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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

23-01-2025

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_23-Jan-2025_Shift-01

MATHMETICS **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. The value of $\left(\sin 70^0\right)\left(\cot 10^0 \cot 70^0 - 1\right)$ is

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

Key: 4

Sol: $\cancel{\sin 70}.\dfrac{\left(\cos 10.\cos 70 - \sin 10 \sin 70\right)}{\sin 10.\cancel{\sin 70}} = \dfrac{\cos 80}{\sin 10} = 1$

2. Let the arc AC of a circle subtend a right angle at the centre O. If the point B on the arc AC, divides the arc AC such that $\dfrac{length\ of\ arc\ AB}{length\ of\ arc\ BC} = \dfrac{1}{5}$, and $OC = \alpha\overrightarrow{OA} + \beta\overrightarrow{OB}$, then $\alpha + \sqrt{2}\left(\sqrt{3}-1\right)\beta$ is equal to

1) $5\sqrt{3}$ 2) $2+\sqrt{3}$ 3) $2\sqrt{3}$ 4) $2-\sqrt{3}$

Key:4

Sol: Let $\overline{OA} = r\bar{i}, \overline{OC} = r\bar{j}$

$\overline{OB} = \left(r\cos 15\right)\bar{i} + \left(r\sin 15\right)\bar{j}$

$= \left(\dfrac{\sqrt{3}+1}{2\sqrt{2}}\right)\overline{OA} + \left(\dfrac{\sqrt{3}-1}{2\sqrt{2}}\right)\overline{OC} \rightarrow \overline{OC} = \left(\dfrac{1+\sqrt{3}}{1-\sqrt{3}}\right)\overline{OA} + \left(\dfrac{2\sqrt{2}}{\sqrt{3}-1}\right)\overline{OB}$

$\therefore \alpha = \dfrac{1+\sqrt{3}}{1-\sqrt{3}}, \beta = \dfrac{2\sqrt{2}}{\sqrt{3}-1} \rightarrow \alpha + \sqrt{2}\left(\sqrt{3}-1\right)\beta = \dfrac{1+\sqrt{3}}{1-\sqrt{3}} + 4 = -2-\sqrt{3}+4 = 2-\sqrt{3}$

3. Let $\left|\dfrac{\bar{z}-i}{2\bar{z}+i}\right| = \dfrac{1}{3}, z \in C$ be the equation of a circle with center at C. If the area of the triangle whose vertices are at the points (0,0), C and $(\alpha, 0)$ is 11 square units, then α^2

1) 100 2) 50 3) $\dfrac{81}{25}$ 4) $\dfrac{121}{25}$

Key: 1

Sol: $\left|\dfrac{\bar{z}-i}{2\bar{z}+i}\right| = \dfrac{1}{3} \Rightarrow \left|\dfrac{\bar{z}-i}{\bar{z}+\dfrac{i}{2}}\right| = \dfrac{2}{3} \Rightarrow 3\left|z+i\right| = 2\left|z-\dfrac{i}{2}\right|$

$\Rightarrow 9\left(x^2+(y+1)^2\right)=4\left(x^2+\left(y-\frac{1}{2}\right)^2\right)$

$\Rightarrow 5x^2+5y^2+\frac{22}{5}y-\frac{8}{5}=0\rightarrow C=\left(0,-\frac{11}{5}\right)$

Area of triangle$=\frac{1}{2}\left|0+\frac{11\alpha}{5}\right|$ vertices $(0,0),\left(0,-\frac{11}{5}\right),(\alpha,0)$

$\Rightarrow 11=\frac{1}{2}\left|\frac{11\alpha}{5}\right|\Rightarrow \alpha=10\rightarrow\alpha^2=100$

4. If A, B and $\left(adj\left(A^{-1}\right)+adj\left(B^{-1}\right)\right)$ are non-singular matrices of same order, then the inverse of $A\left(adj\left(A^{-1}\right)+adj\left(B^{-1}\right)\right)^{-1}B$, equal to

1) $\frac{AB^{-1}}{|A|}+\frac{BA^{-1}}{|B|}$ 2) $AB^{-1}+A^{-1}B$

3) $adj\left(B^{-1}\right)+adj\left(A^{-1}\right)$ 4) $\frac{1}{|AB|}\left(adj(B)+adj(A)\right)$

Key:4

Sol: $\left[A\left(adj\left(A^{-1}\right)+adj\left(B^{-1}\right)\right)^{-1}B\right]^{-1}=B^{-1}.\left(adjA^{-1}+adjB^{-1}\right)A^{-1}$

$=B^{-1}\left|A^{-1}\right|+\left|B^{-1}\right|A^{-1}$ $=\frac{1}{|B|}adjB\frac{1}{|A|}+\frac{1}{|B|}\frac{1}{|A|}adjA$

$=\frac{1}{|AB|}(adjB+adjA)\because XadjX=|X|I=(adjX)X$ $X^{-1}=\frac{1}{|X|}.adjX$

5. If the line 3x-2y+12=0 intersects the parabola $4y=3x^2$ at the points A and B, then at the vertex of the parabola, the line segment AB subtends an angle equal to

1) $\tan^{-1}\left(\frac{4}{5}\right)$ 2) $\frac{\pi}{2}-\tan^{-1}\left(\frac{3}{2}\right)$ 3) $\tan^{-1}\left(\frac{9}{7}\right)$ 4) $\tan^{-1}\left(\frac{11}{9}\right)$

Key:3

Sol: By homogenising $3x^2=4y(1)$

$3x^2=4y\left(\frac{2y-3x}{12}\right)$

$9x^2+3xy-2y^2=0$ represents OA and OB

$Tan\theta=\frac{2\sqrt{h^2-ab}}{|a+b|}=\frac{9}{7}\rightarrow\theta=Tan^{-1}\frac{9}{7}$

6. The value of $\int_{e^2}^{e^4}\frac{1}{x}\left(\frac{e^{\left((\log_e x)^2+1\right)^{-1}}}{e^{\left((\log_e x)^2+1\right)^{-1}}+e^{\left((6-\log_e x)^2+1\right)^{-1}}}\right)dx$ is

1) e^2 2) 1 3) 2 4) $\log_e 2$

Key: 2

Sol: put $\log_e^x = t \to \frac{1}{x}dx = dt$

Given $I = \int_2^4 \frac{e^{\frac{1}{1+t^2}}}{e^{\frac{1}{1+t^2}} + e^{\frac{1}{1+(6-t)^2}}}dt$, (king's rule) , $2I = \int_2^4 1dt \to I = 1$

7. One die has two faces marked 1,two faces marked 2, one face marked 3 and one face marked 4. Another die has one face marked 1, two faces marked 2, two faces marked 3 and one face marked 4.The probability of getting the sum of numbers to be 4 or 5, when both the dice are thrown

1) $\frac{3}{5}$ 2) $\frac{2}{3}$ 3) $\frac{4}{9}$ 4) $\frac{1}{2}$

Key:3

Sol: $\left.\begin{matrix} D_1 \to 1,1,2,2,3,4 \\ D_2 \to 1,2,2,3,3,4 \end{matrix}\right\} n(s) = 36$

$sum4 = (1,3)(2,2)(3,1)$

$sum5 = (1,4)(2,3)(3,2)(4,1)$

$p(sum4) = \frac{2}{6}.\frac{2}{6} + \frac{2}{6}.\frac{2}{6} + \frac{1}{6}.\frac{1}{6} = \frac{9}{36}$

$p(sum5) = \frac{2}{6}.\frac{1}{6} + \frac{2}{6}.\frac{2}{6} + \frac{1}{6}.\frac{2}{6} + \frac{1}{6}.\frac{1}{6} = \frac{9}{36}$

$n(E) = 18 \to p(E) = \frac{18}{36} = \frac{1}{2}$

8. Marks obtains by all the students of class 12 are presented in a frequency distribution with classes of equal width. Let the median of this grouped data be 14 with median class interval 12-18 and median class frequency 12. If the number of students whose marks are less than 12 is 18, then total number of students is

1) 40 2) 52 3) 44 4) 48

Key: 3

Sol: median= $= L + \frac{\frac{N}{2} - m}{f}.C$

$14 = 12 + \frac{\left(\frac{N}{2} - 18\right)}{12}.6 \to N = 44$

9. Let $f(x) = \log_e x$ and $g(x) = \frac{x^4 - 2x^3 + 3x^2 - 2x + 2}{2x^2 - 2x + 1}$ Then the domain of fog is

1) $[0,\infty)$ 2) $(0,\infty)$ 3) $[1,\infty)$ 4) R

Key:4

Sol: $fog(x) = f(g(x)) = \log\left(\frac{x^4 - 2x^3 + 3x^2 - 2x + 2}{2x^2 - 2x + 1}\right)$

$\forall x \in R, 2x^2 - 2x + 1 > 0 (D < 0.a > 0)$

$x^4-2x^3+3x^2-2x+2=\left(x^4+2x^2+1\right)+\left(-2x^3+x^2-2x+1\right)$

$=\left(x^2+1\right)^2+\left(x^2+1\right)-2x\left(x^2+1\right)$

$\left(x^2+1\right)\left\{x^2+1+-2x\right\}=\left(x^2+1\right)\left[\left(x-1\right)^2+1\right]>0\forall x\in R$

$\therefore$ Doman=R

10. Let the position vectors of the vertices A, B and C of tetrahedron ABCD be $\hat{i}+2\hat{j}+\hat{k},\hat{i}+3\hat{j}-2\hat{k}$ and $2\hat{i}+\hat{j}-\hat{k}$ respectively. The altitude from the vertex D to the opposite face ABC meets the median line segment through A of the triangle ABC at the point E. If the length of AD is $\frac{\sqrt{110}}{3}$ and the volume of the tetrahedron is $\frac{\sqrt{805}}{6\sqrt{2}}$, then the position vector of E is

1) $\frac{1}{6}\left(12\hat{i}+12\hat{j}+\hat{k}\right)$ 2) $\frac{1}{6}\left(7\hat{i}+12\hat{j}+\hat{k}\right)$ 3) $\frac{1}{12}\left(7\hat{i}+4\hat{j}+3\hat{k}\right)$ 4) $\frac{1}{2}\left(\hat{i}+4\hat{j}+7\hat{k}\right)$

Key:2

Sol: ΔABC

$=\frac{1}{2}\left|\overline{AB}\times\overline{AC}\right|$ $=\frac{1}{2}\begin{vmatrix} i & j & k \\ 0 & 1 & -3 \\ 1 & -1 & -2 \end{vmatrix}=\frac{1}{2}\left|-5i-3j-k\right|$

$=\frac{1}{2}\sqrt{25+9+1}=\frac{\sqrt{35}}{2}$ $\frac{1}{3}.\frac{\sqrt{35}}{2}.h=\frac{\sqrt{805}}{6\sqrt{2}}$

$h=\sqrt{\frac{23}{2}}$ $AE^2=\frac{110}{9}-\frac{23}{2}=\frac{13}{18}$ $AE=\frac{\sqrt{13}}{3\sqrt{2}}$

$\overline{AF}=\frac{\overline{AB}+\overline{AC}}{2}$ $\overline{AF}=\frac{1}{2}\left(i-5K\right)$

$\overline{AE}=\frac{\sqrt{13}}{3\sqrt{2}}.\overset{\frown}{AF}$ $=\frac{\sqrt{13}}{3\sqrt{2}}.\frac{\left(i-5K\right)}{\sqrt{26}}$ $\overline{OE}-\overline{OA}=\pm\frac{i-5K}{6}$

$\overline{OE}=\frac{i-5K}{6}+\left(i+2j+K\right)=\frac{1}{6}\left(7i+12j+K\right)$

11. If the system of equations

$\left(\lambda-1\right)x+\left(\lambda-4\right)y+\lambda z=5$

$\lambda x+\left(\lambda-1\right)y+\left(\lambda-4\right)z=7$

$\left(\lambda+1\right)x+\left(\lambda+2\right)y-\left(\lambda+2\right)z=9$ has infinitely many solutions , then $\lambda^2+\lambda$ is equal to

1) 10 2) 20 3) 12 4) 6

Key:3

Sol: $D=0,D_x=0,D_y=0,D_z=0$

$D=\begin{vmatrix} \lambda-1 & \lambda-4 & \lambda \\ \lambda & \lambda-1 & \lambda-4 \\ \lambda+1 & \lambda+2 & -\lambda-2 \end{vmatrix}=0$ $D_x=0\Rightarrow\lambda=3,\lambda=\frac{23}{2}$ $\therefore\lambda=3$ $\lambda^2+\lambda=9+3=12$

12. If the first term of an A.P. is 3 and the sum of its first four terms is equal to one-fifth of the next four terms, then the sum of the first 20 terms is equal to

1) -1020 2) -1080 3) -1200 4) -120

Key:2

Sol: Let a=3, $3+3+d+3+2d+3+3d=\frac{1}{5}\left(3+4d+3+5d+3+6d+3+7d\right)$

$5\left(12+6d\right)=12+22d\rightarrow d=-6$

$S_{20}=\frac{20}{2}\left\{2\left(3\right)+19\left(-6\right)\right\}=10\left(-108\right)=-1080$

13. Let P be the foot of the perpendicular from the point Q(10,-3,-1) on the line $\frac{x-3}{7}=\frac{y-2}{-1}=\frac{z+1}{-2}$ Then the area of the right angled triangle PQR where R is the point (3,-2,1) is

1) $8\sqrt{15}$ 2) $3\sqrt{30}$ 3) $9\sqrt{15}$ 4) $\sqrt{30}$

Key:2

Sol: Let $P=\left(7\lambda+3,-\lambda+2,-2\lambda-1\right)$

Dr's of PQ= $7\lambda-7,-\lambda+5,-2\lambda$

Dr's of the =7,-1-2

$\therefore 7\left(7\lambda-7\right)-1\left(-\lambda+5\right)-2\left(-2\lambda\right)=0$

$\lambda=1 \qquad \therefore P=\left(10,1,-3\right)$

P=(10,1-3),Q(10,-3-1),R(3,-2,1)

$PQ\perp QR\rightarrow Area=\frac{1}{2}PQ.QR=\frac{1}{2}\sqrt{54}.\sqrt{20}=3\sqrt{30}$

14. If the function $f\left(x\right)=\begin{cases}\frac{2}{x}\left\{\sin\left(k_1+1\right)x+\sin\left(k_2-1\right)x\right\}, & x<0\\ 4, & x=0\\ \frac{2}{x}\log_e\left(\frac{2+k_1x}{2+k_2x}\right), & x>0\end{cases}$

is continuous at x=0, then $k_1^2+k_2^2$ is equal to

1) 10 2) 5 3) 20 4) 8

Key:1

Sol: $f\left(0\right)=\underset{x\rightarrow0^-}{Lt}f\left(x\right)\rightarrow4=\underset{x\rightarrow0}{Lt}2\left(\frac{\sin\left(K_1+1\right)x+\sin\left(K_2-1\right)x}{x}\right)$

$\rightarrow2=K_1+1+K_2-1\Rightarrow K_1+K_2=2$

$f\left(0\right)=\underset{x\rightarrow0^+}{Lt}f\left(x\right)\rightarrow4=\underset{x\rightarrow0^+}{Lt}2\left(\frac{\log\left(2+K_1x\right)-\log\left(2+K_2x\right)}{x}\right)$

$\rightarrow2=\frac{K_1}{2}-\frac{K_2}{2}\Rightarrow K_1-K_2=4$

$\therefore K_1^2+K_2^2=10$

15. Let R ={(1,2),(2,3),(3,3)} be a relation defined on the set {1,2,3,4}. Then the minimum number of elements, needed to be added in R so that R becomes an equivalence relation, is :

1) 7 2) 8 3) 10 4) 9

Key:1

Sol: A={1,2,3,4}, R{(1,2) (2,3) (3,3)}

For equivalence, need to add (1,1),(2,2)(4,4)(2,1)(3,2)(1,3)(3,1)

Min no of elements =7

16. Let the area of a ΔPQR with vertices P(5,4), Q(-2,4) and R(a,b) be 35 square units. If its orthocenter and centroid are $O(2,\frac{14}{5})$ and $C(c,d)$ respectively, then c+2d is equal to

1) $\frac{8}{3}$ 2) 2 3) $\frac{7}{3}$ 4) 3

Key: 3

Sol: Ortho=$\left(2,\frac{14}{5}\right)$ Equation of QR: 5x+2y+2=0

Equation of PR:10x-3y-38=0

$$\therefore R=(2-6)\to centriod=\left(\frac{5}{3},\frac{2}{3}\right)=(c,d)\to c+2d=3$$

17. The number of words, which can be formed using all the letters of the word "DAUGHTER", so that all the vowels never come together, is

1) 37000 2) 35000 3) 36000 4) 34000

Key:3

Sol: letter of word D,G,H,T,R,A,U,E

All vowels never come together=Total-all vowels come together

$$=8!-6!3!=6!(56-6)=720\times 50=36000$$

18. Let $I(x)=\int\frac{dx}{(x-11)^{\frac{11}{13}}(x+15)^{\frac{15}{13}}}.If\ I(37)-I(24)=\frac{1}{4}\left(\frac{1}{b^{\frac{1}{13}}}-\frac{1}{c^{\frac{1}{13}}}\right),b,c\in N,3(b+c)$ is equal to

1) 26 2) 40 3) 22 4) 39

Key:4

Sol: $I_{(x)}=\int\frac{dx}{(x-11)^{\frac{11}{13}}(x+15)^{\frac{15}{13}}}=\int\frac{dx}{\left(\frac{x-11}{x+15}\right)^{\frac{11}{13}}.(x+15)^2}$

$$put\ \frac{x-11}{x+15}=t\Rightarrow\frac{26}{(x+15)^2}dx=dt$$

$$I(x)=\int\frac{1}{t^{\frac{11}{13}}}.\frac{1}{26}dt=\frac{1}{26}.\frac{t^{2/13}}{2/13}=\frac{1}{4}\left(\frac{1}{4^{1/13}}-\frac{1}{9^{1/13}}\right)$$

$$\therefore b=4,c=9\}3(b+c)=39$$

19. If $\frac{\pi}{2} \le x \le \frac{3\pi}{4}$, then $\cos^{-1}\left(\frac{12}{13}\cos x + \frac{5}{13}\sin x\right)$ is equal to

1) $x - \tan^{-1}\frac{5}{12}$ 2) $x + \tan^{-1}\frac{5}{12}$ 3) $x + \tan^{-1}\frac{4}{5}$ 4) $x - \tan^{-1}\frac{4}{3}$

Key:1

Sol: $\cos^{-1}\left(\cos\alpha\cos x + \sin\alpha\sin x\right) = \cos^{-1}\left(\cos\left(x-\alpha\right)\right), \frac{\pi}{2} \le x \le \frac{3\pi}{4}$ *where* $\cos\alpha = \frac{12}{13}, \sin\alpha = \frac{5}{13}$

$= x - \alpha$ $= x - Tan^{-1}\frac{5}{12}$, $\frac{\pi}{2} - \alpha \le x - \alpha \le \frac{3\pi}{4} - \alpha$

20. Let a curve y=f(x) pass through the points (0,5) and $\left(\log_e 2, k\right)$. If the curve satisfies the differential equation $2\left(3+y\right)e^{2x}dx - \left(7+e^{2x}\right)dy = 0,$ then k is equal to

1) 4 2) 32 3) 8 4) 16

Key:3

Sol: $2\left(3+y\right)e^{2x}dx = \left(7+e^{2x}\right)dy \rightarrow \frac{dy}{dx} = \frac{2\left(3+y\right)e^{2x}}{7+e^{2x}}$ $\rightarrow \frac{dy}{dx} = \left(\frac{-2e^{2x}}{7+e^{2x}}\right)y = \frac{6e^{2x}}{7+e^{2x}}$

If $e^{\int\frac{-2e^{2x}}{7+e^{2x}}dx} = e^{-\int\frac{1}{t}dt} = e^{-\log t} = \frac{1}{t} = \frac{1}{7+e^{2x}}$

$y.\frac{1}{7+e^{2x}} = \int\frac{6e^{2x}}{7+e^{2x}}.\frac{1}{7+e^{2x}}dx$

$\frac{y}{7+e^{2x}} = 3\int\frac{2e^{2x}}{\left(7+e^{2x}\right)^2}dx \Rightarrow \frac{y}{7+e^{2x}} = \frac{-3}{7+e^{2x}} + C$

$sub\left(0,5\right) \rightarrow \frac{5}{8} = -\frac{3}{8} + C \rightarrow C = 1$

$\therefore Sol\ is\ y = -3+7+e^{2x} \rightarrow y = 4+e^{2x}$

Sub(log2,K)

K=4+4=8

(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. If the area of the larger portion bounded between the curves $x^2 + y^2 = 25$ and $y = |x-1|$ is $\frac{1}{4}\left(b\pi + c\right), b, c \in \mathbb{N}$ then b+c is equal to _____

Key:77

Sol: $x^2 + y^2 = 25$, $y = |x-1|$

By solving PI=(-3,4)(4,3)

$Area = \int_{-3}^{4}\sqrt{25-x^2} - \frac{1}{2}.4.4 - \frac{1}{2}3.3$

$$=\left(\frac{x}{2}\sqrt{25-x^2}+25\sin^{-1}\frac{x}{5}\right)_{-3}^{4}-8-\frac{9}{2}$$

$$=\left(2.3+\frac{25}{2}\sin^{-1}\frac{4}{5}\right)-\left(-\frac{3}{2}.4-\frac{25}{2}\sin^{-1}\frac{3}{5}\right)-8-\frac{9}{2}$$

$$=6+6-8-\frac{9}{2}+\frac{25}{2}\left(\sin^{-1}\frac{4}{5}+\sin^{-1}\frac{3}{5}\right)=\frac{-1}{2}+\frac{25\pi}{4}$$

$$\text{Re}\,quired\ area=25\pi+\frac{1}{2}-\frac{25\pi}{4}=\frac{1}{4}(75\pi+2)$$

b+c=77

22. The sum of all rational terms in the expansion of $\left(1+2^{1/3}+3^{1/2}\right)^6$ is equal to ____

Key: 612

Sol: Given = $\left(1+2^{1/3}+3^{1/2}\right)^6$

General term= $\frac{6!}{p!q!r!}(1)^p.\left(2^{1/3}\right)^q\left(3^{1/2}\right)^r=\frac{6!}{p!q!r!}1^p.2^{q/3}.3^{r/2}$

$p+q+r=6$

p	q	r
6	0	0
4	0	2
2	0	4
0	0	6
3	3	0
1	3	2
0	6	0

Sum=1+45+135+27+40+360+4=612

23. Let the circle C touch the line x-y+1=0,have the centre on the positive x-axis cut off a chord of length $\frac{4}{\sqrt{13}}$ along the line $-3x+2y=1.$ Let H be the hyperbola $\frac{x^2}{\alpha^2}-\frac{y^2}{\beta^2}=1,$ whose one of the foci is the centre of C and the length of the transverse axis is the diameter of C . Then $2\alpha^2+3\beta^2$ is equal to ___

Key: 19

Sol: c=(h,0)

$2\sqrt{r^2-d^2}=\frac{4}{\sqrt{13}}$ where

$r=\left|\frac{h+1}{\sqrt{2}}\right|, d=\left|\frac{3h+1}{\sqrt{13}}\right|$

By solving h=3

Centre=(3,0) $=(\alpha e,0)$

Now, $r=2\sqrt{2}$

$\alpha e=3$

$2\alpha=4\sqrt{2}$

$\therefore \alpha^2=8, \beta^2=1 \qquad 2\alpha^2+3\beta^2=19$

24. If the equation $a(b-c)x^2+b(c-a)x+c(a-b)=0$ has equal roots, where a+c=15 and $b=\frac{36}{5}$, then a^2+c^2 is equal to ____

Key: 117

Sol: from the given equation roots are 1, $\frac{c(a-b)}{a(b-c)}$

For equal roots 2ac=b(a+c)

$\Rightarrow ac=54$

$\therefore a^2+c^2=(a+c)^2-2ac \Rightarrow 117$

25. If the set of all values of a, for which the equation $5x^3-15x-a=0$ has three distinct real roots, is the interval (α,β), then $\beta-2\alpha$ is equal to _____

Key: 30

Sol: $f(x)=5x^3-15x-a$

$f'(x)=0 \Rightarrow x=-1,1$

For and distinct roots $f(-1).f(1)<0$

$\Rightarrow (a+10)(a-10)<0$

$\Rightarrow a\in(-10,10)=(\alpha,\beta)$

$\beta-2\alpha=10+20$

=30

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. The electric field of an electromagnetic wave in free space is

$$\vec{E} = 57\cos\left[7.5\times10^{6}t - 5\times10^{-3}(3x+4y)\right]\left(4\hat{i}-3\hat{j}\right)N/C$$

The associated magnetic field in Tesla is

1) $\vec{B} = -\frac{57}{3\times10^{8}}\cos\left[7.5\times10^{6}t - 5\times10^{-3}(3x+4y)\right]\left(\hat{k}\right)$

2) $\vec{B} = +\frac{57}{3\times10^{8}}\cos\left[7.5\times10^{6}t - 5\times10^{-3}(3x+4y)\right]\left(\hat{k}\right)$

3) $\vec{B} = -\frac{57}{3\times10^{8}}\cos\left[7.5\times10^{6}t - 5\times10^{-3}(3x+4y)\right]\left(5\hat{k}\right)$

4) $\vec{B} = +\frac{57}{3\times10^{8}}\cos\left[7.5\times10^{6}t - 5\times10^{-3}(3x+4y)\right]\left(5\hat{k}\right)$

Key: 2

Sol: $B_{\circ} = \frac{E_{\circ}}{C} = \frac{57}{3\times10^{8}}$ $\qquad \vec{c} \parallel \vec{E}\times\vec{B}$

$\left(3\hat{i}+4\hat{j}\right) \parallel \left(4\hat{i}-3\hat{j}\right)\times\vec{B} \Rightarrow \vec{B} \parallel \hat{k}$

$\vec{B} = B_{\circ}\cos\left(wt - \vec{k}.\vec{r}\right)\hat{n} = \frac{57}{3\times10^{8}}\cos\left[7.5\times10^{6} - \left(-5\times10^{-3}(3x+4y)\right)\right]\hat{k}$

27. The position of a particle moving on x-axis is given by x(t) $= A\sin t + B\cos^2 t + Ct^2 + D$, where t is time. The dimension of $\frac{ABC}{D}$ is

1) L 2) L^2T^{-2} 3) L^2 4) L^3T^{-2}

Key: 2

Sol: $x = A\sin t + B\cos^2 t + ct^2 + D$

$[n] = [A] = [B] = \left[Ct^2\right] = [D] = [L]$ $\qquad \frac{ABC}{D} = \frac{L.L.LT^{-2}}{L} = \left[L^2T^{-2}\right]$

28. What is the lateral shift of a ray refracted through a parallel-sided glass slab of thickness ‘h’ in terms of the angle of incidence ‘i’ and angle of refraction ‘r’, if the glass slab is placed in air medium?

1) $\frac{h\cos(i-r)}{\sin r}$ 2) $\frac{h\sin(i-r)}{\cos r}$ 3) h 4) $\frac{h\tan(i-r)}{\tan r}$

Key: 2

Sol: Lateral shift

$= BC$

$= AB\sin(i-r)$

$= \frac{AD}{Cosr} Sin(i-r)$

$= \frac{h}{Cosr}\sin(i-r)$

29. Refer to the circuit diagram given in the figure. Which of the following observations are correct?

1) Total resistance of circuit is 6 Ω

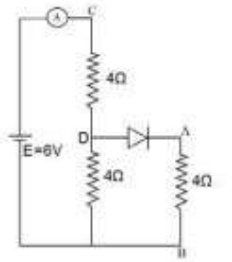
2) Current in Ammeter is 1A

3) Potential across AB is 4 Volts.

4) Potential across CD is 4 Volts

5) Total resistance of the circuit is 8 Ω

Choose the correct answer from the options given below:



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

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

Key: 3

Sol: Diode in F.B, so does not produce any resistance

Req= $f_1 + f_2 \| f_3$ $= 4 + 4 \| 4$ $= 4 + 2 = 6$

Current $I = \frac{\varepsilon}{\text{Re}q}$ $= \frac{6}{6} = 1A$

Current in AB $= I/2 = \frac{1}{2}A$

Potential AB = iR $= \frac{1}{2} \times 4 = 2V$

Potential $C_D = iB$ $= 1 \times 4 = GV$

Correct A, B, D

30. Consider a circular disc of radius 20 cm with centre located at the origin. A Circular hole of radius 5 cm is cut from this disc in such a way that the edge of the hole touches the edge of the disc. The distance of centre of mass of residual or remaining disc from the origin will be

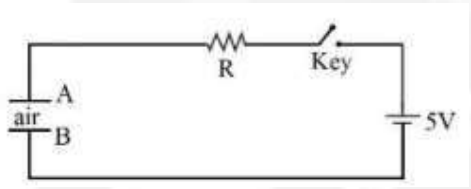
1) 0.5 cm 2) 1.0 cm 3) 2.0 cm 4) 1.5 cm

Key: 2

Sol: $X_{cm} = \frac{M \times_{few} - M \times_{hole}}{M - m} = \frac{M(0) - \frac{M}{16}(3R/4)}{M - M/16}$

$= \frac{-3R/4}{15} = -R/20 = -1cm$

31. Identify the valid statements relevant to the given circuit at the instant when the key is closed.



1) There will be no current through resistor R.

2) There will be maximum current in the connecting wires.

3) Potential difference between the capacitor plates A and B is minimum.

4) Charge on the capacitor plates is minimum.

Choose the correct answer from the options given below:

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

Key: 2

Sol: At moment switch closed, potential across capacitor in Zen current in circuit

$i_{\circ} = \varepsilon / L$

After time t, Current in Circuit

$i = i_{\circ} e^{-t/Rc}$

$i = \frac{\varepsilon}{R} e^{-t/Rc} \to \frac{\varepsilon}{R} as\, t \to 0$

Potential as Capacitor

$V = \varepsilon\left(1 - e^{-tlRc}\right) \to 0\, ast \to 0$

Charge on Capacitor

$q = c\varepsilon\left(1 - e^{-t/Rc}\right) \to 0\, as\, t \to 0$

32. A sub-atomic particle of mass $10^{-30}\,kg$ is moving with a velocity $2.21\times10^{6}\,m/s.$ Under the matter wave consideration, the particle will behave closely like ____.

$\left(h=6.63\times10^{-34}\,J.s\right)$

1) Gamma rays
2) Visible radiation
3) Infra-red radiation
4) X-rays

Key: 4

Sol: Worden eth of De Brojlie wave is

$$\lambda=\frac{\lambda}{my} \qquad =\frac{6.63\times10^{-34}}{10^{-30}\times2.21\times10^{6}}=3\times10^{-10}=3A^{\circ}$$

This is matching in the X-ray

33. Given below are two statements:

Statement I: The hot water flows faster than cold water

Statement II: Soap water has higher surface tension as compared to fresh water.

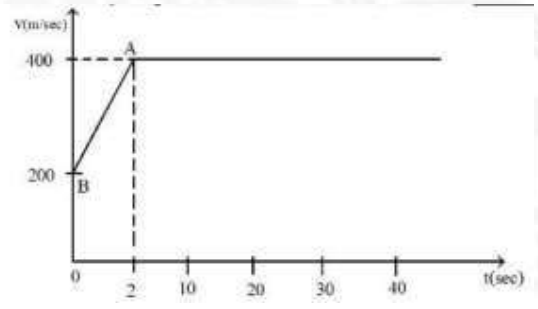
In the light above statements, choose the correct answer from the options given below

1) Statement I is false but Statement II is true
2) Both Statement I and Statement II are flase
3) Both Statement I and Statement II are true
4) Statement I is true but Statement II is false

Key: 4

Sol: Conceptual

34. The motion of an airplane is represented by velocity-time graph as shown below. The Distance covered by airplane in the first 30.5 second is_____km.



1) 6
2) 3
3) 9
4) 12

Key: 4

Sol: Area of graph

$400+200+28.5\times400 \quad =12000\,m \qquad =12\,km$

35. A gun fires a lead bullet of temperature 300 K into a wooden block. The bullet having Melting temperature of 600 K penetrates into the block and melts down. If the total Heat required for the process is 625 J, then the mass of the bullet is _____grams. (Latent heat of fusion of lead $=2.5\times10^4\,JKg^{-1}$ and specific heat capacity of lead $=125JKg^{-1}K^{-1}$)

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

Key: 4

Sol: $Q=m\left[S\Delta\theta+L\right]$ $625=m\left[125\times300+2.5\times10^4\right]$

$625=m\left[3.75+2.5\right]10^4$ $100=6.25\times10^4 m$ $m=10^{-2}kg=10g$

36. A spherical surface of radius of curvature R, separates air from glass (refractive index=1.5). The centre of curvature is in the glass medium. A point Object 'O' placed in air on the optic axis of the surface, so that its real image is formed at 'I' inside glass. The line OI intersects the spherical surface at P and PO=PI. The distance PO equals to

1) 1.5 R 2) 2 R 3) 5 R 4) 3 R

Key: 3

Sol: $u=\nu\ given$ $\frac{3/2}{\upsilon}-\frac{1}{-\upsilon}=\frac{3/2-1}{R}$

$\frac{3}{2\upsilon}+\frac{1}{\upsilon}=\frac{1}{2R}$ $\frac{5}{2\upsilon}=\frac{1}{2R}=4=5R$

37. Consider a moving coil galvanomenter (MCG):

1) The torsional constant in moving coil galvanometer has dimentions $\left[ML^2T^{-2}\right]$

2) Increasing the current sensitivity may not necessarily increase the voltage Sensitivity.

3) If we increase number of turns (N) to its double (2N), then the voltage Sensitivity doubles.

4) MCG can be converted into an ammeter by introducing a shunt resistance of Large value in parallel with galvanometer.

5) Current sensitivity of MCG depends inversely on number of turns of coil.

Choose the correct answer from the options given below:

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

Key: 2

Sol: BiAN=$c\theta$ $c \to [Torque] = M^2L^2T^2$

$\frac{\theta}{i} = \frac{BAN}{c}$ $\frac{\theta}{V} = \frac{\theta}{iR} = \frac{BNA}{RC}$

38. A radioactive nucleus n_2 has 3 times the decay constant as compared to the decay Constant of another radioactive nucleus n_1. If initial number of both nuclei are the Same, what is the ratio of number of nuclei of n_2 to the number of nuclei of n_1, after one half-life of n_1 ?

1) $1/4$ 2) 8 3) $1/8$ 4) 4

Key: 1

Sol: $\lambda_2 = 3\lambda_1$ $\frac{1}{T_2} = 3\frac{1}{T_1} \Rightarrow T_1 = 3T_2$

$\frac{n_2}{n_1} = \frac{e^{-\lambda 2t}}{e^{-\lambda 1t}} = e^{-2\lambda_1 t} \because t = T_1$ $= e^{\frac{-2\ln 2 \times T1}{T1}}$ $\frac{n_2}{n_1} = \frac{1}{e^{\log_e 2^2}} = \frac{1}{4}$

39. A light hollow cube of side length 10 cm and mass 10g, is floating in water. It is Pushed down and released to execute simple harmonic oscillations. The time period Of oscillations is $y\pi \times 10^{-2} s$, where the value of y is

(Acceleration due to gravity, $g = 10 m/s^2$, density of water $= 10^3 kg/m^3$)

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

Key: 2

Sol: $mg = Ahdwg \to 1$ $A[h+x]dwg - mg = ma$

$a = \frac{Adwg}{m}.x$ $a = w^2 x$

$T = \frac{2\pi}{w} = 2\pi\sqrt{\frac{m}{l^2 dwg}}$ $T = 2\pi\sqrt{\frac{10\times10^{-3}}{10^{-2}\times10^3\times10}}$ $T = 2\pi\times10^{-2}$ $\therefore y = 2$

40. Regarding self –inductance:

1) The self-inductance of the coil depends on its geometry.

2) Self-inductance does not depend on the permeability of the medium.

3) Self-induced e.m.f. opposes any change in the current in a circuit

4) Self- inductance is electromagnetic analogue of mass in mechanies.

5) Work needs to be done against self-induced e.m.f. in establishing the current.

Choose the correct answer from the options given below:

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

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

Key: 2

Sol: $L=\frac{\mu_0 N^2 A}{2\pi R}$

41. The electric flux is $\phi=\alpha\sigma+\beta\lambda$

Where λ and σ are linear and surface charge density, respectively. $\left(\frac{\alpha}{\beta}\right)$ represents

1) Electric field 2) charge 3) displacement 4) area

Key: 3

Sol: $\alpha\sigma=\beta\lambda \quad \frac{\alpha}{\beta}=\frac{\lambda}{\sigma}=\frac{\frac{Q}{l}}{\frac{Q}{A}}=\frac{A}{l}=\frac{L^x}{L}=L$

42. Given a thin convex lens (refractive index μ_2), kept in a liquid $(refractive\,index\,\mu_1,\mu_1<\mu_2)$ Having radii of curvatures $|R_2|and|R_2|$. Its second surface is silver polished. Where Should an object be placed on the optic axis so that a real and inverted image is formed at the same place?

1) $\frac{\mu_1|R_1|.|R_2|}{\mu_2(|R_1|+|R_2|)-\mu_1|R_1|}$ 2) $\frac{\mu_1|R_1|.|R_2|}{\mu_2(|R_1|+|R_2|)-\mu_1|R_2|}$

3) $\frac{\mu_1|R_1|.|R_2|}{\mu_2(2|R_1|+|R_2|)-\mu_1\sqrt{|R_1|.|R_2|}}$ 4) $\frac{(\mu_2+\mu_1)|R_1|}{(\mu_2-\mu_1)}$

Key: 2

Sol: $\frac{1}{f}=2\left(\frac{\mu_2}{\mu_4}-1\right)\left(\frac{1}{R_1}+\frac{1}{R_2}\right)+\frac{2}{R_2}$ $\left(\because\frac{1}{f}=\frac{2}{fl}+\frac{2}{R}\right)\because O\,\&\,I$ Coincide

$\frac{2}{d}=\frac{l}{f}$ $\frac{1}{d}=\frac{(\mu_2-\mu_4)}{\mu_4}\frac{(R_1+R_2)}{R_1R_2}+\frac{1}{R_2}\;d=\frac{\mu_1R_1R_2}{\mu_2(R_1+R_2)-\mu_1R_2}$

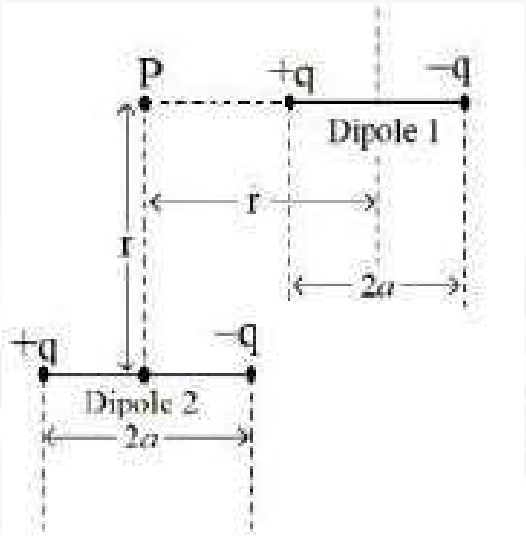
43. A solid sphere of mass ‘m’ and radius ‘r’ is allowed to roll without slipping from the Highest point of an inclined plane of length ‘L’ and makes an angle 30° with the Horizontal. The speed of the particle at the botton of the plane is v_1. If the angle of Inclination is increased to 45° while keeping L constant. Then the new speed of the Sphere at the bottom of the plane is v_2. The ratio $v_1^2:v_2^2$ is

1) 1: 3 2) 1:2 3) $1:\sqrt{2}$ 4) $1:\sqrt{3}$

Key: 3

Sol: $V^2 = \dfrac{2gLSin\theta}{\left(1+\dfrac{k^2}{R^2}\right)}$ $v^2 \alpha \sin\theta$ $\dfrac{V_1^2}{V_2^2} = \dfrac{\sin 30°}{\sin 45} = \dfrac{1}{2}\times\dfrac{\sqrt{2}}{1}$ $= \dfrac{1}{\sqrt{2}}$

44. A point particle of charge Q is located at P along the axis of an electric dipole 1 at at a distance r as shown in the figure. The point P is also on the equatorial plane of a second electric dipole 2 at a distance r. The dipoles are made of opposite charge q separated by a distance $2a$. For the charge particle at P not to experience any net force, which of the following correctly describes the situation?



1) $\dfrac{a}{r} \sim 20$ 2) $\dfrac{a}{r} \sim 10$ 3) $\dfrac{a}{r} \sim 3$ 4) $\dfrac{a}{r} \sim 0.5$

Key: 4

Sol: $F_1 = \dfrac{1}{4\pi\in_0}\dfrac{p_1.q}{\left(r^2+a^2\right)^{3/2}}$

$p_1 = p_2$ $F_1 = F_2$

$F_2 = \dfrac{1}{4\pi\in_0}\dfrac{2p_2ar}{\left(r^2-a^2\right)^2}$ $r\left(r^2+a^2\right)3/2 = 2\left(r^2-a^{v}\right)^2$

$r^4\left[1+\left(\dfrac{a}{r}\right)^2\right]^{3/2} = 2r^4\left[1-\left(\dfrac{a}{r}\right)^2\right]^2$

$\dfrac{a}{r} = x$ $1+3/2^{x^2} = 2+4x^2$

$11\dfrac{1}{2}x^2 = 1$

$x = \sqrt{\dfrac{2}{11}} = 0.426\left(Option\ not\ matching\right)$

45. Match the LIST-I with LIST-II

	LIST-I		LIST-II
A	Pressure varies inversely with volume of an ideal gas	I.	Adiabatic process
B	Heat absorbed goes partly to increase internal energy and partly to do work	II.	Isochoric process
C	Heat is neither absorbed nor released by a system.	III.	Isothermal process
D	No work is done on or by a gas.	IV.	Isobaric process

Choose the correct answer from the options given below:

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

Key: 4

Sol: $A \to P\alpha\frac{1}{V} \to PV = k \to Isothermal$

$B \to 1st\ Law\ of\ ther\ \text{mod}\ ynamics \to Isobaric$

$c \to dq = 0 \to Adiabatic$

$D \to dw = 0 \to Isochoric$

(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. A positive ion A and a negative ion B has charges $6.67\times10^{-19}C$ and $9.6\times10^{-10}C$, and masses $19.2\times10^{-27}kg$ and $9\times10^{-27}kg$ respectively. At an instant, the ions are separated by a certain Distance r. At that instant the ratio of the magnitudes of electrostatic force to Gravitational force is $P\times10^{-13}$, where the value of P is _____.

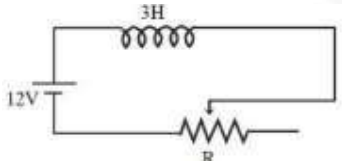
$\left(Take\frac{1}{4\pi\varepsilon_0} = 9\times10^9\ Nm^2C^{-1}\ and\ universal\ graviational\ cons\tan t\ as\ 6.67\times10^{-11}\ Nm^2kg^{-2}\right)$

Key: Bonus

Sol: $\frac{F_e}{F_g} = \frac{9\times10^9\times6.67\times10^{-19}\times9.6\times10^{-10}}{6.67\times10^{-11}\times19.2\times10^{-27}\times9\times10^{-27}}$

$= \frac{1}{2}\times\frac{10^{-20}}{10^{-65}} = \frac{1}{2}\times10^{+45} = 0.5\times10^{45}\left(Bonus\right) = 50\times10^{43}$

47.



In the given circuit the sliding contact is pulled outwards such that electric current In the circuit changes at the rate of 8 A/s. At an instant when R is 12 Ω. The value Of the current in the circuit will be_____A.

Key: 3

Sol: $\because R \to increasing$

$i \to decreasing$

$$12 + 2\frac{di}{dt} = iR$$

$$12 + 3 \times 8 = 12i$$

$$i = \frac{36}{12} = 3A$$

48. Two particles are located at equal distance from origin . The position vectors of Those are represented by $\overline{A} = 2\hat{i} + 3n\hat{j} + 2\hat{k}\ and\ \overline{B} = 2\hat{i} - 2\hat{j} + 4p\hat{k}$, respectively. If both the Vectors are at right angle to each other, value of n^{-1} is _____.

Key: 3

Sol: $\vec{A} \perp \vec{B}$

$$\vec{A}.\vec{B} = 0$$

$$4 - 6n + 8p = 0$$

$$\because |\vec{A}| = |\vec{B}|$$

$$9n^2 = 16p^2$$

$$3n = \pm 4P$$

$$4 - 6n - 6n = 0$$

$$\therefore n = \frac{1}{3}$$

$$n^{-1} = 3$$

49. A force $f = x^2y\hat{i} + y^2\hat{j}$ acts on a particle in a plane $x + y = 10$. The work done by this force During a displacement from (0,0) to $(4m, 2m)$ is ___ Joule (round off to the nearest Integer)

Key: 152

Sol: $W = \int \vec{F}.\overrightarrow{ds}$

$$W = \int_0^4 x^2(10 - x)dx + \int_0^2 y^2 dy$$

$$= 152J$$

50. An ideal gas initially at 0°C temperature, is compressed suddenly to one fourth of its Volume. If the ratio of specific heat at constant pressure to that at constant volume Is 3/2, the change in temperature due to the thermodynamic process is _____K.

Key: 273

Sol: $T_1 = 273k$

$V_2 = V_1 / 4$

$\gamma = 3/2$

$$T_2 = T_1\left[\frac{v_1}{v_2}\right]^{\gamma - 1}$$

$$T_2 = 546k$$

$$\Delta T = T_2 - T_1 = 273k$$

CHEMISTRY **Max Marks: 100**

(SINGLE CORRECT ANSWER TYPE)

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

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

51. Match the LIST-I WITH LIST-II

LIST-I (Classification of molecules based on octet rule)		LIST-II (Example)	
A.	Molecules obeying octet rule	I.	NO, NO_2
B.	Molecules with incomplete octet	II.	$BCl_3, AlCl_3$
C.	Molecules with incomplete octet with odd electron	III.	H_2SO_4, PCl_5
D.	Molecules with expanded octet	IV.	CCl_4, CO_2

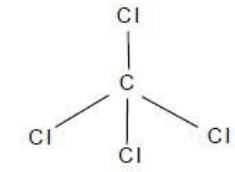
Choose the correct answer from the options given below:

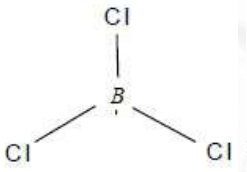
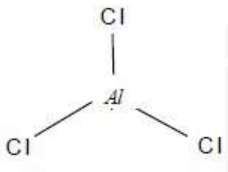
1) A-III,B-II,C-I,D-IV 2) A-IV,B-I,C-III,D-II

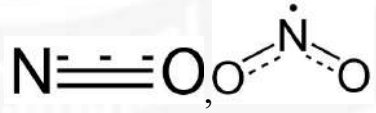
3) A-IV,B-II,C-I,D-III 4) A-II,B-IV,C-III,D-I

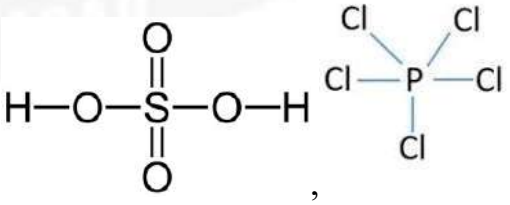
Key:3

Sol: LIST-I LIST-II

A) Octet rule IV)  O=C=O $8e^-$

B) incomplete octet II)  ,  $6e^-$

C) odd e^- I) 

D) Expanded octet III)  ,

52. Given below are two statements:

Statement I: In Lassaigne's test, the covalent organic molecules are transformed into ionic compounds.

Statement II: The sodium fusion extract of an organic compound having N and S gives Prussian blue colour with $FeSO_4$ and $Na_4\left[Fe(CN)_6\right]$

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

1) Both Statement I and Statement II are true

2) Both Statement I and Statement II are false

3) Statement I is true but Statement II is false

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

Key:3

Sol: If both N and S are present they give blood red color with $FeCl_3$

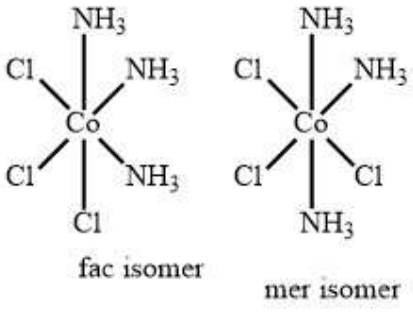
53. The complex that shows Facial –Meridional isomerism is:

1) $\left[Co(en)_2Cl_2\right]^+$ 2) $\left[Co(NH_3)_3Cl_3\right]$ 3) $\left[Co(en)_3\right]^{3+}$ 4) $\left[Co(NH_3)_4Cl_2\right]^+$

Key:2

Sol: Fac-Mer Isomerism by

Ma_3b_3 type.molecule



54. Heat treatment of muscular pain involves radiation of wavelength of about 900nm.Which spectral line of H atom is suitable for this?

(Given Rydberg constant $R_H = 10^5 cm^{-1}, h = 6.6\times10^{-34} Js, c = 3\times10^8 m/s$)

1) Balmer series, $\infty \to 2$ 2) Paschen series, $5 \to 3$

3) Paschen series, $\infty \to 3$ 4) Lyman series, $\infty \to 1$

Key:3

Sol: $\lambda = 900\,nm = 900\times10^{-9}\,m \qquad = 900\times10^{-7}\,cm$

Rydberg equation is.

$$\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$$

$$\frac{1}{900\times10^{-7}} = 10^5\times(1)^2\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$$

$$\frac{1}{9\times10^{-5}} = 10^{-5}\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$$

$$\therefore\ \frac{1}{9} = \frac{1}{n_1^2}-\frac{1}{n_2^2}$$

$$\Rightarrow\ n_1 = 3;\ n_2 = \infty$$

$\therefore$ The suitable spectral line is last line of paschen series; i.e., from $\infty \to 3$

55. The element that does not belong to the same period of the remaining elements (modern periodic table) is :

1) Iridium 2) Palladium 3) Platinum 4) Osmium

Key:2

Sol: element-not belonging to same period.

$Os, Ir, Pt \Rightarrow 6th\ period$

Pd-5th period

56. $FeO_4^{2-} \xrightarrow{+2.0v} Fe^{3+} \xrightarrow{0.8v} Fe^{2+} \xrightarrow{-0.5v} Fe^0$ In the above diagram, the standard electrode potentials are given in volts (over the arrow).The value of $E^{\Theta}_{FeO_4^{2-}/Fe^{2+}}$ is

1) 1.7 V 2) 1.4 V 3) 1.2 V 4) 2.1 V

Key:1

Sol: $FeO_4^{2-} \xrightarrow{+2.0V} Fe^{3+} \xrightarrow{0.8V} Fe^{2+} \xrightarrow{-0.5V} Fe^0$

$E^0_{FeO_4^{-2}}\Big|Fe^{2+} = ?$

i) $FeO_4^{-2} \longrightarrow Fe^{3+};\ E^0_{FeO_4^{-2}}\Big|Fe^{3+} = 2.0V$

ii) $Fe^{3+} \longrightarrow Fe^{2+};\ E^0_{Fe^{3+}}\Big|Fe^{2+} = 0.8\,V$

iii) $FeO_4^{-2} \longrightarrow Fe^{2+};\ E^0_{FeO_4^{-2}|Fe^{2+}} = ?$

iv) $= (i)+(ii)$

$\therefore\ \Delta G_{iii} = \Delta G_i^0 + \Delta G_{ii}^0$

$-n_{iii} FE_{iii}^0 = -n_i F\, E_i^0 + \left(-n_{ii} FE_{ii}^0\right)$

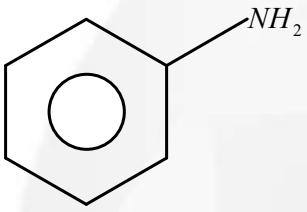
$n_{iii}\, E_{iii}^0 = n_i E_i^0 + -n_{ii}\, FE_{ii}^0$

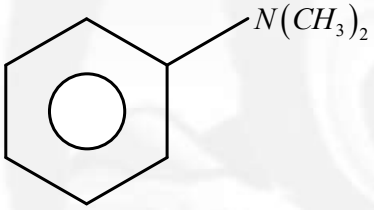
$4\left(E_{iii}^0\right) = 3(2) + (1)(0.8)$

$= 6.8$

$\therefore\ E_{Fe}^0 O_4^{2-} \left| Fe^{2+} = 1.7V \right.$

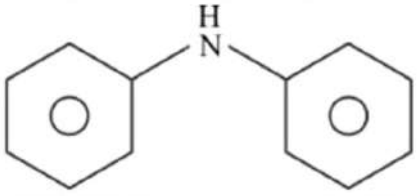
57. Which among the following react with Hinsberg's reagent ?

A) 

B) 

C) $CH_3 - NH_2$

D) $N(CH_3)_3$

E) 

choose the correct answer from the options given below

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

Key: 4

Sol: 1^0 and 2^0 amines react with Hinsberg's reagent

58. Given below are two statements:

Statement I: fructose does not contain an aldehydic group but still reduces Tollen's reagent

Statement II: In the presence of base, fructose undergoes rearrangement to give glucose.

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

1) Both Statement I and Statement II are true

2) Both Statement I and Statement II are false

3) Statement I is are but Statement II is false

4) Statement I is false but Statement II is true

Key:1

Sol: Conceptual

59. $CrCl_3.xNH_3$ can exist as a complex,0.1 molal aqueous solution of this complex shows a depression in freezing point of 0.558^0C. Assuming 100% ionization of this complex and coordination number of Cr is 6, the complex will be (Given $K_f = 1.86K\,kg\,mol^{-1}$)

1) $\left[Cr(NH_3)_3Cl_3\right]$ 2) $\left[Cr(NH_3)_4Cl_2\right]Cl$

3) $\left[Cr(NH_3)_5Cl\right]Cl_2$ 4) $\left[Cr(NH_3)_6\right]Cl_3$

Key:3

Sol: $\Delta T_f = i.K_f.M$ $0.558 = i.(1.86)0.1$

$\therefore i = \dfrac{0.558}{0.186} = 3$ $\therefore$ No. of particles the complex $CrCl_3XNH_3$ produces in aqueous solution = 3 ($\because \alpha = 100\%$)

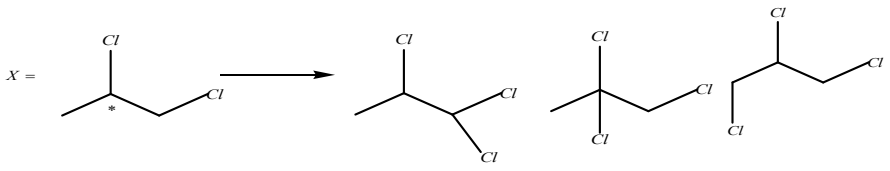
And coordination number of complexes is 6.$\therefore$ The complex is $\left[CrCl(NH_3)_5\right]Cl_2$

60. Propane molecule on chlorination under photochemical condition gives two di-chloro products, “x” and “y”. Amongst “x” and “y”, “x” is an optically active molecule. How many tri-chloro products(consider only structural isomers) will be obtained from “x” when it is further treated with chlorine under the photochemical condition?

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

Key:4

Sol:



61. The major product of the following reaction is

$$CH_3CH_2CH{=}O \xrightarrow[\text{reflux}]{\text{excess HCHO, alkali}} ?$$

1) $CH_3-\underset{\underset{CH_2}{\|}}{C}-CH=O$

2) $CH_3-C(CH_2-OH)_2-CH_2-OH$

3) $CH_3-\underset{\underset{CH_2-OH}{|}}{CH}-CH=O$

4) $CH_3-CH_2-CH_2-OH$

Key:2

Sol: Aldol reactions followed by cannizzaro's reaction

62. 2.8×10^{-3} mol of CO_2 is left after removing 10^{21} molecules from its 'x' mg sample. The mass of CO_2 taken initially is Given $N_A = 6.02\times10^{23}\,mol^{-1}$

1) 98.3 mg 2) 196.2 mg 3) 150.4 mg 4) 48.2 mg

Key:2

Sol: Initial weight of $CO_2 = x\,mg$ $= x\times10^{-3}\,gm$

Initial moles of $CO_2 = \dfrac{x\times10^{-3}}{44}$ moles

Initial molecules of $CO_2 = \dfrac{x\times10^{-3}}{44}\times602\times10^{23}$

No. of molecules of CO_2 = removed $= 10^{21}$

No. of moles of CO_2 left $= 2.8\times10^{-3}$

No. of molecules of CO_2 left = $2.8\times10^{-3}\times6.02\times10^{23}$ $= 16.856\times10^{20}$

No. of molecules of CO_2 left = No. of initial molecules of CO_2 - No. of molecules removed

$\therefore\ 16.856\times10^{20} = \dfrac{x\times10^{-3}\times6.02\times10^{23}}{44} - 10^{21}$

$= \left(0.1368x\times10^{20}\right) - \left(10\times10^{20}\right)$ $\therefore\ 16.856 = 0.1368x - 10$

$26.856 = 0.1368x$ $\therefore\ x = \dfrac{26.856}{0.1368} = 196.2$ $\therefore$ mass of CO_2 taken initially $= 196.2\,mg$

63. The incorrect statement among the following is

1) PH_3 shows lower proton affinity than NH_3.

2) PF_3 exists but NF_5 does not.

3) NO_2 can dimerise easily.

4) SO_2 can act an oxidizing agent, but not as a reducing agent.

Key: 4

Sol: Incorrect Statement

1) PH_3 shows lower proton affinity than NH_3

$PH_3 + H^+ \rightarrow pH_4^+$

$NH_3 + H^+ \rightarrow NH_4^+$ Basic strength $NH_3 > PH_3$

Due to high charge density on 'N'

2) PF_3 exist but NF_5-does not

Max.valency of N=4

3) NO_2 dimerise to N_2O_4

4) SO_2-oxidising agent and reducing agent

$\overset{-2}{S} \leftarrow \overset{+4}{SO_2} \rightarrow^{+6} S$

Acts as both

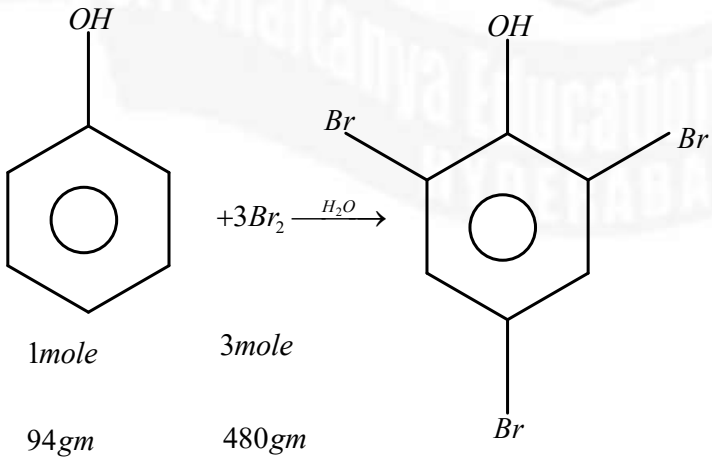
64. What amount of bromine will be required to convert 2g of phenol into 2,4,6-tribromophenol?

(Given molar mass in g $mol^{-1}$of C,H,O,Br are 12,1,16,80 respectively)

1) 20.44g 2) 4.0g 3) 10.22g 4) 6.0 g

Key: 3

Sol:



$2gm \rightarrow \frac{2\times 480}{94} = 10.22gm$

65. The correct set of ions (aqueous solution) with same colour from the following is :

1) V^{2+}, Cr^{3+}, Mn^{3+} 2) Ti^{4+}, V^{4+}, Mn^{2+} 3) $Sc^{3+}, Ti^{3+}, Cr^{2+}$ 4) Zn^{2+}, V^{3+}, Fe^{3+}

Key:1

Sol: ions with same color

$V^{+2}, Cr^{+3}, Mn^{+3} - violet$

66. Ice at -5^{0}C is heated become vapor with temperature of 110 ^{0}C at atmospheric pressure. The entropy change associated with this process can obtained from

1) $\int_{268K}^{383K} C_p dT + \xrightarrow[273]{\Delta H_{melting}} + \xrightarrow[373]{\Delta H_{boiling}}$

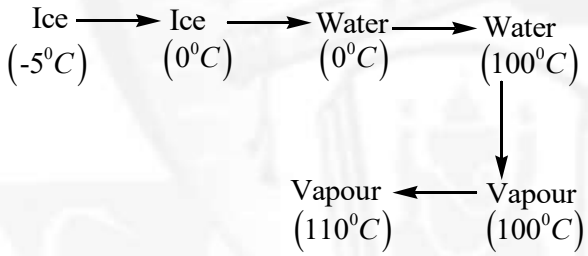
2) $\int_{268K}^{273K} C_p, mdT + \xrightarrow[T_f]{\Delta H_m, flusion} + \xrightarrow[T_b]{\Delta H_m, vaporisation} + \int_{273K}^{373K} C_p.mdT + \int_{373K}^{383K} C_p.mdT$

3) $\int_{268K}^{273K} \frac{C_p, m}{T} dT + \xrightarrow[T_f]{\Delta H_m, flusion} + \xrightarrow[T_b]{\Delta H_m, vaporisation} + \int_{273K}^{373K} \frac{C_p.mdT}{T} + \int_{373K}^{383K} \frac{C_p.mdT}{T}$

4) $\int_{268K}^{383K} C_p dT + \frac{q_{rev}}{T}$

Key:3

Sol:



$$\therefore \Delta S = \int_{268K}^{273K} \frac{C_{P,m}}{T} dT + \frac{\Delta H_m \text{ fusion}}{T_f}$$

$$+ \int_{273K}^{373K} \frac{C_{P.m}}{T} dT + \frac{\Delta H_m, \text{Vaporisation}}{T_b}$$

$$+ \int_{373K}^{373K} \frac{C_{P.m}}{T} dT$$

67. Which of following happens when NH_4OH is added gradually to the solution containing 1 M $A^{2+} and\, 1M\, B^{3+}$ ions?

Given: $K_{sp}\left[A(OH)_2\right] = 9\times 10^{-10}$ *and* $K_{sp}\left[B(OH)_3\right] = 27\times 10^{-18}$ at 298 K

1) $A(OH)_2$ will precipitate before $B(OH)_3$

2) Both $A(OH)_2$ and $B(OH)_3$ do not show precipitation with NH_4OH

3) $A(OH)_2$ and $B(OH)_3$ will precipitate together

4) $B(OH)_3$ will precipitate before $A(OH)_2$

Key:4

Sol: $\underset{S_A}{A(OH)_2} \rightleftharpoons \underset{S_A}{A^{2+}} + \underset{2S_A}{2OH^-}$

K_{S_P} of $A(OH)_2 = \left[A^{+2}\right]\left[OH^-\right]^2$

$9\times10^{-10} = (1)\left(OH^-\right)^2$

$\therefore \left[OH^-\right] = \sqrt{9\times10^{-10}} = 3\times10^{-5}M$

$\underset{S_B}{B(OH)_3} \rightleftharpoons \underset{S_B}{B^{3+}} + \underset{3S_B}{3OH^-}$

K_{S_P} of $B(OH)_3 = \left[B^{+3}\right]\left[OH^-\right]^3$

$27\times10^{-18} = (1)\left(OH^-\right)^3$

$\therefore \left[OH^-\right] = \left(27\times10^{-18}\right)^{1/3} = 3\times10^{-6}M$

$\therefore$ The $\left[OH^-\right]$ concentration required for precipitation of $B(OH)_3$ is less than that required for $A(OH)_2$.

So, $B(OH)_3$ precipitates first.

68. Match the LIST-I with LIST-II

LIST-I Name reaction		LIST-II Product obtainable	
A.	Swarts reaction	I.	Ethyl benzene
B.	Sadmeyer's reaction	II.	Ethyl iodide
C.	Wurtz fitting reaction	III.	Cyanobenzene
D.	Finkelstein reaction	IV.	Ethyl fluoride

Choose the correct answer from the options given below:

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

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

Key:2

Sol: Conceptual

69. The d-electronic configuration of an octahedral Co(II) complex having magnetic moment of 3.95 BM is :

1) $t_{2g}^6 e_g^1$ 2) $t_{2g}^3 e_g^0$ 3) $t_{2g}^5 e_g^2$ 4) $e^4 t_2^3$

Key:3

Sol: CO^{+2} $\mu = 3.95 B.M$

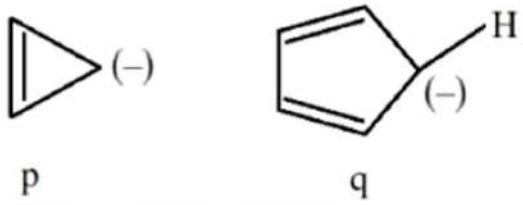
n=3unpaired e^-

Co=(Ar)$4s^2 3d^7$

$Co^{+2} : (Ar) 3d^7 4s^0$

Configuration: $t_{2g}^5 eg^2$

70. The correct stability order of the following species/molecules is :



p q r

1) r>q>p 2) q>r>p 3) q>p>r 4) p>q>r

Key:2

Sol: $q \rightarrow Aromatic, r \rightarrow nonaromatic, p \rightarrow Antiaromatic$

$\therefore q > r > p$

(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. For the thermal decomposition of $N_2O_5(g)$ at constant volume, the following table can be formed,

$2N_2O_5(g) \rightarrow 2N_2O_4(g) + O_2(g)$

Sr.no	Time/s	Total pressure/(atm)
1	0	0.6
2	100	x

x=____ $\times 10^{-3} atm$ [nearest integer]

Given: Rate constant for the reaction is $4.606 \times 10^{-2} s^{-1}$.

Key: 897

Sol: $2N_2O_5 \rightarrow 2N_2O_4 + O_2$

At $t=0$ 0.6 - -

P P $\frac{P}{2}$

At t = 100 0.6-P P $\frac{P}{2}$

$\therefore$ Total pressure = $0.6-P+P+\frac{P}{2}$

$=0.6+\frac{P}{2}=x$

Rate constant $=4.606\times10^{-2}\,s^{-1}$ and so it is a first order reaction.

$\therefore\ K=\frac{2.303}{t}\log\frac{[A_0]}{[A]}$

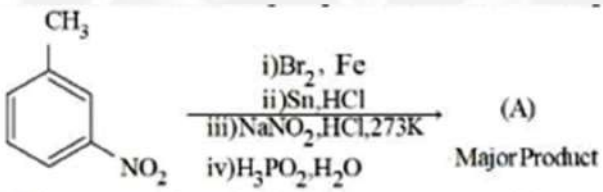
$4.606\times10^{-2}=\frac{2.303}{100}\log\frac{0.6}{[A]}$

$2=\log\frac{0.6}{[A]}\quad \log10^2=\log\frac{0.6}{[A]}$

$\therefore\ 10^2=\frac{0.6}{[A]}\Rightarrow[A]=0.006\qquad \therefore\ 0.6-P=0.006\Rightarrow P=0.6-0.006\qquad =0.594$

$\therefore\ P_7=x=0.6+\frac{P}{2}=0.6+\frac{0.594}{2}\qquad =0.6+0.297\qquad =0.897=897\times10^{-3}\,atm$

72. Consider the following sequence of reactions to produce major product(A)

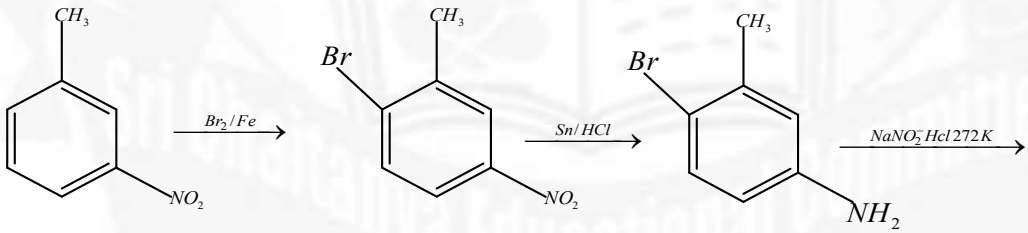


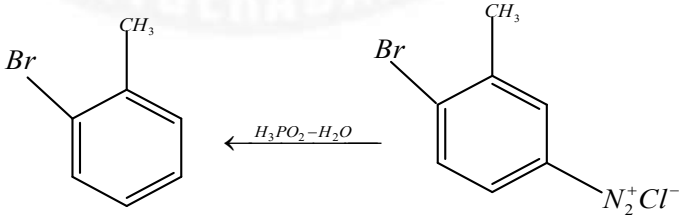
Molar mass of product (A) is _____ g mol^{-1}.

(Given molar mass in g mol^{-1} of C : 12, H: 1, O :16, Br : 80, N : 14, P:31)

Key: 171

Sol:





MW=171gm

73. During "S" estimation, 160 mg of an organic compound gives 466 mg of barium sulphate. The percentage of Sulphur in the given compound is ____ %.
(Given molar mass in g mol^{-1} of Ba: 137, S: 32, O: 16)

Key: 40

Sol: $\%S = \frac{32}{233} \times \frac{wt\ of\ BaSO_4}{wt\ of\ O.C} \times 100$

$= \frac{32}{233} \times \frac{466}{160} \times 100$ =40

74. The standard enthalpy and standard entropy of decomposition of N_2O_4 to NO_2 are 55.0kJmol^{-1} and 175.0 J/K/mol respectively. The standard free energy change for this reaction at 25^0C in J mol^{-1} is ____(Nearest integer)

Key: 2850

Sol: $\Delta H = 55\,KJ\ mol^{-1}$

$\Delta S = 175\,KJ\ mol^{-1}$

$\Delta G = ?\left(in\ J\ mol^{-1}\right)$

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

$= (55 \times 1000) - (298)(175)$

$= 55000 - 52150$

$= 2850\ J\ mol^{-1}$

75. If 1mM solution of ethylamine produces pH=9, then the ionization constant (K_b) of ethylamine is 10^{-x}. The value of x is ____(nearest integer).
[The degree of ionization of ethylamine can be neglected with respect to unity]

Key: 7

Sol: C=10^{-3}M

pH=9,pOH=5 $\therefore \left[OH^-\right] = 10^{-5}$

$BOH \rightleftharpoons B^+ + OH^-$

$c(1-\alpha)\quad c\alpha\quad c\alpha$

$\approx c$

$\therefore \left[OH^-\right] = c\alpha$

$10^{-5} = 10^{-3}.\alpha$

$\alpha = 10^{-2}$

$k_b = c\alpha^2$

$10^{-3} \times \left(10^{-2}\right)^2$

$= 10^{-7} = 10^{-x}$

$\therefore$ The value of x is 7

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