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HIGHLIGHTS

- BELOW 100 ALL INDIA OPEN CATEGORY RANKS: 30
- BELOW 500 ALL INDIA OPEN CATEGORY RANKS: 122
- BELOW 1000 ALL INDIA OPEN CATEGORY RANKS: 203
- BELOW 100 ALL INDIA CATEGORY RANKS COUNT: 146
- BELOW 1000 ALL INDIA CATEGORY RANKS COUNT: 721
- NUMBER OF QUALIFIED RANKS: 4187+

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JEE MAIN (JAN) 2025 - SHIFT 2

23-01-2025

Sri Chaitanya IIT Academy., India.

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A right Choice for the Real Aspirant

ICON Central Office – Madhapur – Hyderabad

2025_Jee-Main_23-Jan-2025_Shift-02

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.

1. If in the expansion of $(1+x)^p(1-x)^q$,the coefficients of x and x^2 are 1 and -2 respectively , then p^2+q^2 is equal to:

1)18 2)13 3)8 4)20

Key: 2

Sol: Given expansion is $(1+px+\frac{p(p-1)}{2}x^2+.....)(1-qx+\frac{q(q-1)}{2!}x^2+....)$

Coefficient of $x = p-q = 1.....(1)$

Coefficient of $x^2 = \frac{q(q-1)}{2}+\frac{p(p-1)}{2}-pq=-2$

$\Rightarrow (p-q)^2-(p+q)=-4.....(2)$

$(1),(2) \Rightarrow p=3,q=2 \Rightarrow p^2+q^2=13$

2. If $I=\int_0^{\frac{\pi}{2}}\frac{\sin^{\frac{3}{2}}x}{\sin^{\frac{3}{2}}x+\cos^{\frac{3}{2}}x}dx$, then $J=\int_0^{21}\frac{x\sin x\cos x}{\sin^4 x+\cos^4 x}dx$ equals:

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

Key: 3

Sol: Given $I=\int_0^{\frac{\pi}{2}}\frac{\sin^{\frac{3}{2}}x}{\sin^{\frac{3}{2}}x+\cos^{\frac{3}{2}}x}dx$ .....(1)

$I=\int_0^{\frac{\pi}{2}}\frac{\cos^{\frac{3}{2}}x}{\cos^{\frac{3}{2}}x+\sin^{\frac{3}{2}}x}dx.....(2)$ (By king's property)

(1)+(2) = $2I=\int_0^{\frac{\pi}{2}}1dx=\frac{\pi}{2}\Rightarrow I=\frac{\pi}{4}$

Let $J=\int_0^{2I}\frac{x\sin x\cos x}{\sin^4 x+\cos^4 x}dx=\int_0^{\pi/2}\frac{x\sin x\cos x}{\sin^4 x+\cos^4 x}dx.....(3)$

$$J=\int_0^{\pi/2}\frac{\left(\frac{\pi}{2}-x\right)\sin x\cos x}{\sin^4 x+\cos^4 x}dx \ldots\ldots\ldots\ldots..(4)$$ (By king's property)

$(3)+(4) \Rightarrow 2J=\frac{\pi}{2}\int_0^{\pi/2}\frac{\sin x\cos x}{\sin^4 x\cos^4 x}dx=\frac{\pi}{4}\int_0^{\pi/2}\frac{\sin 2x}{1+\cos^2 2x}dx$

(put cos2x=t) $=\frac{\pi}{4}\int_{-1}^{1}\frac{1}{1+t^2}dt$

$\Rightarrow J=\frac{\pi}{8}\left(\frac{\pi}{4}-\left(\frac{-\pi}{4}\right)\right)=\frac{\pi^2}{16}$

3. The number of complex numbers z, satisfying $|z|=1$ and $\left|\frac{z}{\bar{z}}+\frac{\bar{z}}{z}\right|=1$, is :

1)8 2)10 3)4 4)6

Key: 1

Sol: $|z|=1,\left|\frac{z}{\bar{z}}+\frac{\bar{z}}{z}\right|=1\Rightarrow\left|\frac{cis\theta}{cis(-\theta)}+\frac{cis(-\theta)}{cis\theta}\right|=1 \quad \theta\in[0,2\pi)$

$\Rightarrow 2|\cos 2\theta|=1\Rightarrow\cos 2\theta=\pm\frac{1}{2} \quad 2\theta\in[0,4\pi)$

$\Rightarrow 2\theta=\frac{\pi}{3},\frac{2\pi}{3},\frac{4\pi}{3},\frac{5\pi}{3},\frac{7\pi}{3},\frac{8\pi}{3},\frac{10\pi}{3},\frac{11\pi}{3}\Rightarrow 8$

4. Let the point A divide the line segment joining the points $P(-1,-1,2)$ and $Q(5,5,10)$ internally in the ratio $r:1(r>0)$. If O is the origin and $(\overrightarrow{OQ}.\overrightarrow{OA})-\frac{1}{5}\left|\overrightarrow{OP}\times\overrightarrow{OA}\right|^2=10$, then the value of r is :

1)14 2) $\sqrt{7}$ 3)3 4)7

Key: 4

Sol: Let A divide $\overrightarrow{PQ}$ in the ratio $\lambda:1-\lambda=r:1\left(r=\frac{\lambda}{1-\lambda},0<\lambda<1\right) \Rightarrow A(6\lambda-1,6\lambda-1,8\lambda+2)$

$\lambda:1-\lambda \quad (0<\lambda<1)$

P A Q

$(-1,-1,2)$ $(5,5,10)$

Given $5\left(\overrightarrow{OQ}.\overrightarrow{OA}\right)-\left|\overrightarrow{OP}\times\overrightarrow{OA}\right|^2=50$

$5[140\lambda+10]-\left(800\lambda^2\right)=50$

$\Rightarrow\lambda=\frac{7}{8},\ \therefore r=\frac{\lambda}{1-\lambda}=7$

5. Let $\int x^3\sin x dx=g(x)+C$, where C is the constant of integration. If $8\left(g\left(\frac{\pi}{2}\right)+g'\left(\frac{\pi}{2}\right)\right)=\alpha\pi^3+\beta\pi^2+\gamma,\alpha,\beta,\gamma\in Z,$ then $\alpha+\beta-\gamma$ equals:

1)47 2)62 3)48 4)55

Key: 4

Sol: Given $\int x^3 \sin x dx = x^3(-\cos x) + 3x^2 \sin x + 6x\cos x - 6\sin x + c$

Given g(0)=0 $g(x) = -x^3\cos x + 3x^2 \sin x + 6x\cos x - 6\sin x$

$\therefore g\left(\frac{\pi}{2}\right) = \frac{3\pi^2}{4} - 6,\ g'\left(\frac{\pi}{2}\right) = \frac{\pi^3}{8}$

$\therefore 8\left[g\left(\frac{\pi}{2}\right) + g'\left(\frac{\pi}{2}\right)\right] = 6\pi^2 - 48 + \pi^3$

$= \alpha = 1, \beta = 6, \gamma = -48 \quad = \alpha + \beta - \gamma = 55$

6. If the square of the shortest distance between the lines $\frac{x-2}{1} = \frac{y-1}{2} = \frac{z+3}{-3}$ and $\frac{x+1}{2} = \frac{y+3}{4} = \frac{z+5}{-5}$ is $\frac{m}{n}$, where m , n are coprime numbers, then $m+n$ is equal to :

1)14 2)9 3)6 4)21

Key: 2

Sol: $(shortest\ distance)^2 = \left(\frac{\left|[\bar{a}-\bar{c}\ \ \bar{b}\ \bar{d}]\right|}{\left|\bar{b}\times\bar{d}\right|}\right)^2 = \left(\frac{2}{\sqrt{5}}\right)^2 = \frac{4}{5} = \frac{m}{n}$

$\therefore m+n = 9$

$\bar{a} = 2i + j - 3k$, $\bar{c} = -i - 3j - 5k$, $\bar{b} = i + 2j - 3k$, $\bar{r} = 2i + 4j - 5k$

$\left|\bar{b}\times\bar{d}\right| = |2i - j| = \sqrt{5} \qquad \left|[\bar{a}-\bar{c}\ \ \bar{b}\ \bar{d}]\right| = \begin{vmatrix} 3 & 4 & 2 \\ 1 & 2 & -3 \\ 2 & 4 & -5 \end{vmatrix} = 2$

7. The length of the chord of the ellipse $\frac{x^2}{4} + \frac{y^2}{2} = 1$, whose mid-points is $\left(1, \frac{1}{2}\right)$, is :

1) $\frac{1}{3}\sqrt{15}$ 2) $\frac{5}{3}\sqrt{15}$ 3) $\sqrt{15}$ 4) $\frac{2}{3}\sqrt{15}$

Key: 4

Sol: equation of chord is $s_1 = s_{11} \Rightarrow x + 4 = \frac{3}{2}$

Solving with $\frac{x^2}{4} + \frac{4^2}{2} = 1$ Gives $6x^2 - 12x + 1 = 0$

Let x_1, x_2 be roots $\Rightarrow x_1 + x_2 = 2,\ x_1x_2 = \frac{1}{6}$

If $(x_1, y_1), (x_2, y_2)$ are extremities of chord

Length of chord = $\sqrt{(x_1-x_2)^2 + (y_1-y_2)^2}$

$= \sqrt{(x_1-x_2)^2 + (x_1-x_2)^2} \quad \because y_1 - y_2 = \left(\frac{3}{2} - x_1\right) - \left(\frac{3}{1} - x_2\right)$

$= \sqrt{2((x_1+x_2)^2 - 4x_1x_2)} \qquad = -(x_1 - x_2)$

$= \sqrt{2\left(4 - \frac{2}{3}\right)} = \sqrt{\frac{2(10)}{3}} = 2\sqrt{\frac{5}{3}} = \frac{2}{3}\sqrt{15}$

8. A rod of length eight units moves such that its ends A and B always lie on the lines $x-y+2=0$ and $y+2=0$, respectively. If the locus of the point P, that divides the rod AB internally in the ratio $2:1$ is $9(x^2+\alpha y^2+\beta xy+\gamma x+28y)-76=0$, then $\alpha-\beta-\gamma$ is equal to :

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

Key: 3

Sol: Let $A(\alpha,\alpha+2), B(\beta,-2)$ be ends of rod

$= p(x,y)=\left(\frac{\alpha+2\beta}{3},\frac{\alpha-2}{3}\right)\Rightarrow \alpha+2\beta=3x, \alpha=3y+2, \beta=\frac{3x-3y-2}{2}$

Given $(\alpha-\beta)^2+(\alpha+4)^2=64$

$(9y-3x+6)^2+4(34+6)^2-256=0$

$\Rightarrow 9(x^2+13y^2-6xy-4x+28y)-76=0 \qquad \therefore \alpha=13, \beta=-6, \gamma=-4$

9. A board has 16 squares as shown in the figure:

Out of these 16 squares, two squares are choses at random. The probability that they have no side in common is :

1)3/5 2)23/30 3)7/10 4)4/5

KEY: 4

SOL: Total number of ways of selections 2 squares = $16c_2=120$

No of ways of selecting 2 squares having no side

common = 120-no of ways of selecting 2 adjacent squares 120-2(3)(4)=96

$\therefore$ probability = $\frac{96}{120}=\frac{4}{5}$

10. Let $X=R\times R$. Define a relation R on X as :

$(a_1,b_1)R(a_2,b_2)\Leftrightarrow b_1=b_2$

Statement -I : R is equivalence relation .

Statement -II: for some (a, b) $\in X$, the set $S=\{(x,y)\in X:(x,y)R(a,b)\}$ represents a line parallel to y=x.

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: 'is equal to' is an equivalent relation $\therefore$ R is equivalence relation (for any a_1, a_2)

$\therefore$ I is true , (in fact any two points on a horizontal line as related)

$\therefore$ II is false , ($(a_1,b_1)R(a_2,b_2) \Leftrightarrow b_1 = b_2$) points are on the same horizontal line :

11. The system of equations

$x + y + z = 6,$

$x + 2y + 5z = 9,$

$x + 5y + \lambda z = \mu,$

has no solution if

1) $\lambda = 17, \mu \neq 18$ 2) $\lambda = 17, \mu = 18$ 3) $\lambda = 15, \mu \neq 17$ 4) $\lambda \neq 17, \mu \neq 18$

Key:1

Sol: $x + y + z = 6$ -------(1)

$x + 2y + 5z = 9$ ------(2)

$x + 5y + \lambda z = \mu$ -----(3)

(1)-(2) $\Rightarrow -y - 4z =$ -----3

$y + 4z = 3$ -----(4)

(2)-(3) $\Rightarrow -3y + (5 - \lambda)z = 9 - \mu$

$$y + \frac{(\lambda - 5)z}{3} = \frac{-9 + \mu}{3} \text{-------(5)}$$

No solution $\Rightarrow 4 = \frac{\lambda - 5}{3}$ $\frac{-9 + \lambda}{3} \neq 3$

$\lambda = 17$ $\mu \neq 18$

12. A spherical chocolate ball has a layer of ice-cream of uniform thickness around it. When the thickness of the ice-cream layer is 1 cm, the ice-cream melts at the rate of 81 cm^3/min and the thickness of the ice-cream layer decreases at the rate of $\frac{1}{4\pi} cm/\min$. The surface are (in cm^2) of the chocolate ball (without the ice-cream layer) is:

1)128π 2)256π 3)225π 4)196π

Key: 2

Sol: $\frac{dv}{dt} = 81$

$$V = \frac{4}{3}\pi\left((r+1)^3 - r^3\right)$$

$$\frac{dv}{dy} = \frac{4}{3}\pi\left[3(r+1)^2\right]\frac{dr}{dt}$$

$81 = (r+1)^2$ $r + 1 = 9$ $r = 8$

$S = 4\pi r^2 = 256\pi$

13.Let $x = x(y)$ be the solution of the differential equation $y = \left(x - y\frac{dx}{dy}\right)\sin\left(\frac{x}{y}\right), y > 0$ and $x(1) = \frac{\pi}{2}$. Then cos(x(2)) is equal to:

1) $1-2(\log_e 2)^2$ 2) $1-2(\log_e 2)$ 3) $2(\log_e 2)-1$ 4) $2(\log_e 2)^2-1$

Key:1

Sol: $y = \left(x - y\frac{dx}{dy}\right)\sin\frac{x}{y}$

X=yv

$\frac{dx}{dy} = V + y\frac{dv}{dy}$

$1 = \left(\frac{x}{y} - \frac{dx}{dy}\right)\sin\frac{x}{y}$

$1 = \left(\not{y} - \not{y} - y\frac{dv}{dy}\right)\sin v$

$\int\frac{dy}{y} = \int -\sin v dv$

logy=cos v + c

$\log y = \cos\left(\frac{x}{y}\right) + C$

0 = O+C C=0

$\log_e y = \cos\left(\frac{x}{y}\right)$

$\frac{x}{y} = \cos^{-1}\left[\log_e y\right]$

$x = y\cos^{-1}\left[\log_e y\right]$

$x(2) = 2\cos^{-1}(\log_e 2)$

$\cos x(2) = \cos\left[2\cos^{-1}(\log_e 2)\right]$

$= 2(\log_e 2)^2 - 1$ or $1-2(\log_e 2)^2$

14. Let $A = \left[a_{ij}\right]$ be a 3×3 matrix such that $A\begin{bmatrix}0\\1\\0\end{bmatrix} = \begin{bmatrix}0\\0\\1\end{bmatrix}, A\begin{bmatrix}4\\1\\3\end{bmatrix} = \begin{bmatrix}0\\1\\0\end{bmatrix}$ and $A\begin{bmatrix}2\\1\\2\end{bmatrix} = \begin{bmatrix}1\\0\\0\end{bmatrix}$, then a_{23} equals:

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

Key:3

Sol:

$$A=\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}\begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}=\begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

$$a_{12}=0$$

$$a_{22}=0$$

$$a_{32}=1$$

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}\begin{bmatrix} 4 \\ 1 \\ 3 \end{bmatrix}=\begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}$$

$$\left.\begin{aligned} 4a_{11}+a_{12}+3a_{13}&=0 \\ 4a_{21}+a_{22}+3a_{23}&=1 \\ 4a_{31}+a_{32}+3a_{33}&=0 \end{aligned}\right\} \Rightarrow \begin{aligned} 4a_{11}+3a_{13}&=0 \\ 4a_{21}+3a_{23}&=1 \\ 4a_{31}+3a_{33}&=-1 \end{aligned}$$

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}\begin{bmatrix} 2 \\ 1 \\ 2 \end{bmatrix}=\begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$$

$$\left.\begin{aligned} 2a_{11}+a_{12}+2a_{13}&=1 \\ 2a_{21}+a_{22}+2a_{23}&=0 \\ a_{31}+a_{32}+2a_{33}&=0 \end{aligned}\right\} \Rightarrow \begin{aligned} 2a_{11}+2a_{13}&=1 \\ 2a_{21}+2a_{23}&=0 \\ a_{31}+2a_{33}&=-1 \end{aligned}$$

$$a_{21}+a_{23}=0 \qquad 4a_{21}+3a_{23}=1$$

$$a_{21}=-a_{23} \qquad a_{21}=1$$

$$a_{23}=-1$$

15. Let the shortest distance from (a,0), a>0, to the parabola $y^2=4x$ be 4. Then the equation of the circle passing through the point (a,0) and the focus of the parabola, and having its centre on the axis of the parabola is:

1) $x^2+y^2-6x+5=0$ 2) $x^2+y^2-4x+3=0$

3) $x^2+y^2-10x+9=0$ 4) $x^2+y^2-8x+7=0$

Key:1

Sol: S=(1,0)

$P(t^2,2t)$

Normal at $y+xt=2t+t^3$

Passes through (a,0)

$at=2t+t^3$

$t=0$ or $t^2=a-2$

$a=t^2+2$

$\therefore$ Given point $(t^2+2,0)$

$\sqrt{4+4t^2}=4$ (given)

$4+4t^2=16$

$t^2=3$

$\therefore$ point (5,0)

S=(1,0)

Circle is $x^2+y^2+2yx+c=0$

Passes through (5,0)& (1,0)

$25+10g+c=0$

24+10g=0

g=-3

c=5

Circle is $x^2+y^2-6x+5=0$

16. If the area of the region $\left\{(x,y):-1\le x\le 1, 0\le y\le a+e^{|x|}-e^{-x}, a>0\right\}$ is $\frac{e^2+8e+1}{e}$,then the value of a is:

1)8 2)5 3)7 4)6

Key: 2

Sol: $\left|\int_{-1}^{1}\left(a+e^{|x|}-e^{-x}\right)dx\right| = \left|\int_{-1}^{0}\left(a+e^{-x}-e^{-x}\right)dx+\int_{0}^{1}\left(a+e^{x}-e^{-x}\right)dx\right|$

$=\left|a(1)+\left(ax+e^x+e^{-x}\right)_0^1\right|$

$=\left|a+a+e+e^{-1}-2\right| = \left|2a+e+\frac{1}{e}-2\right|$

$=\left|2a+\frac{e^2-2e+1}{e}\right| = \left|\frac{e^2+8e+1}{e}\right|$

$2a=\left|\frac{-10e}{e}\right|$ $a=5$

17. The distance of the line $\frac{x-2}{2}=\frac{y-6}{3}=\frac{z-3}{4}$ from the point $(1,4,0)$ along the line $\frac{x}{1}=\frac{y-2}{2}=\frac{z+3}{3}$

1) $\sqrt{14}$ 2) $\sqrt{15}$ 3) $\sqrt{17}$ 4) $\sqrt{13}$

Key:1

Sol: $\frac{x}{1}=\frac{y-2}{2}=\frac{z+3}{3}=k$

$A(k,2k+2,3k-3)$ lies on first line

$\frac{k-2}{2}=\frac{2k-4}{3}=\frac{3k-6}{4}$

$\frac{k-2}{2}=\frac{2k-4}{3}\Rightarrow 3k-6=4k-4$

$\therefore k=2\ \therefore A=(2,6,3), B=(1,4,0)$

$AB=\sqrt{1+4+9}=\sqrt{14}$

18. Let the range of function $f(x)=6+16\cos x.\cos\left(\frac{\pi}{3}-x\right).\cos\left(\frac{\pi}{3}+x\right).\sin 3x.\cos 6x, x\in R$ be $[\alpha,\beta]$.

Then the distance of the point (α,β) from the line $3x+4y+12=0$ is:

1)8 2)11 3)9 4)10

Key: 2

Sol: $f(x)=6+4\cos 3x\sin 3x\cos 6x$

$f(x)=6+\sin 12x$

Range = [5,7]

$(\alpha,\beta)=(5,7)$

$\perp$ distance $\frac{15+28+12}{5}=11$

19. $\lim\limits_{x\to\infty}\frac{\left(2x^2-3x+5\right)(3x-1)^{\frac{x}{2}}}{\left(3x^2+5x+4\right)\sqrt{(3x+2)^x}}$ is equal to:

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

Key:4

Sol: $\lim\limits_{x\to\infty}\frac{2}{3}.\frac{(3x-1)^{x/2}}{(3x+2)^{x/2}}=\frac{2}{3}\lim\limits_{x\to\infty}\left(\frac{3x-1}{3x+2}\right)^{x/2}=\frac{2}{3}e^k$

Where k = $\lim\limits_{x\to\infty}\frac{x}{2}\left[\frac{3x-1}{3x+2}-1\right]$

$=\lim\limits_{x\to\infty}\frac{x}{2}\left[\frac{-3}{3x+2}\right]=\lim\limits_{x\to\infty}\frac{-3x}{(3x+2)2}=\frac{-1}{2}$

Limit = $\frac{2}{3}e^{-1/2}=\frac{2}{3\sqrt{e}}$

20. Let $A=\{(x,y)\in R\times R:|x+y|\geq 3\}$ $B=\{(x,y)\in R\times R:|x|+|y|\leq 3\}$. If

$C=\{(x,y)\in A\cap B: x=0 \text{ or } y=0\}$, then $\sum\limits_{(x,y)\in C}|x+y|$ is:

1) 18 2) 24 3) 12 4) 15

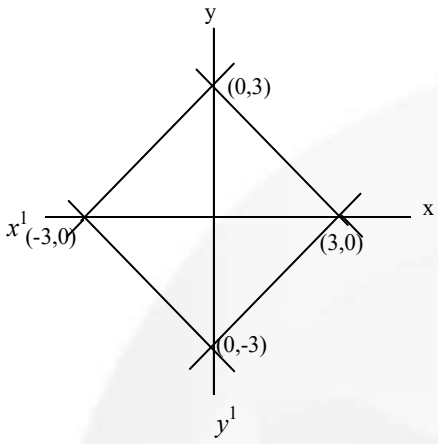
Key:3

Sol: $|x+y| \geq 3$

$-3 \leq x+y \;\; or \;\; x+y \geq 3$

$x+y+3 \geq 0 \;\; or \;\; x+y-3 \leq 0$

$|x|+|y| \leq 3$



(x, y)=(3,0),(-3,0),(0,3),(0,-3)

Required sum =12

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. The variance of the numbers 8,21,34,47,…..,320 is_____

Key: 8788

Sol: Mean $= \dfrac{8+21+34+....+320}{25} = \dfrac{25}{2}\left(\dfrac{8+320}{25}\right) = 164$

Variance $= \dfrac{8^2+4^2+....+320^2}{25} - 164 = 8788$

22. The roots of the quadratic equation $3x^2 - px + q = 0$ and 10^{th} and 11^{th} terms of an arithmetic progression with common difference $\dfrac{3}{2}$. If the sum of the first 11 terms of this arithmetic progression is 88,then q-2p is equal to_____

Key: 474

Sol: $S_{11} = \dfrac{11}{2}\left(2a+(11-1)d\right) = 88 \Rightarrow a+5d = 8$

$a = 8-5\left(\dfrac{3}{2}\right) = \dfrac{1}{2}$

$T_{10} = a+9d = \dfrac{1}{2}+9.\dfrac{3}{2} = \dfrac{1+27}{2} = 14$

$T_{11} = a+10d = \dfrac{1}{2}+10.\dfrac{3}{2} = \dfrac{31}{2}$

$S.O.R = 14 + \frac{31}{2} = \frac{p}{3}$ $P.O.R = 14.\frac{31}{2} = \frac{q}{3}$

$\frac{p}{3} = \frac{59}{2}, q = 7.31.3$ $p = \frac{59.3}{2}$ $q = 651$ q-2p=651-59 ×3=474

23. Let α, β be the roots of the equation $x^2 - ax - b = 0$ with Im(α)<Im(β).Let $p_n = \alpha^n - \beta^n$.If $p_3 = -5\sqrt{7}i, p_4 = -3\sqrt{7}i, p_5 = 11\sqrt{7}i$ *and* $p_6 = 45\sqrt{7}i$, *then* $\left|\alpha^4 + \beta^4\right|$ is equal to_____

Key: 31

Sol: $p_5 - ap_4 - bp_3 = 0$

$p_6 - ap_5 - bp_4 = 0$

$11\sqrt{7}i + a3\sqrt{7}i + b5\sqrt{7}i = 0 \Rightarrow 11 + 3a + 5b = 0$ -------(1)

$45\sqrt{7}i + 11\sqrt{7}ia + 3\sqrt{7}ib = 0 \Rightarrow 45 - 11a + 3b = 0$ ------(2)

Solving (1) ×(2), $a = 3, b = -4 \Rightarrow x^2 - 3x + 4 = 0$

$\alpha^2 + \beta^2 = 9 - 8 = 1$ $\alpha + \beta = 3$ $\alpha\beta = 4$

$\alpha^2 + \beta^4 = \left(\alpha^2 + \beta^2\right) - 2\alpha^2\beta^2 = -31$

$\left|\alpha^4 + \beta^4\right| = 31$

24. The focus of the parabola $y^2 = 4x + 16$ is the centre of the circle C of radius 5. If the values of λ, for which C passes through the point of intersection of the lines $3x - y = 0$ and $x + \lambda y = 4$,are λ_1 and $\lambda_2, \lambda_1 < \lambda_2$,then $12\lambda_1 + 29\lambda_2$ is equal to____

Key:15

Sol: Focus $S(-3,0)$

Center C=$(-3,0)$, radius =5

P.O.I=P= $\left[\frac{4}{1+3\lambda}, \frac{12}{1+3\lambda}\right]$, $cp = 5$

$\sqrt{\left(\frac{4}{1+3\lambda} + 3\right)^2 + \left(\frac{12}{1=3\lambda}\right)^2} = 5$

$\lambda_1 = \frac{-7}{6}$ $\lambda_2 = 1$ $12\lambda_1 + 29\lambda_2 = -14 + 29 = 15$

25. The number of ways, 5 boys and 4 girls can sit in a row so that either all the boys sit together or no two boys sit together, is _____

Key: 17280

Sol: All the boys together =5! .5!

No boys sit together= 4!.5!

Sum =5!.5!+ 4!.5!=17280

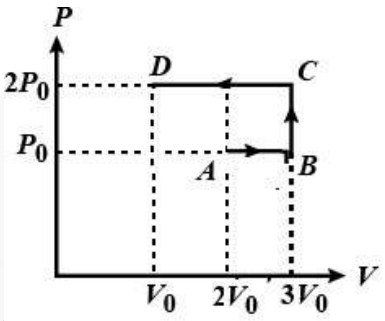
PHYSICS

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. Using the given P-V diagram, the work done by an ideal gas along the path ABCD is



1) $3P_0V_0$ 2) $-4P_0V_0$ 3) $-3P_0V_0$ 4) $4P_0V_0$

Key: 3

Sol: $W = P-V$ diagram area under graph

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

$W = P_0(3V_0 - 2V_0) + 0 + 2P_0(V_0 - 3V_0)$

$= P_0V_0 - 4P_0V_0 = -3P_0V_0$

27. Two charges $7\mu c$ and $-4\mu c$ are placed at (-7cm,0,0) and (7cm,0,0) respectively. Given, $\in_0 = 8.85\times10^{-12} C^2N^{-1}m^{-2}$, the electrostatic potential energy of the charge configuration is

1) -1.2J 2) -1.8J 3) -1.5J 4) -2.0J

Key: 2

Sol: $U = \dfrac{1}{4\pi\in_0}\dfrac{q_1q_2}{r_{12}}$

$= 9\times10^9 \dfrac{\left(7\times10^{-6}\right)\left(-4\times10^{-6}\right)}{[7-(-7)]\times10^{-2}}$

$= 9\times10^9\times10^{-12}\left(\dfrac{-28}{14}\right)\times10^2$

$= -1.8J$

28. Match List –I with List-II

List –I	List-II
(A) Permeability of free space	(I) $[ML^2T^{-2}]$
(B) Magnetic filed	(II) $[MT^{-2}A^{-1}]$
(C) Magnetic moment	(III) $[MLT^{-2}A^{-2}]$

(D) Torsional constant (IV) $[L^2A]$

Choose the correct answer from the options given below

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

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

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

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

Key: 2

Sol: A) Permeability of free space = $[MLT^{-2}A^{-2}]$

B) Magnetic field = $[MT^{-2}A^{-1}]$

C) Magnetic moment = $[L^2A]$

D) Torsional constant = $[ML^2T^{-2}]$

29. Water flows in a horizontal pipe whose one end is closed with a valve. The reading of the pressure gauge attached to the pipe is P_1. The reading of the pressure gauge falls to P_2 when the valve is opened. The speed of water flowing in the pipe is proportional to

1) $P_1 - P_2$ 2) $\sqrt{P_1 - P_2}$ 3) $(P_1 - P_2)^2$ 4) $(P_1 - P_2)^4$

Key: 2

Sol: $P + \rho gh + \frac{1}{2}\rho v^2 = \text{constant}$

$P_1 = P_2 + \frac{1}{2}\rho v^2$ $P_1 - P_2 = \frac{1}{2}\rho v^2$ $\therefore v\alpha\sqrt{P_1 - P_2}$

30. A galvanometer having a coil of resistance 30Ω need $20mA$ of current for full-scale defection. If a maximum current of $3A$ is to be measured using this galvanometer, the resistance of the shunt to be added to the galvanometer should be $\frac{30}{X}\Omega$, where X is

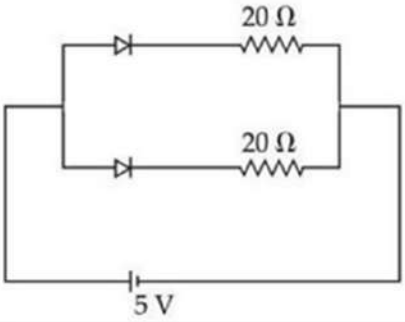
1) 298 2) 596 3) 447 4) 149

Key : 4

Sol: $S = \frac{G}{\frac{i}{ig} - 1}$

$$\frac{30}{X}=\frac{30}{\left(\frac{3}{20\times10^{-3}}-1\right)} \qquad x=\frac{3}{20\times10^{-3}}-1 \qquad x=\frac{300}{2}-1=149$$

31. What is the current through the battery in the circuit shown below?



1) 1.0A 2) 0.5A 3) 1.5A 4) 0.25A

Key: 2

Sol: $R_{eq}=\frac{R_1R_2}{R_1+R_2}$

$=\frac{20\times20}{20+20}=10\ \Omega$

$V=iR$

$i=\frac{V}{R}=\frac{5}{10}=0.5A$

32. A concave mirror of focal length f in air is dipped in a liquid of reflective index μ. Its focal length in the liquid will be

1. μf 2. f 3. $\frac{\mu}{f}$ 4. $\frac{f}{(\mu-1)}$

Key: 2

Sol : Since refraction does not take place in case reflecting surfaces as in case of curved mirrors and plane mirrors

33. The refractive index of the material of a glass prism is $\sqrt{3}$. The angle of minimum deviation is equal to the angle of the prism. What is the angle of the prism?

1) 60^0 2) 48^0 3) 58^0 4) 50^0

Key : 1

Sol: $\mu = \dfrac{\sin\left(\dfrac{A+\delta_m}{2}\right)}{\sin\left(\dfrac{A}{2}\right)}$ $\therefore \delta_m = A$ as given data

$$\sqrt{3} = \frac{\sin\left(\frac{A+A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$\sqrt{3} = \frac{\sin A}{\sin\frac{A}{2}}$$

$$\sqrt{3} = \frac{2\sin\frac{A}{2}\cos\frac{A}{2}}{\sin\frac{A}{2}}$$

$$\sqrt{3} = \cos\frac{A}{2}, \qquad \cos 30^0 = \cos\frac{A}{2}$$

$$\frac{A}{2} = 30^0 \Rightarrow A = 60^0$$

34. The width of one of the two slits in Young's double slit experiment is d while that of the other slit is xd. If the ratio of the maximum to the minimum intensity in the interference pattern on the screen is 9:4 then what t is the value of x?
(Assume that the filed strength varies according to the slit width)
1) 2 2) 5 3) 4 4) 3

Key : 2

Sol : $\dfrac{I_{max}}{I_{mix}} = \left(\dfrac{I_1 + I_2}{I_1 - I_2}\right)^2$ $(\therefore I \alpha w)$

$$\frac{9}{4} = \left(\frac{xd+d}{xd-d}\right)^2$$

$$\frac{3}{2} = \frac{d(x+1)}{d(x-1)}$$

$$\therefore 3x - 3 = 2x + 2$$

$$x = 5$$

35. A plane electromagnetic wave of frequency 20 MHz travels in free space along the +x direction. At a particular point in space and time, the electric filed vector of the wave is $E_y = 9.3 Vm^{-1}$. Then, the magnetic field vector of the wave at that point is

1) $B_z = 3.1\times10^{-8}T$ 2) $B_z = 9.3\times10^{-8}T$

3) $B_z = 1.55\times10^{-8}T$ 4) $B_z = 6.2\times10^{-8}T$

Key : 1

Sol : $E_0 = B_0 C$

$$B_0 = \frac{E_0}{C} = \frac{9.3}{3\times10^8} = 3.1\times10^{-8}T$$

36. A ball having kinetic energy KE is projected at an angle of 60^0 from the horizontal. What will be the kinetic energy of ball at the highest point of its flight?

1) $\frac{(KE)}{4}$ 2) $\frac{(KE)}{2}$ 3) $\frac{(KE)}{16}$ 4) $\frac{(KE)}{8}$

Key : 1

Sol : $KE = \frac{1}{2}mv^2$

$$KE' = \frac{1}{2}mv_x{}^2 = \frac{1}{2}mv^2\cos^2\theta$$

$$= KE\times\cos^2 60^0$$

$$KE' = \frac{KE}{4}$$

37. The energy of a system is given as $E(t) = \alpha^3 e^{-\beta t}$, where t is the time and $\beta = 0.3 s^{-1}$. The errors in the measurement of α and t are 1.2 % and 1.6 %, respectively. At t=5s, maximum percentage error in the energy is

1) 11.6% 2) 8.4 % 3) 4% 4) 6%

Key : 4

Sol : $\frac{\Delta E}{E} = 3\left(\frac{\Delta\alpha}{\alpha}\right) + \beta\left(\frac{\Delta t}{t}\right)t$

$= 3(1.2\%) + 0.3\times1.6\%\times5 \quad = 5.85\% \simeq 6\%$

38. The equation of a transverse wave travelling along a string is $y(x,t) = 4.0\sin[20\times10^{-3}x + 600t]mm$, where x is in mm and t is in second. The velocity of the wave is:

1) -60 m/s 2) +60m/s 3) -30m/s 4) +30 m/s

Key: 3

Sol: $V = -\frac{\omega}{k} = -\frac{600\times10^{-3}}{20\times10^{-3}}$

$V = -30m/s$

39. If a satellite orbiting the Earth is 9 times closer to the Earth than the Moon, what is the time period of rotation of the satellite? Given rotational time period of Moon =27 days and gravitational attraction between in satellite and the moon in neglected

1) 1 day 2) 81 days 3) 3 days 4) 27 days

Key: 1

Sol: $T\alpha R^{\frac{3}{2}}$ $\frac{T_1}{T_2} = \left(\frac{R_1}{R_2}\right)^{\frac{3}{2}}$

$\frac{T_m}{T_S} = \left(\frac{R}{R/9}\right)^{\frac{3}{2}}$ $\frac{T_m}{T_S} = (3)^3$

$T_1 = 1\,\text{day}$

40. A circular disk of radius R meter and mass M kg is rotating around the axis perpendicular to the disk. An external torque is applied to the disk such that $\theta(t) = 5t^2 - 8t$, where $\theta(t)$ is the angular position of the rotating disc as a function of time t.

How much power s delivered by the applied torque, where t= 2s?

1) 108 MR^2 2) 72 MR^2 3) 60 MR^2 4) 8 MR^2

Key : 3

Sol : $\omega = 10t - 8 = 10(2) - 8 = 12rad/s$ $\alpha = 10rad/s^2$

$\tau = I\alpha = \frac{MR^2}{2}\times10 = 5MR^2$

$P = \tau.\omega = 5MR^2(12)$ $P = 60MR^2$

41. Water of mass m gram is slowly heated to increase the temperature form T_1 to T_2. The change in entropy of the water, given specific heat of water is $1 Jkg^{-1}K^{-1}$, is :

1) $m(T_2 - T_1)$ 2) zero 3) $m\ln\left(\frac{T_2}{T_1}\right)$ 4) $m\ln\left(\frac{T_1}{T_2}\right)$

Key: 3

Sol: $\Delta S = \frac{\Delta Q}{T} = ms\frac{dT}{T} = m\frac{dT}{T} \quad (\because S = 1) \quad ds = \int_{T_1}^{T_2} m\frac{dT}{T} = m\ln\left(\frac{T_2}{T_1}\right)$

42. Two point charge $-4\mu c$ and $4\mu c$, constituting an electric dipole , are placed at (-9,0,0) cm and (9,0,0) cm in a uniform electric field of strength $10^4 NC^{-1}$. The work done on the dipole in rotating it form the equilibrium through 180^0 is

1) 14.4 mJ 2) 16.4mJ 3) 12.4 mJ 4) 18.4 mJ

Key : 1

Sol :

$P = 2l \times q = 18 \times 10^{-2} \times 4 \times 10^{-6}$

$E = 10^4$

$W = -PE(\cos\theta_2 - \cos\theta_1)$

$= -18 \times 10^{-2} \times 4 \times 10^{-6} \times 10^4 (-1-1) = 14.4mJ$

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

Assertion (A): The binding energy per nucleon is found to be practically independent of the atomic number A, for nuclei with mass numbers between 30 and 170

Reason (R): Nuclear force is along range

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

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

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

3. Both (A) and (R) are true (R) is NOT the correct explanation of (A)

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

Key : 1

Sol : Binding energy per nucleon is almost same for nuclei of mass number ranging 30 to 170.

44. In photoelectric effect an Em-wave is incident on a metal surface and electrons are ejected from the surface. If the work function of the metal is 2.14 eV and stopping potential is 2V, what is the wavelength of the Em-wave?

(Given $hc = 1242$ eVnm where h is the Planck's constant and c is the speed of light in vaccum)

1) 600nm 2) 400nm 3) 200nm 4) 300nm

Key : 4

Sol :

$$KE = \frac{hc}{\lambda} - \phi$$

$$eV_0 = \frac{hc}{\lambda} - \phi$$

$$1.6\times10^{-19}\times2 = \frac{1242\times1.6\times10^{-19}\times10^{-9}}{\lambda} - 2.14\times1.6\times10^{-19}$$

$$2 = \frac{1242}{\lambda}\times10^{-9} - 2.14$$

$$\lambda = \frac{1242}{4.14}nm = 300nm$$

45. A massless spring gets elongated by amount x_1 under a tension of 5N. Its elongation is x_2 under the tension of 7N. For the elongated of $(5x_1 - 2x_2)$, the tension in the spring will be

1) 20N 2) 15 N 3) 39 N 4) 11 N

Key : 4

Sol:

$$F \alpha x$$

$$F = Kx$$

$$5 = Kx_1$$

$$7 = Kx_2$$

$$T = K\left(5x_1 - 2x_2\right)$$

$$T = 5Kx_1 - 2Kx_2$$

$$T = 5\times5 - 2\times7$$

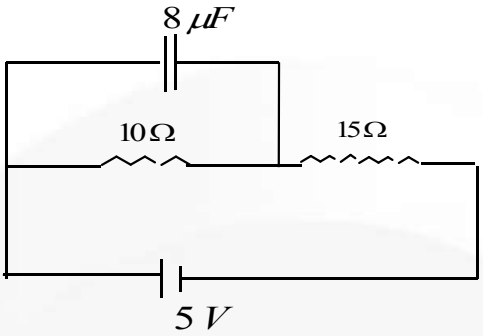
$$T = 11N$$

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. At steady sate the charge on the capacitor, as shown in the circuit below is _____ μC



Key: 16

Sol: In steady state the capacitor is open

$R = R_1 + R_2 = 10 + 15 = 25\Omega$

$i = \frac{V}{R} = \frac{5}{25} = 0.2A$

The potential difference across 10Ω resistor is V= iR=0.02x10=2V

The charge on capacitor Q=CV $Q = 8 \times 10^{-6} \times 2 = 16\mu C$

47. An air bubbled of radius 1.0 mm is observed at a depth of 20 cm below the free surface of a liquid having surface tension 0.095 J/m^2 and density $10^3 kg/m^3$. The difference between pressure inside the bubble and atmospheric pressure is _____ N/m^2 (Take g = 10 m/s^2)

Key: 2190

Sol: $R = 1mm = 10^{-3} m$, $h = 20cm = 20 \times 10^{-2} m$

$T = 0.095 J/m^2$

$\rho = 10^3 kg/m^3$

$p - p_0 = \frac{2T}{R} + \rho gh$

$p - p_0 = 10^3 \times 10 \times 20 \times 10^{-2} + \frac{2 \times 95 \times 10^{-3}}{10^{-3}}$

$p - p_0 = 2 \times 10^3 + 190 = 2190 pa$

48. A time varying potential difference is applied between the plates of a parallel plate capacitor of capacitance 2.5 μF. The dielectric constant of the medium between the capacitor plates is 1. It produces an instantaneous displacement current of 0.25 mA in the intervening space between the capacitor plates, the magnitude of the rate of change of the potential difference will be _____ Vs^{-1}

Key: 100V

Sol: $c = 2.5\mu F, k = 1, i_d = 0.25mA \quad \frac{dv}{dt} = ?$

$$i_d = c\frac{dv}{dt} \Rightarrow 0.25\times10^{-3} = 2.5\times10^{-6}\times\frac{dv}{dt}$$

$$25\times10^{-5} = 25\times10^{-7}\times\frac{dv}{dt}$$

$$\frac{dv}{dt} = 100V$$

49. A satellite of mass $\frac{M}{2}$ is revolving around earth in a circular orbit at a height of $\frac{R}{2}$ from earth surface. The angular momentum of the satellite is $M\sqrt{\frac{GMR}{x}}$. The value of x is ___ where M and R are the mass and radius of earth , respectively.

(G is the gravitational constant)

Key: 3

Sol: Angular moment of revolving satellite around earth is

$$L = m\sqrt{GM(R+h)}, L = \frac{M}{2}\sqrt{GM\left(R+\frac{R}{3}\right)},$$

$$L = \frac{M}{2}\sqrt{GM\left(\frac{4R}{3}\right)}, L = M\sqrt{\frac{GM}{4}\left(\frac{4R}{3}\right)}, L = M\sqrt{\frac{GMR}{3}}$$

50. In a series LCR circuit , a resistor of 300Ω, a capacitor of 25 nF and an inductor of 100 mH are used. For maximum current in the circuit, the angular frequency of the ac source is _____ $\times10^4$ radians s^{-1}.

Key: 2

Sol: For maximum current in LCR circuit minimum impedance (i.e Resonance condition)

$$X_L = X_C$$

$$\omega L = \frac{1}{\omega C}$$

$$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{100\times10^{-3}\times25\times10^{-9}}}$$

$$\omega = \frac{1}{\sqrt{2500\times10^{-12}}} = \frac{1}{50\times10^{-6}} = \frac{100}{50}\times10^4$$

$$\omega = 2\times10^4 rad/s$$

CHEMISTRY **Max Marks: 100**

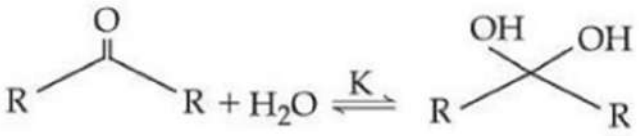
SECTION-I (SINGLE CORRECT ANSWER TYPE)

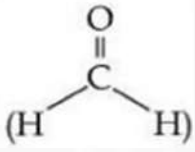
This section contains **20 Multiple Choice Questions.** Each question has 4 options (1), (2), (3) and (4) for its answer, out of which ONLY ONE option can be correct.

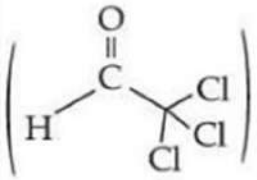
Marking scheme: +4 for correct answer, 0 if not attempted and –1 in all other cases.

51. Given below are two statements:

Consider the following reaction



Statement (I) : In the case of formaldehyde  , K is about 2280, due to small substituents, hydration is faster

Statement (II) : In the case of trichloro acetaldehyde  , K is about 2000 due to – I effect of - Cl.

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)Both Statement I and Statement II are true

3)Statement I is false but Statement II is true

4)Statement I is true but Statement II is false

Key: (2)

Sol: Statement-1 : Formaldehyde reacts with water so readily because its substitutents are very small – a stericfactor

Statement-2 : Electronegative atoms such as halogens attached to the carbon atom next to the carbonyl group can increase the extent of hydration by the – I.E. – Electronic effect.

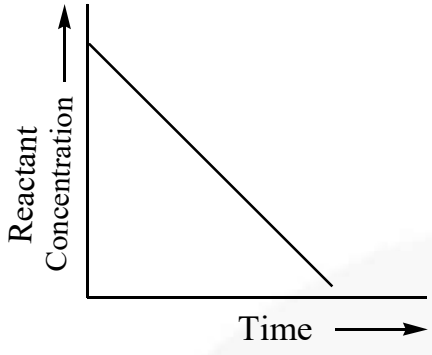
Chloral is completely hydrated in water, & product is chloral hydrate.

Steric factor and electronic effects are the two main factors dominating the reactivity of nucleophiles

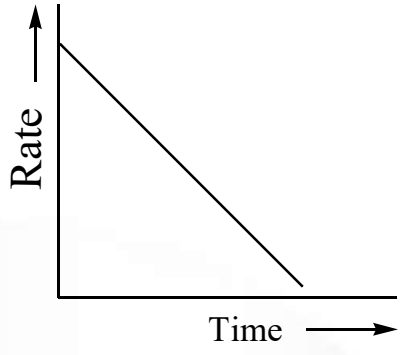
Formaldehyde K – 2280

Chloral K – 2000 (Factual data from Clayden)

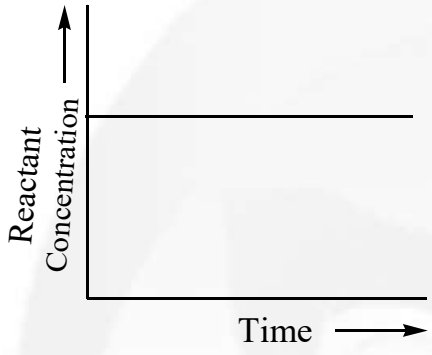
52. Which of the following graphs most appropriately represents a zero order reaction?



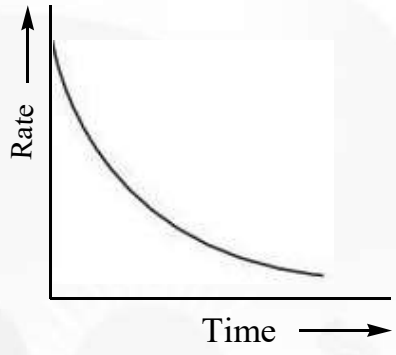
1)



2)



3)



4)

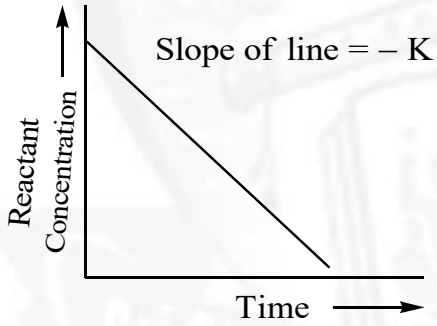
Key: (1)

Sol: Any reaction of zero order must obey equation $[A]_t = [A]_0 - Kt$

This shows that the concentration of reactant decreases linearly with time

The plot of [A] versus t will be straight line with slope = - K

and intercept on the concentration axis = $[A]_0$



53. Given below are the atomic numbers of some group 14 elements. The atomic number of the element with lowest melting point is:

1) 82 2) 14 3) 6 4) 50

Key: (4)

Sol:

	C	Si	Ge	Sn	Pb
At.No.	6	14	32	50	82
Melting point (K)	4373	1693	1218	505	600

Order of Melting point: C > Si > Ge > Pb > Sn

$\therefore$ Atomic Number of element = 50

54. Consider a binary solution of two volatile liquid components 1 and 2. x_1 and y_1 are the mole fractions of component 1 in liquid and vapour phase, respectively. The slope and intercept of the linear plot of $\frac{1}{x_1}$ vs $\frac{1}{y_1}$ are given respectively as:

1) $\frac{P_2^0}{P_1^0}, \frac{P_2^0 - P_1^0}{P_2^0}$ 2) $\frac{P_1^0}{P_2^0}, \frac{P_2^0 - P_1^0}{P_2^0}$ 3) $\frac{P_1^0}{P_2^0}, \frac{P_1^0 - P_2^0}{P_2^0}$ 4) $\frac{P_2^0}{P_1^0}, \frac{P_1^0 - P_2^0}{P_2^0}$

Key: (2)

Sol: $P_1 = P_1^0 x_1$ liquid phase

$P_1 = P_T^0 y_1$ Vapour phase $\therefore P_T y_1 = P_1^0 x_1$ $\frac{P_T}{x_1} = \frac{P_1^0}{y_1}$

$P_T = P_1^0 x_1 + P_2^0 x_2 \Rightarrow P_1^0 x_1 + P_2^0 (1 - x_1) \Rightarrow P_1^0 x_1 + P_2^0 - P_2^0 x_1$

$P_T = P_2^0 + x_1 (P_1^0 - P_2^0)$ $\frac{P_2^0 + x_1 (P_1^0 - P_2^0)}{x_1} = \frac{P_1^0}{y_1}$ $\frac{P_2^0}{x_1} + \frac{x_1 (P_1^0 - P_2^0)}{x_1} = \frac{P_1^0}{y_1}$

dividing all terms with P_2^0

$\frac{P_2^0}{x_1} \times \frac{1}{P_2^0} + \frac{x_1 (P_1^0 - P_2^0)}{x_1 \times P_2^0} = \frac{P_1^0}{y_1 \times P_2^0}$

$\frac{1}{x_1} + \frac{P_1^0 - P_2^0}{P_2^0} = \frac{P_1^0}{P_2^0} \times \frac{1}{y_1}$, $\frac{1}{x_1} = \frac{P_1^0}{P_2^0} \times \frac{1}{y_1} + \frac{P_2^0 - P_1^0}{P_2^0}$

Slope $= \frac{P_1^0}{P_2^0}$, Intercept $= \frac{P_2^0 - P_1^0}{P_2^0}$

55. Consider the reaction $X_2Y(g) \rightleftharpoons X_2(g) + \frac{1}{2} Y_2(g)$

The equation representing correct relationship between the degree of dissociation (x) of $X_2Y(g)$ with its equilibrium constant Kp is _____

Assume x to be very very small.

1) $x = \sqrt[3]{\frac{2Kp^2}{p}}$ 2) $x = \sqrt[3]{\frac{Kp}{2p}}$ 3) $x = \sqrt[3]{\frac{2Kp}{p}}$ 4) $x = \sqrt[3]{\frac{Kp}{p}}$

Key: (1)

Sol:

	$x_2 y$	$\rightleftharpoons x_2$	$+ \frac{1}{2} y_2$
Initial	1	0	0
Dissociated	α	α	$\frac{\alpha}{2}$
Left	$1 - \alpha$	$\rightleftharpoons \alpha$	$\frac{\alpha}{2}$

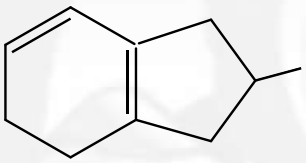
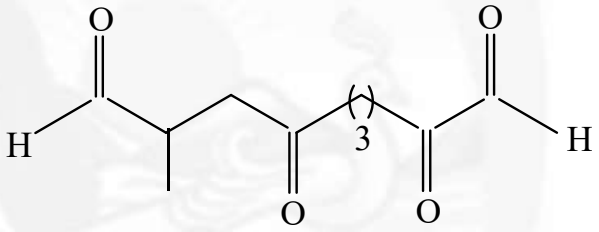
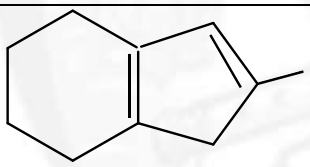
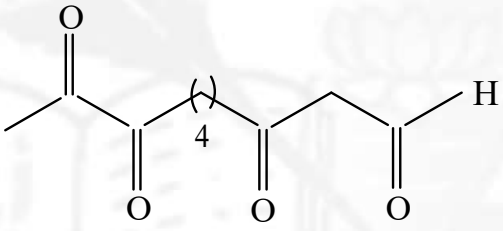
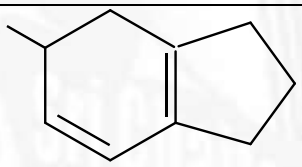
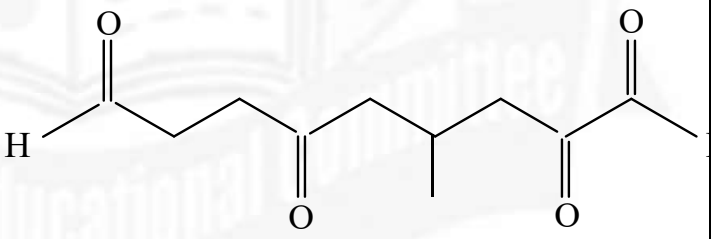
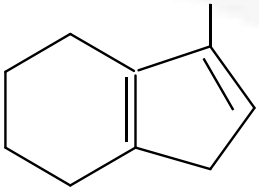
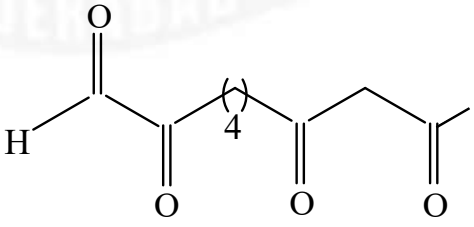
Total moles $= \left(1 + \frac{\alpha}{2}\right)$

$$P_{x_2y} = P \times \frac{1-\alpha}{1+\frac{\alpha}{2}} \quad ; \quad P_{x_2} = \frac{P \times \alpha}{1+\frac{\alpha}{2}}; \quad P_{y_2} = \frac{P \times \frac{\alpha}{2}}{1+\frac{\alpha}{2}};$$

$$K_P = \frac{P_{x_2} \times P_{y_2}^{1/2}}{P_{x_2y}} = = \frac{\frac{P \times \alpha}{1+\frac{\alpha}{2}} \times \left(\frac{P \times \frac{\alpha}{2}}{1+\frac{\alpha}{2}}\right)^{1/2}}{P \times \frac{1-\alpha}{1+\frac{\alpha}{2}}} = \frac{\left(\frac{\alpha}{1+\frac{\alpha}{2}}\right)\frac{\left(\frac{\alpha}{2}\right)^{1/2} \times P^{1/2}}{\left(1+\frac{\alpha}{2}\right)^{1/2}}}{\frac{1-\alpha}{1+\frac{\alpha}{2}}} = \frac{\alpha}{1+\frac{\alpha}{2}} \times \frac{\alpha^{1/2}}{2^{1/2}} \times P^{1/2}$$

$$K_P = \frac{\alpha^{3/2}}{2^{1/2}} \times P^{1/2} \Rightarrow \alpha^{3/2} = \frac{K_P \times 2^{1/2}}{P^{1/2}} \Rightarrow \alpha^3 = \frac{K_P{}^2 \times 2}{P} \Rightarrow \alpha = \left(\frac{K_P^2 \times 2}{P}\right)^{1/3} \quad \alpha = \sqrt[3]{\frac{2Kp^2}{p}}$$

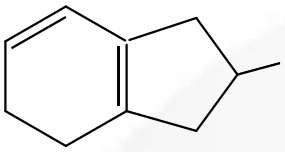
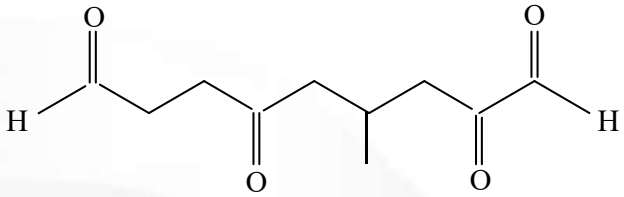
56. Match List-I with List-II.

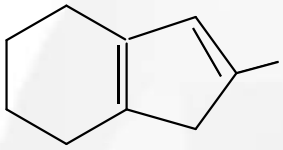
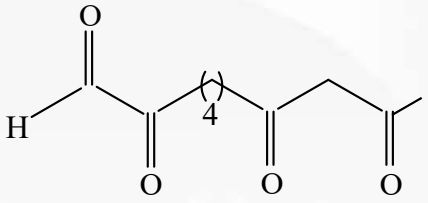
List – I (Isomers of $C_{10}H_{14}$)	List – II (Ozonolysis of product)
(A) 	(I) 
(B) 	(II) 
(C) 	(III) 
(D) 	(IV) 

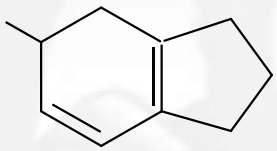
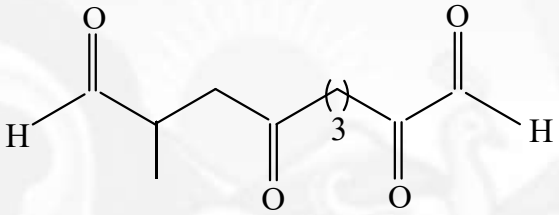
Choose the correct answer from the options given below:

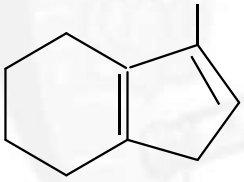
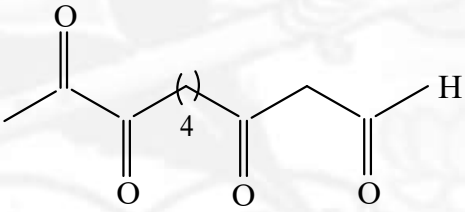
1) $(A)-(III),(B)-(II),(C)-(I),(D)-(IV)$
2) $(A)-(III),(B)-(IV),(C)-(I),(D)-(II)$
3) $(A)-(II),(B)-(III),(C)-(I),(D)-(IV)$
4) $(A)-(I),(B)-(IV),(C)-(III),(D)-(II)$

Key: (2)

Sol: (A) -  $\rightarrow$ (III) - 

(B) -  $\rightarrow$ (IV) - 

(C) -  $\rightarrow$ (I) - 

(D) -  $\rightarrow$ (II) - 

57. Given below are two statements:

Statement (I) : For a given shell, the total number of allowed orbitals is given by n^2

Statement (II) : For any subshell, the spatial orientation of the orbitals is given by $-l$ to $+l$ values including zero.

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

Key: (3)

Sol: Statement I : Total number of orbitals present in a shell is n^2 is true

Example for L shell $n=2=2^2=4$ orbitals

Statement II : The value of m for a particular value of l varies from $-l$ to $+l$ values including zero.

$n=1, m=+1,0,-1,\ P_x, P_y, P_z$ $\therefore$ Both Statement I and Statement II are true

58. Given below are two statements:

Statement (I) : The boiling points of alcohols and phenols increase with increase in the number of C-atoms.

Statement (II) : The boiling points of alcohols and phenols are higher in comparison to other class of compounds such as ethers, haloalkanes.

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

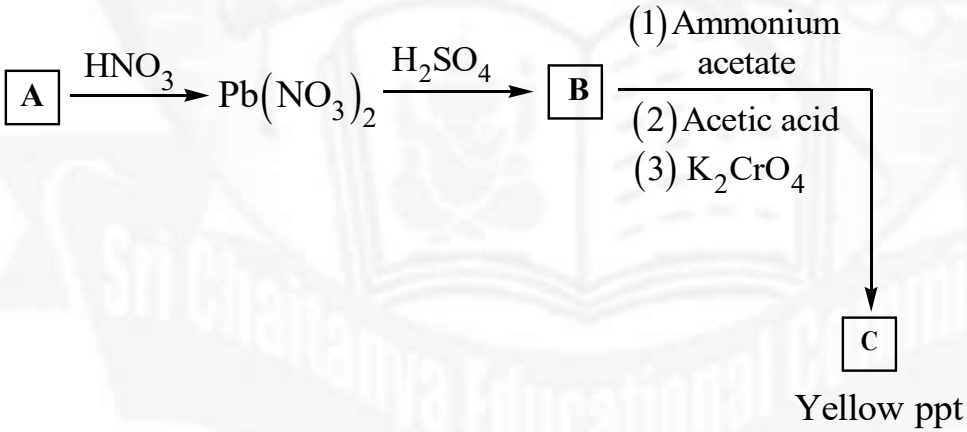
4) Statement I is true but Statement II is false

Key: (3)

Sol: Statement-I : The boiling points of alcohols and phenols increases with increase in the number of carbon atoms (Increased in Vanderwaals forces)

Statement-II : The high boiling points of alcohols and phenols are higher in comparison to other class of compounds such as ethers, haloalkanes, due to presence of intermolecular hydrogen bonding in them which is lacking in ethers & Hydrocarbons

59. Identify A, B and C in the given below reaction sequence



1) $PbCl_2, Pb(SO_4)_2, PbCrO_4$ 2) $PbCl_2, PbSO_4, PbCrO_4$

3) $PbS, PbSO_4, Pb(CH_3COO)_2$ 4) $PbS, PbSO_4, PbCrO_4$

Key: (4)

Sol: $PbS + HNO_3 \rightarrow Pb(NO_3)_2 + NO + S + H_2O$

(A)

$Pb(NO_3)_2 + H_2SO_4 \rightarrow PbSO_4 \downarrow +2HNO_3$

(B)

$PbSO_4 + 2CH_3COONH_4 \xrightarrow{CH_3COOH} (CH_3COO)_2\, pb + (NH_4)_2\, SO_4$

Ammonium acetate

$\downarrow K_2Cr_2O_7$

$2PbCrO_4 + 2CH_3COOK + 2CH_3COOH$

(lead chromate)

C

60. Consider the following reactions

$$K_2Cr_2O_7 \xrightarrow[-H_2O]{KOH} [A] \xrightarrow[-H_2O]{H_2SO_4} [B] + K_2SO_4$$

The products [A] and [B], respectively are :

1) K_2CrO_4 and $K_2Cr_2O_7$ 2) K_2CrO_4 and CrO

3) K_2CrO_4 and Cr_2O_3 4) $K_2Cr(OH)_6$ and Cr_2O_3

Key: (1)

Sol: $K_2Cr_2O_7 \xrightarrow[-H_2O]{KOH} A$

$K_2Cr_2O_7 + 2KOH \rightarrow 2K_2CrO_4$ (A) $+ H_2O$

Potassium chromate

$K_2CrO_4 + H_2SO_4 \rightarrow K_2Cr_2O_7$ (B) $+ K_2SO_4 + H_2O$

Potassium dichromate

61. The $\alpha-$ Helix and $\beta-$Pleated sheet structures of protein are associated with its:

1) primary structure 2) secondary structure

3) quaternary structure 4) tertiary structure

Key: (2)

Sol: $\alpha-$ Helix and $\beta-$ pleated sheet structures of protein are associated with secondary structure

62. pH of water is 7 at 25^0C. If water is heated to 80^0C., it's pH will:

1) Remains the same 2) Increase 3) Decrease

4) H^+ concentration increases, OH^- concentration decreases

Key: (3)

Sol: At 25^0C $K_W = 10^{-14}M^2$

$$\left[H^+\right] = \left[OH^-\right] = 10^{-7}\,M$$

$$P^H = -\log\left(10^{-7}\right) = 7$$

As the temperature increases, K_W increases $\left[H^+\right]$ concentration increases,

P^H decreases

63. When a non-volatile solute is added to the solvent, the vapour pressure of the solvent decreases by 10 mm Hg. The mole fraction of the solute in the solution is 0.2. What would be the mole fraction of the solvent if decrease in vapour pressure is 20 mm of Hg?

1) 0.4 2) 0.6 3) 0.8 4) 0.2

Key: (2)

Sol:

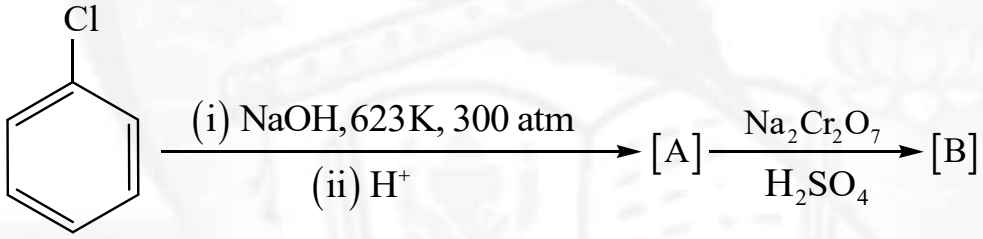
$$\frac{P^0 - P}{P^0} = X_{Solute} \quad \text{Given } P^0 - P = 10 \text{ mm of Hg}$$

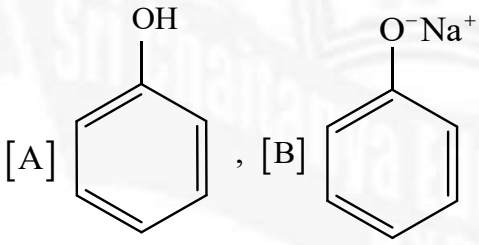
$$X_{Solute} = 0.2 \qquad \frac{10}{P^0} = 0.2 \qquad \therefore P^0 = 50$$

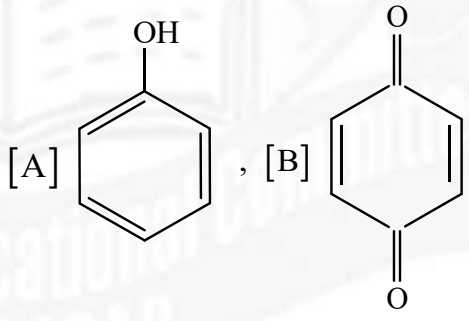
decrease in V.P. = 20 mm of Hg, $P^0 = 50$ $\therefore \frac{20}{50} = X_{solute}$

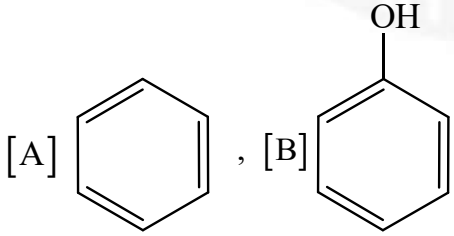
$$X_{solute} = 0.4 \qquad X_{solvent} = 1 - 0.4 = 0.6$$

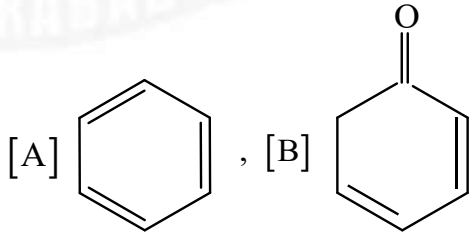
64. Identify the products [A] and [B], respectively in the following reaction:



1) 

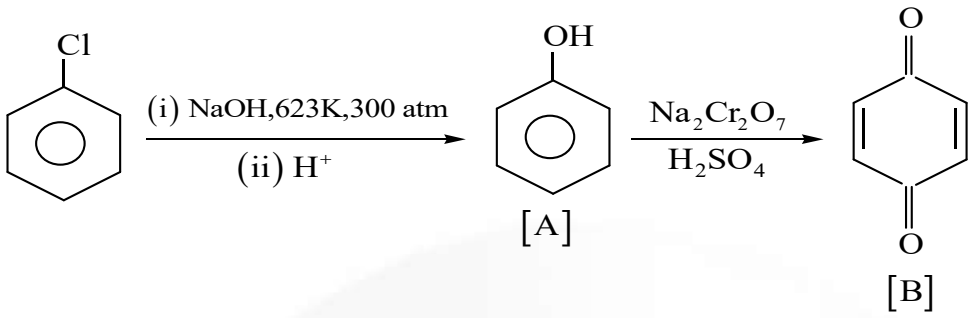
2) 

3) 

4) 

Key: (2)

Sol:



65. Identify the coordination complexes in which the central metal ion has d^4 configuration.

(A) $\left[FeO_4\right]^{2-}$ (B) $\left[Mn(CN)_6\right]^{3-}$ (C) $\left[Fe(CN)_6\right]^{3-}$

(D) $Cr_2\left(O-\overset{\overset{O}{\|}}{C}-Me\right)_4\left(H_2O\right)_2$ (E) $\left[NiF_6\right]^{2-}$

Choose the correct answer from the options given below

1) (B), (C) and (D) only 2) (B) and (D) only

3) (A), (B) and (E) only 4) (C) and (E) only

Key: (2)

Sol: (A) $\left[FeO_4\right]^{-2}$ $x+4(-2)=-2;\ x=-2+8=+6$ $Fe^{+6}-3d^2$

(B) $\left[Mn(CN)_6\right]^{3-}$ $x+6(-1)=-3;\ x=+3$ $Mn^{+3}-3d^4$

(C) $\left[Fe(CN)_6\right]^{3-}$ $x+6(-1)=-3;\ x=+3$ $Fe^{+3}-3d^5$

(D) $Cr_2\left(O-C-Me\right)_4\left(H_2O\right)_2$ $2x+4(-1)+2(0)=0;\ x=+2;$ $Cr^{+2}-3d^4$

(E) $\left[NiF_6\right]^{-2}$ $x+6(-1)=-2;\ x=+4$ $Ni^{+4}-3d^6$

66. Standard electrode potentials for a few half cells are mentioned below:

$E^0_{Cu^{2+}/Cu}=0.34\,V, E^0_{Zn^{2+}/Zn}=-0.76\ V$

$E^0_{Ag^{+}/Ag}=0.80\,V, E^0_{Mg^{2+}/Mg}=-2.37\ V$

Which one of the following cells gives the most negative value of ΔG^0?

1) $Cu\left|Cu^{2+}(1M)\right|\left|Ag^{+}(1M)\right|Ag$ 2) $Ag\left|Ag^{+}(1M)\right|\left|Mg^{2+}(1M)\right|Mg$

3) $Zn\left|Zn^{2+}(1M)\right|\left|Ag^{+}(1M)\right|Ag$ 4) $Zn\left|Zn^{2+}(1M)\right|\left|Mg^{2+}(1M)\right|Mg$

Key: (3)

Sol: $\Delta G^0=-nFE^0_{cell}$

If E^0_{cell} is maximum, ΔG^0 value becomes most negative

1) $E^0_{cell}=E^0_{cathode}-E^0_{anode}=0.8\text{-}0.34=0.46\ V$

2) $E^0_{cell}=-2.37-(0.8)=-3.17\,V$

3) $E^0_{cell}=E^0_{Ag^{+}/Ag}-E^0_{Zn^{+2}/Zn}=0.8-(-0.76)=1.56\ V$

4) $E^0_{cell}=E^0_{Mg^{+3}/Mg^{-}}-E^0_{Zn^{+2}/Zn}=-2.37-(-0.76)=-1.61\ V$

67. The effect of temperature on spontaneity of reactions are represented as:

	ΔH	ΔS	Temperature	Spontaneity
(A)	+	–	any T	Non spontaneous
(B)	+	+	low T	Spontaneous
(C)	–	–	low T	Non spontaneous
(D)	–	+	any T	Spontaneous

The incorrect combinations are:

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

Key: (4)

Sol: $\Delta G = \Delta H - T\Delta S$

If $\Delta G = -Ve$ Spontaneous

If $\Delta G = +Ve$ Non-Spontaneous

(A) $\Delta G = +Ve$ Non-Spontaneous

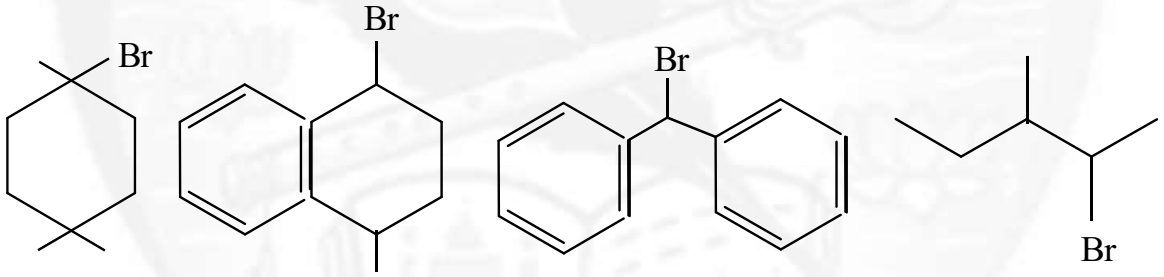
(B) $\Delta G = +Ve$ Non-Spontaneous

(C) $\Delta G = -Ve$ Spontaneous

(D) $\Delta G = -Ve$ Spontaneous

$\therefore$ B & C are incorrect

68. The ascending order of relative rate of solvolysis of following compounds is:

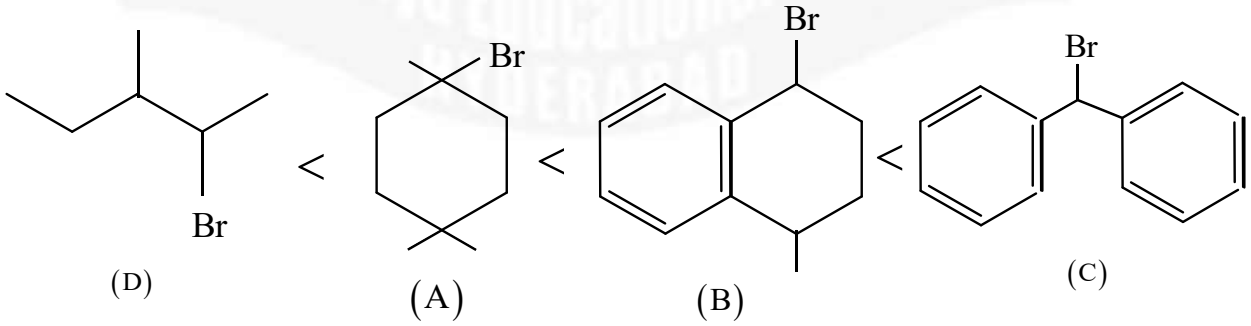


(A) (B) (C) (D)

1) (C) < (D) < (B) < (A)
2) (D) < (A) < (B) < (C)
3) (D) < (B) < (A) < (C)
4) (C) < (B) < (A) < (D)

Key: (2)

Sol: Ascending order of rate of solvolysis (SN^1) depends on stability of carbocation



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

69. Match List-I with List-II.

	List-I		List-II
(A)	Bronze	(I)	Cu, Ni
(B)	Brass	(II)	Fe, Cr, Ni, C
(C)	UK silver coin	(III)	Cu, Zn
(D)	Stainless steel	(IV)	Cu, Sn

Choose the correct answer from the options given below

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

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

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

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

Key: (3)

Sol: Bronze: Cu, Sn

Brass: Cu, Zn

UK silver coin: Cu, Ni

Stainless steel: Fe,Cr, Ni, C

70. Given below are two statements about X-ray spectra of elements:

Statement (I): A plot of $\sqrt{v}$ (v = frequency of X-rays emitted) vs atomic mass is a straight line.

Statement (II): A plot of v (v = frequency of X-rays emitted) vs atomic number is a straight line.

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 false but Statement II is true

Key: (2)

Sol: A plot of $\sqrt{v}$ (when v is frequency of x-rays emitted) against atomic number (x) is straight line .

$\therefore$ Statement I & Statement II are false

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. 0.01 mole of an organic compound (X) containing 10% hydrogen, on complete combustion produced 0.9 g H_2O. Molar mass of (X) is _____ g mol^{-1}.

Key: (100)

Sol: $\%H = \frac{2}{18} \times \frac{wt\ of\ H_2O\ formed}{wt\ of\ organic\ compound} \times 100$

$10 = \frac{2}{18} \times \frac{0.9}{wt.of\ organic\ compound} \times 100$

$\therefore wt.of\ organic\ compound = 1\ gram$

Given 0.01 mole of organic compound = 1 g

1 mole of organic compound (Molecular weight) = 100 g

72. The bond dissociation enthalpy of X_2 ΔH^0_{bond} calculated from the given data is _____ kJ mol^{-1}. (Nearest Integer)

$M^+X^-(s) \rightarrow M^+(g) + X^-(g)\ \Delta H^0_{lattice} = 800\,kJ\ mol^{-1}$

$M(s) \rightarrow M(g)\ \Delta H^0_{sub} = 100\,kJ\ mol^{-1}$

$M(g) \rightarrow M^+(g) + e^-(g)\ \Delta H^0_{i} = 500\,kJ\ mol^{-1}$

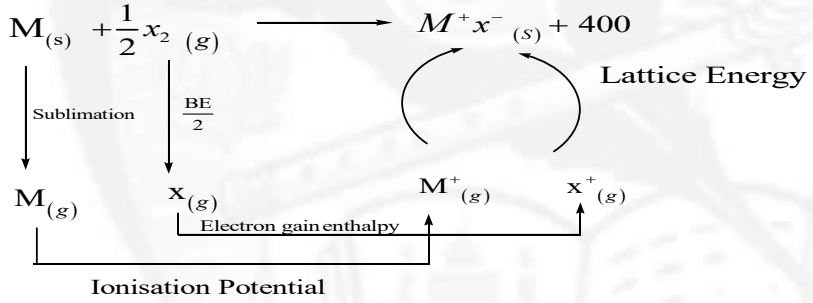
$X(g) + e^-(g) \rightarrow X^-(g)\ \Delta H^0_{eg} = -300\,kJ\ mol^{-1}$

$M(s) + \frac{1}{2}X_2(g) \rightarrow M^+X^-(s)\ \Delta H^0_{f} = -400\,kJ\ mol^{-1}$

[Given: M^+X^- is a pure ionic compound and X forms a diatomic molecule X_2 in gaseous state]

Key: 200

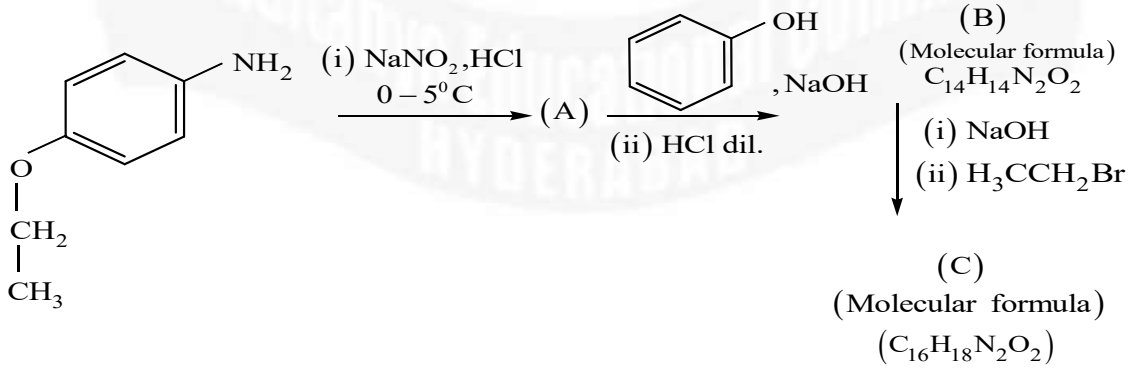
Sol:



$\Delta H_f(M^+X^-) = \Delta H_{Sub} + I.P. + \frac{BE}{2} + Eg + LE$

$-400 = 100 + 500 + \frac{BE}{2} + (-300) + (-800) \qquad \therefore B.E = 200\ KJ/mol$

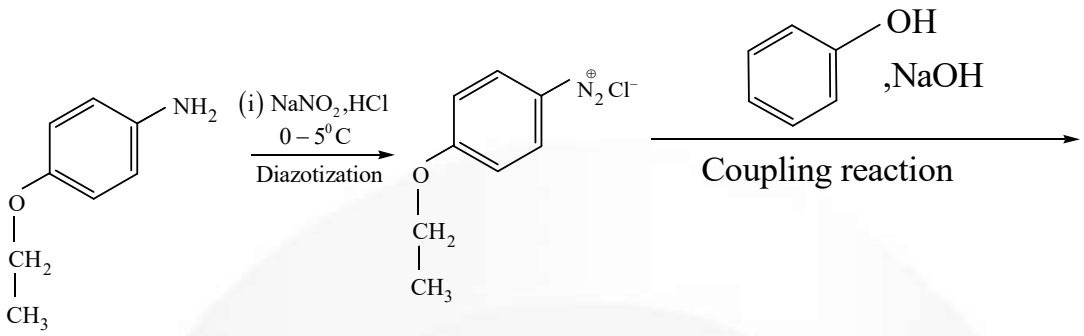
73. Consider the following sequence of reactions.

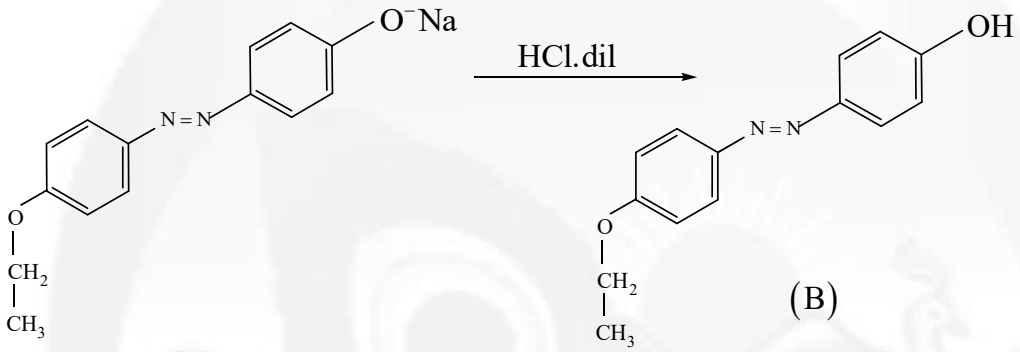


Total number of sp^3 hybridized carbon atoms in the major product C formed is _____

Key: (4)

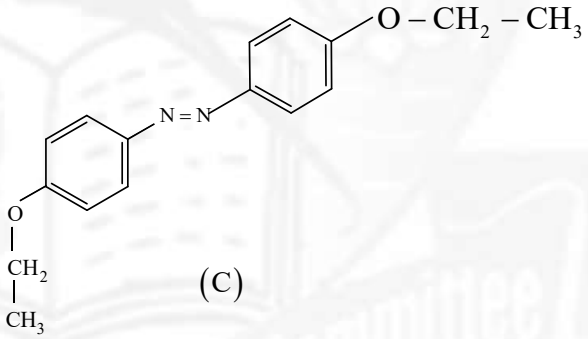
Sol:





$C_{14}H_{14}N_2O_2$

SN^2 reaction: (i) NaOH, (ii) $CH_3 - CH_2 - Br$



$C_{16}H_{18}N_2O_2$

Number of sp^3 hybridized carbon in 'C' is '4'.

74. A compound 'X' absorbs 2 moles of hydrogen and 'X' upon oxidation with $KMnO_4 | H^+$ gives

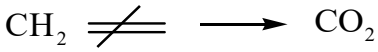
$CH_3 - \underset{\underset{O}{\|}}{C} - CH_3$, $CH_3 - \underset{\underset{O}{\|}}{C} - OH$ and $CH_3 - \underset{\underset{O}{\|}}{C} - CH_2CH_2 - \underset{\underset{O}{\|}}{C} - OH$

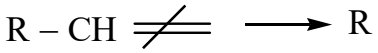
The total number of σ bonds present in the compound 'X' is _____

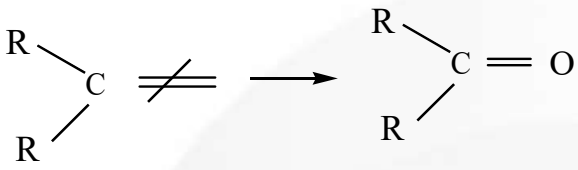
Key: (27)

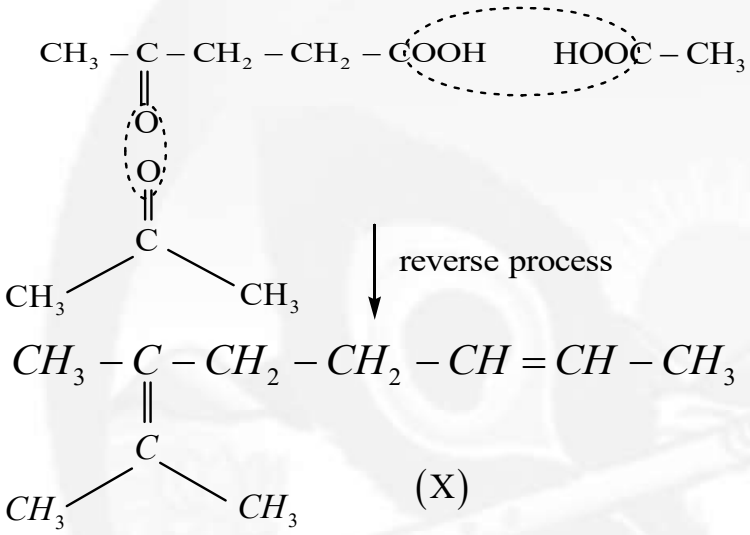
Sol: Alkenes on reaction with acidified $KMnO_4$

Rules :









(x) absorbs 2 moles of hydrogen

Number of sigma bonds in 'X' is 27.

75. When 81.0 g of aluminium is allowed to react with 128.0 g of oxygen gas, the mass of aluminium oxide produced in grams is _____ (Nearest integer)

Given:

Molar mass of Al is 27.0 g mol^{-1}

Molar mass of O is 16.0 g mol^{-1}

Key: (153)

Sol: No. of moles of Al $= \frac{81}{27} = 3$ moles

No. of moles of $O_2 = \frac{128}{32} = 4$ moles

$4Al + 3O_2 \rightarrow 2Al_2O_3$

4 mole 3 mole $\rightarrow$ 2 mole

Given 3 mole 4 mole $\rightarrow$?

Limiting reagent excess reagent

$\therefore$ No. of moles of $Al_2O_3 = \frac{3}{4} \times 2 = 1.5$ *moles*

Molecular weight of Al_2O_3 = 102

$\therefore$ Weight of 1.5 moles of $Al_2O_3 = 1.5 \times 102 = 153\ g$.

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