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ICON Central Office – Madhapur – Hyderabad

08-Apr-2025_Jee-Main_2025_Shift-02_Q.Paper, Key and Solutions

MATHEMATICS

Max Marks: 100

(SINGLE CORRECT ANSWER TYPE)

This section contains **20 Multiple Choice Questions.** Each question has 4 options (1), (2), (3) and (4) for its answer, out of which ONLY ONE option can be correct.

Marking scheme: +4 for correct answer, 0 if not attempted and –1 in all other cases.

01. Given below are two statements:

Statement-I: $\lim\limits_{x\to 0}\left(\dfrac{\tan^{-1}x+\log_e\sqrt{\dfrac{1+x}{1-x}}-2x}{x^5}\right)=\dfrac{2}{5}$

Statement-II: $\lim\limits_{x\to 1}\left(\dfrac{2}{x^{1-x}}\right)=\dfrac{1}{e^2}$

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

1) Both statement I and Statement II are true

2) Both statement I and Statement II are false

3) Statement I is true but statement II is false

4) Statement I is true but statement II is true

Key: 1

Sol: $L=\lim\limits_{x\to 0}\dfrac{\tan^{-1}x+\frac{1}{2}\left(\log_e(1+x)-\log_e(1-x)\right)-2x}{x^5}$

$$=\lim_{x\to 0}\frac{\left(x-\frac{x^3}{3}+\frac{x^5}{5}......\right)+\frac{1}{2}\left(x-\frac{x^2}{2}+\frac{x^3}{3}.........\right)-\frac{1}{2}\left(-x-\frac{x^2}{2}-\frac{x^3}{3}....\right)-2x}{x^5}$$

$$=\lim_{x\to 0}\frac{x^5\left(\frac{1}{5}+\frac{1}{10}+\frac{1}{10}\right)+x^7(.....)+.....}{x^5}=\frac{2}{5}$$

$\Rightarrow$ Statement I is true

S-II $L=\lim\limits_{x\to 1}x^{\left(\frac{2}{1-x}\right)}\quad\{1^\infty\}$

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

$\Rightarrow$ Statement II is true

02. Let $A=\begin{bmatrix}2 & 2+p & 2+p+q\\ 4 & 6+2p & 8+3p+2q\\ 6 & 12+3p & 20+6p+3q\end{bmatrix}$. If $\det\left(adj\left(adj\left(3A\right)\right)\right)=2^m.3^n, m,\in N,$ then $m+n$ is equal to

1) 22 2) 26 3) 24 4) 20

Key: 3

Sol: $|A|=\begin{vmatrix}2 & 2+p & 2+p+q\\ 4 & 6+2p & 8+3p+2q\\ 6 & 12+3p & 20+6p+3q\end{vmatrix}$

$R_2\to R_2-2R_1; R_3\to R_3-3R_1$

$A=\begin{bmatrix}2 & 2+p & 2+p+q\\ 0 & 2 & 4+p\\ 0 & 6 & 14+3p\end{bmatrix}$

$=2\left(28+6p-24-6p\right)$

$=2(4)=8$

Now, $adj.\left(adj\left(3A\right)\right)=|3A|^1\left(3A\right)$

$=3^3|A|(3A)$

$=3^3\times 2^3\times 3^1 A$

$=2^3 3^4 A$

$\Rightarrow \det\left(adj.\left(adj.\left(3A\right)\right)\right)=\det.\left(2^3 3^4 A\right)$

$\left(2^3 3^4\right)^3|A|$

$=2^9 3^{12}\times 2^3=2^{12}3^{12}$

$\Rightarrow m=12, n=12 \Rightarrow m+n=24$

3. Let a be the length of a side of square OABC with O being the origin. Its side OA makes an acute angle α with the positive x-axis and the equations of its diagonals are $\left(\sqrt{3}+1\right)x+\left(\sqrt{3}-1\right)y=0$ and $\left(\sqrt{3}-1\right)x-\left(\sqrt{3}+1\right)y8\sqrt{3}=0$. Then a^2 is equal to

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

Key: 2

Sol: Given diagonals are

$\left(\sqrt{3}+1\right)x+\left(\sqrt{3}-1\right)y=0$ & $\left(\sqrt{3-1}\right)x-\left(\sqrt{3}+1\right)y+8\sqrt{3}=0$

On solving, $P\left(\sqrt{3}-3,3+\sqrt{3}\right)$ is centre of the given square

$\Rightarrow OP=2\sqrt{6}=\dfrac{a}{\sqrt{2}}$

$a=4\sqrt{3}$

$\Rightarrow a^2=48$

4. There are 12 points in a plane, no three of which are in the same straight line, except 5 points which are collinear. Then the total number of triangles that can be formed with the vertices at any three of these 12 points is

1) 230 2) 210 3) 220 4) 200

Key: 2

Sol: No of traingles $={}^{12}C_3-{}^{5}C_3$

= 220-10

= 210

5. Let $f(x)=x-1$ and $g(x)=e^x$ for $x\in\mathbb{R}$.If $\frac{dy}{dx}=\left(e^{-2\sqrt{x}}g(f(x))-\frac{y}{\sqrt{x}}\right), y(0)=0,$ then $y(1)$ is

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

Key: 2

Sol : $f(x)=x-1,\ g(x)=e^x$

$\Rightarrow f(f(x))=(x-1)-1=x-2$

$\Rightarrow g(f(f(x)))=e^{x-2}\Rightarrow\frac{dy}{dx}=e^{-2\sqrt{x}}.e^{x-2}-\frac{y}{\sqrt{x}}\Rightarrow\frac{dy}{dx}+\frac{1}{\sqrt{x}}.y=e^{x-2\sqrt{x}-2}$

$If=e^{\int\frac{1}{\sqrt{x}}dx}=e^{2\sqrt{x}}$

G.S $y.e^{2\sqrt{x}}=\int e^{x-2}dx=e^{x-2}+C$

$y(0)=0\Rightarrow 0=e^{-2}+C\Rightarrow C=-e^{-2}$ $\Rightarrow y.e^{2\sqrt{x}}=e^{x-2}-e^{-2}$

At $x=1, y.e^2=e^{-1}-e^{-2}\Rightarrow y=e^{-3}-e^{-4}=\frac{e-1}{e^4}$

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

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

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

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

1. 18 2. 23 3. 15 4. 24

Key: 3

Sol: Given $\frac{1}{1^4}+\frac{1}{2^4}+\frac{1}{3^4}+.....\infty=\frac{\pi^4}{90}$

$\Rightarrow\left(\frac{1}{1^4}+\frac{1}{3^4}+\frac{1}{5^4}+....\right)+\left(\frac{1}{2^4}+\frac{1}{4^4}+\frac{1}{6^4}+....\right)=\frac{\pi^4}{90}$

$\Rightarrow\alpha+\beta=\frac{\pi^4}{90}$ ……….. (1)

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

$\Rightarrow\beta=\frac{1}{2^4}\left(\frac{1}{1^4}+\frac{1}{2^4}+\frac{1}{3^4}+.....\right)$ $\Rightarrow\beta=\frac{1}{16}\times\frac{\pi^4}{90}$

Put in (1) $\alpha=\frac{15}{16}\times\frac{\pi^4}{90}$ $\Rightarrow\frac{\alpha}{\beta}=15$

7. Let $A=\{0,1,2,3,4,5\}$. Let R be a relation on A defined by $(x,y)\in R$ if and only if max $\{x,y\}\in\{3,4\}$. Then among the statements

S_1: The number of elements in R is 18, and

S_2: The relation R symmetric but neither reflexive nor transitive

1) Only S_1 is true
2) Both are true
3) Only S_2 is true
4) Both are false

Key: 4

Sol: S-1: No. of elements $=2^2+2\times3+3\times2$

$=4+6+6=16$

$\Rightarrow S_1$ is false

S-2: R is not reflexive

R is symmetric

R is transitive

$\Rightarrow S_2$ is false

8. The number of integral terms in the expansion of $\left(5^{\frac{1}{2}}+7^{\frac{1}{8}}\right)^{1016}$ is

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

Key: 2

Sol: $\left(5^{\frac{1}{2}}+7^{\frac{1}{8}}\right)^{1016}=\sum_{r=0}^{1016}{}^{1016}C_r\,5^{\frac{1016-r}{2}}7^{\frac{r}{8}}$

$\Rightarrow$ For integral terms, $r=8\lambda,\lambda\in W$

$\Rightarrow$ No. Of integral terms =128

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

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

Key: 2

Sol:

$|x-2|^2+|x-2|-2=0$

$|x-1|=-2 \quad or \quad |x-2|=1$

is not possible $\quad x-2=\pm1$

$x=1 \; or \; 3$

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

if $x<3$

$x^2+2x-6-5=0$

$x^2+2x-11=0$

$x=\frac{-2\pm\sqrt{48}}{2}$

$=\frac{-2\pm4\sqrt{3}}{2}=-1\pm2\sqrt{3}$

$if \ x \geq 3$

$x^2 - 2x + 6 - 5 = 0$

$(x-1)^2 = 0$

$x = 1$

No solution since $x \geq 3$

Sum of the squares $= 1^2 + 3^2 + \left(2\sqrt{3}-1\right)^2 + \left(-\left(2\sqrt{3}+1\right)\right)^2$

$= 36$

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

1) $3+2\pi$ **2)** $1+3\pi$ **3)** $4+\pi$ **4)** $2+3\pi$

Key: 2

Sol: $\int_{-1}^{\frac{3}{2}} \left|\pi^2 x \sin \pi x\right| dx.$

$$\int_{-1}^{\frac{3}{2}} \left|\pi^2 x \sin \pi x\right| dx.$$

$t = \pi x \Rightarrow dt = \pi dx.$

$$\int_{-\pi}^{\frac{3\pi}{2}} |t \sin t| dt = \int_{-\pi}^{\pi} |t \sin t| dt + \int_{\pi}^{\frac{3\pi}{2}} |t \sin t| dt$$

$$= 2\int_{0}^{\pi} t \sin t \ dt - \int_{\pi}^{\frac{3\pi}{2}} t \sin t \, dt$$

$$= 3\pi + 1 (by \ using \ integration \ by \ parts)$$

11. If A and B are two events such that $P(A) = 0.7$, $P(B) = 0.4$ and $P\left(A \cap \overline{B}\right) = 0.5$, where $\overline{B}$ denotes the compliment of B, then $P\left(B\left(A \cup \overline{B}\right)\right)$ is equal to

1) $\frac{1}{2}$ **2)** $\frac{1}{4}$ **3)** $\frac{1}{6}$ **4)** $\frac{1}{3}$

Key: 2

Sol: $P(A) = 0.7 \quad P(B) = 0.4 \quad P\left(A \cap \overline{B}\right) = 0.5$

$P(A) - P(A \cap B) = 0.5$

$P(A \cap B) = 0.2$

$$P\left(B / A \cup \overline{B}\right) = P\left(\frac{B \cap \left(A \cup \overline{B}\right)}{P\left(A \cup \overline{B}\right)}\right) = \frac{P(A \cap B)}{P\left(A \cup \overline{B}\right)} = \frac{0.2}{0.8} = \frac{1}{4}$$

WHERE

$P\left(A \cup \overline{B}\right) = P(A) + P\left(\overline{B}\right) - P\left(A \cap \overline{B}\right)$

$= 0.7 + 0.6 - 0.5$

$= 0.8$

12. Let the function $f(x)=\frac{x}{3}+\frac{3}{x}+3, x\neq 0$ be strictly increasing in $(-\infty,\alpha_1)\cup(\alpha_2,\infty)$ and strictly decreasing in $(\alpha_3,\alpha_4)\cup(\alpha_4,\alpha_5)$. Then $\sum_{i=1}^{5}\alpha_i^2$ is equal to

1) 36 **2) 40** **3) 28** **4) 48**

Key: 1

Sol:

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

$$=\frac{x^2-9}{3x^2}=\frac{(x+3)(x-3)}{3x^2}$$

For strictly increasing $f^{|}(x)>0\Rightarrow x\in(-\infty,-3)\cup(3,\infty)$

For strictly increasing $f^{|}(x)<0\Rightarrow x\in(-3,0)\cup(0,3)$

$\therefore \alpha_1=-3, \alpha_2=3 \quad \alpha_3=-3, \alpha_4=0 \quad \alpha_5=3$

$$\sum_{i=1}^{5}\alpha_i^2=36$$

13. Let the values of λ for which the shortest distance between the lines $\frac{x-1}{2}=\frac{y-2}{3}=\frac{z-3}{4}$ and $\frac{x-\lambda}{3}=\frac{y-4}{4}=\frac{z-5}{5}$ *is* $\frac{1}{\sqrt{6}}$ *be* λ_1 *and* λ_2. Then the radius of the circle passing through the points $(0,0),(\lambda_1,\lambda_2)$ *and* (λ_2,λ_1) is

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

Key: 2

Sol:

$$\text{Shortest distance } =\left|\frac{\left[\bar{a_2}-\bar{a_1}\ \ \bar{b_1}\ \ \bar{b_2}\right]}{\left|\bar{b_1}\times\bar{b_2}\right|}\right|=\frac{1}{\sqrt{6}}$$

$$=\left|\frac{3-\lambda}{\sqrt{6}}\right|=\frac{1}{\sqrt{6}}$$

$$|\lambda-3|=1$$

$$\lambda-3=\pm1$$

$$\lambda=4,2$$

Radius of circle through (0,0) (2,4) (4,2) is $\frac{5\sqrt{2}}{3}$

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

1) 68 **2) 78** **3) 74** **4) 70**

Key: 4

Sol:

$Ellipse\ 3x^2 + py^2 = 4$

$Circle\ x^2 + y^2 - 2x - 4y - 11 = 0$

$r = 4\quad center\ C(1,2) lies\ on\ Ellipse$

$\therefore 3.1^2 + p(4) = 4$

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

$equation\ of\ Ellipse\ is\ \frac{x^2}{\frac{4}{3}} + \frac{y^2}{16} = 1$

$e^2 = \frac{11}{12}$

$f_1 f_2 = b^2 - e^2 y_1^2 = \frac{37}{3}$

$6 f_1 f_2 - r = 70$

15. A line passing through the point $P(a,0)$ makes an acute angle α with the positive x-axis. Let this line be rotated about the point P through an angle $\frac{\alpha}{2}$ in the clock-wise direction. If in the new position, the slope of the line is $2-\sqrt{3}$ and its distance from the origin is $\frac{1}{\sqrt{2}}$, then the value of $3a^2 \tan^2\alpha - 2\sqrt{3}$ is

1) 6 **2) 4** **3) 8** **4) 5**

Key: 2

Sol:

$\text{Tan}\frac{\alpha}{2} = 2 - \sqrt{3} = \tan\frac{\pi}{12}$

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

$Equation\ of\ new\ line\ is\ y - 0 = \tan\frac{\alpha}{2}(x - a)$

$dis\tan ce\ from\ (0,0) = \frac{\left|-a\tan\frac{\alpha}{2}\right|}{\sqrt{1+\tan^2\frac{\alpha}{2}}} = \frac{1}{\sqrt{2}}$

$\frac{a\tan\frac{\alpha}{2}}{\sec\frac{\alpha}{2}} = \frac{1}{\sqrt{2}} \Rightarrow a = \sqrt{3}+1$

$3a^2\tan^2\alpha - 2\sqrt{3} = 4$

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

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

Key: 4

Sol: Let $\bar{c}=x\bar{a}+y\bar{b}$

$\left|\bar{a}\right|=\sqrt{6}$

$\left|\bar{b}\right|=\sqrt{6}$

$\bar{a}.\bar{b}=3$

Apply let product with $\bar{a}$

$\bar{a}.\bar{c}=x\bar{a}^2+y\left(\bar{a}.\bar{b}\right)$

$0=6x+3y\Rightarrow y=-2x$ 1

$\bar{c}^2=x^2\bar{a}^2+y^2\bar{b}^2+2xt\left(\bar{a}.\bar{b}\right)$

$1=6x^2+6y^2+6xy$ 2

By solving 1 & 2

$x=\pm\frac{1}{3\sqrt{2}}$ $y=\mp\frac{2}{3\sqrt{2}}$

$\therefore\bar{c}=\frac{1}{\sqrt{2}}\left(-\hat{i}+\hat{k}\right)$

17. The value of $\cot^{-1}\left(\frac{\sqrt{1+\tan^2(2)}-1}{\tan(2)}\right)-\cot^{-1}\left(\frac{\sqrt{1+\tan^2\left(\frac{1}{2}\right)}+1}{\tan\left(\frac{1}{2}\right)}\right)$ is equal to

1) $\pi-\frac{5}{4}$ 2) $\pi+\frac{5}{2}$ 3) $\pi+\frac{3}{2}$ 4) $\pi-\frac{3}{2}$

Key : 1

Sol : $E=\cot^{-1}\left(\frac{-\sec 2-1}{\tan 2}\right)-\cot^{-1}\left(\frac{\sec\frac{1}{2}+1}{\tan\frac{1}{2}}\right)$

$=\cot^{-1}\left(-\left(\frac{1+\cos 2}{\sin 2}\right)\right)-\cot^{-1}\left(\frac{1+\cos\frac{1}{2}}{\sin\frac{1}{2}}\right)$

$=\cot^{-1}(-\cot 1)-\cot^{-1}\left(\cot\frac{1}{4}\right)$

$=\pi-1-\frac{1}{4}$ $=\pi-\frac{5}{4}$

18. Let $A=\left\{\theta\in[0,2\pi]:1+10\operatorname{Re}\left(\frac{2\cos\theta+i\sin\theta}{\cos\theta-3i\sin\theta}\right)=0\right\}$. Then $\sum_{\theta\in A}\theta^2$ is equal to

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

Key : 2

Sol : Given $1+10\,\text{Re}al\left(\frac{2\cos\theta+i\sin\theta}{\cos\theta-3i\sin\theta}\right)=0$

$$\Rightarrow\ 1+10\,\text{Re}al\left(\frac{(2\cos\theta+i\sin\theta)(\cos\theta+3i\sin\theta)}{\cos^2\theta+9\sin^2\theta}\right)=0$$

$$\Rightarrow\ 1+10\left[\frac{2\cos^2\theta-3\sin^2\theta}{\cos^2\theta+9\sin^2\theta}\right]=0 \qquad \Rightarrow\ 21\cos^2\theta=21\sin^2\theta$$

$$\Rightarrow\ \tan^2\theta=1=\tan^2\frac{\pi}{4}\Rightarrow\ \theta=n\pi\pm\frac{\pi}{4},n\in Z,\ \theta\in[0,2\pi]$$

If $n=0,\ \theta=\frac{\pi}{4}$

$n=1,\ \theta=\frac{3\pi}{4},\frac{7\pi}{4}$

$n=2,\ \theta=\frac{7\pi}{4},\frac{9\pi}{4}$

$$\therefore \sum_{\theta\in\pi}\theta^2=\frac{\pi^2}{16}+\frac{9\pi^2}{16}+\frac{25\pi^2}{16}+\frac{49\pi^2}{16}=\frac{84\pi^2}{16}=\frac{21\pi^2}{4}$$

19. Let α be a solution of $x^2+x+1=0$, and for some a and b in R, $[4\ \ a\ \ b]\begin{bmatrix}1 & 16 & 13\\ -1 & -1 & 2\\ -2 & -14 & -8\end{bmatrix}=[0\ \ 0\ \ 0]$. If $\frac{4}{\alpha^4}+\frac{m}{\alpha^a}+\frac{n}{\alpha^b}=3$, then $m+n$ is equal to ____

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

Key : 2

Sol : Given $[4\ \ a\ \ b]\begin{bmatrix}1 & 16 & 13\\ -1 & -1 & 2\\ -2 & -14 & -8\end{bmatrix}=[0\ \ 0\ \ 0]$

$\Rightarrow\ a+2b=4$ ......(1)

$a+14b=64$ ......(2)

$2a-3b=-52$ ......(3)

Solving (1), (2), (3), we get $a=-6, b=5$

Given equation is $\frac{4}{\alpha^4}+\frac{m}{\alpha^a}+\frac{n}{\alpha^b}=3$ ($\because$ α is root of $x^2+x+1=0$ *ie* $\alpha=w$ *or* w^2)

$$\Rightarrow\ \frac{4}{w}+m+\frac{n}{w^2}=3\ (\because a=-6, b=5)$$

$$\Rightarrow\ 4w^2+m+nw=3$$

$$\Rightarrow\ 4w^2+4w+m=3 \quad \text{if } n=4$$

$\Rightarrow \; 4(w^2+w)+m=3$

$\Rightarrow \; 4(-1)+m=3$

$\Rightarrow \; n=7, \; n=4$

$\therefore \; m+n=11$

20. Let $f(x)$ be a positive function and $I_1=\int_{-\frac{1}{2}}^{1} 2xf\left(2x(1-2x)\right)dx$ and $I_2=\int_{-1}^{2} f\left(x(1-x)\right)dx$. Then the value of $\frac{I_2}{I_1}$ is equal to ______

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

Key : 2

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

Put $2x=t$ L.L at $x=\frac{-1}{2}, \; t=-1$

$dx=\frac{dt}{2}$ U.L at $x=1$ then $t=2$

$\therefore \; I_1=\int_{-1}^{2} t\; f\left(t(1+t)\right)\frac{dt}{2}$

$I_1=\frac{1}{2}\int_{-1}^{2} t\,f\left(t(1-t)\right)dt \quad \ldots\ldots..(1)$

By king's property

$I_1=\frac{1}{2}\int_{-1}^{2}(1-t)\,f\left[(1-t)t\right]dt$

$I_1=\frac{1}{2}\int_{-1}^{2}(1-t)\,f\left(t(1-t)\right)dt \quad \ldots\ldots(2)$

$\therefore \; (1)+(2), \; 2I_1=\frac{1}{2}\int_{-1}^{2} f\left(t(1-t)\right)dt$

$\Rightarrow \; 2I_1=\frac{1}{2}I_2$

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

SECTION-II (NUMERICAL VALUE TYPE)

This section contains **5 Numerical Value Type Questions.** The Answer should be within **0 to 9999.** If the Answer is in **Decimal** then round off to the **Nearest Integer** value (Example i,e. If answer is above **10** and less than **10.5** round off is **10** and If answer is from **10.5** and less than **11** round off is **11).**

Marking scheme: +4 for correct answer, 0 if not attempt and -1 in all other cases..

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

Key : 56

Sol : Given lines are $\frac{x+2}{1}=\frac{y-1}{1}=\frac{z}{1}=t\,(say)$

$\Rightarrow (x, y, z)=(t-2, t+1, t)$ ……(1)

$\frac{x-3}{5}=\frac{y}{-1}=\frac{z-1}{1}=s\ (say)$

$\Rightarrow (x, y, z)=(5s+3, -s, s+1)$ …..(2)

$\frac{x}{-3}=\frac{y-3}{3}=\frac{z-2}{1}=r\ (say)$

$\Rightarrow (x, y, z)=(-3r, 3r+3, r+2)$ ….(3)

(1) $\cap$(2); $A=(-2,1,0)$

(2) $\cap$(3); $B=(3,0,1)$

(3) $\cap$(1); $C=(0,3,2)$

Dr's of $\overleftrightarrow{AB}=(5,-1,1)$

$\overleftrightarrow{AC}=(-2,-2,-2)$

Area of $\Delta le\ ABC=\frac{1}{2}\left\|\overleftrightarrow{AB}\times\overleftrightarrow{AC}\right\|$

$$=\frac{1}{2}\left\|\begin{matrix}\bar{i} & \bar{j} & \bar{k}\\ 5 & -1 & 1\\ -2 & -2 & -2\end{matrix}\right\|$$

$$=\frac{1}{2}\left|(-2)\left|\begin{matrix}\bar{i} & \bar{j} & \bar{k}\\ 5 & -1 & 1\\ 1 & 1 & 1\end{matrix}\right|\right|$$

$=6\left|(-2,-4,-6)\right|$

$=2\left|(1,2,3)\right|$

$=2\sqrt{1+4+9}$

$A=2\sqrt{14}\Rightarrow A^2=4(14)=56$

22. Let the area of the bounded region

$\left\{(x, y): 0\le 9x\le y^2,\ y\ge 3x-6\right\}$ be A. Then 6A is equal to _____

Key : 81

Sol : Let $y^2=9x$ ....(1) $y=3x-6$ ....(2)

(1) $\cap$ (2); $x=1,4$

$x=1,\ y=-3$; $x=4, y=6$

R. Area A = $\int_{-3}^{6}\left|\frac{y+6}{3}-\frac{y^2}{9}\right|dy$

$$A=\frac{27}{2} \quad \Rightarrow 6A=81$$

23. The product of the last two digits of $(1919)^{1919}$ is ______

Key : 63

Sol : $E\equiv(1919)^{1919}$

$\equiv(1920-1)^{1919}$

$=1919C_0(1920)^{1919}-1919C_1(1920)^{1918}+.....+1919c_{1918}(1920)^1-1919C_{1919}(1)$

For last '2' digits : $1919C_{1918}(1920)-1$

$=3684479$

So last '2' digits is 79 and product of two digits 7 x 9 = 63

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

Key : 30

Sol : Equation of normal to $y^2=9x$ at P(4, 6) is

$$\boxed{4x+3y=34} \text{ .....(1)}$$

Let centre of circle $C(x,r)$

$'C'$ lies on (1) $4x+3r=34$ $\Rightarrow x=\frac{34-3r}{4}$ .....(2)

Now $CP=r$

$$CP^2=r^2 \quad \Rightarrow \left(\frac{34-3r}{4}-4\right)^2+(r-6)^2=r^2$$

Simplifying we get

$\boxed{r=30}$ *or* $\frac{10}{3}$ rejected

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

Key : 96

Sol : $f(x)=\cos^{-1}\left(\frac{4x+5}{3x-7}\right)$ $g(x)=\log_2(2-6\log_{27}(2x+5))$

Meaningful when $-1\le\frac{4x+5}{3x-7}\le1$

$C_1: -1\le\frac{4x+5}{3x-7}\le1$

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

$$\Rightarrow x \leq \frac{2}{7} \text{ or } x \geq \frac{7}{3} \text{ and } x \neq \frac{7}{3}$$

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

$$C_2 : \frac{4x+5}{3x-7} \leq 1$$

$$\Rightarrow \frac{x+12}{3x-7} \leq 0 \text{ and } x \neq \frac{7}{3}$$

$$\Rightarrow xt\left[-12, \frac{7}{3}\right) \Rightarrow x \in [\alpha, \beta], \alpha = -12, \beta = \frac{7}{3}$$

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

Meaningful when

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

$$x > \frac{-5}{2} \text{ and } x \neq \frac{-5}{2}$$

$$\Rightarrow (2x+5)^2 < 3^2$$

$$\Rightarrow (x+4)(x+1) < 0$$

$$\Rightarrow x \in (-4, -1) \ \& \ x > \frac{-5}{2} \ \& \ x \neq \frac{-5}{2}$$

$$\Rightarrow x \in \left(\frac{-5}{2}, -1\right) \Rightarrow x \in (\gamma, \delta)$$

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

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

$$= \left|7\left(\frac{-82}{7}\right) + 4\left(\frac{-7}{2}\right)\right| = 96$$

PHYSICS marks:100

SECTION-I (SINGLE CORRECT ANSWER TYPE)

This section contains **20 Multiple Choice Questions**. Each question has 4 options (1), (2), (3) and (4) for its answer, out of which ONLY ONE option can be correct.

Marking scheme: +4 for correct answer, 0 if not attempted and –1 in all other cases.

26. A rod of linear mass density 'λ'and length 'L' is bent to form a ring of radius R'. Moment of inertia of ring about any of its diameter is

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

Key : 4

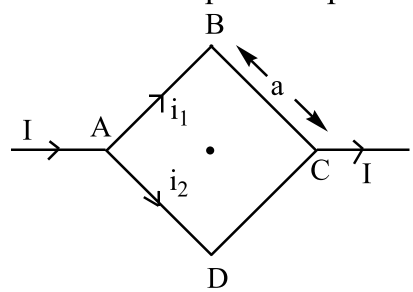
Sol : Moment of inertia of ring about its Diameter = $\frac{MR^2}{2}$

Here $M = \lambda L$

$$L = 2\pi R \Rightarrow R = \frac{L}{2\pi}$$

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

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



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

Key : 1

Sol : According to Biot-savert law the magnetic field due to a strait current carrying wire

$$B = \frac{\mu_o i}{4\pi r}(Sin\alpha + Sin\beta)$$

Due to part ABC

= Due to part AB + part BC

$$= \frac{\mu_0 i_1}{4\pi\ a/2}(Sin 45^0 + Sin 45^0) + \frac{\mu_0 i_1}{2\pi\ a/2}(Sin 45^0 + Sin 45^0)$$

$$= \frac{\mu_0 i_1}{2\pi a}\left(\frac{1}{\sqrt{2}} \times 2\right) 2 \otimes \text{ ....}(I)$$

Due to ADC

= Due to part AD + Due to part DC

$$= \frac{\mu_0 i_2}{4\pi \frac{a}{2}}(Sin 45^0 + Sin 45^0) + \frac{\mu_0 i_2}{4\pi \frac{a}{2}}(Sin 45^0 + Sin 45^0)$$

$$= \frac{\mu_0 i_2}{2\pi a}\left(\frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}}\right) + \frac{\mu_0 i_2}{2\pi a}\left(\frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}}\right) \odot$$

$$= \frac{\mu_0 i_2}{2\pi a}\frac{2}{\sqrt{2}} \ (2) \odot \ ....(II)$$

Due to total square loop the magnetic field at the centre is

$= Equation\ (I) + Equation (II)$

$$B = \frac{\mu_0}{2\pi a}\frac{2}{\sqrt{2}}(i_1 - i_2) \ ..... (III)$$

$i_1 + i_2 = I$ $\qquad \frac{i_1}{i_2} = \frac{R_2}{R_1} = \frac{2r}{r}$

$$\Rightarrow\ i_1 = \frac{2}{3}I,\ \ i_2 = \frac{1}{3}I$$

$$\therefore\ (III) = B = \frac{\mu_0}{\sqrt{2}\pi a}\left(\frac{2}{3} - \frac{1}{3}\right)I$$

$$= \frac{\mu_0 2I}{3\sqrt{2}\pi a} = \frac{\sqrt{2}\mu_0 I}{3\pi a}$$

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

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

Key : **4**

Sol : $Y = \frac{FL}{Ae} = \frac{mgL}{\pi r^2 e}$

m = 50 kg, $g = 3\pi\, m/s^2$, L = 3m

$r = 3 \times 10^{-3} m,\ \ e = 0.1 \times 10^{-3}$

$y = 5 \times 10^{11}\ Nm^{-2}$

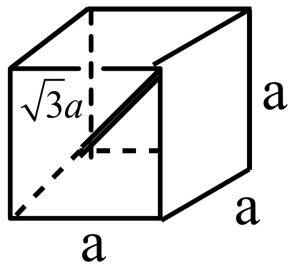
29. An infinitely long wire has uniform linear charge density $\lambda = 2nC/m$. The net flux through a Gaussian cube of side length $\sqrt{3}\, cm$, if the wire passes through any two corners of the cube, that are maximally displaced from each other, would be $x\, Nm^2C^{-1}$, where x is :

[Neglect any edge effects and use $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ SI units]

1) 0.72π 2) 6.48π 3) 1.44π 4) 2.16π

Key : **4**

Sol :



$\lambda = 2\frac{nC}{m},\ L = \sqrt{3}cm$

$$\phi = \frac{1}{\epsilon_0}Q$$

$$= \frac{1}{\epsilon_0}(\lambda, \ell)$$

ℓ = length of diagonal

$$= \sqrt{3}L$$

$$= \frac{1}{\epsilon_0}\left(2\times10^{-9}\times\sqrt{3}\times\sqrt{3}\times10^{-2}\right)$$

$$= 4\pi\times9\times10^{9}\left(6\times10^{-11}\right)$$

$$= 2.16\pi$$

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

Assertion A : Work done in moving a test charge between two points inside a uniformly charged spherical shell is zero, no matter which path is chosen.

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

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

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

Key : **4**

Sol : Assertion is true since the potential is constant every where in the shell

$$w = (V_2 - V_1)q$$
$$= 0$$

Reason is true as $V = \frac{KQ}{R}$ from centre to surface

'R' is correct explanation for 'A'

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

1) there shall be no interference fringes
2) there shall be alternate interference fringes of red and green
3) there shall be an interference pattern, where each fringe's pattern center is green and outer edges is red

4) there shall be an interference pattern for red distinct from that for green

Key : **1**

Sol : There will be no interference as the two sources are "incoherent"
Since the wavelengths are not same

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

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

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

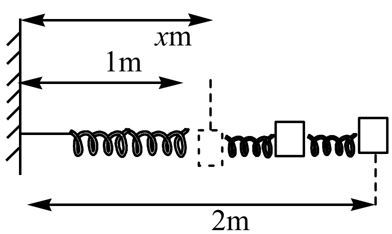
Key : **1**

Sol : In spring motion

$$\frac{1}{2}mv^2-\frac{1}{2}mu^2=\frac{1}{2}kx_2^{\,2}-\frac{1}{2}kx_1^{\,2}......(1)$$

$$v=v.\ i=0,\ x_2=(2-x)m\,x_1=(2-1)$$

$$=1\text{m}$$



K = 200 N/m
M = 2 kg

$$(1)\ \Rightarrow\ \frac{1}{2}2(v^2-0)$$

$$=\frac{1}{2}200\left((2-1)^2-(2-x)^2\right)$$

$$\Rightarrow\ v^2=100\left(1-(2-x)^2\right)$$

$$v=10\sqrt{1-(2-x)^2}$$

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

1) $A^{\frac{2}{3}}$ 2) Independent of A

3) $A^{\frac{1}{3}}$ 4) A^3

Key : **2**

Sol : As the density of nucleus is constant
E is independent of A

$$e\propto A^o$$

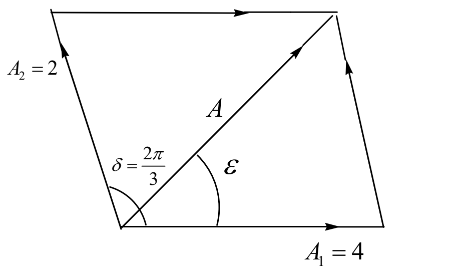
34. The amplitude and phase of a wave that is formed by the superposition of two harmonic travelling waves, $y_1(x,t) = 4\ \sin(kx - \omega t)$ and $y_2(x,t) = 2\sin(kx - \omega t + \frac{2\pi}{3})$ are : (Take the angular frequency of initial waves same as ω)

1) $\left[\sqrt{3}, \frac{\pi}{6}\right]$ **2)** $\left[2\sqrt{3}, \frac{\pi}{6}\right]$ **3)** $\left[6, \frac{2\pi}{3}\right]$ **4)** $\left[6, \frac{\pi}{3}\right]$

Key: 2

Sol: $y = y_1 + y_2$

$= A_1 \sin(kx - \omega t) + A_2 \sin(kx - \omega t + \delta)$



$$A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2 \cos\delta}$$

$$\& \ \varepsilon = \tan^{-1}\left(\frac{A_2 \sin\delta}{A_1 + A_2 \cos\delta}\right)$$

$$A = \sqrt{4^2 + 2^2 + 2(4)(2)\cos\left(\frac{2\pi}{3}\right)}$$

$$= 2\sqrt{3}$$

$$\& \ \ \varepsilon = \tan^{-1}\left(\frac{2\sin\frac{2\pi}{3}}{4 + 2\cos\frac{2\pi}{3}}\right)$$

$$= \tan^{-1}\left(\frac{1}{\sqrt{3}}\right) \quad = \frac{\pi}{6}$$

35. A monatomic gas having $\gamma = \frac{5}{3}$ is stored in a thermally insulated container and the gas is suddenly compressed to $\left(\frac{1}{8}\right)^{th}$ of its initial volume. The ratio of final pressure and initial pressure is (γ is the ratio of specific heats of the gas at constant pressure and at constant volume)

1) 16 **2) 40** **3) 28** **4) 32**

Key: 4

Sol:

$P_1V_1^\gamma = P_2V_2^\gamma$

$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^\gamma$

$= \left(\frac{V_1}{\frac{V_1}{8}}\right)^{\frac{5}{3}}$

$= 32$

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

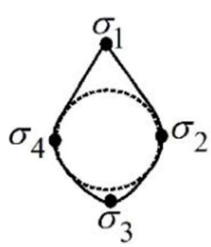
1) $3\hat{i} + 4\hat{j} + 5\hat{k}$ **2)** $3\hat{i} + 4\hat{j} + \sqrt{5}\hat{k}$ **3)** $4\hat{i} + 3\hat{j} + 5\hat{k}$ **4)** $3\hat{i} + 4\hat{j} - 5\hat{k}$

Key: 1

Sol: $V_z = a_z t = \frac{6}{2} \times \frac{5}{3} = 5ms^{-1}$

$\vec{V}_{final} = 3\hat{i} + 4\hat{j} + 5\hat{k}\ ms^{-1}$

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



(A) $\sigma_1 > \sigma_3; \sigma_2 = \sigma_4$ (B) $(\sigma_1 > \sigma_2; \sigma_3 > \sigma_4$

C) $\sigma_1 > \sigma_3 > \sigma_2 = \sigma_4$ (D) $\sigma_1 < \sigma_3 < \sigma_2 = \sigma_4$

(E) $\sigma_1 = \sigma_2 = \sigma_3 = \sigma_4$

1) D & E only **2)** A & C only

3) A,B and C only **4)** B and C only

Key: 3

Sol: $\sigma \alpha \frac{1}{r}$ where r is local radius of curvature

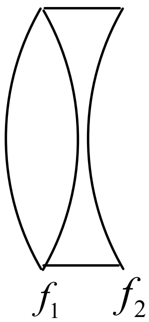
$\therefore \sigma_1 > \sigma_3 > \sigma_2 = \sigma_4$ $\left(Since\ r_1 < r_3 < r_2 = r_4\right)$

38. A convex lens of focal length 30 cm is placed in contact with a concave lens of focal length 20cm. An object is placed at 20 cm to the left of this lens system. The distnace of the image from the lens in cm is ______

1) 15 **2)** 30 **3)** $\frac{60}{7}$ **4)** 45

Key: 1

Sol:

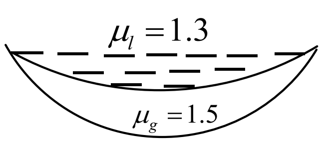


$$\frac{1}{f_e}=\frac{1}{f_1}+\frac{1}{f_2}$$
$$=\frac{1}{30}+\frac{1}{(-20)}$$
$$=\frac{-1}{60}$$
$$f_e=-60\ cm$$
$$\frac{1}{f_e}=\frac{1}{v}-\frac{1}{u}$$
$$\frac{1}{-60}=\frac{1}{v}-\frac{1}{-20}$$
$$\Rightarrow v=-15\ cm$$

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

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

Key: 4



Sol:

$$\frac{1}{f_e}=\frac{1}{f_1}+\frac{1}{f_2}$$
$$=(\mu_l-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)+(\mu_g-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$
$$=(1.3-1)\left(\frac{1}{\infty}-\frac{1}{-30}\right)+(1.5-1)\left(\frac{1}{-30}-\frac{1}{-20}\right)$$
$$=\frac{11}{600}$$
$$\therefore f_e=\frac{600}{11}\ cm$$

40. Two metal speres of radius R and 3R have same surface charge density σ. If they are brought in contact and then separated, the surface charge density on smaller and bigger sphere becomes σ_1 and σ_2 respectively. The ratio $\frac{\sigma_1}{\sigma_2}$ is

1) 3 **2)** $\frac{1}{9}$ **3)** $\frac{1}{3}$ **4)** 9

Key: 1

Sol:

Before contact

$$\sigma = \frac{Q_1}{4\pi R^2} = \frac{Q_2}{4\pi (3R)^2}$$

$$\Rightarrow Q_2 = 9Q_1$$

After contact

$$V_1 = V_2$$

$$\frac{KQ_1'}{R} = \frac{KQ_2'}{3R} \Rightarrow Q_2' = 3Q_1'$$

$$Q_1' = \left(\frac{R_1}{R_1 + R_2}\right)(Q_1 + Q_2)$$

$$= \left(\frac{R}{R+3R}\right)(Q_1 + 9Q_1)$$

$$= \frac{5}{2}Q_1$$

$$Q_2' = 10Q_1 - \frac{5}{2}Q_1$$

$$= \frac{15}{2}Q_1$$

$$\frac{\sigma_1}{\sigma_2} = \frac{\frac{Q_1'}{4\pi R^2}}{\frac{Q_2'}{4\pi (3R)^2}} = 3$$

41. Two strings with circular cross section and made of same material, are stretched to have same amount of tension. A transverse wave is then made to pass through both the strings, The velocity of the wave in the first having the radius of cross section R is V_1, and that in the other string having the radius of cross section R/2 is V_2, Then $\frac{V_2}{V_1}$ *is*

1) $\sqrt{2}$ **2)** 2 **3)** 4 **4)** 8

Key: 2

Sol:

$v=\sqrt{\frac{T}{\rho A}} \Rightarrow v \alpha \frac{1}{\sqrt{A}}$

$\Rightarrow v \alpha \frac{1}{\sqrt{\pi R^2}} \Rightarrow v \alpha \frac{1}{R}$

$\therefore \frac{v_2}{v_1}=\frac{R_1}{R_2}=\frac{R}{\left(\frac{R}{2}\right)}=2$

42. Water falls from a height of 200 m into a pool. Calculate the rise in temperature of the water assuming no heat dissipation from the water in the pool.
(Take $g=10\,m/s^2$, specific heat of water $=4200\,J/(kgK)$)

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

KEY: 1

SOL: $mgh=ms\Delta T$

$\Delta T=\frac{10\,m/s^2\times 200m}{4200\,J/kg.K}$

$\Delta T=0.48K$

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

1) 0.7 2) 0.6 3) 0.8 4) 0.1

KEY: 1

SOL: $Q=x^{-2}y^{+\frac{3}{2}}z^{-\frac{2}{5}}$

$\Rightarrow \frac{\Delta Q}{Q}=2\frac{\Delta x}{x}+\frac{3}{2}\frac{\Delta y}{y}+\frac{2}{5}\frac{\Delta z}{z}$

$\Rightarrow \frac{\Delta Q}{Q}=2\times 0.1+\frac{3}{2}\times 0.2+\frac{2}{5}\times 0.5$

$\Rightarrow \frac{\Delta Q}{Q}=0.7$

44. Two balls with same mass and initial velocity, are projected at different angle in such a way that maximum height reached by first ball is 8 times higher than that of the second ball. T_1 and T_2 is

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

KEY: 2

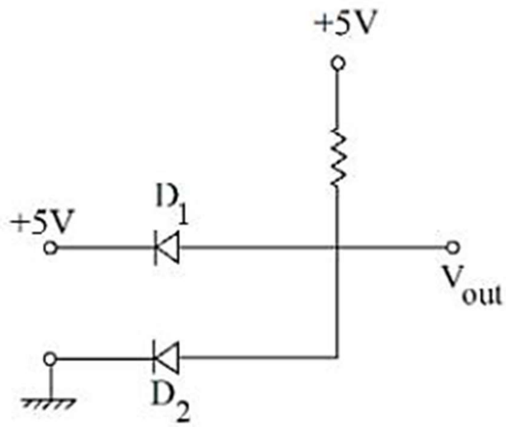
SOL: $h=\frac{1}{2}g\left(\frac{T}{2}\right)^2$

$\frac{H_1}{H_2}=\left(\frac{T_1}{T_2}\right)^2$

$\Rightarrow \frac{T_1}{T_2}=(8)^{1/2}$

$\Rightarrow \frac{T_1}{T_2} = 2\sqrt{2} : 1$

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



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

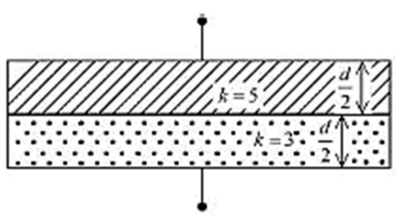
KEY: 2

SOL: D_2 is in Forward bias
So $V_{out} = 0$

SECTION-II (NUMERICAL VALUE TYPE)

This section contains **5 Numerical Value Type Questions.** The Answer should be within **0 to 9999.** If the Answer is in **Decimal** then round off to the **Nearest Integer** value (Example i,e. If answer is above **10** and less than **10.5** round off is **10** and If answer is from **10.5** and less than **11** round off is **11).**
Marking scheme: +4 for correct answer, 0 if not attempt and -1 in all other cases.

46.



Space between the plates of a parallel plate area $4cm^2$ and separation of (d) 1.77 mm, is filled with uniform dielectric materials with dielectric constants (3 and 5) as shown in figure. Another capacitor of capacitance 7.5 pF is connected in parallel with it. The effective capacitance of this combination is ____pF.
(Given $\in_0 = 8.85\times10^{-12}\, F/m$)

Key: 15

Sol: $$\frac{1}{C_1} = \frac{1}{\left(\frac{5\in_0 A}{d/2}\right)} + \frac{1}{\left(\frac{3\in_0 A}{d/2}\right)} = \frac{d}{10\in_0 A} + \frac{d}{6\in_0 A} = \frac{16d}{60\in_0 A}$$

$$C_1 = \frac{15}{4}\times\frac{8.85\times10^{-12}\times4\times10^{-4}}{1.77\times10^{-3}} = 75\times10^{-13} = 7.5\,pF$$

$C_2 = 7.5\,pF$

$C_{eff} = C_1 + C_2 = 15\,pF$

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

Key: 40

Sol: $\omega_2 - \omega_1 = \alpha t$

$$(2100-1800)\frac{2\pi}{60} = \alpha \times 40$$

$$\pi = 4\alpha \Rightarrow \alpha = \frac{\pi}{4}$$

$$\tau = I\alpha$$

$$25\pi = \frac{mR^2}{4}\alpha \Rightarrow 25\pi = \frac{(I)R^2}{4}\frac{\pi}{4}$$

$$400 = R^2$$

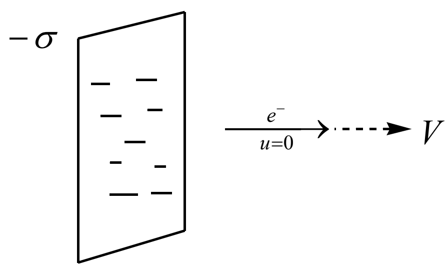
$$R = 20m$$

$$D = 40m$$

48. An electron is released from rest near an infinite non-conducting sheet of uniform charge density $'-\sigma'$. The rate of charge of de-Broglie wave length associated with the electron varies inversely as nth power of time. The numerical value of n is____

Key: 2

Sol:



$$a = \frac{Eq}{m}$$

$$v = u + at = 0 + \frac{Ee}{m}t$$

$$\lambda = \frac{h}{mv}$$

$$= \frac{hm}{mEet} = \frac{h}{Eet}$$

$$\frac{d\lambda}{dt} = \frac{h}{Ee}\left(\frac{-1}{t^2}\right)$$

$$n = 2$$

49. A sample of a liquid is kept at I atm. It is compressed to 5 atm which leads to change of volume of $0.8cm^3$. If the bulk modulus of the liquid is 2 GPa. The initial volume of the liquid was ____litre.

(Take 1 atm $=10^5 Pa$)

Key: 4

Sol: $B = \dfrac{\Delta P}{\dfrac{-\Delta V}{V}}$

$$2\times 10^9 = \frac{(5-1)\times 10^5}{\left(\dfrac{0.8\times 10^{-6}}{V}\right)}$$

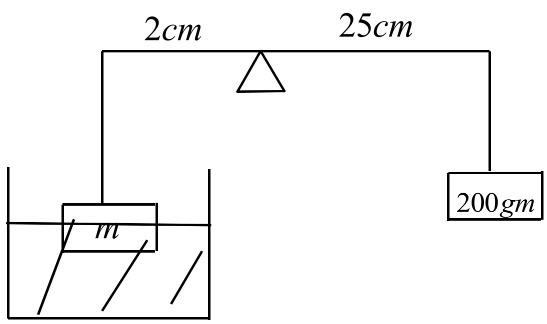
$$\frac{2\times 0.8\times 10^{-2}}{4} = V$$

$$V = 0.4\times 10^{-2} = 4\times 10^{-3} m^3 = 4ltr$$

50. A cube having a side of 10 cm with unknown mass and 200 gm mass were hung at two ends of an uniform rigid rod of 27 cm long. The rod along with masses was placed on a wedge keeping the distance between wedge point and 200 gm weight as 25 cm. Initially the masses were not at balance. A beaker is placed beneath the unknown mass and water is added slowly to it. At given point the masses were in balance and half volume of the unknown mass was inside the water. (Take the density of unknown mass is more than that of the water, the mass did not absorb water and water density is 1 gm/cm^3). The unknown mass is ___kg

Key: 3

Sol:



$$\left(mg - \frac{V}{2}\rho g\right)2\times 10^{-2} = 200\times 10^{-3} g\times 25\times 10^{-2} \Rightarrow m - \frac{10^3\times 10^{-6}\times 10^3}{2} = 2.5$$

$$m - \frac{1}{2} = 2.5 \Rightarrow 2m = 6$$

$$m = 3Kg$$

CHEMISTRY

Max Marks: 100

SECTION-I (SINGLE CORRECT ANSWER TYPE)

This section contains **20 Multiple Choice Questions**. Each question has 4 options (1), (2), (3) and (4) for its answer, out of which ONLY ONE option can be correct.

Marking scheme: +4 for correct answer, 0 if not attempted and –1 in all other cases.

51. Which of the following binary mixture does not show the behaviour of minimum boiling azeotrope?

1) $CH_3OH + CHCl_3$
2) $CS_2 + CH_3COCH_3$
3) $C_6H_5OH + C_6H_5NH_2$
4) $H_2O + CH_3COC_2H_5$

Key : 3

Sol :

Phenol – Aniline system shows negative deviation from Raoult's law and hence is maximum boiling Azeotrope.

52. The correct decreasing order only magnetic moment value (BM) of Cu^{+}, Cu^{2+}, Cr^{2+} and Cr^{3+}

1) $Cr^{3+} > Cr^{2+} > Cu^{+} > +Cu^{2+}$
2) $Cu^{2+} > Cu^{+} > Cr^{2+} > Cr^{3+}$
3) $Cr^{2+} > Cr^{3+} > Cu^{2+} > Cu^{+}$
4) $Cu^{+} > Cu^{2+} > Cu^{3+} > Cr^{2+}$

Key : 3

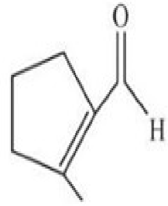
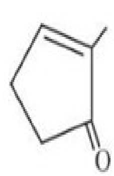
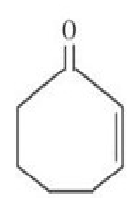
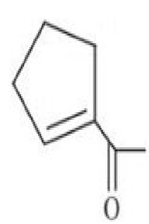
Sol :

ION	CONFIGURATION	NO. OF UNPAIRED ELECTRONS (n)
Cu^{+}	d^{10}	0
Cu^{+2}	d^{9}	1
Cr^{+2}	d^{4}	4
Cr^{+3}	d^{3}	3

$$\mu_s = \sqrt{n(n+2)}\ BM$$

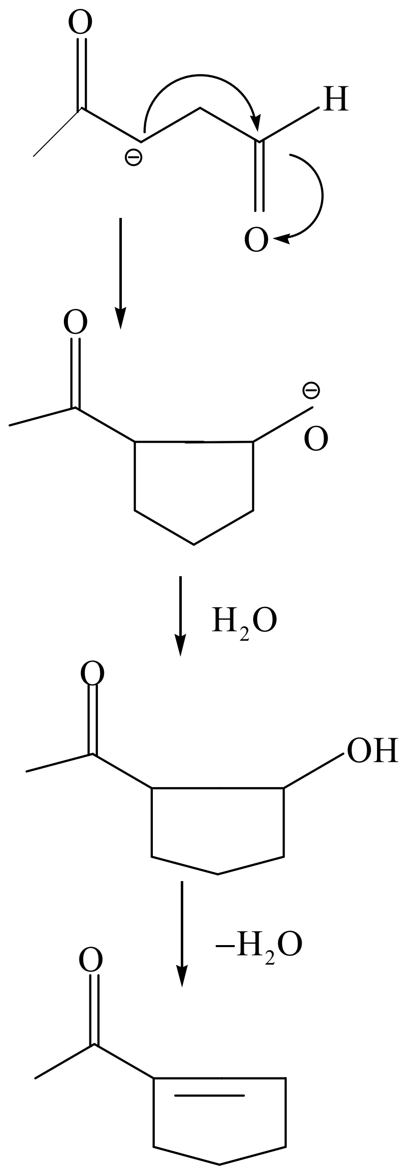
$$\therefore \mu_s \text{ of } Cr^{+2} > Cr^{+3} > Cu^{+2} > Cu^{+}$$

53. When  undergoes intramolecular aldol condensation the major Product formed is :

1) 
2) 
3) 
4) 

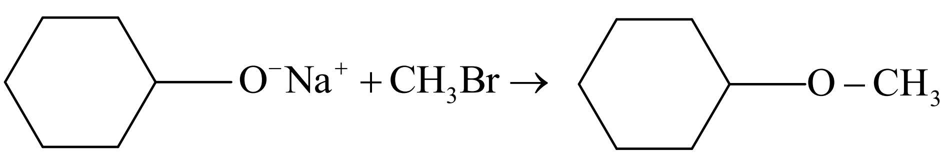
Key : 4

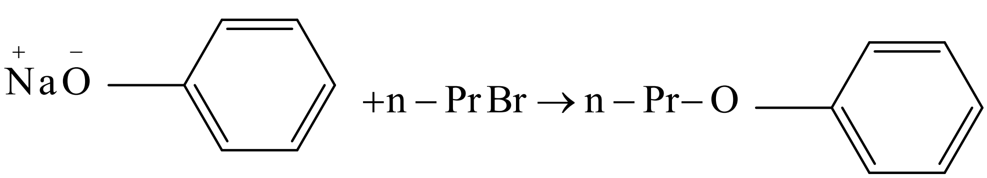
Sol :



5-membered ring system is more stable than 7 membered ring system

54. Which one of the following reaction will not lead to the desired ether formation in major-proportion? (iso-Bu$\Rightarrow$isobutyl ,sec -Bu$\Rightarrow$sec-butyl ,nPr$\Rightarrow$n-propyl.

1) 

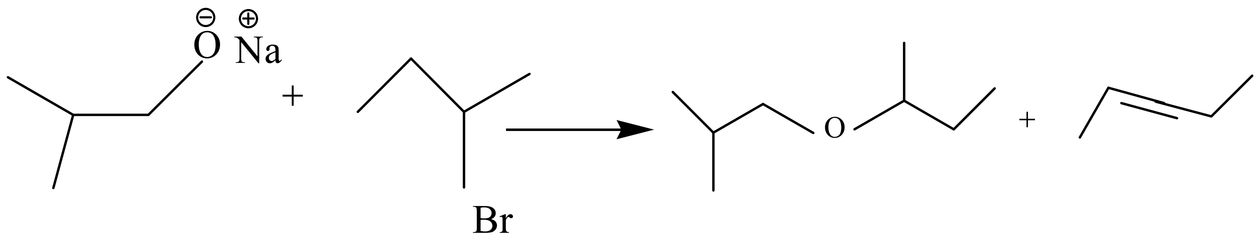
2) 

3) $^{t}Bu\overset{-}{O}\overset{+}{N}a + EtBr \rightarrow {}^{t}Bu - O - Et$

4) $iso - Bu\overset{-}{O}\overset{+}{N}a + sec - BuBr \rightarrow sec - Bu - O - iso - Bu$

Key : 4

Sol :



Elimination product is also formed along with substitution product

55. The atomic number of the element from the following with lowest 1st ionisation enthalpy is

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

Key : **1**

Sol :

19^{K}

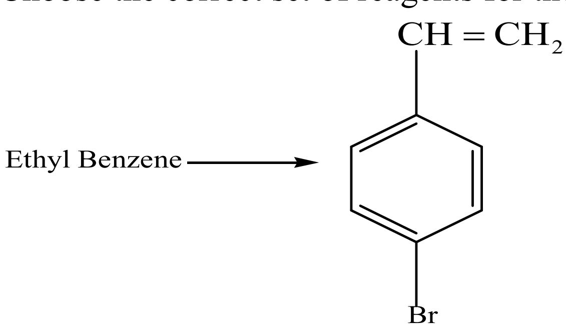
87^{Fr}

35^{Br}

32^{Ge}

K & Fr are alkali metals and Fr possess least ionisation potential as on moving down the group I.P decreases.

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



1) Cl_2 / Fe; Br_2 / anhy.$AlCl_3$; aq. KOH

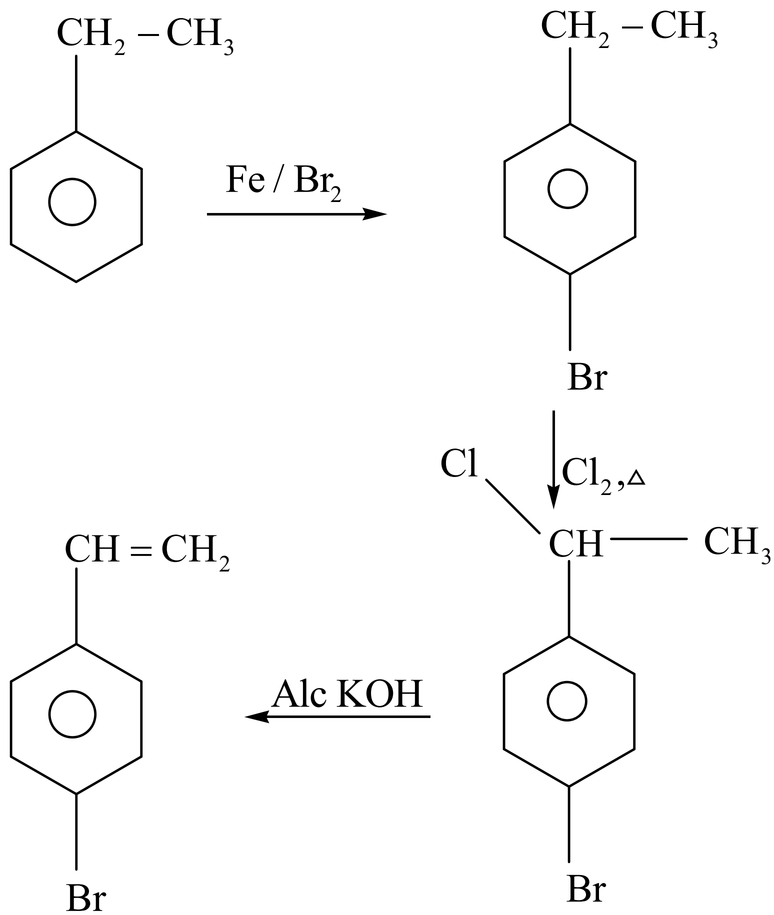
2) Cl_2 / anhy.$AlCl_3$; Br_2 / Fe; alc.KOH

3) Br_2 / Fe; Cl_2, $\triangle$; alc.KOH

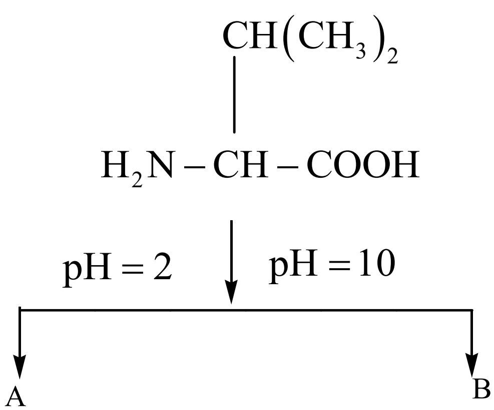
4) Br_2 / anhy.$AlCl_3$; Cl_2, $\triangle$; aq.KOH

Key : 3

Sol :



57.



Choose the correct option for structures of A and B respectively

1) $H_3^+N-\underset{\substack{| \\ CH(CH_3)_2}}{CH}-COO^-$ and $H_3^+N-\underset{\substack{| \\ CH(CH_3)_2}}{CH}-COOH$

2) $H_2N-\underset{\displaystyle CH(CH_3)_2}{\underset{|}{CH}}-CO\overset{\ominus}{O}$ and $H_3{}^{+}N-\underset{\displaystyle CH(CH_3)_2}{\underset{|}{CH}}-COO^{-}$

3) $H_2N-\underset{\displaystyle CH(CH_3)_2}{\underset{|}{CH}}-COO^{-}$ and $H_3{}^{+}N-\underset{\displaystyle CH(CH_3)_2}{\underset{|}{CH}}-COOH$

4) $H_3{}^{+}N-\underset{\displaystyle CH(CH_3)_2}{\underset{|}{CH}}-COOH$ and $H_2N-\underset{\displaystyle CH(CH_3)_2}{\underset{|}{CH}}-CO\overset{-}{O}$

Key : 4

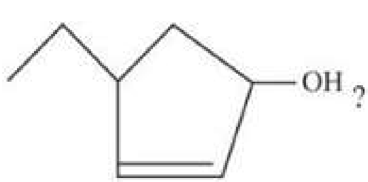
Sol :

$$H_2N-\overset{\displaystyle CH(CH_3)2}{\overset{|}{CH}}-COOH$$

$$P^{H}=2 \quad \xleftarrow[\text{medium}(H^{+})]{\text{acidic}} \qquad \xrightarrow[\text{medium}(\overset{-}{O}H)]{\text{Alkaline}} \quad PH=10$$

$$H_3{}^{+}N-\underset{\displaystyle CH(CH_3)_2}{\underset{|}{CH}}-COOH \qquad H_2N-\underset{\displaystyle CH(CH_3)_2}{\underset{|}{CH}}-CO\overset{-}{O}$$

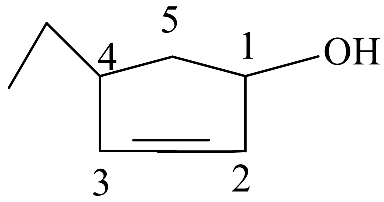
58. What is the correct IUPAC name of



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

Key: 3

Sol:



4-Ethyl cyclopent -2-en-1-ol
priority of numbering : functional group >double bond >substituent

59. On combustion 0.210 g of an organic compound containing C, H and O gave 0.127 g H_2O and 0.307 g of CO_2. The percentage of hydrogen and oxygen in the given organic compound respectively are:

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

Key: 3

Sol:

$$percentage\ of\ hydrogen = \left(\frac{2\times 0.127}{18\times 0.210}\right)100$$
$$=6.7195$$
$$=6.72$$
$$Percentage\ of\ carbon = \left(\frac{12\times 0.307}{44\times 0.210}\right)100$$
$$=39.87$$
$$Percentage\ of\ oxygen = 100-(6.72)-(39.87)$$
$$=53.41$$

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

LIST –I		LIST-II	
A.	Carbocation	I.	Species that can supply a pair of electrons.
B.	C-Free radical	II.	Species that can receive a pair of electrons.
C.	Nucleophile	III.	Sp^2 hybridized carbon with empty p-orbital
D.	Electrophile	IV.	Sp^2 / Sp^3 hybridized carbon with one unpaired electron.

Choose the ***correct*** answer form the options given below

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

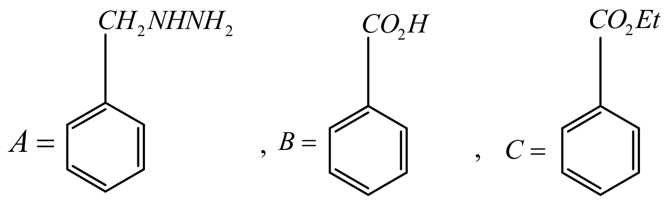
Key: 4

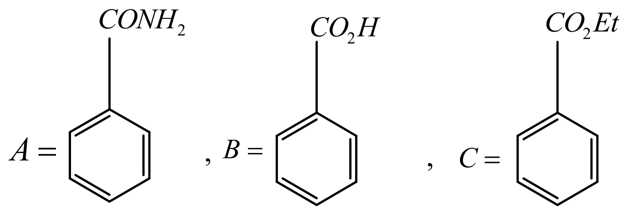
Sol: Carbocation - SP^2 Hybridized carbon with empty p – orbital
C – free radical - SP^2 / SP^3 Hybridized carbon with one unpaired electron.

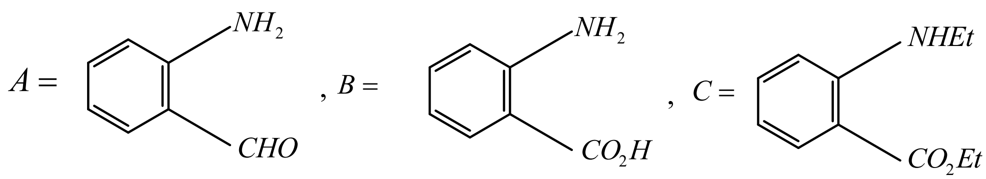
Nucleophile – Species that can supply a pair of electrons.
Electrophile – Species that can receive a pair of electrons.
A – III, B – IV, C – I, D - II

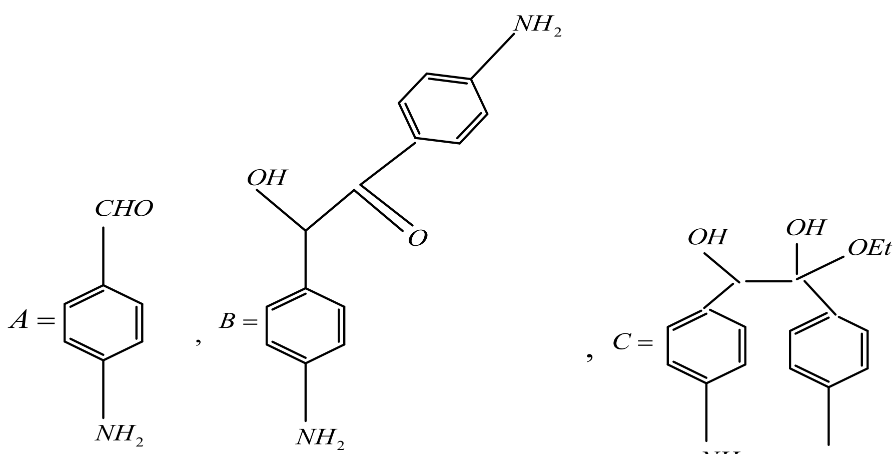
61. $A \xrightarrow[(ii)H_3O^+]{(i)NaOH} B \xrightarrow[(ii)H_2SO_4,\Delta]{(i)EtOH} C$ 'A' shows positive Lassaign's test for N and its molar mass is 121. 'B' gives effervescence with aq $NaHCO_3$. 'C' gives fruity smell.

Identify A, B and C from the following.

1) 

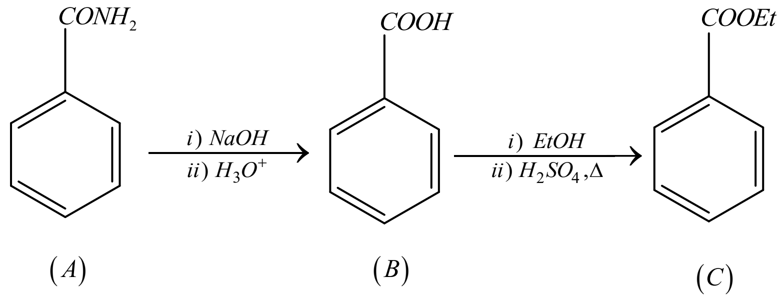
2) 

3) 

4) 

Key: 2

Sol:



→ $C_6H_5CONH_2$, Contains nitrogen with molar mass 121.

→ Carboxylic acid liberate CO_2 gas with $NaHCO_3$

→ Ester gives fruity smell

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

$\left[Co\left(NH_3\right)_6\right]^{3+}$, SF_6, $\left[CoF_6\right]^{3-}$, $\left[Mn\left(CN\right)_6\right]^{3-}$ and $\left[MnCl_6\right]^{3-}$

1) 5 **2) 3** **3) 6** **4) 4**

Key: 2

NTA KEY: 4

Sol:

$\left[Co\left(NH_3\right)_6\right]^{3+} - d^2sp^3$

$SF_6 - sp^3d^2$

$\left[CrF_6\right]^{3-} - d^2sp^3$

$\left[CoF_6\right]^{3-} - sp^3d^2$

$\left[Mn(CN)_6\right]^{3-} - d^2sp^3$

$\left[MnCl_6\right]^{3-} - sp^3d^2$

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

LIST-I (Complex/species)		LIST-II (Shape & magnetic moment)	
A.	$\left[Ni(CO)_4\right]$	I	Tetrahedral, 2.8 BM
B.	$\left[Ni(CN)_4\right]^{2-}$	II.	Square planar, 0 BM
C.	$\left[NiCl_4\right]^{2-}$	III.	Tetrahedral, 0 BM
D.	$\left[NiBr_4\right]^{2-}$	IV	Tetrahedral, 5.9 BM

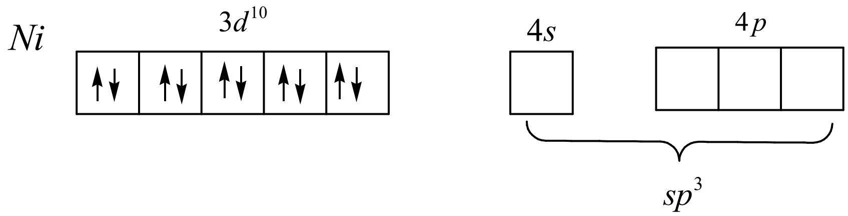
Choose the ***Correct*** answer from the options given below:

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

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

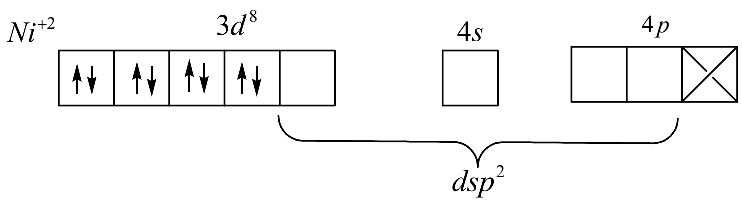
Key: 3

Sol: $\left[Ni(CO)_4\right]-sp^3, Tetrahedral$



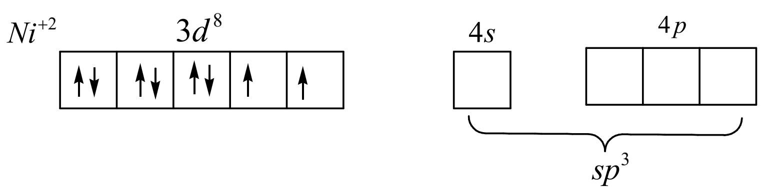
Magnetic moment = 0

$\left[Ni(CN)_4\right]^{2-}-dsp^2, Square\ planar$



Magnetic moment = 0

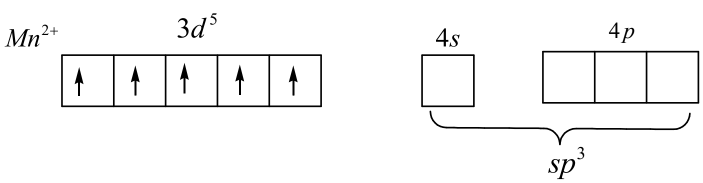
$\left[NiCl_4\right]^{2-}-sp^3, Tetrahedral$



Magnetic momnet = $\sqrt{2(2+2)}$

2.828 BM

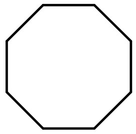
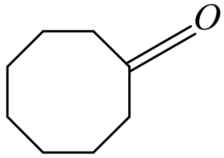
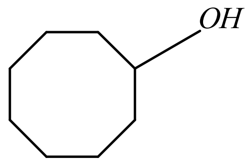
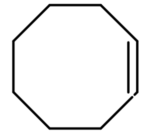
$\left[MnBr_4\right]^{2-}-sp^3, Tetrahedral$



Magnetic moment = $\sqrt{5(5+2)}$

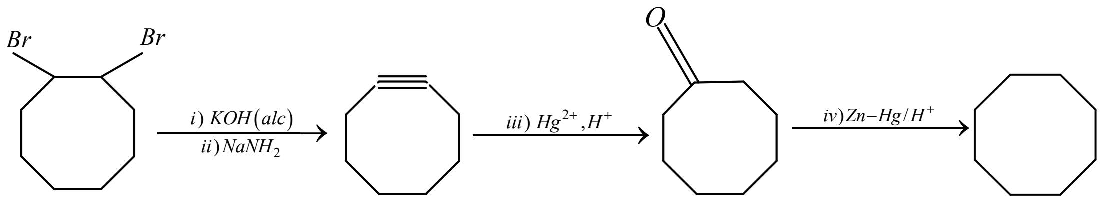
= 5.916 BM

64. 1, 2-dibromocyclooctane $\xrightarrow[\substack{(ii) NaNH_2 \\ (iii) Hg^{2+}/H^+ \\ (iv) Zn-Hg/H^+}]{(i) KOH(alc)}$ $\underset{(major\ product)}{P}$ 'P' is

1)  2)  3)  4) 

Key: 1

Sol:



65. In a first order decomposition reaction, the time taken for the decomposition of reactant to one fourth and one eight of its initial concentration are t_1 *and* $t_2(s)$, respectively. The ratio t_1/t_2 will be:

1) $\frac{4}{3}$ 2) $\frac{3}{2}$ 3) $\frac{3}{4}$ 4) $\frac{2}{3}$

Key: 4

Sol: For first order reaction half – life remain constant

$t_{75\%} = 2t_{50\%}$

$t_{87.5\%} = 3t_{50\%}$

$\therefore t_1 = 2t_{50\%}$ *and* $t_2 = 3t_{50\%}$

$\frac{t_1}{t_2} = \frac{2}{3}$

66. Given below are two statements:

Statement I: A homoleptic octahedral complex, formed using monodentate ligands, will not show stereosiomerism

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

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

1) Both Statement I and Statement II are false

2) Statement I is false but Statement II is true

3) Statement I is true but Statement II is false

4) Both Statement I and Statement II are true

Key: 3

Sol: Statement – I is true but

Statement – II is false

cis – and trans – platin are heteroleptic complexes of Pt

67. Correct statements for an element with atomic number 9 are:

A) There can be 5 electrons for which $m_s = +\frac{1}{2}$ and 4 electrons for which $m_s = -\frac{1}{2}$

B) There is only one electron in P_Z orbital.

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

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

Choose the correct answer from the options given below:

1) C and D Only 2) A and B Only 3) A and C Only 4) A, C and D Only

Key: 3

Sol : The element with atomic number 9 is fluorine. Its electronic configuration is:

$1s^2\ 2s^2\ 2p^5$

Now let's evaluate each statement:

1. A. There can be 5 electrons for which $m_s = +½$ and 4 electrons for which ms = –½.
   - Fluorine has 9 electrons.
   - In orbitals, electrons are filled with opposite spins.
   - So we can have 5 electrons with +½ spin and 4 with –½ spin.

   → Correct
2. B. There is only one electron in P_z orbital.
   - In the 2p subshell ($2p^5$), there are 3 orbitals: p_x, p_y, and p_z.
   - Electrons fill one in each orbital first, then pairing occurs.
   - So only one orbital has only one electron; but not necessarily p_z.

   → Not necessarily true (incorrect generalization)
3. C. The last electron goes to orbital with n = 2 and l = 1.
   - Yes, the last electron goes to the 2p orbital.
   - For 2p: n = 2, l = 1.

   → Correct
4. D. The sum of angular nodes of all the atomic orbitals is 1.
   - Angular nodes = l (azimuthal quantum number).
   - 1s (l = 0) → 0 nodes
   - 2s (l = 0) → 0 nodes
   - 2p (l = 1) → each 2p orbital has 1 angular node
   - There are 3 orbitals in 2p, and 5 electrons occupy them.
   - Total angular nodes = number of orbitals × l = 3 × 1 = 3

   → Incorrect

Final correct options: A and C only

68. Given below are two statements:

Statement I : H_2Se is more acidic than H_2Te

Statement II : H_2Se has higher bond enthalpy for dissociation than H_2Te

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

Key : 1

Sol:

Statement I: H_2Se is more acidic than H_2Te → **False**

Reason: Acidic strength increases down the group in chalcogens due to increasing atomic size and decreasing bond strength. So, H_2Te is more acidic than H_2Se.

Statement II: H_2Se has higher bond enthalpy for dissociation than H_2Te → **True**

Reason: Bond enthalpy decreases down the group. Se–H bond is stronger than Te–H bond.

Correct Answer: Option 1 (Statement I is false but Statement II is true)

69. Match the LIST-I with LIST-II

LIST-I (Reagent)		**LIST-II** (Functional Group detected)	
A	Sodium bicarbonate solution	I	double bond/ unsaturation
B	Neutral ferric chloride	II	carboxylic acid
C	ceric ammonium nitrate	III	phenolic – OH
D	alkaline KMnO4	IV	alcoholic - OH

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

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

Key: 1

Sol: Matching List-I with List-II:

A. Sodium bicarbonate solution → Carboxylic acid (II)

Reason: Carboxylic acids react with $NaHCO_3$ to release CO_2 gas.

B. Neutral ferric chloride → Phenolic -OH (III)

Reason: Gives colored complexes with phenols.

C. Ceric ammonium nitrate → Alcoholic -OH (IV)

Reason: Reacts with alcohols causing color change.

D. Alkaline $KMnO_4$ → Double bond/unsaturation (I)

Reason: Oxidizes alkenes (Baeyer's test).

Correct Matching: A–II, B–III, C–IV, D–I

Correct Answer: Option 1

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

The freezing point depression of a 0.1 m aqueous solution of a monobasic weak acid HA is 0.20^0C. The dissociation constant for the acid is:

Given: $K_f(H_2O) = 1.8K\ kgmol^{-1}$, molality = molarity

1) 1.89×10^{-1}
2) 1.90×10^{-3}
3) 1.38×10^{-3}
4) 1.1×10^{-2}

Key : 3

Sol : $\Delta T_f = i \times K_f \times m$

$0.20 = i \times 1.8 \times 0.1$

$i = 0.20 / 0.18 = 1.11$

Since HA is a weak acid,

$i = 1 + \alpha \Rightarrow \alpha = 0.11$

$$Ka = C\alpha^2/(1-\alpha) = (0.11)^2/0.89 = 1.36\times10^{-3}$$

SECTION-II (NUMERICAL VALUE TYPE)

This section contains **5 Numerical Value Type Questions.** The Answer should be within **0 to 9999.** If the Answer is in **Decimal** then round off to the **Nearest Integer** value (Example i,e. If answer is above **10** and less than **10.5** round off is **10** and If answer is from **10.5** and less than **11** round off is **11).**

Marking scheme: +4 for correct answer, 0 if not attempt and -1 in all other cases.

71. The equilibrium constant for decomposition of $H_2O_{(g)}$

$H_2O(g) \rightleftharpoons H2(g) + \frac{1}{2}O2(g)(\Delta G\circ = 92.34kJmol^{-1})$ is 8.0×10^{-3} at 2300K and total pressure at equilibrium is 1bar. Under this condition, the degree of dissociation (α) of water is _______$\times10^{-2}$ (nearest integer value).

[Assume α is negligible with respect to 1]

Key: 5

Sol: $P_{H2O} \approx 1, \alpha \ll 1$

$K = \alpha \times (\alpha/2)^{1/2} = \alpha^{3/2} \times (1/2)^{1/2}$

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

$\alpha = 5.04 \times 10^{-2}$

72. 20mL of sodium iodide solution gave 4.74g silver iodide when treated with excess of silver nitrate solution. The molarity of the sodium iodide solution is ______M. (Nearest Integer value)

(Given : Na = 23, I = 127, Ag = 108, N = 14, O = 16gmol^{-1})

Key : 1

Sol:

Given:

- Molar mass of AgI = 108 + 127 = 235 g/mol
- Moles of AgI = 4.74 / 235 = 0.02017
- Volume = 20 mL = 0.020 L

Molarity = 0.02017 / 0.020 = 1.0085 ⇒ 1 M

Answer: 1 M

73. Consider the following half cell reaction

$Cr_2O_7^{2-}(aq) + 6e^- + 14H^+(aq) \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$

The reaction was conducted with the ratio of $\frac{\left[Cr^{3-}\right]^2}{\left[Cr_2O_7^{2-}\right]} = 10^{-6}$

The pH value at which the EMF of the half cell will become zero is ______ (nearest integer value)

[Given : standard half cell reduction potential $E^O_{Cr_2O_7^{2+}, H^+/Cr^{3+}} = 1.33V, \frac{2.303Rt}{F} = 0.059V$]

Key: 10

$$E = E^O - \frac{0.059}{n}\log\frac{\left[cr^{34}\right]^2}{\left[cr_2o_7^{2-}\right]\left[H^1\right]^{14}}$$

$$E = o = 1.33 - \frac{0.059}{6}\left[\log\frac{\left[cr^{3+}\right]}{cr_2o_7^{2-}} + \log\frac{1}{\left[h^+\right]^{14}}\right]$$

Sol: $$1.33 = \frac{0.06}{6}\left[\log 10^{-6} - 14\log^{\left[H+\right]}\right]$$

$$1.33 = \frac{0.06}{6}\left[-6 + 14P^H\right]$$

After calculating we get $P^H = 10$

74. The energy of an electron in the first Bohr orbit of H-atom is −13.6eV. The magnitude of energy value of electron in the first excited state of Be^{3+} is ______eV (nearest integer value).

Key: 54

Sol: $\Delta H_{IE} = -E_n = -E_0 \dfrac{Z^2}{n^2}$

$= -(-13.6)\left[\dfrac{4^2}{2^2}\right] n = 2, z = 4$

$\Delta H_{IE} = 13.6.\dfrac{16}{4}$

$\Delta H_{IE} = 54.4 ev$

$Ans = 54$

75. Resonance in X2Y can be represented as:

$$\overset{\ominus}{\ddot{\underset{..}{X}}} = \overset{\oplus}{X} = \ddot{\underset{..}{Y}} \leftrightarrow :X = \overset{\oplus}{X} - \overset{\ominus}{\ddot{\underset{..}{Y}}}:$$

The enthalpy of formation of $X_2Y(X = X(g) + \frac{1}{2}Y = Y(g) \to X_2Y(g))$ *is* 80 *kJ mol*$^{-1}$

The magnitude of resonance energy of X_2Y is ______kJ mol^{-1} (nearest integer value).
Given : Bond energies of X≡X, X=X, Y=Y and X=Y are 940,410,500 and 602kJmol^{-1} respectively.
valence X:3,Y:2

Key: 98

Sol: $x \equiv x + \frac{1}{2} y_2 \to x_2 \quad \Delta h = 80 \dfrac{kj}{mol}$

$$\left(\varepsilon_{x\equiv x} + \frac{1}{2}\varepsilon y_2\right) - \left(\varepsilon_{x=x} + \varepsilon_{x=y}\right)$$

$Therotical\ \Delta h = \left(940 + \dfrac{500}{2}\right) - (410 + 602)$

$= (940 + 250) - (1012)$

$\Delta h = 1190 - 1012 = 178 kj$

$\text{Re} sonence energy = Theoretical\ \Delta h - practical\ \Delta h$

$= 178 - 80$

$\text{Re} sonence = 98 \dfrac{kj}{mol}$

$= 98$