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

1 AIR	4 AIR	5 AIR	6 AIR	9 AIR	10 AIR
RAGHAV SHARMA Ht. No. 242053073*	RHYTHM KEDIA Ht. No. 247025176*	P KUSHAL KUMAR Ht. No. 246150349	RAJDEEP MISHRA Ht. No. 241016176*	DHRUVIN H DOSHI Ht. No. 241106162	A SIDHVIK SUHAS Ht. No. 246119101

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

29-01-2025

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_29-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. Two parabolas have the same focus (4, 3) and their directrices are the x-axis and the y-axis, respectively. If these parabolas intersects at the points A and B, then $(AB)^2$ is equal to:

1)96 2)392 3)384 4)192

Key: 4

Solution:

$(x-4)^2 = 6(y-3/2)$ ---- A

$(y-3)^2 = 8(x-2)$ -----B

$x^2 - 8x + 16 - 6y + 9 = 0$ --------1

$y^2 - 6y + 9 - 8x + 16 = 0$ --------2

$1-2 \Rightarrow (x-y)(x+y) = 0 \Rightarrow x = y \quad or \quad x = -y$

$A \Rightarrow (x-4)^2 = 6(x-3/2)$

$\Rightarrow x^2 - 14x + 25 = 0 \rightarrow x_1, x_2$

$AB^2 = 2(x_1 - x_2)^2 = 2\left((x_1 + x_2)^2 - 4x_1x_2\right)$

$= 2(196 - 4 \times 25) = 192$

2. Let the area of the region $\left\{(x, y) : 2y \le x^2 + 3, y + |x| \le 3, y \ge |x-1|\right\}$ be A. Then 6A is equal to:

1)16 2)14 3)12 4)18

Key:2

Solution:

$3-x=\frac{x^2+3}{2}\Rightarrow x^2+2x-3=0$ $\Rightarrow (x+3)(x-1)=0$ $\Rightarrow x=1,-3$

$y=-x+1$ & $y=\frac{x^2+3}{2}$ $\Rightarrow -x+1=\frac{x^2+3}{2}\Rightarrow x^2+2x+1=0$

$\Rightarrow (x+1)^2=0$ $\Rightarrow x=-1$ $\Rightarrow$ $(-1,2)$

A= Area = $2\sqrt{2}\times\sqrt{2}-2\left(\int_0^1\left((3-x)-\left(\frac{x^2+3}{3}\right)\right)dx\right)$ $=4-2\left\{\frac{3x}{2}-\frac{x^2}{2}-\frac{x^3}{6}\Big|_0^1\right\}$

$=4-2\left(\frac{3}{2}-\frac{1}{2}-\frac{1}{6}\right)$ $=4-2\times\frac{5}{6}=4-\frac{5}{3}=\frac{7}{3}$ $6A=6\times\frac{7}{3}=14$

3. Let $x_1,x_2,....,x_{10}$ be ten observations such that

$\sum_{i=1}^{10}(x_i-2)=30,\sum_{i=1}^{10}(x_i-\beta)^2=98,\beta>2,$ and their variance is 4/5 .if μ and σ^2 are respectively the mean and the variance of $2(x_1-1)+4\beta$,

$2(x_2-1)+4\beta,...,2(x_{10}-1)+4\beta$, then $\frac{\beta\mu}{\sigma^2}$ is equal to

1) 100 2) 120 3) 90 4) 110

Key: 1

Solution:

$\sum x_1=50,\ \sum x_1^2=98-10\beta^2+2\beta\times 50$

$(\sigma^1)^2=\frac{\sum x_1^2}{1}-\mu^{1^2}=\frac{4}{5}\Rightarrow\sum x_1^2=\left(\frac{4}{5}+25\right)10=258$

$10\beta^2-100\beta+160=0\Rightarrow\beta^2-10\beta+16=0$

$\beta=2,8\ \mu=2(\mu^1)-2+4\beta=2(5)-2+4(8)=40$

$\sigma^2=4(\sigma^1)^2=4\times\frac{4}{5}=\frac{16}{5}$ $\frac{\beta\mu}{\sigma^2}=\frac{8\times 40}{\frac{16}{5}}=100$

4. Let P be the set of seven digit numbers with sum of their digits equal to 11. If the Numbers in P are formed by using the digits 1, 2 and 3 only, then the number of Elements in the set P is:

1)158 2) 161 3) 164 4) 173

Key: 2

Solution:

$1112222 \rightarrow \frac{7!}{3!4!} = 35$

$1111223 \rightarrow \frac{7!}{4!2!} = 105$

$1111133 \rightarrow \frac{7!}{5!2!} = 21$ $= 161$

5. Let $A = \left[a_{ij}\right] = \begin{bmatrix} \log_5 128 & \log_4 5 \\ \log_5 8 & \log_4 25 \end{bmatrix}$ If A_{ij} is the factor of a_{ij},

$C_{ij} = \sum_{k=1}^{2} a_{ik} A_{jk}, 1 \le i, j \le 2,$ and $C = \left[C_{ij}\right]$, then $8|C|$ is equal to

1)288 2) 262 3) 222 4) 242

Key: 4

Solution:

$C = A(adj(A)) = |A| I \Rightarrow 8|C| = 8 \times |A|^2 \times 1$

$= 8 \times \left(\frac{\log 128}{\log 5} \frac{\log 5}{\log 4} - \frac{\log 5}{\log 4} \frac{\log 8}{\log 5} \right)^2 = 8\left(\log_4 \frac{128^2}{8} \right)$ $= 8 \times \left(\frac{11}{2} \right)^2 = 242$

6. Consider an A. P. of positive integers, whose sum of the first three terms is 54 and the sum of the first twenty terms lies between 1600 and 1800. Then its 11^{th} term is:

1) 90 2)108 3) 84 4)122

Key: 1

Solution: a+a+d+a+2d = 54 $\Rightarrow$ a + d = 18

$S_{20} = \frac{20}{2}(2a + 19d) = 20a + 190d = 20(a + d) + 170d$ $= 360 + 170d$

$1600 \le 360 + 170d \le 1800$

$1240 \le 170d \le 1440$

$7.29 \le d \le 8.47 \Rightarrow d = 8$

$T_{11} = a + 10d = 10 + 80 = 90$

7. The value of $\lim_{n \to \infty} \left(\sum_{k=1}^{n} \frac{k^3 + 6k^2 + 11k + 5}{(k+3)!} \right)$ is:

1)7/3 2) 2 3)5/3 4) 4/3

Key: 3

Solution

$$\lim_{x\to\infty}\sum_{k=1}^{n}\frac{(k+1)(k+2)(k+3)-1}{(k+3)!}$$

$$=\lim_{x\to\infty}\sum_{k=1}^{2n}\frac{n}{k=1}\frac{1}{k!}-\frac{1}{(k+3)!}=\frac{1}{1!}-\frac{1}{4!}+\frac{1}{2!}-\frac{1}{5!}+\frac{1}{5!}-\frac{1}{6!}$$

$$+\frac{1}{4!}-\frac{1}{7!}\ldots\ldots\ldots=5/3$$

8. Let M and m respectively be the maximum and the minimum values of

$$f(x)=\begin{vmatrix}1+\sin^2 x & \cos^2 x & 4\sin 4x\\ \sin^2 x & 1+\cos^2 x & 4\sin 4x\\ \sin^2 x & \cos^2 x & 1+4\sin 4x\end{vmatrix},x\in R$$ Then M^4-m^4 is equal to

1)1280 2)1215 3)1295 4)1040

Key: 1

Sol:

$$C_1\to C_1+C_2+C_3$$

$$f(x)=(2+4\sin 4x)\begin{vmatrix}1 & \cos^2 x & 4\sin 4x\\ 1 & 1+\cos^2 x & 4\sin 4x\\ 1 & \cos^2 x & 1+4\sin 4x\end{vmatrix}$$

$R_2\to R_2-R_1$ $\quad R_3\to R_3-R_1=(2+4\sin 4x)\begin{vmatrix}1 & \cos^2 x & 4\sin 4x\\ 0 & 1 & 0\\ 0 & 0 & 1\end{vmatrix}$

$=2+4\sin 4x$ $\quad m=-2$ $\quad M=6$

$M^4-m^4=1296-16=1280$

9. Let the ellipse $E_1:\frac{x^2}{a^2}+\frac{y^2}{b^2}=1,a>b$ and $E_2:\frac{x^2}{A^2}+\frac{y^2}{B^2}=1,A<B$ have same eccentricity $\frac{1}{\sqrt{3}}$. Let the product of their lengths of latus rectums be $\frac{32}{\sqrt{3}}$ and the distance between the foci of E_1 be 4. If E_1 and E_2 meet at A, B, C and D, then the area of the quadrilateral ABCD equals:

1) $6\sqrt{6}$ 2) $\frac{12\sqrt{6}}{5}$ 3) $\frac{24\sqrt{6}}{5}$ 4) $\frac{18\sqrt{6}}{5}$

Key: 3

Sol:

$$2a\left(\frac{1}{\sqrt{3}}\right)=4\Rightarrow a=2\sqrt{3}\Rightarrow b=2\sqrt{2}$$

$$\frac{2b^2}{a}\times\frac{2A^2}{B}=\frac{32}{\sqrt{3}} \qquad \Rightarrow\frac{2\times8\times2b^2}{2\sqrt{3}}\times2\frac{A^2}{B^2}B=\frac{32}{\sqrt{3}}\Rightarrow\frac{1}{2}\times\frac{2}{3}B=1\Rightarrow B=3\Rightarrow a=\sqrt{6}$$

$$\varepsilon_1:\frac{x^2}{12}+\frac{y^2}{8}=1$$

$$\varepsilon_2:\frac{x^2}{6}+\frac{y^2}{9}=1\Rightarrow\frac{x^2}{6}+\frac{8\left(1-\frac{x^2}{12}\right)}{9}=1$$

$$\Rightarrow\frac{x^2}{6}+\frac{8}{9}-\frac{2x^2}{27}=1 \qquad \Rightarrow x^2\frac{(9-4)}{54}=\frac{1}{9} \qquad \Rightarrow x^2=\frac{6}{5}\Rightarrow x=\sqrt{\frac{6}{5}} \qquad \Rightarrow y=\sqrt{8-\left(1-\frac{x^2}{12}\right)}$$

$$\sqrt{8\left(1-\frac{1}{10}\right)}=\frac{6}{\sqrt{5}} \quad \text{Area}=4\times xy=4\sqrt{\frac{6}{5}}\ \frac{6}{\sqrt{5}}=\frac{24}{5}\sqrt{6}$$

10. Let y= y(x) be the solution of the differential equation

$$\cos x\left(\log_e(\cos x)\right)^2dy+\left(\sin x-3y\sin x\log_e(\cos x)\right)dx=0,\ x\in\left(0,\frac{\pi}{2}\right).\text{If}$$

$$y\left(\frac{\pi}{4}\right)=\frac{-1}{\log_e 2},y\left(\frac{\pi}{6}\right)\text{ is equal to}$$

1) $\dfrac{1}{\log_e(4)-\log_e(3)}$

2) $\dfrac{1}{\log_e(3)-\log_e(4)}$

3) $-\dfrac{1}{\log_e(4)}$

4) $\dfrac{2}{\log_e(3)-\log_e(4)}$

Key: 2

Solution:

$$\frac{dy}{dx}+\left(\frac{-3\sin x}{\cos x(\ln\cos x)}\right)y=\frac{-\sin x}{\cos x(\ln\cos x)^2}$$

$$IF=e^{\int\frac{-3\sin x}{\cos x\ln\cos x}dx}=e^{\int\frac{3}{t}dt}=e^{3\ln t}=(\ln\cos x)^3$$

$$\ln\cos x=t$$

$$\frac{1}{\cos x}(-\sin x)dx=dt$$

$$y\times(\ln\cos x)^3=\int(\ln\cos x)^3\times\frac{-\sin x}{\cos x(\ln\cos x)^2}dx$$

$y(\ln\cos x)^3 = \int t\ dt$

$\ln\cos x = t \Rightarrow \dfrac{1}{\cos x}(\sin x)dx = dt$

$y(\ln\cos x)^3 = \dfrac{(\ln\cos x)^2}{2} + C \qquad \Rightarrow c = 0$

$y\left(\ln\dfrac{\sqrt{3}}{2}\right)^3 = \dfrac{\left(\ln\dfrac{\sqrt{3}}{2}\right)^2}{2} \qquad \Rightarrow y = \dfrac{1}{\ln 3 - \ln 4}$

11. The least value of n for which the number of integral terms in the Binomial expansion of $\left(\sqrt[3]{7} + \sqrt[12]{11}\right)^n$ is 183 , is:

1)2184 2)2148 3)2196 4)2172

Key: 1

Sol: $\left(7^{\frac{1}{3}} + 11^{\frac{1}{12}}\right)^n \qquad K = 0 \qquad l = \dfrac{n}{12}$

$= {}^nC_r\, 7^{\frac{n-r}{3}} 11^{\frac{r}{12}} \qquad K = 4 \qquad l = \dfrac{n-12}{12}$

$n - r = 3k \qquad K = 728 \quad l = 0$

$r = 12l$

$n = 3k + 12l \qquad n = 3 \times 728$

12. The number of solutions of the equation $\left(\dfrac{9}{x} - \dfrac{9}{\sqrt{x}} + 2\right)\left(\dfrac{2}{x} - \dfrac{7}{\sqrt{x}} + 3\right) = 0$ is:

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

Key: 4

Sol:

$(9 - 9\sqrt{x} + 2x)(2 - 7\sqrt{x} + 3x) = 0$

$\sqrt{x} = \dfrac{9 \pm \sqrt{81-72}}{4},\ \dfrac{7 \pm \sqrt{49-24}}{6} \qquad = \dfrac{9 \pm 3}{4},\ \dfrac{7 \pm 5}{6}$

$= 3, \dfrac{3}{2}, 2, \dfrac{1}{3} \Rightarrow x = 9, \dfrac{9}{4}, 4, \dfrac{1}{9}$

13. Let $L_1 : \frac{x-1}{1} = \frac{y-2}{-1} = \frac{z-1}{2}$ and $L_2 : \frac{x+1}{-1} = \frac{y-2}{2} = \frac{z}{1}$ be two lines . Let L_3 be a line passing through the point (α, β, γ) and be perpendicular to both L_1 and L_2. If L_3 intersects L_1, then $|5\alpha - 11\beta - 8\gamma|$ equals:

1)25 2)18 3)16 4)20

Key: 1

Sol: $\vec{b} = \begin{vmatrix} i & j & k \\ 1 & -1 & 2 \\ -1 & 2 & 1 \end{vmatrix} = i(-5) - j(3) + k(1)$

$$\frac{x-\alpha}{-5} = \frac{y-\beta}{-3} = \frac{z-\gamma}{1}$$

$$\begin{vmatrix} \alpha-1 & \beta-2 & \gamma-1 \\ 1 & -1 & 2 \\ -5 & -3 & 1 \end{vmatrix} = 0 \qquad \Rightarrow (\alpha-1)(5) - (\beta-2)(11) + (\gamma-1)(-8) = 0$$

$$|5\alpha - 11\beta - 8\gamma| = 25$$

14. The integral $80\int_0^{\frac{\pi}{4}} \left(\frac{\sin\theta + \cos\theta}{9 + 16\sin 2\theta} \right) d\theta$ is equal to:

1) $2\log_e 3$ 2) $6\log_e 4$ 3) $3\log_e 4$ 4) $4\log_e 3$

Key: 4

Sol:

$$\sin\theta - \cos\theta = t \Rightarrow (\cos\theta + \sin\theta)dx = dt$$

$$1 - \sin 2\theta = t^2$$

$$80\int_{-1}^{0} \frac{dt}{9 - 16(1-t^2)} = 5\int_{-1}^{0} \frac{dt}{\left(\frac{5}{4}\right)^2 - t^2} \qquad = 5\frac{1}{2\times\frac{5}{4}} \ln\left|\frac{\frac{5}{4}+t}{\frac{5}{4}-t}\right|_{-1}^{0}$$

$$= 2\left(\ln 1 - \ln\left(\frac{1/4}{9/4}\right) \right) \quad = 2\times 2\ln 3 \qquad = 4\ \ln 3$$

15. Let the line x + y = 1 meet the circle $x^2+y^2=4$ at the points A and B. If the line perpendicular to AB and passing through the mid-point of the chord AB intersects the circle at C and D, then the area of the quadrilateral ADBC is equal to:

1) $2\sqrt{14}$ 2) $5\sqrt{7}$ 3) $3\sqrt{7}$ 4) $\sqrt{14}$

Key: 1

Sol: $Area = \left(\frac{1}{2}ABh_1 + \frac{1}{2}ABh_2\right)$ $= \frac{AB}{2}(h_1 + h_2)$

$= AB \times 2$ $= 2 \times 2\sqrt{r^2 - d^2}$ $= 4\sqrt{4 - \left(\frac{1}{\sqrt{2}}\right)^2}$ $= 4\frac{\sqrt{7}}{\sqrt{2}} = 2\sqrt{14}$

16. Let $|z_1 - 8 - 2i| \le 1$ and $|z_2 - 2 + 6i| \le 2$, $z_1, z_2 \in C$. Then the maximum value of $|z_1 - z_2|$ is:

1)7 2) 10 3)13 4)3

Key: 1

Sol: $\min = \sqrt{(8-2)^2 + (2+6)^2} - r_1 - r_2$ $= 10 - 1 - 2$ $= 7$

17. Let $\vec{a} = 2\hat{i} - \hat{j} + 3\hat{k}, \vec{b} = 3\hat{i} - 5\hat{j} + \hat{k},$ and $\vec{c}$ be a vector such that $\vec{a} \times \vec{c} = \vec{c} \times \vec{b}$ and $\left(\vec{a} + \vec{c}\right).\left(\vec{b} + \vec{c}\right) = 168$. Then the maximum value of $\left|\vec{c}\right|^2$ is:

1)462 2)154 3)308 4)77

Key: 3

Sol: $(a+b) \times c = 0 \Rightarrow c = \lambda(a+b)$

$(a+c).(b+c) = 168 \Rightarrow a.b + c.(a+b) + |c|^2 = 168$

$\Rightarrow (6+5+3) + \lambda \times |a+b|^2 + |c|^2 = 168$

$\Rightarrow 14 + \lambda \times (25+36+16) + \lambda^2(25+36+16) = 168$

$\Rightarrow 77\lambda^2 + 77\lambda - 154 = 0 \Rightarrow \lambda^2 + \lambda - 2 = 0 \Rightarrow (\lambda+2)(\lambda-1) = 0$ $\Rightarrow \lambda = 1, -2$

$\max |c|^2 = 4|a+b|^2 = 4 \times 77 = 308$

18. Let ABC be a triangle formed by the lines 7x - 6y + 3 = 0, x + 2y - 31 = 0 and 9x - 2y - 19 = 0 Let the point (h, k) be the image of the centroid of ΔABC the 3x + 6y - 53 = 0. Then $h^2 + k^2 + hk$ is equal to:

1)36 2)40 3)47 4)37

Key: 4

Sol:

$7x - 6y + 3 = 0$ -------1 $1 \& 2 \Rightarrow A(9,11)$

$x + 2y - 31 = 0$ -------2 $2 \& 3 \Rightarrow B(5,13)$

$9x-2y-19=0$ --------3 $\quad 3\&1 \Rightarrow C(3,4)$

$G=\frac{A+B+C}{3}=\left(\frac{17}{3},\frac{28}{3}\right)$ $\quad \frac{h-\frac{17}{3}}{3}=\frac{k-\frac{28}{3}}{6}=\frac{-2(17+56-53)}{45}=\frac{-8}{9}$

$(h,k)=(3,4) \Rightarrow h^2+k^2+hk=37$

19. Define a relation R on the interval $\left[0,\frac{\pi}{2}\right)$ by x R y if and only if $\sec^2 x-\tan^2 y=1$ Then R is

1) Both reflexive and symmetric but not transitive

2) An equivalence relation

3) Reflexive but neither symmetric not transitive

4) Both reflexive and transitive but not symmetric

Key: 2

Sol:

$x=y \quad (x,x) \Rightarrow$ reflexive

$(x,y) \Rightarrow (y,x) \Rightarrow symmetric$

$(x,y),(y,z) \Rightarrow (x,z) \Rightarrow$ transistive

Equivalence

20. Let $\vec{a}=\hat{i}+2\hat{j}+\hat{k}$ and $\vec{b}=2\hat{i}+7\hat{j}+3\hat{k}$. Let $L_1:\vec{r}=\left(-\hat{i}+2\hat{j}+\hat{k}\right)+\lambda\vec{a},\ \lambda\in R$ and $L_2:\vec{r}=\left(\hat{j}+\hat{k}\right)+\mu\vec{b},\mu\in R$ be two lines. If the line L_3 passes through the point of intersection of L_1 and L_2, and is parallel to $\vec{a}+\vec{b}$, then L_3 passes through the point:

1) (2, 8, 5) 2) (8, 26, 12) 3) (5, 17, 4) 4) (-1, -1, 1)

Key: 2

Sol: $(-1+\lambda,2+2\lambda,1+\lambda)=(2\mu,1+7\mu,1+3\mu)$

$2\mu-\lambda+1=0$ ------1 $\Rightarrow 4\mu-2\lambda+2=0$

$7\mu-2\lambda-1=0$ ------2 $7\mu-2\lambda-1=0\ -3\mu+3=0$ $\mu=1$

$P(2,8,4)$ $\quad \vec{a}+\vec{b}=\ (3i+9j+4k)$

$\frac{x-2}{3}=\frac{y-8}{9}=\frac{z-4}{4}=t$ $\quad (8,26,12)$ Satisfies

(NUMERICAL VALUE TYPE)

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

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

21. Let $f:(0,\infty)\to R$ be a twice differentiable function. If for some $a\neq 0$,

$\int_0^1 f(\lambda x)d\lambda = af(x), f(1)=1$ and $f(16)=\frac{1}{8}, then\ 16-f^1\left(\frac{1}{16}\right)$ is equal to ____

Key: 112

Sol: $\int_0^1 \frac{\partial f(\lambda x)}{\partial x}d\lambda = af^1(x) \quad \Rightarrow \int_0^1 f^1(\lambda x)\lambda\, d\lambda = af^1(x)$

Integrating by parts w.r.t λ

$\Rightarrow \frac{f(x)}{x}(1-a)=af^1(x) \quad \Rightarrow \int\frac{d(x)}{x}=\left(\frac{a}{1-a}\right)\int\frac{df(x)}{f(x)}+c \Rightarrow \ln x=\frac{a}{1-a}\ln f(x)+c$

As f(1) =1 $\Rightarrow$ c= 0 $f(x)=x^{\frac{1-a}{a}}=x^{\frac{-3}{4}} \Rightarrow 16-f^1\left(\frac{1}{16}\right)=112$

22. Let $S=\left\{m\in Z: A^{m^2}+A^m=3I-A^{-6}\right\}$ where $A=\begin{bmatrix}2&-1\\1&0\end{bmatrix}$. Then n(S) is equal to ____

Key: 2

Sol: $A=\begin{bmatrix}1&0\\0&1\end{bmatrix}+\begin{bmatrix}1&-1\\1&-1\end{bmatrix}=I+\begin{bmatrix}1&-1\\1&-1\end{bmatrix}=I+B \qquad \Rightarrow A^n=I+nB$

$A^{m^2}+A^m=I+m^2B+I+mB=3I-A^{-6}$

$\Rightarrow (m^2+m)B=I-A^{-6}=\begin{bmatrix}6&-6\\6&-6\end{bmatrix}=6B$

$\Rightarrow (m^2+m)=6 \qquad \Rightarrow m=2,-3$

23. Let [t] be the greatest integer less than or equal to t. Then the least value of $p\in N$ for which

$\lim_{x\to 0^+}\left(x\left(\left[\frac{1}{x}\right]+\left[\frac{2}{x}\right]+\ldots+\left[\frac{p}{x}\right]\right)-x^2\left(\left[\frac{1}{x^2}\right]+\left[\frac{2^2}{x^2}\right]+\ldots+\left[\frac{9^2}{x^2}\right]\right)\right)\geq 1$ is equal to _____

Key: 24

So: $\lim_{x\to 0^+}\left(x\left(\frac{p(p+1)}{2x}\right)-x^2\left(\frac{9\times 10\times 19}{6x^2}\right)\right)\geq 1$

$\Rightarrow \frac{p(p+1)}{2x}-285\geq 1$

$\Rightarrow p(p+1)\geq 572$

$\Rightarrow p\geq 24$ min. value=24

24. Let $S=\left\{x:\cos^{-1}x=\pi+\sin^{-1}x+\sin^{-1}\left(2x+1\right)\right\}$. then $\sum_{x\in S}\left(2x-1\right)^2$ is equal to _____

Key: 5

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

Domain $\in[-1,0]$

$\Rightarrow \sin\left(\frac{-\pi}{2}-2\sin^{-1}x\right)=2x+1$

$\Rightarrow -\cos\left(2\sin^{-1}x\right)=2x+1 \qquad \sin^{-1}x=\theta$

$\Rightarrow -(1-2x^2)=2x+1 \qquad \sin\theta=x$

$\Rightarrow 2x^2-2x-2=0 \Rightarrow x=\frac{1+\sqrt{1+4}}{2}=\frac{1\pm\sqrt{5}}{2}$

$\Rightarrow x=\frac{1-\sqrt{5}}{2} \Rightarrow (2x-1)^2=5$

25. The number of 6-letter words, with or without meaning that can be formed using the letters of the word MATHS such that any letter that appears in the word must appear at least twice, is__

Key: 1405

Sol:

All same = $5_{C_1}\times\frac{6!}{6!}=5$

2 same, 4 same $=5_{C_2}\times 2\times\frac{6!}{4!2!}$

$=300$

3 same, 3 same $=5_{C_2}\times\frac{6!}{3!3!}$

$=200$

2 same, 2 same, 2same $=5_{C_3}\times\frac{6!}{2!2!2!}$

$=10\times 9=900$

Total = 1405

PHYSICS **Max Marks: 100**

(SINGLE CORRECT ANSWER TYPE)

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

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

26. A coil of area A and N turns is rotating with angular velocity ω & in a uniform magnetic field $\vec{B}$ about an axis perpendicular to $\vec{B}$. Magnetic flux φ and induced emf $\mathcal{E}$ across it, at an instant when $\vec{B}$ is parallel to the plane of coil, are:

1) $\varphi = AB, \varepsilon = 0$ 2) $\varphi = AB, \varepsilon = NAB\omega$

3) $\varphi = 0, \varepsilon = NAB\omega$ 4) $\varphi = 0, \varepsilon = 0$

Key: 3

SOL:

$$\varnothing = \overline{B} \bullet \overline{A} = NBA\cos\theta = NBA\cos 90^0 = 0$$

$$e = \frac{-d\varnothing}{dt} = \frac{d}{dt}(NBA\cos\theta) = -\frac{d}{dt}(NBA\cos\omega t)$$

$$= NBA\omega \sin wt = NAB\omega$$

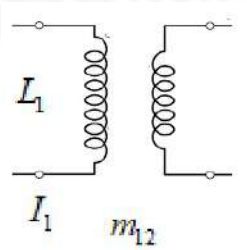
27. Consider I_1 and I_2 are the currents flowing simultaneously in two nearby coils 1 & 2, respectively. If L_1= self-inductance of coil 1, M_{12} = mutual inductance of coil 1 with respect to coil 2, then the value of induced emf in coil 1 will be

1) $\varepsilon_1 = -L_1\frac{dI_1}{dt} - M_{12}\frac{dI_1}{dt}$ 2) $\varepsilon_1 = -L_1\frac{dI_1}{dt} - M_{12}\frac{dI_2}{dt}$

3) $\varepsilon_1 = -L_1\frac{dI_2}{dt} - M_{12}\frac{dI_1}{dt}$ 4) $\varepsilon_1 = -L_1\frac{dI_1}{dt} - M_{12}\frac{dI_2}{dt}$

Key: 4

Sol:



$$\in_1 = -L_1\frac{dI_1}{dt} - M_{12}\frac{dI_2}{dt}$$

28. Match List - I with List - II.

List – I	List - II
A) Electric field inside (distance r > 0 from center) Of a uniformly charged spherical shell with Surface charge density σ, and radius R.	I) σ / ε_0
B) Electric field at distance r>0 from a uniformly Charged infinite plane sheet with surface Charge density σ.	II) $\sigma / 2\varepsilon_0$
C) Electric field outside (distance r>0 from center) Of a uniformly charged spherical shell with surface Charge density σ, and radius R.	III) 0
D) Electric field between 2 oppositely charged infinite Plane parallel sheets with uniform surface charge Density σ.	IV) $\frac{\sigma}{\varepsilon_0 r^2}$

Choose the correct answer from the options given below:

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

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

Key: 2

Sol: A) Electric field inside spherical shell is zero

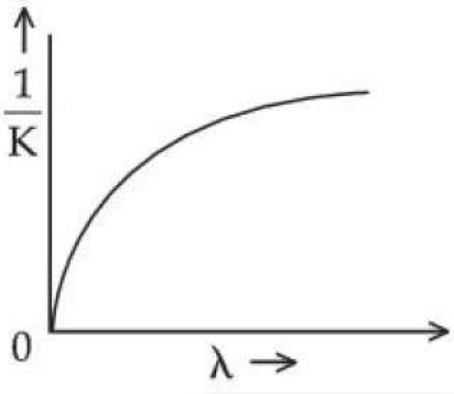
B) Electric field on a infinite plane sheet is $\frac{\sigma}{2 \in_0}$

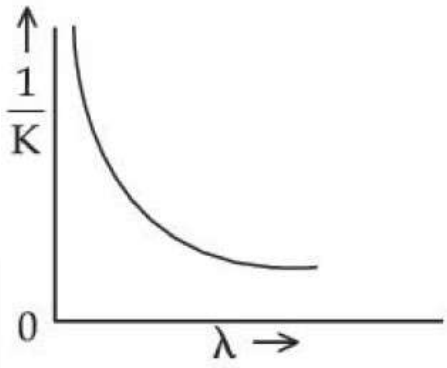
C) Electric field outside aspherical shell is $\frac{KQ}{r^2}$

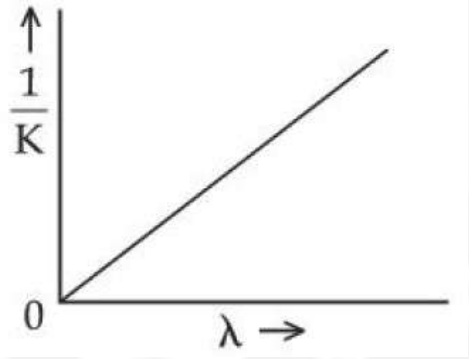
$$\frac{Q}{4\pi R^2} = \sigma \rightarrow Q = \sigma 4R\pi^2 \rightarrow Electric\ field\ is\ \frac{\sigma}{\in_0}\frac{R^2}{r^2}$$

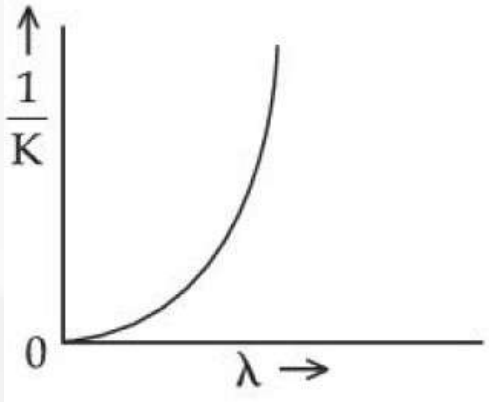
D) Electric field is between 2 opposite changed infinite parallel plates = $\sigma / \in_0$

29. If λ and K are de Broglie wavelength and kinetic energy, respectively, of a particle with Constant mass. The correct graphical representation for the particle will be

1) 

2) 

3) 

4) 

Key: 4

Sol: $\lambda = \frac{h}{\sqrt{2mK}} \Rightarrow \lambda\varepsilon\frac{1}{\sqrt{K}} \Rightarrow \lambda\alpha\sqrt{\frac{1}{K}}$

30. At the interface between two materials having refractive indices n_1 and n_2, the critical angle for reflection of an em wave is θ_{1C}. The n_2 material is replaced by another material having refractive index n_3, such that the critical angle at the interface between n_1 and n_3 materials is θ_{2C}. If $n_3 > n_2 > n_1$; $\frac{n_2}{n_3} = \frac{2}{5}$ and $\sin\theta_{2C} - \sin\theta_{1C} = \frac{1}{2}$, then θ_{1C} is

1) $\sin^{-1}\left(\frac{1}{3n_1}\right)$ 2) $\sin^{-1}\left(\frac{1}{6n_1}\right)$ 3) $\sin^{-1}\left(\frac{5}{6n_1}\right)$ 4) $\sin^{-1}\left(\frac{2}{3n_1}\right)$

Key: No answer

Sol: I) $\sin\theta_{1C} = \frac{n_1}{n_2}$ ii) $\sin\theta_{2C} = \frac{n_1}{n_3}$ iii) $\sin\theta_{2C} - \sin\theta_{1C} = \frac{1}{2}$ iv) $\frac{n_2}{n_3} = \frac{2}{5}$

$$\sin\theta_{2C}-\sin\theta_{1C}=\frac{1}{2}$$

$$\frac{n_1}{n_3}-\frac{n_1}{n_2}=\frac{1}{2}$$

$$n_1\left(\frac{n_2}{n_3}-1\right)=\frac{1}{2}$$

$$\frac{n_1}{n_2}\left(\frac{2}{3}-1\right)=\frac{1}{2}$$

$$\frac{n_1}{n_2}=\frac{1}{2}\left(-\frac{3}{1}\right) \quad not\ exist$$

31. The pair of physical quantities not having same dimensions is:

1) Angular momentum and Planck's constant

2) Surface tension and impulse

3) Pressure and Young's modulus

4) Torque and energy

Key: 2

$$\left[Surafce\ Tension\right]=\frac{[F]}{[\ell]}=M^1L^0T^{-2}$$

Sol:

$$=M^1T^{-2}$$

$$impulse(J)=m\Delta V$$

$$=MLT^{-1}$$

32. The fractional compression $\left(\frac{\Delta V}{V}\right)$ of water at the depth of 2.5 km below the sea level is _____%. Given, the Bulk modulus of water = $2\times10^9\ Nm^{-2}$, density of water = 10^3 kg m^{-3}, acceleration due to gravity =g=10m s^{-2}

1)1.5 2) 1.0 3) 1.75 4)1.25

Key: 4

Sol:

$$K=\frac{P\Delta V}{\Delta V}(Bulk\ \text{modulus})$$

$$\frac{\Delta V}{V}=-\frac{P}{K}=-$$

The fraction of compression = $-\frac{\Delta V}{V}\times100$

$$= \frac{P}{K} \times 100$$

$$= \frac{heg}{K} \times 100$$

$$= \frac{2.5 \times 10 \times 10 \times 10}{2 \times 107} \times 100$$

$$= 1.25\%$$

33. A body of mass 'm' connected to a massless and unstretchable string goes in vertical circle of radius 'R 'under gravity g. The other end of the string is fixed at the center of circle. If velocity at top of circular path is $n\sqrt{gR}$, where, $n \geq 1$, then ratio of kinetic energy of the body at bottom to that at top of the circle is

1) $\frac{n+4}{n}$ 2) $\frac{n}{n+4}$ 3) $\frac{n^2+4}{n^2}$ 4) $\frac{n^2}{n^2+4}$

Key: 3

Sol:

$$\vartheta_1 = n\sqrt{gr}$$

$$At\ bottom\ \ K_1 = \frac{1}{2}m\vartheta_1^2$$

$$At\ \ top\ \ K_2 = \frac{1}{2}m\vartheta_2^2$$

$$But\ \ \vartheta_1^2 = \vartheta_2^2 + 4gr$$

$$= n^2 gR + 4gR$$

$$= (n^2+4)gR$$

$$\therefore \frac{K_1}{K_2} = \frac{\frac{1}{2}m\vartheta_1^2}{\frac{1}{2}m\vartheta_2^2} = \frac{\left(n^2+4\right)}{\left(n\sqrt{gR}\right)^2} = \frac{n^2+4}{n^2}$$

34. An electric dipole of mass m, charge q, and length l is placed in a uniform electric field $\vec{E} = E_0\hat{i}.$ when the dipole is rotated slightly from its equilibrium position and released, the time period of its oscillations will be:

1) $2\pi\sqrt{\frac{ml}{2qE_0}}$ 2) $\frac{1}{2\pi}\sqrt{\frac{ml}{2qE_0}}$ 3) $2\pi\sqrt{\frac{ml}{qE_0}}$ 4) $\frac{1}{2\pi}\sqrt{\frac{2ml}{qE_0}}$

Key: 2

Sol: $\hat{P} = q.L, I = \frac{ml^2}{4}, T = 2\pi\sqrt{\frac{I\theta}{\tau}}, = 2\pi\sqrt{\frac{2ml^2}{4} \times \frac{\theta}{qlE_0\theta}}, T = 2\pi\sqrt{\frac{ml}{2qE_0}}$

35. The expression given below shows the variation of velocity (v) with time (t),

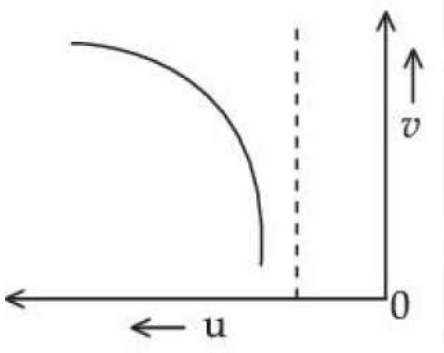
$v = At^2 + \frac{Bt}{C+t}$. the dimension of ABC is:

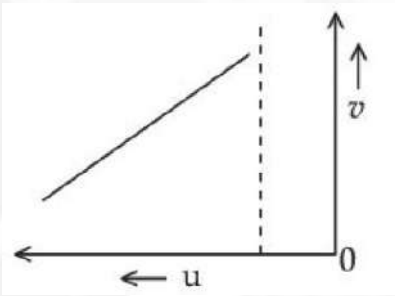
1) $\left[M^0L^1T^{-3}\right]$ 2) $\left[M^0L^1T^{-2}\right]$ 3) $\left[M^0L^2T^{-3}\right]$ 4) $\left[M^0L^2T^{-2}\right]$

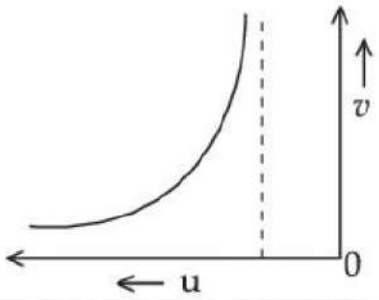
Key: 3

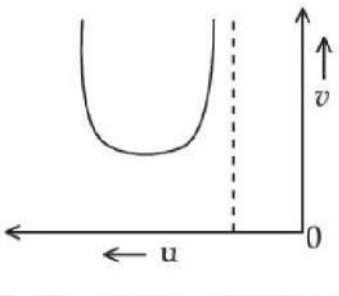
Sol: $\vartheta = At^2 + \frac{Bt}{C+t}, ABC = \frac{LT^{-1}}{T^2} \times LT^{-1} \times T, \quad = L^2T^{-3}$

36. Let u and v be the distances of the object and the image from a lens of focal length f. The correct graphical representation of u and v for a convex lens when $|u| > f$, is

1) 

2) 

3) 

4) 

Key: 3

Sol:

$\frac{1}{V} - \frac{1}{u} = \frac{1}{f}$

$V = \frac{uf}{u+f}$

$u = -x$

$|u| > f$

$\rightarrow x > f$

$V = \frac{-xf}{-x+f} = \frac{xf}{x-f}$

$x \rightarrow \infty \quad \rightarrow v = f$

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

Assertion (A): Electromagnetic waves carry energy but not momentum. Reason (R): Mass of a photon is zero.

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

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

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

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

4) Both (A) and (R) are true but (R) is not the correct explanation of (A)

Key: 3

Sol: EM waves are like photon's so they carry energy & momentum

Assertion is false

Rest mass of photon = 0

Reason is true

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

Assertion (A): Choke coil is simply a coil having a large inductance but a small resistance. Choke coils are used with fluorescent mercury-tube fittings. If household electric power is directly connected to a mercury tube, the tube will be damaged.

Reason (R): By using the choke coil, the voltage across the tube is reduced by a factor $\left(R/\sqrt{R^2+\omega^2L^2}\right)$, where ω is frequency of the supply across resistor R and inductor L. If the choke coil were not used, the voltage across the resistor would be the same as the applied voltage. In the light of the above statements, choose the most appropriate answer from the options given below:

1) Both (A) and (R) are true but (R) is not the correct explanation of (A)

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

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

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

Key: 3

Sol:

$$I = \frac{V_{vms}}{Z} = \frac{V_{vms}}{\sqrt{R^2 + \omega^2 L^2}} \; take\ resis\tan ce\ of\ coil\ almost\ zero$$

$$V_R = IR$$

$$= \frac{V_{vms}}{\sqrt{R^2 + \omega^2 L^2}} \times R \to V_{vms} \frac{R}{\sqrt{R^2 + \omega^2 L^2}}$$

Given assertion & reason is true & reason us correct explanation of assertion.

39. Two projectiles are fired with same initial speed from same point on ground at angles of $(45^0 - \alpha)$ and $(45^0 + \alpha)$, respectively, with the horizontal direction. The ratio of their maximum heights attained is:

1) $\frac{1+\sin 2\alpha}{1-\sin 2\alpha}$ 2) $\frac{1-\sin 2\alpha}{1+\sin 2\alpha}$ 3) $\frac{1+\sin \alpha}{1-\sin \alpha}$ 4) $\frac{1-\tan \alpha}{1+\tan \alpha}$

Key: 2

Sol:

$$\frac{H_1}{H_2} = \frac{\sin^2(45^0 - \alpha)}{\sin^2(45 + \alpha)} = \left(\frac{\cos\alpha - \sin\alpha}{\cos\alpha + \sin\alpha}\right)^2$$

$$\frac{H_1}{H_2} = \frac{1 - 2\sin\alpha\cos\alpha}{1 + 2\sin\alpha\cos\alpha}$$

$$= \frac{1 - \sin 2\alpha}{1 + \sin 2\alpha}$$

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

Assertion (A): Time period of a simple pendulum is longer at the top of a mountain than that at the base of the mountain.

Reason (R): Time period of a simple pendulum decreases with increasing value of acceleration due to gravity and vice-versa.

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

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

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

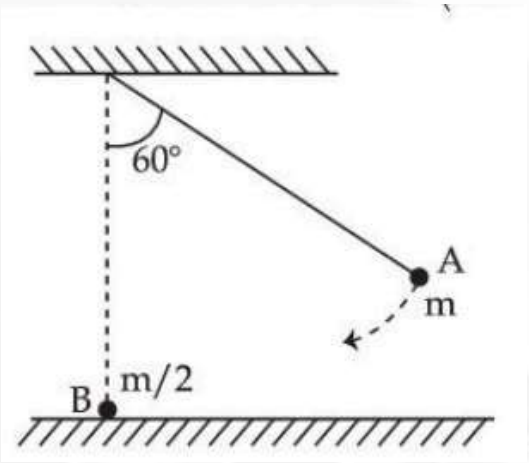
3) Both (A) and (R) are true but (R) is not the correct explanation of (A)

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

Key: 2

Sol: $g_{top} < g_{bottom} \Rightarrow As\ T\alpha\sqrt{\frac{1}{g}} \Rightarrow T_{top} > T_{bottam}$

41. As shown below, bob A of a pendulum having massless string of length 'R' is released from 60° to the vertical. It hits another bob B of half the mass that is at rest on a friction less table in the center. Assuming elastic collision, the magnitude of the velocity of bob A after the collision will be (take ‘g ‘ as acceleration due to gravity.)



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

Key: 3

Sol:

$$\vartheta_1 = \sqrt{2gR(1-\cos 60)} = \sqrt{gR}$$

$$\vartheta_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 \,\&\, u_2 = 0 \quad = \left(\frac{m - m/2}{m + m/2}\right)\sqrt{gr} \quad = \frac{1}{3}\sqrt{gr}$$

42. Consider a long straight wire of a circular cross-section (radius a) carrying a steady current I. The current is uniformly distributed across this cross-section. The distances from the center of the wire's cross-section at which the magnetic field [inside the wire, outside the wire] is half of the maximum possible magnetic field, anywhere due to the wire, will be

1) $\left[\frac{a}{2}, 3a\right]$ 2) $\left[\frac{a}{2}, 2a\right]$ 3) $\left[\frac{a}{4}, \frac{3a}{2}\right]$ 4) $\left[\frac{a}{4}, 2a\right]$

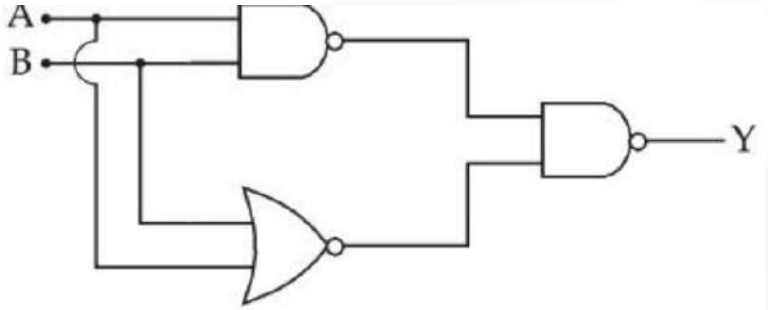
Key: 2

Sol:

$$B_{\max}=\frac{\mu oi}{2\pi R}, B_{in}=\frac{1}{2}B_{\max}, \frac{\mu_o i r^2}{2\pi R}=\frac{1}{2}\bullet\frac{\mu_0 i}{2\pi R}, r=\frac{R}{2}, r=\frac{a}{2}$$

$$B_{r\,out}=\frac{1}{2}B_{man}, \frac{\mu_o i}{2\pi r}=\frac{1}{2}\bullet\frac{\mu_o i}{2\pi R}, r=2R, r=2a, \left(\frac{a}{2}, 2a\right)$$

43.



For the circuit shown above, equivalent GATE is:

1)AND gate 2) OR gate 3) NAND gate 4) NOT gate

Key: 2

Sol: $Q=\left(\overline{\overline{A\bullet B}}\right)\bullet\left(\overline{\overline{A+B}}\right)=\overline{\overline{A\bullet B}}+\overline{\overline{A+B}}=A\bullet B+A+B=A(B+1)+B=A+B\therefore OR\ gate$

44. The work done in an adiabatic change in an ideal gas depends upon only:

1) change in its temperature 2) change in its pressure

3) Change in its volume 4) change in its specific heat

Key: 1

Sol: Work done dw = - dy $=\frac{-nR}{\Upsilon-1}[\Delta t]$

Depends on change in temperature.

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

Assertion (A): Emission of electrons in photoelectric effect can be suppressed by applying a sufficiently negative electron potential to the photo emissive substance.

Reason (R): A negative electric potential, which stops the emission of electrons from the surface of a photo emissive substance, varies linearly with frequency of incident radiation.

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 and (R) is the correct explanation of (A)

4) Both (A) and (R) are true but (R) is not the correct explanation of (A)

Key: 4

Sol: $V_S = \frac{h}{e}(f_0 - f), V_S$ Varies linearly with f but R does not explain suppression of electron.

(NUMERICAL VALUE TYPE)

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

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

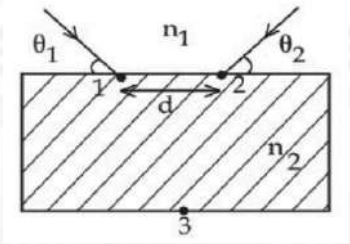
46. The coordinates of a particle with respect to origin in a given reference frame is (1, 1, 1) meters. If a force of $\vec{F} = \hat{i} - \hat{j} + \hat{k}$ acts on the particle, then the magnitude of torque (with respect to origin) in z-direction is_____.

Key: 2

Sol: $T = \bar{r} \times \bar{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 1 & 1 \\ 1 & -1 & 1 \end{vmatrix} = (1+1)\hat{i} - (1-1)\hat{j} + (-1-1)\hat{K} = 2\hat{i} - 2\hat{k}, \overline{T_Z} = -2\hat{K}, \left|\overline{T_Z}\right| = 2$

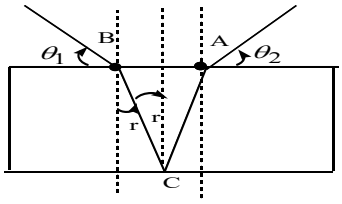
47. Two light beams fall on a transparent material block at point 1 and 2 with angle θ_1, and θ_2, respectively, as shown in figure. After refraction, the beams intersect at point 3 which is exactly on the interface at other end of the block.

Given: the distance between 1 and 2, $d = 4\sqrt{3}$ cm and $\theta_1 = \theta_2 = \cos^{-1}\left(\frac{n_2}{2n_1}\right)$ where refractive Index of the block n_2 > refractive index of the outside medium n_1, then the thickness of the Block is _____cm.



Key: 6

Sol:



1) Given $\theta_1 = \theta_2 = \cos^{-1}\left(\frac{n_2}{2n_1}\right) \Rightarrow \cos\theta_1 = \frac{n_2}{2n_1}$

2) $n_1 \sin(90-\theta_1) = n_2 \sin r, n_1 \cos\theta_1 = n_2 \sin r, n_2 \sin r = n_R \times \frac{n_2}{2n_1}, \sin r = 30^0$

$\tan r = \frac{2\sqrt{3}}{CB} \quad CB = \frac{2\sqrt{3}}{\tan r}, CB = \frac{2\sqrt{3}}{\tan 30^0} \quad = 2\sqrt{3} \times \frac{\sqrt{3}}{1} \quad = 6$

48. A container of fixed volume contains a gas at 27° C. To double the pressure of the gas, the temperature of gas should be raised to _____°C.

Key: 327

Sol: At constant volume, $P\alpha T, P_1 = P_1, P_2 = 2P$

$\frac{T_2}{T_1} = \frac{P_2}{P_1}$

$T_2 = (273+27)\frac{2P}{P}$

$T_2 = 600K$

$t_2 = 600 - 273$

$t_2 = 327^0 c$

49. In a hydraulic lift, the surface area of the input piston is 6 cm² and that of the output piston is 1500 cm². If 100 N force is applied to the input piston to raise the output piston by 20 cm, then the work done is _____ kJ.

Key: 5

Sol: $A_1 = 61m^2, A_2 = 1500cm^2, F_1 = 100N$

$W = P\Delta V = \frac{F_1}{A_1} \times (A_2 \times 4) = \frac{100}{6\times10^{-4}} \times (500\times10^{-4}) = 5000\ J, 5\ KJ$

50. The maximum speed of a boat in still water is 27 km/h. Now this boat is moving Downstream in a river flowing at 9 km/h. man in the boat throws a ball vertically upwards With speed of 10 m/s. Range of the ball as observed by an observer at rest on the river bank, is _____cm. (Take g = 10 m/s²)

Key: 2000 cm

Sol: $27 + 36\ kmph = 36 \times \frac{5}{18} = 10 ms^{-1},$

$u_x = u_g = 100\ ms^{-1} Range = u_x \times \frac{2u_y}{10} = 10 \times \frac{2\times10}{10}, \quad = 20m = 2000cm$

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. The correct option with order of melting points of the pairs (Mn, Fe), (Tc, Ru) and (Re, Os) is:

Options

1) Fe < Mn, Ru < Tc and Os < Re 2) Mn < Fe, Tc < Ru and Re < Os

3) Fe < Mn, Ru < Tc and Re < Os 4)Mn < Fe, Tc < Ru and Os < Re

Key: 4

Sol: Metals Mn and Tc have unusually low m.pt though having five unpaired electrons but metal Re has expected higher m.pt than Osmium

52. The molar conductivity of a weak electrolyte when plotted against the square root of its concentration, which of the following is expected to be observed?

1) A small increase in molar conductivity is observed at infinite dilution.

2) A small decrease in molar conductivity is observed at infinite dilution.

3) Molar conductivity decreases sharply with increase in concentration.

4) Molar conductivity increases sharply with increase in concentration.

Key: 3

Sol: Due to suppression of dissociation of weak electrolyte at higher concentration the molar conductivity decreases shorply.

53. 1.24 g of AX_2, (molar mass 124 g mol^{-1}) is dissolved in 1 kg of water to form a solution with boiling point of 100.0156^0C, while 25.4 g of AY_2, (molar mass 250 g mol^{-1}) in 2 kg of water constitutes a solution with a boiling point of 100.0260^0C.

$K_b(H_2O)$=0.52 K kg mol^{-1} Which of the following is correct?

1) AX_2 is completely unionised while AY_2 is fully ionised.

2) AX_2 and AY_2 (both) are fully ionised.

3) AX_2 is fully ionised while AY_2 is completely unionised.

4) AX_2 and AY_2 (both) are completely unionised.

Key: 3

Sol: $i = \dfrac{\Delta Tb}{k_b \times m}$

$Ax_2\ i = \frac{0.0156}{0.52\times10^{-2}} = 3 \qquad Ay_2\ i = \frac{0.0260}{0.52\times0.05} = 1$

54. If a_0 is denoted as the Bohr radius of hydrogen atom, then what is the de-Broglie Wavelength (λ) of the electron present in the second orbit of hydrogen atom? [n: any integer]

1) $\frac{2a_0}{n\pi}$ 2) $\frac{4n}{\pi a_0}$ 3) $\frac{8\pi a_0}{n}$ 4) $\frac{4\pi a_0}{n}$

Key: 3

Sol: $r_n = \frac{a_o n^2}{z} \quad For\ 2nd\ orbit\ r_n = \frac{a_0 2^2}{1} = 4a_0$

$n\lambda = 2\pi r_n \quad \lambda = \frac{2\pi 4a_0}{2} = 4\pi a_0 = \frac{8\pi a_0}{n} \quad where\ n = 2$

55. The reaction $A_2 + B_2 \rightarrow 2AB$ follows the mechanism

$A_2 \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} A + A$ (fast)

$A + B_2 \xrightarrow{k_2} AB + B$ (slow)

$A + B \rightarrow AB$ (fast)

The overall order of the reaction is:

1)1.5 2)2 3)2.5 4)3

Key: 1

Sol : Rate of slowest step $r = k_2[A][B_2]$

From step 1) $K = \frac{[A]^2}{[A_2]}\ or\ [A] = k^{1/2}[A_2]^{1/2}$

$r = k_2 k^{1/2}[A_2]^{1/2}[B_2] \qquad = k[A_2]^{1/2}[B_2]$

Over all order of reaction = $\frac{1}{2} + 1 = 1.5$

56. Total number of nucleophiles from the following is:

$NH_3, PhSH, (H_3C)_2S, H_2C = CH_2, \bar{O}H, H_3O^{\oplus}, (CH_3)_2CO, \quad > = NCH_3$

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

Key: 4

Sol: Nucleophiles $NH_3, phSH, CH_2 = CH_2, OH^-, (CH_3)_2 Co$

$>= NCH_3$

57. Match List-I with List-II

List-I (Carbohydrate)	**List-II (Linkage Source)**
A) Amylose	I) $\beta - C_1 - C_4$, plant
B) Cellulose	II) $\alpha - C_1 - C_4$, animal
C) Glycogen	III) $\alpha - C_1 - C_4, \alpha - C_1 - C_6$, plant
D) Amylopectin	IV) $\alpha - C_1 - C_4$, plant

Choose the correct answer from the options given below:

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

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

Key: 3

Sol: Amylose $\alpha - C_1 - C_4$, plant

Cellulose $\beta - C_1 - C_4$, plant

Glycogen $\alpha - C_1 - C_4$, animal

Amylopectin $\alpha - C_1 - C_4, \alpha - C_1 - C_6$, plant

Amylose and Amylopectin present in starch.

58. The standard reduction potential values of some of the p-block ions are given below. Predict the one with the strongest oxidizing capacity.

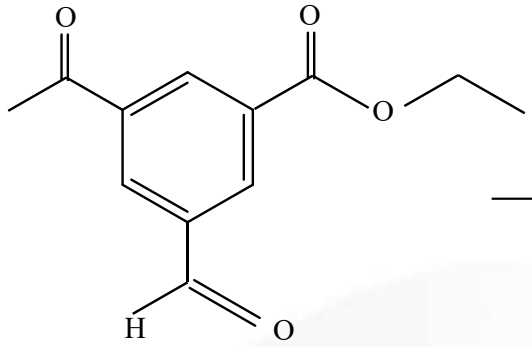
1) $E^-_{Tl^{3+}/Tl} = +1.26V$ 2) $E^-_{Al^{3+}/Al} = -1.66V$

3) $E^-_{Sn^{4+}/Sn^{2+}} = +1.15V$ 4) $E^-_{Pb^{4+}/Pb^{2+}} = +1.67V$

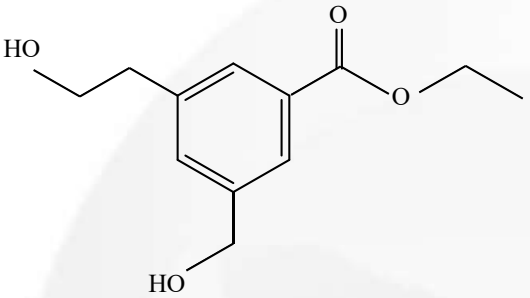
Key: 4

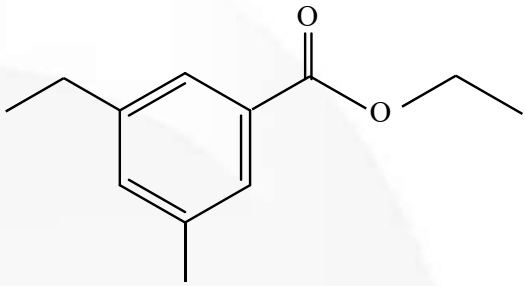
Sol: Higher the value of E^0 standard reduction potential stronger is the oxidising capacity.

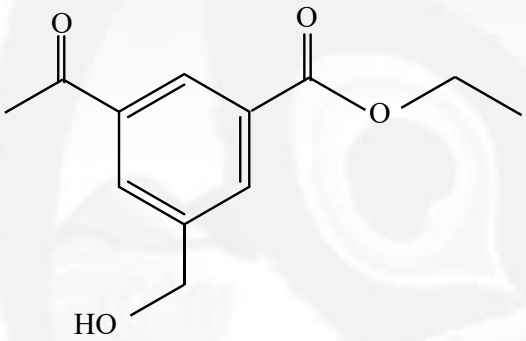
59. The product (P) formed in the following reaction is:

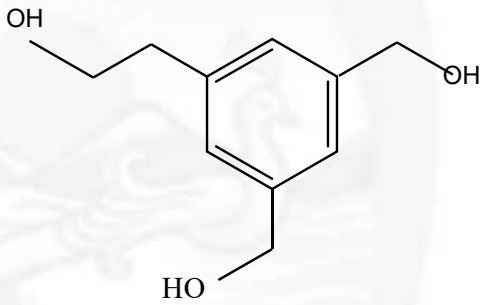


$\xrightarrow[HCl]{Zn-Hg}$ Product (P)

1) 

2) 

3) 

4) 

Key: 2

Sol: Zn-Hg, HC*l* will reduce aldehyde anf ketone carbonyl to methylene and will not reduce ester

60. Match List - I with List - II.

List-1 (Complex)	**List - II (Hybridization & Magnetic characters)**
(A) $[MnBr_4]^{2-}$	I) d^2sp^3 & diamagnetic
(B) $[FeF_6]^{3-}$	(II) sp^3d^2 & paramagnetic
(C) $[Co(C_2O_4)]^{3-}$	(III) sp^3 & diamagnetic
(D) $[Ni(CO)_4]$	(IV) sp^3 & paramagnetic

Choose the correct answer from the options given below:

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

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

Key: 3

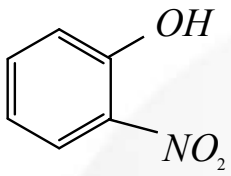
Sol: $[MnBr_4]^{2-}$ d^5 and weak field ligand-sp^3

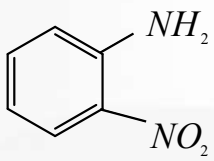
$[FeF_6]^{3-}$ d^5 and weak field ligand-sp^3 d^2

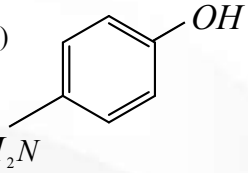
$[Co(C_2O_4)]^{3-}$ d^6 chelating ligand d^2sp^3

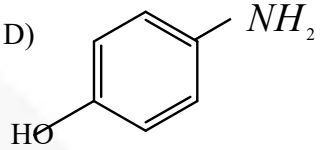
$[Ni(CO)_4]$ d^{10}, strong ligand

61. The steam volatile compounds among the following are:

A) 

B) 

C) 

D) 

Choose the correct answer from the options given below

1) (B) and (D) Only 2) (A) and (C) Only

3) (A) and (B) Only 4) (A), (B) and (C) Only

Key: 3

Sol: Compounds A and B has intra molecular H-bond and hence is steam volatile.

62. Given below are two statements:

Statement (I): The radii of isoelectronic species increases in the order.

$Mg^{2+} < Na^+ < F^- < O^{2-}$

Statement (II): The magnitude of electron gain enthalpy of halogen decreases in the order. $Cl > F > Br > I$

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

1) Statement I is incorrect but Statement II is correct
2) Both Statement I and Statement II are correct
3) Statement I is correct but Statement II is incorrect
4) Both Statement I and Statement II are incorrect

Key: 2

Sol: Radii of isoelectronic species decrease with increase in cationic charge and increase with increase in anionic charge Due to small size, fluorine has lower electron gain enthalpy than chlorine.

63. At temperature T, compound $AB_{2(g)}$ dissociates as $AB_{2(g)} \rightleftharpoons AB_{(g)} + \frac{1}{2}B_{2(g)}$ having degree of dissociation x (small compared to unity). The correct expression for x in terms of K_p and p is

1) $\sqrt{K_P}$ 2) $\sqrt[3]{\frac{2K_P^2}{P}}$ 3) $\sqrt[4]{\frac{2K_P}{P}}$ 4) $\sqrt[3]{\frac{2K_P}{P}}$

Key: 2

Sol:

$$AB_2 \rightleftarrows AB + \frac{1}{2}B_2$$

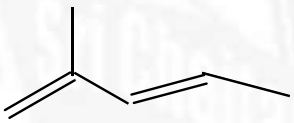
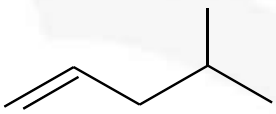
$$1-x \qquad x \qquad \frac{x}{2}$$

$$\text{Total moles } 2+\frac{x}{2}\ k_p = \frac{\left(\frac{2x}{2+x}\right)P\left(\frac{x}{2+x}\right)^{1/2}P^{1/2}}{\left(\frac{1-x}{2+x}\right)P}$$

$$\sin ce\ x\ is\ small\ 1-x=1 \qquad 2+x=2$$

$$\left(\frac{x^3}{2}\right)^{1/2} = \frac{K_p}{P^{1/2}} \qquad x = \sqrt[3]{\frac{2K^2{}_p}{P}}$$

64. Match List - I with List - II.

List – I (Structure)	**List - II (IUPAC Name)**
A) $H_3C-CH_2-\underset{\underset{C_2H_5}{\vert}}{CH}-CH_2-\underset{\underset{CH_3}{\vert}}{CH}-C_2H_5$	(I) 4-Methylpent-1-ene
(B) $(CH_3)_2C(C_3H_7)_2$	(II) 3-Ethyl-5-methylheptane
C) 	(III) 4, 4-Dimethylheptane
D) 	(IV) 2-Methyl-1, 3-pentadiene

Choose the correct answer from the options given below:

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

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

Key: 2

Sol: A & B – Longest continuous carbon chain C & D –Double bond should be given preference.

65. 500 J of energy is transferred as heat to 0.5 mol of Argon gas at 298 K and 1.00 atm. The final temperature and the change in internal energy respectively are:

Given: R=8.3 JK^{-1} mol^{-1}

1) 348 K and 300 J 2) 378 K and 500 J

3) 368 K and 500 J 4)378 K and 300 J

Key: 1

Sol: $\Delta H = nc_p\Delta T$

$$500 = 0.5\times\frac{5}{2}8.314(T-298)$$

$$T = 348$$

$$\Delta U = nc_v\Delta T$$

$$= 0.5\times\frac{3}{2}\times 8.314\times 50 = 300$$

66. For a $Mg\left|Mg^{2+}(aq)\right|\left|Ag^{+}(aq)\right|Ag$ the correct Nernst Equation is:

1) $E_{cell} = E^0_{cell} - \frac{RT}{2F}\ln\frac{\left[Ag^+\right]}{\left[Mg^{2+}\right]}$ 2) $E_{cell} = E^0_{cell} + \frac{RT}{2F}\ln\frac{\left[Ag^+\right]^2}{\left[Mg^{2+}\right]}$

3) $E_{cell} = E^0_{cell} - \frac{RT}{2F}\ln\frac{\left[Ag^+\right]^2}{\left[Mg^{2+}\right]}$ 4) $E_{cell} = E^0_{cell} - \frac{RT}{2F}\ln\frac{\left[Mg^{2+}\right]}{\left[Ag^+\right]}$

Key: 2

Sol: Cell reaction $Mg_{(g)} + 2Ag^+ \rightarrow Mg^{2+} + 2Ag$

$$E_{cell} = E^0_{cell} - \frac{RT}{2F}\ln\frac{\left[Mg^{2+}\right]}{\left[Ag^+\right]^2}$$

$$E_{cell} = E^0_{cell} + \frac{RT}{2F}\ln\frac{\left[Ag^+\right]^2}{\left[Mg^{2+}\right]}$$

67. The correct increasing order of stability of the complexes based on Δ_O, value is:

I. $[Mn(CN)_6]^{3-}$ II. $[Co(CN)_6]^{4-}$ III. $[Fe(CN)_6]^{4-}$ IV. $[Fe(CN)_6]^{3-}$

1) II < III < I < IV 2) IV < III < II < I 3) III < II < IV < I 4) I <II < IV < III

Key: 4

Sol: More the number of t_2g electron more is stability

$[Mn(CN)_6]^{3-}$ $t_{2g}^4 eg^0$ CFSE = -1.6 Δ_0 $[Co(CN)_6]^{4-}$ $t_{2g}^6 eg^1$ CFSE = -1.8 Δ_0

$[Fe(CN)_6]^{4-}$ $t_{2g}^6 eg^0$ CFSE = -2.4 Δ_0 $[Fe(CN)_6]^{3-}$ $t_{2g}^2 eg^0$ CFSE = -2.0 Δ_0

68. An element 'E' has the ionisation enthalpy value of 374 kJ mol^{-1}, 'E' reacts with elements A, B, C and D with electron gain enthalpy values of -328,-349,-325 and -295 kJ mol^{-1}, respectively.

The correct order of the products EA, EB, EC and ED in terms of ionic character is:

1) ED > EC > EB > EA 2) EB > EA > EC > ED

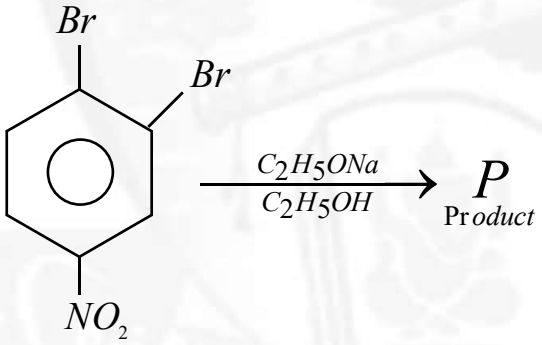
3) EA > EB > EC > ED 4) ED > EC > EA > EB

Key: 2

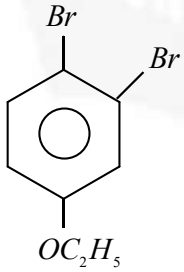
Sol: Solution more the electronegativity difference more is ionic character .Given ΔH_{eg} are gr 17

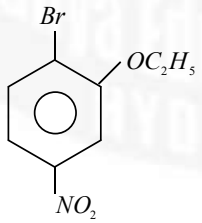
Halogens A-C*l*, B-F, C-Br, D-I

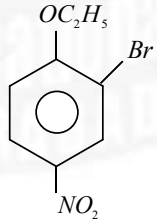
69. In the following substitution reaction:

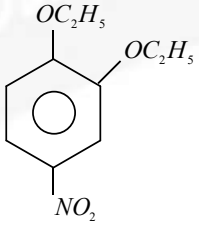


Product 'P' formed is :

1) 

2) 

3) 

4) 

Key: 3

Sol: In SnAr, Leaving group para to electron withdrawing group is more prone for substitution

70. Choose the correct statements.

(A) Weight of a substance is the amount of matter present in it.

(B) Mass is the force exerted by gravity on an object.

(C) Volume is the amount of space occupied by a substance.

(D) Temperatures below 0°C are possible in Celsius scale, but in Kelvin scale negative Temperature is not possible.

(E) Precision refers to the closeness of various measurements for the same quantity.

Choose the correct answer from the options given below:

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

3) (C), (D) and (E) Only 4) (A), (D) and (E) Only

Key: 3

Sol: Weight is force exerted by gravity and mass is amount of substance.

(NUMERICAL VALUE TYPE)

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

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

71. The molar mass of the water insoluble product formed from the fusion of chromite ore ($FeCr_2O_4$) with Na_2CO_3 in presence of O_2 is _____ g mol^{-1}.

Key: 160

Sol: Fe_2O_3 is water insoluble

$$4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$$

72. If A_2B is 30% ionised in an aqueous solution, then the value of van't Hoff factor (i) is _____ $x10^{-1}$.

Key: 16

Sol:

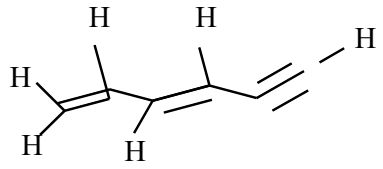
$$\underset{1-\alpha}{A_2B} \rightleftharpoons \underset{2\alpha}{2A^+} + \underset{\alpha}{B^{2-}}$$

Total Particle: $1+2\alpha = i, \alpha = 0.3 \quad 1.6 = 16\times10^{-1}$

73. The sum of sigma (σ) and pi (π) bonds in Hex-1,3-dien-5-yne is_____

Key: 15

Sol:

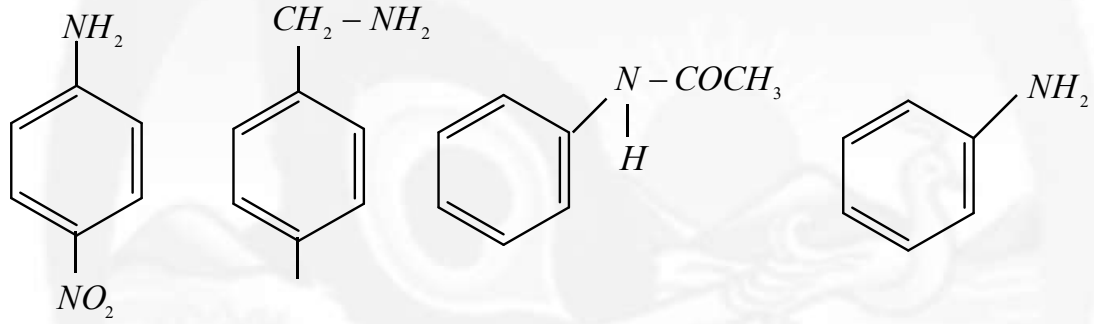


Pi bonds 4

Sigma bonds 11

……
15
……

74. Given below are some nitrogen containing compounds



Each of them is treated with HC*l* separately. 1.0 g of the most basic compound will c

Consume _____mg of HC*l*

(Given molar mass in g mol^{-1}C: 12, H: 1, O: 16, C*l*: 35.5)

Key: 341

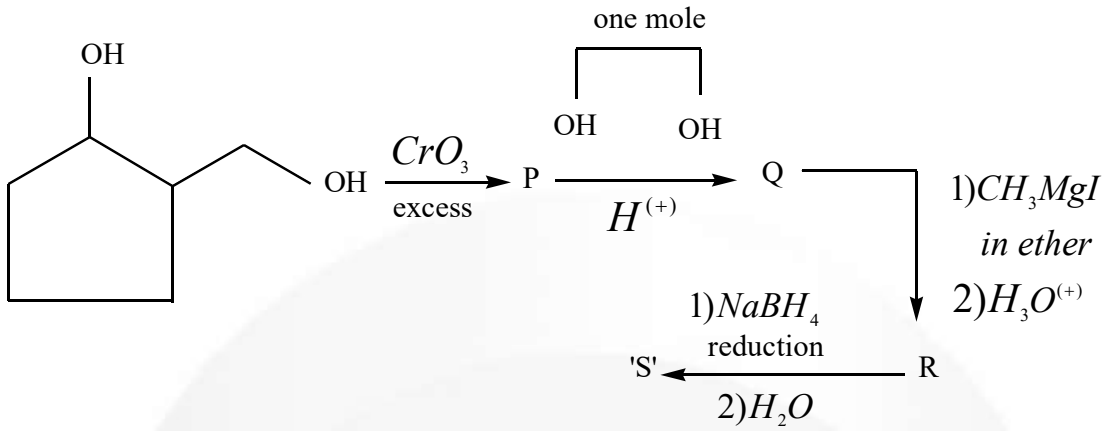
Sol: $phCH_2NH_2$ *most basic*

$$phCH_2NH_2 + HCl \rightarrow phCH_2\overset{\oplus}{N}H_3 + \overset{\odot}{C}l$$

$$\frac{1}{107} \qquad \frac{W}{36.5}$$

W = 0.341 g (or) 341 mg

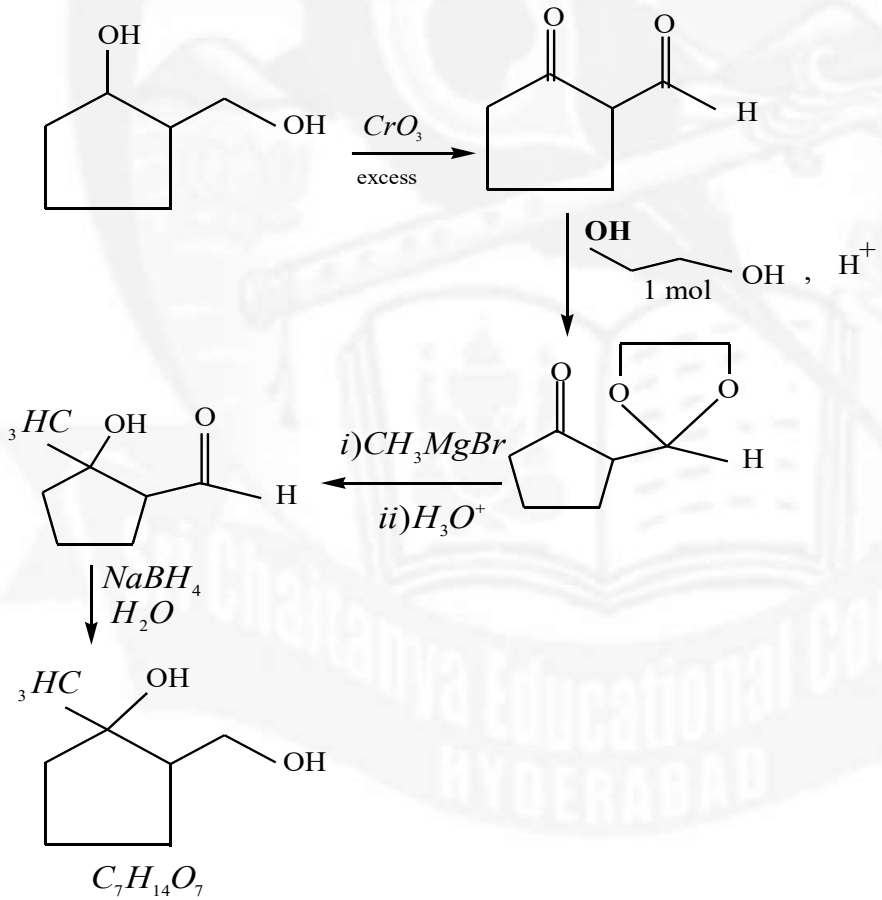
75.



0.1 mole of compound 'S' will weigh _____ g. (Given molar mass in g mol^{-1}C: 12, H: 1, O: 16)

Key: 13

Sol:



mol.wt = 130 g

0.1 mol will weigh 13.0 g

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