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1 AIR	4 AIR	5 AIR	6 AIR	9 AIR	10 AIR
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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

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-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. 1.

1. For a statistical data $x_1, x_2, \ldots\ldots, x_{10}$ of 10 values, a student obtained the mean as 5.5 and $\sum_{i=1}^{10} x_i^2 = 371$. He later found that he had noted two values in the data incorrectly as 4 and 5, instead of the correct values 6 and 8, respectively. The variance of the corrected data is

1) 7 2) 9 3) 5 4) 4

Key: 1

Sol: $\bar{x} = 5.5$

New mean $\left(\bar{x}\right) = \dfrac{55-4-5+6+8}{10} = 6$

New varience $= \dfrac{371-4^2-5^2+6^2+8^2}{10} - 36 = 43-36 = 7$

2. Let $\vec{a} = \hat{i}+2\hat{j}+3\hat{k}$, $\vec{b} = 3\hat{i}+\hat{j}-\hat{k}$ and $\vec{c}$ be three vectors such that $\vec{c}$ is coplanar with $\vec{a}$ and $\vec{b}$. If the vector $\vec{c}$ is perpendicular to $\vec{b}$ and $\vec{a}$. $\vec{c} = 5$, then $|\vec{c}|$ is equal to

1) 18 2) $\sqrt{\dfrac{11}{6}}$ 3) $\dfrac{1}{3\sqrt{2}}$ 4) 16

Key: 2

Sol: $\vec{c} = x(-i+2j+3k) + y(3i+j-k)$

$\vec{c}.\vec{b} = 0 \quad \Rightarrow \quad x(3+2-3)+y(9+1+1) = 0$

$\Rightarrow \quad 2x+11y = 0 \qquad \rightarrow ①$

$\Rightarrow \quad y = \dfrac{-2}{11}x$

$\vec{c}.\vec{c} = 5 \quad \Rightarrow \quad x(1+4+9)+y(3+2-3) = 5 \qquad \Rightarrow \quad 14x+2y = 5$

$14x + 2\left(\dfrac{-2}{11}x\right) = 5$

$\Rightarrow 154x-4x=55 \qquad x=\frac{55}{150}=\frac{11}{30} \qquad y=\frac{-2}{4}\times\frac{11}{30}=\frac{-1}{15}$

$\therefore \vec{c}=\frac{11}{30}(i+2j+3k)+\frac{2}{30}(3i+j-k)=\frac{5i+20j+35k}{30}=\frac{1}{6}(i+4j+7k)$

$\left|\vec{c}\right|=\frac{1}{6}\sqrt{1+16+49}=\frac{\sqrt{66}}{6}=\sqrt{\frac{11}{6}}$

3. Let circle C be the image of $x^2+y^2-2x+4y-4=0$ in the line $2x-3y+5=0$ and A be the point on C such that OA is parallel to x-axis and A lies on the right hand side of the centre O of C. If $B(\alpha,\beta)$, with $\beta<4$, lies on C such that the length of the arc AB is $(1/6)^{th}$ of the perimeter of C, then $\beta-\sqrt{3}\alpha$ is equal to :

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

Key: 1

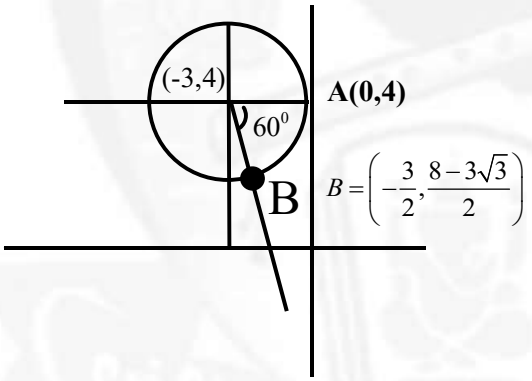
Sol: $(1,-2);\frac{\alpha-1}{2}=\frac{\beta+2}{-3}=-2\frac{(13)}{3}$

$\alpha=-3,\beta=4$

$(-3,4);\gamma=\sqrt{1+4+4}=\sqrt{9}=3$

$C:(x+3)^2+(y-4)^2=9$

$\beta-\sqrt{3}\alpha=\frac{8}{2}=4$

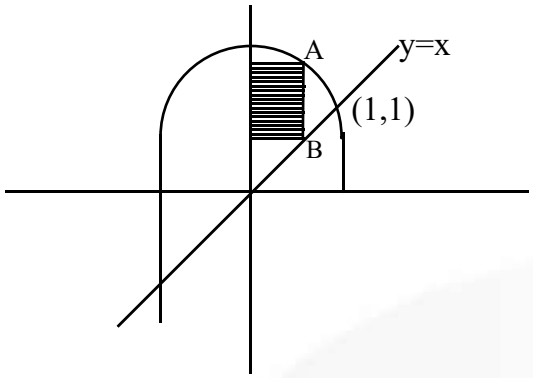


4. Consider the region $R=\left\{(x,y):x\le y\le 9-\frac{11}{3}x^2,\ x\ge 0\right\}$. The area of the largest rectangle of sides parallel to the coordinate axes and inscribed in R, is :

1) $\frac{821}{123}$ 2) $\frac{730}{119}$ 3) $\frac{567}{121}$ 4) $\frac{625}{111}$

Key: 3

Sol:



$$A=\left(t,9-\frac{11t^2}{3}\right)$$

$$B=(t,t)$$

$$A=Area=t\left(9-\frac{11t^2}{3}-t\right)=9t-t^2-\frac{11t^3}{3}$$

$$\frac{dA}{dt}=9-2t-11t^2=0$$

$$\Rightarrow\ t=-1\ (or)\ t=\frac{9}{11}$$

Largest Area we get at $t=\frac{9}{11}$

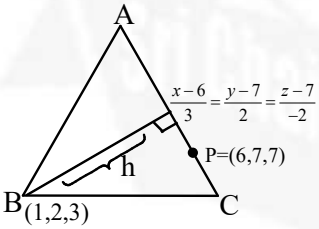
$$A=\frac{9}{11}\left(9-\frac{11}{13}.\frac{81}{121}-\frac{9}{11}\right)=\frac{9}{11}\times\frac{63}{11}=\frac{567}{121}$$

5. Let in a ΔABC, the length of the side AC be 6, the vertex B be (1, 2, 3) and the vertices A, C lie on the line $\frac{x-6}{3}=\frac{y-7}{2}=\frac{z-7}{-2}$. Then the area (in sq. units) of ΔABC is :

1) 42 2) 56 3) 21 4) 17

Key: 3

Sol: $AC=6, B=(1,2,3)$



$$h=\frac{\left|\overrightarrow{BP}\times(3,2,-2)\right|}{|3,2,-2|}=\frac{\left|(5,5,4)\times(3,2,-2)\right|}{\sqrt{9+4+4}}$$

$$\begin{vmatrix} i & j & k \\ 5 & 5 & 4 \\ 3 & 2 & -2 \end{vmatrix}=-18i+22j-5k=\sqrt{324+25+484}$$

$$Area = \frac{1}{2}(6)\sqrt{\frac{833}{17}} = 3\sqrt{\frac{833}{17}} = 21.$$

6. For some $n \neq 10$, let the coefficients of the 5th, 6th and 7th terms in the binomial expansion of $(1+x)^{n+4}$ be in A.P. Then the largest coefficient in the expansion of $(1+x)^{n+4}$ is

1) 10 2) 70 3) 35 4) 20

Key: 3

Sol: ${}^{(n+4)}C_4, {}^{(n+4)}C_5, {}^{(n+4)}C_6$

$$2\,{}^{(n+4)}C_5 = {}^{(n+4)}C_4 + {}^{(n+4)}C_6$$

$$2 = \frac{1}{\frac{n+5-5+1}{5}} + \frac{n+4-6+1}{6}$$

$$2 = \frac{5}{n+1} + \frac{n-1}{6} \quad \Rightarrow n = 35.$$

7. The product of all the rational roots of the equation $(x^2-9x+11)^2 - (x-4)(x-5) = 3$, is equal to

1) 14 2) 21 3) 7 4) 28

Key: 1

Sol: $(x^2-9x+11)^2 - (x^2-9x+20) = 3$

Let $x^2-9x+11 = t$

$$t^2 - (x+9) = 3$$

$$t^2 - t - 12 = 0 \quad \Rightarrow t = \frac{1 \pm \sqrt{1+48}}{2} \quad \Rightarrow t = 4, -3$$

$$\Rightarrow x^2-9x+11 = 4 \quad \Rightarrow x^2-9x+7 = 0 \quad (or) \quad x^2-9x+14 = 0 \qquad x = 2, 7$$

Product of rational roots

8. A and B alternately throw a pair of dice. A wins if the throws a sum of 5 before B throws a sum of 8, and B wins if he throws a sum of 8 before A throws a sum of 5. The probability, that A wins if A makes the first throw, is :

1) $\frac{8}{17}$ 2) $\frac{8}{19}$ 3) $\frac{9}{17}$ 4) $\frac{9}{19}$

Key: 4

Sol: $(1,4)\ (2,3)\ (3,2)\ (4,1) \quad \Rightarrow P(A) = \frac{4}{36} = \frac{1}{9}$

$(2,6)\ (3,5)\ (4,4)\ (5,3)\ (6,2) \quad \Rightarrow P(B) = \frac{5}{36}$

Probability of A wining $P(A) = \frac{1}{9} + \frac{1}{9} \times \frac{31}{36} \times \frac{8}{9} + 0 \ldots\ldots\ldots = \frac{\frac{1}{9}}{1 - \frac{8 \times 31}{36 \times 9}} = \frac{36}{369 - 8 \times 31} = \frac{9}{19}$

9. Let the lines $3x-4y-\alpha=0, 8x-11y-33=0$ and $2x-3y+\lambda=0$ be concurrent. If the image of the point (1, 2) in the line $2x-3y+\lambda=0$ is $\left(\frac{57}{13},\frac{-40}{13}\right)$, then $|\alpha\lambda|$ is equal to

1) 101 2) 91 3) 113 4) 84

Key: 2

Sol: $\text{Midpoint}=\left(\frac{76}{2\times13},\frac{-14}{2\times13}\right)=\left(\frac{35}{13},\frac{-7}{13}\right)$

Lies on $2x-3y+\lambda=0$

$\Rightarrow \quad \frac{70}{13}+\frac{21}{13}+\lambda=0 \Rightarrow 13\lambda=-91 \qquad \lambda=-7$

$$\begin{vmatrix}3 & -4 & -\alpha\\ 8 & -11 & -33\\ 2 & -3 & -2\end{vmatrix}=0$$

$\Rightarrow 3(-22)+4(10)-\alpha(-2)=0$

$\Rightarrow -66+40+2\alpha=0 \qquad \Rightarrow \alpha=13.$

10. Let $\mathbb{R}-\{0\}\to\mathbb{R}$ be a function such that $f(x)-6f\left(\frac{1}{x}\right)=\frac{35}{3x}-\frac{5}{2}$. If the $\lim\limits_{x\to0}\left(\frac{1}{\alpha x}+f(x)\right)=\beta;\ \alpha,\beta\in\mathbb{R}$, then $\alpha+2\beta$ is equal to :

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

Key: 4

Sol: $f(x)-6f\left(\frac{1}{x}\right)=\frac{35}{3x}-\frac{5}{2} \qquad \to ①$

$6\left(f\left(\frac{1}{x}\right)-6f(x)=\frac{35}{3}x-\frac{5}{2}\right) \qquad \to ②$

$-35f(x)=70x-15+\frac{35}{3x}-\frac{5}{2}$

$\Rightarrow f(x)=-2x+\frac{15}{35}-\frac{1}{3x}+\frac{5}{35}\times\frac{1}{2}=-2x+\frac{3}{7}-\frac{1}{3x}+\frac{1}{14}=-2x-\frac{1}{3x}+\frac{1}{2}$

$\underset{x\to0}{Lt}\left(\frac{1}{\alpha x}-2x-\frac{1}{3x}+\frac{1}{2}\right)=\beta$

$\alpha=3;\beta=\frac{1}{2}$

$\alpha+2\beta=3+1=4.$

11. Let $f(x)=\frac{2^{x+2}+16}{2^{2x+1}+2^{x+4}+32}$. Then the value of $8\left(f\left(\frac{1}{15}\right)+f\left(\frac{2}{15}\right)+....+f\left(\frac{59}{15}\right)\right)$ is equal to

1) 108 2) 92 3) 118 4) 102

Key: 3

Sol: $f(x)=\dfrac{4\left(2^x+4\right)}{\left(2^x\right)^2.2+16.2^x+32}=\dfrac{4\left(2^x+4\right)}{2\left(2^x+4\right)^2}=\dfrac{2}{2^x+4}$

$$f(x)+f(4-x)=\frac{2}{2^x+4}+\frac{2}{2^{4-x}+4}=\frac{2}{2^x+4}+\frac{2.2^x}{2^4+4.2^x}=\frac{2}{2^x+4}+\frac{2^x.2}{4\left(2^x+4\right)}=\frac{2\left(4+2^x\right)}{4\left(2^x+4\right)}=\frac{1}{2}$$

$$f\left(\frac{1}{15}\right)+.....f\left(\frac{59}{15}\right)=29\left(1/2\right)+f(2)=14.50+0.25=14.75\ .$$

12. $\lim\limits_{x\to 0}\operatorname{cosec}x\left(\sqrt{2\cos^2 x+3\cos x}-\sqrt{\cos^2 x+\sin x+4}\right)$ is :

1) $-\dfrac{1}{2\sqrt{5}}$ 2) $\dfrac{1}{2\sqrt{5}}$ 3) 0 4) $\dfrac{1}{\sqrt{15}}$

Key: 1

Sol: $\underset{x\to 0}{Lt}\dfrac{\cos^2 x+3\cos x-\sin x-4}{(\sin x)\left(\sqrt{2\cos^2 x+3\cos x}+\sqrt{\cos^2 x+\cos x+4}\right)}=\dfrac{-1}{2\sqrt{5}}.$

13. If $I(m,n)=\int\limits_0^1 x^{m-1}(1-x)^{n-1}\,dx$, m, n > 0, then I(9, 14) + I(10, 13) is

1) I(9, 13) 2) I(9, 1) 3) I(1, 13) 4) I(19, 27)

Key: 1

Sol: $I(9,14)+I(10,13)=\rightarrow\int\limits_0^1 x^8(1-x)^{12}(1-x+x)\,dx=I(9,13)$

14. If α and β are the roots of the equation $2z^2-3z-2i=0$, where $i=\sqrt{-1}$, then 16.

$\operatorname{Re}\left(\dfrac{\alpha^{19}+\beta^{19}+\alpha^{11}+\beta^{11}}{\alpha^{15}+\beta^{15}}\right).\operatorname{lm}\left(\dfrac{\alpha^{19}+\beta^{19}+\alpha^{11}+\beta^{11}}{\alpha^{15}+\beta^{15}}\right)$ is equal to

1) 409 2) 312 3) 441 4) 398

Key: 3

Sol: $Z\left(z-\dfrac{i}{z}\right)=3 \quad \Rightarrow z-\dfrac{i}{z}=\dfrac{3}{2}$

$$\alpha-\frac{i}{\alpha}=\frac{3}{2}$$

$$\alpha^2-\frac{1}{\alpha^2}-2i+9/4$$

$$\alpha^2-\frac{1}{\alpha^2}=2i+9/4$$

$$\alpha^2+\frac{1}{\alpha^4}-2=9i-4+\frac{81}{16}$$

$$\alpha^4+\frac{1}{\alpha^4}=\frac{49}{16}+9i \quad \rightarrow \quad ①$$

$$\beta^4+\frac{1}{\beta^4}=\frac{49}{16}+9i \quad \rightarrow ②$$

$$\text{Question}=\frac{\alpha^{15}\left(\alpha^4+\frac{1}{\alpha^4}\right)+\beta^{15}\left(\beta^4+\frac{1}{\beta^4}\right)}{\alpha^{15}+\beta^{15}}=\frac{\left(\frac{49}{16}+9i\right)\left(\alpha^{15}+\beta^{15}\right)}{\alpha^{15}+\beta^{15}}$$

$$\text{Real}=\frac{49}{16},\ im=9$$

$$16\times\frac{49}{16}\times 9=441.$$

15. Let the product of the focal distances of the point $\left(\sqrt{3},\frac{1}{2}\right)$ on the ellipse $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1,(a>b)$, be $\frac{7}{4}$. Then the absolute difference of the eccentricities of two such ellipses is

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

Key: 1

Sol: $\frac{3}{a^2}+\frac{1}{4b^2}=1$

$$\frac{3}{a^2}+\frac{1}{4b^2}=1 \Rightarrow \frac{3}{a^2}+\frac{1}{4a^2\left(1-e^2\right)}=1 \quad \rightarrow(1)$$

$$\Rightarrow a^2=3+\frac{1}{4\left(1-e^2\right)}$$

$$\left(a-ex_1\right)\left(a+ex_1\right)=\frac{7}{4}$$

$$a^2-o^2(3)=\frac{7}{4}\Rightarrow a^2-3e^2=\frac{7}{4} \quad \rightarrow(2)$$

$$\therefore 3+\frac{1}{4\left(1-e^2\right)}-3e^2=\frac{7}{4}$$

Let $e^2=t$

$$12(1-t)-12t(1-t)=7(1-t)$$

$$\Rightarrow 12t^2-17t+6=0$$

$$t_1+t_2=\frac{17}{12},\ t_1t_2=\frac{6}{12}$$

$$e_1^2+e_2^2=\frac{17}{12},\ e_1.e_2=\frac{1}{\sqrt{2}}$$

$$(e_1 - e_2)^2 = \frac{17}{12} - \frac{2}{\sqrt{2}}$$

$$|e_1 - e_2| = \frac{3 - 2\sqrt{2}}{2\sqrt{3}}$$

16. Let y = y(x) be the solution of the differential equation $\left(xy - 5x^2\sqrt{1+x^2}\right)dx + \left(1+x^2\right)dy = 0,\ y(0) = 0$. Then $y\left(\sqrt{3}\right)$ is equal to

1) $\sqrt{\frac{15}{2}}$ 2) $2\sqrt{2}$ 3) $\frac{5\sqrt{3}}{2}$ 4) $\sqrt{\frac{14}{3}}$

Key: 3

Sol: $\left(1+x^2\right)\frac{dy}{dx} + xy = 5x^2\sqrt{1+x^2}$

$$\frac{dy}{dx} + \frac{x}{1+x^2}y = \frac{5x^2}{\sqrt{1+x^2}}$$

$$I.F = e^{\int \frac{x}{1+x^2}dx} = e^{\frac{1}{2}\log\left(1+x^2\right)} = \sqrt{1+x^2}$$

$$y\sqrt{1+x^2} = \int 5x^2 dx$$

$$y\sqrt{1+x^2} = \frac{5}{3}x^3 + c \quad 0 = c$$

$$y\sqrt{1+x^2} = \frac{5}{3}x^3 \qquad 2y = \frac{5}{3}3\sqrt{3} \quad y = \frac{5\sqrt{3}}{2}$$

17. If the system of equations

$$2x - y + z = 4$$

$$5x + \lambda y + 3z = 12$$

$$100x - 47y + \mu z = 212,$$

has infinitely many solutions, then $\mu - 2\lambda$ is equal to

1) 59 2) 57 3) 56 4) 55

Key: 2

Sol: $-5y - 2\lambda y - z = -4 \qquad \Rightarrow (5 + 2\lambda)y + z = 4 \ \rightarrow (1)$

$$(20\lambda + 47)y + (60 - \mu)z = 28 \ \rightarrow (2)$$

$$\frac{20\lambda + 47}{5 + 2\lambda} = \frac{60 - \mu}{1} = 7$$

$$9 + 2 = 108 + (n-1)36$$

$$\mu = 53$$

$$20\lambda + 47 = 35 + 14\lambda$$

$$6\lambda = -12 \Rightarrow \lambda = -2$$

$$57 = \mu - 2\lambda$$

18. Let $S_n = \frac{1}{2}+\frac{1}{6}+\frac{1}{12}+\frac{1}{20}+\ldots\ldots$ upto 'n' terms. If the sum of the first six terms of an A.P with first term –p and common difference 'p' is $\sqrt{2026S_{2025}}$, then the absolute difference between 20th and 15th terms of the A.P is

1) 20 2) 45 3) 90 4) 25

Key: 4

Sol: $S_n = \sum_{n=1}^{11} \frac{1}{n(n+1)}$

$= \sum_{n=1}^{8}\left(\frac{1}{n}-\frac{1}{n+1}\right) \quad = 1-\frac{1}{n+1}=\frac{n}{n+1}$

$2026 \times S_{2025} = 2026 \times \frac{2025}{2026}$

$= 2025$

$\sqrt{2026 \times S_{2025}} = \sqrt{2025} = 45$

$-P, o, p, zp, 3p, 4p$

$qp = 45 \Rightarrow p = 5$

$T_{20} = -p + 1qp = -5 + 19(5) = 18 \times 5 = 90$

$T_{15} = -p + 14p = 13(5) = 65$

$T_{20} - T_{15} = 25$

19. Let the line passing through the points $(-1, 2, 1)$ and parallel to the line $\frac{x-1}{2}=\frac{y+1}{3}=\frac{z}{4}$ intersect the line $\frac{x+2}{3}=\frac{y-3}{2}=\frac{z-4}{1}$ at the point 'P'. Then the distance of 'P' from the point Q(4, -5, 1) is

1) $5\sqrt{5}$ 2) 10 3) $5\sqrt{6}$ 4) 5

Key: 1

Sol: $L: \frac{x+1}{2}=\frac{y-2}{3}=\frac{z-1}{4}=\lambda$

$P = (2\lambda-1, 3\lambda+2, 4\lambda+1)$

$\frac{2\lambda+1}{3}=\frac{3\lambda-1}{2}=\frac{4\lambda-3}{1} \quad \Rightarrow 4\lambda+2 = 9\lambda-3 \Rightarrow \lambda = 1$

$P = (1, 5, 5)$

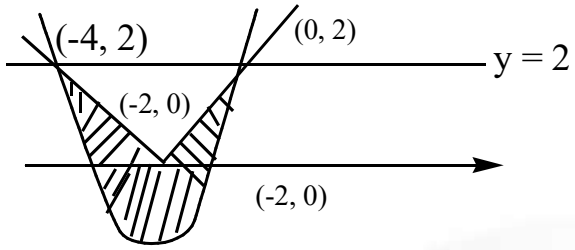
$PQ = \sqrt{9+100+16} = \sqrt{125} = 5\sqrt{5}$

20. The area of the region $\{(x, y) : x^2 + 4x + 2 \le y \le |x+2|\}$ is equal to

1) 7 2) $\frac{24}{5}$ 3) 5 4) $\frac{20}{3}$

Key: 4

Sol:



$$\text{Re}.A=\int_{-4}^{0}\left(2-\left(x^2+4x+2\right)\right)dx-\frac{1}{2}\times 2\times 4$$

$$=-\frac{1}{3}\left(x^3\right)_{-4}^{0}-2\left(x^2\right)_{-4}^{0}-4 \quad =32-\frac{64}{3}-4=\frac{20}{3}$$

SECTION-II (NUMERICAL VALUE TYPE)

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

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

21. Let $S=\{p_1,p_2,.....,p_{10}\}$ be the set of first ten prime numbers. Let $A=S\cup P$, where P is the set of all possible products of distinct elements of 'S'. Then the number of all ordered pairs (x, y), $x\in S$, $y\in A$, such that 'x' divides 'y', is ……

Key: 5110

Sol: $10_4\times\left(2^9-1\right)=10\times 511=5110$

22. The number of 3-digit numbers, that are divisible by 2 and 3, but not divisible by 4 and 9 is ……..

Key: 125

Sol: Number of 3 digit numbers divisible by 6 – Number of 3 digit numbers divisible by 36
$=150-25=125$

23. Let A be a 3×3 matrix such that $X^TAX=O$ for all non-zero 3×1 matrices $X=\begin{bmatrix}x\\y\\z\end{bmatrix}$. If

$$A\begin{bmatrix}1\\1\\1\end{bmatrix}=\begin{bmatrix}1\\4\\-5\end{bmatrix},\ A\begin{bmatrix}1\\2\\1\end{bmatrix}=\begin{bmatrix}0\\4\\-8\end{bmatrix},\ \text{and det}\left(\text{adj}\left(2\left(A+I\right)\right)\right)=2^{\alpha}3^{\beta}5^{\gamma},\ \alpha,\beta,\gamma\in N,$$

then $\alpha^2+\beta^2+\gamma^2$ is ……

Key: 44

Sol: Let $A=\begin{bmatrix}a & b & c\\ d & e & f\\ g & h & i\end{bmatrix}$

$$X^TAX=0 \quad \rightarrow ①$$

$$X^TAX=X^TA^TX=0 \quad \rightarrow ②$$

$X^TAX + X^TA^TX \Rightarrow A = -A^T \quad \therefore a = e = \ell = 0$

$$\begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix}\begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} = \begin{bmatrix} 1 \\ 4 \\ -5 \end{bmatrix}$$

$a+b+c=1 \quad \rightarrow \quad a+2b+c=0 \quad \Rightarrow c=-2b$

$d+e+f=4 \quad \rightarrow \quad d+2e+f=4$

$g+h+i=-5 \quad \rightarrow \quad g+2h+i=-8$

$b=-1, c=2; \quad h=-3, g=-2$

$$A=\begin{bmatrix} 0 & -1 & 2 \\ -1 & 0 & 3 \\ -2 & -3 & 0 \end{bmatrix} \qquad |A+I| = 10+7-2=15$$

$$A+I=\begin{bmatrix} 1 & -1 & 2 \\ 1 & 1 & 3 \\ -2 & -3 & 1 \end{bmatrix} \qquad |2(A+I)|^2 = (2^3)^2 |A+I|^2 = 2^6 \times (15)^2$$

$$= 2^6 \times 3^2 \times 5^2 = 2^6 \times 3^2 \times 5^2$$

$\alpha^2+\beta^2+\gamma^2 = 36+4+4 = 44.$

24. Let 'f' be a differentiable function such that $2(x+2)^2 f(x) - 3(x+2)^2 = 10\int_0^x (t+2) f(t)dt,\ x \geq 0.$ The f(2) is equal to …….

Key: 4

Sol: $2(x+2)^2 . f^1(x) + f(x).4(x+2) - 6(x+2) = 10(x+2) f(x)$

$\Rightarrow \quad f^1(x).(x+2) + 2f(x) - 3 = 5f(x)$

$f^1(x)x + 2 = 3f(x) + 3 \qquad \int \frac{f^1(x)}{f(x)+1} = \int \frac{3}{x+2} \qquad \log(1+f(x)) = 3\log(x+2) + \log c.$

$8f(0) - 12 = 0 \ \Rightarrow f(0) = 3/2 \qquad 1+f(x) = c(x+2)^3 \ \rightarrow ①$

$1+\frac{3}{2} = 2c \qquad \Rightarrow c = 5/16 \qquad f(2) = 19$

25. If for some $\alpha, \beta;\ \alpha \leq \beta,\ \alpha+\beta=8$ and $\sec^2(\tan^{-1}\alpha) + \operatorname{cosec}^2(\cot^{-1}\beta) = 36$, then $\alpha^2+\beta$ is …….

Key: 14

Sol:

$1+\alpha^2+1+\beta^2 = 36 \qquad \Rightarrow \alpha^2+\beta^2 = 34 \qquad \rightarrow ①$

$\alpha^2+18\alpha+15=0 \qquad \alpha+\beta=8$

$\alpha = 3 \ (or) \ 5 \qquad \alpha^2+(8-\alpha)^2 = 34$

$\alpha=3, \beta=5 \qquad \Rightarrow \quad 2\alpha^2-16x+30=0 \qquad \alpha^2+\beta=14$

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. For an experimental expression $y = \frac{32.3 \times 1125}{27.4}$, where all the digits are significant. Then to report the value of y we should write :-

1) y = 1326.2 **2)** y = 1326.19 **3)** y = 1326.186 **4)** y = 1330

Key: 4

Sol: $\frac{32.3 \times 1125}{27.4} = 1330$

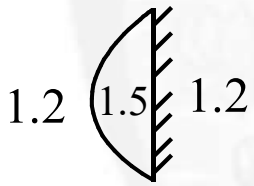
Number of significant figures is three

27. A thin plano convex lens made of glass of refractive index 1.5 is immersed in a liquid of refractive index 1.2. When the plane side of the lens is silver coated for complete reflection, the lens immersed in the liquid behaves like a concave mirror of focal length 0.2 m. The radius of curvature of the curved surface of the lens is :-

1) 0.15 m **2)** 0.10 m **3)** 0.20 m **4)** 0.25 m

Key: 2

Sol: $\frac{1}{F} = \frac{2}{f_l} + \frac{1}{f_m}, F = -0.2$



$\frac{1}{f_1} = \left(\frac{1.5}{1.2} - 1\right)\left(\frac{1}{R}\right) \quad \frac{1}{-0.2} = \frac{4}{R}\left(\frac{15}{12} - 1\right) + \frac{1}{\infty}$

$= \frac{2}{R} \times \frac{3}{12} + 0 = \frac{1}{2R} \quad \Rightarrow 2R = 0.2 \Rightarrow R = 0.1m$

28. The Young's double slit interference experiment is performed using light consisting of 480 nm and 600 nm wavelengths to form interference patterns. The least number of the bright fringes of 480 nm light that are required for the first coincidence with the bright fringes formed by 600 nm light is :-

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

Key: 4

Sol: Distance $y_1 = \frac{n\lambda_1 D}{d}; y_2 = \frac{m\lambda_2 D}{d}$

$y_1 = y_2 \qquad n\lambda_1 = m \Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{m}{n}$

$\lambda_1 = 480\,nm; \lambda_2 = 600nm$ $\Rightarrow \frac{480}{600} = \frac{m}{n} = \frac{4}{5} \Rightarrow n = 5$

29. What is the relative decrease in focal length of a lens for an increase in optical power by 0.1 D from 2.5 D ? ['D' stands for dioptre]

1) 0.04 **2)** 0.40 **3)** 0.1 **4)** 0.01

Key: 1

Sol: $2.5 = \frac{1}{f_1} \Rightarrow f_1 = \frac{1}{2.5} = \frac{1000}{25} = 40\,cm$

$f_2 = \frac{1}{2.6} = \frac{1000}{26}$

$\frac{f_1 - f_2}{f_1} = 1 - \frac{f_2}{f_1} = 1 - \frac{1000}{26 \times 40} = 1 - \frac{25}{26} = \frac{1}{26} = 0.04$

30. An electron of mass 'm' with an initial velocity $\vec{v} = v_o \hat{i}\left(v_0 > 0\right)$ enters an electric field $\vec{E} = -E_o \hat{k}$. If the initial de Broglie wavelength is λ_0, the value after time t would be :-

1) $\frac{\lambda_0}{\sqrt{1 + \frac{e^2 E_0^2 t^2}{m^2 v_0^2}}}$ **2)** $\frac{\lambda_0}{\sqrt{1 - \frac{e^2 E_0^2 t^2}{m^2 v_0^2}}}$ **3)** λ_0 **4)** $\lambda_0 \sqrt{1 + \frac{e^2 E_0^2 t^2}{m^2 v_0^2}}$

Key: 1

Sol: $\lambda_0 = \frac{h}{m v_o}, But \vec{v} = v_0 \hat{i} + \frac{E_0 q t \hat{k}}{m}$

$\left|\vec{v}\right| = \sqrt{v_0^2 + \left(\frac{E_0 et}{m}\right)^2}$

$\lambda = \frac{h}{m\sqrt{v_0^2 + \left(\frac{E_0 et}{m}\right)^2}}$ $= \frac{h}{m v_o \sqrt{1 + \frac{E_0^2 e^2 t^2}{m v_0^2}}} = \frac{\lambda_0}{\sqrt{1 + \frac{E_0^2 e^2 t^2}{m^2 v_0^2}}}$

31. The amount of work done to break a big water drop of radius 'R' into 27 small drops of equal radius is 10 J. The work done required to break the same big drop into 64 small drops of equal radius will be :-

1) 15 J **2)** 10 J **3)** 20 J **4)** 5 J

Key: 1

Sol: $W = S\left[A_f - A_i\right] = S\left[27.4\pi r^2 - 4\pi R^2\right]$

$\frac{4}{3}\pi R^3 = 27.\frac{4}{3}\pi r^3$; $W = S4\pi\left[27\frac{R^2}{3^2} - R^2\right] = 4\pi R^2 S\left[3-1\right]$

$R = 3r \_\_\_\_(1)$; $10 = 8\pi R^2 S \_\_\_\_(2)$

$\frac{4}{3}\pi R^3 = 64\frac{4}{3}\pi r^3 = R = 4r \_\_\_\_(3)$

$$W = 4\pi S\left[64\times\frac{R^2}{16} - R^2\right] = 4\pi R^2 S\times 3 \quad \text{____}(4)$$

$$= 5\times 3 = 15J$$

32. A particle is executing simple harmonic motion with time period 2s and amplitude1cm. If D and d are the total distance and displacement covered by the particle in 12.5 s, then $\frac{D}{d}$ is :-

1) $\frac{15}{4}$ **2)** 25 **3)** 10 **4)** $\frac{16}{5}$

Key: 2

Sol: T = 2s $x = A\sin\omega t$

A = 1 cm $x = A\sin\frac{2\pi}{T}\times\frac{T}{4}$

t = 12.5 = 12 + 0.5 x = A $= 6T + \frac{T}{4}$

Displacement is A

Distance 6 × 4A + A = 25 A, hence d = A, D = 25A

33. A force $F = \alpha + \beta x^2$ acts on an object in the x-direction. The work done by the force is 5J when the object is displaced by 1 m. If the constant $\alpha = 1N$ then β will be

1) 15 N/m^2 **2)** 10 N/m^2 **3)** 12 N/m^2 **4)** 8 N/m^2

Key: 3

Sol: $W = \int_0^1 (\alpha + \beta x^2)dx = 1[1] + \beta\left[\frac{x^3}{3}\right]_0^1 = 5$

$$\frac{\beta}{3} = 4$$

34. An air bubble of radius 0.1 cm lies at a depth of 20 cm below the free surface of a liquid of density 1000 kg/m^3. If the pressure inside the bubble is 2100 N/m^2 greater than the atmospheric pressure, then the surface tension of the liquid in SI unit is (use g = 10 m/s^2)

1) 0.02 **2)** 0.1 **3)** 0.25 **4)** 0.05

Key: 4

Sol: $P_1 - P_2 = \frac{2S}{r}$ $P_0 + 2100 - (P_0 + \rho gh) = \frac{2S}{r}$

$$2100 - 1000\times 10\times 20\times 10^{-2} = \frac{2S}{r}$$

$2100 - 2000 = \frac{2S}{r}$ $\frac{100\times r}{2} = S$

$\frac{100\times 0.1\times 10^{-2}}{2} = S$ $5\times 10^{-2} = S$

35. A satellite is launched into a circular orbit of radius 'R' around the earth. A second statellite is launched into an orbit of radius 1.03 R. The time period of revolution of the second satellite is larger than the first one approximately by

1) 3 % **2)** 4.5 % **3)** 9 % **4)** 2.5 %

Key: 2

Sol: $T^2 \alpha r^3$ $\quad 2\frac{\Delta T}{T} = 3\frac{\Delta r}{r}$

$$\frac{\Delta T}{T} = \frac{3}{2} \times 0.03 \times 100 = \frac{9}{2}\%$$

36. An alternating current is given by $I = I_A \sin \omega t + I_B \cos \omega t$. The r.m.s. current will be :-

1) $\sqrt{I_A^2 + I_B^2}$ **2)** $\frac{\sqrt{I_A^2 + I_B^2}}{2}$ **3)** $\sqrt{\frac{I_A^2 + I_B^2}{2}}$ **4)** $\frac{|I_A + I_B|}{\sqrt{2}}$

Key: 3

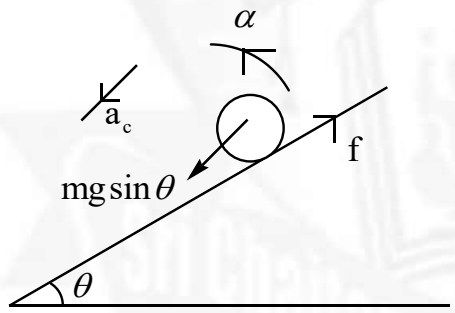
Sol: $i_{rms} = \sqrt{\frac{\int_0^T \left[I_A \sin(\omega t) + I_B \cos(\omega t) \right]^2}{T} dt} = \sqrt{\frac{I_A^2 + I_B^2}{2}}$

37. A uniform solid cylinder of mass 'm' and radius 'r' rolls along an inclined rough plane of inclination 45°. If it starts to roll from rest from the top of the plane then the linear acceleration of the cylinder axis will be :-

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

Key: 3

Sol: $mg \sin \theta - f = ma_c$



$$fR = \frac{mR^2}{2}\alpha \quad , a_c = R\alpha$$

$$f = \frac{mR\alpha}{2} = \frac{ma}{2}$$

$$mg = \frac{3}{2}ma$$

$$a = \frac{2}{3} g / \sqrt{2} = \frac{\sqrt{2}g}{3}$$

38. A parallel plate capacitor was made with two rectangular plates, each with a length of l = 3 cm and breath of b = 1 cm. The distance between the plates is $3\mu m$. Out of the following, which are the ways to increase the capacitance by a factor of 10 ?

A. l = 30 cm, b = 1 cm, d = 1 μm

B. $l = 3\ cm,\ b = 1\ cm,\ d = 30\mu m$

C. $l = 6\ cm,\ b = 5\ cm,\ d = 3\mu m$

D. $l = 1\ cm,\ b = 1\ cm,\ d = 10\mu m$

E. $l = 5\ cm,\ b = 2\ cm,\ d = 1\mu m$

Choose the correct answer from the options given below :

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

Key: 1

Sol: $C_0 = \in_0 \times \frac{3\times 1}{3} = \in_0$

$C_1 = \in_0 \times \frac{30\times 1}{1} = 30 \in_0$

$C_2 = \in_0 \times \frac{3\times 1}{30} = \frac{\in_0}{10}$

$C_3 = \in_0 \times \frac{6\times 5}{3} = 10 \in_0$

$C_4 = \in_0 \times \frac{1\times 1}{10} = \frac{\in_0}{10}$

$C_5 = \in_0 \times \frac{5\times 2}{1} = 10 \in_0$

39. Consider the following statements:

A. The junction area of solar cell is made very narrow compared to a photo diode.

B. Solar cells are not connected with any external bias.

C. LED is made of lightly doped p-n junction.

D. Increase of forward current results in continuous increase of LED light intensity.

E. LEDs have to be connected in forward bias for emission of light.

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

Key: 4

Sol: Conceptual

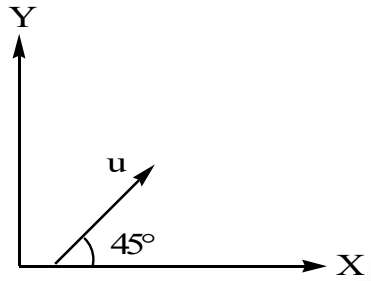
40. An object of mass 'm' is projected from origin in a vertical xy plane at an angle 45° with the x-axis with an initial velocity v_0. The magnitude and direction of the angular momentum of the object with respect to origin, when it reaches at the maximum height, will be [g is acceleration due to gravity]

1) $\frac{mv_0^3}{2\sqrt{2}g}$ along negative z-axis **2)** $\frac{mv_0^3}{2\sqrt{2}g}$ along positive z-axis

3) $\frac{mv_0^3}{4\sqrt{2}g}$ along positive z-axis **4)** $\frac{mv_0^3}{4\sqrt{2}g}$ along negative z-axis

Key: 4

Sol:



$$\vec{L} = m\left(\vec{r}\times\vec{u}\right) \qquad = mv\cos 45 \times H\left(-\hat{k}\right) = m\frac{v}{\sqrt{2}}\frac{v_0^2\sin^2 45}{2g} = \frac{mv_0^3}{4\sqrt{2}g}$$

41. A plano-convex lens having radius of curvature of first surface 2 cm exhibits focal length of f_1 in air. Another plano-convex lens with first surface radius of curvature 3 cm has focal length of f_2 when it is immersed in a liquid of refractive index 1.2. If both the lenses are made of same glass of refractive index 1.5, the ratio of f_1 and f_2 will be :-

1) 3 : 5 **2)** 1 : 3 **3)** 1 : 2 **4)** 2 : 3

Key: 2

Sol:

$$\frac{1}{f_1} = (\mu - 1)\left(\frac{1}{2}\right) = (1.5-1)\left(\frac{1}{2}\right) \qquad \frac{1}{f_2} = \left(\frac{\mu}{1.2} - 1\right)\left(\frac{1}{3}\right) = \left(\frac{1.5}{1.2} - 1\right)\left(\frac{1}{3}\right)$$

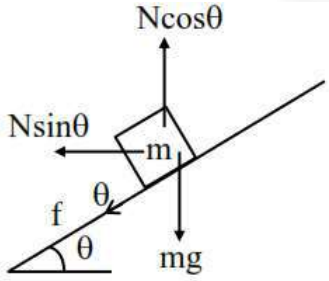
$$\frac{f_2}{f_1} = \frac{\frac{1}{4}}{\left(\frac{5}{4}-1\right)\frac{1}{3}} = \frac{3}{4} = \frac{1}{\frac{1}{4}} = 3$$

42. A car of mass 'm' moves on a banked road having radius 'r' and banking angle θ. To avoid slipping from banked road, the maximum permissible speed of the car is v_0. The coefficient of friction μ between the wheels of the car and the banked road is :-

1) $\mu = \frac{v_0^2 + rg\tan\theta}{rg - v_0^2\tan\theta}$ **2)** $\mu = \frac{v_0^2 + rg\tan\theta}{rg + v_0^2\tan\theta}$ **3)** $\mu = \frac{v_0^2 - rg\tan\theta}{rg + v_0^2\tan\theta}$ **4)** $\mu = \frac{v_0^2 - rg\tan\theta}{rg - v_0^2\tan\theta}$

Key: 3

Sol:



$$N\cos\theta = f\sin\theta + mg$$

$$f\cos\theta + N\sin\theta = \frac{mv_0^2}{r}$$

$$\mu N\cos\theta + N\sin\theta = \frac{mv_0^2}{r}$$

$$N\cos\theta = \mu N\sin\theta + mg \qquad \Rightarrow \ \mu = \frac{v_0^2 - gr\tan\theta}{gr + v_0^2\tan\theta}$$

43. Consider a parallel plate capacitor of area A (of each plate) and separation 'd' between the plates. If E is the electric field and ε_0 is the permittivity of free space between the plates, then potential energy stored in the capacitor is :-

1) $\frac{1}{2}\varepsilon_0 E^2 Ad$ **2)** $\frac{3}{4}\varepsilon_0 E^2 Ad$ **3)** $\frac{1}{4}\varepsilon_0 E^2 Ad$ **4)** $\varepsilon_0 E^2 Ad$

Key: 1

Sol: $U = \frac{1}{2}\in_0 E^2 Ad =$ Energy density × volume

44. An ideal gas goes from an initial state to final state. During the process, the pressure of gas increases linearly with temperature.

A. The work done by gas during the process is zero.

B. The heat added to gas is different from change in its internal energy.

C. The volume of the gas is increased.

D. The internal energy of the gas is increased.

E. The process is isochoric (constant volume process)

Choose the correct answer from the options given below :-

1) A, B, C, D Only **2)** A, D, E Only

3) E Only **4)** A, C Only

Key: 2

Sol: The given process is isochoric (conceptual)

45. During the transition of electron from state A to state C of a Bohr atom, the wavelength of emitted radiation is 2000 Å and it becomes 6000 Å when the electron jumps from state B to state C. Then the wavelength of the radiation emitted during the transition of electrons from state A to state B is :-

1) 3000 Å **2)** 6000 Å **3)** 4000 Å **4)** 2000 Å

Key: 1

Sol: $\frac{hc}{2000} = E_A - E_C \qquad \frac{hc}{6000} = E_B - E_C$

$$hc\left[\frac{1}{2000} - \frac{1}{6000}\right] = E_A - E_B = \frac{hc}{x}$$

$$\frac{1}{2000}\left[1 - \frac{1}{3}\right] = \frac{1}{x} \Rightarrow x = \frac{3}{2}\times 2000 = 3000A^\circ$$

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 least count of a screw guage is 0.01 mm. If the pitch is increased by 75% and number of divisions on the circular scale is reduced by 50%, the new least count will be _____ $\times 10^{-3} mm.$

Key: 35

Sol: $L.C = \frac{P}{N} = 0.01$

$$\frac{P+0.75P}{N-0.5N} = \frac{1.75P}{0.5N} = \frac{1.75}{0.5} \times 0.01 = \frac{175}{50} \times 0.01$$

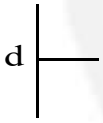
$$= \frac{7}{2} \times 0.01 \qquad = 7 \times 0.005 \qquad = 0.035 mm$$

47. A current of 5A exists in a square loop of side $\frac{1}{\sqrt{2}} m.$ Then the magnitude of the magnetic field B at the centre of the square loop will be $p \times 10^{-6} T.$ Where, value of p is _____.

$\left[\text{Take } \mu_0 = 4\pi \times 10^{-7} TmA^{-1}\right]$

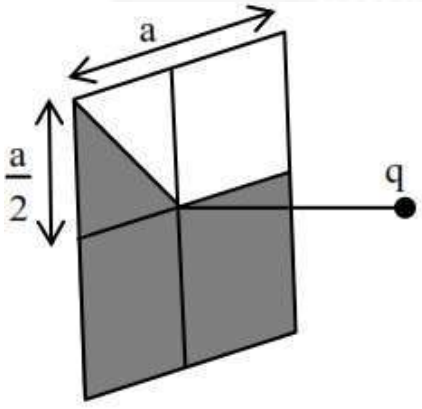
Key: 8

Sol:



$$B = \frac{\mu_0 i}{4\pi \frac{d}{2}} \times 2 \times \frac{1}{\sqrt{2}} \times 4 \qquad = \frac{\mu_0 i}{4\pi} \times \frac{16}{\sqrt{2} \times \frac{1}{\sqrt{2}}} = 16 \times 10^{-7} \times 5 = 8 \times 10^{-6} T$$

48. A square loop of sides a = 1 m is held normally in front of a point charge q = 1C. The flux of the electric field through the shaded region is $\frac{5}{p} \times \frac{1}{\varepsilon_0} \frac{Nm^2}{C}$, where the value of p is ____.



Key: 48

Sol: $\phi = \frac{Q}{6\in_0} \times \frac{1}{2} + \frac{q}{6\in_0} \times \frac{1}{4} \times \frac{1}{2}$ (assume the distance of point charge is a/2 from centre)

$= \frac{q}{12\in_0} + \frac{q}{48\in_0} = \frac{1}{12\in_0}\left[1+\frac{1}{4}\right] = \frac{5}{4} \times \frac{1}{12\in_0} = \frac{5}{48\in_0}$

49. The temperature of 1 mole of an ideal monoatomic gas is increased by 50°C at constant pressure. The total heat added and change in internal energy are E_1 and E_2, respectively. If $\frac{E_1}{E_2} = \frac{x}{9}$ then the value of x is _____.

Key: 15

Sol: $E_1 = nC_p(\Delta T)$

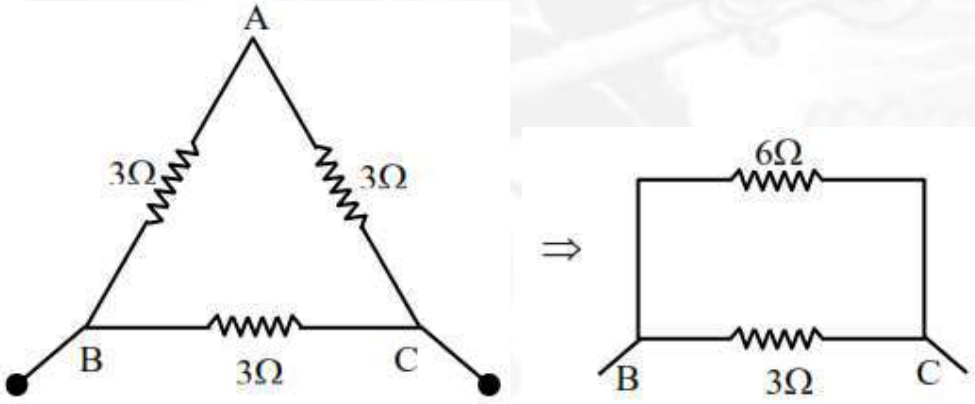
$E_2 = nC_v(\Delta T)$

$\frac{E_1}{E_2} = \frac{C_p}{C_v} = \frac{5}{3} = \frac{15}{9}$

50. A wire of resistance 9Ω is bent to form an equilateral triangle. Then the equivalent resistance across any two vertices will be __ohm.

Key: 2

Sol:



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.

51. Which of the following statements are NOT true about the periodic table?

A) The properties of elements are function of atomic weights.

B) The properties of elements are function of atomic numbers.

C) Elements having similar outer electronic configurations are arranged in same period.

D) An element's location reflects the quantum numbers of the last filled orbital.

E) The number of elements in a period is same as the number of atomic orbitals available in energy level that is being filled.

Choose the correct answer the from the options given below :

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

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

Key : 1

Sol : The no. of valency electrons are same in any group and number of elements in a period is not equal to number of atomic orbitals available in the given energy level.

52. Which of the following arrangements with respect to their reactivity in nucleophilic addition reaction is correct?

1) benzaldehyde < acetophenone < p-nitrobenzaldehyde < p-toluadehyde

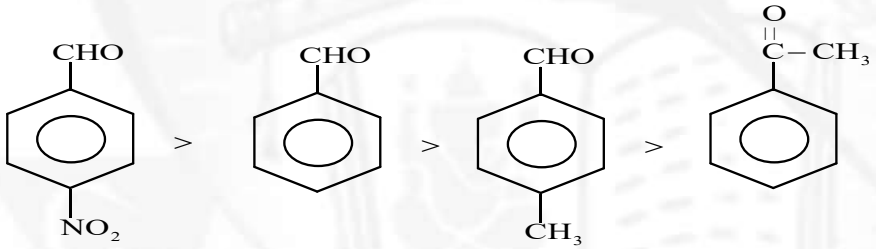
2) acetophenone < benzaldehyde < p-toluadehyde < p-nitrobenzaldehyde

3) p-nitrobenzaldehyde < benzaldehyde < p-toluadehyde < acetophenone

4) acetophenone < p-toluadehyde < benzaldehyde < p-nitrobenzaldehyde

Key: 4

Sol:



p-nitrobenzaldehyde p-tolyaldehyde acetophenone

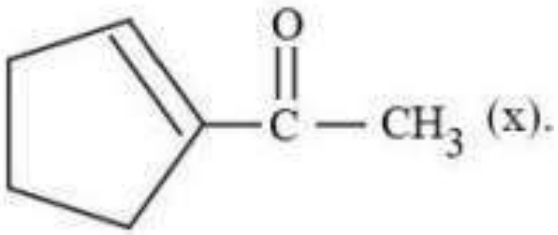
53. One mole of the octahedral complex compound $Co(NH_3)_5Cl_3$ gives 3 moles of ions on dissolution in water. One mole of the same complex reacts with excess of $AgNO_3$ solution to yield two moles of $AgCl(s)$. The structure of the complex is :

1) $[Co(NH_3)_5Cl]Cl_2$ 2) $[Co(NH_3)_3Cl_3].2NH_3$

3) $[Co(NH_3)_4Cl_2].Cl.NH_3$ 4) $[Co(NH_3)_4Cl].Cl_2.NH_3$

Key: 1

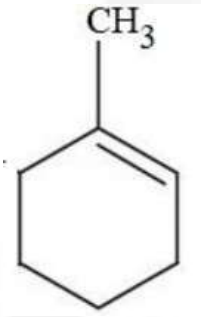
Sol: $[Co(NH_3)_5Cl]Cl_2 + 2AgNO_3 \rightarrow [Co(NH_3)_5Cl](NO_3)_2 + 2AgCl$

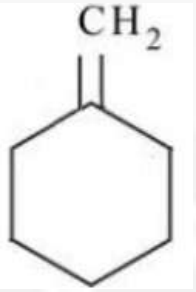


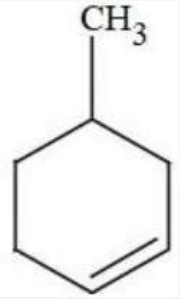
(x).

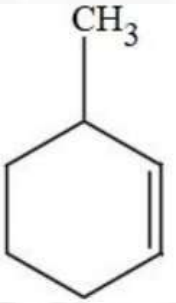
54. Aman has been asked to synthesis the molecule

He thought of preparing the molecule using an aldol condensation reaction. He found a few cyclic alkenes in his laboratory. He thought of performing ozonolysis reaction on alkene to produce a dicarbonyl compound followed by aldol reaction to prepare 'x'. Predict the suitable alkene that can lead to the formation of 'x'.

1) 

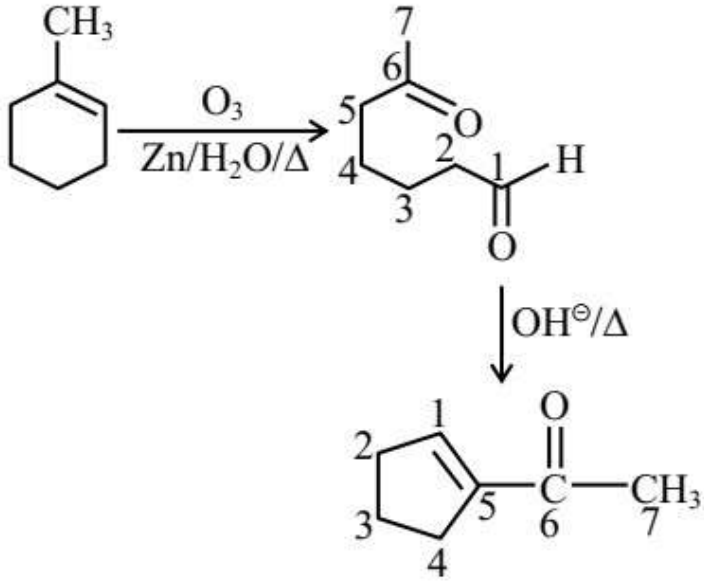
2) 

3) 

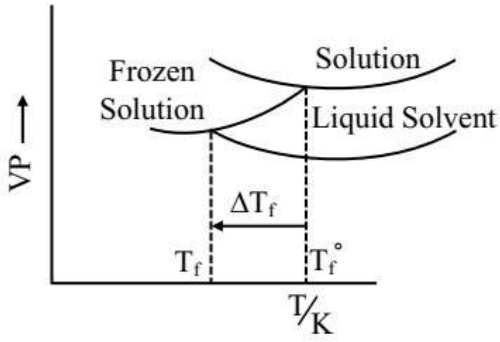
4) 

Key: 1

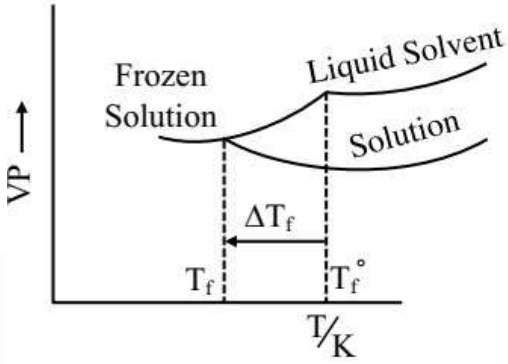
Sol:



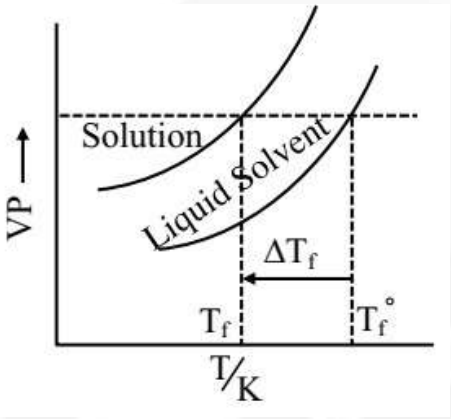
55. Consider the given plots of vapour pressure (VP) vs temperature (T/K). Which amongst the following options is correct graphical representation showing ΔT_f, depression in the freezing point of a solvent in a solution?



1)



2)



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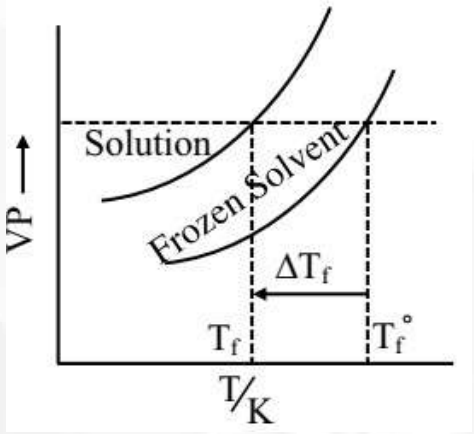


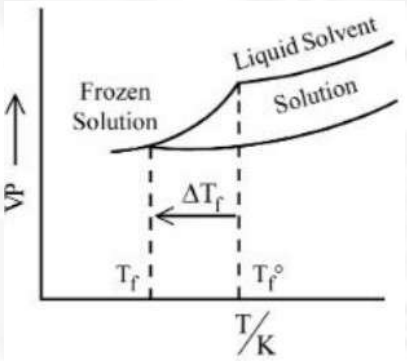
4)

Key:2

Sol: An adding non-volatile solute in a solvent the freezing point of solution decreases graph.

$P^0 > P$

$T_f^0 > T_f^s$



56. For the given cell

$Fe^{2+}_{(aq)} + Ag^{+}_{(aq)} \rightarrow Fe^{3+}_{(aq)} + Ag_{(s)}$

The standard cell potential of the above reaction is

Given :

$Ag^+ + e^- \rightarrow Ag$ $\quad E^\theta = xV$

$Fe^{2+} + 2e^- \rightarrow Fe$ $\quad E^\theta = yV$

$Fe^{3+} + 3e^- \rightarrow Fe$ $\quad E^\theta = zV$

1) $x + 2y - 3z$ 2) $x + y - z$ 3) $x + 2y$ 4) $y - 2x$

Key: 1

Sol: $Fe^{+2} + Ag^{+} \rightarrow Fe^{+3} + Ag$

(aq) (aq) (aq) (s)

$Fe \xrightarrow{\Delta G_1} Fe^{+2} \xrightarrow{\Delta G_2} Fe^{+3}$

$Ag^{+} + e^{-} \rightarrow Ag \;\; \Delta G_1 = -Fx \;.....(1)$

$Fe^{+2} + 2e^{-} \rightarrow Fe \;\; \Delta G_2 = -2F_y \;....(2)$

$Fe \rightarrow Fe^{+3} + 3e^{-} \;\; \Delta G_3 = 3FZ \;....(3)$

From (1), (2) and (3) = x + 2y – 3z

57. The carbohydrate 'Ribose' present in DNA, is

A) A pentose sugar B) Present in pyranose from

C) in 'D' configuration D) a reducing sugar, when free

E) in α -anomeric form

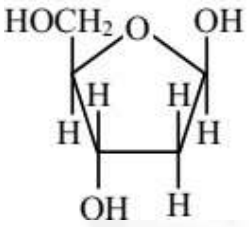
Choose the correct answer from the options given below :

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

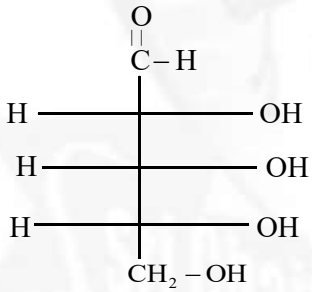
3) A, D and E only 4) A, B and E only

Key: 2

Sol: De oxy nuclic acid



$\beta - D - 2 -$ deoxyribose



D-ribose

D-Configuration

58. Which of the following linear combination of atomic orbitals will lead to formation of molecular orbitals in homonuclear diatomic molecules [internuclear axis in z-direction]?

A) $2p_z$ and $2p_x$ **B)** 2s and $2p_x$ **C)** $3d_{xy}$ and $3d_{x^2-y^2}$ **D)** 2s and $2p_z$

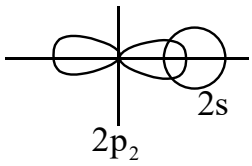
E) $2p_z$ and $3d_{x^2-y^2}$

Choose the correct answer from the options given below :

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

Key: 4

Sol:



Different directional orbitals or different nodal plane orbital do not gives molecular orbitals

59. Let us consider an endothermic reaction which is non-spontaneous at the freezing point of water. However, the reaction is spontaneous at boiling point of water. Choose the correct option :

1) Both ΔH and ΔS are $(+ve)$ 2) Both ΔH and ΔS are $(-ve)$

3 ΔH is $(+ve)$ but ΔS is $(-ve)$) 4) ΔH is $(-ve)$ but ΔS is $(+ve)$

Key: 1

Sol: $\Delta H = +ve$

$\Delta S = +ve$ spontaneous

60. For a reaction, $N_2O_{5(g)} \rightarrow 2NO_{2(g)} + \frac{1}{2}O_{2(g)}$ in a constant volume container, no products were present initially. The final pressure of the system when 50% of reaction gets completed is

1) 5/2 times of initial pressure 2) 7/4 times of initial pressure

3) 7/2 times of initial pressure 4) 5 times of initial pressure

Key: 2

Sol: $N_2O_5 \rightarrow 2NO_2 + \frac{1}{2}O_2$

$P_0 \quad 0 \quad 0$

$P_0 - x \quad 2x \quad \frac{x}{2}$

$P_0 - \frac{P_0}{2} \quad P_0 \quad \frac{P_0}{4}$

Total pressure $= P_0 - \frac{P_0}{2} + P_0 + \frac{P_0}{4} = \frac{7}{4}P_0$

61. The product (A) formed in the following reaction sequence is

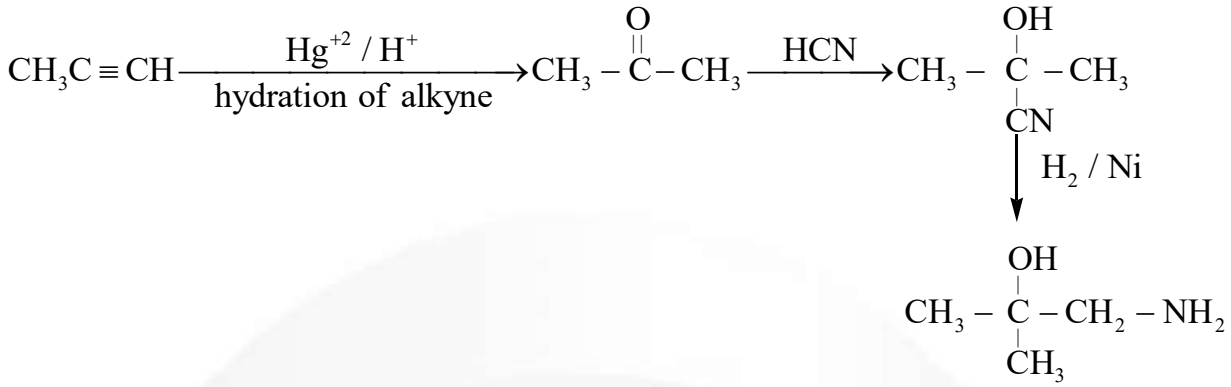
$$CH_3 - C \equiv CH \xrightarrow[\text{iii) } H_2/Ni]{\text{i) } Hg^{2+}, H_2SO_4 \text{ ii) HCN}} (A) \text{ product}$$

1) $CH_3 - CH_2 - \underset{NH_2}{\underset{|}{CH}} - CH_2 - OH$ 2) $CH_3 - CH_2 - \underset{OH}{\underset{|}{CH}} - CH_2 - NH_2$

3) $CH_3 - \underset{CH_3}{\underset{|}{\overset{NH_2}{\overset{|}{C}}}} - CH_2 - OH$ 4) $CH_3 - \underset{CH_3}{\underset{|}{\overset{OH}{\overset{|}{C}}}} - CH_2 - NH_2$

Key: 4

Sol:



62. Which of the following statement is true with respect to H_2O, NH_3 and CH_4?

A) The central atoms of all the molecules are sp^3 hybridized.

B) The H – O – H, H – N – H and H – C – N angles in the above molecules are $104.5^0, 107.5^0$ and 109.5^0 , respectively

C) The increasing order of dipole moment is $CH_4 < NH_3 < H_2O$

D) Both H_2O and NH_3 are Lewis acids and CH_4 is a Lewis base.

E) A solution of NH_3 in H_2O is basic. In this solution NH_3 and H_2O act as Lowry-Bronsted acid and base respectively.

Choose the correct answer from the options given below :

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

Key: 2

Sol: Dipole moment $H_2O > NH_3 > CH_4$

$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$

NH_3 acts as Lowry – Bronsted base

63. Given below are two statements – I and II.

Statement – I : Dumas method is used for estimation of 'Nitrogen' in an organic compound

Statement – II : Dumas method involves the formation of ammonium sulphate by heating the organic compound with conc. H_2SO_4

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: Statement – II false

In Dumas method, nitrogen is present in organic compound is converted in to N_2

64. Which of the following ions is the strongest oxidizing agent?
(Atomic number of Ce = 58, Eu = 63, Tb = 65, Lu = 71)

1) Eu^{2+} 2) Ce^{3+} 3) Lu^{3+} 4) Tb^{4+}

Key: 4

Sol: Tb^{+4} is the strongest oxidizing agent based on SRP value and oxidation state.

65. Preparation of potassium permanganate from MnO_2 involves two step process in which the 1st step is a reaction with KOH and KNO_3 to produce

1) $K_4\left[Mn(OH)_6\right]$ 2) $KMnO_4$ 3) K_2MnO_4 4) K_3MnO_4

Key: 3

Sol: $MnO_2 + 2KOH + KNO_3 \rightarrow K_2MnO_4 + H_2O + KNO_2$

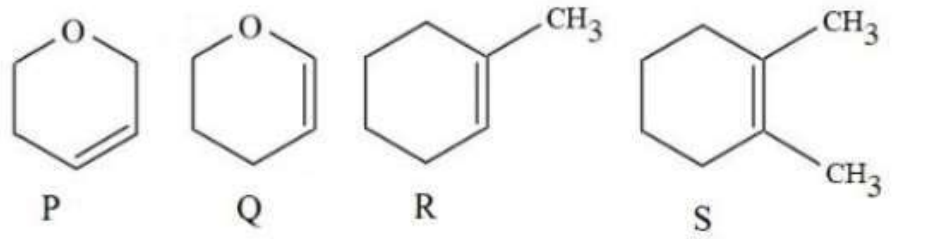
66. The large difference between the melting and boiling points of oxygen and sulphur may be explained on the basis of

1) Atomicity 2) Electronegativity
3) Atomic size 4) Electron gain enthalpy

Key: 1

Sol: Largest difference between the melting point and boiling point of oxygen and sulphur explained by atomicity. Oxygen is a diatomic gaseous molecule and sulphur is a octa atomic solid.

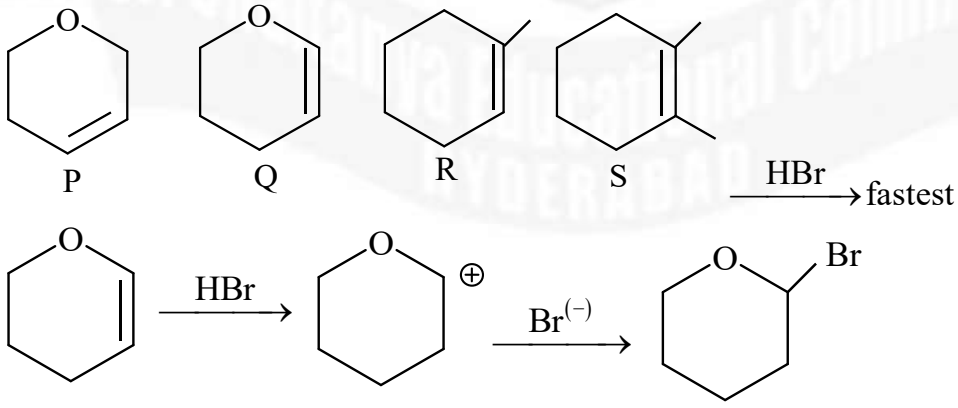
67. Following are the four molecules P, Q, R and S. Which one among the four molecules will react with $H-Br_{(aq)}$ at the fastest rate?



1) Q 2) P 3) R 4) S

Key: 1

Sol:



Stable. Carbocation due to + M (electrophilic additional mechanism)

68. K_{sp} for $Cr(OH)_3$ is 1.6×10^{-30}. What is the molar solubility of this salt in water?

1) $4\sqrt{\frac{1.6\times10^{-30}}{27}}$ 2) $2\sqrt{1.6\times10^{-30}}$ 3) $5\sqrt{1.8\times10^{-30}}$ 4) $\frac{1.8\times10^{-30}}{27}$

Key: 1

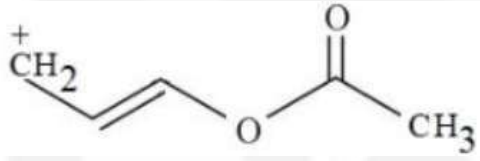
Sol: $Cr(OH)_3 \rightleftharpoons Cr^{+3} + 3OH^-$

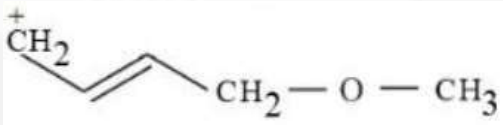
$K_{sp} = 27S^4$

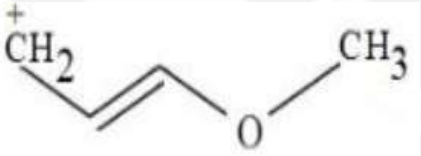
$S^4 = \frac{1.6\times10^{-30}}{27}$

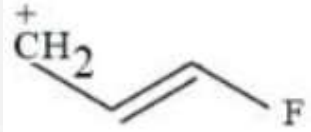
$S = 4\sqrt{\frac{1.6\times10^{-30}}{27}}$

69. Which one of the carbocations from the following is most stable?

1) 

2) 

3) 

4) 

Key: 3

Sol:

Order of stability 3 > 4 > 1 > 2

More stable due to resonance effect

70. Given below are two statements :

Statement – I : The conversion proceeds well in the less polar medium.

$$CH_3-CH_2-CH_2-CH_2-Cl \xrightarrow{HO^-} CH_3-CH_2-CH_2-CH_2-OH + Cl^{(-)}$$

Statement – II : The conversion proceeds well in the more polar medium.

$$CH_3-CH_2-CH_2-CH_2-Cl \xrightarrow{R_3\ddot{N}} CH_3-CH_2-CH_2-CH_2-\overset{R}{\underset{R}{\overset{|}{\underset{|}{N^{(+)}}}}}-R\,Cl^{(-)}$$

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: Statement – I is true but Statement – II is false

Both are polar a protic. (SN^2 mechanism)

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. Among the following cations, the number of cations which give characteristic precipitate in their identification tests with $K_4\left[Fe(CN)_6\right]$ is .....

$Cu^{2+}, Fe^{3+}, Ba^{2+}, Ca^{2+}, NH_4^+, Mg^{2+}, Zn^{2+}$

Key: NTA key : 3 & Chaitanya key : 4

Sol: Only Cu^{2+}, Fe^{3+} and Zn^{2+} form precipitate with $K_4\left[Fe(CN)_6\right]$

In Vogel's book $Ca_2\left[Fe(CN)_6\right]$ is a white ppt. So answer is 4

72. Consider the following occurring in the blast furnace :

$$Fe_3O_{4(s)} + 4CO_{(g)} \rightarrow 3Fe_{(l)} + 4CO_{2(g)}$$

'x' kg of irons is produced when 2.32×10^3 kg Fe_3O_4 and 2.8×10^2 kg CO are brought together in the furnace. The value of 'x' is …… (nearest integer)

(Given :

Molar mass of $Fe_3O_4 = 232\,g\ mol^{-1}$

Molar mass of $CO = 28\,g\ mol^{-1}$

Molar mass of $Fe = 56\,g\ mol^{-1}$)

Key: 420

Sol: No. of moles of $Fe_3O_4 = \dfrac{2.32\times10^3\times10^3}{232} = 10^4$ mole

No. of moles of $CO = \dfrac{2.8\times10^2\times10^3}{28} = 10^4$ moles

$Fe_3O_4 + 4CO \rightarrow 3Fe + 4CO_2$

4 mole CO $\rightarrow$ 3 mole Fe

10^4 mole CO ……..?

$\dfrac{10^4\times3}{4} = 0.75\times10^4$ moles

$= 0.75\times10^4\times56$

$= 42\times10^4$ gms

$= 420$ kg

73. 37.8 g N_2O_5 was taken in a 1 L reaction vessel and allowed to undergo the following reaction at 500 K

$2N_2O_{5(g)} \rightleftharpoons 2N_2O_{4(g)} + O_{2(g)}$

The total pressure at equilibrium was found to be 18.65 bar.

Then, $Kp = ...\times 10^{-2}$ [nearest integer]

Assume N_2O_5 to behave ideally under these conditions.

Given : $R = 0.082$ bar L $mol^{-1}K^{-1}$

Key: 962

Sol: Initial pressure N_2O_5 $P = \frac{nRT}{V}$

$= \frac{37.8 \times 0.082 \times 500}{108 \times 1} = 14.35$ bar

$2N_2O_5 \rightleftharpoons 2N_2O_4 + O_2$

$14.35 \quad O \quad O$

$14.35 - 2P \quad 2P \quad P$

Total pressure = 14.35 – 2P + 2P + P = 18.65

P = 4.3

$P_{N_2O_5} = 5.75$

$P_{N_2O_4} = 8.6$

$P_{O_2} = 4.3$

$K_P = \frac{8.6 \times 8.6 \times 4.3}{5.75 \times 5.75} = 9.618$

$= 961.8 \times 10^{-2} = 962$

74. Standard entropies of X_2, Y_2 and XY_5 are 70, 50 and 110 JK^{-1} mol^{-1} respectively. The temperature in Kelvin at which the reaction

$\frac{1}{2}X_2 + \frac{5}{2}Y_2 \rightleftharpoons XY_5 \Delta H^{\odot} = -35\,kJ\ mol^{-1}$

Will be at equilibrium is ……. (nearest integer)

Key: 700

Sol: $\frac{1}{2}X_2 + \frac{5}{2}Y_2 \rightleftharpoons XY_5$

$\Delta S = S_P - S_R$

$= 110 - \left[\frac{1}{2}(70) + \frac{5}{2}(50)\right] = -50$

$\Delta S = \frac{\Delta H \times 10^3}{T}$ J/mol

$T = \frac{-35 \times 1000}{-50}$

75. Xg of benzoic acid on reaction with aq. $NaHCO_3$ released CO_2 that occupied 11.2 L volume at STP. X is …… g

Key: 61

Sol: $C_6H_5COOH + NaHCO_3 \longrightarrow C_6H_5COONa + H_2O + CO_2$

122 22.4

61 11.2

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