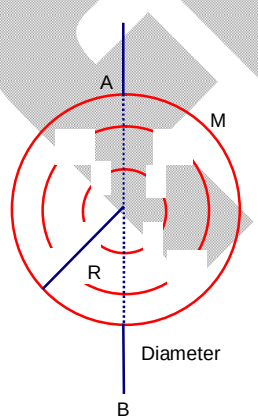
(D) 2E = U

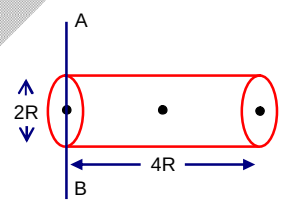
**Ans.** **D**

**Sol.** KE = - E

U = 2E

**Q33.** Ratio of radius of gyration of a hollow sphere to that of a solid cylinder of equal mass, for moment of inertia about their diameter axis AB as shown in figure is $\sqrt{\frac{8}{x}}$. The value of x is:




(A) 51

(B) 67

(C) 34

(D) 17

**Ans. B**

**Sol.** $I_{H\cdot S} = \frac{2}{3}MR^2 = Mk_1^2$

$$I_{S\cdot C} = \frac{M(4R)^2}{12} + \frac{MR^2}{4} + M(2R)^2$$

$$I_{S\cdot C} = \frac{67}{12}MR^2 = Mk_2^2$$

$$\frac{k_1}{k_2} = \sqrt{\frac{2\times 12}{3\times 67}} = \sqrt{\frac{8}{67}} = \sqrt{\frac{8}{x}}$$

$x = 67$

**Q34.** If G be the gravitational constant and u be the energy density then which of the following quantity have the dimensions as that of the $\sqrt{uG}$ :

(A) Force per unit mass
(B) Pressure gradient per unit mass
(C) Gravitational potential
(D) Energy per unit mass

**Ans.** **A**

**Sol.** $u = \left[M^1 L^{-1} T^{-2}\right]$

$G = \left[M^{-1} L^3 T^{-2}\right]$

$\sqrt{4G} = \left[LT^{-2}\right]$ = Force per unit mass

**Q35.** A simple pendulum doing small oscillations at a place R height above earth surface has time period of $T_1 = 4s$. $T_2$ would be it's time period if it is brought to a point which is at a height 2R from earth surface. Choose the correct relation [R = radius of earth] :

(A) $2T_1 = 3T_2$
(B) $3T_1 = 2T_2$
(C) $2T_1 = T_2$
(D) $T_1 = T_2$

**Ans.** **B**

**Sol.** $T_1 = 2\pi\sqrt{\frac{\ell}{GM}(2R)^2}$

$T_2 = 2\pi\sqrt{\frac{\ell}{GM}(3R)^2}$

$\therefore \frac{T_1}{T_2} = \frac{2}{3}$

**Q36.** Match List I with List II :

| | **LIST I** | | **LIST II** |
|---|---|---|---|
| a. | Kinetic energy of planet | I. | $-\frac{GMm}{a}$ |
| b. | Gravitation Potential energy of sun-planet system | II. | $\frac{GMm}{2a}$ |
| c. | Total mechanical energy of planet | III. | $\frac{Gm}{r}$ |
| d. | Escape energy at the surface of planet for unit mass object | IV. | $-\frac{GMm}{2a}$ |

Where a = radius of planet orbit, r= radius of planet, M = mass of sun, m= mass of planet)
Choose the correct answer from the options given below:

(A) (a)–(III), (b)–(IV), (c)–(I), (d)–(II)
(B) (a)–(I), (b)–(IV), (c)–(II), (d)–(III)
(C) (a)–(I), (b)–(II), (c)–(III), (d)–(IV)
(D) (a)–(II), (b)–(I), (c)–(IV), (d)–(III)

**Ans.** **D**

**Sol.** $KE = \frac{1}{2}mv^2 = \frac{GMm}{2a}$

$PE = -2kE = \frac{-GMm}{a}$

$TE = -kE = \frac{-GMm}{2a}$

Escape energy $= \frac{Gm}{r}$

**Q37.** In hydrogen like system the ratio of coulombian force and gravitational force between an electron and a proton is in the order of :

(A) $10^{36}$ (B) $10^{39}$

(C) $10^{29}$ (D) $10^{19}$

**Ans.** **B**

**Sol.** $Fe = \frac{kq_1q_2}{r^2} = \frac{9\times10^9\times1.6\times10^{-19}\times1.6\times10^{-19}}{r^2}$

$Fg = \frac{Gm_1m_2}{r^2} = \frac{6.67\times10^{-11}\times9.1\times10^{-31}\times1.6\times10^{-27}}{r^2}$, $\frac{Fe}{Fg} \approx 10^{39}$

**Q38.** Given below are two statements:

**Statement I :** When a capillary tube is dipped into a liquid, the liquid neither rises nor falls in the capillary. The contact angle may be $0^0$.

**Statement II :** The contact angle between a solid and a liquid is a property of the material of the solid and liquid as well.

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

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

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

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

(D) **Statement I** is true and **Statement II** is false

**Ans.** **B**

**Sol.** $h = \frac{2T\cos\theta}{\rho rg}$

$\theta = 0^\circ$

$h = \frac{2T}{\rho rg} \neq 0$

(i) False, (ii) True

**Q39.** If the collision frequency of hydrogen molecules in a closed chamber at $27^0$C is Z, then the collision frequency of the same system at $127^0$C is :

(A) $\frac{\sqrt{3}}{2}Z$ (B) $\frac{3}{4}Z$

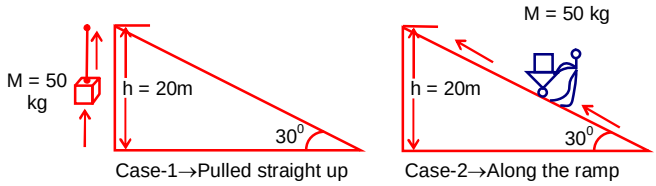
(C) $\frac{4}{3}Z$ (D) $\frac{2}{\sqrt{3}}Z$

**Ans.** **D**

**Sol.** $f \alpha \sqrt{T}$ $\frac{f_1}{f_2} = \sqrt{\frac{T_1}{T_2}} = \sqrt{\frac{300}{400}}$

$f_2 = \sqrt{\frac{4}{3}}f_1 = \sqrt{\frac{4}{3}}z = \frac{2}{\sqrt{3}}z$

**Q40.** A body of mass 50 kg is lifted to a height of 20 m from the ground in the two different ways as shown in the figures. The ratio of work done against the gravity in both the respective cases, will be :



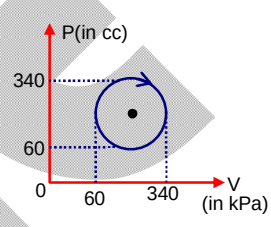

(A) 1 : 2 (B) $\sqrt{3}$ : 2

(C) 2 : 1 (D) 1 : 1

**Ans.** **D**

**Sol.** Work done by gravity does not depends on path, its only depends vertical displacement so, work done by given in both case same.

**Q41.** The heat absorbed by a system in going through the given cyclic process is :




(A) 19.6 J (B) 431.2 J

(C) 616 J (D) 61.6 J

**Ans.** **D**

**Sol.** In cyclic process

$\Delta U = 0$

$\Delta Q = \Delta W + \Delta U = \Delta W = \pi r_1 \times r_2$

$\Delta Q = \pi \times 140 \times 10^3 \times 140 \times 10^{-6}$

$\Delta Q = 61.6J$

**Q42.** A wooden block of mass 5 kg rests on a soft horizontal floor. When an iron cylinder of mass 25 kg is placed on the top of the block, the floor yields and the block and the cylinder together go down with an acceleration of $0.1 ms^{-2}$. The action force of the system on the floor is equal to:

(A) 297 N (B) 294 N

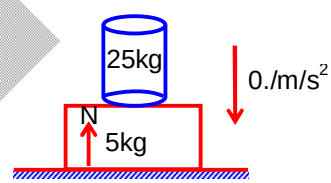
(C) 196 N (D) 291 N

**Ans.** **D**

**Sol.** $30g - N = 30 \times 0.1$

$N = 30 \times 9 \cdot 8 - 3$

$N = 291N$



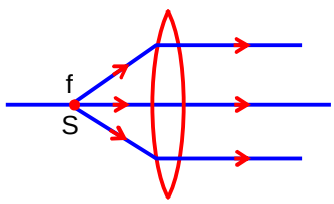

**Q43.** Light emerges out of a convex lens when a source of light kept at its focus. The shape of wavefront of the light is:

(A) spherical (B) plane

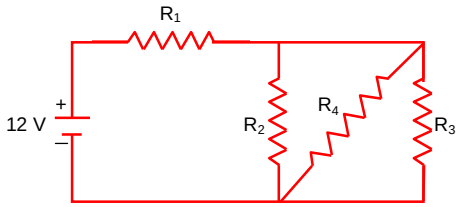
(C) both spherical and cylindrical (D) cylindrical

**Ans.** **B**

**Sol.** Wave front is planner



**Q44.** In the given figure $R_1 = 10\Omega$, $R_2 = 8\Omega$, $R_3 = 4\Omega$ and $R_4 = 8\Omega$. Battery is ideal with emf 12V. Equivalent resistant of the circuit and current supplied by battery are respectively:




(A) $10.5\Omega$ and 1.14 A
(B) $10.5\Omega$ and 1 A
(C) $12\Omega$ and 11.4 A
(D) $12\Omega$ and 1A

**Ans.** **D**

**Sol.** $$Reqv = R_1 + \frac{1}{\frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_4}}$$

$$Reqv = 10 + \frac{1}{\frac{1}{8}+\frac{1}{4}+\frac{1}{8}}$$

$$Reqv = 12\Omega$$

$$i = \frac{V}{R} = \frac{12}{12} = 1A$$

**Q45.** An alternating voltage of amplitude 40V and frequency 4 kHz is applied directly across the capacitor of $12\mu F$. The maximum displacement current between the plates of the capacitor is nearly:

(A) 13 A
(B) 12 A
(C) 10 A
(D) 8 A

**Ans.** **B**

**Sol.** $$x_C = \frac{1}{C \times 2\pi f} = \frac{1}{12 \times 10^{-6} \times 2 \times \pi \times 4 \times 10^3}$$

$$x_C = 3.317\Omega$$

$$i = \frac{V}{x_C} = \frac{40}{3.317} = 12A$$

**Q46.** The angle between vector $\vec{Q}$ and the resultant of $\left(2\vec{Q}+2\vec{P}\right)$ and $\left(2\vec{Q}-2\vec{P}\right)$ is :

(A) $\tan^{-1}\dfrac{\left(2\vec{Q}-2\vec{P}\right)}{2\vec{Q}+2\vec{P}}$
(B) $\tan^{-1}\left(\dfrac{2Q}{P}\right)$
(C) $\tan^{-1}\left(\dfrac{P}{Q}\right)$
(D) $0^0$

**Ans.** **D**

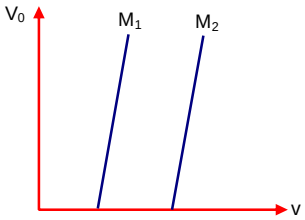
**Sol.** $\vec{V}_1 = \vec{Q}$

$\vec{V}_2 = 2\vec{Q}+2\vec{P}+2\vec{Q}-2\vec{P} = 4\vec{Q}$

$\vec{V}_1 \| \vec{V}_2$

$\theta = 0^\circ$

**Q47.** Given below are two statements :




**Statement I :** Figure shows the variation of stopping potential with frequency $(v)$ for the two photosensitive materials $M_1$ and $M_2$. The slope gives value of $\frac{h}{e}$, where h is Planck's constant, e is the charge of electron.

**Statement II :** $M_2$ will emit photoelectrons of greater kinetic energy for the incident radiation having same frequency.

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

(A) **Statement I** is incorrect but **Statement II** is correct
(B) Both **Statement I** and **Statement II** are incorrect
(C) Both **Statement I** and **Statement II** are correct
(D) **Statement I** is correct and **Statement II** is incorrect

**Ans.** **B**

**Sol.** $h\nu = \phi + ev_0$

$$v_0 = \frac{h}{e}\nu - \frac{\phi}{e}$$

$\phi_{M_2} > \phi_{M_1}$

So k.E. of electron for $M_1$ is greater.

**Q48.** Time periods of oscillation of the same simple pendulum measured using four different measuring clocks were recorded as 4.62 s, 4.632 s, 4.6 s and 4.64 s. The arithmetic mean of these readings in correct significant figure is:

(A) 4.6 s (B) 5 s
(C) 4.623 s (D) 4.62 s

**Ans.** **A**

**Sol.** $A.M = \frac{\text{Sum}}{\text{Total number}} = \frac{4.6 + 4.6 + 4.6 + 4.6}{4}$

A.M = 4.6sec

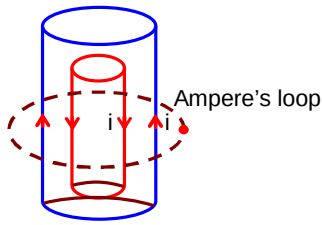
**Q49.** In a co-axial straight cable, the central conductor and the outer conductor carry equal currents in opposite directions. The magnetic field is zero :

(A) inside the outer conductor (B) inside the inner conductor
(C) outside the cable (D) in between the two conductors

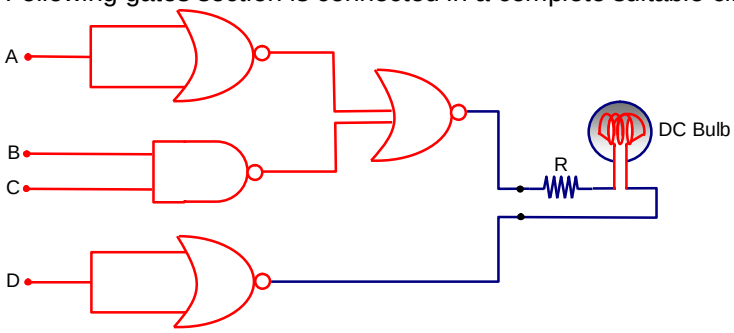
**Ans.** **C**

**Sol.** $\oint \vec{B} \cdot \vec{d\ell} = \mu_0 i_{in}$

for outside current inside ampere's loop is zero.



**Q50.** Following gates section is connected in a complete suitable circuit.




For which of the following combination, bulb will glow (ON) :

(A) A = 1, B = 0, C = 0, D = 0 (B) A = 1, B = 1, C = 1, D = 0

(C) A = 0, B = 1, C = 1, D = 1 (D) A = 0, B = 0, C = 0, D = 1

**Ans.** **A**

**Sol.** If one end of bulb is (1) and other end of bulb is (0) then bulb is (0 N).

If A = 1, B = 0, C = 0 then one end of bulb is 0

If D = 0 then other end of bulb is

## SECTION - B

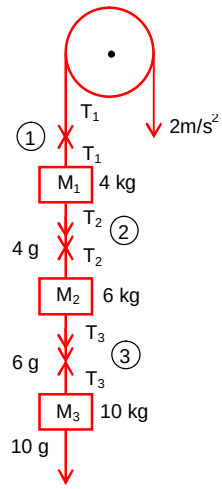
**(Numerical Answer Type)**

This section contains **10** Numerical based questions. The answer to each question is rounded off to the nearest integer value.

---

**Q51.** Three blocks $M_1$, $M_2$, $M_3$ having masses 4 kg, 6 kg and 10 kg respectively are hanging from a smooth pully using rope 1, 2 and 3 as shown in figure. The tension in the rope 1. $T_1$ when they are moving upward with acceleration of $2ms^{-2}$ is……N

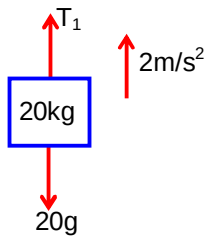
(if $g = 10\, m/s^2$).




**Ans.** **240**

**Sol.** $T_1 = 20 \times 2 + 20 \times 10$

$T_1 = 240$ N



**Q52.** The density and breaking stress of a wire are $6\times10^4$ kg/m$^3$ and $1.2\times10^8$ N/m$^2$ respectively. The wire is suspended from a rigid support on a planet where acceleration due to gravity is $\frac{1}{3}^{rd}$ of the value on the surface of earth. The maximum length of the wire with breaking is……. m (take, $g = 10\ m/s^2$).

**Ans.** **600**

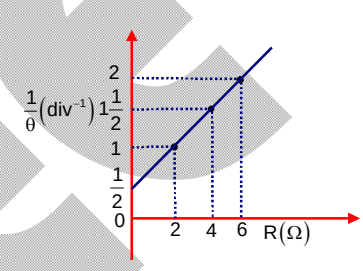
**Sol.** T = mg

$$\text{Stress} = \frac{T}{A} = \frac{mg}{A} = \frac{(\rho A\ell)g}{A}$$

$$\ell = \frac{\text{Stress}}{\rho g} = \frac{1.2\times10^8}{6\times10^4\times\left(\frac{10}{3}\right)} = 600\,m$$

**Q53.** In the experiment to determine the galvanometer resistance by half-deflection method, the plot of $\frac{1}{\theta}$ vs the resistance (R) of the resistance box is shown in the figure. The figure of merit of the galvanometer is……$\times10^{-1}$ A/division.

[The source has emf 2V]




**Ans.** **5**

**Sol.** $i = k\theta$ , $k = \frac{i}{\theta}$

$$\frac{2}{G+R} = k\theta$$

$$\frac{1}{\theta} = R\times\frac{k}{2} + \frac{kG}{2}$$

$$\text{Slope} = \frac{k}{2} = \frac{1}{4}$$

$$k = \frac{1}{2} = 0.5 = 5\times10^{-1}$$

**Q54.** In Young's double slit experiment, carried out with light of wavelength 5000 Å, the distance between the slits is 0.3 mm and the screen is at 200 cm from the slits. The central maximum is at x = 0 cm. The value of x for third maxima is…….mm.

**Ans.** **10**

**Sol.** $$x = \frac{nD\lambda}{d} = \frac{3\times2\times5000\times10^{-10}}{0.3\times10^{-3}}$$

x = 10 mm

**Q55.** If three helium nuclei combine to form a carbon nucleus then the energy released in this reaction is……$\times10^{-2}$ MeV . (Given $1u = 931\,MeV/c^2$, atomic mass of helium = 4.002603u)

**Ans.** **727**

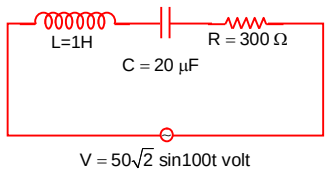
**Sol.** $\Delta m = (3\times m_{He} - m_C) = (3\times4.002603 - 12)$

= 0.007809 amu

$E = \Delta mc^2 = \Delta m\times931 = 0.007809\times931$

$E = 7.27\,Mev = 727\times10^{-2}\,Mev$

**Q56.** An ac source is connected in given series LCR circuit. The rms potential difference across the capacitor of $20\mu F$ is……V.




**Ans.** **50**

**Sol.** $Z = \sqrt{\left(L\omega - \frac{1}{C\omega}\right)^2 + R^2}$

$Z = \sqrt{\left(100 - \frac{1}{100 \times 20 \times 10^{-6}}\right)^2 + 300^2}$

$Z = \sqrt{(100 - 500)^2 + 300^2}$

$Z = 500$

$i_{rms} = \frac{V_{rms}}{z} = \frac{50}{500} = 0.1A$

These $V_{rms}$ across capacitor.

$V_{rms} = x_C \, x i_{rms} = 500 \times 0.1 = 50V$

**Q57.** A 2A current carrying straight metal wire of resistance $1\Omega$, resistivity $2 \times 10^{-6}\Omega m$, area of cross-section $10\,mm^2$ and mass 500 g is suspended horizontally in mid air by applying a uniform magnetic field $\vec{B}$. The magnitude of B is…….$\times 10^{-1}$T (given, $g = 10\,m/s^2$).

**Ans.** **5**

**Sol.** $mg = Bil$ -(i)

$R = \frac{\rho \ell}{A}$ (ii)

$mg = Bi \times \frac{RA}{\rho}$

$B = \frac{\rho mg}{iRA} = \frac{2 \times 10^{-6} \times 0.5 \times 10}{2 \times 1 \times 10 \times 10^{-6}}$

$B = 0.5T = 5 \times 10^{-1}T$

**Q58.** Three capacitors of capacitances $25\mu F$, $30\mu F$ and $45\mu F$ are connected in parallel to a supply of 100 V. Energy stored in the above combination is E. When these capacitors are connected in series to the same supply, the stored energy is $\frac{9}{x}E$. The value of x is……

**Ans.** **86**

**Sol.** In parallel combination

$C_{eqv} = C_1 + C_2 + C_3$

$E_P = \frac{1}{2} \times C_{eqv} \times V^2 = \frac{1}{2}(C_1 + C_2 + C_3)V^2 3$

$E_P = \frac{1}{2}\left(100 \times 10^{-6}\right) \times 100^2 = E$

In series combination

$\frac{1}{C_{eqv}} = \frac{1}{25} + \frac{1}{30} + \frac{1}{45} = \frac{18 + 15 + 10}{450}$

$C_{eqv} = \frac{450}{43}$

$$E_s = \frac{1}{2} \times C_{eqv} \times v2 = \frac{1}{2}\left(\frac{450}{43} \times 10^{-6}\right) \times 100^2 = \frac{9}{x}E$$

$$\Rightarrow \frac{100}{\frac{450}{43}} = \frac{x}{9}$$

$$\Rightarrow x = \frac{100 \times 9 \times 43}{450} = 86$$

**Q59.** The electric field between the two parallel plates of a capacitor of 1.5μF capacitance drops to one third of its initial value is 6.6μs when the plates are connected by a thin wire.
The resistance of this wire is……$\Omega$ . (Given, $\log 3 = 1.1$)

**Ans.** **4**

**Sol9.** $E \alpha v$

$$\frac{v_0}{3} = v_0 e^{-\frac{t}{\tau}}$$

$$t = \tau\, \ell n(3)$$

$$t = RC\, \ell n(3)$$

$$R = \frac{t}{C\ell n(3)} = \frac{6.6 \times 10^{-6}}{1.5 \times 10^{-6} \times 1.1}$$

$$R = 4\Omega$$

**Q60.** A body moves on a frictionless plane starting from rest. If $S_n$ is distance moved between $t = n-1$ and $t = n$ and $S_{n-1}$ is distance moved between t = n – 2 and t = n – 1, then the ratio $\frac{S_{n-1}}{S_n}$ is $\left(1-\frac{2}{x}\right)$ for n = 10. The value of x is……

**Ans.** **19**

**Sol.**

$$\frac{S_{n-1}}{S_n} = \frac{\frac{1}{2}a(2n-2-1)}{\frac{1}{2}a(2n-1)}$$

$$\frac{S_{n-1}}{S_n} = \frac{2n-3}{2n-1} = \frac{2 \times 10^{-3}}{2 \times 10^{-1}} = \frac{17}{19}$$

$$1 - \frac{2}{x} = \frac{17}{19}$$

$$\Rightarrow \frac{2}{19} = \frac{2}{x}$$

$$\Rightarrow x = 19$$

# PART – C (CHEMISTRY)

## SECTION - A

**(One Options Correct Type)**

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

**Q61.** The metal that shows highest and maximum number of oxidation state is:

(A) Mn (B) Co

(C) Ti (D) Fe

**Ans.** **A**

**Sol.** $Mn_{(25)} = -4s^2 3d^5$

Thus highest oxidation state of $Mn = (+7)$. It has also maximum number of oxidation state.

**Q62.** The number of neutrons present in the more abundant isotope of boron is 'x' Amorphous boron upon heating with air forms a product, in which the oxidation state of boron 'y'. The value of x+y is_____.

(A) 3 (B) 4

(C) 6 (D) 9

**Ans.** **D**

**Sol2.** More abundant isotope of B is $5^{B^{11}}$

Number of neutrons $= 11-5 = 6 = x$

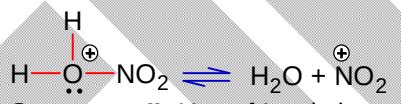
Amorphous $B + O_2 \longrightarrow B_2O_3$

Oxidation state of B in $B_2O_3 = (+3) = y$

$\therefore (x+y) = 6+3 = 9$

**Q63.** Given below are two statements:

**Statement I:**



**Statement II:** Use of Lewis base promotes the electrophilic substitution of benzene.

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

(A) **Statement I** is correct but **Statement II** is incorrect

(B) **Statement I** is incorrect but **Statement II** is correct

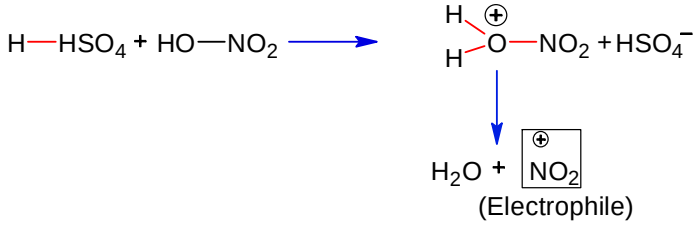
(C) Both **Statement I** and **Statement II** are incorrect

(D) Both **Statement I** and **Statement II** are correct.

Generation of $E^{\oplus}$ promoted by Lewis acid not by Lewis base.

**Ans.** **A**

**Sol.** Nitration of benzene required reagent is $(C.HNO_3 + C.H_2SO_4)$, which generate electrophile $\overset{\oplus}{N}O_2$



Generation of $E^{\oplus}$ promoted by Lewis acid not by Lewis base.

**Q64.** For the compounds:

(A) $H_3C-CH_2-O-CH_2-CH_2-CH_3$

(B) $H_3C-CH_2-CH_2-CH_2-CH_3$

(C) $CH_3-CH_2-\underset{\underset{O}{\|}}{C}-CH_2-CH_3$

(D) $H_3C-\underset{\underset{OH}{|}}{CH}-CH_2-CH_2-CH_3$

The increasing order of boiling point is:

Choose the correct answer from the options given below:

(A) (A) < (B) < (C) < (D)

(B) (B) < (A) < (C) < (D)

(C) (B) < (A) < (D) < (C)

(D) (D) < (C) < (A) < (B)

**Ans.** **B**

**Sol.** Boiling point depends on

H- Bonding & polarity

In alcohol H- bonding possible and in carbonyl compounds polarity is present

**Q65.** Molar ionic conductivities of divalent cation and anion are 57 S $cm^2$ $mol^{-1}$ and 73 $Scm^2$ $mol^{-1}$ respectively. The molar conductivity of solution of an electrolyte with the above cation and anion will be:

(A) 187 S $cm^2$ $mol^{-1}$

(B) 260 S $cm^2$ $mol^{-1}$

(C) 130 S $cm^2$ $mol^{-1}$

(D) 65 S $cm^2$ $mol^{-1}$

**Ans.** **C**

**Sol5.** $\left(\wedge_M\right)_{\text{cations}}^{C^{+2}\text{type}} = 57\,S\,cm^2mol^{-1}$

$\left(\wedge_M\right)_{\text{anions}}^{A^{-2}\text{type}} = 73Scm^2mol^{-1}$

$\therefore \left(\wedge_M\right)_{\text{solution}} = \left(\wedge_M\right)_{\text{cation}} + \left(\wedge_M\right)_{\text{Anion}}$

$= (57+73)\,S\,cm^2mol^{-1}$

$= 130\,Scm^2mol^{-1}$

**Q66.** An organic compound has 42.1% carbon, 64% hydrogen and remainder is oxygen. If its molecular weight is 342, then its molecular formula is:

(A) $C_{12}H_{22}O_{11}$

(B) $C_{11}H_{18}O_{12}$

(C) $C_{14}H_{20}O_{10}$

(D) $C_{12}H_{20}O_{12}$

**Ans.** **A**

**Sol.** Molecular wt. in $C_{12}H_{22}O_{11} = 12\times12+22\times1+16\times11 = 144+22+176 = 342$

Molecular . wt of $C_{11}H_{18}O_{12}$

$= 12\times11+18+16\times12$

$= 132+18+192 = 342$

$M_{C_{14}H_{20}O_{10}} = 12\times14+20\times1+16\times10$

$= 168+20+160 = 348$

$M_{C_{12}H_{20}O_{12}} = 12\times12+20+16\times12$

$= 144+20+192 = 356$

$\therefore$ % of C in $C_{12}H_{22}O_{11} = \frac{144}{342}\times100 = 42.1$

% of C in $C_{11}H_{18}O_{12} = \frac{132}{342}\times100 = 38.59$

**Q67.** The following reaction occurs in the Blast furnance where iron ore is reduced to iron metal

$Fe_2O_{3(s)} + 3CO_{(g)} \rightleftharpoons Fe_{(\ell)} + 3CO_{2(g)}$

Using the Le-chatelier's principle, predict which one of the following will not disturb the equilibrium.

(A) Removal of $CO_2$ (B) Addition of $Fe_2O_3$

(C) Removal of CO (D) Addition of $CO_2$

**Ans.** **B**

**Sol.** When solid added no effect on equilibrium because there will be no change in concentration.

**Q68.** Which one of the following complexes will exhibit the least paramagnetic behaviour

[Atomic number, Cr=24, Mn=25, Fe=26, Co=27]

(A) $\left[Cr(H_2O)_6\right]^{2+}$ (B) $\left[Co(H_2O)_6\right]^{2+}$

(C) $\left[Mn(H_2O)_6\right]^{2+}$ (D) $\left[Fe(H_2O)_6\right]^{2+}$

**Ans.** **B**

**Sol.** (a) $\left[Cr(H_2O)_6\right]^{+2} \Rightarrow Cr^{+2} = -4s^0 3d^4$ u.e = 4

(b) $\left[Co(H_2O)_6\right]^{+2} \Rightarrow Co^{+2} = -4s^0 3d^7$ u.e = 3

(c) $\left[Mn(H_2O)_6\right]^{+2} \Rightarrow Mn^{+2} = -4s^0 3d^5$ u.e = 5

(d) $\left[Fe(H_2O)_6\right]^{+2} \Rightarrow Fe^{+2} = -4s^0 3d^6$ u.e = 4

Thus $\left[Co(H_2O)_6\right]^{+2}$ has least paramagnetic character

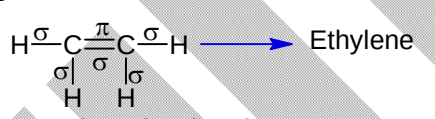
**Q69.** Number of $\sigma$ and $\pi$ bonds present in ethylene molceucle is respectively:

(A) 4 and 1 (B) 5 and 1

(C) 5 and 2 (D) 3 and 1

**Ans.** **B**

**Sol.**



Ethylene

$\therefore$ Number of $\sigma$-bonds =5

Number of $\pi$-bonds =1

**Q70.** The statement(s) that are correct about the species $O^{2-}$,$F^-$,$Na^+$ and $Mg^{2+}$

(a) All are isoelectronic

(b) All have the same nuclear charge

(c) $O^{2-}$ has the largest ionic radii

(d) $Mg^{2+}$ has the smallest ionic radii

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

(A) (b), (c) and (d) only (B) (c) and (d) only

(C) (a), (b), (c) and (d) (D) (a), (c) and (d) only

**Ans.** **D**

**Sol.** ${}_8O^{-2} \Rightarrow$ No. of $e^- = 10$

${}_9F^- \Rightarrow$ No. of $e^- = 10$

${}_{11}Na^+ \Rightarrow$ No. of $e^- = 10$

${}_{12}Mg^{+2} \Rightarrow$ No. of $e^- = 10$

Ionic radii = $O^{-2} > F^- > Na^+ > Mg^{+2}$

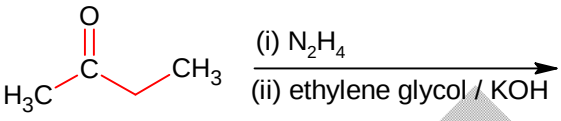
$Z_{eff} = Mg^{+2} > Na^+ > F^- > O^{-2}$

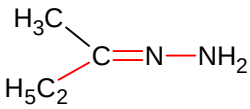
**Q71.** The incorrect postulates of the Dalton's atomic theory are:
(a) Atoms of different elements differ in mass.
(b) Matter consists of divisible atoms.
(c) Compounds are formed when atoms of different element combine in a fixed ratio.
(d) All the atoms of given element have different properties including mass.
(e) Chemical reactions involves the reorganisation of atoms.
Choose the correct answer from the options given below:
(A) (c), (d), (e) only (B) (b), (d) , (e) only
(C) (a), (b), (d) only (D) (b), (d) only

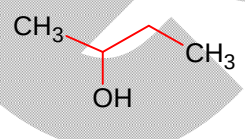
**Ans.** **D**

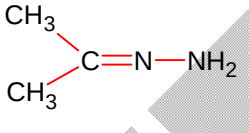
**Sol.** Daltons postulates
(1) Smallest part of any matter is atom
(2) Atoms are indivisible
(3) Atoms of same elements are equivalent in all respect shape, size, structure & properties

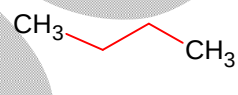
**Q72.** Identify 'X' in the following reaction :



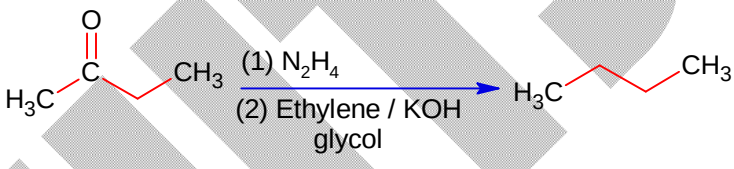

(A) 


(B) 


(C) 


(D) 


**Ans.** **D**

**Sol.** 


This is Wolf – Kishner reduction, in which $> C = O$ group changes to $>C\begin{matrix}H\\H\end{matrix}$ group

**Q73.** The reaction at cathode in the cells commonly used in clocks involves.
(A) reduction of Mn from +4 to +3 (B) oxidation of Mn from +3 to +4
(C) reduction of Mn from +7 to +2 (D) oxidation of Mn from +2 to +7

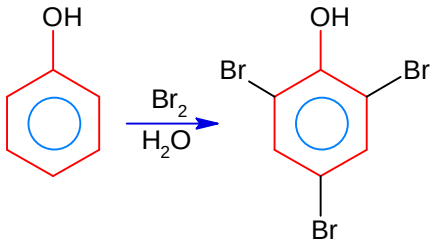
**Ans.** **A**

**Sol.** $Mn^{+4} + e^- \longrightarrow Mn^{+3}$ (Reduction)
This reaction occurs at cathode in clocks cell.

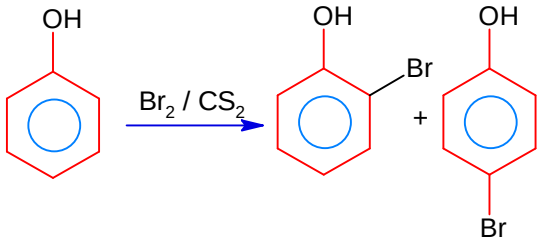
**Q74.** Given below are two statements:
**Statement I :** Bromination of phenol in solvent with low polarity such as $CHCl_3$ or $CS_2$ requires Lewis acid catalyst.
**Statement II:** The Lewis acid catalyst polarizes the bromine to generate $Br^+$.
In the light of the above statements, choose the **correct** answer from the options given below:
(A) Both **Statement I** and **Statement II** are false.
(B) **Statement I** is true but **Statement II** is false.
(C) **Statement I** is false but **Statement II** is true
(D) Both **Statement I** and **Statement II** are true

**Ans.** **C**

**Sol.**




Phenol is highly activated compound which can undergo bromination directed without any Lewis acid.




**Q75.** Given below are two statements:
**Statement I :** In group 13, the stability of +1 oxidation state increases down the group.
**Statement II:** The atomic size of gallium is greater than that of aluminium
In the light of the above statements, choose the **most appropriate** answer from the options given below:
(A) **Statement I** is incorrect but **Statement II** is correct.
(B) Both **Statement I** and **Statement II** are correct.
(C) Both **Statement I** and **Statement II** are incorrect
(D) **Statement I** is correct. but **Statement II** is incorrect.

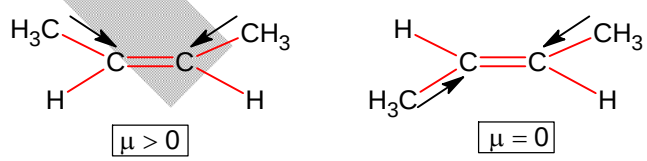
**Ans.** **D**

**Sol.** The number of d & f electrons increases down the group and due to poor shielding of d and f electrons, stability of lower oxidation state increases down the group. This is known as inert pair effect. The atomic size of Al is greater than Ga.

**Q76.** Give below are two statements: One is labelled as **Assertion (A)** and the other is labelled as **Reason (R):**
**Assertion (A):** Cis form of alkene is found to be more polar than the trans form
**Reason (R):** Dipole moment of trans isomer of 2-butente is zero.
In the light of the above statements, choose the correct answer from the options given below:
(A) Both **(A)** and **(R)** are true and **(R)** is **NOT** the correct explanation of **(A)**
(B) (A) is false but **(R)** is true.
(C) Both (A) and **(R)** are true and **(R)** is the correct explanation of **(A)**
(C) **(A)** is true but **(R)** is false.

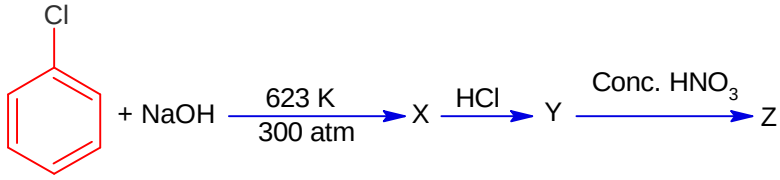
**Ans.** **C**

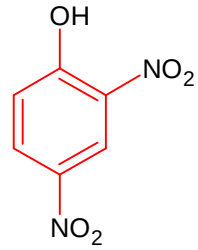
**Sol.**

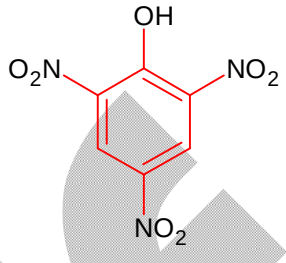


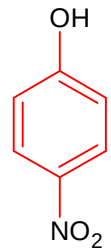

$\mu$ of cis is greater than trans form thus cis form is more polar than trans form.

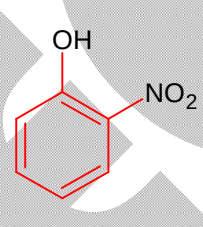
**Q77.** Identify compound (Z) in the following reaction sequence.



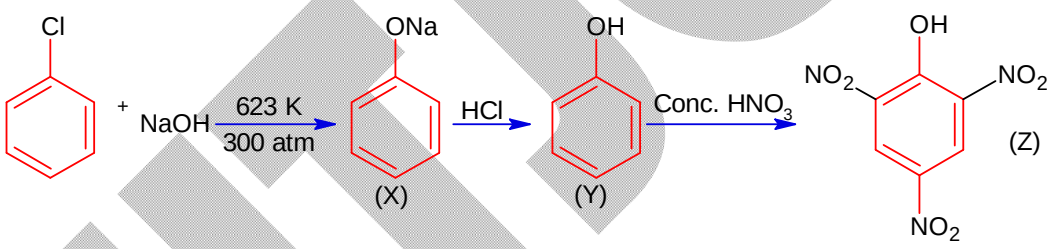

(A) 


(B) 


(C) 


(D) 


**Ans.** **B**

**Sol.** 


**Q78.** Which of the following gives a positive test with ninhydrin?

(A) Cellulose (B) Polyvinyl chloride

(C) Egg albumin (D) Starch

**Ans.** **C**

**Sol.** Ninhydrin test is a test of amino acids Egg albumin contains protein which is a natural polymer of amino acids. All amino acids gives violet colour product except proline & 4-Hydroxy proline.

**Q79.** The correct order of ligands arranged in increasing field strength

(A) $F^- < Br^- < I^- < NH_3$ (B) $Cl^- < \bar{O}H < Br^- < CN^-$

(C) $H_2O < \bar{O}H < CN^- < MH_3$ (D) $Br^- < F^- < H_2O < NH_3$

**Ans.** **D**

**Sol.** The correct order of ligand in increasing field strength is

$Br^- < F^- < H_2O < NH_3$

**Q80.** Given below are two statements: One is labelled as **Assertion (A)** and the other is labelled as **Reason (R):**

**Assertion (A):** Enthalpy of neutralization of strong monobasic acid with strong monoacidic base is always -57 kJ $mol^{-1}$

**Reason (R):** Enthalpy of neutralization is the amount of heat liberated when one mole of $H^+$ ions furnished by acid combine with one mole of $^-OH$ ions furnished by base to form one mole of water.

In the light of the above statements, choose the correct answer from the options given below:
(A) Both **(A)** and **(R)** are true but **(R)** is **NOT** the correct explanation of **(A)**
(B) Both (A) and **(R)** are true but **(R)** is the correct explanation of **(A)**
(C) (A) is false but **(R)** is true.
(D) **(A)** is true but **(R)** is false.

**Ans.** **B**

**Sol.** Enthalpy of neutralization of S.A & S.B is always $-57\,kJ/mole$.

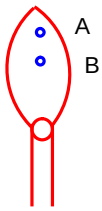
$$\left(H^+\right)_{S.A}+\left(OH^-\right)_{S.B}\longrightarrow H_2O \qquad \Delta H=-57\,kJ$$

# SECTION - B

**(Numerical Answer Type)**

This section contains **10** Numerical based questions. The answer to each question is rounded off to the nearest integer value.

**Q81.**




In a borax bead test under hot condition, a metal salt (one from the given) is heated at point B of the flame, resulted in green colour salt bead. The spin-only magnetic moment value of the salt is _____BM (Nearest integer)
[Given atomic number of Cu =29, N- = 28, Mn= 25, Fe=26]

**Ans.** **6**

**Sol.** In borax-bead test green colour bead given by Fe. When heated at point B.

$Fe^{+3}=4s^0 3d^5$

Number of unpaired $e^-=5$

$\therefore$ Spin only magnetic moment $=\sqrt{5(5+2)}$

$=\sqrt{35}\,B.M=5.92\,B.M$

$\approx 6\,B.M$

**Q82.** The spin- only magnetic moment value of the ion among $Ti^{2+}$,$V^{2+}$,$Co^{3+}$ and $Cr^{2+}$, that acts as strong oxidizing agent in aqueous solution is _____BM (Near integer)
(Given atomic numbers: Ti:22, V:23, Cr:24,Co:27)

**Ans.** **5**

**Sol.** $Co^{+3}=-4s^0 3d^6$

$Ti^{+2}=-4s^0 3d^2$

$V^{+2}=-4s^0 3d^3$

$Cr^{+2}=-4s^0 3d^4$

$\therefore Co^{+3}$ is strongest oxidizing agent

Number of unpaired $e^-=4$

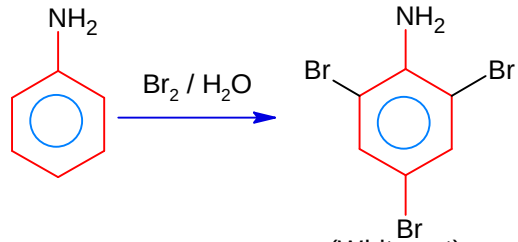
$\therefore$ Spin only magnetic moment $=\sqrt{4(4+2)}\,B.M$

$=\sqrt{24}\,B.M=4.89\,B.M\approx 5$

**Q83.** 9.3 g of pure aniline is treated with bromine water at room temperature to give a white precipitate of the product 'P'. The mass of product 'P' obtained is 26.4 g. The percentage yield is_____%.

**Ans.** **80**

**Sol.**




(White ppt)
(p)

$\because$ 93 g aniline produces 330g of Tri bromo aniline

$\therefore$ 9.3 g aniline produces $\frac{330}{93}\times 9.3g$

$= 33g$

$\therefore$ % yield $= \frac{26.4}{33}\times 100 = 80\%$

**Q84.** The heat of combustion of solid benzoic acid at constant volume is -321.30 kJ at 27°C. The heat of combustion of constant pressure is (-321.30-xR) kJ, the value of x is_____.

**Ans.** **150**

**Sol.** $C_6H_5COOH(s)+\frac{15}{2}O_2(g)\rightarrow 7CO_2(g)+3H_2O(\ell)$

$\Delta U = -321.30kJ$

$\Delta H = \Delta U + \Delta n_g RT$

$\left(-321.30 - xR\right) = 321.30 + \left(-\frac{1}{2}\right)R\times 300$

$-xR = -\frac{1}{2}R\times 300$

$x = 150$

**Q85.** An artificial cell is made by encapsulating 0.2 M glucose solution within semipermeable membrane. The osmotic pressure developed when the artificial cell is placed within a 0.05 M solution of NaCl at 300K is _____ $\times 10^{-1}$ bar (nearest integer)

[Given: R = 0.083 L bar $mol^{-1}$ $K^{-1}$]

Assume complete dissociation of NaCl

**Ans.** **25**

**Sol.** $NaC\ell \longrightarrow \underset{0.05(M)}{Na^+} + \underset{0.05(M)}{C\ell^-}$

$\therefore \text{Total}[NaC\ell] = 0.05 + 0.05 = 0.1(M)$

$\therefore$ Concentration of glucose = 0.2(M)

$\therefore$ Final concentration when glucose placed in NaCl solution

$= (0.2 - 0.1) = 0.1(M)$

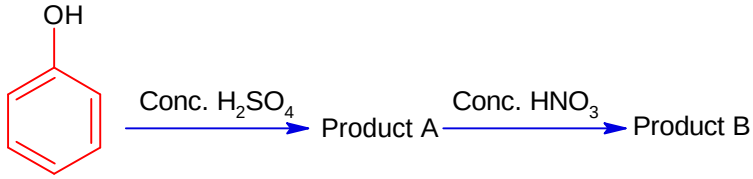
Osmotic pressure $(\pi) = CRT$

$= 0.1\times 0.083\times 300$

$= 2.49$ bar

$= 24.9\times 10^{-1}$ bar $\approx 25\times 10^{-1}$ bar

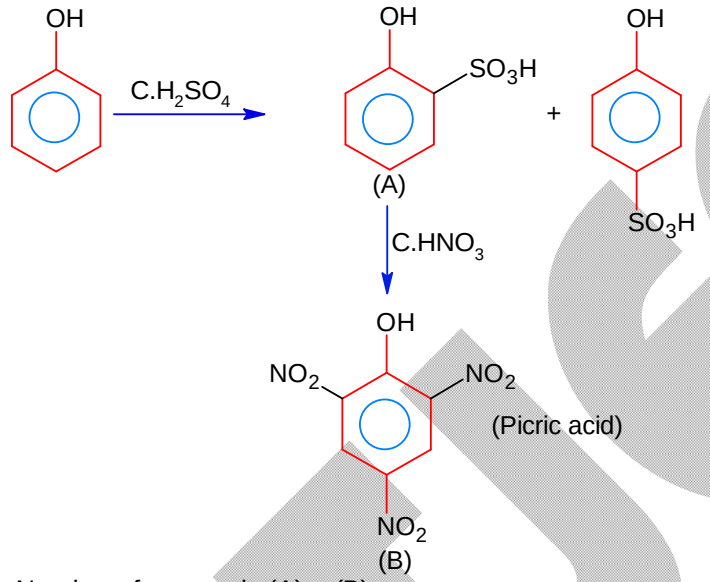
**Q86.** Consider the given chemical reaction sequence:




Total sum of oxygen atoms in product A and product B are_____.

**Ans.** **14**

**Sol.**




$\therefore$ Number of oxygen is (A) + (B)
= 4 + 7 = (11)

**Q87.** The value of Rydberg constant ($R_H$) is $2.18\times10^{-18}$ J. The velocity of electron having mass $9.1\times10^{-31}$ kg in Bohr's first orbit of hydrogen atom= _____$\times10^5$ $ms^{-1}$ (nearest integer)

**Ans.** **22**

**Sol.** $V = 2.18\times10^6\times\frac{z}{n}m/sec$

$= 21.8\times10^5\times\frac{1}{1}m/sec$

$= 21.8\times10^5 m/sec$

$\approx 22\times10^5 m/sec$

**Q88.** During Kinetic study of reaction $2A+B\rightarrow C+D$, the following results were obtained:

| | **A[M]** | **B[M]** | **initial rate of formation of D** |
|---|---|---|---|
| I | 0.1 | 0.1 | $6.0\times10^{-3}$ |
| II | 0.3 | 0.2 | $7.2\times10^{-2}$ |
| III | 0.3 | 0.4 | $2.88\times10^{-1}$ |
| IV | 0.4 | 0.1 | $2.40\times10^{-2}$ |

Based on above data, overall order of the reaction is_____.

**Ans.** **3**

**Sol.** $r = k[A]^x[B]^y$

$6\times10^{-3} = k(0.1)^x(0.1)^y$

$2.4\times10^{-2} = k(0.4)^x(0.1)^y$

$\therefore \dfrac{24\times10^{-3}}{6\times10^{-3}} = \dfrac{k(0.4)^x(0.1)^y}{k(0.1)^x(0.1)^y}$

$\therefore 4 = (4)^x \qquad \therefore \boxed{x=1}$

$2.88\times10^{-1} = k(0.3)^x(0.4)^y$

$7.2\times10^{-2} = k(0.3)^x(0.2)^y$

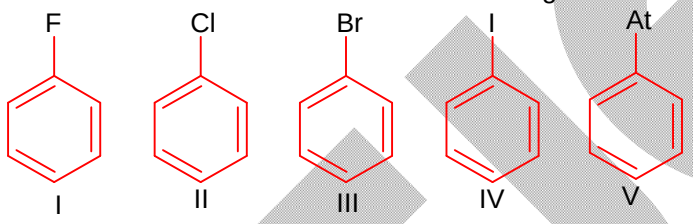
$\therefore \dfrac{28.8\times10^{-2}}{7.2\times10^{-2}} = \dfrac{k(0.3)^x(0.4)^y}{k(0.3)^x(0.2)^y}$

$\therefore 4 = 2^y \qquad \therefore \boxed{y=2}$

$\therefore r = k[A]^1[B]^2$

$\therefore$ order = 1+2=3

**Q89.** The number of halobenzenes from the following that can be prepared bySandmeyer's reaction is



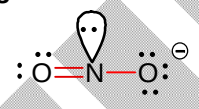

**Ans.** **2**

**Sol.** In sandmeyer's reaction only bromobenzene and chlorobenzene are prepared.

**Q90.** In the lewis dot structure of $NO_2^-$, total number of valence electrons around nitrogen is_____.

**Ans.** **8**

**Sol.**



$\therefore$ total number of valence $e^-$ around nitrogen = 8…