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

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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 1

22-01-2025

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_22-Jan-2025_Shift-01

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. Let the triangle PQR be the image of the triangle with vertices (1,3), (3,1), (2,4) in the line $x+2y=2$. If the centroid of ΔPQR is the point (α,β), then $15(\alpha-\beta)$ is equal to ___.

1) 24 2) 19 3) 22 4) 21

Key: 3

Sol: Centroid of vertices (1,3), (3,1), (2,4) is $\left(\frac{1+3+2}{3},\frac{3+1+4}{3}\right)=\left(2,\frac{8}{3}\right)$

Image of (2,8/3) wrt the line $x+2y=2$ is (α,β)

$$\frac{h-2}{1}=\frac{k-\frac{8}{3}}{2}=\frac{-2\left(2+2\left(\frac{8}{3}\right)-2\right)}{4+1}\Rightarrow\frac{h-2}{1}=\frac{k-\frac{8}{3}}{2}=\frac{-32}{15}$$

$$h-2=-\frac{32}{15}\Rightarrow h=\frac{-2}{15}\quad\text{and}\quad\frac{k-\frac{8}{3}}{2}=-\frac{32}{15}\Rightarrow k=-\frac{24}{15}$$

$$\therefore 15(\alpha-\beta)=15\left[\left(\frac{-2}{15}\right)-\left(\frac{-24}{15}\right)\right]=22$$

02. From all the English alphabets, five letters are chosen and are arranged in alphabetical order. The total number of ways, in which the middle letter M, is

1) 14950 2) 6084 3) 5148 4) 4356

Key: 3

Sol:

$$\underbrace{A,B,C,D,.....,M}_{\text{12 Letters}}\ \underbrace{N,O,P,.....,X}_{\text{13 Letters}},Y,Z.$$

We should select 2. We should select 2.

$$\underbrace{\therefore {}^{12}C_2\times1.....M.....{}^{13}C_2\times1}_{\text{Arrangement in Alphabetical Order}}$$

$$The ways={}^{12}C_2\times{}^{13}C_2=\frac{12(11)}{2}\times\frac{(13)12}{2}=5148$$

03. Using the principle values of the inverse trigonometric functions, the sum of maximum and minimum values of $16\left(\left(\sec^{-1}x\right)^2+\left(\text{cosec}^{-1}x\right)^2\right)$ is :

1) $31\pi^2$ 2) $18\pi^2$ 3) $22\pi^2$ 4) $24\pi^2$

Key: 3

Sol: $Sec^{-1}x = a \in [0,\pi]-\left\{\frac{\pi}{2}\right\}$ $\cos ec^{-1}x = \frac{\pi}{2}-a$

$$16\left[\left(\sec^{-1}x\right)^2+\left(\text{cosec}^{-1}x\right)^2\right]=16\left[a^2+\left(\frac{\pi}{2}-a\right)^2\right]=16\left[2a^2-\pi a+\frac{\pi^2}{4}\right]$$

$$\max]_{a=\pi}=16\left[2\pi^2-\pi^2+\frac{\pi^2}{4}\right]=20\pi^2 \qquad \min]_{a=\pi/4}=16\left[\frac{2\pi^2}{16}-\frac{\pi^2}{4}+\frac{\pi^2}{4}\right]=2\pi^2$$

$\therefore Sum = 22\pi^2$

04. Let for $f(x)=7\tan^8 x+7\tan^6 x-3\tan^4 x-3\tan^2 x$, $I_1=\int_0^{\pi/4} f(x)dx$ and $I_2=\int_0^{\pi/4} x.f(x)dx$, then $7I_1+12I_2$ is equal to

1) π 2) 1 3) 2 4) 2π

Key: 2

Sol: $f(x)=7\tan^8 x+7\tan^6 x-3\tan^4 x-3\tan^2 x$

$$f(x)=7(\tan^8 x+\tan^6 x)-3(\tan^4 x+\tan^2 x)=7(\tan^6 x\sec^2 x)-3(\tan^2 x\sec^2 x)$$

$$I_1=\int_0^{\pi/4} f(x)dx=7\int_0^{\pi/4}\tan^6 x\sec^2 x.dx-3\int_0^{\pi/4}\tan^2 x\sec^2 x.dx$$

$$I_1=7\left[\frac{\tan^7 x}{7}\right]_0^{\pi/4}-3\left[\frac{\tan^3 x}{3}\right]_0^{\pi/4}=7\left(\frac{1}{7}-0\right)-3\left(\frac{1}{3}-0\right)=0$$

$$I_2=\left[x\left(\tan^7 x-\tan^3 x\right)\right]_0^{\pi/4}-\int_0^{\pi/4}\left(\tan^7 x-\tan^3 x\right)dx$$

$$I_2=0-\int_0^{\pi/4}\tan^3 x\left(\tan^2 x-1\right)\left(\tan^2 x+1\right)dx$$

Let $\tan x = t \Rightarrow \sec^2 x.dx = dt$

$$I_2=-\int_0^1 t^3\left(t^2-1\right)dt=-\left[\frac{t^6}{6}-\frac{t^4}{4}\right]_0^1=\frac{1}{12}\Rightarrow 12I_2=1 \qquad \therefore 7I_1+12I_2=0+1=1$$

05. Let $f:R\to R$ be a twice differentiable function such that $f(x+y)=f(x)f(y)$ for all $x,y\in R$. If $f'(0)=4a$ and f satisfies $f''(x)-3af'(x)-f(x)=0, a>0$, then the area of the region $R=\{(x,y)\mid 0\le y\le f(ax), 0\le x\le 2\}$ is

1) e^2+1 2) e^4-1 3) e^4+1 4) e^2-1

Key: 4

Sol : $f(x)=p^x \Rightarrow f'(x)=p^x \log p$

$f'(0)=p^0.\log p=4a \Rightarrow p=e^{4a}$

$f(x)=e^{4ax}$

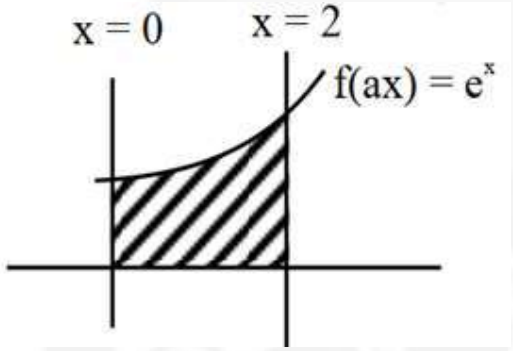
$f''(x)-3af'(x)-f(x)=0$

$16a^2e^{4ax}-12a^2e^{4ax}-e^{4ax}=0 \Rightarrow 4a^2-1=0 \Rightarrow a=\frac{1}{2}$

$f(x)=e^{2x}$

$0 \le y \le f(1/2)=e^x$.

$R.A=\int_0^2 e^x.dx=e^2-e^0=e^2-1$



06. Let $A=\{1,2,3,4,5,6,7,8,9,10\}$, $B=\{m/n : m,n \in A, m<n \text{ and } \gcd(m,n)=1\}$. then $n(B)$ is equal to

1) 37 2) 31 3) 36 4) 29

Key: 2

Sol:

$m=1,\ n=2,3,.....,10 \rightarrow 9$

$m=2,\ n=3,5,7,9 \rightarrow 4$

$m=3,\ n=4,5,7,8,10 \rightarrow 5$

$m=4,\ n=5,7,9 \rightarrow 3$

$m=5,\ n=6,7,8,9 \rightarrow 4$

$m=6,\ n=7 \rightarrow 1$

$m=7,\ n=8,9,10 \rightarrow 3$

$m=8,\ n=9 \rightarrow 1$

$m=9,\ n=10 \rightarrow 1$

31

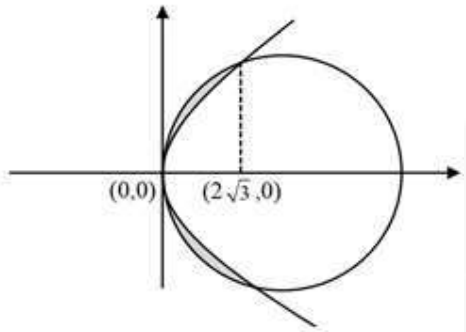
07. The area of the region, inside the circle $\left(x-2\sqrt{3}\right)^2+y^2=12$ and outside the parabola $y^2=2\sqrt{3}x$ is

1) $6\pi-16$ 2) $3\pi+8$ 3) $3\pi-8$ 4) $6\pi-8$

Key: 1

Sol: $\text{Area}=2\left[\frac{1}{4}\pi\left(2\sqrt{3}\right)^2-\left(\int_0^{2\sqrt{3}}\sqrt{2\sqrt{3}}\times\sqrt{x}.dx\right)\right]$

$$=2\left[3\pi-\sqrt{2\sqrt{3}}\left[\frac{x^{3/2}}{3/2}\right]_0^{2\sqrt{3}}\right]=2\left[3\pi-\frac{2\sqrt{2\sqrt{3}}\left(2\sqrt{3}\right)^{3/2}}{3}\right] \qquad =2\left[3\pi-\frac{3\times 2^3}{3}\right]=6\pi-16$$



08. Let $f(x)$ be a real differentiable function such that $f(0)=1$ and $f(x+y)=f(x)f'(y)+f'(x)f(y)$ for all $x,y\in R$, then $\sum_{n=1}^{100}\log_e f(n)$ is equal to.

1) 5220 2) 2525 3) 2384 4) 2406

Key: 2

Sol: $f(x+y)=f(x)f'(y)+f(y)f'(x).....(1)$

Put $x=0,y=0$

$$f(0)=2f(0)f'(0)\Rightarrow f'(0)=\frac{1}{2}$$

Put $y=0$ in equation(1)

$$f(x)=f(x)f'(0)+f(0)f'(x)$$

$$f(x)=\frac{f(x)}{2}+f'(x)\Rightarrow\frac{f(x)}{2}=f'(x)$$

$$\Rightarrow\frac{1}{2}=\frac{1}{f(x)}f'(x)\Rightarrow\int\frac{1}{2}dx=\int\frac{1}{f(x)}f'(x).dx$$

$$\Rightarrow\log_e f(x)=\frac{x}{2}+c$$

Where $f(0)=1\Rightarrow 0=0+c\Rightarrow c=0$

$$\therefore\sum_{r=1}^{100}\log_e f(n)=\sum_{r=1}^{100}\left(\frac{n}{2}\right)=\frac{1}{2}\left(\frac{100(100+1)}{2}\right)=2525$$

09. The Product of all solutions of the equation $e^{5(\log_e x)^2+3}=x^8, x>0$ is

1) $e^{6/5}$ 2) e^2 3) $e^{8/5}$ 4) e

Key: 3

Sol: Let equation had two solution be x_1 and x_2. $e^{5(\log_e x)^2+3}=x^8$

Taking log on both sides, we get

$$5(\log_e x)^2-8\log_e x+3=0 \qquad \Rightarrow\log_e x_1x_2=\frac{8}{5}\Rightarrow x_1x_2=e^{8/5}$$

10. Let $x = x(y)$ be the solution of the differential equation $y^2dx + \left(x - \frac{1}{y}\right)dy = 0$. If $x(1) = 1$, then $x\left(\frac{1}{2}\right)$ is

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

Key: 3

Sol: $y^2dx + \left(x - \frac{1}{y}\right)dy = 0 \Rightarrow \frac{dx}{dy} + x\left(\frac{1}{y^2}\right) = \frac{1}{y^3}$

$IF = e^{\int \frac{1}{y^2}dy} = e^{\frac{1}{y}-1}$

$xe^{\frac{-1}{y}} = \int e^{\frac{-1}{y}}\left(\frac{1}{y}\right)\left(\frac{1}{y^2}dy\right) = -\int e^z(z).dz = -\left[ze^z - e^z\right] + c$

$\Rightarrow xe^{\frac{-1}{y}} = -e^z\left[z-1\right] + c = -e^{\frac{-1}{y}}\left[\frac{-1}{y} - 1\right] + c$

$\Rightarrow x = \left(\frac{1}{y} + 1\right) + ce^{\frac{1}{y}} \quad \because x(1) = 1 \Rightarrow 1 + 2 + ce \Rightarrow c = \frac{-1}{e}$

$x = \left(\frac{1}{y} + 1\right) + e^{\frac{1}{y}-1}$

$y = \frac{1}{2} \Rightarrow \frac{1}{y} = 2 \qquad x = (2+1) - e^{2-1} = 3 - e$

11. Let the foci of a hyperbola be (1, 14) and (1, -12). If it passes through the point (1,6), then the length of its latus-rectum is:

1) $\frac{145}{5}$ 2) $\frac{25}{6}$ 3) $\frac{288}{5}$ 4) $\frac{24}{5}$

Key: 3

Sol: $2a = \left|\sqrt{(1-1)^2 + (14-6)^2} - \sqrt{(1-1)^2 + (-12-6)^2}\right| \Rightarrow 2a = |8-18| \Rightarrow a = 5$

$2ae = \sqrt{(1-1)^2 + (14-(-12))^2} = 26 \Rightarrow e = \frac{26}{10} = \frac{\sqrt{a^2+b^2}}{5}$

$\sqrt{25 + b^2} = 13 \Rightarrow b = 12$

length of latus rectum $= \frac{2b^2}{a} = \frac{2(144)}{5} = \frac{288}{5}$

12. Let z_1, z_2 and z_3 be three complex numbers on the circle $|z| = 1$ with $\arg(z_1) = \frac{-\pi}{4}$, $\arg(z_2) = 0$ and $\arg(z_3) = \frac{\pi}{4}$. If $\left|z_1\overline{z_2} + z_2\overline{z_3} + z_3\overline{z_1}\right|^2 = \alpha + \beta\sqrt{2}$, $\alpha, \beta \in Z$, then the value of $\alpha^2 + \beta^2$ is

1) 29 2) 41 3) 31 4) 24

Key: 1

Sol: $|z|=1,\ \arg(z_1)=\frac{-\pi}{4},\ \arg(z_1)=\frac{-\pi}{4},\ \arg(z_3)=\frac{\pi}{4}$

$$\left|z_1\overline{z_2}+z_2\overline{z_3}+z_3\overline{z_1}\right|^2=\left|\left(\frac{1}{\sqrt{2}}-\frac{i}{\sqrt{2}}\right)+\left(\frac{1}{\sqrt{2}}-\frac{i}{\sqrt{2}}\right)+\left(\frac{1}{\sqrt{2}}-\frac{i}{\sqrt{2}}\right)^2\right|^2$$

$$=\left|2\left(\frac{1}{\sqrt{2}}-\frac{i}{\sqrt{2}}\right)++\left(0+\frac{2i}{2}\right)\right|^2=\left|\sqrt{2}-i\sqrt{2}+i\right|^2=\left|\sqrt{2}+i\left(1-\sqrt{2}\right)\right|^2$$

$$=2+\left(1-\sqrt{2}\right)^2=5-2\sqrt{2}=\alpha+\beta\sqrt{2}$$

$$\therefore \alpha^2+\beta^2=(5)^2+(-2)^2=29$$

13. Let $a_1,a_2,a_3,.....$ be a GP of increasing positive terms. if $a_1a_5=28$ and $a_2+a_4=29$ then a_6 is

1) 526 2) 812 3) 628 4) 784

Key: 4

Sol: $r>1$

$$a_1a_5=28\Rightarrow a_1\left(a_1r^4\right)=28\Rightarrow a_1{}^2r^4=28\Rightarrow a_1r^2=2\sqrt{7}$$

$$a_2+a_4=29\Rightarrow a_1r+a_1r^3=29\Rightarrow a_1r(1+r^2)=29$$

$$a_1r=a_2=28,\ a_2=1=a_1r$$

$$a_6=a_1r^5=\frac{1}{\sqrt{28}}\left(\sqrt{28}\right)^5=784$$

14. A coin is tossed three times. Let X denote the number of times a tail follows a head. If μ and σ^2 denote the mean and variance of X, then the value of $64\left(\mu+\sigma^2\right)$ is

1) 48 2) 64 3) 32 4) 51

Key: 1

Sol:

$\underset{0}{HHH}$	$\underset{1}{HHT}$	$\underset{1}{HTH}$	$\underset{0}{THH}$	$\underset{1}{HTT}$	$\underset{1}{THT}$	$\underset{0}{TTH}$	$\underset{0}{TTT}$
$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$

$X=x$	0	1
$P(X=x)$	4/8	4/8

$$\mu=\sum_i x_iP(X=x_i)=\frac{4}{8}=\frac{1}{2}$$

$$\sigma^2=\sum_i\left(x_i{}^2P(X=x_i)\right)-\left(\mu^2\right)=0+\frac{1}{8}+0+\frac{1}{8}+\frac{1}{8}-\frac{1}{4}=\frac{1}{4}$$

$$\therefore 64\left(\mu+\sigma^2\right)=64\left(\frac{1}{2}+\frac{1}{4}\right)=48$$

15. Two balls are selected at random one by one without replacement from a bag containing 4 white and 6 black balls. If the probability that the first selected ball is black, given that the second selected ball is also black, is m/n, where $\gcd(m,n)=1$, then $m+n$ is equal to

1) 14 2) 11 3) 13 4) 4

Key: 1

Sol: by Baye's Theorem

$$P\left(\frac{\text{1st is black}}{\text{2nd is black}}\right)=\frac{\frac{6}{10}\times\frac{5}{9}}{\left(\frac{4}{10}\times\frac{6}{9}\right)+\left(\frac{6}{10}\times\frac{5}{9}\right)}=\frac{5}{9}=\frac{m}{n}$$

$\therefore m+n=5+9=14$

16. A circle C of radius 2 lies in the second quadrant and touches both the coordinate axes. Let *r* be the radius of a circle that has centre at the point (2, 5) and intersects the circle C at exactly two points. If the set of all possible values of r is the interval (α,β), then $3\beta-2\alpha$ is equal to

1) 10 2) 12 3) 15 4) 14

Key: 3

Sol: Centre is $C_1(-2, 2)$

Radius $r_1=2$

$C_2(2, 5)$ $r_2=r$

$|r_1-r_2|<C_1C_2<r_1+r_2$

$|r-2|<5<r+2$

$r+2>5\Rightarrow r>3$ or $|r-2|<5\Rightarrow r<7$

$3<r<7$

$(\alpha,\beta)=(3,7)$

$\therefore 3\beta-2\alpha=21-6=15$

17. Let $L_1:\frac{x-1}{2}=\frac{y-2}{3}=\frac{z-3}{4}$ and $L_2:\frac{x-2}{3}=\frac{y-4}{4}=\frac{z-5}{5}$ be two lines. Then which of the following points lies on the line of the shortest distance between L_1 and L_2?

1) $\left(2,3,\frac{1}{3}\right)$ 2) $\left(\frac{14}{3},-3,\frac{22}{3}\right)$ 3) $\left(\frac{8}{3},-1,\frac{1}{3}\right)$ 4) $\left(-\frac{5}{3},-7,1\right)$

Key: 2

Sol: $P=(2t+1,3t+2,4t+3)$ $Q=(3s+2,4s+4,5s+5)$

D.R's of PQ $=(3s-2t+1,4s-3t+2,5s-4t+2)$

D.R's of $L_1=(2,3,4)$

D.R's of $L_2=(3,4,5)$

Then, D.R's of PQ=(1,-2,1)

$$\frac{3s-2t+1}{1}=\frac{4s-3t+2}{-2}=\frac{5s-4t+2}{1}$$

On solving, $s=\frac{-1}{6},t=\frac{1}{3}$

$P=\left(\frac{5}{3},3,\frac{13}{3}\right)$ $Q=\left(\frac{3}{2},\frac{10}{3},\frac{25}{6}\right)$

Equation of PQ is $\frac{x-\frac{5}{3}}{1}=\frac{y-3}{-2}=\frac{z-\frac{13}{3}}{1}$

$\left(\frac{14}{3},-3,\frac{22}{3}\right)$ lies on PQ.

18. If $\sum_{r=1}^{n}T_r=\frac{(2n-1)(2n+1)(2n+3)(2n+5)}{64}$, then $\lim_{n\to\infty}\sum_{r=1}^{n}\left(\frac{1}{T_r}\right)$ is equal to :

1) $\frac{2}{3}$ 2) 1 3) $\frac{1}{3}$ 4) 0

Key: 1

Sol: $T_n=S_n-S_{n-1}=\frac{(2n-1)(2n+1)(2n+3)(2n+5)}{64}-\frac{(2n-3)(2n-1)(2n+1)(2n+3)}{64}$

$=\frac{8(2n-1)(2n+1)(2n+3)}{64}=\frac{(2n-1)(2n+1)(2n+3)}{8}$

$\frac{1}{T_r}=\frac{8}{(2r-1)(2r+1)(2r+3)}$

$\lim_{n\to\infty}\sum_{r=1}^{n}\left(\frac{1}{T_r}\right)=\lim_{n\to\infty}\sum_{r=1}^{n}\left(\frac{8}{(2r-1)(2r+1)(2r+3)}\right)$

$=2\lim_{n\to\infty}\sum_{r=1}^{n}\left(\frac{1}{(2r-1)(2r+1)}-\frac{1}{(2r+1)(2r+3)}\right)=2\lim_{n\to\infty}\left(\frac{1}{(1)(3)}-\frac{1}{(2n+1)(2n+3)}\right)=\frac{2}{3}$

19. Let the parabola $y=x^2+px-3$, meet the coordinate axes at the points P, Q and R. If the circle C with centre at (–1,-1) passes through the points P, Q and R, then the area of ΔPQR is

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

Key: 2

Sol: $y=x^2+px-3$

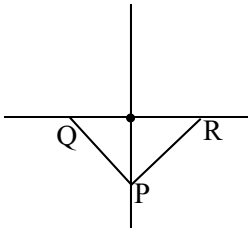
$\Rightarrow x=0\Rightarrow y=-3 \quad P(0,-3)$

Centre C=(-1, -1) and radius $r=CP=\sqrt{5}$

Equation of circle is $(x+1)^2+(y+1)^2=5$

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

Q(-3, 0) and R(1,0)



$\Delta = \frac{1}{2}(QR)(OP) = 6$

20. The number of non empty equivalence relations on the set $\{1,2,3\}$ is

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

Key: 3

Sol: No. of equivalence relations =Bell no.

Bell no.

For n=1 1

For n=2 1 2

For n=3 2 3 5

No. of equivalence relations=5

SECTION-II (NUMERICAL VALUE TYPE)

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

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

21. Let the function

$$f(x) = \begin{cases} -3ax^2 - 2, & x < 1 \\ a^2 + bx, & x \geq 1 \end{cases}$$

be differentiable for all $x \in R$, where $a > 1, b \in R$. If the area of the region enclosed by $y = f(x)$ and the line $y = -20$ is $\alpha + \beta\sqrt{3}$, $\alpha, \beta \in Z$, then the value of $\alpha + \beta$ is _____.

Key: 34

Sol:

f is continuous and differentiable at x=1

$-3a - 2 = a^2 + b$ and $-6a = b$

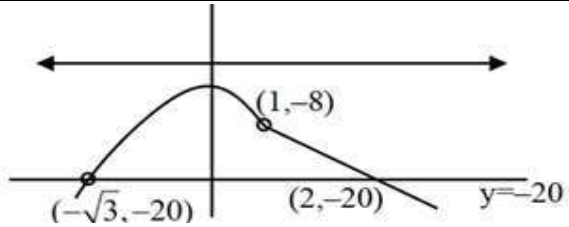
$\Rightarrow a = 1$ or 2, $\because a > 1, a = 2, b = -12$

$a^2 - 3a + 2 = 0 \qquad \Rightarrow a = 1$ or 2, $\because a > 1, a = 2, b = -12$

$$\therefore f(x) = \begin{cases} -6x^2 - 2, x < 1 \\ 4 - 12x, x \geq 1 \end{cases}$$

$$R.A. = \int_{-\sqrt{3}}^{1} \left[\left(-6x^2 - 2\right) - (-20)\right] dx + (\text{Area of } \Delta ABC)$$

$= \left(-2x^3 + 18x\right)_{-\sqrt{3}}^{1} + \frac{1}{2}(1)(12) = 22 + 12\sqrt{3} = \alpha + \beta\sqrt{3} \qquad \therefore \alpha + \beta = 22 + 12 = 34$



22. Let A be a square matrix of order 3 such that $\det(A) = -2$ and $\det\left(3adj\left(-6adj\left(3A\right)\right)\right) = 2^{m+n}.3^{mn}$ $m > n$ then $4m+2n$ is equal to _____.

Key: 34

Sol: $|A| = -2$

$\left|3adj\left(-6adj\left(3A\right)\right)\right| = 3^3\left|adj\left(-6adj\left(3A\right)\right)\right|$

$= 3^3\left|-6Adj(3A)\right|^2 = 3^3(-6)^6\left|Adj(3A)\right|^2$

$= 3^3.2^6.3^6\left|3A\right|^4 = 3^9.2^6.3^{12}\left|A\right|^4 = 2^{10}3^{21} = 2^{m+n}.3^{mn}$

$m+n=10, mn=21 \Rightarrow m=7, n=3$

$4m+2n = 28+6 = 34$

23. let $L_1 : \frac{x-1}{3} = \frac{y-1}{-1} = \frac{z+1}{0}$ and $L_2 : \frac{x-2}{2} = \frac{y}{0} = \frac{z+4}{\alpha}$, $\alpha \in R$, be two lines which intersect at the point B. If P is the foot of perpendicular from the point A(1,1-1) on L_2, then the value of $26\alpha(PB)^2$ is _____.

Key: 216

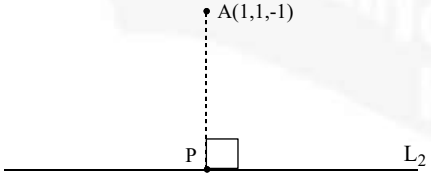
Sol: let $L_1 : \frac{x-1}{3} = \frac{y-1}{-1} = \frac{z+1}{0} = t$ and $L_2 : \frac{x-2}{2} = \frac{y}{0} = \frac{z+4}{\alpha} = s$

$B = (3t+1, -t+1, -1) = (2s+2, 0, \alpha s-4)$

$3t+1 = 2s+2, \quad -t+1 = 0 \Rightarrow t = 1, \quad -1 = \alpha s - 4$

$\Rightarrow 4 = 2s+2 \Rightarrow s = 1 \quad \Rightarrow \alpha = 3$

$\therefore B = (4,0,-1)$



Let $P = (2\lambda+2, 0, 3\lambda-4)$

D.R.s of AP=$(2\lambda+1, -1, 3\lambda-3)$

$AP \perp L_2 \Rightarrow 2(2\lambda+1)+0+3(3\lambda-3) = 0 \Rightarrow \lambda = \frac{7}{13}$

$$P=\left(\frac{40}{13},0,\frac{-31}{13}\right)$$

$$PB^2=\frac{468}{169}$$

$$\therefore 26\alpha PB^2=26(3)\left(\frac{468}{169}\right)=216$$

24. If $\sum_{r=0}^{5}\frac{^{11}C_{2r+1}}{2r+2}=\frac{m}{n}$, $\gcd(m,\,n)=1$, then $m-n$ is equal to _____.

Key: 2035

Sol:

$$^{n+1}C_{r+1}=\frac{n+1}{r+1}\,^{n}C_{r}$$

Putting $n=11$ and r by $2r+1$

$$^{11}C_{2r+1}\cdot\frac{12}{2r+2}=\,^{12}C_{2r+2}\Rightarrow\frac{^{11}C_{2r+1}}{2r+2}=\frac{^{12}C_{2r+2}}{12}$$

$$\therefore\sum_{r=0}^{5}\frac{^{11}C_{2r+1}}{2r+2}=\frac{1}{12}\sum_{r=0}^{5}\,^{12}C_{2r+2}=\frac{1}{12}\left[\,^{12}C_2+\,^{12}C_4+.....+\,^{12}C_{12}\right]$$

$$=\frac{1}{12}\left[\left(\,^{12}C_0+\,^{12}C_2+\,^{12}C_4+.....+\,^{12}C_{12}\right)-\,^{12}C_0\right]=\frac{2^{11}-1}{12}=\frac{m}{n}$$

$$\therefore m-n=(2^{11}-1)-12=2035$$

25. Let $\vec{c}$ be the projection vector of $\vec{b}=\lambda\hat{i}+4\hat{k},\lambda>0$, on the vector $\vec{a}=\hat{i}+2\hat{j}+2\hat{k}$. If $\left|\vec{a}+\vec{c}\right|=7$, then the area of the parallelogram formed by the vectors $\vec{b}$ and $\vec{c}$ is _____

Key: 16

Sol: $\vec{c}=\left(\frac{\vec{b}.\vec{a}}{\left|\vec{a}\right|^2}\right)\vec{a}=\vec{c}=\left(\frac{\lambda+8}{9}\right)\vec{a}$

$$\left|\vec{a}+\vec{c}\right|=7\Rightarrow\left|\vec{a}+\left(\frac{\lambda+8}{9}\right)\vec{a}\right|=7\Rightarrow\left|\lambda+17\right|=21\Rightarrow\lambda=4(\lambda>0)\qquad\vec{c}=\frac{4}{3}\vec{a}$$

Area of parallelogram $=\left|\vec{b}\times\vec{c}\right|=\frac{4}{3}\left|\vec{b}\times\vec{a}\right|=\frac{4}{3}\sqrt{144}=16$

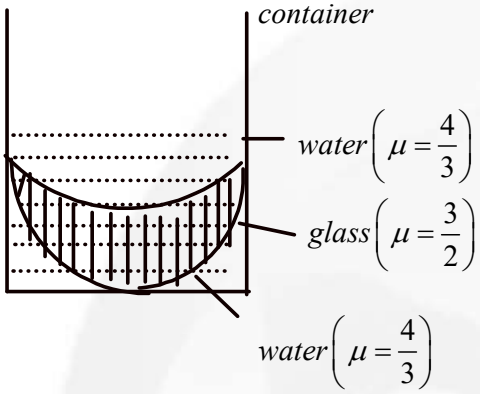
PHYSICS

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. In the diagram given below, there are three lenses formed, considering negligible thickness of each of them as compared to $|R_1|$ and $|R_2|$ i.e., the radii of curvature for upper and lower surfaces of the glass lens, the power of the combination is



1) $\frac{1}{6}\left[\frac{1}{|R_1|}+\frac{1}{|R_2|}\right]$ **2)** $-\frac{1}{6}\left[\frac{1}{|R_1|}+\frac{1}{|R_2|}\right]$ **3)** $-\frac{1}{6}\left[\frac{1}{|R_1|}-\frac{1}{|R_2|}\right]$ **4)** $\frac{1}{6}\left[\frac{1}{|R_1|}-\frac{1}{|R_2|}\right]$

Key: 3

Sol: $\frac{1}{f_{e_2}}=\frac{1}{f_1}+\frac{1}{f_2}+\frac{1}{f_3}$

$Pe_q=P_1+P_2+P_3$

$P_1=\left(\frac{4}{3}-1\right)\left(\frac{1}{\infty}-\frac{1}{-R_1}\right)$

$=\frac{1}{2}\left(\frac{1}{R_2}-\frac{1}{R_1}\right)$

$P_1=\frac{1}{3R_1}$

$P_2=\frac{1}{2}\left(\frac{-1}{R_1}=\frac{1}{-R_2}\right)$

$P_3=\frac{1}{3}\left(-\frac{1}{R_2}-\frac{1}{\infty}\right)=\frac{-1}{3R_2}$

$P_{e_2}=\frac{-1}{6}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

27. The work functions of cesium (Cs) and lithium (Li) metals are 1.9eV & 2.5eV, respectively. If we incident a light of wavelength 550 nm on these two metal surfaces, then photo –electric effect is possible for the case of

1) Li Only **2)** Neither Cs nor Li

3) Both Cs and Li **4)** Cs only

Key: 4

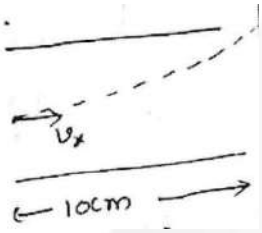
Sol: $E=\frac{12400}{\lambda(A^{\bullet})}=\frac{12+0}{\lambda(nm)}=\frac{1240}{550}=2.25\ ev$

28. An electron is made to enter symmetrically between two parallel and equally but oppositely charged metal plates, each of 10cm length. The electron emerges out of the electric field region with a horizontal component of velocity $10^6 m/s$. if the magnitude of the electric field between the plates is $9.1 V/cm$, then the vertical component of velocity of electron is (mass of electron=9.1×10^{-31}kg, and charge of electron=1.6×10^{-19} C).

1) 0 **2)** $16\times10^4 m/s$ **3)** $16\times10^6 m/s$ **4)** $1\times10^6 m/s$

Key: 3

Sol:



time $t=\dfrac{l}{v_x}=\dfrac{10\times10^{-2}}{10^6}=10^{-7}$

$$v_y=u_y+oyt=o+\left(\frac{eE}{m}\right)t$$

$$=\frac{1.6\times10^{-19}}{9.1\times10^{-31}}\times9.1\times10^{-2}\times10^{-7}$$

$$=16\times10^6 \quad m/s$$

29. A parallel capacitor of capacitance $40\mu F$ is connected to a 100V power supply. Now the intermediate space between the plates is filled with a dielectric material of dielectric constant K=2. Due to the introduction of dielectric material, the extra charge and the change in the electrostatic energy in the capacitor, respectively, are

1)2 mC and 0.4J **2)**2mC and 0.2 J **3)**4 mC and 0.2J **4)**8mC and 2.0J

Key: 3

Sol: $\Delta q=(kc-c)\,v$

$$=4.0\times10^{-6}\times100=4mc$$

$$\Delta U=\frac{1}{2}C^1V^2-\frac{1}{2}C\,V^2$$

$$=\frac{1}{2}CV^2(2-1)$$

$$=\frac{1}{2}CV^2=\frac{1}{2}\times4.0\times10^{-6}\times10000$$

$$=0.2J$$

30. Given is a thin convex lens of glass (refractive index μ)and each side having radius of curvature R. one side is polished for complete reflection. At what distance from the lens, an object be placed on the optic axis so that the image gets formed on the object itself?

1) $R/(2\mu-3)$ **2)** R/μ **3)** μR **4)** $R/(2\mu-1)$

Key: 4

Sol: $P_{eo_2} = 2P_1 + P_m$

$$-\frac{1}{f_n} = \frac{2}{f_1} - \frac{1}{f_m}$$

$$= \frac{4(u-1)}{R} - \frac{2}{-R} = \frac{1}{R}(4u - 4 + 2)$$

$$-\frac{1}{feo_2} = \frac{1}{R}(4u - 2)$$

$$\frac{1}{feo_2} = \frac{-1}{R}(4u - 2)$$

$$feo_2 = \frac{R}{2}$$

$$R = 2\,feo_2 = -2\left(\frac{R}{4u-2}\right)$$

$$= R\,\frac{-R}{2u-1}$$

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

Assertion-(A)- If young's double slit experiment is performed in an optically denser medium than air, then the consecutive fringes come closer.

Reason-(R): The speed of light reduces in an optically denser medium than air while its frequency does not change.

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

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

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

3) Both (**A)** and (R) are true but (R) is not the correct explanation of (**A)**.

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

Key: 4

Sol: $fringe\ \ width\ \ \beta = \frac{\lambda D}{d}$

$$and\ \ u = \frac{\lambda o}{\lambda}$$

32. Two spherical bodies of same materials having radii 0.2m and 0.8 m are placed in same atmosphere. The temperature of the smaller body is 800k and temperature of the bigger body is 400K.. If the energy radiated from the smaller body is E, the energy radiated from the smaller body is E, the energy radiated from the bigger body is (assume, effect of the surrounding temperature to be negligible),

1)E **2)** 64E **3)** 16E **4)** 256E

Key: a

Sol: $\frac{do}{dt} = \sigma AeT^{+}$

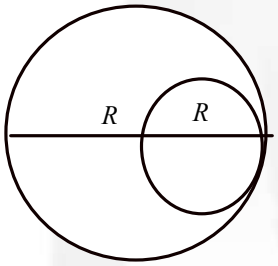
$P\alpha AT^{+}$

$$\frac{Psmaler}{P_{larger}} = \frac{(0.2)^2 \times (800)^{+}}{(0.8)^2 \times (400)^4}$$

$$= \frac{1}{16} \times 16 = 1$$

$$P_{smaller} = P_{larger}$$

33. A uniform circular disc of radius 'R' and mass 'M' is rotating about an axis perpendicular to its plane & passing through its center. A small circular part of radius R/2 is removed from the original disc as shown in the figure. Find the moment of inertia of the remaining part of the original disc about the axis as given above.



1) $\frac{7}{32}MR^2$ **2)** $\frac{17}{32}MR^2$ **3)** $\frac{13}{32}MR^2$ **4)** $\frac{9}{32}MR^2$

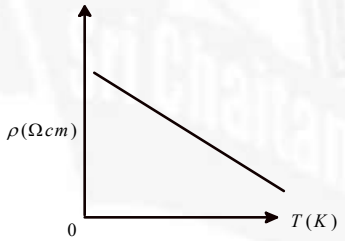
Key: 3

Sol: $I_{remainry} = I_{total} - I_{removed}$

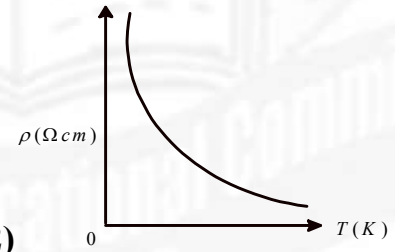
$$\frac{Me^2}{2} - \left[\frac{\frac{M}{4}\left(\frac{R}{2}\right)^2}{2} + \frac{M}{4}\left(\frac{R}{2}\right)^2\right] = \frac{13}{32}MR^2$$

34. Which of the following resistivity (ρ) v/s temperature (T) curves is most suitable to be used in wire bound standard resistors?

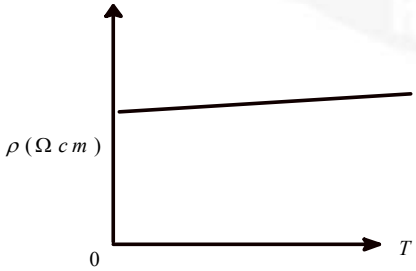
1)



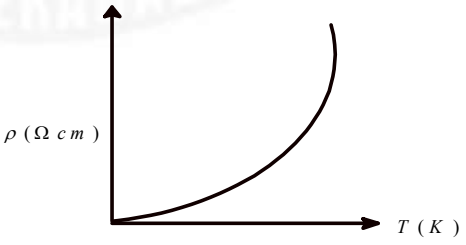
2)



3)



4)



Key: 3

Sol: Conceptual

35. Given below are two statements:

Statement-I: The equivalent emf of two nonideal batteries connected in parallel is smaller than either of the two emfs.

Statement-II: The equivalent internal resistance of two non ideal batteries connected in parallel is smaller than the internal resistance of either of the two batteries.

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

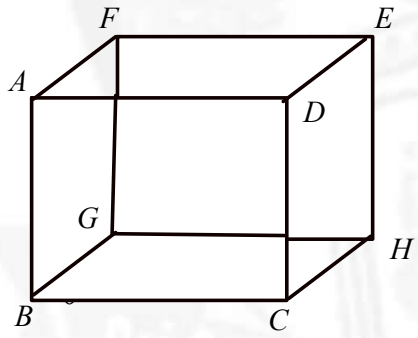
3)Statement-I is false but statement-II is true.

4)Statement-I is true but Statement-II is false.

Key: 3

Sol: $E_{eo_2}=\dfrac{\dfrac{E_1}{r_1}+\dfrac{E_2}{r_2}}{\dfrac{1}{r_1}+\dfrac{1}{r_2}}$

36. A line charge of length '$\frac{a}{2}$' is kept at the center of an edge BC of a cube ABCDEFGH having edge length 'a' as shown in the figure. If the density of line charge is λ C per unit length, then the total electric flux through all the faces of the cube will be ……(Take, ε_0 as the free space permittivity)



1) $\dfrac{\lambda a}{4\varepsilon_0}$ **2)** $\dfrac{\lambda a}{8\varepsilon_0}$ **3)** $\dfrac{\lambda a}{16\varepsilon_0}$ **4)** $\dfrac{\lambda a}{2\varepsilon_0}$

Key: 2

Sol: $cube=\dfrac{\lambda\left(\dfrac{a}{2}\right)}{4}=\dfrac{\lambda a}{8}$

$\phi=\dfrac{2_{in}}{e_0}=\dfrac{\lambda a}{8\in_0}$

37. A closed organ and an open organ tube are filled by two different gases having same bulk modulus but different densities ρ_1 and ρ_2, respectively. The frequency of 9th harmonic of closed tube is identical with 4th harmonic of open tube. If the length of the closed tube is 10cm and the density ratio of the gases is $\rho_1:\rho_2=1:16$, then the length of the open tube is:

1) $\frac{15}{9}cm$ **2)** $\frac{20}{7}cm$ **3)** $\frac{15}{7}cm$ **4)** $\frac{20}{9}cm$

Key: 4

Sol: 9th harmonic of closed

$$Pipe = \frac{9v_1}{4p_1}$$

4th harmonic or open pipe $= \frac{4v_2}{2p_2} = \frac{2v_2}{p_2}$

$\frac{9v_1}{4l_1} = \frac{2v_2}{l_2}$ $\frac{9}{4P_1}\sqrt{\frac{B}{P_1}} = \frac{2}{l_2}\sqrt{\frac{B}{P_2}}$ $l_2 = \frac{20}{9}\,cm$

38. An amount of ice of mass $10^{-3}kg$ kg and temperature $-10°C$ is transformed to vapour of temperature $110°C$ by applying heat. The total amount of work required for this conversion is, (Take ,specific heat of ice=2100J $kg^{-1}K^{-1}$, specific heat of water =4180 J $kg^{-1}K^{-1}$, specific heat of steam =1920 J $kg^{-1}K^{-1}$, Latent heat of ice= $3.35\times10^5 Jkg^{-1}$ and Latent heat of steam= $2.25\times10^6 Jkg^{-1}$)

1)3003J **2)** 3022J **3)** 3024J **4)** 3043J

Key: 4

Sol: $\Delta Q_1 = mS\Delta T = 10^{-3}\times2100\times10 = 21J$

$\Delta Q_1 = mL = 10^{-3}\times3.35\times10^5$ =335J

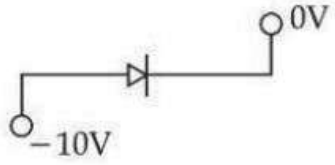
$\Delta Q_3 = mS\Delta T = 10^{-3}\times4180\times100 = 418J$

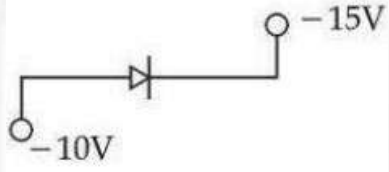
$\Delta Q_4 = mL = 10^{-3}\times2.25\times10^6 = 2250J$

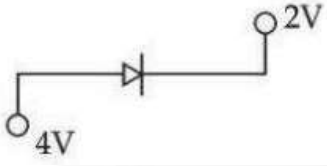
$\Delta Q_5 = mS\Delta T = 10^{-3}\times1920\times10 = 19.2J$

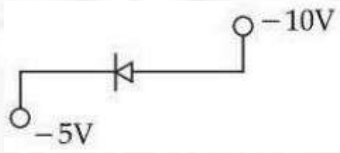
$\Delta Q_{total} = 3043.2J$

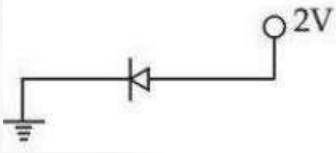
39. Which of the following circuits represents a forward biased diode?

A) 

B) 

C) 

D) 

e) 

Choose the correct answer from the options given below.

1) (C)and (E) only **2)** (**A**) and (**D**) only

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

Key: 4

Sol: Conceptual

40. An electron in the ground state of the hydrogen atom has the orbital radius of 5.3×10^{-11} m while that for the electron in third excited state is 8.48×10^{-10} m. The ratio of the de Broglie wavelengths of electron in the ground state to that in the excited state is

1)3 **2)**16 **3)**4 **4)** 9

Key: 3

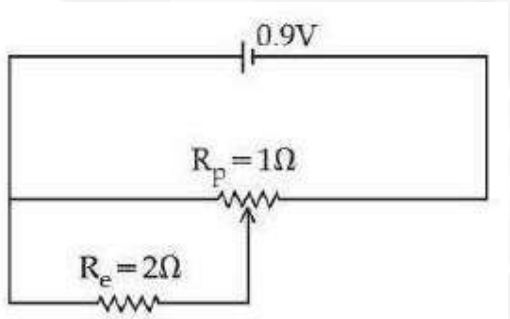
Sol: $\lambda=\frac{h}{mr}$ $mvr=\frac{nh}{2\pi}$

$mv=\frac{nh}{2\pi r}$ $\lambda=\frac{2\pi rh}{nh}$ $\lambda\alpha\frac{r}{n}$

$\frac{\lambda_1}{\lambda_2}=\frac{r_1n_4}{n_1r_4}=\frac{5.3\times10^{-11}\times4}{1\times84.8\times10^{11}}$

$\frac{\lambda_1}{\lambda_2}=\frac{1}{4}$

41.

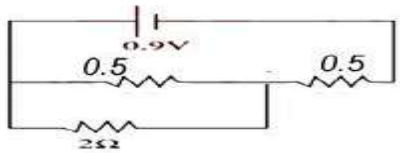


Sliding contact of a potentiometer is in the middle of the potentiometer wire having resistance $R_P=1\Omega$ as shown in the figure. An external resistance $R_e=2\Omega$ of is connected via the sliding contact the electric current in the circuit is :

1)1.0A **2)** 1.35A **3)** 0.3A **4)**0.9A

Key: 1

Sol:



$\text{Re}q=0.5+\frac{0.5\times2}{2+0.5}$

$=\frac{5}{10}+\frac{10}{25}=\frac{45}{50}$ $=0.9\pi$

$i=\frac{V}{R}=\frac{0.9}{0.9}=1A$ $\lambda=\frac{2\pi rh}{nh}$ $\lambda\alpha\frac{r}{n}$

$\frac{\lambda_1}{\lambda_2}=\frac{r_1n_4}{n_1r_4}=\frac{5.3\times10^{-11}\times4}{1\times84.8\times10^{11}}$ $\frac{\lambda_1}{\lambda_2}=\frac{1}{4}$

42. Given below are two statements:

Statement I- In a Vernier Caliper's, one Vernier scale division is always smaller than one main scale division.

Statement II- The Vernier constant is given by one main scale division multiplied by the number of Vernier scale divisions.

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

1) Both Statement I and Statemente II are false

2) Statement I is true but Statement II is false

3) Both Statement I and Statement II are true

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

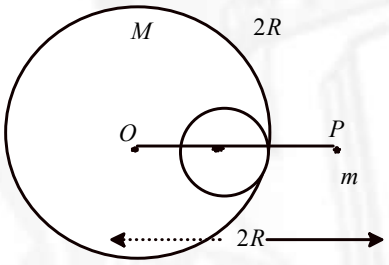
Key: 2

Sol: In general on c V. S. O is

Smaller than 1 MSD

$$LC = \frac{1M.SD}{No.of\ vernierscale\ divisions}$$

43. A small point of mass m is placed at a distance 2R from the center 'O' of a big uniform solid sphere of mass 'M' and radius R. The gravitational force on 'm' due to 'M' is F_1. A spherical part of radius R/3 is removed from big sphere as shown in the figure and the gravitational force on m due to remaining part of M is found to be F_2.The value of ratio $F_1 : F_2$ is



1)12:9 **2)** 12:11 **3)** 16:9 **4)** 11:10

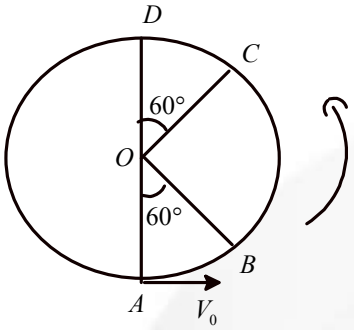
Key: 2

Sol: $F_1 = \frac{GMm}{(2R)^2}$

$$F_2 = F_{total} - F_{remored} = \frac{GMm}{(2R)^2} - \frac{G\left(\frac{M}{27}\right)m}{\left(\frac{4R}{3}\right)^2} = \frac{11}{48}\frac{GMm}{R^2}$$

$$F_1 : F_2 = 12 = 11$$

44. A bob of mass m is suspended at a point 'O' by a light string of length 'l' and left to perform vertical motion (circular) as shown in figure. Initially, by applying horizontal velocity V_0 at the point 'A', the string becomes slack when the bob reaches at the point 'D'. The ratio of the kinetic energy of the bob at the points B and C is



1) 1 **2)** 3 **3)** 2 **4)** 4

Key: 3

Sol: Form conservation of energy

$$\frac{1}{2}mV_A^2 = \frac{1}{2}mV_B^2 + mgh$$

$$\frac{1}{2}m(5g\ell) = \frac{1}{2}mV_B^2 + mg\left(\frac{\ell}{2}\right)$$

$$KE_C = \frac{1}{2}mg\ell + mg\frac{\ell}{2} = mg\ell \qquad \frac{KE_B}{KE_C} = 2$$

45. If B is magnetic field and μ_0 is permeability of free space, then the dimensions of $\left(B/\mu_0\right)$ is

1) $LT^{-2}A^{-1}$ **2)** $MT^{-2}A^{-1}$ **3)** $ML^2T^{-2}A^{-1}$ **4)** $L^{-1}A$

Key: d

Sol: $B = \mu_0 ni$

$$\frac{B}{\mu_0} = ni = L^{-1}A^1$$

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. The position vectors of two 1 kg particles,(A) and (B) , are given by

$\vec{r_A} = \left(\alpha_1 t^2\hat{i} + \alpha_2 t\hat{j} + \alpha_3 t\hat{k}\right)$ m and $\vec{r_B} = \left(\beta_1 t\hat{i} + \beta_2 t^2\hat{j} + \beta_3 t\hat{k}\right)$ respectively ;

$(\alpha_1 = 1m/s^2, \alpha_2 = 3nm/s, \alpha_3 = 2m/s, \beta_1 = 2m/s, \beta_2 = -1m/s^2, \beta_3 = 4pm/s)$

Where t is time , n and P are constants. At t=1 s, $\left|\vec{V_A}\right| = \left|\vec{V_B}\right|$ and velocities $\vec{V_A}$ and $\vec{V_B}$ of the particles are orthogonal to each other. At t=1 s, the magnitude of angular momentum of particle (A) with respect to the position of particle (B) is $\sqrt{L}kgm^2s^{-1}$. The value of L is ……..

Key: 90

Sol: $\vec{V}_A = 2t\hat{i} + 3n\hat{j} + 2\hat{k}$ $\vec{V}_B = 2\hat{i} - 2t\hat{j} + 4p\hat{k}$

$\vec{V}_A.\vec{V}_B = 0$ 4- 6n + 8p = 0

$3^n = 2 + 4p$ $\left|\vec{V}_A\right| = \left|\vec{V}_B\right|$

$4 + 9n^2 + 4 = 4 + 4 + 16p^2$ $P = \frac{-1}{4}$ & $n = \frac{1}{3}$

$\vec{L} = m_A\left(\vec{r}_{A/B} - X\vec{V}_A\right)$

$\vec{r}_{A/B} = (\alpha_1 - \beta_1)\hat{i} + (\alpha_2 - \beta_2)\hat{j} + (\alpha_3 - \beta_3)\hat{k} = (1-2)\hat{i} + (1+1)\hat{j} + 3\hat{k}$

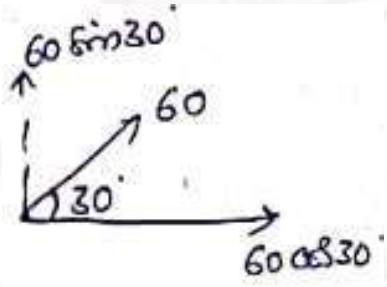
$$\vec{L} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -1 & 2 & 3 \\ 2 & 1 & 2 \end{vmatrix} = \hat{i} + 8\hat{j} - 5\hat{k}$$

$\left|\vec{L}\right| = \sqrt{1 + 654 + 25} = \sqrt{90}$

47. A partical is projected at an angle of $30°$ from horizontal at a speed of 60m/s. The height traversed by the particle in the first second is h_0 and height traversed in the last second, before it reaches the maximum height, is h_1. the ratio $h_0 : h_1$ is (Take, g=10m/s^2)

Key: 5

Sol:



$s_1 = 30 \times 1 - \frac{1}{2}(10)1 = 25$ $s_2 = 30 \times \left(\frac{-10}{2}\right)(2 \times 3 - 1)$ =5

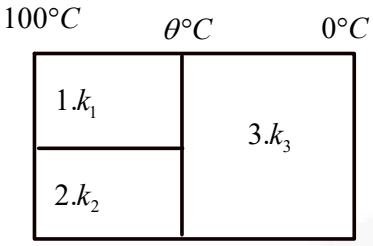
$\frac{s_1}{s_2} = \frac{25}{5} = 5$

48. Two soap bubbles of radius 2 cm and 4 cm . respectively, are in contact with each other. The radius of curvature of the common surface , in cm, is ……..

Key: 4

Sol: $r = \frac{r_1 r_2}{r_1 - r_2} = \frac{2 \times 4}{4 - 2}$ = 4 Cm

49. Three conductors of same length having thermal conductivity k_1, k_2 and k_3 are connected as shown in figure.

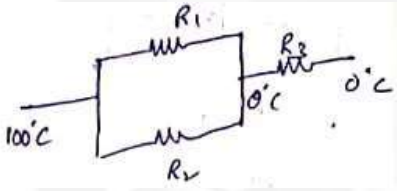


Area of cross sections of 1st and 2nd conductor are same and for 3rd conductor it is double of the 1st conductor. The temperatures are given in the figure . In steady state condition, the value of θ is …….. $^{\circ}C$

(Given : $k_1 = 60 Js^{-1}m^{-1}K^{-1}, k_2 = 120 Js^{-1}m^{-1}K^{-1}, k_3 = 135 Js^{-1}m^{-1}K^{-1}$)

Key: 40

Sol:



$$R_1 = \frac{2L}{k_1 A} \qquad R_2 = \frac{2L}{k_2 A} \qquad R_3 = \frac{L}{k_3 A} \qquad \frac{0-100}{\left(\frac{R_1 R_2}{R_1 + R_2}\right)} + \frac{\theta - 0}{R_3} = 0 \;\; \theta = 40$$

50. The driver sitting inside a parked car is watching vehicles approaching from behind with the help of his side view mirror, which is a convex mirror with radius of curvature R=2m. Another car approaches him from behind with a uniform speed of 90km/hr. When the car is at a distance of 24m from him, the magnitude of the acceleration of the image of the car in the side view mirror is 'a'. The value of 100a is …….. m/s^2

Key: 8

Sol: $V = \frac{uf}{u-f} = \frac{24}{25} \qquad m = \frac{-v}{u} = \frac{24}{25(-24)} = \frac{1}{25}$

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \qquad v_i = -m^2 v_0 = -\frac{1}{25}$$

$$\frac{-1}{v^2}\left(\frac{dv}{dt}\right) + \frac{1}{u^2}\left(\frac{du}{dt}\right) = 0 \; a_1 = \frac{2}{v}\left(v_i^2\right) - \frac{2v^2}{u^3}\left(v_0^2\right)$$

$$= \frac{2}{(24)25} - \frac{2}{24} = -\frac{2}{25} \qquad 100a_1 = \frac{2}{25} \times 100 = 8$$

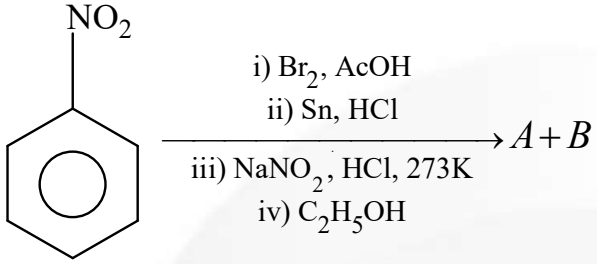
CHEMISTRY **Max Marks: 100**

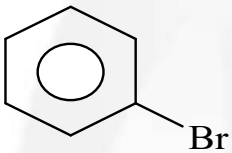
SECTION-I (SINGLE CORRECT ANSWER TYPE)

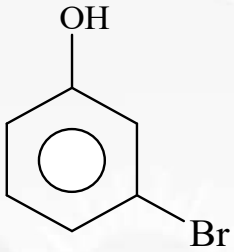
This section contains **20 Multiple Choice Questions.** Each question has 4 options (1), (2), (3) and (4) for its answer, out of which ONLY ONE option can be correct.

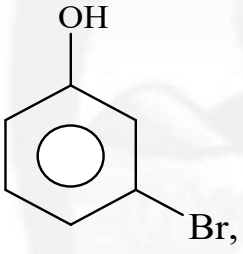
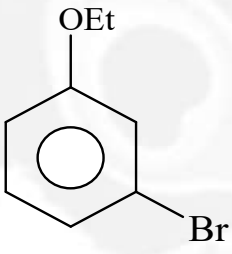
Marking scheme: +4 for correct answer, 0 if not attempted and –1 in all other cases.

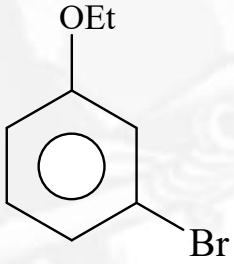
51. The products formed in the following reaction sequence are



1)  , CH_3-CHO

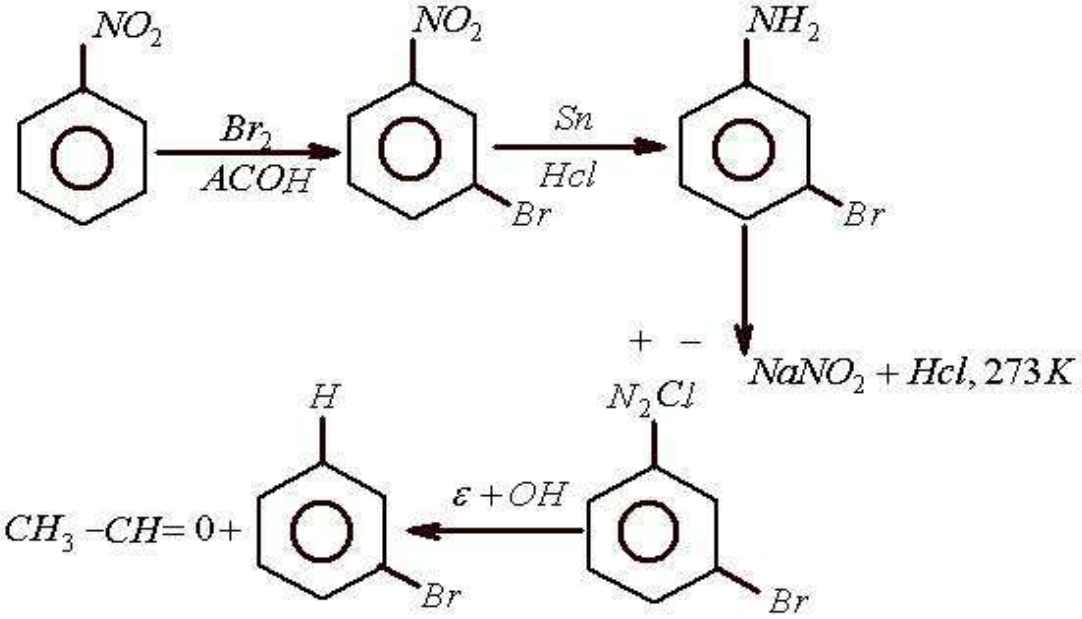
2)  , CH_3-CHO

3)  

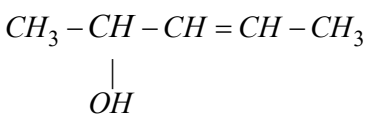
4)  , CH_3-COOH

Key: 1

Sol:



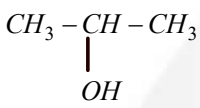
52. How many different stereoisomers are possible for the given molecule?



1) 4 **2)** 1 **3)** 3 **4)** 2

Key: 1

Sol:



$n=$ stereo centres / stereogenic area; 2

Total $SI=2^2=4$

53. From the magnetic behavior of $\left[NiCl_4\right]^{2-}$ (paramagnetic) and $\left[Ni(CO)_4\right]$ (diamagnetic), choose the correct geometry and oxidation state.

1) $\left[NiCl_4\right]^{2-}: Ni^{II}$, tetrahedral
$\left[Ni(CO)_4\right]: Ni^{II}$, square planar

2) $\left[NiCl_4\right]^{2-}: Ni^{II}$, square planar
$\left[Ni(CO)_4\right]: Ni(0)$, square planar

3) $\left[NiCl_4\right]^{2-}: Ni^{II}$, tetrahedral
$\left[Ni(CO)_4\right]: Ni(0)$, tetrahedral

4) $\left[NiCl_4\right]^{2-}: Ni(0)$, tetrahedral
$\left[Ni(CO)_4\right]: Ni(0)$, square planar

Key: 3

Sol: $\left[NiCl_4\right]^{2-} \Rightarrow Ni \to +2$, tetrahedral
$\left[Ni(CO)_4\right] \Rightarrow Ni \to 0$, tetrahedral

54. A vessel at 1000K contains CO_2 with pressure of 0.5atm. Some of CO_2 is converted into CO on addition of graphite. If total pressure at equilibrium is 0.8atm, then Kp is

1) 0.18 atm **2)** 3 atm **3)** 1.8 atm **4)** 0.3 atm

Key: 3

Sol:

$$\underset{0.5}{CO_2(g)} + C(s) \rightleftharpoons \underset{0}{2CO(g)}$$

$$\underset{0.5-x}{} \qquad \underset{2x}{}$$

$0.5+x=0.8 \Rightarrow x=0.3$

$$Kp=\frac{0.6\times 0.6}{0.2}=1.8atm$$

55. A liquid when kept inside a thermally insulated closed vessel at 25^oC was mechanically stirred from outside. What will be the correct option for the following thermodynamic parameters?

1) $\Delta U = 0, q < 0, w > 0$ **2)** $\Delta U < 0, q = 0, w > 0$

3) $\Delta U = 0, q = 0, w = 0$ **4)** $\Delta U > 0, q = 0, w > 0$

Key: 4

Sol: Adiabatic process $\Rightarrow q = 0$

Work done on the system $\Rightarrow W > 0$

$\Delta U = q + w \Rightarrow \Delta U > 0$

56. The incorrect statements regarding geometrical isomerism are.

a) Propene shows geometrical isomerism.

b) Trans-isomer has identical atoms/groups on the opposite sides of the double bond.

c) Cis-but-2-ene has higher dipole moment than trans-but-2-ene.

d) 2-metylbut-2-ene shows two geometrical isomers.

e) Trans-isomer has lower melting point than cis isomer

Choose the correct answer from the options given below

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

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

Key: 1

Sol: A) $CH_3 - CH = CH_2 :\rightarrow$ donot show GI

B) donot shows GI

$$CH_3 - \underset{\underset{CH_3}{|}}{C} = CH - CH_3$$

E) Trans Isomer has high melting point than cis.

57. Given below are two statements :

Statement - I : One mole of propyne reacts with excess of sodium to liberate half a mole of H_2 gas.

Statement - II : four g of propyne reacts with $NaNH_2$ to liberate NH_3 gas which occupies 224mL at STP.

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

1) Both Statement – I and Statement – II are correct.

2) Statement – I is incorrect but Statement – II is correct.

3) Statement – I is correct but Statement – II is incorrect.

4) Both Statement – I and Statement – II are incorrect.

Key: 3

Sol: $CH_3-C\equiv C-H+Na\rightarrow H_3C\equiv\overline{C}Na^+\frac{1}{2}H_2$

$CH_3-C\equiv C-H+NaNH_2\rightarrow CH_3-C\equiv\overline{C}Na^++NH_3$

Mwt:- $40g$

$1mole\rightarrow 1mole\ NH_3$

$0.1mole\rightarrow 0.1mole\,NH_3$

$0.1mole\,NH_3\rightarrow 2240mL\ NH_3$

Statement – I:- correct Statement – II:- NH_3

58. Radius of the first excited state of Helium ion is given as

$a_0\rightarrow$ radius of first stationary state of hydrogen atom.

1) $r=2a_0$ **2)** $r=\frac{a_0}{4}$ **3)** $r=4a_0$ **4)** $r=\frac{a_0}{2}$

Key: 1

Sol: $r\propto\frac{n^2}{Z}$

59. Which of the following statement is not true for radioactive decay?

1) Decay constant increases with increase in temperature

2) Decay constant does not depend upon temperature

3) Half life is ln 2 times of $\frac{1}{\text{rate constant}}$

4) Amount of radioactive substance remained after three half lives is 1/8th of original amount

Key: 1

Sol: The decay constant depends only on the particular radioactive nuclide and decay mechanism involved. It does not depend on the number of nuclei present or on any external conditions (such as temperature).

60. Which of the following acids is a Vitamin.

1) Adipic acid **2)** Ascorbic acid **3)** Aspartic acid **4)** Saccharic acid

Key: 2

Sol: Ascorbic acid Vitamin C.

61. Match List-I with List-II.

	List-I		List-II
A	$Al^{3+} < Mg^{2+} < Na^{+} < F^{-}$	I)	Ionisation Enthalpy
B	B < C < O < N	II)	Metallic character
C	B < Al < Mg < K	III)	Electronegativity
D	Si < P < S < Cl	IV)	Iconic radii

Choose the correct answer from the options given below:

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

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

Key: 3

Sol: $Al^{3+} < Mg^{3+} < Na^{+} < F^{-}$: Ionic radii

B < C < N < O : Ionisation Enthalpy

B < Al < Mg < K : Metallic character

Si < P < S < Cl : Electronegativity

62. A solution of aluminium chloride is electrolysed for 30 minutes using a current of 2A.

The amount of the aluminium deposited at the cathode is _____.

[Given: molar mass of aluminium and chlorine are $27g\ mol^{-1}$ and $35.5g\ mol^{-1}$ respectively.

Faraday constant= $96500\ C\ mol^{-1}$]

1) 0.441g **2)** 1.007g **3)** 0.336g **4)** 1.660g

Key: 3

Sol: Amount of Al deposited $= \frac{30\times60\times2\times9}{96500} = 0.336g$

63. In which of the following complexes the CFSE, Δ_o will be equal to zero?

1) $\left[Fe(en)_3\right]Cl_3$ **2)** $\left[Fe\left(NH_3\right)_6\right]Br_2$ **3)** $K_3\left[Fe\left(SCN\right)_6\right]$ **4)** $K_4\left[Fe\left(CN\right)_6\right]$

Key: 3

Sol: SCN^{-} is a weak field ligand

$Fe^{3+} \rightarrow$ 1 1 1 1 1

t_2g eg

$CFS5 = \left(-0.4\times3+0.6\times2\right)\Delta_0 = 0$

64. Which of the following electrolyte can be used to obtain $H_2S_2O_8$ by the process of electrolysis?

1) Dilute solution of Sodium sulphate

2) Dilute solution of Sulphuric acid

3) Acidified dilute solution of Sodium sulphate

4) Concentrated solution of Sulphuric acid

Key: 4

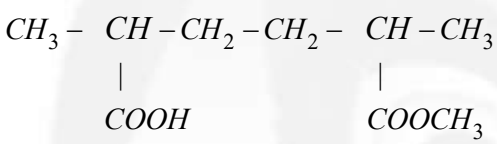
Sol: con, solution of H_2SO_4 (electrolysis).

$$\underset{(a)}{H_2SO_4} \longrightarrow H^+ + SO_4^{2-}$$

At cathode $2H^+ + 2e^- \rightarrow H_2$

At anode $2SO_4^{2-} \rightarrow S_2O_8^{2-} + 2e^-$

65. The IUPAC name of the following compound is



1) Methyl-5-carboxy-2- methylhexanoate

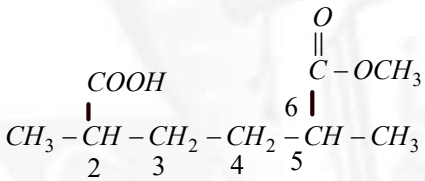
2) Methyl-6-carboxy-2,5- dimethylhexanoate

3) 6-methoxycarbonyl-2,5-dimethylhexanoic acid

4) 2-carboxy-5-methoxycarbonylhexane

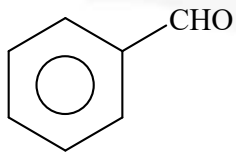
Key: 3

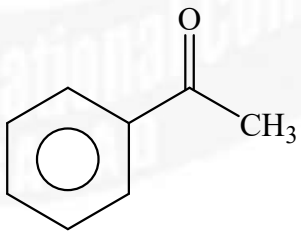
Sol:



6-Methoxy carbonyl -2,5 - dimethyl hexanoic acid.

66. The compounds which give positive Fehling's test are.

a) 

b) 

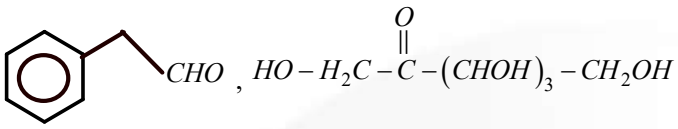
d) $HOCH_2 - CO - (CHOH)_3 - CH_2 - OH$ **d)**  E)

Choose the correct answer from the options given below :

1) A, B & C only **2)** A, C & D only **3)** C, D & E only **4)** A, D & E only

Key: 3

Sol:



CHO , $HO-H_2C-\overset{\overset{O}{\|}}{C}-(CHOH)_3-CH_2OH$

$CH_3-CH=O;$ $\rightarrow$ given positive Fehling's test

67. Arrange the following solutions in order of their increasing boiling points

$(I)10^{-4}$ M NaCl $(II)10^{-4}$ M Urea $(III)10^{-3}$ M NaCl $(IV)10^{-2}$ M NaCl

1) II < I ≡ III < IV **2)** IV < III < I < II

3) I < II < III < IV **4)** II < I < III < IV

Key: 4

Sol: $\Delta T_b = i \times kb \times m$

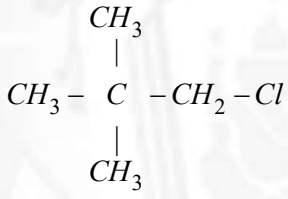
i For $NaCl = 2$

i For $Urea = 1$

$ii < i < iii < iv$

68. Given below are two statements :

Statement-l: CH_3-O-CH_2-Cl will undergo S_N1 reaction though it is a primary halide.



Statement-II: will not undergo S_N2 reaction very easily though it is a primary halide

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

1) Both Statement – I and Statement – II are correct.

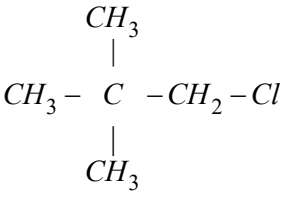
2) Both Statement – I and Statement – II are incorrect.

3) Statement – I is correct but Statement – II is incorrect.

4) Statement – I is incorrect but Statement – II is correct.

Key: 1

Sol: CH_3-O-CH_2-Cl gives S_N1. Stable carbocation due to back bonding



not gives S_N2 due to steric crowding

69. Lanthanide ions with $4f^7$ configuration are :

a) Eu^{2+} **b)** Gd^{3+} **c)** Eu^{3+} **d)** Tb^{3+} E) Sm^{2+}

Choose the correct answer from the options given below

1) A and D only **2)** B and C only **3)** A and B only **4)** B and E only

Key: 3

Sol: $4f^7$

$Eu^{2+} \rightarrow 4f^7$ $Gd^{3+} \rightarrow [Xe]4f^7$

$Eu^{2+} \rightarrow [Xe]4f^7$ $Gd^{3+} \rightarrow [Xe]4f^7$

70. Which of the following electronegativity order is incorrect

1) Mg < Be < B < N **2)** Al < Si < C < N

3) S < Cl < O < F **4)** Al < Mg < B < N

Key: d

Sol: $Mg \rightarrow 1.2$ $Be \rightarrow 1.5$ $Be \rightarrow 1.5$ $B \rightarrow 2.0$ $N \rightarrow 3.0$

$O \rightarrow 3.5$

$F \rightarrow 4.0$ $Si \rightarrow 1.8$ $C \rightarrow 2.5$ $S \rightarrow 2.5$ $Cl \rightarrow 3.0$

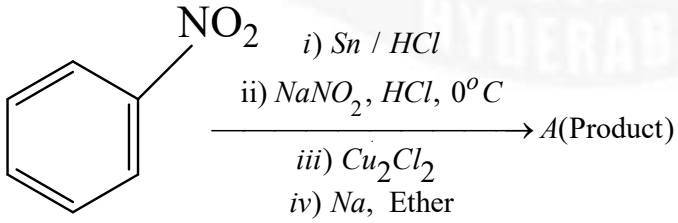
As compare in options , option d is incorrect.

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.

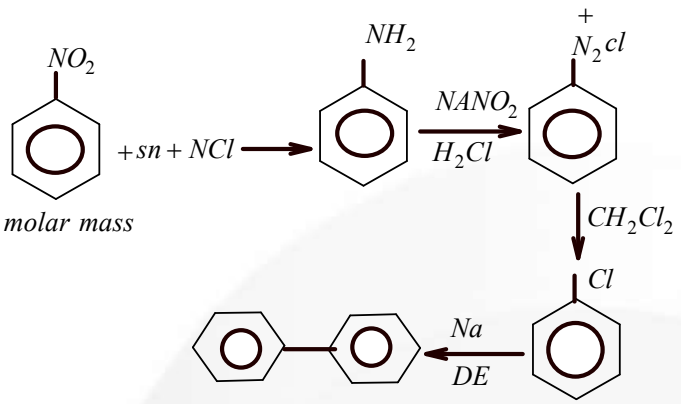
71. Consider the following sequence of reactions :



Molar mass of the product formed (A) is _____ $g\ mol^{-1}$.

Key: 154

Sol:



$=154g$

72. In Carius method for estimation of halogens, 180mg of an organic compound produced 143.5 mg of AgCl. The percentage composition of Chlorine in the compound is _____% [Given : molar mass in $g\ mol^{-1}$ of Ag:108, Cl:35.5].

Key: 20

Sol: percentage of Cl

$$=\frac{35.5}{143.5}\times\frac{143.5\times10^{-3}}{180\times10^{-3}}\times100$$

$$=19.7\simeq20\%$$

73. The number of molecules/ions that show linear geometry among the following is _____.

SO_2, $BeCl_2$, CO_2, N_3^-, NO_2, F_2O, XeF_2, NO_2^+, I_3^-, O_3,

Key: 6

Sol: $BeCl_2, CO_2, N_3^-, XeF_2, NO_2^+, I_3^-$ $-\boxed{6}$

74. $A \rightarrow B$

The molecule of A changes into its isomeric form B by following a first order kinetics at a temperature of 1000K. If the energy barrier with respect to reactant energy for such isomeric transformation is 191.48 $Kjmol^{-1}$ and the frequency factor is 10^{20}, the time required for 50% molecules of A to become B is _____picoseconds (nearest integer). [Given $R=8.314J\ K^{-1}mol^{-1}$]

Key: 69

Sol: $k=Ae^{-\frac{\Delta H}{RT}}$ $\log k=\frac{-\Delta H}{2303RT}+\log A$

$$\log k = \frac{-191.48\times10^3}{2303\times8.314\times1000} + \log 10^{20}$$

$\log k = -10 + 20$ $\log k = 10$ $k = 10^{10}$

$t_{1/2} = \frac{0.693}{10^{10}} = 0.693\times10^{-10}$ 1 pico second $= 10^{-12}$ sec $= 69.3$ pico seconds

75. Some CO_2 gas was kept in a sealed container at a pressure of 1 atm and at 273K. This entire amount of CO_2 gas was later passed through an aqueous solution of $Ca(OH)_2$. The excess unreacted $Ca(OH)_2$ was later neutralized with 0.1M of 40mL HCl. If the volume of the sealed container of CO_2 was *x*, then *x* is _____ cm^3. (nearest integer)

[Given: The entire amount of CO_2(g) reacted with exactly half the initial amount of $Ca(OH)_2$ present in the aqueous solution.]

Key: 45

Sol: moles of HCl used to neutralise excess $Ca(OH)_2$

Mole of $HCl = \frac{0.1\times40}{1000} = 0.004\,moles$

$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$

Moles of $Ca(OH)_2$ neutralized $= 0.002\,moles$

Initially we have $4\,mmole$ of $Ca(OH)_2$

Volume of $CO_2 = 0.002\,mole$

$PV = nRT$

$1\times V = 0.002\times0.0821\times273$

$V = 0.0448\,lt$

$= 44.8ml \simeq 45ml$

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