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SRI CHAITANYA NATION'S 1ST CHOICE FOR IIT-JEE SUCCESS

5 STUDENTS IN TOP 10 IN JEE-ADVANCED 2024 OPEN CATEGORY

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4	RHYTHM KEDIA	247025176*
5	P KUSHAL KUMAR	246150349
6	RAJDEEP MISHRA	241016176*
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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

24-01-2025

Sri Chaitanya IIT Academy., India.

A.P, TELANGANA, KARNATAKA, TAMILNADU, MAHARASHTRA, DELHI, RANCHI

A right Choice for the Real Aspirant

ICON Central Office – Madhapur – Hyderabad

2025_Jee-Main_24-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.

01. If the equation of the parabola with vertex $V\left(\frac{3}{2},3\right)$ and the directrix $x+2y=0$ is $\alpha x^2+\beta y^2-\gamma xy-30x-60y+225=0$, then $\alpha+\beta+\gamma$ is equal to:

1)7 2)8 3)6 4)9

Key: 4

Sol: Foot of directrix is

$$\frac{h-\frac{3}{2}}{1}=\frac{k-3}{2}=-\frac{\left(\frac{3}{2}+6\right)}{5}$$

$$(h,k)=(0,0)$$

Then focus is $\left(2\left(\frac{3}{2}\right)-0,2(3)-0\right)$

$$S(3,6)$$

$$p(x_1,y_1)$$

$$SP^2=PM^2$$

$$(x_1-3)^2+(y_1-6)^2=\frac{(x_1+2y_1)^2}{5}$$

$$5x_1^{\ 2}+5y_1^{\ 2}-30x_1-60y_1+225=x_1^{\ 2}+4y_1^{\ 2}+4x_1y_1$$

$$4x_1^{\ 2}+y_1^{\ 2}-30x_1-60y_1-4x_1y_1+225=0$$

$$\alpha=4\quad\beta=1\quad\gamma=4$$

02. If $\alpha>\beta>\gamma>0$, then the expression

$$\cot^{-1}\left\{\beta+\frac{(1+\beta^2)}{(\alpha-\beta)}\right\}+\cot^{-1}\left\{\gamma+\frac{(1+\gamma^2)}{(\beta-\gamma)}\right\}+\cot^{-1}\left\{\alpha+\frac{(1+\alpha^2)}{(\gamma-\alpha)}\right\}$$ is equal to:

1) $\frac{\pi}{2}-(\alpha+\beta+\gamma)$ 2) π 3)0 4) 3π

Key: 2

Sol: $\alpha > \beta > \gamma > 0$

$$\cot^{-1}\left(\frac{1+\alpha\beta}{\alpha-\beta}\right)+\cot^{-1}\left(\frac{1+\gamma\beta}{\beta-\gamma}\right)+\cot^{-1}\left(\frac{1+\alpha\gamma}{\gamma-\alpha}\right)$$

$$\tan^{-1}\alpha-\tan^{-1}\beta+\tan^{-1}\beta-\tan^{-1}\gamma+\pi+\tan^{-1}\gamma-\tan\alpha=\pi \qquad (\therefore \alpha>\gamma)$$

03. Let $A=\left\{x\in(0,\pi)-\left\{\frac{\pi}{2}\right\}:\log_{(2/\pi)}|\sin x|+\log_{(2/\pi)}|\cos x|=2\right\}$ and $B=\left\{x\geq 0:\sqrt{x}\left(\sqrt{x}-4\right)-3\left|\sqrt{x}-2\right|+6=0\right\}$. Then $n(A\cup B)$ is equal to:

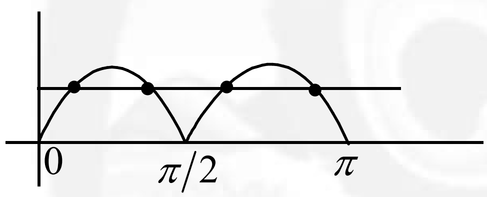
1)4 2)6 3)8 4)2

Key: 3

Sol: $\log_{\frac{2}{\pi}}|\sin x\cos x|=2$

$$|\sin x\cos x|=\frac{4}{\pi^2}$$

$$|\sin 2x|=\frac{8}{\pi^2}$$



$n(A)=4$

Case: 1

$\sqrt{x}\geq 2$

$\Rightarrow\left(\sqrt{x}\right)^2-7\sqrt{x}+12=0$

$\left(\sqrt{x}-4\right)\left(\sqrt{x}-3\right)=0$

$x=16, x=9$

Case : 2

$\sqrt{x}<2$

$\Rightarrow\left(\sqrt{x}\right)^2-\sqrt{x}=0$

$\sqrt{x}=0, \sqrt{x}=1$

$x=0,1$

$n(B)=4$

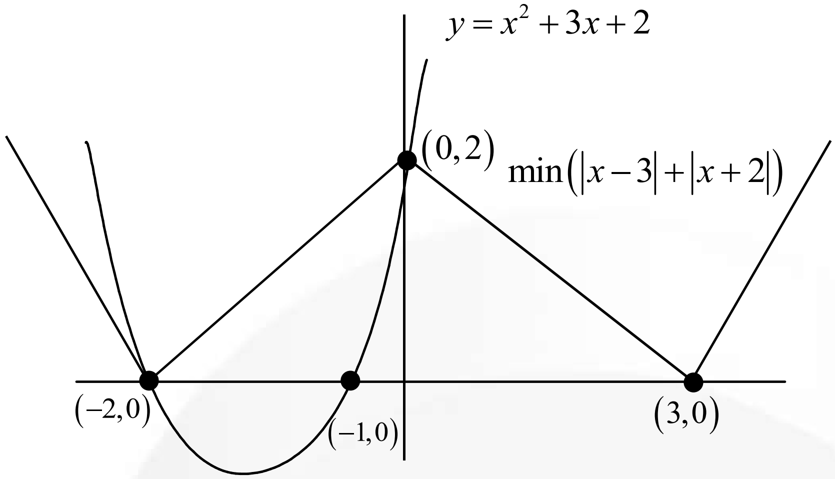
$\boxed{n(A\cup B)=8}$

04. The number of real solution(s) of the equation $x^2+3x+2=\min\{|x-3|,|x+2|\}$ is:

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

Key: 4

Sol:



05. The equation of the chord, of the ellipse $\frac{x^2}{25}+\frac{y^2}{16}=1$, whose mid-point is (3,1) is:

1) $5x+16y=31$ 2) $48x+25y=169$ 3) $25x+101y=176$ 4) $4x+122y=134$

Key: 2

Sol: chord is $S_1 = S_{11}$

$$\frac{3x}{25}+\frac{y}{16}-1=\frac{9}{25}+\frac{1}{16}-1$$

$$\boxed{48x+25y=169}$$

06. Let $\vec{a}=3\hat{i}-\hat{j}+2\hat{k}, \vec{b}=\vec{a}\times(\hat{i}-2\hat{k})$ and $\hat{c}=\vec{b}\times\hat{k}$. Then the projection of $\vec{c}-2\hat{j}$ on $\vec{a}$ is:

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

Key: 3

Sol:

$$\vec{b}=\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ 3 & -1 & 2\\ 1 & 0 & -2\end{vmatrix}$$

$$\vec{b}=2\hat{i}+8\hat{j}+\hat{k}$$

$$\vec{c}=(2\hat{i}+8\hat{j}+\hat{k})\times\hat{k}$$

$$=-2\hat{j}+8\hat{i}$$

$$\vec{c}-2\hat{j}=-4\hat{j}+8\hat{i}$$

$$\frac{|(\bar{c}-2j).\bar{a}|}{|\bar{a}|}=\frac{|(8\hat{i}-4\hat{j}).(3\hat{i}-\hat{j}+2\hat{k})|}{|3i-j+2k|}$$

$$=\frac{28}{\sqrt{14}}=2\sqrt{14}$$

07. In an arithmetic progression, if $S_{40}=1030$ and $S_{12}=57$, then $S_{30}-S_{10}$ is equal to:

1)515 2)505 3)510 4)525

Key: 1

Sol:

$$S_{40} = 1030 = 20[2a + 39d]$$

$$S_{12} = 57 = 6[2a + 11d]$$

$$2a + 39d = \frac{103}{2}$$

$$2a + 11d = \frac{57}{6}$$

$$28d = 42$$

$$d = \frac{3}{2} \Rightarrow a = \frac{-7}{2}$$

$$s_{30} - s_{10} = 15[2a + 29d] - 5[2a + 9d]$$

$$= 20a + 390d$$

$$= -70 + 585$$

$$= 515$$

08. Let [x] denote the greatest integer function, and let m and n respectively be the numbers of the points, where the function $f(x) = [x] + |x - 2|, -2 < x < 3$, is not continuous and not differentiable. Then m + n is equal to:

1)7 2)8 3)9 4)6

Key: 2

Sol: $f(x) = [x] + |x - 2|$ $\quad -2 < x < 3$

f is not continuous at $x = -1, 0, 1, 2$

Not differentiable at $x = -1, 0, 1, 2$ as it is not continuous

09. If the system of equations

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

$$2x + \lambda y + 5z = 5$$

$$14x + 3y + \mu z = 33$$

Has infinitely many solutions, then $\lambda + \mu$ is equal to:

1)13 2)10 3)11 4)12

Key: 4

Sol: $(x + 2y - 3z - 2) + \alpha(2x + \lambda y + 5z - 5)$

$$= 14x + 3y + \mu z - 33$$

$$\frac{1 + 2\alpha}{14} = \frac{2 + \alpha\lambda}{3} = \frac{-3 + 5\alpha}{\mu} = \frac{-2 - 5\alpha}{-33} = \frac{-5}{\mu - 33}$$

$$-33 - 66\alpha = -28 - 70\alpha$$

$$4\alpha = 5 \Rightarrow \alpha = \frac{5}{4}$$

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

$$\frac{7}{2.14} = \frac{2+\frac{5}{4}\lambda}{3} = \frac{-3+\frac{25}{4}}{4} = \frac{1}{4}$$

$$\mu = -12+25 = 13$$

$$\frac{5}{4}\lambda = \frac{3}{4} - 2$$

$$5\lambda = -5$$

$$\lambda = -5 \Rightarrow \lambda = -1$$

$$\mu + \lambda = 12$$

10. Let $f:(0,\infty)\to R$ be a function which is differentiable at all points of its domain and satisfies the condition $x^2 f'(x) = 2xf(x)+3$, with $f(1)=4$. Then $2f(2)$ is equal to:

1)23 2)39 3)19 4)29

Key: 2

Sol:

$$x^2\frac{dy}{dx} = 2xy+3$$

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

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

$$IF = \frac{1}{x^2}$$

$$\Rightarrow \left(y.\frac{1}{x^2}\right) = \int \frac{3}{x^4}dx$$

$$\frac{y}{x^2} = \frac{1}{-x^3} + c$$

$$y = -\frac{1}{x} + cx^2$$

$$given\ f(1) = 4$$

$$4 = -1 + c$$

$$c = 5$$

$$y = -\frac{1}{x} + 5x^2$$

$$2y_{(2)} = \left(\frac{-1}{2} + 5.2^2\right).2$$

$$= 39$$

11. If $7=5+\frac{1}{7}(5+\alpha)+\frac{1}{7^2}(5+2\alpha)+\frac{1}{7^3}(5+3\alpha)+......\infty$, then the value of α is:

1)1 2)6 3) $\frac{6}{7}$ 4) $\frac{1}{7}$

Key: 2

Sol:

$$7=5+\frac{1}{7}(5+\alpha)+\frac{1}{7^2}(5+2\alpha)+\frac{1}{7^3}(5+3\alpha)+......\infty$$

$$7=5+\frac{5}{7}+\frac{\alpha}{7}+\frac{5}{7^2}+\frac{5}{7^3}+\frac{3\alpha}{7^2}+........$$

$$7=5\left(1+\frac{1}{7}+\frac{1}{7^2}+\frac{1}{7^3}+....\right)+\alpha\left(\frac{1}{7}+\frac{2}{7^2}+\frac{3}{7^3}+.....\right)$$

$$7=5\left(\frac{1}{1-\frac{1}{7}}\right)+\alpha\times\frac{1}{7}\times\left(1-\frac{1}{7}\right)^{-2}$$

$$7=5\left(\frac{7}{6}\right)+\alpha\left(\frac{1}{7}.\frac{49}{36}\right)$$

$$7-\frac{35}{6}=\alpha\left(\frac{7}{36}\right)\Rightarrow\frac{7}{6}=\frac{7}{36}\alpha\Rightarrow\alpha=6$$

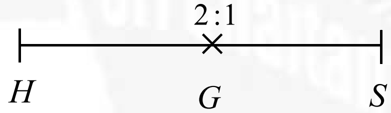
12. Let the position vectors of three vertices of a triangle be $4\vec{p}+\vec{q}-3\vec{r},-5\vec{p}+\vec{q}+2\vec{r}$ and $2\vec{p}-\vec{q}+2\vec{r}$. If the position vectors of the orthocenter and the circumcenter of the triangle are $\frac{\vec{p}+\vec{q}+\vec{r}}{4}$ and $\alpha\vec{p}+\beta\vec{q}+\gamma\vec{r}$ respectively, then $\alpha+2\beta+5\gamma$ is equal to:

1)4 2)3 3)6 4)1

Key: 2

Sol: $\overrightarrow{OA}=4\vec{p}+\vec{q}-3\vec{r},\overrightarrow{OB}=-5\vec{p}+\vec{q}+2\vec{r},\ \overrightarrow{OC}=2\vec{p}-\vec{q}+2\vec{r}$

$$\overrightarrow{OH}=\frac{\vec{p}+\vec{q}+\vec{r}}{4},\quad \overrightarrow{OG}=\frac{\overrightarrow{OA}+\overrightarrow{OB}+\overrightarrow{OC}}{3}=\frac{\vec{p}+\vec{q}+\vec{r}}{3}$$



$$\Rightarrow\overrightarrow{OG}=\frac{2\left(\overrightarrow{OS}\right)+1\left(\overrightarrow{OH}\right)}{2+1}$$

$$\Rightarrow\overrightarrow{OS}=\frac{\left(\overrightarrow{OG}\right)-\overrightarrow{OH}}{2}=\frac{3\left(\frac{\vec{p}+\vec{q}+\vec{r}}{3}\right)-\left(\frac{\vec{p}+\vec{q}+\vec{r}}{4}\right)}{2}$$

$$\Rightarrow\overrightarrow{OS}=\frac{3\left(\vec{p}+\vec{q}+\vec{r}\right)}{8}\quad\therefore\alpha=\frac{3}{8}=\beta=\gamma$$

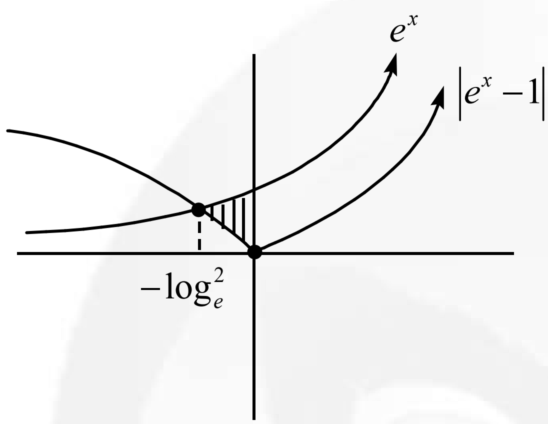
$\alpha + 2\beta + 5\gamma = 8\alpha = 8.\frac{3}{8} = 3$

13. The area of the region enclosed by the curves $y = e^x, y = \left|e^x - 1\right|$ and y-axis is:

1) $2\log_e 2 - 1$ 2) $1 - \log_e 2$ 3) $1 + \log_e 2$ 4) $\log_e 2$

Key: 2

Sol: $y = e^x, y = \left|e^x - 1\right|$



$$A = \int_{-\log_e^2}^{0} \left(e^x - \left(1 - e^x\right)\right) dx = \int_{-\log_e^2}^{0} \left(2e^x - 1\right) dx = 2\left(e^x\right)_{-\log_e^2}^{0} - \left(x\right)_{-\log_e^2}^{0} = 1 - \log_e^2$$

14. Group A consists of 7 boys and 3 girls, while group B consists of 6 boys and 5 girls. The number of ways, 4 boys and 4 girls can be invited for a picnic if 5 of then must be from group A and the remaining 3 from group B, is equal to:

1)8750 2)8575 3)8925 4)9100

Key: 3

Sol:

	GroupA		*GroupB*	
	$B(7)$	$G(3)$	$B(6)$	$G(5)$
(i)	2	3	2	1
(ii)	3	2	1	2
(iii)	4	1	0	3

(iv) Required number of ways

$= {}^7C_2.{}^3C_3.{}^6C_2.{}^5C_1 + {}^7C_3.{}^3C_2.{}^6C_1.{}^5C_2 + {}^7C_4.{}^3C_1.{}^6C_0.{}^5C_3$

$= 21.1.15.5 + 35.3.6.10 + 35.3.1.10$

$= 1575 + 6300 + 1050 = 8925$

15. Let (2,3) be the largest open interval in which the function $f(x) = 2\log_e(x-2) - x^2 + ax + 1$ is strictly increasing and (b,c) be the largest open interval, in which the function $g(x) = (x-1)^3(x+2-a)^2$ is strictly decreasing. Then $100(a+b-c)$ is equal to:

1)160 2)280 3)360 4) 420

Key: 3

Sol: $f'(x)=\dfrac{2}{x-2}-2x+a$

$f'(3)=0\Rightarrow \dfrac{2}{3-2}-2(3)+a=0$

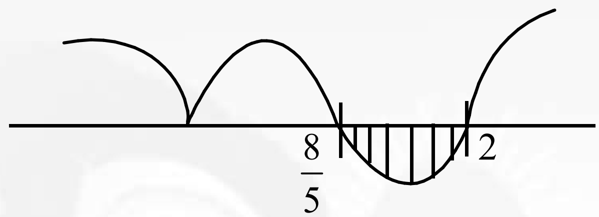
$\Rightarrow a=4$

$g(x)=(x-1)^3(x-2)^2$

$g'(x)=(x-1)^3.2(x-2)+(x-2)^2.3(x-1)^2<0$

$(x-1)^2.(x-2)\{2(x-1)+3(x-2)\}<0$

$(x-1)^2(x-2)(5x-8)<0$



$\therefore (b,c)=\left(\dfrac{8}{5},2\right)$

$100(a+b-c)=100\left(4+\dfrac{8}{5}-2\right)=100\left(\dfrac{18}{5}\right)=360$

16. Let $A=\left[a_{ij}\right]$ be a square matrix of order 2 with entries either 0 or 1. Let E be the event that A is an invertible matrix. Then the probability P(E) is:

1) $\frac{3}{8}$ 2) $\frac{3}{16}$ 3) $\frac{1}{8}$ 4) $\frac{5}{8}$

Key: 1

Sol: $n(S)=2.2.2.2=16$

E: matrix is invertible $\Rightarrow |A|\neq 0$

$$\left\{\begin{pmatrix}1&1\\1&0\end{pmatrix}\begin{pmatrix}1&1\\0&1\end{pmatrix}\begin{pmatrix}1&0\\1&1\end{pmatrix}\begin{pmatrix}0&1\\1&1\end{pmatrix}\begin{pmatrix}1&0\\0&1\end{pmatrix}\begin{pmatrix}0&1\\1&0\end{pmatrix}\right\}=6$$

$P(E)=\dfrac{6}{16}=\dfrac{3}{8}$

17. For some a, b, let $f(x)=\begin{vmatrix} a+\frac{\sin x}{x} & 1 & b \\ a & 1+\frac{\sin x}{x} & b \\ a & 1 & b+\frac{\sin x}{x}\end{vmatrix}, x\neq 0, \lim_{x\to 0} f(x)=\lambda+\mu a+vb$. Then $(\lambda+\mu+v)^2$ is equal to:

1)25 2)16 3)9 4)36

Key: 2

Sol: $\underset{x\to 0}{lt}\frac{\sin x}{x}=1$

$$\underset{x\to 0}{lt} f(x)=\begin{vmatrix} a+1 & 1 & b \\ a & 2 & b \\ a & 1 & b+1\end{vmatrix} \begin{matrix} R_1\to R_1-R_2 \\ R_2\to R_2-R_3\end{matrix}$$

$$=\begin{vmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ a & 1 & b+1\end{vmatrix}$$

$$=b+1+1+(a)$$

$$=a+b+2$$

$$=\mu a+\upsilon b+\lambda$$

$\mu=1 \quad \upsilon=1 \quad \lambda=2$

$(\lambda+\mu+\upsilon)^2=16$

18. Suppose A and B are the coefficients of 30^{th} and 12^{th} terms respectively in the binomial expansion of $(1+x)^{2n-1}$. If 2A = 5B, then n is equal to:

1)20 2)22 3)19 4)21

Key: 4

Sol: $A=$coefficient of T_{30} is the Binomial expansion of $(1+x)^{2n-1}={}^{2n-1}C_{29}$

$B=$ coefficient of T_{12} in the Binomial expansion of $(1+x)^{2n-1}={}^{2n-1}C_{11}$

Given $2A=5B$

$2\ {}^{2n-1}C_{29}=5\ {}^{2n-1}C_{11}$

$$\frac{2\lfloor 2n-1}{\lfloor 2n-30\ \ \lfloor 29}=\frac{5\ \ \lfloor 2n-1}{\lfloor 2n-12\ \ \ \lfloor 11}$$

$$\frac{\lfloor 2n-12}{\lfloor 2n-30} = \frac{5}{2}\frac{\lfloor 29}{\lfloor 14}$$

$$= \frac{5}{2}\frac{\lfloor 29}{\lfloor 14} \times \frac{6}{6} = \frac{30}{12}\frac{\lfloor 29}{\lfloor 11} = \frac{\lfloor 30}{\lfloor 12}$$

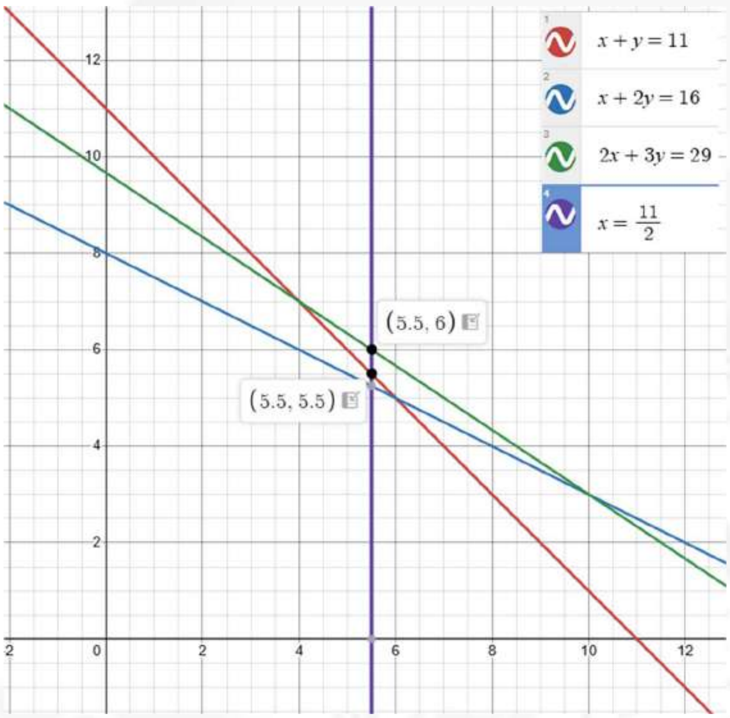
$$\boxed{\therefore n = 21}$$

19. Let the points $\left(\frac{11}{2}, \alpha\right)$ lie on or inside the triangle with sides $x+y=11, x+2y=16$ and $2x+3y=29$. Then the product of the smallest and largest values of α is equal to:

1)55 2)44 3)33 4)22

Key: 3

Sol:



$$\alpha_{\min} = \frac{11}{2}, \alpha_{\max} = 6$$

$\therefore product = 33$

20. The function $f:(-\infty,\infty) \to (-\infty,1)$, defined by $f(x) = \frac{2^x - 2^{-x}}{2^x + 2^{-x}}$ is:

1)Neither one-one nor onto 2)Both one-one and onto

3)One-one but not onto 4)Onto but not one-one

Key: 3

Sol: $f(x) = \frac{2^x - 2^{-x}}{2^x + 2^{-x}} = \frac{2^{2x}-1}{2^{2x}+1}$

$$f'(x) = \frac{\begin{vmatrix} 1 & -1 \\ 1 & 1 \end{vmatrix}}{\left(2^{2x}+1\right)^2} \frac{d}{dx}\left(2^{2x}\right)$$

$$=\frac{2}{\left(2^{2x}+1\right)^2}\left(2^{2x}.2.\log_e^2\right)$$

$$=\frac{2^{2(x+1)}\log_e^2}{\left(2^{2x}+1\right)^2}>0\ \forall x$$

f is an increasing function on R $\Rightarrow f\ is\ 1-1\ function$

for on-to, $\frac{y}{1}=\frac{2^{2x}-1}{2^{2x}+1}\Leftrightarrow\frac{y+1}{y-1}=-2^{2x}$

$\therefore x=\frac{1}{2}\log_2\left(\frac{y+1}{1-y}\right)$

The range of f is $(-1,1)$ not equal to co domain

$\therefore$ f is not on-to

(NUMERICAL VALUE TYPE)

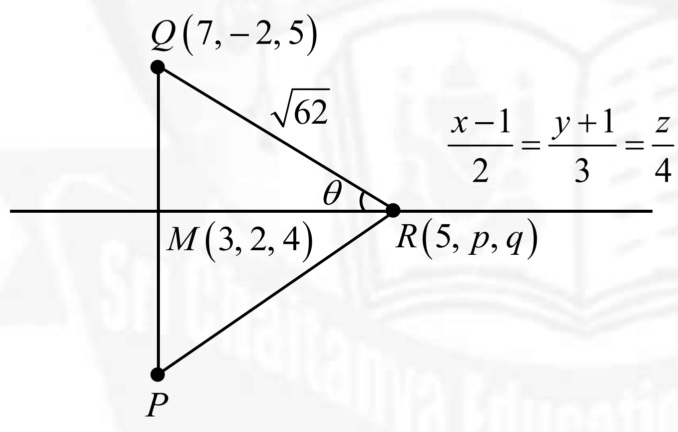
This section contains 10 questions. Each question is numerical value type. For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to second decimal place. (e.g. 6.25, 7.00, 0.33, 30, 30.27, 127.30). Attempt any five questions out of 10.

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

21. Let P be the image of the point Q(7,-2,5) in the line $L:\frac{x-1}{2}=\frac{y+1}{3}=\frac{z}{4}$ and R(5,p,q) be a point on L. Then the square of the area of ΔPQR is________.

Key: 957

Sol:



Say $\angle MRQ=\theta$

$\left|\overline{QR}\right|=\sqrt{62}$

$\Rightarrow\left|\overline{MR}\right|=\sqrt{62}\cos\theta,\ \left|\overline{QM}\right|=\sqrt{62}\sin\theta$

Area of $\Delta PQR=2\left(Area\ of\ \Delta QMR\right)$

$$=2\times\frac{1}{2}\times\sqrt{62}\cos\theta.\sqrt{62}\sin\theta$$

$$= 62\sin\theta\cos\theta$$

$$\cos\theta = \frac{\overrightarrow{QR}.\overrightarrow{MR}}{\left|\overrightarrow{QR}\right|\left|\overrightarrow{MR}\right|} = \frac{\sqrt{29}}{\sqrt{62}}$$

$$\sin\theta = \frac{\sqrt{33}}{\sqrt{62}}$$

Area of $\Delta PQR = 62.\frac{\sqrt{29}}{\sqrt{62}}.\frac{\sqrt{33}}{\sqrt{62}} = \sqrt{597}$

22. If $\int \frac{2x^2+5x+9}{\sqrt{x^2+x+1}}dx = x\sqrt{x^2+x+1}+\alpha\sqrt{x^2+x+1}+\beta\ \log_e\left|x+\frac{1}{2}+\sqrt{x^2+x+1}\right|+C$, where C is the constant of integration, then $\alpha+2\beta$ is equal to_____.

Key: 16

Sol: Differentiate both sides

$$\frac{2x^2+5x+9}{\sqrt{x^2+x+1}} = \sqrt{x^2+x+1}+\frac{x(2x+1)}{2\sqrt{x^2+x+1}}+\frac{\alpha(2x+1)}{2\sqrt{x^2+x+1}}+\frac{\beta\left(1+\frac{(2x+1)}{2\sqrt{x^2+x+1}}\right)}{\left|x+\frac{1}{2}+\sqrt{x^2+x+1}\right|}$$

Now put $x=0$

$$9 = 1+0+\frac{\alpha}{2}+\frac{\beta\left(1+\frac{1}{2}\right)}{1+\frac{1}{2}}$$

$$8 = \frac{\alpha}{2}+\beta \Rightarrow \boxed{\alpha+2\beta=16}$$

23. Let y = y(x) be the solution of the differential equation $2\cos x\frac{dy}{dx} = \sin 2x - 4y\sin x, x \in \left(0,\frac{\pi}{2}\right)$.

If $y\left(\frac{\pi}{3}\right)=0$, then $y'\left(\frac{\pi}{4}\right)+y\left(\frac{\pi}{4}\right)$ is equal to___________.

Key: 1

Sol: Given $2\cos x\frac{dy}{dx} = \sin 2x - 4y\sin x$

$$\frac{dy}{dx} = \sin x - 2y\tan x$$

$$\frac{dy}{dx} + y(2\tan x) = \sin x$$

$$\Rightarrow y\sec^2 x = \int \sin x\left(\sec^2 x\right)dx$$

$$= \sec x + c$$

$$y = \cos x + c.\cos^2 x$$

$y(\pi/3)=0 \Rightarrow \frac{1}{2}+\frac{c}{4}=0$

$\boxed{c=-2}$

$y=\cos x-2\cos^2 x$

$y=\cos x-2\cos^2 x$

$y(\pi/4)=\frac{1}{\sqrt{2}}-2\left[\frac{1}{2}\right]=\frac{1}{\sqrt{2}}-1$

$y'(\pi/4)=-\sin x+4\sin x\cos x$

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

Hence, the value of $y(\pi/4)+y'(\pi/4)=\frac{1}{\sqrt{2}}-1-\frac{1}{\sqrt{2}}+2=1$

24. Let $H_1:\frac{x^2}{a^2}-\frac{y^2}{b^2}=1$ and $H_2:-\frac{x^2}{A^2}+\frac{y^2}{B^2}=1$ be two hyperbolas having length of latus rectums $15\sqrt{2}$ and $12\sqrt{5}$ respectively. Let their eccentricities be $e_1=\sqrt{\frac{5}{2}}$ and e_2 respectively. If the product of the lengths of their transverse axes is $100\sqrt{10}$, then $25\,e_2^2$ is equal to_______.

Key: 55

Sol: $H_1=\frac{x^2}{a^2}-\frac{y^2}{b^2}=1$; $H_2=\frac{-x^2}{A^2}+\frac{y^2}{B^2}=1$

$\frac{2b^2}{a}=15\sqrt{2}$ $\quad\frac{2A^2}{B}=12\sqrt{5}$

$e_1=\sqrt{\frac{5}{2}}$

$(2a)(2B)=100\sqrt{10}$

On solving the given information

$1+\frac{b^2}{a^2}=\frac{5}{2}$

$\frac{b^2}{a^2}=\frac{3}{2};\ \frac{2b^2}{a}=15\sqrt{2}$

$\boxed{\begin{array}{l}a=5\sqrt{2}\\ b=5\sqrt{3}\end{array}}$

$aB=25\sqrt{10}\Rightarrow\boxed{B=5\sqrt{5}}$

$2\left(\frac{A}{B}\right)^2.B=12\sqrt{5}$

$\left(\frac{A}{B}\right)^2=\frac{12}{10}$

$$e_2 = \sqrt{1 + \left(\frac{A}{B}\right)^2}$$

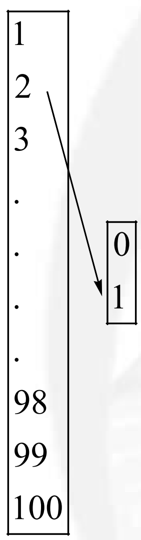
$$\boxed{e_2 = \sqrt{\frac{11}{5}}}$$

$$\Rightarrow 25e_2^2 = 55$$

25. Number of functions $f:\{1,2,....,100\} \to \{0,1\}$, that assign 1 to exactly one of the positive integers less than or equal to 98, is equal to_____.

Key: 392

Sol:



'1' can be assigned to any one number from 1 to 98, this can be done in 98 ways and that remaining 97 numbers should be assigned to '0'.

99 and 100 can be assigned to either 0 or 1 and this can be done in $2 \times 2 = 4$ ways

$\Rightarrow$ Number of required functions $= 98 \times 4 = 392$

PHYSICS **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.

26. A photograph of a landscape is captured by a drone camera at a height of 18 km. The size of the camera film is $2\,cm \times 2\,cm$ and the area of landscape photographed is $400\,km^2$. The focal length of the lens in the drone camera is:

1) $0.9\,cm$ **2)** $2.8\,cm$ **3)** $2.5\,cm$ **4)** $1.8\,cm$

Key: 4

Sol:

$$m_t^{\,2} = \frac{4\,cm^2}{400\,km^2} = \frac{1}{100} \times \frac{10^{-4}\,m^2}{10^6\,m^2}$$

$$= 10^{-12}$$

$$m_t = 10^{-6}$$

$$\frac{f}{f+u} = 10^{-6}$$

$$f = 10^{-6} f + 10^{-6} u$$

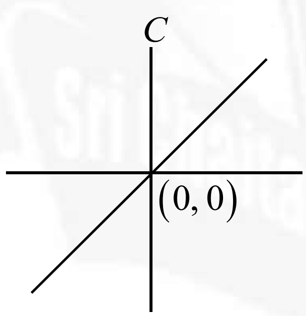
$$f - 10^{-6} f = 10^{-6} u$$

$$f \approx 10^{-6} \times 18\,km$$

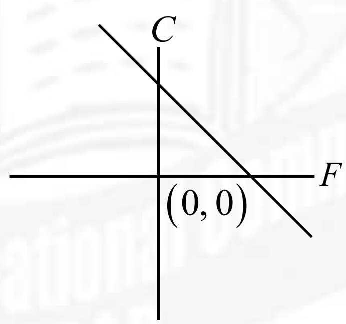
$$\approx 18 \times 10^{-3}\,m$$

$$\approx 1.8 cm$$

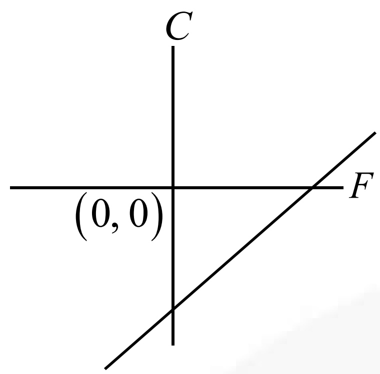
27. Which of the following figure represents the relation between Celsius and Fahrenheit temperatures?



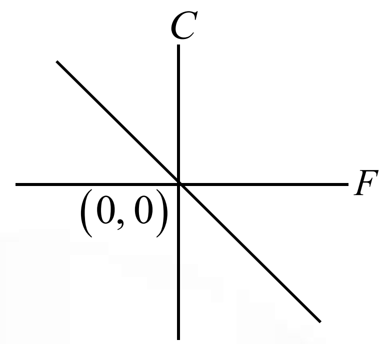
1)



2)



3)



4)

Key: 3

Sol: Relation between ^{0}C and ^{0}F scale $\frac{C}{5} = \frac{F-32}{9}$

$\Rightarrow C = \frac{5}{9}F - \frac{160}{9}$

28. In photoelectric effect, the stopping potential (V_0) v/s frequency (v) curve is plotted.

(h is the Planck's constant and ϕ_0 is work function of metal)

A. V_0 v/s v is linear

B. The slope of V_0 v/s v curve $= \frac{\phi_0}{h}$

C. h constant is related to the slope of V_0 v/s v line.

D. The value of electric charge of electron is not required to determine h using the V_0 v/s v curve

E. The work function can be estimated without knowing the value of h.

Choose the correct answer from the options given below:

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

3) (D) and (E) only **4)** (A), (C) and (E) only

Key: 4

Sol: Given photo electric experiment

We can write $ev_0 = hv - \phi_0$

Hence graph is linear and slope is $\frac{h}{e}$ and intercept is $\frac{\phi_0}{e}$, which is independent of 'h' so statement (A) (C) and (E) are correct

Hence graph will be straight line with –ve intercept on μ-axis

29. Young's double slit interference apparatus is immersed in a liquid of refractive index 1.44. It has slit separation of 1.5mm. The slits are illuminated by a parallel beam of light whose wavelength in air is 690nm. The fringe-width on a screen placed behind the plane of slits at a distance of 0.72m, will be.

1) 0.23mm **2)** 0.46mm **3)** 0.33mm **4)** 0.63mm

Key: 1

Sol: Given $D = 0.72\,m$

$d = 1.5\,nn, \lambda = 690\,nm$ and $\mu = 1.44$.

Hence finge width,

$$\beta = \frac{D\lambda}{\mu\alpha} = \frac{0.72 \times 690 \times 10^{-9}}{1.44 \times 1.5 \times 10^{-3}}$$

30. Arrange the following in the ascending order of wavelength (λ)

A) Microwaves (λ_1)

B) Ultraviolet rays (λ_2)

C) Infrared rays (λ_3)

D) X-rays (λ_4)

Choose the most appropriate answer from the options given below

1) $\lambda_4 < \lambda_3 < \lambda_1 < \lambda_2$ **2)** $\lambda_4 < \lambda_2 < \lambda_3 < \lambda_1$ **3)** $\lambda_3 < \lambda_4 < \lambda_2 < \lambda_1$ **4)** $\lambda_4 < \lambda_3 < \lambda_2 < \lambda_1$

Key: 2

Sol: From the Electromagnetic spectrum series , we know the wavelength order as

$$\lambda_{\text{microwave}} > \lambda_{\text{infrared}} > \lambda_{\text{ultra-voilet}} > \lambda_{x-ray}$$

31. A small uncharged conducting sphere is placed in contact with an identical sphere but having $4 \times 10^{-8} C$ charge and then removed to a distance such that the force of repulsion between them is $9 \times 10^{-3} N$. The distance between them is (taken $\frac{1}{4\pi \in_0}$ is 9×10^9 in SI units)

1) 4cm 2) 2cm 3)3cm 4) 1cm

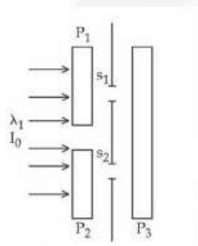
Key: 2

Sol: When the spheres are in contact, they share the charge equally since the spheres are identical

$$\therefore\ F=\frac{1}{4\pi\varepsilon_0}\frac{\left(\frac{q}{2}\right)^2}{r^2}\Rightarrow 9\times10^{-3}=\frac{9\times10^9\times\left(2\times10^{-8}\right)^2}{r^2}$$

$$\Rightarrow r^2=4\times10^{-4}\Rightarrow r=2\times10^{-2}m=2cm$$

32. In a young's double slit experiment, three polarizers are kept as shown in the figure. The transmission axes of P_1 and P_2 are orthogonal to each other. The polarizer P_3 covers both the slits with its transmission axis at 45^0 to those of P_1 and P_2 . An unpolarized light of wavelength λ and intensity I_0 is incident on P_1 and P_2. The intensity at a point after P_3 where the path difference between the light waves from s_1 and s_2 is $\frac{\lambda}{3}$, is



1) $\frac{I_0}{4}$ **2)** $\frac{I_0}{2}$ **3)** I_0 **4)** $\frac{I_0}{3}$

Key: 1

Sol: Intensity after emergence from p_3 is given by

$$I=\frac{I_0}{2}\cos^2 45^0$$

$$=\frac{I_0}{4}$$

Interference

$$I=I_1+I_2+2\sqrt{I_1I_2}\cos\delta$$

$$Here\ \delta=\frac{2\pi}{\lambda}\times\frac{\lambda}{3}$$

$$=\frac{2\pi}{3}$$

$$\therefore\ I=\frac{I_0}{4}+\frac{I_0}{4}+2\sqrt{\frac{I_0}{4}\frac{I_0}{4}}\cos\frac{2\pi}{3}$$

$$=\frac{I_0}{4}$$

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

Assertion (A) : A electron in a certain region of uniform magnetic field is moving with constant velocity in a straight line path ;

Reason (R) : The magnetic field in that region is along the direction of velocity of the electron. In the light of the above statements, choose the correct answer from the options given below :

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

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

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

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

Key: 1

Sol: If magnetic field is along the direction of motion, then magnetic force on the particle will be zero as

$$\vec{F}_m = q\left(\vec{v} \times \vec{B}\right), \theta = 0^0, F_m = 0$$

And assertion I also true, if no force is there then particle will move with constant velocity

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

Assertion (A) : In an insulated container, a gas is adiabatically shrunk to half of its initial volume. The temperature of the gas decreases.

Reason (R) : Free expansion of an ideal gas is an irreversible and an adiabatic process. In the light of the above statements, choose the **correct** answer from the options given below :

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

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

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

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

Key: 4

Sol: As in adiabatic process, TV^{y-1} =Constant Hence gf $V\downarrow$ then $T\uparrow$ so (A) is false.

As in free expansions, it is fast so hence adiabatic process

35. The energy E and momentum p of a moving body of mass m are related by some equation. Given that c represents the speed of light, identify the correct equation

1) $E^2 = pc^2 + m^2c^2$ 2) $E^2 = p^2c^2 + m^2c^2$ 3) $E^2 = p^2c^2 + m^2c^4$ 4) $E^2 = pc^2 + m^2c^4$

Key: 3

Sol: Only equation, $E^2 = p^2c^2 + m^2c^4$ is dimensionally consistent with dimensions,

$E \equiv \left[ML^2T^{-2}\right]$ $c = \left[LT^{-1}\right]$, $p = \left[MLT^{-1}\right]$

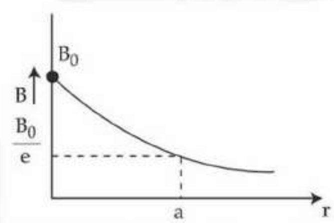
36. A solid sphere is rolling without slipping on a horizontal plane. The ratio of the linear kinetic energy of the centre of mass of the sphere and rotational kinetic energy is

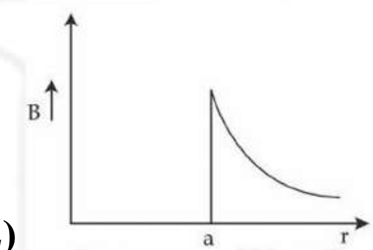
1) $\frac{2}{5}$ 2) $\frac{5}{2}$ 3) $\frac{3}{4}$ 4) $\frac{4}{3}$

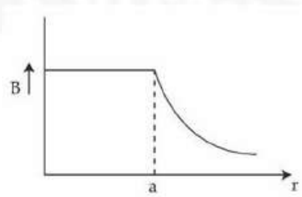
Key: 2

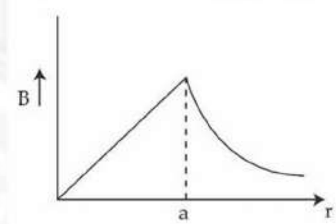
Sol: $\frac{\text{Linear } KE}{\text{Rotational } KE} = \frac{\frac{1}{2}Mv^2}{\frac{1}{2}I\omega^2} = \frac{\cancel{M}v^2}{\frac{2}{5}\cancel{M}R^2\omega^2} = \frac{5}{2}$ $[\because V = R\omega]$

37. A long straight wire of a circular cross-section with radius ‘a’ carries a steady current I. The current I is uniformly distributed across this cross-section. The plot of magnitude of magnetic field B with distance r from the centre of the wire is given by

1) 

2) 

3) 

4) 

Key 4

Sol: Applying Ampere circuital law

$\oint \vec{B}.\vec{dl} = \mu_0 i$

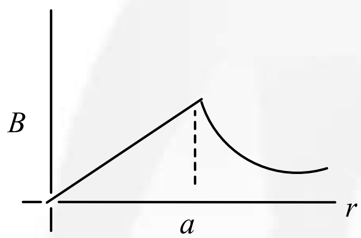
I) Within the wire

$$B(2\pi r)=\mu_o \frac{I}{\pi R^2}(\pi r^2)$$

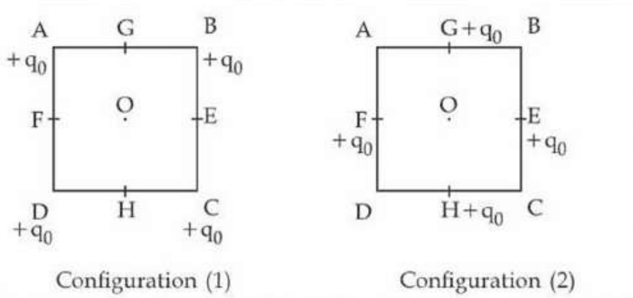
$$B=\frac{\mu_o I}{2\pi}\left(\frac{r}{R^2}\right) \Rightarrow B \propto r$$

II) Outside the wire

$$B=\frac{\mu_o I}{2\pi r} \Rightarrow B \propto \frac{1}{r}$$



38.

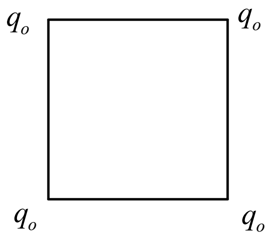


In the first configuration (1) as shown in the figure, four identical charges (q_0) are kept at the corners A,B,C and D of square of side length 'a'. In the second configuration (2), the same charges are shifted to mid points G,E,H and F, of the square . If $K=\frac{1}{4\pi \in_0}$, the difference between the potential energies of configuration (2), and (1) is given by

1) $\frac{Kq_0^2}{a}\left(4-2\sqrt{2}\right)$ **2)** $\frac{Kq_0^2}{a}\left(3\sqrt{2}-2\right)$ **3)** $\frac{Kq_0^2}{a}\left(4\sqrt{2}-2\right)$ **4)** $\frac{Kq_0^2}{a}\left(3-\sqrt{2}\right)$

Key: 2

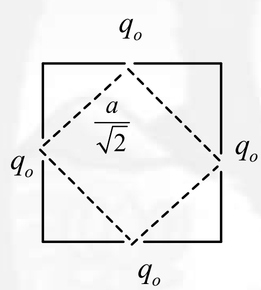
Sol: Configuration (1)



$$PE_1 = K\left[\frac{4q_o^2}{a} + \frac{2q_o^2}{\sqrt{2}a}\right]$$

$$= \frac{Kq_o^2}{a}\left[4+\sqrt{2}\right]$$

Configuration (2)

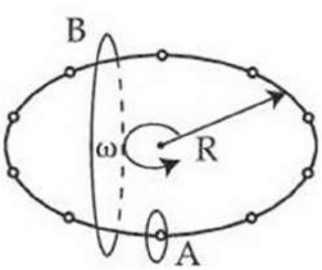


$$PE_2 = K\left[\frac{4q_o^2}{\frac{a}{\sqrt{2}}} + \frac{2q_o^2}{a}\right]$$

$$= \frac{Kq_o^2}{a}\left[4\sqrt{2}+2\right]$$

$$\therefore PE_2 - PE_1 = \frac{Kq_o^2}{a}\left[4\sqrt{2}+2-4-\sqrt{2}\right] = \frac{Kq_o^2}{a}\left[3\sqrt{2}-2\right]$$

39.



N equally spaced charges each of value q, are placed on a circle of radius R. The circle rotates about its axis with an angular velocity ω as shown in the figure. A bigger Amperian loop B encloses the whole circle where as a smaller Amperian loop A encloses a small segment. The difference between enclosed currents $I_A - I_B$, for the given Amperian loops is

1) $\frac{N}{2\pi}q\omega$ **2)** $\frac{2\pi}{N}q\omega$ **3)** $\frac{N}{\pi}q\omega$ **4)** $\frac{N^2}{2\pi}q\omega$

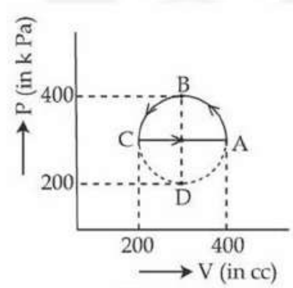
Key: 1

Sol: The incoming and outing currents through loop B is same. Hence net current through B is Zero. $(I_B = 0)$

Current through loop A is $N\,q\,f = \frac{Nq\omega}{2\pi} = I_A$

$\therefore I_A - I_B = \frac{Nq\omega}{2\pi}$

40. The magnitude of heat exchanged by a system for the given cyclic process ABCA (as shown in figure) is (in SI unit)



1) Zero **2)** 10π **3)** 40π **4)** 5π

Key:4

Sol: For the given cyclic process $dU = 0$

From 1[st] law of thermodynamics $dQ = dU + dW$

$\Rightarrow dQ = dW\,[\because dU = 0]$

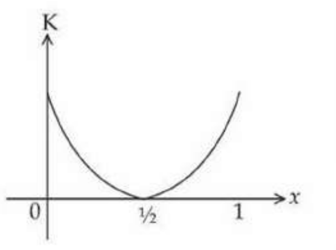
$|dQ| = |dW| =$ Area under p-v graph $= \frac{\pi r_1 r_2}{2}$

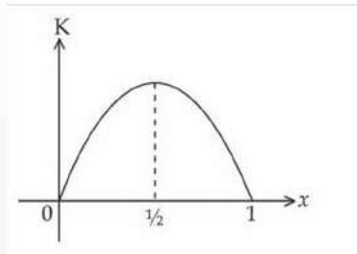
In the given graph $r_1 = \frac{400-200}{2}kPa = 100\times10^3\,Pa$

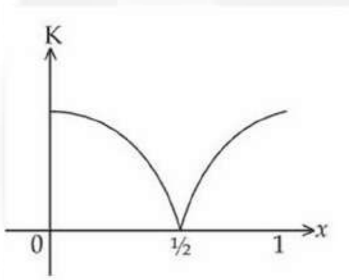
$r_2 = \frac{400-200}{2}cc = 100\times10^{-6}\,m^3$

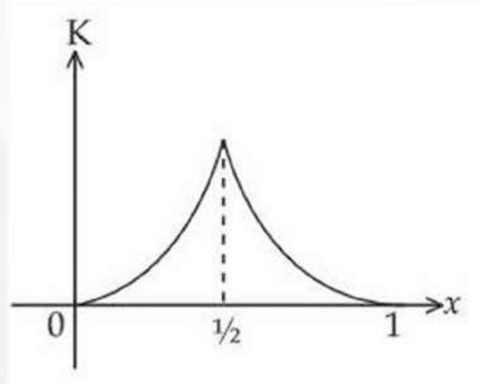
$\therefore |dQ| = \frac{\pi r_1 r_2}{2} = \frac{\pi}{2} \times 10^5 \times 10^{-4} = 5\pi J$

41. A particle oscillates along the x-axis according to the law, $x(t) = x_0 \sin^2\left(\frac{t}{2}\right)$ where $x_0 = 1m$. The kinetic energy (K) of the particle as a function of x is correctly represented by the graph

1) 

2) 

3) 

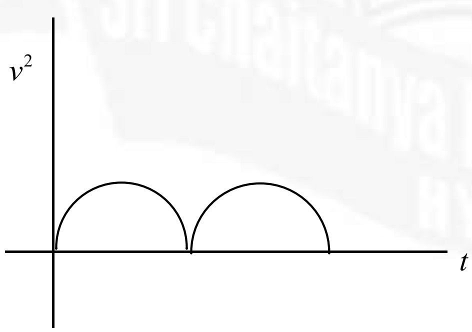
4) 

Key: 2

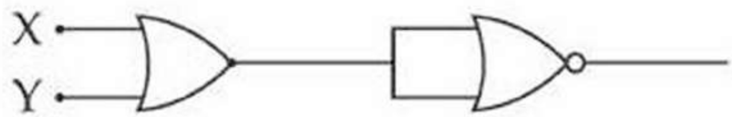
Sol: $x = x_0 \sin^2 \frac{t}{2}$

$x = \frac{x_o}{2}(1 - \cos t)$

$v^2 = \frac{x_o^2}{4}\sin^2 t$



42. The output of the circuit is low (zero) for :



A) X=0,Y=0 B) X=0,Y=1

C) X=1,Y=0 D) X=1,Y=1

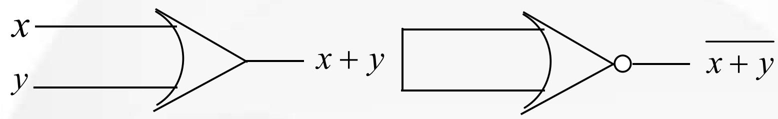
Choose the **Correct** answer from the options given below.

1) (A),(C) and (D) only **2)** (A),(B) and (C) Only

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

Key: 4

Sol:



Output $=\overline{x+y}$

$= 0$

If $x=1, y=1$

Or $x=0, y=1$

Or $x=1, y=0$

43. The temperature of a body in air falls from 40^0C to 24^0C in 4 minutes. The temperature of the air is 16^0C. The temperature of the body in the next 4 minutes will be :

1) $\frac{42}{3}\,{}^0C$ **2)** $\frac{28}{3}\,{}^0C$ **3)** $\frac{56}{3}\,{}^0C$ **4)** $\frac{14}{3}\,{}^0C$

Key : 3

Sol: $\frac{-dT}{dt} = k\left(T_{avg} - T_0\right)$

$$\frac{40-24}{4}=K\left(\frac{40+24}{2}-16\right)$$

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

$$\frac{24-T}{4}=\frac{1}{4}\left(\frac{24+T}{2}-16\right)$$

$$T=\frac{56}{3}$$

44. A solid sphere and a hollow sphere of the same mass and of same radius are rolled on an inclined plane. Let the time taken to reach the bottom by the solid sphere and the hollow sphere be t_1 and t_2 respectively , then

1) $t_1=2t_2$ **2)** $t_1=t_2$ **3)** $t_1>t_2$ **4)** $t_1<t_2$

Key: 4

Sol:

$$\frac{a_1}{a_2}=\frac{1+I_2/MR^2}{1+I_1/MR^2}$$

$$=\frac{1+\frac{2}{3}}{1+\frac{2}{5}}=\frac{25}{21}$$

$$t^2 \alpha\, a^{-1}$$

$$\frac{t_1}{t_2}=\sqrt{\frac{a_2}{a_1}}=\sqrt{\frac{21}{25}}$$

$$t_1<t_2$$

45. The position vector of a moving body at any instant of time is given as $\vec{r}=\left(5t^2\hat{i}-5t\hat{j}\right)m.$ The magnitude and direction of velocity at t=2s is

1) $5\sqrt{17}m/s$ making an angle of $\tan^{-1}4$ with –ve y axis

2) $5\sqrt{15}m/s$ making an angle of $\tan^{-1}4$ with +ve X axis

3) $5\sqrt{15}m/s$ making an angle of $\tan^{-1}4$ with –ve Y axis

4) $5\sqrt{17}m/s$ making an angle of $\tan^{-1}4$ with +ve X axis

Key: 1

Sol: $r=5t^2\hat{i}-5t\hat{j}$

$v = 10t\hat{i} - 5\hat{j}$

$t = 2$

$v = 20\hat{i} - 5\hat{j}$

$|v| = 5\sqrt{17}$

$\theta = Tan^{-1}\frac{20}{5} = Tan^{-1}4 \ with \ (-y) \ axis$

(NUMERICAL VALUE TYPE)

This section contains 10 questions. Each question is numerical value type. For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to second decimal place. (e.g. 6.25, 7.00, 0.33, 30, 30.27, 127.30). Attempt any five questions out of 10.

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

46. Acceleration due to gravity on the surface of earth is ‘g’. If the diameter of earth is reduced to one third of its original value and mass remains unchanged, then the acceleration due to gravity on the surface of the earth is ….g.

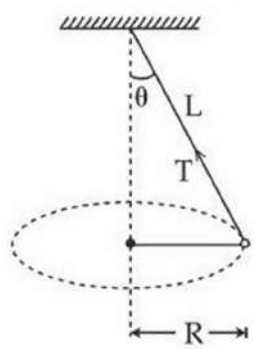
Key: 9

Sol: $g = \frac{GM}{R^2}$

$g^1 = \frac{GM}{\left[\frac{R}{3}\right]^2} = 9\frac{GM}{R^2}$

$\therefore g^1 = 9g$

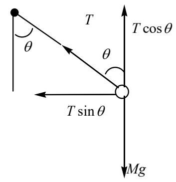
47.



A string of length L is fixed at one end and carries a mass of M at the other end. The mass makes $\left(\frac{3}{\pi}\right)$ rotations per second about the vertical axis passing through end of the string as shown . The tension in the string is ….ML.

Key: 36

Sol:



$w = \frac{3}{\pi} \times 2\pi$

$= 6.$

$T\sin\theta = Mrw^2$

$T\sin\theta = M\ L\sin\theta w^2$

$T = MLw^2$

$= 36\,ML$

48. A tightly wound long solenoid carries a current of 1.5A. An electron is executing uniform circular motion inside the solenoid with a time period of 75ns. The number of turns per metre in the solenoid is….

(Take mass of electron $m_e = 9\times10^{-31}kg.$ charge of electrons

$|q_0| = 1.6\times10^{-19}C, \mu_0 = 4\pi\times10^{-7}\frac{N}{A^2}, 1ns = 10^{-9}s]$

Key: 250

Sol: $T = \frac{2\pi m}{QB}$

$= \frac{2\pi m}{Q\mu_0 ni}$

$n = \frac{2\pi m}{Q\mu_o iT} = 250\text{ turns per metre}.$

49. The ratio of the power of a light source S_1 to that the light source S_2 is 2. S_1 is emitting 2×10^{15} photons per second at 600nm. If the wavelength of the source S_2 is 300nm, then the number of photons per second emitted by S_2 is ………..$\times10^{14}$.

Key: 5

Sol: $\frac{p^1}{p_2} = 2$

$\frac{n_1\frac{nc}{\lambda_1}}{n_2\frac{nc}{\lambda_2}} = 2$

$\frac{n_1}{2}\frac{\lambda_2}{\lambda_1} = n_2$

$n_2 = \frac{2\times10^{15}}{2}\times\frac{300}{600}$

$= 5\times10^{14}$

50. The increase in pressure required to decrease the volume of a water sample by 0.2% is $P\times10^5\,Nm^{-2}$. Bulk modulus of water is $2.15\times10^9\,Nm^{-2}$. The value of P is

Key: 43

Sol: $B = \frac{\Delta p}{\frac{-\Delta v}{v}}$

$\Delta p = B\left(\frac{-\Delta v}{v}\right)$

$= 2.15\times10^9\times\left(\frac{0.2}{100}\right)$

$= 43\times10^5\ pa$

CHEMISTRY 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.

51. Given below are two statements:

Statement (I): Experimentally determined oxygen-oxygen bond lengths in the O_3 are found to be same and bond length is greater than that of a O=O (double bond) but less than that of a single ($O-O$) bond.

Statement (II): The strong lone pair- lone pair repulsion between oxygen atoms is solely responsible for the fact that the bond length in ozone is smaller than that of a double bond (O=O) but more than that of a single bond($O-O$).

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

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

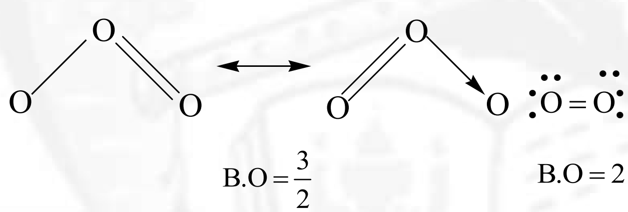
2) Statement I is false but **Statement II** is true

3) Both **Statement I** and **Statement II** are false

4) Both **Statement I** and **Statement II** are true

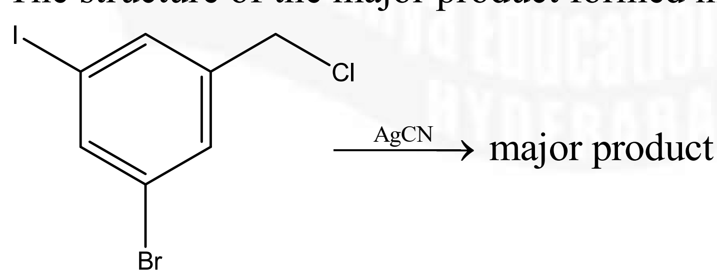
Key: 1

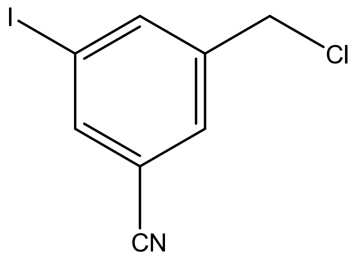
Sol:

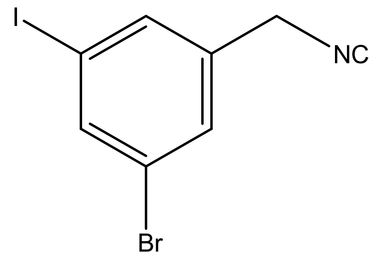


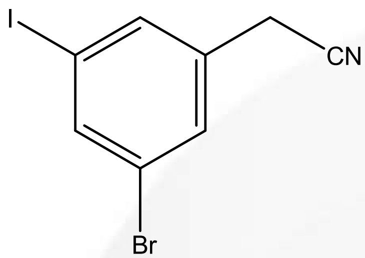
$$B.O \propto \frac{1}{B.L.}$$

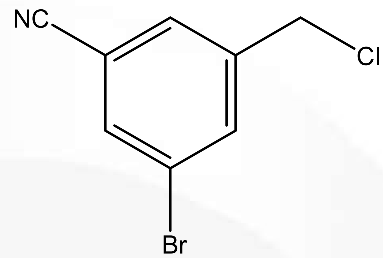
52. The structure of the major product formed in the following reaction is:



1) 

2) 

3) 

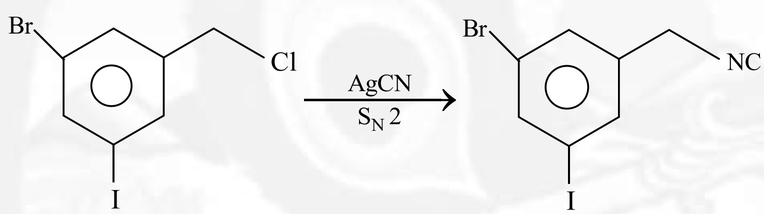
4) 

Key: 2

Sol:

Aromatic halides do not undergo nucleophilic substitution.

AgCN being a covalent compound attack from N atom to form isocyanide.



53. When Ethane-1,2-diamine is added progressively to an aqueous solution of Nickel (II) chloride, the sequence of colour change observed will be:

1) Pale Blue → Blue → Violet → Green

2) Pale Blue → Blue → Green → Violet

3) Violet → Blue → Pale Blue → Green

4) Green → Pale Blue → Blue → Violet

Key: 4

Sol:

$$\left[Ni\left(H_2O\right)_6\right]^{+2}(aq.) + en(aq.) \rightarrow \underset{pale\ blue}{\left[Ni\left(H_2O\right)_4(en)\right]^{+2}}(aq.) + 2H_2O$$

$$\left[Ni\left(H_2O\right)_4(en)\right]^{+2}(aq.) + en(aq.) \rightarrow \underset{blue\ /\ purple}{\left[Ni\left(H_2O\right)_2(en)_2\right]^{+2}}(aq.) + 2H_2O$$

$$\left[Ni\left(H_2O\right)_2\left(en\right)_2\right]^{+2}(aq.) + en(aq.) \rightarrow \left[Ni\left(en\right)_3\right]^{+2}(aq.) + 2H_2O$$

violet

54. For hydrogen atom, the orbital/s with lowest energy is/ are:

(A) 4s (B) $3p_x$ (C) $3d_{x^2-y^2}$ (D) $3d_{z^2}$ (E) $4p_z$

Choose the correct answer from the options given below:

1) (B) only **2) (A) only**

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

Key: 4

Sol: For same value of n in hydrogen atom energy of orbitals is same

55. The conditions and consequence that favours the $t_{2g}^3 e_g^1$ configuration in a metal complex are:

1) Weak field ligand, high spin complex

2) Strong field ligand, low spin complex

3) Strong field ligand, high spin complex

4) Weak field ligand, low spin complex

Key: 1

Sol:

$3d^4$

If Ligand is SFL: $t_{2g}^4 e_g^0$ (Low spin)

If Ligand is WFL: $t_{2g}^3 e_g^1$ (high spin)

56. Identify correct statement/s:

(A) $-OCH_3$ and $-NHCOCH_3$ are activating group.

(B) $-CN$ and –OH are meta directing group.

(C) $-CN$ and $-SO_3H$ are meta directing group.

(D) Activating groups act as ortho-and para directing groups.

(E) Halides are activating groups

Choose the correct answer from the options given below:

1) (A) and (C) only **2) (A), (B) and (E) only**

3) (A), (C) and (D) only **4) (A) only**

Key: 3

Sol:

$-OCH_3$, $-NH-\overset{O}{\overset{||}{C}}-CH_3$ are overall donating groups and hence activating.

All activating groups are ortho/para directing groups.

All –M groups are deactivating and meta directing.

Halogens are deactivating and ortho/para directing groups.

57. Find the compound 'A' from the following reaction sequences.

$A \xrightarrow{\text{aqua-regia}} B \xrightarrow[(2)AcOH]{(1)KNO_2|NH_4OH}$ yellow ppt

1) MnS **2) CoS** **3) ZnS** **4) NiS**

Key:2

Sol. $CoS \xrightarrow[regia]{aqua} CoCl_2 \xrightarrow[CH_3COOH]{KNO_2}$

$K_3\left[Co\left(NO_2\right)_6\right]$

yellow ppt

$$CoS + HNO_3 + 3HCl \rightarrow CoCl_2 + NOCl + S + 2H_2O$$

$$CoCl_2 + 7KNO_2 + 2CH_3COOH \rightarrow \underset{(yellow\ ppt)}{K_3\left[Co\left(NO_2\right)_6\right]} + 2KCl + 2CH_3COOK + NO + H_2O$$

58. $S(g)+\frac{3}{2}O_2(g)\rightarrow SO_3(g)+2x\ kcal$

$SO_2(g)+\frac{1}{2}O_2(g)\rightarrow SO_3(g)+y\ kcal$

The heat of formation of $SO_2(g)$ is given by:

1) y-2x kcal 2) 2x+y kcal 3) x+y kcal 4) $\frac{2x}{y}kcal$

Key: 1

Sol:

$$A)\ S(s) + \frac{3}{2}O_2(g)\rightarrow SO_3(g):\ \Delta H_1 = -2x\ kcal$$

$$B)\ SO_3(g)\rightarrow SO_2(g)+\frac{1}{2}O_2(g):\Delta H = +y\ kcal$$

$$S(g)+O_2(g)\rightarrow SO_2(g)\quad \Delta H = -2x+y=(y-2x)$$

59. Which of the following mixing of 1M base and 1M acid leads to the largest increase in temperature?

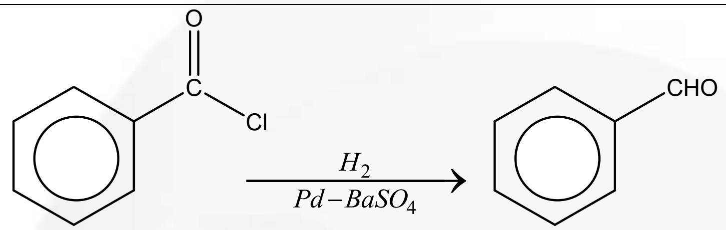
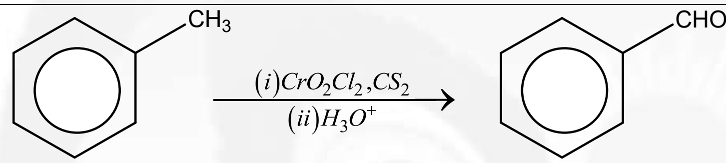
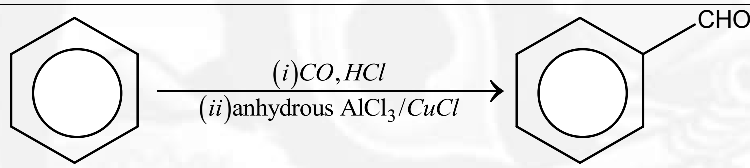
1) 30 mL HCl and 30 mL NaOH **2)** 30 mL CH_3COOH and 30 mL NaOH

3) 50 mL HCl and 20 mL NaOH **4)** 45 mL CH_3COOH and 25 mL NaOH

Key: 1

Sol: Heat of neutralisation of SA and SB is more than that of WA and SB

60. Match List-I with List-II

List-I	List-II
A) $RCN \xrightarrow[(ii) H_3O^+]{(i) SnCl_2, HCl} R\ CHO$	(I) Etard reaction
B) 	(II)Gatterman-Koch reaction
C) 	(III)Rosenmund reduction
D) 	(IV) Stephen reaction

Choose the correct answer from the options given below

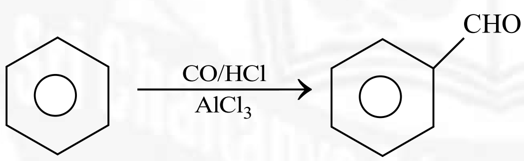
1) A-I; B-III; C-II; D-IV **2) A-III; B-IV; C-I; D-II**

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

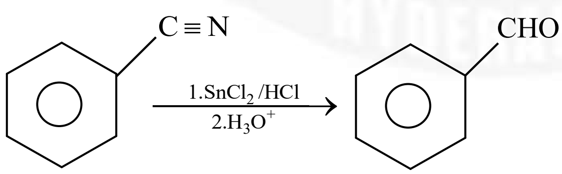
Key:4

Sol:

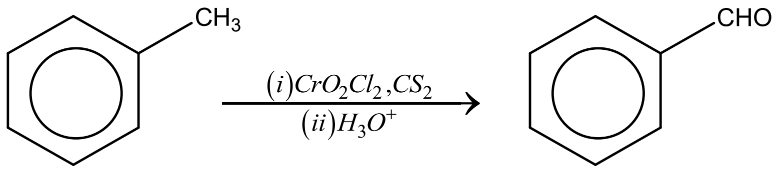
Gattermann Koch reaction



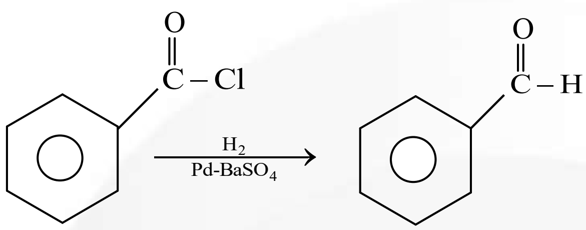
Stephen's reduction



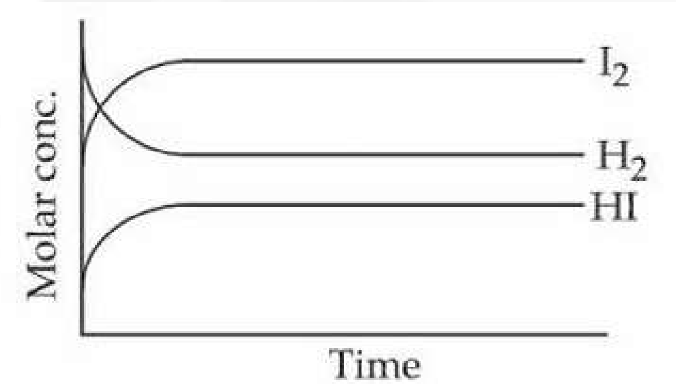
Etard reaction



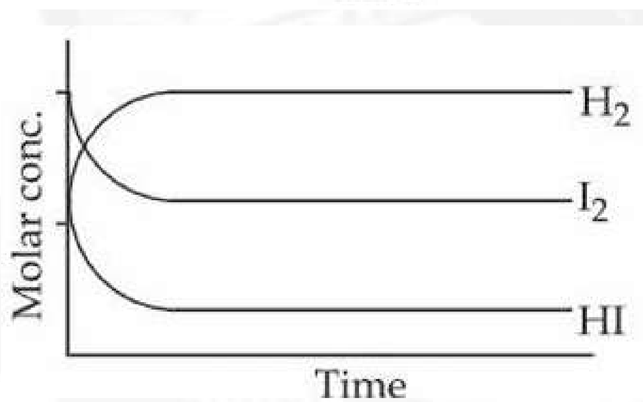
Rosenmund reduction



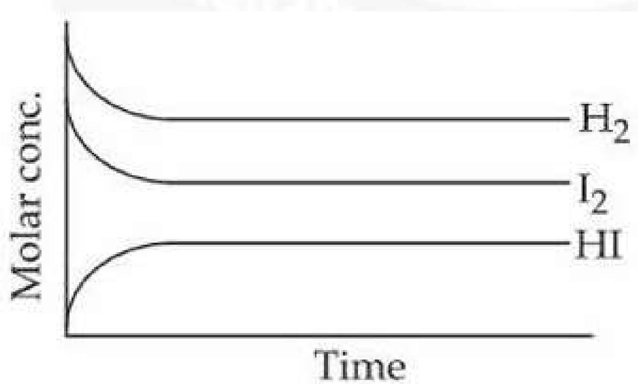
61. For the reaction, $H_2(g)+I_2(g)\rightleftharpoons 2HI(g)$
attainment of equilibrium is predicted correctly by:



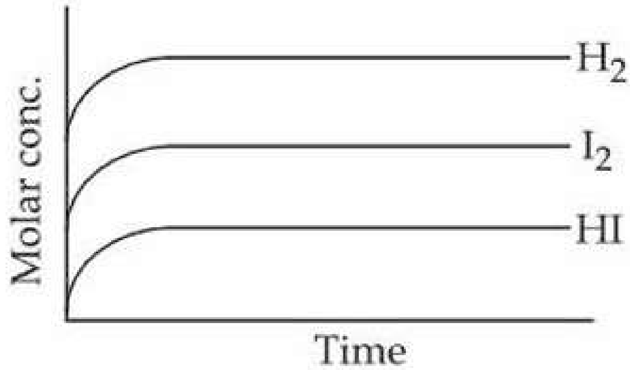
1)



2)



3)



4)

Key: 3

Sol:

Concentration of reactants H_2 & I_2 decreases parallelly to reach a constant value at equilibrium.
However, the concentration of product HI increases to reach a constant value at equilibrium

62. Match List-I with List-II

List-I (Transition metal ion)	List-II (Spin only magnetic moment (B.M))
A) Ti^{3+}	(I) 3.87
B) V^{2+}	(II) 0.00
C) Ni^{2+}	(III)1.73
D) Sc^{3+}	(IV) 2.84

Choose the correct answer from the options given below:

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

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

Key: 4

Sol:

$Sc^{3+} = 3d^0$ $\mu_{spin} = 0$

$V^{2+} = 3d^3$ $\mu_{spin} = 3.87\ BM$

$Ni^{2+} = 3d^8$ $\mu_{spin} = 2.82\,BM$

$Ti^{3+} = 3d^1$ $\mu_{spin} = 1.73\ BM$

63. Based on the data given below:

$E^\circ_{Cr_2O_7^{2-}/Cr^{3+}} = 1.33\,V$ $E^\circ_{Cl_2/Cl^{(-)}} = 1.36\,V$

$E^\circ_{MnO_4^-/Mn^{2+}} = 1.51\,V$ $E^\circ_{Cr^{3+}/Cr} = -0.74\,V$

The strongest reducing agent is:

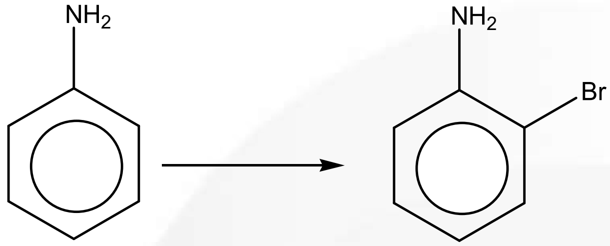
1) MnO_4^- **2)** Cl^- **3)** Mn^{2+} **4)** Cr

Key: 4

Sol: Reducing power $\alpha \dfrac{1}{\text{standard reduction potential value}}$

$E^0 Cr^{+3} / Cr = -0.74V$

64. For reaction



(Major)

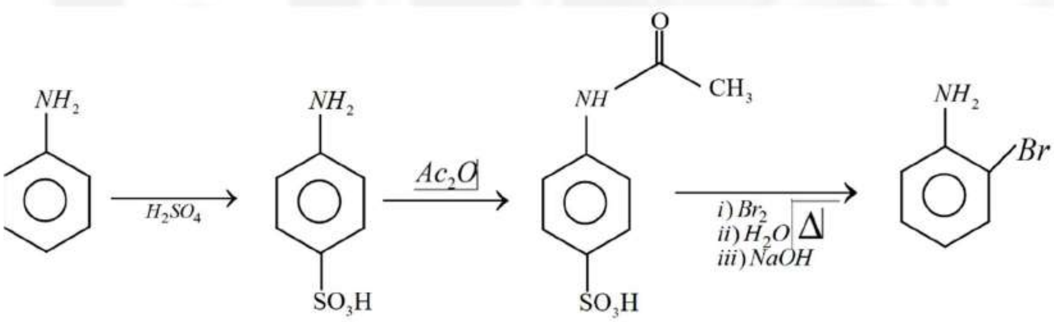
The correct order of set of reagents for the above conversion is:

1) $Ac_2O, Br_2, H_2O(\Delta), NaOH$ **2)** $Ac_2O, H_2SO_4, Br_2, NaOH$

3) $H_2SO_4, Ac_2O, Br_2, H_2O(\Delta), NaOH$ **4)** $Br_2 | FeBr_3, H_2O(\Delta), NaOH$

Key: 3

Sol:



65. The elemental composition of a compound is 54.2% C, 9.2% H and 36.6% O. If the molar mass of the compound is 132g mol^{-1}, the molecular formula of the compound is:{Given: The relative atomic mass of C:H:O=12:1:16}

1) $C_6H_{12}O_3$ **2)** $C_4H_9O_3$ **3)** $C_4H_8O_2$ **4)** $C_6H_{12}O_6$

Key: 1

Sol:

$$\text{No. of C-atoms} = \frac{132 \times 54.2}{100 \times 12} \simeq 6$$

$$\text{No. of H-atoms} = \frac{132 \times 9.2}{100 \times 1} \simeq 12$$

$$\text{No. of O-atoms} = \frac{132 \times 36.6}{100 \times 1} \simeq 3$$

Molecular formula - $C_6H_{12}O_3$.

66. Given below are two statements:

Statement (I): The first ionization energy of Pb is greater than that of Sn.

Statement (II): The first ionization energy of Ge is greater than that of Si.

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

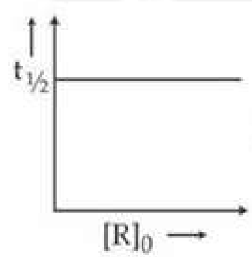
Key: 3

Sol:

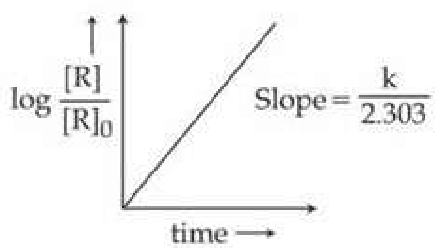
Order of I.E $\rightarrow$ C > Si > Ge > Sn < Pb

I.E. in KJ/mole 1086,786,761,708,715

67. Given below are two statements:

Statement (I) : 

is valid for first order reaction.

Statement (II) : 

is valid for first order reaction.

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 false but Statement II is true

4) Statement I is true but Statement II is false

Key: 4

Sol: $t_{1/2} = \frac{\ell n2}{K}; t_{1/2}$ does not depend on initial Concentration of reactants

$$t = \frac{2.303}{K}\log\frac{C_0}{C_t} \quad t = -\frac{2.303}{K}\log\left(\frac{C_t}{C_0}\right)$$

68. The successive 5 ionisation energies of an element are are 800,2427,3658,25024 and 32824 kJ/mol, respectively. By using the above values predict the group in which the above element is present:

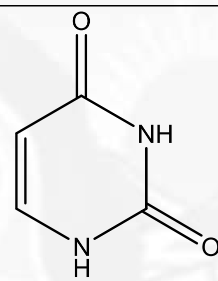
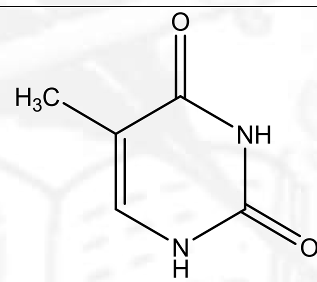
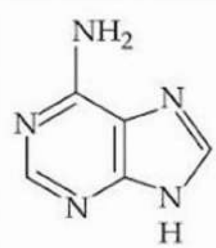
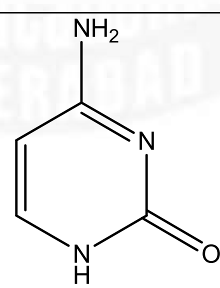
1) Group 13 **2)** Group 14 **3)** Group 4 **4)** Group 2

Key: 1

Sol:

Gap between 3rd and 4th ionization energy is large. It contains '3' valence electrons. It belongs to Group 13

69. Match List – I with List – II

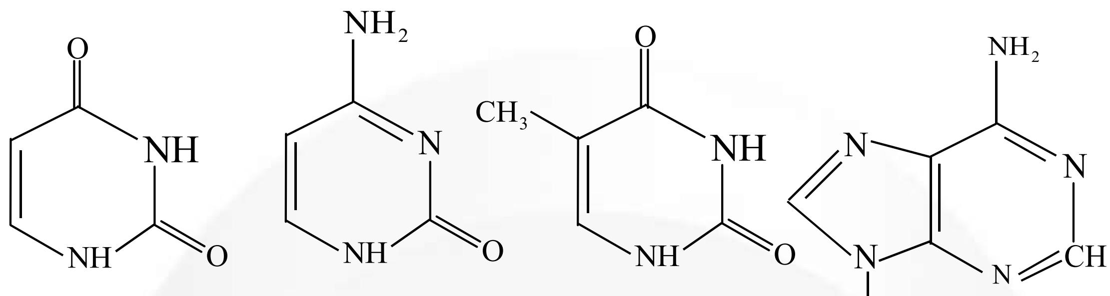
List-I	List-II
A) Adenine	(I) 
B) Cytosine	(II) 
C) Thymine	(III) 
D) Uracil	(IV) 

Choose the correct answer from the options given below:

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

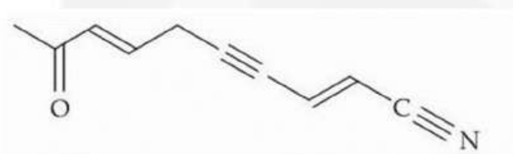
Key: 3

Sol:



Uracil Cytosine Thymine Adenine

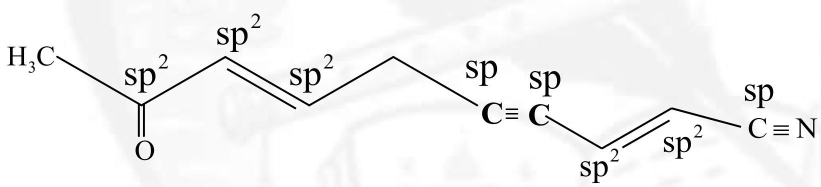
70. In the given structure, number of sp and sp^2 hybridized carbon atoms present respectively are:



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

Key: 1

Sol:



(NUMERICAL VALUE TYPE)

This section contains 10 questions. Each question is numerical value type. For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to second decimal place. (e.g. 6.25, 7.00, 0.33, 30, 30.27, 127.30). Attempt any five questions out of 10.

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

71. The hydrocarbon (X) with molar mass $80\,\text{g mol}^{-1}$ and 90% carbon has ________degree of unsaturation.

Key: 3

Sol:

. Mass of carbon = $= \frac{80 \times 90}{100} = 72\text{gm}$

No. of C-atoms $= \frac{72}{12} = 6$

Mass of Hydrogen $=\frac{80\times100}{100}=8$

No. of H-atoms $=\frac{8}{1}=8$

So molecular formula C_6H_8.

Degree of unsaturation $=6+1-\frac{8}{2}=7-4=3$

72. In Carious method of estimation of halogen, 0.25 g of an organic compound gave 0.15 g of silver bromide (AgBr). The percentage of Bromine in the organic compound is ________$\times10^{-1}$% (Nearest integer).
(Given: Molar mass of Ag is 108 and Br is $80\,g\ mol^{-1}$)

Key: 255

Sol. 1 Mole $AgBr \Rightarrow\ 108+80=188\ g/mole$

Br present in 0.15 g $AgBr$ sample$=\left(0.15\times\frac{80}{188}\right)g$

% of Br in 0.25 g organic compound

$=\left(0.15\times\frac{80}{188}\times\frac{1}{0.25}\right)\times100$

$=\frac{800\times3}{94}$

= 25.53

$=\ 255.3\ \times\ 10^{-1}$

Ans is 255 (as nearest integer)

73. The observed and normal molar masses of compound MX_2 are 65.6 and 164 respectively. The percent degree of ionisation of MX_2 is _________%.(nearest integer)

Key: 75

Sol:

$$MX_2(s)\rightarrow\quad M^{+2}_{(aq.)}+2X^{-}_{(aq.)}$$

a	$-$	$-$
$a(1-\alpha)$	$a\alpha$	$2a\alpha$

$: i = \frac{a(1+2\alpha)}{a} = (1+2\alpha)$

$\Rightarrow Van't\ Hoff\ \ factor(i) = \frac{\text{Total moles of solute after dissociation}}{\text{Initial moles of solute taken}}$

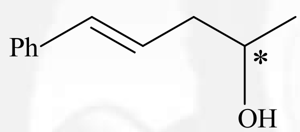
$\Rightarrow (1+2\alpha) = \frac{\frac{w}{M_{observed}}}{\frac{w}{M_{theoretical}}}$

$\Rightarrow (1+2\alpha) = \frac{M_{theoretical}}{M_{observed}} = \frac{164}{65.4} = 2.5 \quad \Rightarrow \alpha = 0.75\ or\ 75\%$

74. The possible number of stereoisomers for 5-phenylpent-4-en-2-ol is_______.

Key : 4

Sol:



$T.S.I = 2^n = 2^2 = 4$ Stereoisomers are possible
where n is stereogenic area for G.I. and O.I.

(cis, trans) × (d,l)

75. Consider a complex reaction taking place in three steps with rate constants k_1, k_2 and k_3 respectively. The overall rate constant k is given by the expression $k = \sqrt{\frac{k_1 k_3}{k_2}}$. If the activation energies of the three steps are 60, 30 and 10 $kJ\ mol^{-1}$ respectively, then the overall energy of activation in $kJ\ mol^{-1}$ is_________. (nearest integer)

Key: 20

Sol: $K = Ae^{-Ea/RT}$

$K_{eq} = \sqrt{\frac{K_1 K_3}{K_2}} = \left(\frac{A_1 A_3}{A_2} e^{-\frac{(Ea_1 + Ea_3 - Ea_2)}{RT}}\right)^{1/2}$

$= \left(\frac{A_1 A_3}{A_2}\right)^{1/2} e^{\frac{-(Ea_1 + Ea_3 - Ea_2)}{2RT}}$

$(E_a)_{net} = \frac{Ea_1 + Ea_3 - Ea_2}{2}$

$= \frac{60+10-30}{2} = 20KJ/mol$

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