JEE (Main)-2025 (Online) Session-2

Question Paper with Solutions

(Mathematics, Physics, And Chemistry)

3 April 2025 Shift – 2

Time: 3 hrs. **M.M : 300**

IMPORTANT INSTRUCTIONS:

(1) The test is of **3 hours** duration.

(2) This test paper consists of 75 questions. Each subject (PCM) has 25 questions. The maximum marks are 300.

(3) This question paper contains Three Parts. Part-A is Physics, Part-B is Chemistry and Part-C is Mathematics. 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. 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.

SECTION-A

1. Let f : R $\to$ R be a function defined by $f(x) = \|x+2|-2|x|\|$. If m is the number of points of local minima and n is the number of points of local maxima of f, then m + n is

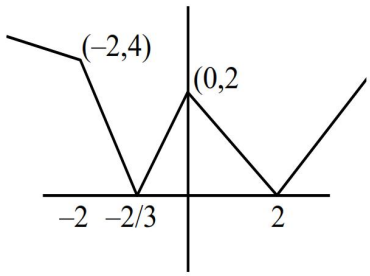
(1) 5 (2) 3

(3) 2 (4) 4

Ans. (2)

Sol. $f(x) = \|x+2|-2|x|\|$

Critical points, $0, -2, 2, -\frac{2}{3}$



No. of maxima = 1

No. of minima = 2

option (2)

2. Each of the angles β and γ 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-axes. Then the sum of all possible values of the angle β is

(1) $\frac{3\pi}{4}$ (2) π

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

Ans. (1)

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

$\cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1$

$\cos^2\alpha + 2\cos^2\frac{\alpha}{2} = 1$

$\cos^2\alpha + \cos\alpha = 0$

$\cos\alpha(\cos\alpha + 1) = 0$

$\cos\alpha = 0, -1$

$\alpha = \frac{\pi}{2}, \pi$

Now $\beta = \frac{\alpha}{2} \Rightarrow \frac{\pi}{4}, \frac{\pi}{2}$

so sum is $\frac{3\pi}{4}$

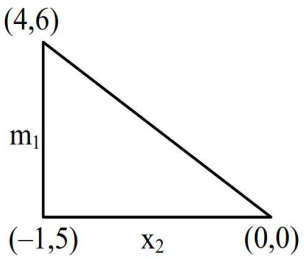
3. If the four distinct points (4, 6), (–1,5), (0,0) and (k, 3k) lie on a circle of radius r, then $10k + r^2$ is equal to

(1) 32 (2) 33

(3) 34 (4) 35

Ans. (4)

Sol.



$m_1m_2 = -1$ so right angle equation circle is

$(x-4)(x-0) + (y-6)(y-0) = 0$

$x^2 + y^2 - 4x - 6y = 0$

(k,3k) lies on it so

$k^2 + 9k^2 - 4k - 18k = 0$

$10k^2 - 22k = 0$

$k = 0, \frac{11}{5}$

k = 0 is not possible so $k = \frac{11}{5}$

also $r = \sqrt{4+9} = \sqrt{13}$

so $10k + r^2 = 10.\frac{11}{5} + \left(\sqrt{13}\right)^2 = 35$

4. Let the Mean and Variance of five observations $x_1 = 1$, $x_2 = 3$, $x_3 = a$, $x_4 = 7$ and $x_5 = b$, $a > b$, be 5 and 10 respectively. Then the Variance of the observations $n + x_n$, $n = 1, 2, \ldots\ldots 5$ is

(1) 17 (2) 16.4

(3) 17.4 (4) 16

Ans. (4)

Sol. $\bar{x} = \frac{\sum x_i}{n} = \frac{1+3+a+7+b}{5} = 5$

$a + b = 14$

$\sigma^2 = \frac{\Sigma x_i^2}{n} - (\bar{x})^2$

$\Rightarrow \frac{1^2+3^2+a^2+7^2+b^2}{5} - 25 = 10$

$a^2 + b^2 = 116$

$a > b \quad a = 10 \quad b = 4$

$n + x_n : 2,5,13,11,9$

$\sigma^2 = \frac{2^2+5^2+13^2+11^2+9^2}{5} - \left(\frac{2+5+13+11+9}{5}\right)^2$

$= 80 - 64 = 16$

option 4

5. Consider the lines $x(3\lambda + 1) + y(7\lambda+2) = 17\lambda + 5$, λ 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) 20 (2) 30

(3) 10 (4) 15

Ans. (1)

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

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

intersection of family of lines

P(1,2)

Let Q(3,6)

$d = PQ = \sqrt{2^2 + 4^2} = \sqrt{20}$

$d^2 = 20$

option (1)

6. 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) 13 (4) 14

Ans. (1)

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

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

$\ell = 6$

$m = 3$

$n = 3$

$\ell + m + n = 12$

7. let the equation $x(x + 2)(12-k) = 2$ have equal roots. Then the distance of the point $\left(k, \frac{k}{2}\right)$ from the line $3x + 4y + 5 = 0$ is

(1) 15 (2) $5\sqrt{3}$

(3) $15\sqrt{5}$ (4) 12

Ans. (1)

Sol. $(x^2 + 2x)(12 - k) = 2$

$\lambda x^2 + 2\lambda x - 2 = 0 \quad k \neq 12$ Let $12 - k = \lambda$

$D = 0$

$4\lambda^2 + 8\lambda = 0$

$\lambda = 0$ or $\lambda = -2$

$\Rightarrow 12 - k = -2$

$k = 14$

So $P\left(k, \frac{k}{2}\right) = (14, 7)$

$d = \left|\frac{3\times14 + 4\times7 + 5}{5}\right| = 15$

option (1)

8. Line L_1 of slope 2 and line L_2 of slope $\frac{1}{2}$ intersect at the origin O. In the first quadrant, $P_1, P_2, \ldots P_{12}$ are 12 points on line L_1 and $Q_1, Q_2, \ldots Q_9$ are 9 points on line L_2. Then the total number of triangles, that can be formed having vertices at three of the 22 points O, $P_1, P_2, \ldots P_{12}, Q_1, Q_2, \ldots Q_9$, is:

(1) 1080 (2) 1134

(3) 1026 (4) 1188

Ans. (2)

Sol. Total number of $\Delta$are

$= {}^9C_1\,{}^{12}C_2 + {}^9C_2\,{}^{12}C_1 + {}^1C_1\,{}^9C_1\,{}^{12}C_1$

$= 594 + 432 + 108$

$= 1134$

9. The integral $\int_0^{\pi} \frac{8x\,dx}{4\cos^2 x + \sin^2 x}$ is equal to

(1) $2\pi^2$ (2) $4\pi^2$

(3) π^2 (4) $\frac{3\pi^2}{2}$

Ans. (1)

Sol. $I = \int_0^{\pi} \frac{8x\,dx}{4\cos^2 x + \sin^2 x}$

$I = \int_0^{\pi} \frac{8(\pi - x)\,dx}{4\cos^2 x + \sin^2 x}$

$2I = 8\pi \int_0^{\pi} \frac{dx}{4\cos^2 x + \sin^2 x}$

$2I = 8\pi \times 2 \int_0^{\pi/2} \frac{\sec^2 x}{4 + \tan^2 x} dx$

$I = 8\pi \int_0^{\infty} \frac{dt}{4 + t^2} = 8\pi \times \frac{1}{2}\left(\tan^{-1}\frac{t}{2}\right)_0^{\infty}$

$= 4\pi \times \frac{\pi}{2} = 2\pi^2$

option (1)

10. 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) 11 (2) 10

(3) 12 (4) 13

Ans. (1)

Sol. $f(x) + 3\, f\left(\frac{24}{x}\right) = 4x$

Put $x = 3$ $\quad f(3) + 3f(8) = 12$

Put $x = 8$ $\quad f(8) + 3f(3) = 32$

Add both $\quad 4(f(3) + f(8)) = 44$

$f(3) + f(8) = 11$

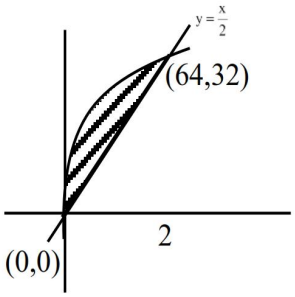
11. The area of the region $\left\{(x,y) : |x - y| \le y \le 4\sqrt{x}\right\}$ is

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

(3) $\frac{512}{3}$ (4) $\frac{2048}{3}$

Ans. (2)

Sol.



$|x - y| \le y \le 4\sqrt{x}$

Now $y = |x - y|$

$y^2 = (x - y)^2$

$\Rightarrow y = \frac{x}{2}$ and $x = 0$

Now area $= \int_0^{64} \left(4\sqrt{x} - \frac{x}{2}\right) dx$

$= \left[\frac{4x^{3/2}}{3/2} - \frac{x^2}{4}\right]_0^{64} = \frac{8}{3}.8^3 - \frac{64^2}{4} = 64^2\left(\frac{1}{12}\right)$

$= \frac{1024}{3}$

12. If the domain of the function $f(x) = \log_7(1 - \log_4(x^2 - 9x + 18))$ is $(\alpha, \beta) \cup (\gamma,\delta)$, then $\alpha + \beta + \gamma + \delta$ is equal to

(1) 18 (2) 16

(3) 15 (4) 17

Ans. (1)

Sol. Domain $1 - \log_4(x^2 - 9x + 18) > 0$

Also $x^2 - 9x + 18 > 0$

$(x - 3)(x - 6) > 0$

$x \in (-\infty, 3) \cup (6, \infty)$ ....(1)

also $x^2 - 9x + 18 < 4$

$x^2 - 9x + 14 < 0$

$x \in (2,7)$ ....(2)

(1) $\cap$ (2) $(2,3) \cup (6,7) = (\alpha,\beta) \cup (\gamma,\delta)$

$\Rightarrow \alpha + \beta + \gamma + \delta = 18$

13. If the probability that the random variable X takes the value x is given by $P(X = x) = k(x + 1)3^{-x}$, $x = 0,1,2,3.....$, where k is a constant, then $P(X \geq 3)$ is equal to

(1) $\frac{7}{27}$ (2) $\frac{4}{9}$

(3) $\frac{8}{27}$ (4) $\frac{1}{9}$

Ans. (4)

Sol. $\sum_{x=0}^{\infty} k(x+1)3^{-x} = 1$

$$\Rightarrow \frac{1}{k} = 1 + \frac{2}{3} + \frac{3}{3^2} + \frac{4}{3^3} + \ldots \text{(i)}$$

$$\frac{1}{3k} = \frac{1}{3} + \frac{2}{3^2} + \frac{3}{3^3} + \ldots. \quad \ldots\text{(ii)}$$

$$\text{(i)- (ii)} \Rightarrow \frac{1}{k} - \frac{1}{3k} = 1 + \frac{1}{3} + \frac{1}{3^2} + \ldots$$

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

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

$$= 1 - k\left(1 + \frac{2}{3} + \frac{3}{9}\right) = \frac{1}{9}$$

14. 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) $\frac{2}{3}$ (2) $\frac{4}{3}$

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

Ans. (2)

Sol. $\frac{dy}{dx} + 3\left(\sec^2 x\right)y = \sec^2 x, y(0) = \frac{1}{3} + e^3$

$$\text{If} = e^{3\int \sec^2 x dx} = e^{3\tan x}$$

$\therefore$ Solution is

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

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

$$\because\ y(0) = \frac{1}{3} + e^3 \Rightarrow c = e^3$$

$$\therefore\ y\left(\frac{\pi}{4}\right) = \frac{\frac{e^3}{3} + e^3}{e^3} = \frac{4}{3}$$

15. If $z_1, z_2, z_3 \in C$ 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)

(3) i (4) –i

Ans. (1)

Sol. $z_1 + z_2 + z_3 = 3z_0$

$(z_1 + z_2 + z_3)^2 = 9{z_0}^2$

$$\Rightarrow z_1^2 + z_2^2 + z_3^2 + 2\left(z_1^2 + z_2^2 + z_3^2\right) = 9z_0^2$$

$$\Rightarrow z_1^2 + z_2^2 + z_3^2 = 3z_6^2$$

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

$$= z_1^2 + z_2^2 + z_3^2 + 3z_0^2 - 2\left(z_1 + z_2 + z_3\right)z_0$$

$$= 6z_0^2 - 6z_0^2$$

$$= 0$$

16. The number of solutions of 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) 4 (2) 3

(3) 6 (4) 5

Ans. (4)

Sol. $\left(4-\sqrt{3}\right)\sin x - 2\sqrt{3}\cos^2 x = \frac{-4}{1+\sqrt{3}}, x \in \left[-2\pi, \frac{5\pi}{2}\right]$

$\Rightarrow \left(4-\sqrt{3}\right)\sin x - 2\sqrt{3}\left(1-\sin^2 x\right) = 2\left(1-\sqrt{3}\right)$

$\Rightarrow 2\sqrt{3}\sin^2 x + 4\sin x - \sqrt{3}\sin x - 2 = 0$

$\Rightarrow \left(2\sin x - 1\right)\left(\sqrt{3}\sin x + 2\right) = 0$

$\Rightarrow \sin x = \frac{1}{2}$

$\therefore$ Number of solution = 5

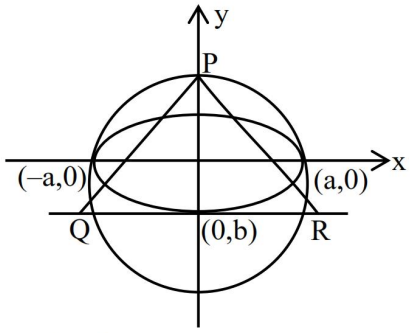
17. Let C be the circle of minimum area enclosing the ellipse E : $\frac{x^2}{a^2}+\frac{y^2}{b^2} = 1$ with eccentricity $\frac{1}{2}$ and foci(±2, 0). Let PQR be a variable triangle, whose vertex P is on the circle C and the side QR of length 29 is parallel to the major axis of E and contains the point of intersection of E with the negative y-axis. Then the maximum area of the triangle PQR is :

(1) $6\left(3+\sqrt{2}\right)$ (2) $8\left(3+\sqrt{2}\right)$

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

Ans. (4)

Sol.



Area of ΔPQR

$= \frac{1}{2}(2a)(a\sin\theta + b)$

$\therefore$ maximum area = a(a + b)

$= 4(4 + 2\sqrt{3}) = 8\left(2+\sqrt{3}\right)$

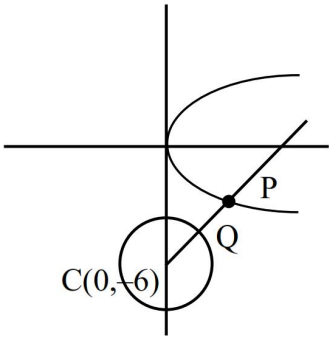
18. The shortest distance between the curves $y^2 = 8x$ and $x^2 + y^2 + 12y + 35 = 0$ is :

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

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

Ans. (4)

Sol.



Equation of normal to parabola

$y^2 = 8x$ is $y = mx - 4m - 2m^3$

passes through (0,–6) we get

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

$\Rightarrow m^3 + 2m - 3 = 0$

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

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

$\therefore$ Shortest distance = PC – r

$= \left(2\sqrt{2} - 1\right)$

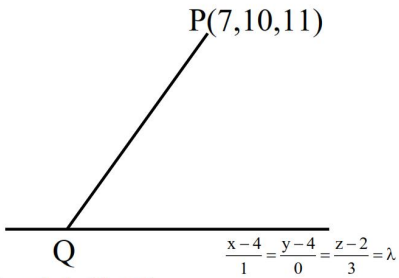
19. The distance of the point (7, 10, 11) from the line $\frac{x-4}{1} = \frac{y-4}{0} = \frac{z-2}{3}$ along the line $\frac{x-9}{2} = \frac{y-13}{3} = \frac{z-17}{6}$ is

(1) 18 (2) 14

(3) 12 (4) 16

Ans. (2)

Sol.



$(\lambda+4,4,3\lambda+2)$

$\because$ line PQ is parallel to line $\frac{x-9}{2}=\frac{y-3}{3}=\frac{z-17}{6}$

$\therefore \frac{\lambda-3}{2}=\frac{-6}{3}=\frac{3\lambda-9}{6}\Rightarrow\lambda=-1$

$Q=(3,4,-1)$

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

20. The sum $1+\frac{1+3}{2!}+\frac{1+3+5}{3!}+\frac{1+3+5+7}{4!}+...$ upto ∞ terms, is equal to

(1) $6e$ (2) $4e$

(3) $3e$ (4) $2e$

Ans. (4)

Sol. $S=1+\frac{1+3}{2!}+\frac{1+3+5}{3!}+...$

$=\sum_{r=1}^{\infty}\frac{r^2}{r!}$

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

$=2e$

SECTION-B

21. Let I be the identity matrix of order 3×3 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 $adj(A\ adj(A^2))$. Then $|(\lambda B+1)|$ is equal to _____

Ans. (38)

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

$\lambda(16)-2(-34)+3(-39)=-1$

$16\lambda=48\Rightarrow\lambda=3$

$B^{-1}=adj(A.adj\ (A^2))$

Let $C=A.\ adj\ (A^2)$

$AC=A^2\ adj(A^2)=|A|^2.I=I\Rightarrow C=A^{-1}$

Now $B^{-1}=adj(A^{-1})=B=adj(A)$

Now $\lambda B+I\Rightarrow 3B+I$

Let $P=3B+I$

$P=3adj\ (A)+I$

$AP=3Aadj(A)+A$

$AP=3|A|.I+A$

$AP=A-3I$

$|AP|=|A-3I|$

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

$|P|=-38$

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

Ans. (239)

Sol. $(1+x+x^2)^{10}=a_0+a_1x+a_2x^2+....+a_{20}x^{20}$

$\therefore 3^{10}=a_0+a_1+a_2+....+a_{20}$ ....(i)

$1=a_0-a_1+a_2.....+a_{20}$ ...(ii)

(i) - (ii) $\Rightarrow a_1+a_3+....+a_{19}=\frac{3^{10}-1}{2}=29524$

Also $\{1+x(1+x)\}^{10}=1$

$+{}^{10}C_1x\ (1+x)+{}^{10}C_2x^2(1+x)^2+.....$

$\therefore a_2={}^{10}C_1+{}^{10}C_2=55$

$\therefore \frac{(a_1+a_3+...+a_{19})-11a_2}{121}=239$

23. If $\lim\limits_{x\to 0}\left(\dfrac{\tan x}{x}\right)^{\frac{1}{x^2}} = p$, then $96\log_e p$ is equal to ___

Ans. (32)

Sol. $P=\lim\limits_{x\to 0}\left(\dfrac{\tan x}{x}\right)^{\frac{1}{x^2}}$

$$\Rightarrow P=e^{\lim\limits_{x\to 0}\left(\frac{\tan x-x}{x^3}\right)}$$

$$=e^{\lim\limits_{x\to 0}\frac{\left(x+\frac{x^3}{3}+\frac{2x^5}{15}+.....-x\right)}{x^3}}$$

$$=e^{1/3}$$

$$\therefore 96\log_e^{p}=96\times\frac{1}{3}=32$$

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 _____.

Ans. (128)

Sol. $\vec{b}\times\vec{d}=\vec{c}\times\vec{d}$-and $\vec{a}\,.\,\vec{d}=4$

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

$$\because\ \vec{a}.\vec{d}=4\Rightarrow\lambda=-2$$

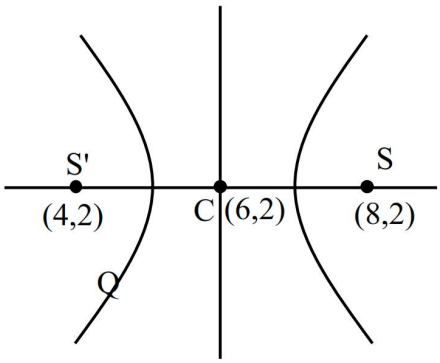
Also. $\left|\vec{a}\times\vec{d}\right|^2+\left|\vec{a}\,.\,\vec{d}\right|^2=|\vec{a}|^2|\vec{d}|^2$

$$\Rightarrow\left|\vec{a}\times\vec{d}\right|^2=6\times4\times6-16=128$$

25. 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 _____.

Ans. (141)

Sol.



Equation of hyperbola is

$$\frac{(x-6)^2}{a^2}-\frac{(y-2)^2}{4-a^2}=1$$

$$\Rightarrow\left(4-a^2\right)(x-6)^2-a^2(y-2)^2=a^2\left(4-a^2\right)$$

comparing with $3x^2-y^2-\alpha x+\beta y+\gamma=0$, we get

$a^2 = 1$ and $\alpha = 36$, $\beta = 4$ and $\gamma = 101$

$\therefore\ \alpha+\beta+\gamma=141$

SECTION-A

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° with magnetic field. The potential energy of the dipole is :

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

(3) – 60 J (4) – 80 J

Ans. **(4)**

Sol. $\tau = M \times B = MB\sin 60 = \frac{\sqrt{3}}{2}MB = 80\sqrt{3}$

$MB = 160$

$U = -M.B = -MB\cos 60$

$U = -160 \times 1/2 = -80$ J

27. 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) 335 m/s (2) 370 m/s

(3) 340 m/s (4) 360 m/s

Ans. **(4)**

Sol. Fundamental frequency in close/organ pipe

$$(f) = \frac{v}{4\ell}$$

$$f_1 = \frac{v}{4\ell_1} \ \& \ f_2 = \frac{v}{4\ell_2}$$

$$\text{Beat} = (f_1 - f_2) = \frac{v}{4}\left(\frac{1}{\ell_1} - \frac{1}{\ell_2}\right)$$

$$15 = \frac{v}{4}\left(\frac{1}{1} - \frac{1}{1.2}\right)$$

$$v = \left(\frac{15 \times 4 \times 1.2}{0.2}\right) = 60 \times 6 = 360 \text{ m/s}$$

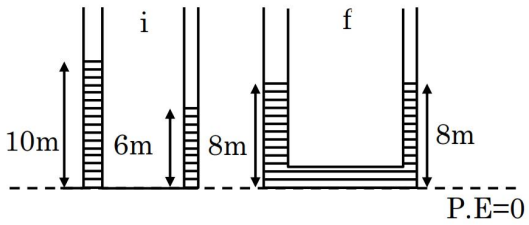
28. Two cylindrical vessels of equal cross sectional area of $2m^2$ contain water upto height 10m and 6m, respectively. If the vessels are connected at their bottom then the work done by the force of gravity is : (Density of water is 10^3 kg/m^3 and g = 10 m/s^2)

(1) 1×10^5 J (2) 4×10^4 J

(3) 6×10^4 J (4) 8×10^4 J

Ans. **(4)**

Sol.



$U_i = (\rho A \times 10)g \times 5 + (\rho A 6)g \times 3$

$U_i = \rho Ag(50 + 18)$

$U_i = 68\rho Ag$

$U_f = (\rho A \times 16)g \times 4$

$= (\rho Ag) \times 64$

$\omega = \Delta U = 4 \times \rho Ag$

$= 4 \times 1000 \times 2 \times 10 = 8 \times 10^4$ J

29. 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) $(3+2\sqrt{2}):(3-2\sqrt{2})$

(3) 9 : 1 (4) 3 : 1

Ans. **(2)**

Sol. $I \propto$ width $\quad I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$

$\therefore I_1 = I_0, I_2 = 2I_0 \quad I_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$

$$\frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{2}+1\right)^2}{\left(\sqrt{2}-1\right)^2} \Rightarrow \frac{3+2\sqrt{2}}{3-2\sqrt{2}}$$

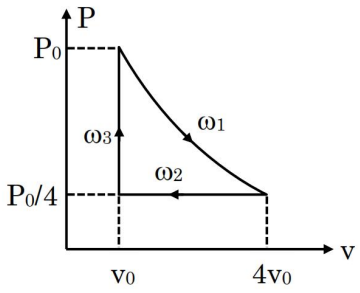
30. An ideal gas exists in a state with pressure P_0, volume V_0.It is isothermally expanded to 4 times of its initial volume (V_0), then isobarically compressed to its original volume. Finally the system is heated isochorically to bring it to its initial state. The amount of heat exchanged in this process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

(1) $P_0V_0(2\ln 2 - 0.75)$ (2) $P_0V_0(\ln 2 - 0.75)$

(3) $P_0V_0(\ln 2 - 0.25)$ (4) $P_0V_0(2\ln 2 - 0.25)$

Ans. **(1)**

Sol.



$\omega_1 = P_0v_0\ell n4$

$\omega_2 = \frac{P_0}{4}(-3v_0) = -\frac{3P_0v_0}{4}$

$\omega_3 = 0$

$Q_T = \Delta U_{cyclic} + \omega$

$Q_T = \omega \qquad (\Delta U_{cyclic} = 0)$

$Q_T = P_0v_0\left(\ell n4 - \frac{3}{4}\right)$

$= P_0v_0(2\ell n2 - 0.75)$

31. 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) 8 : 1 (2) 9 : 1

(3) 3 : 1 (4) 4 : 1

Ans. **(4)**

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

32. 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) Both **A** and **R** are true but **R** is **NOT** the correct explanation of **A**.

(2) **A** is false but **R** is true.

(3) Both **A** and **R** are true and **R** is the correct explanation of **A**.

(4) **A** is true but **R** is false.

Ans. **(3)**

Sol. Conceptual

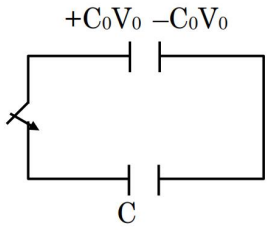
33. Using a battery, a 100 pF capacitor is charged to 60 V and then the battery is removed. After that, a second uncharged capacitor is connected to the first capacitor in parallel. If the final voltage across the second capacitor is 20 V, its capacitance is : (in pF)

(1) 600 (2) 200

(3) 400 (4) 100

Ans. **(2)**

Sol.



New potential $= \frac{C_0V_0}{C_0 + C} = \frac{V_0}{3}$

$3C_0V_0 = C_0V_0 + CV_0$

$2C_0V_0 = CV_0$

$C \Rightarrow 2C_0$

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

(1) 300 nm (2) 600 nm

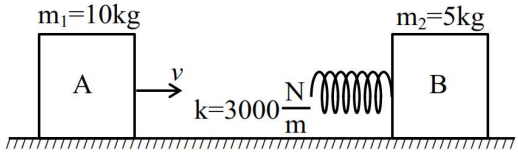
(3) 400 nm (4) 500 nm

Ans. **(1)**

Sol. $f\lambda = v \quad \lambda_{medium} = \frac{\lambda_{vacuum}}{\mu}$

$$\lambda_{medium} \Rightarrow \frac{3\times10^{8}}{2\times5\times10^{14}} \Rightarrow 0.3 \times 10^{-6} \Rightarrow 300 \text{ nm}$$

35.



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) 0.4 m

(3) 0.1 m (4) 0.3 m

Ans. **(3)**

Sol. $m_1v_1 + m_2v_2 = (m_1 + m_2)v_{cm}$

$$v_{cm} \Rightarrow \frac{10\times3}{10+5} \Rightarrow \frac{30}{15} = 2\text{m/s}$$

$$\frac{1}{2}kx^2 = \frac{1}{2}(10)(3)^2 - \left[\frac{1}{2}(15)(2)^2\right]$$

$$\Rightarrow 90 - 60 = 30 = 3000\,x^2$$

$$x^2 \Rightarrow \frac{30}{3000} = \frac{1}{100}$$

$$x \Rightarrow \frac{1}{10}\text{m}.$$

36. 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) 6 (2) 18

(3) 12 (4) 24

Ans. **(4)**

Sol. Range $= 3H_{max}$

$$\frac{u^2\sin2\theta}{g} = \frac{3u^2\sin^2\theta}{2g}$$

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

$$\tan\theta = \frac{4}{3} \Rightarrow \theta = 53°$$

$$R = \frac{u^2\left(2\times\frac{3}{5}\times\frac{4}{5}\right)}{g} \Rightarrow \frac{24u^2}{25g}$$

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

(1) 2.18 (2) 2.38

(3) 1.68 (4) 1.99

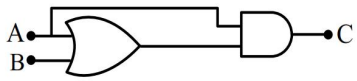
Ans. **(4)**

Sol. $v_T \Rightarrow \frac{2}{9}\frac{(\rho_0 - \rho_\ell)r^2g}{\eta}$

$$\eta = \frac{2}{9}\left(\frac{7825-925}{2.45\times10^{-2}}\right)\times(1.8)^2\times10^{-6}\times9.8$$

$$\eta \approx 1.99$$

38. The truth table corresponding to the circuit given below is



(1)

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

(2)

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

(3)

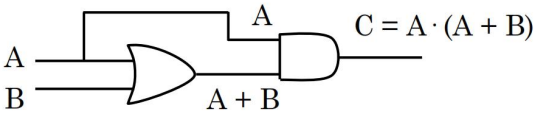
A	B	C
0	0	1
1	0	0
0	1	0
1	1	0

(4)

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

Ans. (2)

Sol.



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

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

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

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 acceleration of the particle is 2c

(3) the initial velocity of the particle is 4c

(4) the acceleration of the particle is $2(c + c_0)$

Ans. (4)

Sol. $v = \frac{dx}{dt} = 2tC_0 + 2C(t-2)$

$$a = \frac{dv}{dt} = 2C_0 + 2C$$

40. An electric bulb rated as 100 W-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) 0.45 A

(3) 2.2 A (4) 0.32 A

Ans. (1)

Sol. $P = v_{rms} i_{rms}$

$$i_{rms} = \frac{100}{220}$$

$$i_0 = \sqrt{2} i_{rms} = 0.64A$$

41. 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-II, B-III, C-IV, D-I

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

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

Ans. (1)

Sol. (A) $[k] = \frac{PV}{NT} = \frac{ML^2T^{-2}}{K} = ML^2T^{-2}K^{-1}$

(B) $[\eta] = \frac{F}{6\pi rv} = \frac{MLT^{-2}}{L^2T^{-1}} = ML^{-1}T^{-1}$

(C) $[h] = \frac{E}{f} = \frac{ML^2T^{-2}}{T^{-1}} = ML^2T^{-1}$

(D) $\frac{dQ}{dt} = k\frac{AdT}{dx}$

$$k = \frac{(ML^2T^{-3})L}{L^2.K} = MLT^{-3}K^{-1}$$

42. Pressure of an ideal gas, contained in a closed vessel, is increased by 0.4% when heated by 1°C. Its initial temperature must be :

(1) 25°C (2) 2500 K

(3) 250 K (4) 250°C

Ans. **(3)**

Sol. Isochoric process

$P \propto T$

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

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

$T = 250$ K

43. 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) 8.4

(3) 2 (4) 6.2

Ans. **(3)**

Sol. $P_{input} = Vi = 100$ W

$$\eta = \frac{P_{out}}{P_{input}} = 0.916$$

$P_{out} = 91.6$ W

Loss = 100 – 91.6 = 8.4 J/s = 2 cal/s

44. 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) 10 m/s (2) 4 m/s

(3) 6 m/s (4) 8 m/s

Ans. **(4)**

Sol. $$a = \frac{F}{m} = -10x$$

$$v\frac{dv}{dx} = -10x$$

$$\int_{10}^{v} vdv = -10\int_{0.1}^{1.9} xdx$$

$$\frac{v^2 - 100}{2} = -10\left(\frac{1.9^2 - 0.1}{2}\right)^2$$

$v = 8$ m/s

45. 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 statement, choose the ***correct*** answer from the options given below

(1) **A** is true but **R** is false

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

(3) **A** is false but **R** is true

(4) Both **A** and **R** are true and **R** is the correct explanation of **A**

Ans. **(1)**

Sol. $$r = \frac{mv}{qB} = \frac{p}{qB}$$

$$r \propto \frac{1}{q}$$

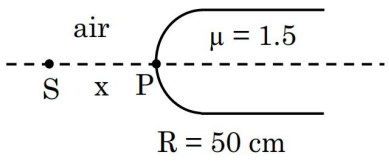
Assertion is true reason is false

SECTION-B

46. 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.

Ans. **(4)**

Sol.



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

$$\frac{1.5}{200} - \frac{1}{-x} = \frac{1.5-1}{50}$$

$$\frac{1}{x} = \frac{1}{100} - \frac{3}{400}$$

$x = 400$ cm

$x = 4$m

47. 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 _____.

Ans. (8)

Sol. $\Delta P = \frac{4T}{R}$

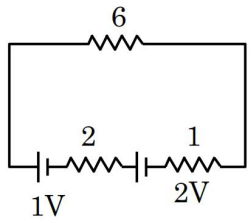
$$\frac{R_A}{R_B} = \frac{\Delta P_B}{\Delta P_A} = 2$$

$$\frac{V_A}{V_B} = \left(\frac{R_A}{R_B}\right)^3 = 8$$

48. Two cells of emf 1V and 2V and internal resistance 2 Ω and 1 Ω, respectively, are connected in series with an external resistance of 6 Ω. 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 _____.

Ans. (4)

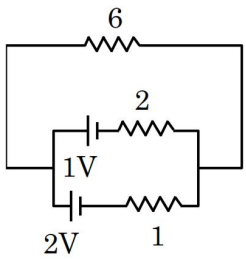
Sol.



$\varepsilon_{eq} = 3$

$R_{eq} = 9$

$i_1 = \frac{3}{9} = \frac{1}{3}$



$$\varepsilon_{eq} = \frac{\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}}$$

$$\varepsilon_{eq} = \frac{\frac{1}{2} + \frac{2}{1}}{\frac{1}{2} + \frac{1}{1}} = \frac{5}{3}$$

$$r_{equ} = \frac{2 \times 1}{3} + 6 = \frac{20}{3}$$

$$i_2 = \frac{1}{4} \Rightarrow \frac{i_1}{i_2} = \frac{4}{3}$$

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

Ans. (2)

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

$$2.86 = 13.6\left(\frac{1}{n^2} - \frac{1}{5^2}\right)$$

$$\frac{1}{n^2} = 0.21 + \frac{1}{2.5}$$

$n^2 = 4$

$n = 2$

Ans. (2)

50. A physical quantity C is related to four other quantities p, q, r and s 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 _____%.

Ans. (15)

Sol. $C = P^1 q^2 r^{-3} s^{1/2}$

$$\left(\frac{dC}{C}\right)_{max} = \frac{dP}{P} + \frac{2dq}{q} + \frac{3dr}{r} + \frac{1}{2}\frac{ds}{s}$$

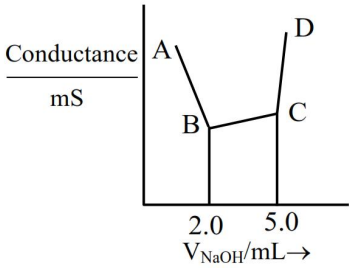
$$= (1 + 2 \times 2 + 3 \times 3 + \frac{1}{2} \times 2)\%$$

$= 15\ \%$

Ans. 15

SECTION-A

51. 40 mL of a mixture of CH_3COOH and HCl (aqueous solution) is titrated against 0.1 M NaOH solution conductometrically. Which of the following statement is **correct**?



(1) The concentration of CH_3COOH in the original mixture is 0.005 M

(2) The concentration of HCl in the original mixture is 0.005 M

(3) CH_3COOH is neutralised first followed by neutralisation of HCl

(4) Point 'C' indicates the complete neutralisation HCl

Ans. (2)

Sol. From the given graph 2 ml NaOH solution is used for neutralisation of HCl and 3 ml NaOH solution is used for neutralisation of CH_3COOH.

$\therefore$ Mole of HCl = Mole of NaOH used

$M \times 40 = 0.1 \times 2$

$M = 0.005$

$\therefore$ Mole of CH_3COOH = Mole of NaOaH used

$M \times 40 = 0.1 \times 3$

$M = 0.0075$

HCl is strong acid and will be neutralised first.

52. 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 is :

(1) 0.2 M NaCl solution

(2) 20 M HCl solution

(3) 10 M HCl solution

(4) Neutral solution

Ans. (2)

Sol. When 10 ml, 2M NaOH solution is added to 20 ml of 1M HCl solution :

	NaOH	+	HCl → NaCl + H_2O
Initial :	$MV = 2 \times 0.1$		$MV = 1 \times 0.2$
	= 0.2 mole		= 0.2 mole
Final	0		0

$\therefore$ Resulting solution becomes neutral.

Now when 10 mol of above solution is poured into a flask containing 2 mole HCl and made solution 100 ml will distilled water.

Molarity of HCl = $\frac{2}{100} \times 1000 = 20$

53. Fat soluble vitamins are :

A. Vitamin B_1

B. Vitamin C

C. Vitamin E

D. Vitamin B_{12}

E. Vitamin K

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

(1) C & D Only

(2) A & B Only

(3) B & C Only

(4) C & E Only

Ans. (4)

Sol. Vit D, E, K. A are fat soluble vitamins.

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

LIST-I (Family)		LIST-II (Symbol of Element)	
A.	Pnicogen (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-I, C-II, D-III

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

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

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

Ans. (2)

Sol. (A) Pnictogen ⇒ Mc (Moscovium),

Atomic No. = 115

(B) Chalcogen ⇒ Lv (Livermorium),

Atomic No. = 116

(C) Halogen ⇒ Ts (Tennessine),

Atomic No. = 117

(D) Noble gas ⇒ Og (Oganesson),

Atomic No. = 118

55. For electron in '2s' and '2p' orbitals, the orbital angular momentum values, respectively are :

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

(3) 0 and $\sqrt{6}\frac{h}{2\pi}$ (4) 0 and $\sqrt{2}\frac{h}{2\pi}$

Ans. (4)

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

$\therefore$ For 2s orbital : $\ell = 0$

Orbital angular momentum = 0

$\therefore$ For 2p orbital : $\ell = 1$

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

$= \sqrt{2}\frac{h}{2\pi}$

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

A. $Na_2Cr_2O_7$

B. Oxalic acid

C. NaOH

D. $FeSO_4 . 6H_2O$

E. Sodium tetraborate

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

(1) B and D Only (2) D and E Only

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

Ans. (4)

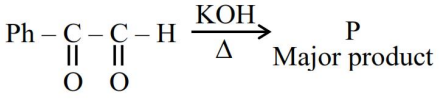
Sol. The primary standard is a highly pure stable compound with a known exact composition that can be accurately weighed and dissolved to creat a solution of known concentration.

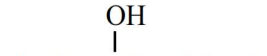
NaOH is hygroscopic and can't be used.

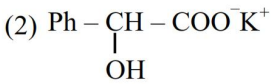
$FeSO_4.6H_2O$ is unstable and can be easily oxidised.

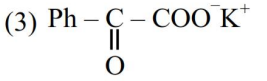
$Na_2Cr_2O_7$ is hygroscopic and can't be used.

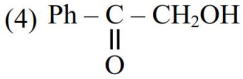
57. The major product (P) in the following reaction is :



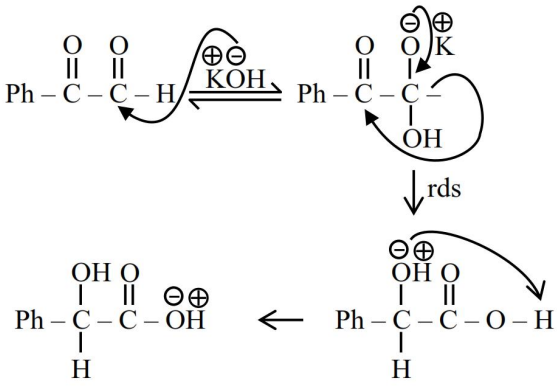
(1) 

(2) 

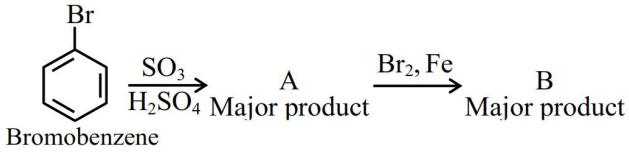
(3) 

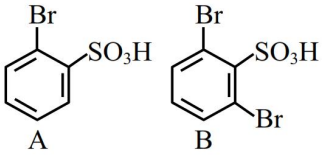
(4) 

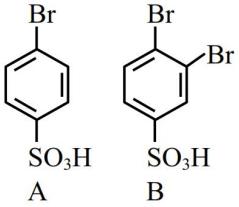
Ans. (2)

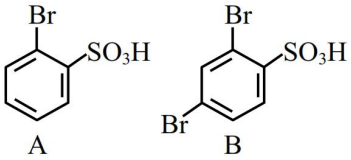
Sol. 

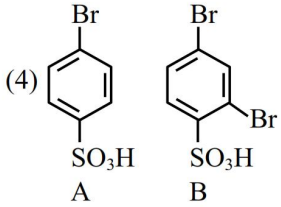
58. In the following series of reactions identify the major products A & B respectively.



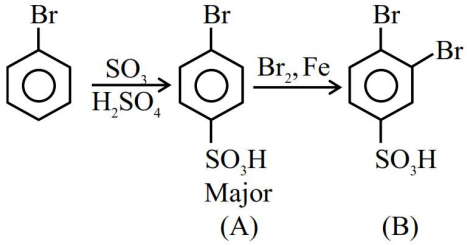
(1) 

(2) 

(3) 

(4) 

Ans. (2)

Sol. 

Both reactions are electrophilic substitution reaction, I[st] is sulphonation and II[nd] is halogenation :

59. The standard cell potential ($E^{\ominus}_{cell}$) 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 O_2 ($E^{\circ}_{O_2/H_2O}$) is 1.229 V.

Choose the correct statement:

(1) The standard half cell reduction potential for the reduction of CO_2 ($E^{\circ}_{CO_2/CH_3OH}$) is 19 mV

(2) Oxygen is formed at the anode.

(3) Reactants are fed at one go to each electrode.

(4) Reduction of methanol takes place at the cathode.

Ans. (1)

Sol. $\because E^{\circ}_{cell} = E^{\circ}_{cathode} - E^{\circ}_{Anode}$

$1.21 = 1.229 - E^{\circ}_{Anode}$

$\because$ Fuel cell involves oxidation of methanol which will occur at anode and reduction of O_2 will occur at cathode.

60. Identify the diamagnetic octahedral complex ions from below ;

A. $[Mn(CN)_6]^{3-}$ B. $[Co(NH_3)_6]^{3+}$

C. $[Fe(CN)_6]^{4-}$ D. $[Co(H_2O)_3F_3]$

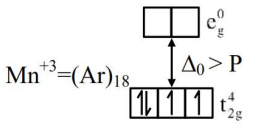
Choose the ***correct*** answer from the options given below :

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

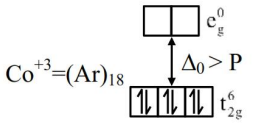
(3) A and C Only (4) B and C Only

Ans. (4)

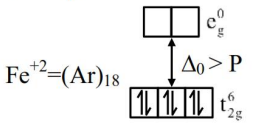
Sol. (A) $[Mn(CN)_6]^{3-}$



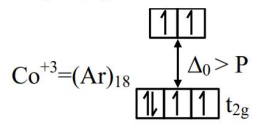
(B) $[Co(NH_3)_6]^{3+}$



(C) $[Fe(CN)_6]^{4-}$



(D) $[Co(H_2O)_3F_3]$



61. 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) 15.71% (2) 20.95%

(3) 17.46% (4) 7.85%

Ans. **(1)**

Sol. Pressure of N_2 gas evolved = 715 – 15

$= 700$ mm Hg

$= \frac{700}{760}$ atm.

$\therefore$ Mole of N_2 evolved $= \frac{PV}{RT}$

$= \frac{700 \times 60 \times 10^{-3}}{760 \times 0.0821 \times 300}$

$= 0.0022$ mole

$\therefore$ wt. of N_2 evolved $= 0.0022 \times 28 = 0.063$ gm

$\therefore$ wt. % of nitrogen in compound

$= \frac{\text{wt. of nitrogen}}{\text{wt. of compound}} \times 100$

$= \frac{0.063}{0.4} \times 100$

$= 15.71\%$

62. 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 g mol^{-1}.

(1) 235.7 g (2) 0.24 mg

(3) 236 mg (4) 2.444 g

Ans. **(3)**

Sol. $Mg + 2HCl \rightarrow MgCl_2 + H_2$

Volume H_2 evolved = 220 ml

Mole of $H_2 = \frac{220 \times 10^{-3}}{22.4}$ = mole of Mg used

$\therefore$ Mass of Mg used $= \frac{220 \times 10^{-3}}{22.4} \times 24$

$= 235.7 \times 10^{-3}$ gm

$= 235.7$ mg

63. 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) Statement I is false but Statement II is true

(2) Statement I is true but Statement II is false

(3) Both Statement I and Statement II are true

(4) Both Statement I and Statement II are false

Ans. **(2)**

Sol. Cellulose derivcative has more number of hydroxy groups, so more H-bonding is present with water in cellulose derivatives cotton cloths.

64. Given below are two statements :

Statement I : CrO_3 is a stronger oxidizing agent than MoO_3

Statement II : Cr(VI) is more stable than Mo(VI)

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

(1) Statement I is false but Statement II is true

(2) Statement I is true but Statement II is false

(3) Both Statement I and Statement II are true

(4) Both Statement I and Statement II are false

Ans. **(2)**

Sol. Statement-I is true but statement II is false.

Cr(VI) is less stable than Mo(VI)

Hence, CrO_3 easily reduce into Cr^{+3} as compared to MoO_3 and show stronger oxidizing nature.

65. 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) Statement I is true but Statement II is false

(2) Both Statement I and Statement II are false

(3) Statement I is false but Statement II is true

(4) Both Statement I and Statement II are true

Ans. (3)

Sol. Hyper conjugation is permanent effect because external reagent is not required, so Statement-I is false and Statement-II is true. because moore alkyl group, more α-H, so more hyperconjugation which results more stability of carbocation.

66. 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) Statement I is true but Statement II is false

(2) Both Statement I and Statement II are false

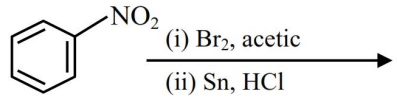
(3) Both Statement I and Statement II are true

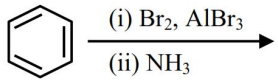
(4) Statement I is false but Statement II is true

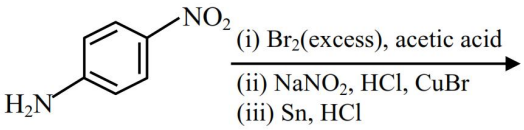
Ans. (3)

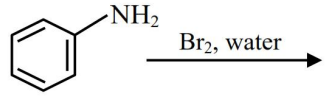
Sol. At melting point when ice melts, supplied heat is utilised to overcome intermolecular attraction within the molecules so temperature remain constant.

67. The sequence from the following that would result in giving predominantly 3, 4, 5 –Tribromoaniline is :

(1) 

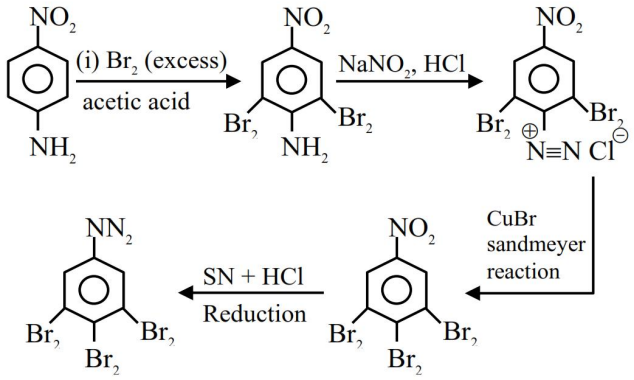
(2) 

(3) 

(4) 

Ans. (3)

Sol.



3,4,5-tri bromo aniline

68. The correct orders among the following are

Atomic radius : B < Al < Ga < In < Tl

Electronegativity : Al < Ga < In < Tl < B

Density : Tl < In < Ga < Al < B

1st Ionisation Energy : In < Al < Ga < Tl < B

Choose the correct answer from the options given below :

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

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

Ans. (1)

Sol.

	B	Al	Ga	In	Tl
Atomic radius (pm)	88	143	135	167	170
Electronegativity	2	1.5	1.6	1.7	1.8
Density (g/cm^3)	2.35	2.7	5.9	7.31	11.85
Ionisation Energy (kJ/mol)	801	577	579	558	589

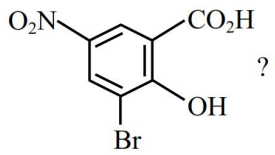
Radius Order $T\ell > In > A\ell > Ga > B$

EN Order $B > T\ell > In > Ga > Al$

Density Order $T\ell > In > Ga > A\ell > B$

IE_1 Order $B > T\ell > Ga > A\ell > In$

69. What is the correct IUPAC name of



?

(1) 3-Bromo-2-hydroxy-5-nitrobenzoic acid

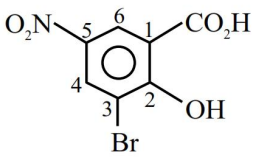
(2) 3-Bromo-4-hydroxy-1-nitrobenzoic acid

(3) 2-Hydroxy-3-bromo-5-nitrobenzoic acid

(4) 5-Nitro-3-bromo-2-hydroxybenzoic acid

Ans. (1)

Sol.



IUPAC 3-Bromo-2-hydroxy-5-nitro-Benzoic acid

70. 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 Ea as used in Arrhenius equation depend on temperature.

E. When Ea >> RT. A and Ea become interdependent.

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

(1) A, C and D Only (2) B, D and E Only

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

Ans. (3)

Sol. Arrhenious equation hold true for elementary as well as complex reactions.

Unit of A is same as unit of k. Rate of reaction is high if activation energy is low,

A and Ea are temperature independent.

SECTION-B

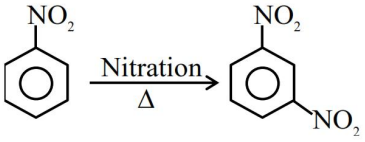
71. X g of nitrobenzene on nitration gave 4.2 g of m-dinitrobenzene.

X = _____ g. (nearest integer)

[Given : molar mass (in g mol^{-1}) C : 12, H : 1, O : 16, N : 14]

Ans. (3)

Sol.



4.2 gm

$C_6H_5NO_2$ $MF = C_6H_4N_2O_4$

$MW = 123$ $MW = 168$

$$\therefore \frac{4.2}{168} = 0.025\,mol$$

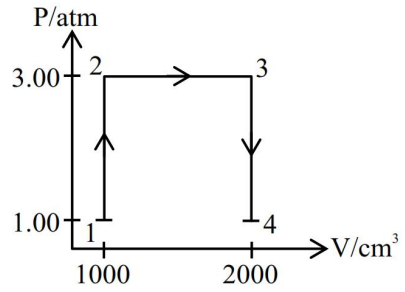
$\because$ required gm of nitro benzene

$= 123 \times 0.025$

$= 3.075$

$\therefore$ Nearest integer is 3

72.



A perfect gas (0.1 mol) having $\overline{C}_v$ = 1.50 R (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^{-1} mol^{-1}]

Ans. (304)

Sol. $W_{1\to2} = 0$

$W_{2\to3} = -P\Delta V$

$= -3\ [2-1]$

$= -3$ atm – ℓ

$W_{3\to4} = 0$

Total work done

$= -3$ atm – ℓ

$= -3 \times 101.3$ Joule

$= -304$ Joule

73. 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^{-1}. 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^{-1} (nearest integer).

Ans. (2500)

Sol. Mole of octane = $\frac{1.14}{114} = 0.01$ mole

Heat evolved = $C \times \Delta T$

$= 5 \times 5$ kJ

$=25$ kJ

$\therefore$ Magnitude of Heat of combustion = $\frac{25}{0.01} = 2500$ kJ/mole

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).

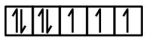
Ans. (4)

Sol.

	Sc	Mn	Co	Cu
Enthalpy of Atomisation (kJ/mole)	326	281	425	339

Highest Co

$Co^{+2} = (Ar)3d^7$



$n = 3$

$\mu = \sqrt{15} = 3.87$

Nearest integer = 4

75. The total number of structural isomers possible for the substituted benzene derivatives with the molecular formula C_9H_{12} is _____.

Ans. (8)

Sol. MF = C_9H_{12}