Answer Key

Mathematics (25 Questions)

Q1. (C)	Q2. (D)	Q3. (A)	Q4. (C)	Q5. (A)
Q6. (B)	Q7. (D)	Q8. (B)	Q9. (C)	Q10. (B)
Q11. (A)	Q12. (C)	Q13. (D)	Q14. (B)	Q15. (B)
Q16. (A)	Q17. (D)	Q18. (A)	Q19. (C)	Q20. (D)
Q21. 27	Q22. 20020	Q23. 2	Q24. 136	Q25. 33

Physics (25 Questions)

Q26. (B)	Q27. (D)	Q28. (C)	Q29. (A)	Q30. (C)
Q31. (B)	Q32. (A)	Q33. (C)	Q34. (B)	Q35. (D)
Q36. (D)	Q37. (D)	Q38. (D)	Q39. (A)	Q40. (A)
Q41. (C)	Q42. (D)	Q43. (C)	Q44. (C)	Q45. (C)
Q46. 250	Q47. 5	Q48. 8	Q49. 180	Q50. 9000

Chemistry (25 Questions)

Q51. (B)	Q52. (B)	Q53. (D)	Q54. (B)	Q55. (C)
Q56. (C)	Q57. (A)	Q58. (B)	Q59. (B)	Q60. (C)
Q61. (B)	Q62. (A)	Q63. (A)	Q64. (B)	Q65. (D)
Q66. (C)	Q67. (A)	Q68. (C)	Q69. (A)	Q70. (B)
Q71. 5	Q72. 6	Q73. 6	Q74. 4	Q75. 20

Solutions

Q1. Solution

Correct Answer: (C)

The integral decomposes as $\mathbf{I}=18\int_0^{\frac{\pi}{3}}\sin\left|3x-\frac{\pi}{6}\right|\mathrm{d}x+18\int_0^{\frac{\pi}{3}}[2\sin x]\mathrm{d}x$. Define $I_1=\int_0^{\frac{\pi}{3}}\sin\left|3x-\frac{\pi}{6}\right|\mathrm{d}x$ and $I_2=\int_0^{\frac{\pi}{3}}[2\sin x]\mathrm{d}x$.

For I_1, the integrand changes at $x=\frac{\pi}{18}$, where $3x-\frac{\pi}{6}=0$.
When $0\leq x\leq\frac{\pi}{18}$, $\left|3x-\frac{\pi}{6}\right|=\frac{\pi}{6}-3x$.
When $\frac{\pi}{18}\leq x\leq\frac{\pi}{3}$, $\left|3x-\frac{\pi}{6}\right|=3x-\frac{\pi}{6}$.

Split and integrate:
$\int_0^{\frac{\pi}{18}}\sin\left(\frac{\pi}{6}-3x\right)\mathrm{d}x=\left[\frac{\cos\left(\frac{\pi}{6}-3x\right)}{3}\right]_0^{\frac{\pi}{18}}=\frac{1}{3}\left(\cos(0)-\cos\left(\frac{\pi}{6}\right)\right)=\frac{1}{3}\left(1-\frac{\sqrt{3}}{2}\right)$.

$\int_{\frac{\pi}{18}}^{\frac{\pi}{3}}\sin\left(3x-\frac{\pi}{6}\right)\mathrm{d}x=\left[\frac{-\cos\left(3x-\frac{\pi}{6}\right)}{3}\right]_{\frac{\pi}{18}}^{\frac{\pi}{3}}=-\frac{1}{3}\left(\cos\left(\frac{5\pi}{6}\right)-\cos(0)\right)=-\frac{1}{3}\left(-\frac{\sqrt{3}}{2}-1\right)=\frac{1}{3}\left(1+\frac{\sqrt{3}}{2}\right)$.

Adding yields $I_1=\frac{2}{3}$.

For $I_2=\int_0^{\frac{\pi}{3}}[2\sin x]\mathrm{d}x$, note that $2\sin x$ ranges from 0 to $\sqrt{3}\approx 1.732$.
$[2\sin x]=0$ for $0\leq x<\frac{\pi}{6}$, and $[2\sin x]=1$ for $\frac{\pi}{6}\leq x\leq\frac{\pi}{3}$.
$I_2=\int_{\frac{\pi}{6}}^{\frac{\pi}{3}}1\mathrm{d}x=\frac{\pi}{6}$.

Combine results:
$\mathbf{I}=18\left(\frac{2}{3}+\frac{\pi}{6}\right)=12+3\pi$.

The coefficients are $P=3$, $Q=12$, so $P+Q=15$.

Q2. Solution

Correct Answer: (D)

$\bar{v}=\lambda\bar{a}+\mu\bar{b}$ Projection of $\vec{v}$ on $\vec{c}$ is $\frac{2}{\sqrt{3}}$ $\therefore\frac{\bar{v}\cdot\bar{c}}{|\vec{c}|}=\frac{2}{\sqrt{3}}\Rightarrow\frac{\lambda\bar{a}\cdot\bar{c}+\mu\vec{b}\cdot\vec{c}}{\sqrt{3}}=\frac{2}{\sqrt{3}}$ Solving (1) and (2)

$\Rightarrow 2\lambda+6\mu=2\rightarrow(1)$

$\Rightarrow\lambda-3\mu=7\rightarrow(2)$

$\lambda=4,\mu=-1$

$\therefore\vec{v}=2\hat{i}+7\hat{j}+7\hat{k}$

$\vec{v}=(\hat{i}+\hat{k})=2+7=9$

Q3. Solution

Correct Answer: (A)

The differential equation $\sin(x)\frac{\mathrm{d}y}{\mathrm{d}x}+\cos(x)y=\frac{\sin x-x\cos x}{\sin^2 x}$ has a left-hand side that is the derivative of $y\sin x$, since $\frac{\mathrm{d}}{\mathrm{d}x}(y\sin x)=y'\sin x+y\cos x$.

Rewriting gives $\frac{\mathrm{d}}{\mathrm{d}x}(y\sin x)=\frac{\sin x-x\cos x}{\sin^2 x}$.
Integrating both sides yields $y\sin x=\int\frac{\sin x-x\cos x}{\sin^2 x}\mathrm{d}x$.

The derivative of $\frac{x}{\sin x}$ is $\frac{\mathrm{d}}{\mathrm{d}x}\left(\frac{x}{\sin x}\right)=\frac{\sin x-x\cos x}{\sin^2 x}$, matching the integrand.
Thus, $y\sin x=\frac{x}{\sin x}+C$, and solving for y gives $y(x)=\frac{x}{\sin^2 x}+\frac{C}{\sin x}$.

Using the initial condition $y(\pi/2)=2$ with $\sin(\pi/2)=1$:
$2=\frac{\pi/2}{1}+C$, so $C=2-\frac{\pi}{2}$.

Substituting $x=\pi/6$ into the particular solution, with $\sin(\pi/6)=1/2$ and $\sin^2(\pi/6)=1/4$:
$y(\pi/6)=\frac{\pi/6}{1/4}+\frac{2-\pi/2}{1/2}=\frac{2\pi}{3}+4-\pi=4-\frac{\pi}{3}$.

Q4. Solution

Correct Answer: (C)

Eliminate n form given equations

$$\mathrm{a}\ell^2+\mathrm{bm}^2+\mathrm{c}\left(\frac{-(\mathrm{p}\ell+\mathrm{qm})}{\mathrm{r}}\right)^2=0$$

The lines are

$$\Rightarrow\quad(\mathrm{ar}^2+\mathrm{cp}^2)\left(\frac{\ell}{\mathrm{m}}\right)^2+2\mathrm{cpq}\left(\frac{\ell}{\mathrm{m}}\right)+\mathrm{br}^2+\mathrm{cq}^2=0$$

parallels then DCs are equal then roots are equal

$$\begin{aligned}&B^2-4AC=0\\ \Rightarrow\quad&[2cpq]^2=4\left(ar^2+cp^2\right)\left(br^2+cq^2\right)\\ \Rightarrow\quad&abr^2+acq^2+bcp^2=0\\ \Rightarrow\quad&\frac{p^2}{a}+\frac{q^2}{b}+\frac{r^2}{c}=0\\ \Rightarrow\quad&\Sigma\frac{p^2}{a}=0\end{aligned}$$

Q5. Solution

Correct Answer: (A)

Hint: trace of $\left(A_n^{-1}\right)=\frac{1}{a_{11}}+\frac{1}{a_{22}}+\frac{1}{a_{33}}+\ldots \mathrm{A}_3=\begin{bmatrix}\mathrm{a}_1 & \mathrm{b}_2 & \mathrm{c}_1 \\ 0 & \mathrm{b}_2 & \mathrm{c}_2 \\ 0 & 0 & \mathrm{c}_3\end{bmatrix}$ then

$A^{-1}=\begin{bmatrix}\frac{1}{a_1} & k_1 & k_2 \\ 0 & \frac{1}{b^2} & k_3 \\ 0 & 0 & \frac{1}{c_3}\end{bmatrix} \quad \therefore \frac{1}{10}\left(\sum_{n=1}^5 \text{trace of}\left(A_n^{-1}\right)\right)$

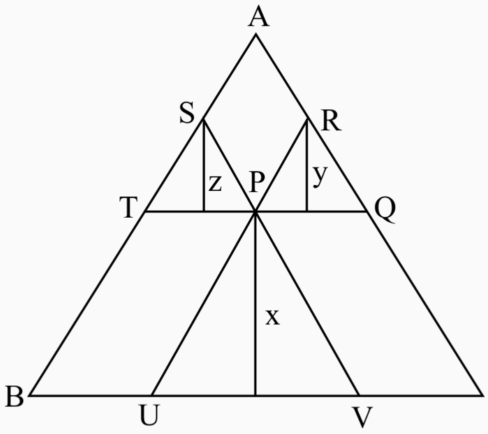
$=\frac{1}{10}\left(\operatorname{tr}\left(\mathrm{A}_1^{-1}\right)+\operatorname{tr}\left(\mathrm{A}_2^{-1}\right)+\operatorname{tr}\left(\mathrm{A}_3^{-1}\right)+\operatorname{tr}\left(\mathrm{A}_4^{-1}\right)+\operatorname{tr}\left(\mathrm{A}_5^{-1}\right)\right)$

$=\frac{1}{10}(5 \times 2+4 \times 8+3 \times 18+2 \times 32+50)$

$=21$

Q6. Solution

Correct Answer: (B)



$\Delta = \frac{1}{2}(BC)h\ \Delta^{le}puv, \Delta^{le}ABC$ are similar $\frac{x}{h} = \frac{uv}{BC}$ $\frac{\frac{1}{2}x \times uv}{\frac{1}{2} \times h \times BC} = \frac{x^2}{h^2} = \frac{49}{\Delta} \Rightarrow \frac{x}{h} = \frac{7}{\sqrt{\Delta}}$ Similarly $\frac{y}{h} = \frac{2}{\sqrt{\Delta}}$

$$\frac{z}{h} = \frac{3}{\sqrt{\Delta}}$$

$$\frac{x+y+z}{h} = \frac{7+2+3}{\sqrt{\Delta}}$$

$$\Rightarrow \frac{h}{h} = \frac{12}{\sqrt{\Delta}}$$

$$\sqrt{\Delta} = 12$$

$$\frac{\sqrt{\Delta}}{4} = 3$$

$$\frac{x}{h} = \frac{uv}{BC}$$

$$\frac{y}{h} = \frac{PQ}{BC}$$

$$\frac{z}{h} = \frac{TP}{BC}$$

$$\frac{x+y+z}{h} = \frac{uv+PQ+TP}{BC} = 1$$

$$x+y+z = h$$

Q7. Solution

Correct Answer: (D)

For $nB_1, B_2, B_3, B_4, B_5, (G_1, G_2, G_3, G_4, G_5)$ Number of arrangements $\Rightarrow n = 5! \times 6!$ For m First arrange 5 boys in 5 ! Ways $\uparrow B_1 \uparrow B_2 \uparrow B_3 \uparrow B_4 \uparrow B_5 \uparrow$ Now, we have to arrange 5 girls in such a way that group of four girls and the fifth girl are arranged in any two of the six positions shown as arrows. Two positions can be selected in ${}^6C_2$ ways. Four girls can be selected in ${}^5C_4$ ways Now, this group and the fifth girl can be arranged in selected two positions is 2! Ways Also, four girls arrange among themselves in 4 ! Ways Hence, number of arrangements

$$= m = 5!{}^6C_2 \times {}^5C_4 \times 2! \times 4! \quad \begin{array}{l} = 5! \times 15 \times 2 \times 5! \\ \therefore \frac{m}{n} = \frac{5! \times 15 \times 2 \times 5!}{5! \times 6!} = 5 \end{array}$$

Q8. Solution

Correct Answer: (B)

Let the given quadratic equation be $P(x) = 2x^2 + 5ax + 100 = 0$. For this equation to have no real roots, its discriminant D must be less than zero. The discriminant D for a quadratic equation $Ax^2 + Bx + C = 0$ is given by $D = B^2 - 4AC$. In our case, $A = 2$, $B = 5a$, and $C = 100$. So, $D = (5a)^2 - 4(2)(100) < 0$ $25a^2 - 800 < 0$ $25a^2 < 800$ $a^2 < \frac{800}{25}$ $a^2 < 32$ To find the range of a, we take the square root of both sides: $-\sqrt{32} < a < \sqrt{32}$ We know that $5^2 = 25$ and $6^2 = 36$. So, $5 < \sqrt{32} < 6$. More precisely, $\sqrt{32} \approx 5.656$. Thus, the range for a is approximately $(-5.656, 5.656)$. This is the open interval (α, β), so $\alpha = -\sqrt{32}$ and $\beta = \sqrt{32}$. The set K consists of all integers n such that $\alpha < n < \beta$. The integers in this interval are: $K = \{-5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5\}$ We need to determine the sum of the squares of the elements in K. Sum of squares $= (-5)^2 + (-4)^2 + (-3)^2 + (-2)^2 + (-1)^2 + 0^2 + 1^2 + 2^2 + 3^2 + 4^2 + 5^2$ Since $n^2 = (-n)^2$, we can write this as: Sum of squares $= 2 \times (1^2 + 2^2 + 3^2 + 4^2 + 5^2) + 0^2$ Sum of squares $= 2 \times (1 + 4 + 9 + 16 + 25) + 0$ Sum of squares $= 2 \times (55)$ Sum of squares $= 110$ Therefore, the sum of the squares of the elements in K is 110.

Q9. Solution

Correct Answer: (C)

According to the given condition, probability distribution function is

X = x	1	2	3	...	n
P(X = x)	$\frac{1}{n}$	$\frac{1}{n}$	$\frac{1}{n}$	...	$\frac{1}{n}$

$$\therefore \quad E(X) = \frac{1+2+\ldots+n}{n} = \frac{n(n+1)}{2n} = \frac{n+1}{2}$$

$$E\left(X^2\right) = \frac{1^2 + 2^2 + \ldots + n^2}{n} = \frac{n(n+1)(2n+1)}{6n} = \frac{(n+1)(2n+1)}{6}$$

$$\begin{aligned}\therefore \quad \operatorname{Var}(X) &= E\left(X^2\right) - [E(X)]^2 \\ &= \frac{(n+1)(2n+1)}{6} - \frac{(n+1)^2}{4} \\ &= \frac{2n^2+3n+1}{6} - \frac{n^2+2n+1}{4} \\ &= \frac{4n^2+6n+2-3n^2-6n-3}{12} = \frac{n^2-1}{12}\end{aligned}$$

Given that $\frac{\operatorname{Var}(X)}{E(X)} = \frac{4}{1}$ $\therefore$ $\frac{\frac{(n+1)(n-1)}{12}}{\frac{(n+1)}{2}} = \frac{4}{1}$

$$\therefore \quad \frac{n-1}{6} = \frac{4}{1}$$

$$\therefore \quad n = 1 + 24$$

$$\therefore \quad n = 25$$

Q10. Solution

Correct Answer: (B)

Let $g(x) = \left(x^{2023} + 1\right)|(x-5)(x+1)|$ not derivable at $\mathrm{x} = 5$ Let $h(x) = \sin(|x|)$ not derivable at $\mathrm{x} = 0$ And let $s(x) = \cos(|x-1|)$ derivable everywhere $\therefore f(x) = g(x) + h(x) + s(x)$ not derivable at 0 and 5 (two point)

Q11. Solution

Correct Answer: (A)

The ellipse $\frac{x^2}{4}+y^2=1$ has semi-major axis $a=2$ and semi-minor axis $b=1$, giving area $A_E=\pi ab=2\pi$.

The parabolic region defined by $|y|=1-\frac{x^2}{4}$ consists of two symmetric curves: $y=1-\frac{x^2}{4}$ for $y\geq 0$ and $y=\frac{x^2}{4}-1$ for $y<0$. These intersect the ellipse at its vertices $(\pm 2,0)$ and $(0,\pm 1)$, confirming the parabola lies entirely within the ellipse.

The area between these curves is computed by integration:

$$A_P=\int_{-2}^{2}\left[\left(1-\frac{x^2}{4}\right)-\left(\frac{x^2}{4}-1\right)\right]dx=\int_{-2}^{2}\left(2-\frac{x^2}{2}\right)dx$$

Exploiting symmetry:

$$A_P=2\int_0^2\left(2-\frac{x^2}{2}\right)dx=2\left[2x-\frac{x^3}{6}\right]_0^2=2\left(4-\frac{4}{3}\right)=\frac{16}{3}$$

The area inside the ellipse but outside the parabola is:

$$K=A_E-A_P=2\pi-\frac{16}{3}$$

Multiplying by 3:

$$3K=6\pi-16=m\pi+n$$

Thus $m=6$, $n=-16$, and $|m-n|=|6-(-16)|=22$.

.

Q12. Solution

Correct Answer: (C)

MI: Use Binomial theorem M2: Congruence Modulo. M1: $3^4 = 81$

$$\Rightarrow 3^4 = 81 = 82 - 1$$
$$= 41\text{ m} - 1$$
$$\Rightarrow 3^{102} = 3^2 \times 3^{100}$$
$$= 9 \times \left(3^4\right)^{25}$$

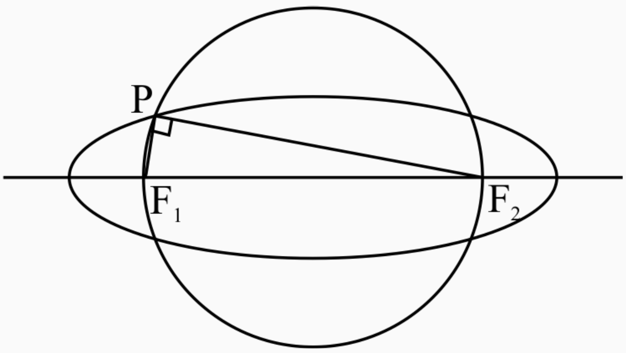
$$N = 9(\underbrace{41m - 1}_{\text{expansion}})^{25} = 9[\underbrace{{}^{25}c_0(4\text{ m})^{25} + \cdots}_{41m_1} + \underbrace{{}^{25}c_{25}(-1)^{25}}]$$

$$= 9\left[41m_1 - 1\right]$$
$$= \underbrace{9 \times 41m_1 - 9}$$
$$N = 41m_2 - 9$$
$$= 41m_2 - 41 + \boxed{41 - 9}$$
$$N = 41m_2 + (32) \to \text{ Remainder}$$

To find the remainder when 3^{102} is divided by 41, we use modular arithmetic. We need to calculate $3^{102} \pmod{41}$. Since 41 is a prime number, we can apply Fermat's Little Theorem, which states that if p is a prime number, then for any integer a not divisible by p, we have $a^{p-1} \equiv 1 \pmod{p}$. Here, $a = 3$ and $p = 41$. Since 41 is prime and 3 is not a multiple of 41, we have: $3^{41-1} \equiv 3^{40} \equiv 1 \pmod{41}$. Now, we can rewrite the exponent 102 in terms of 40: $102 = 2 \times 40 + 22$. So, we can express 3^{102} as: $3^{102} = 3^{2\times 40+22} = (3^{40})^2 \times 3^{22}$. Taking this expression modulo 41: $3^{102} \equiv (3^{40})^2 \times 3^{22} \pmod{41}$ Substitute $3^{40} \equiv 1 \pmod{41}$ into the congruence: $3^{102} \equiv (1)^2 \times 3^{22} \pmod{41}$ $3^{102} \equiv 1 \times 3^{22} \pmod{41}$ $3^{102} \equiv 3^{22} \pmod{41}$. Now, we need to calculate $3^{22} \pmod{41}$. Let's find smaller powers of 3 modulo 41: $3^1 \equiv 3 \pmod{41}$ $3^2 \equiv 9 \pmod{41}$ $3^3 \equiv 27 \pmod{41}$ $3^4 \equiv 3 \times 27 = 81 \pmod{41}$. To simplify $81 \pmod{41}$, we divide 81 by 41: $81 = 2 \times 41 - 1 = 82 - 1$. So, $3^4 \equiv -1 \pmod{41}$. This is a very useful simplification. Now, we use this result to calculate 3^{22}: $3^{22} = 3^{4\times 5+2} = (3^4)^5 \times 3^2$. Taking this expression modulo 41: $3^{22} \equiv (3^4)^5 \times 3^2 \pmod{41}$ Substitute $3^4 \equiv -1 \pmod{41}$ and $3^2 = 9$: $3^{22} \equiv (-1)^5 \times 9 \pmod{41}$ $3^{22} \equiv -1 \times 9 \pmod{41}$ $3^{22} \equiv -9 \pmod{41}$. To express the remainder as a positive integer, we add 41 to -9: $-9 + 41 = 32$. Therefore, $3^{102} \equiv 32 \pmod{41}$. The remainder when 3^{102} is divided by 41 is 32. ,

Q13. Solution

Correct Answer: (D)



$PF_1 + PF_2 = 15 \quad PF_1 \times PF_2 = 52$

$(F_1F_2)^2 = (PF_1 + PF_2)^2 - 2PF_1 \times PF_2 = 225 - 104$

$\Rightarrow \quad F_1F_2 = 11 \Rightarrow \quad 2ae = 11 \Rightarrow ae = 11/2$

Also $b^2 = a^2\left(1 - e^2\right) \quad \Rightarrow \quad b^2 = a^2 - a^2e^2$

$$\Rightarrow \quad a^2 - b^2 = (ae)^2 \quad \Rightarrow \quad 4\left(a^2 - b^2\right) = 4\left(\frac{11}{2}\right)^2 = 121$$

Q14. Solution

Correct Answer: (B)

Domain of $f(x) = \log_3(15x - x^2 - 54)$:
The argument of the logarithm must satisfy $15x - x^2 - 54 > 0$. Multiplying by -1 reverses the inequality to $x^2 - 15x + 54 < 0$, which factors as $(x-6)(x-9) < 0$.
This holds between the roots, so the domain is $(6, 9)$, giving $\alpha = 6$ and $\beta = 9$.

Domain of $g(x) = \log_{(x-2)}\left(\frac{x^2+x-6}{x^2-5x+4}\right)$:
Require the base $x - 2 > 0$ and $x - 2 \neq 1$, so $x > 2$ and $x \neq 3$. The argument must be positive, and factoring numerator and denominator gives $\frac{(x+3)(x-2)}{(x-1)(x-4)} > 0$.
Using a sign chart, the inequality holds for $x \in (-\infty, -3) \cup (1, 2) \cup (4, \infty)$.
Intersecting with $x > 2$ and $x \neq 3$ yields the domain $(4, \infty)$, so $\gamma = 4$.

Final calculation:
$\alpha^2 + \beta^2 + \gamma^2 = 6^2 + 9^2 + 4^2 = 36 + 81 + 16 = 133.$

$\boxed{133}$

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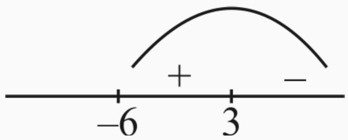
Q15. Solution

Correct Answer: (B)

$\mathrm{AB} = 12 \Rightarrow \mathrm{KA} = 6$ Let $\mathrm{PC} = \ell$ $\mathrm{OK} = 2$ $\mathrm{PQ} = 2\sqrt{40 - (2+\ell)^2}$ Area of rectangle

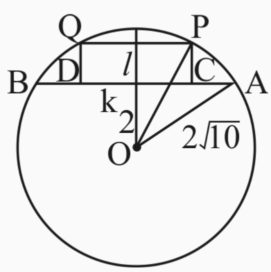
$\mathrm{A} = \ell . 2\sqrt{36 - \ell^2 - 4\ell}$

$$\frac{\mathrm{dA}}{\mathrm{d}\ell} = 2\left\{\frac{\ell(-\ell-2)}{\sqrt{36-\ell^2-4\ell}} + \sqrt{36-\ell^2-4\ell}\right\}$$



$$\Rightarrow \left(-\ell^2 - 2\ell + 36 - \ell^2 - 4\ell\right)\frac{2}{\sqrt{36-\ell^2-4\ell}}$$

$$\Rightarrow -(\ell+6)(\ell-3) \cdot \frac{2}{\sqrt{36-\ell^2-4\ell}}$$



$\mathrm{A}_{(\max)}$ at $\ell = 3 \Rightarrow \mathrm{A}_{\max} = 6\sqrt{15}$

$$\frac{\lambda}{\sqrt{15}} = 6$$

$\mathrm{A}_{\max} = 6\sqrt{15}$

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Q16. Solution

Correct Answer: (A)

Let reflection of $\mathrm{P}(1,0,0)$ in the line $\frac{x+1}{2}=\frac{y+1}{-3}=\frac{z+10}{8}$ be (α, β, γ) Then $\left(\frac{\alpha+1}{2}, \frac{\beta}{2}, \frac{\gamma}{2}\right)$ lies on the line and $(\alpha-1)\hat{i}+\beta\hat{j}+\gamma\hat{k}$ is perpendicular to $2\hat{i}-3j+8\hat{k}$ $\therefore \frac{\frac{\alpha+1}{2}-1}{2}=\frac{\frac{\beta}{2}+1}{-3}=\frac{\frac{\gamma}{2}+10}{8}=\lambda$ And

$2(\alpha-1)-3(\beta)+\gamma(8)=0 \Rightarrow \alpha=5, \beta=-8, \gamma=-4:$

Q17. Solution

Correct Answer: (D)

Let

$E \rightarrow$Event that the tube is defective.

$B_1 \rightarrow$Event when E_1 produces the tube.

$B_2 \rightarrow$Event when E_2 produces the tube.

$B_3 \rightarrow$Event when E_3 produces the tube.

$P(B_1)=\frac{50}{100}=\frac{1}{2}$ and $P\left(\frac{E}{B_1}\right)=\frac{4}{100}=\frac{1}{25}$.

$P(B_2)=\frac{25}{100}=\frac{1}{4}$ and $P\left(\frac{E}{B_2}\right)=\frac{4}{100}=\frac{1}{25}$.

$P(B_3)=\frac{25}{100}=\frac{1}{4}$ and $P\left(\frac{E}{B_3}\right)=\frac{5}{100}=\frac{1}{20}$.

Now,

$P(E)=P\left(\frac{E}{B_1}\right)P(B_1)+\left(\frac{E}{B_3}\right)P(B)+\left(\frac{E}{B_3}\right)P(B_3)$.

$\Rightarrow\ P(E)=\frac{1}{2}\times\frac{1}{25}+\frac{1}{4}\times\frac{1}{25}+\frac{1}{4}\times\frac{1}{20}$

$\Rightarrow\ P(E)=0.0425$

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Q18. Solution

Correct Answer: (A)

For a system of linear equations to have infinitely many solutions, the determinant of the coefficient matrix (D) must be zero, and all the determinants D_x, D_y, D_z (obtained by replacing the respective column of the coefficient matrix with the constant terms) must also be zero. $D = \begin{vmatrix} 1 & 1 & 1 \\ 1 & 3 & 4 \\ 1 & 7 & 10 \end{vmatrix}$ $D = 1(3 \times 10 - 4 \times 7) - 1(1 \times 10 - 4 \times 1) + 1(1 \times 7 - 3 \times 1)$ $D = 1(30 - 28) - 1(10 - 4) + 1(7 - 3)$ $D = 1(2) - 1(6) + 1(4)$ $D = 2 - 6 + 4 = 0$ Since $D = 0$, the system either has no solution or infinitely many solutions. We proceed to calculate D_x, D_y, D_z. $D_x = \begin{vmatrix} 1 & 1 & 1 \\ \mu & 3 & 4 \\ \mu^2 & 7 & 10 \end{vmatrix}$ $D_x = 1(3 \times 10 - 4 \times 7) - 1(10\mu - 4\mu^2) + 1(7\mu - 3\mu^2)$ $D_x = 1(30 - 28) - 10\mu + 4\mu^2 + 7\mu - 3\mu^2$ $D_x = 2 - 3\mu + \mu^2$ For infinitely many solutions, D_x must be 0: $\mu^2 - 3\mu + 2 = 0$ $(\mu - 1)(\mu - 2) = 0$ So, $\mu = 1$ or $\mu = 2$. $D_y = \begin{vmatrix} 1 & 1 & 1 \\ 1 & \mu & 4 \\ 1 & \mu^2 & 10 \end{vmatrix}$ $D_y = 1(10\mu - 4\mu^2) - 1(10 - 4) + 1(\mu^2 - \mu)$ $D_y = 10\mu - 4\mu^2 - 6 + \mu^2 - \mu$ $D_y = -3\mu^2 + 9\mu - 6$ $D_y = -3(\mu^2 - 3\mu + 2)$ If $\mu = 1$, $D_y = -3(1^2 - 3(1) + 2) = -3(1 - 3 + 2) = -3(0) = 0$. If $\mu = 2$, $D_y = -3(2^2 - 3(2) + 2) = -3(4 - 6 + 2) = -3(0) = 0$. Both values of μ satisfy $D_y = 0$. $D_z = \begin{vmatrix} 1 & 1 & 1 \\ 1 & 3 & \mu \\ 1 & 7 & \mu^2 \end{vmatrix}$ $D_z = 1(3\mu^2 - 7\mu) - 1(\mu^2 - \mu) + 1(7 - 3)$ $D_z = 3\mu^2 - 7\mu - \mu^2 + \mu + 4$ $D_z = 2\mu^2 - 6\mu + 4$ $D_z = 2(\mu^2 - 3\mu + 2)$ If $\mu = 1$, $D_z = 2(1^2 - 3(1) + 2) = 2(1 - 3 + 2) = 2(0) = 0$. If $\mu = 2$, $D_z = 2(2^2 - 3(2) + 2) = 2(4 - 6 + 2) = 2(0) = 0$. Both values of μ satisfy $D_z = 0$. Thus, the system has infinitely many solutions for $\mu_1 = 1$ and $\mu_2 = 2$. $\sum_{i=1}^{10}(1^i + 2^i) = \sum_{i=1}^{10} 1^i + \sum_{i=1}^{10} 2^i$ The first sum is $1^1 + 1^2 + \cdots + 1^{10} = 10 \times 1 = 10$. The second sum is a geometric series: $2^1 + 2^2 + \cdots + 2^{10}$. $S_{10} = \frac{2(2^{10}-1)}{2-1} = \frac{2(1024-1)}{1} = 2(1023) = 2046$. Therefore, the total sum is $10 + 2046 = 2056$. .

Q19. Solution

Correct Answer: (C)

Since, $(1, 2) \in S$ but $(2, 1) \notin S \therefore$ S is not symmetric Hence, S is not equivalence relation. Given, $\mathrm{T} = \{(\mathrm{x}, \mathrm{y}) : \mathrm{x} - \mathrm{y} \in \mathrm{I}\}$ Now, $\mathrm{x} - \mathrm{x} = 0 \in \mathrm{I}$, it is reflexive relation. $x - y \in I \Rightarrow \mathrm{y} - \mathrm{x} \in \mathrm{I}$, it is symmetric relation. Let $\mathrm{x} - \mathrm{y} = \mathrm{I}_1$ and $\mathrm{y} - \mathrm{z} = \mathrm{I}_2$ Now, $\mathrm{x} - \mathrm{z} = (\mathrm{x} - \mathrm{y}) + (\mathrm{y} - \mathrm{z}) = \mathrm{I}_1 + \mathrm{I}_2 \in \mathrm{I} \therefore$ T is also transitive. Hence, T is an equivalence relation. ~

Q20. Solution
Correct Answer: (D)

The condition $\cos x + \cos^2 x = 1$ can be rearranged to $\cos x = 1 - \cos^2 x$. Since $\sin^2 x = 1 - \cos^2 x$ by the Pythagorean identity, we obtain the fundamental relation:

$\cos x = \sin^2 x$

The expression $E = (\sin^{12} x + \cot^{12} x) + 3(\sin^{10} x + \cot^{10} x + \sin^8 x + \cot^8 x) + (\sin^6 x + \cot^6 x)$ can be grouped as:

$E = \sin^6 x(\sin^6 x + 3\sin^4 x + 3\sin^2 x + 1) + \cot^6 x(\cot^6 x + 3\cot^4 x + 3\cot^2 x + 1)$

Both parenthetical components are perfect cubes: $(\sin^2 x + 1)^3$ and $(\cot^2 x + 1)^3$, respectively.

$E = \sin^6 x(\sin^2 x + 1)^3 + \cot^6 x(\cot^2 x + 1)^3$

Substituting $\sin^2 x = \cos x$ from our earlier relation:

$\sin^6 x = (\sin^2 x)^3 = \cos^3 x$

$\sin^2 x + 1 = \cos x + 1$

Thus the first term becomes $\cos^3 x(\cos x + 1)^3 = (\cos^2 x + \cos x)^3 = 1^3 = 1$

For the second term, using the identity $\cot^2 x + 1 = \csc^2 x = 1/\sin^2 x = 1/\cos x$

$\cot^6 x = \cos^6 x/\sin^6 x = \cos^6 x/\cos^3 x = \cos^3 x$

Thus the second term becomes $\cos^3 x(1/\cos x)^3 = \cos^3 x/\cos^3 x = 1$

Combining both terms gives $E = 1 + 1 = 2$

$\boxed{2}$

:

Q21. Solution

Correct Answer: 27

$\mathrm{f(x)} + \int_0^{\mathrm{x}} \mathrm{f(t)}\sqrt{1-(\log_{\mathrm{e}} \mathrm{f(t)})^2}\mathrm{dt} = \mathrm{e}$ By Leibnitz condition
$f^1(x) + f(x)\sqrt{1-(\log_e f(x))^2}(1) - 0 = 0 \quad f^1(x) + f(x)\sqrt{1-(\log_e f(x))^2} = 0$
$f^1(x) = -f(x)\sqrt{1-(\log_e f(x))^2} \qquad \frac{1}{\sqrt{1-(\log_e f(x))^2}}\frac{f^1(x)}{f(x)} = -1$ Integrate on both sides
$\int \frac{1}{\sqrt{1-(\log_e f(x))^2}}\frac{f^1(x)}{f(x)}dx = -\int dx \quad \log_e f(x) = t$ Differentiate on both sides w.r.t to
$x \quad \frac{f^1(x)}{f(x)}dx = dt \quad \int \frac{1}{\sqrt{1-t^2}}dt - \int dx \ \sin^{-1}(\mathrm{t}) = -\mathrm{x} + \mathrm{c} \quad \sin^{-1}(\log_{\mathrm{e}} \mathrm{f(x)}) = -\mathrm{x} + \mathrm{c}$. Put
$x = 0 \Rightarrow \sin^{-1}(\log_e f(0)) = 0 + C \because f(0) = e \ \sin^{-1}(1) = c \Rightarrow c = \frac{\pi}{2}$ From (1)
$\sin^{-1}(\log_e f(x)) = -x + \frac{\pi}{2} \log_e f(x) = \sin\left(\frac{\pi}{2} - x\right) \ \log_e f(x) = \cos x$ Put $x = \frac{\pi}{6}$
$\log_e f\left(\frac{\pi}{6}\right) = \cos\frac{\pi}{6} = \frac{\sqrt{3}}{2} \ 6\log_e f\left(\frac{\pi}{6}\right) = 6\left(\frac{\sqrt{3}}{2}\right) = 3\sqrt{3}$ S.O.B $\left(6\log_{\mathrm{e}} \mathrm{f}\left(\frac{\pi}{6}\right)\right)^2 = (3\sqrt{3})^2 = 27$

Q22. Solution

Correct Answer: 20020

The odd-indexed terms themselves form an arithmetic progression: $a_1, a_1 + 2d, a_1 + 4d, \ldots, a_1 + (500)2d$. Its first term is $A_1 = a_1$ and its common difference is $D = 2d$. The sum of these $k = 501$ terms is:
$S_{odd} = \frac{501}{2}[2a_1 + (501-1)(2d)] \ S_{odd} = \frac{501}{2}[2a_1 + 500(2d)] \ S_{odd} = \frac{501}{2}[2a_1 + 1000d]$
$S_{odd} = 501(a_1 + 500d)$ We are given that $S_{odd} = 10020$. Therefore, $501(a_1 + 500d) = 10020$
$a_1 + 500d = \frac{10020}{501} \ a_1 + 500d = 20$ The total number of terms is $N = 1001$. The sum of an AP is given by:
$S_{total} = \frac{1001}{2}[2a_1 + (1001-1)d] \ S_{total} = \frac{1001}{2}[2a_1 + 1000d] \ S_{total} = 1001(a_1 + 500d) \ S_{total} = 1001 \times 20$
$S_{total} = 20020$.

Q23. Solution

Correct Answer: 2

$$\lim_{x\to 0^+}\left[\frac{x}{\pi}\right]=\lim_{h\to 0}\left[\frac{h}{\pi}\right]=0$$

$$\lim_{x\to 0^+}\frac{\sin^2 x}{\left[\frac{x}{\pi}\right]+\frac{x^2}{\pi^2}}\times\frac{\sin(\sin x)-\sin x}{a^5+bx^3+c}=-\frac{\pi^2}{12}$$

$x=0+h$

$$\lim_{h\to 0}\frac{\sin^2 h}{\frac{h^2}{\pi^2}}\times\frac{2\cos\left(\frac{\sin h+h}{2}\right)\sin\left(\frac{\sin h-h}{2}\right)}{ah^{5^2}+bh^3+c}=-\frac{\pi^2}{12}$$

$$\lim_{h\to 0}\frac{\pi^2\cdot\sin^2 h}{h^2}\times 2\cos\left(\frac{\sin h+h}{2}\right)$$

$$\frac{\sin\left(\frac{\sin h-h}{2}\right)}{\frac{\sin h-h}{2}}\times\frac{\frac{\sin h-h}{2}}{ah^5+bh^3+c}=-\frac{\pi^2}{12}$$

$$\Rightarrow\lim_{h\to 0}\frac{\sin h-h}{ah^5+bh^3+c}=-\frac{1}{12}$$

$$\lim_{h\to 0}\frac{\sin h-h^3\left(ah^2+b\right)}{12}=-\frac{1}{12}\quad(c=0)$$

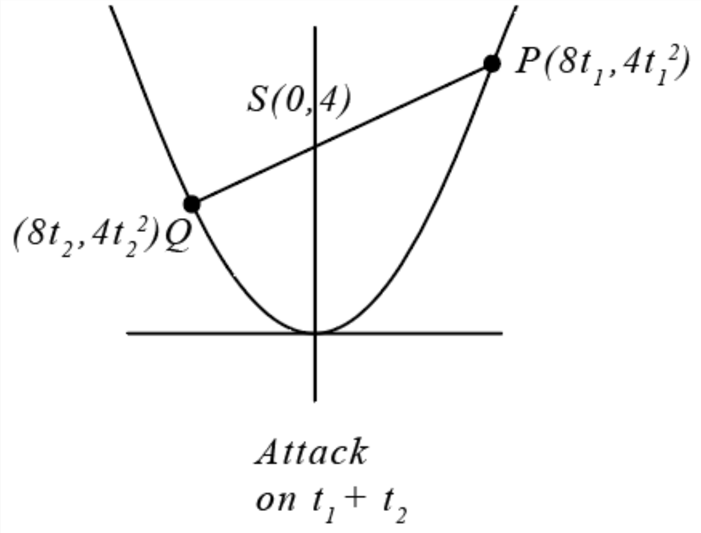
$$-\frac{1}{6(b)}=-\frac{1}{12}\quad\therefore b=2$$

$a\in R, b=2, c=0$

$b+c=2+0=2$

Q24. Solution

Correct Answer: 136



$x^2=4ay \rightarrow$ Paramatric coordinate $x=2at, y=at^2$ coordinate - For Focal chord: $t_1 t_2=-1$ - Focal distance of any Point P($x_1, y_1)=a+y_1$ - Diametric form of Circle:
$\left(x-x_1\right)\left(x-x_2\right)+\left(y-y_1\right)\left(y-y_2\right)=0$ Given: $x^2=16y \Rightarrow a=4$
$P\left(8+1, 4t_1{}^2\right) \quad Q\left(8+2, 4t_2{}^2\right) \rightarrow 4t_2=-1$ PQ as diameter:
$\left(x-8t_1\right)\left(x-8t_2\right)+\left(y-4t^2\right)\left(y-4t_2^2\right)=0$
$\Rightarrow x^2+y^2-8\left(t_1+t_2\right)x-4\left(t_1^2+t_2^2\right)^2 y+64t_1t_2+16\left(t_1t_2\right)^2=0$
$\Rightarrow x^2+y^2-8\left(t_1+t_2\right)x-4\left[\left(t_1+t_2\right)^2-2t_1t_2\right]y+64(-1)+16(-1)^2=0$
$\Rightarrow 1x^2+y^2-8\left(t_1+t_2\right)x-4\left[\left(t_1+t_2\right)^2+2\right]y-48=0-A$
Given (PS)(QS) $=\dfrac{1600}{9}$

$\Rightarrow\left(4t_1^2+4\right)\left(4t_2^2+4\right)=\dfrac{1600}{9} \qquad \left(t_1+t_2\right)^2-2t_1t_2=\dfrac{82}{9}$

$\Rightarrow 16\left(t_1^2+1\right)\left(t_2^2+1\right)=\dfrac{1600}{9}100 \left(t_1+t_2\right)^2=\dfrac{82}{9}-2$

$\Rightarrow t_1^2+t_2^2+\left(t_1t_2\right)^2+1=\dfrac{100}{9} \qquad \left(t_1+t_2\right)^2=\dfrac{64}{9} \qquad$ New circle equation

$\Rightarrow t_1^2+t_2^2+(-1)^2+1=\dfrac{100}{9} \qquad t_1+t_2=\pm\dfrac{8}{3}$

$\Rightarrow t_1^2+t_2^2=\dfrac{100}{9}-2 \qquad$ let $t_1+t_2=\dfrac{8}{3}$

$\Rightarrow t_1^2+t_2^2=\dfrac{82}{9}$

$x^2+y^2-8\left(t_1+t_2\right)x-4\left[\left(t_1+t_2\right)^2+2\right]y-48=0$

$\Rightarrow x^2+y^2-\dfrac{64}{3}x-4\left[\dfrac{64}{9}+2\right]y-48=0$

$\Rightarrow x^2+y^2-\dfrac{64}{3}x-\dfrac{4\times 82}{9}-48=0$
$\Rightarrow 9x^2+9y^2-64\times 3x-328y-48=0$
$\Rightarrow \lambda=-64\times 3 \quad u=328$
$\Rightarrow \lambda+u=328-64\times 3$
$=328-192$
$Ans=136$

Q25. Solution

Correct Answer: 33

$$\left(4+5w+6w^2\right)^{n^{2+2}}\left(1+w^{n^2+2}+w^{2n^2+4}\right)=0$$

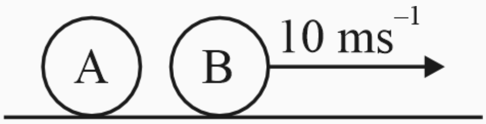
$$\Rightarrow n=3\lambda, n\neq 3\lambda+1, 3\lambda+2 \therefore n=3,6,9,12,\ldots\ldots..99$$

So, number of values of n is 33

Q26. Solution

Correct Answer: (B)

Since A, B and C are identical balls, if any of the two balls undergo elastic collision, they will exchange their velocities.



Thus, when A and B collide, A comes to rest, and B start moving ahead with 10 m s^{-1}.

Similarly, when B collides with C, B comes to rest and C starts moving ahead with a speed of 10 m s^{-1}.

Q27. Solution

Correct Answer: (D)

$$\mathrm{u}=-\left(4+\frac{4}{2}\right)\times 2=-12\text{ cm}$$

$$\frac{1}{\mathrm{v}}+\frac{1}{-12}=\frac{1}{-8}$$

$$\Rightarrow \mathrm{v}=-24\text{ cm}$$

for final image (refraction through plane surface) we can write.

$$24=2\left(\frac{x}{1}+\frac{4}{2}\right)\Rightarrow 24=2x+4$$

$$x=10\text{ cm}$$

so distance from P is 14 cm.

Q28. Solution

Correct Answer: (C)

The net force becomes zero at the mean point. Therefore, linear momentum must be conserved.

$$\therefore Mv_1=(m)v_2$$

$$MA_1\sqrt{\frac{k}{M}}=(M+m)A_2\sqrt{\frac{k}{m+M}}$$

$$\therefore\left(V=A\sqrt{\frac{k}{M}}\right)$$

$$A_1\sqrt{M}=A_2\sqrt{M+m}$$

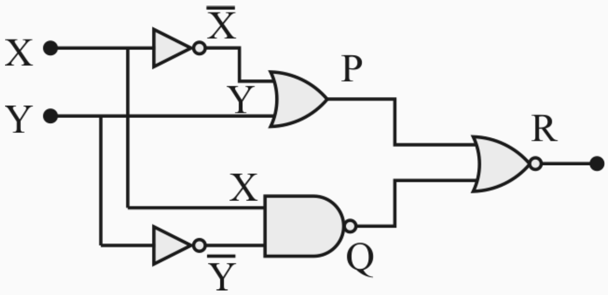
Q29. Solution

Correct Answer: (A)

Statement I: When an ideal gas undergoes adiabatic compression, its temperature always rises.An adiabatic process is one where no heat exchange occurs with the surroundings, i.e., $Q = 0$. According to the First Law of Thermodynamics, $\Delta U = Q - W$, where ΔU is the change in internal energy and W is the work done by the gas. For an adiabatic process, $\Delta U = -W$. When an ideal gas undergoes compression, work is done *on* the gas. Therefore, the work done *by* the gas (W) is negative. Since $W < 0$, then $\Delta U = -W > 0$. For an ideal gas, internal energy U is directly proportional to its absolute temperature T. An increase in internal energy ($\Delta U > 0$) implies an increase in temperature ($\Delta T > 0$). Thus, Statement I is true. Statement II: Free expansion of an ideal gas into a vacuum is an adiabatic process, and no work is performed by the gas during this expansion. Free expansion occurs when a gas expands into a vacuum. In this process, there is no external pressure ($P_{ext} = 0$) against which the gas expands. The work done by the gas is given by $W = \int P_{ext} dV$. Since $P_{ext} = 0$, the work done $W = 0$. Free expansion is also considered an adiabatic process because it happens rapidly and there is no time for heat exchange with the surroundings, so $Q = 0$. Applying the First Law of Thermodynamics: $\Delta U = Q - W$. Since $Q = 0$ and $W = 0$, then $\Delta U = 0$. For an ideal gas, $\Delta U = 0$ implies $\Delta T = 0$. Thus, Statement II is true. Both statements are correct.The final answer is $\boxed{A}$

Q30. Solution

Correct Answer: (C)



The truth table can be written as

X	Y	$\bar{X}$	$\bar{Y}$	$P = \bar{X} + Y$	$Q = \overline{X \cdot \bar{Y}}$	$R = \overline{P + Q}$
0	1	1	0	1	1	0
1	1	0	0	1	1	0
1	0	0	1	0	0	1
0	0	1	1	1	1	0

Hence $X = 1, Y = 0$ gives output $R = 1$

Q31. Solution

Correct Answer: (B)

On increasing temperature, KE of free electron increases. They collide more rapidly hence drift velocity decreases. Also with increase in temperature resistance increases, so conductivity decreases.

$\therefore$ Both statements are true, but reason is not correct explanation of assertion.

Q32. Solution

Correct Answer: (A)

1. The electric field is defined as force per unit charge: $E = \frac{F}{q}$. Dimensions of Force (F) = $[MLT^{-2}]$ Dimensions of Charge (q) = $[AT]$ (since current $I = \frac{q}{t}$, so $q = It$) Dimensions of $E = \frac{[MLT^{-2}]}{[AT]} = [MLT^{-3}A^{-1}]$ This matches **List-II (II)**. 2. Electric potential is defined as work done per unit charge: $V = \frac{W}{q}$. Dimensions of Work (W) = $[ML^2T^{-2}]$ (Work = Force $\times$ Distance) Dimensions of Charge (q) = $[AT]$ Dimensions of $V = \frac{[ML^2T^{-2}]}{[AT]} = [ML^2T^{-3}A^{-1}]$ This matches **List-II (IV)**. 3. From Ohm's Law, resistance is potential difference divided by current: $R = \frac{V}{I}$. Dimensions of Potential (V) = $[ML^2T^{-3}A^{-1}]$ (from above) Dimensions of Current (I) = $[A]$ Dimensions of $R = \frac{[ML^2T^{-3}A^{-1}]}{[A]} = [ML^2T^{-3}A^{-2}]$ This matches **List-II (I)**. 4. Capacitance is defined as charge stored per unit potential difference: $C = \frac{q}{V}$. Dimensions of Charge (q) = $[AT]$ Dimensions of Potential (V) = $[ML^2T^{-3}A^{-1}]$ (from above) Dimensions of $C = \frac{[AT]}{[ML^2T^{-3}A^{-1}]} = [M^{-1}L^{-2}T^4A^2]$

Q33. Solution

Correct Answer: (C)

Let m be the mass of the crop gathered by the machine. The machine operates at a constant forward speed v. The rate at which it gathers crop mass is given as $\frac{\mathrm{dm}}{\mathrm{dt}} \propto v^2$. We can write this as $\frac{\mathrm{dm}}{\mathrm{dt}} = kv^2$, where k is a constant of proportionality. To sustain a constant speed v, the machine must exert a force to accelerate the incoming crop mass from rest to speed v. This is a classic variable mass system problem. The force F required is given by Newton's second law for a variable mass system, considering the relative velocity of the incoming mass. Since the crop is initially at rest relative to the ground and is accelerated to the machine's speed v, the force exerted by the machine on the crop (or the reaction force on the machine) is: $F = v\frac{\mathrm{dm}}{\mathrm{dt}}$ Substitute the given proportionality for $\frac{\mathrm{dm}}{\mathrm{dt}}$: $F = v(kv^2)$ $F = kv^3$ The power P supplied to the machine to sustain this constant speed is given by the product of the force and the speed: $P = F \cdot v$ Substitute the expression for F: $P = (kv^3)v$ $P = kv^4$ Therefore, the power P is proportional to v^4. $P \propto v^4$ The correct option is C.

Q34. Solution

Correct Answer: (B)

Place a coordinate system with origin at the square's center, where the four particles of mass m are positioned at $(-L/2, L/2)$, $(L/2, L/2)$, $(L/2, -L/2)$, and $(-L/2, -L/2)$.
Their initial velocities are $V_0\hat{\imath}$, $-V_0\hat{\jmath}$, $-V_0\hat{\imath}$, and $V_0\hat{\jmath}$, respectively.

The center of mass remains at the origin due to symmetry, as confirmed by $X_{CM} = 0$ and $Y_{CM} = 0$.

Angular momentum about the center of mass is computed for each particle using $\vec{L} = \vec{r} \times m\vec{v}$.
Each calculation yields the same result: $-\frac{1}{2}mLV_0\hat{k}$.

$$\vec{L}_{\text{total}} = 4 \times \left(-\frac{1}{2}mLV_0\hat{k}\right) = -2mLV_0\hat{k}$$

With no external torques, angular momentum is conserved.
The magnitude is $|\vec{L}_{\text{total}}| = 2mLV_0$ initially and at collision.

Q35. Solution

Correct Answer: (D)

Energy of a photon emitted for transition n_2 to n_1 is given by

$$\Delta E = 13.6 \times 4\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)\text{eV} \ldots (1)$$

$$\Delta E = 13.6 \times 4\left(\frac{1}{1^2} - \frac{1}{2^2}\right)\text{eV} = 40.8\text{eV}$$

$$\frac{1}{2}mv^2 = (40.8 - 13.6)\text{eV} = 37.2\text{eV}$$

$$\therefore \quad v = 3.1 \times 10^6 \text{ m/s}$$

$$\therefore \quad x = 6$$

Q36. Solution

Correct Answer: (D)

From first polaroid the unpolarised light will become polarized with half the intensity.

So, $I' = \frac{I_0}{2}$

From second polaroid

$I'' = I' \cos^2\theta = \frac{I_0}{2}\cos^2(60) = \frac{I_0}{2}\,\frac{1}{4} = \frac{I_0}{8}$

Q37. Solution
Correct Answer: (D)

Given,

$\frac{E_A}{E_B}=\frac{1}{2}, \frac{U_A}{U_B}=\frac{1}{2}$

So $E_A=x,\ E_B=2x$

And $U_A=y,\ U_B=2y$

$\because\ \ E_A=U_A+K_A$

And $E_B=U_B+K_B$

here K_A and K_B are kinetic energy of particles A and B

So $K_A=E_A-U_A=(x-y)$ .....(i)

$K_B=E_B-U_B=2(x-y)$ ....(ii)

$\because$ de-Broglie wavelength,

$\lambda=\frac{h}{\sqrt{2mk}}$

So $\lambda_A=\frac{h}{\sqrt{2mK_A}},\ \lambda_B=\frac{h}{\sqrt{2mK_B}}$

$\therefore\quad \frac{\lambda_A}{\lambda_B}=\sqrt{\frac{K_B}{K_A}}$ .....(iii)

From Equation (i), (ii) and (iii),

$\frac{\lambda_A}{\lambda_B}=\sqrt{\frac{2(x-y)}{(x-y)}}=\frac{\sqrt{2}}{1}$

Q38. Solution
Correct Answer: (D)

$12\mu F$ and $6\mu F$ are in series and again are in parallel with $4\mu F$, Therefore, resultant of these three will be $=\frac{12\times6}{12+6}+4=4+4=8\mu$ F This equivalent system is in series with $1\mu F$.
Its equivalent capacitance $=\frac{8\times1}{8+1}=\frac{8}{9}\mu F$ ...(i) Equivalent of $8\mu F, 2\mu F$ and $2\mu F=\frac{4\times8}{4+8}=\frac{32}{12}=\frac{8}{3}\mu F$ ...(ii) (i) and (ii) are in parallel and are in series with C $\therefore\ \frac{8}{9}+\frac{8}{3}=\frac{32}{9}$ and $C_{eq}=1=\frac{\frac{32}{9}\times C}{\frac{32}{9}+C}\Rightarrow C=\frac{32}{33}\mu F$

Q39. Solution

Correct Answer: (A)

The energy of an electromagnetic wave is directly proportional to its frequency ($E = hf$) and inversely proportional to its wavelength ($E = hc/\lambda$), where h is Planck's constant and c is the speed of light. Therefore, waves with higher frequency (and shorter wavelength) have higher energy. Let's list the given electromagnetic waves and their general order in the electromagnetic spectrum from lowest energy to highest energy:(II) Radio waves < (IV) Microwaves < (I) Visible light < (III) X-rays So, $E_{II} < E_{IV} < E_I < E_{III}$.

Q40. Solution

Correct Answer: (A)

$R_1 = \frac{\ell}{kA} = 2R$ $\qquad$ $R_2 = \frac{\ell}{2kA} = R$

in configuration 1 $\qquad$; equivalent $R = 3R$

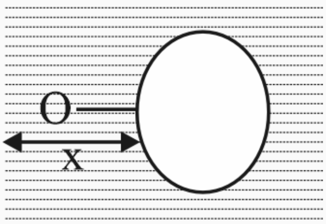
in configuration 2 $\qquad$; equivalent $R = \frac{2}{3}R$

$\Delta Q_1 = \frac{\Delta T}{3R} t_1$ $\qquad$; $\Delta Q_2 = \frac{\Delta T}{\frac{2R}{3}} t_2$

$\Rightarrow \frac{\Delta T}{3R} t_1 = \frac{3\Delta T}{2R} t_2 \Rightarrow t_2 = \frac{2}{9} t_1 = 2\text{sec.}$

Q41. Solution

Correct Answer: (C)



$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

$$\frac{1}{v_1} - \frac{4/3}{-x} = \frac{1 - 4/3}{4} = -\frac{1}{12}$$

$$\frac{1}{v_1} = -\frac{1}{12} - \frac{4}{3x} \quad \ldots (i)$$

$$\Rightarrow \quad v_1 = -\frac{36x}{3x + 48} = -\frac{12x}{x + 16}$$

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

Ans. 8

$$\frac{4/3}{v} + \frac{1}{(8 + v_1)} = \frac{4/3 - 1}{-4} = -\frac{1}{12} \quad \Rightarrow \quad \frac{4}{3(-8)} + \frac{x + 16}{128 + 20x} = -\frac{1}{12}$$

$$\frac{4}{3v} + \frac{1}{8 + \frac{12x}{x+16}} = -\frac{1}{12}$$

$$\frac{x + 16}{128 + 20x} = \frac{1}{6} - \frac{1}{12} = \frac{1}{12}$$

$12x + 192 = 128 + 20x$

$8x = 64 \quad \Rightarrow \quad x = 8 \text{ cm}$

Q42. Solution

Correct Answer: (D)

$W_{12}=\int_1^2 aVdV=4aV_0^2$ by $\frac{P_1V_1}{T_1}=\frac{P_2V_2}{T_2}\Rightarrow T_2=9T_0$ $\mathrm{W}_{23}=\mathrm{RT}_2\ln\left(\frac{\mathrm{P}_2}{\mathrm{P}_3}\right)=9.81\mathrm{RT}_0$ for Isothermal $P_2V_2=P_3T_3\Rightarrow V_3=9V_0\therefore W_{31}=P_0\left(V_1-V_3\right)=-8RT_0$ also in $1\rightarrow 2$ we have by $P_0V_0=RT_0, aV_0{}^2RT_0\therefore W=W_{12}+W_{23}+W_{31}=5.81RT_0$

Q43. Solution

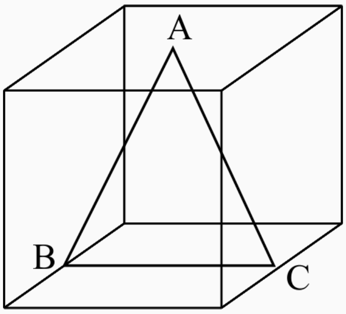
Correct Answer: (C)

$$L\cdot C=\frac{\text{Pitch}}{N}=\frac{0.5\text{ mm}}{50}=0.01\text{ mm}$$

$$\begin{aligned}
&\text{zero error }=MSR+CSR\\
&=-1\times 0.5+30\times 0.01\\
&=-0.20\text{ mm}\\
&\text{Reading }=2\times 0.5+20\times 0.01\\
&=1.20\text{ mm}\\
&\text{thickness }=\text{ Reading }-\text{ zero error}\\
&=1.20-(-0.20)\\
&=1.40\text{ mm}
\end{aligned}$$

Q44. Solution

Correct Answer: (C)



$$AB=\sqrt{\frac{a^2}{4}+a^2}=AC$$

$\mathrm{BC}=\mathrm{a}$

$$L=2\sqrt{\frac{5a^2}{4}}+a$$

$$L=(\sqrt{5}+1)a$$

$$Q=\lambda L$$

$$\text{electric flux }=\frac{Q}{\varepsilon_0}$$

Q45. Solution
Correct Answer: (C)

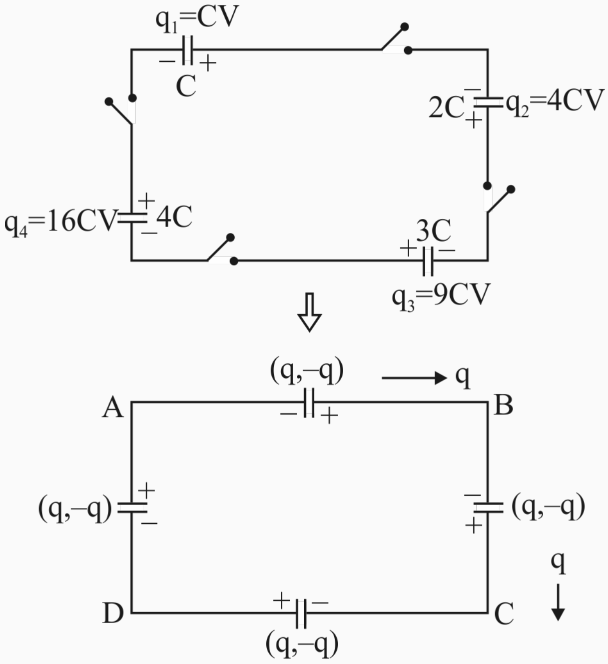
The electrostatic potential energy of a system of three point charges q_1, q_2, q_3 is given by the sum of the potential energies of each pair of charges: $U = K\left(\frac{q_1q_2}{r_{12}} + \frac{q_1q_3}{r_{13}} + \frac{q_2q_3}{r_{23}}\right)$ where $K = \frac{1}{4\pi\varepsilon_0}$ and r_{ij} is the distance between charges i and j. The initial potential energy U_{initial} is: $U_{\text{initial}} = K\left(\frac{q\cdot q}{L} + \frac{q\cdot q}{L} + \frac{q\cdot q}{L}\right) = \frac{3Kq^2}{L}$ The final potential energy U_{final} is: $U_{\text{final}} = K\left(\frac{q\cdot q}{L/2} + \frac{q\cdot q}{L/2} + \frac{q\cdot q}{L/2}\right) = \frac{3Kq^2}{L/2} = \frac{6Kq^2}{L}$ The change in potential energy ΔU is $U_{\text{final}} - U_{\text{initial}}$. $\Delta U = \frac{6Kq^2}{L} - \frac{3Kq^2}{L} = \frac{3Kq^2}{L}$ Thus, the change in the total electrostatic potential energy of the system is $\frac{3Kq^2}{L}$. The final answer is $\boxed{\text{C}}$

Q46. Solution
Correct Answer: 250

The magnetic field inside a long solenoid is given by the formula: $B = \mu_0 nI$ where B is the magnetic field, μ_0 is the permeability of free space, n is the number of turns per unit length, and I is the current flowing through the solenoid. The number of turns per unit length n can also be expressed as $n = \frac{N}{L}$, where N is the total number of turns and L is the length of the solenoid. Substituting this into the formula, we get: $B = \mu_0 \frac{N}{L} I$ We are given the following values: Magnetic field $B = 1.5 \times 10^{-3}$ TLength of the solenoid $L = 5\pi$ cm $= 5\pi \times 10^{-2}$ m Current $I = 0.75$ A Permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ T m/A We need to find the number of turns N. Rearranging the formula to solve for N: $N = \frac{BL}{\mu_0 I}$Now, substitute the given values into the equation: $N = \frac{(1.5\times10^{-3}\text{ T})\times(5\pi\times10^{-2}\text{ m})}{(4\pi\times10^{-7}\text{ T m/A})\times(0.75\text{ A})}$ $N = \frac{1.5\times5\times10^{-3}\times10^{-2}}{4\times0.75\times10^{-7}}$ $N = \frac{7.5\times10^{-5}}{3\times10^{-7}}$ $N = 2.5 \times 10^{(-5-(-7))}$ $N = 2.5 \times 10^2$ $N = 250$

Q47. Solution

Correct Answer: 5



When circuit is closed, let charge q flows in the circuit; then applying Loop Law in ABCDA
$\frac{q_1-q}{C}+\frac{q_2-q}{2C}+\frac{q_3-q}{3C}+\frac{q_4-q}{4C}=0$ Substituting the value of q_1, q_2, q_3 and q_4 we get $q=\left(\frac{24}{5}\right)(cv)$ Hence

$$V_2=\frac{q_2-q}{2C}=\frac{2V}{5}$$

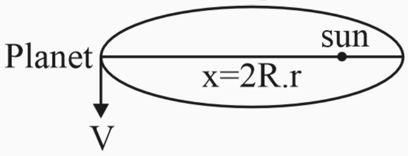
$V_1=\frac{q_1-q}{C}=\frac{19V}{5}$ $V_3=\frac{q_3-q}{3C}=\frac{7V}{5}$

$$V_4=\frac{q_4-q}{4C}=\frac{14V}{5}$$

Q48. Solution

Correct Answer: 8

Area covered by line joining planet and sun in time dt is $dS=\frac{1}{2}x^2d\theta$; Areal velocity $=\mathrm{dS/dt}=\frac{1}{2}x^2d\theta/dt=\frac{1}{2}x^2\omega$ where $\mathrm{x}=$ distance between planet and sun and $\omega=$ angular speed of planet about sun. From Keplers second law Areal velocity of planet is constant. At farthest position



$$A=dS/dt=\frac{1}{2}(2R-r)^2\omega=\frac{1}{2}(2R-r)[(2R-r)\omega]=\frac{1}{2}(2R-r)V_B$$

or (least speed). (Using values) or $V_B=\frac{2A}{2R-r}$ (least speed). (Using values)

$\mathrm{V_B}=40\ \mathrm{km/s}$

Q49. Solution
Correct Answer: 180

The bird keeps on flying with a constant speed till the time of crash. So, let us first find the time of crash. If the two trains crash each other after t hrs, then the total distance travelled by the two trains in the same time of t hrs should be 60 km.

$$\therefore \quad 40\mathrm{t}+60\mathrm{t}=60 \Rightarrow \quad \mathrm{t}=\frac{60}{100}=0.6 \text{ hrs}$$

Now, the distance travelled by the bird in 0.6 h is $0.6 \times 300=180$ km

Q50. Solution
Correct Answer: 9000

1. $X=(25 \pm 0.5)$ cm $\frac{\Delta X}{X} \times 100\%=\frac{0.5}{25} \times 100\%=0.02 \times 100\%=2\%$ 2. $Y=(10 \pm 0.1)$ cm $\frac{\Delta Y}{Y} \times 100\%=\frac{0.1}{10} \times 100\%=0.01 \times 100\%=1\%$ 3. $W=(50 \pm 1)$ cm $\frac{\Delta W}{W} \times 100\%=\frac{1}{50} \times 100\%=0.02 \times 100\%=2\%$ Now, for a quantity $Z=\frac{X^a Y^b}{W^c}$, the maximum possible percentage error in Z is given by: $\frac{\Delta Z}{Z} \times 100\%=\left(a \frac{\Delta X}{X}+b \frac{\Delta Y}{Y}+c \frac{\Delta W}{W}\right) \times 100\%$ In our case, $a=2$, $b=3$, and $c=1$. So, the percentage error in Z is: $\frac{\Delta Z}{Z} \times 100\%=\left(2 \times \frac{\Delta X}{X}+3 \times \frac{\Delta Y}{Y}+1 \times \frac{\Delta W}{W}\right) \times 100\%$ $\frac{\Delta Z}{Z} \times 100\%=(2 \times 2\%+3 \times 1\%+1 \times 2\%)$ $\frac{\Delta Z}{Z} \times 100\%=(4\%+3\%+2\%)$ $\frac{\Delta Z}{Z} \times 100\%=9\%$ So, $9\%=\frac{m}{1000}$

Q51. Solution
Correct Answer: (B)

Halving the volume of the container increases the concentration of each gas component and doubles the partial pressures, provided temperature remains constant. Thus, statement (I) is correct.

The equilibrium $\mathrm{H}_2(\mathrm{g})+\mathrm{I}_2(\mathrm{g}) \rightleftharpoons 2\mathrm{HI}(\mathrm{g})$ has $\Delta n_g=0$, so no net shift occurs in response to the pressure change. Statement (II) is therefore incorrect.

The equilibrium constant K_c depends solely on temperature, which is fixed, so it remains unchanged. Statement (III) is correct.

After halving the volume, all concentrations double, and since the equilibrium position is unaffected, the new concentrations are not equal to the original equilibrium values. Statement (IV) is incorrect.

Statements (I) and (III) are correct. The answer is $\boxed{\mathrm{B}}$.

Q52. Solution

Correct Answer: (B)

Let x be the pressure of C_2H_4msub decompose after 20 minutes of decompostion.

Then, $80 - x + 2x = 120$,

x = 40 torr = 50 % of initial pressure

Here $t_{1/2} = 20$ min.

For 75 % reaction, fraction left $= \frac{25}{100} = \frac{1}{4} = \left(\frac{1}{2}\right)^2$

No. of half lives = 2.

Time needed for 75% reaction $= 2 \times 20 = 40$ min.

Q53. Solution

Correct Answer: (D)

$FeCr_2O_4$ is chromite ore.

The concentrated Chromite on reaction with sodium carbonate in presence of air results in formation of sodium chromate.

$$4\,FeCr_2O_4 + 8\,Na_2CO_3 + 7O_2 \xrightarrow{\text{Fusion}} \underset{(X)}{8Na_2CrO_4} + 2\,Fe_2O_3 + 8\,CO_2$$

Sodium chromate is extracted with water, which on treatment with calculated amount of acid converts into sodium dichromate.

$$\underset{(X)}{2Na_2CrO_4} \xrightarrow[H_2O]{H^+} \underset{(Y)}{Na_2Cr_2O_7} + Na_2SO_4 + H_2O$$

Dichromate ion on treatment with H_2O_2 gives a deep blue solution of CrO_5. It is highly unstable and hence the colour fades out due to formation of $Cr_2(SO_4)_3$.

$$Na_2Cr_2O_7 + H_2SO_4 + 4H_2O_2 \rightarrow \underset{(Z)}{2CrO_5} + Na_2SO_4 + 5H_2O$$

Chromium exhibits $+6$ oxidation state in Na_2CrO_4, $Na_2Cr_2O_7$ and CrO_5.

CrO_5 is chromium peroxide. It has four oxygen involved in peroxide bonding and one with a double bond. Hence, oxidation state of chromium will be $+6$.

Q54. Solution

Correct Answer: (B)

P. $[\mathrm{Fe(CN)_6}]^{3-}$

Iron has oxidation state +3, with electronic configuration $[\mathrm{Ar}]\ 3d^5$. Cyanide is a strong field ligand, so electrons pair in octahedral splitting: $(t_{2g})^5(e_g)^0$, producing one unpaired electron. The complex is paramagnetic.

Q. $[\mathrm{CoF_6}]^{3-}$

Cobalt has oxidation state +3, with electronic configuration $[\mathrm{Ar}]\ 3d^6$. Fluoride is a weak field ligand, leading to high spin configuration: $(t_{2g})^4(e_g)^2$ with four unpaired electrons. The complex is paramagnetic.

R. $[\mathrm{Zn(NH_3)_6}]^{2+}$

Zinc has oxidation state +2 and configuration $[\mathrm{Ar}]\ 3d^{10}$, with all electrons paired regardless of ligand field. The complex is diamagnetic.

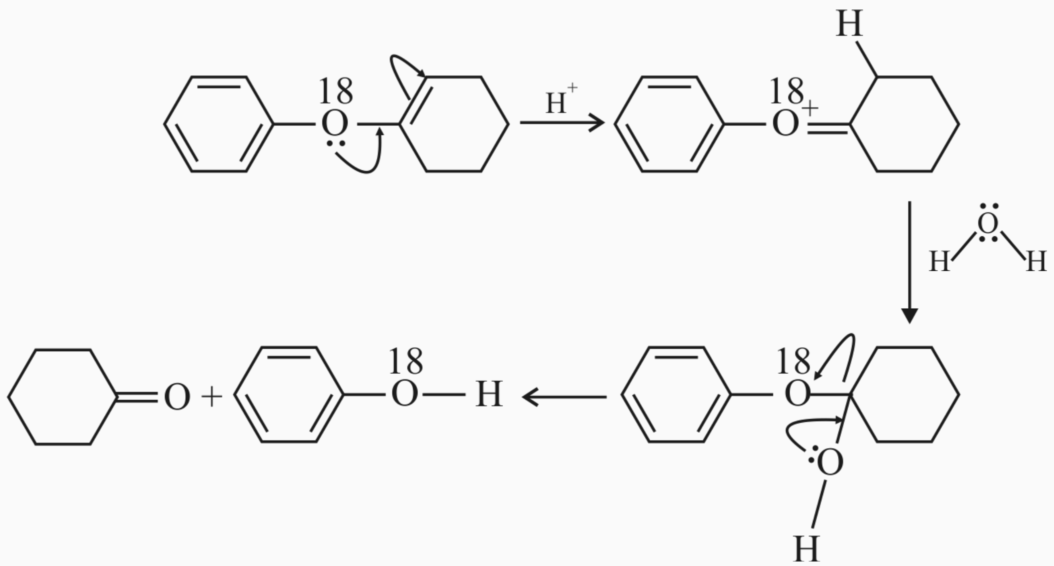
S. $[\mathrm{Ti(H_2O)_6}]^{3+}$

Titanium has oxidation state +3, with configuration $[\mathrm{Ar}]\ 3d^1$, placing one unpaired electron in a t_{2g} orbital. The complex is paramagnetic.

Paramagnetic complexes are P, Q, and S, corresponding to option $\boxed{B}$.

Q55. Solution

Correct Answer: (C)



Q56. Solution

Correct Answer: (C)

$\pi = \mathrm{iCRT}$

$\pi \propto \mathrm{iC}$

Molality is same for all and hence $\pi \propto \mathrm{i}$

Glucose $\rightarrow 1$

$\mathrm{KNO_3} \rightarrow 2$

$\mathrm{K_2SO_4} \rightarrow 3$

$\mathrm{K_3PO_4} \rightarrow 4$

and hence highest for $\mathrm{K_3PO_4}$

$\mathrm{d} > \mathrm{c} > \mathrm{b} > \mathrm{a}$

Q57. Solution

Correct Answer: (A)

Let's analyze each statement: I. Mercury cells are primary cells that provide a constant operating voltage throughout their useful life. This characteristic makes them highly suitable for small, button-sized devices such as hearing aids, watches, and calculators, where a stable voltage output is critical. Therefore, statement I is correct. II. Inverters are devices that convert direct current (DC) to alternating current (AC) and are commonly used for backup power. Lead-acid batteries are secondary (rechargeable) batteries known for their ability to deliver high currents and their robust rechargeability. These properties make them ideal for energy storage in inverters and automotive applications. Therefore, statement II is correct. III. Dry cells (Leclanché cells) are primary batteries, meaning they are not rechargeable. They consist of a zinc anode and a carbon (graphite) cathode. While they are common in low-drain portable devices, they are not suitable for high-drain applications like electric vehicles. Electric vehicles require high-capacity, rechargeable batteries with high energy density, such as lithium-ion batteries, to provide sustained power. Therefore, statement III is incorrect. Based on the analysis, only statements I and II are correct. The final answer is $\boxed{A}$.

Q58. Solution

Correct Answer: (B)

$U = -\frac{Ke^2}{2r^3} \Rightarrow U \propto \frac{1}{r^3}$

As the negative gradient of potential energy gives the force, so the force between the electron and proton is, $F = -\frac{\mathrm{d}U}{\mathrm{d}r}$

$\Rightarrow F = \frac{Ke^2}{r^4}$

According to first postulate of Bohr's atomic model, $\frac{mv^2}{r} = F = \frac{Ke^2}{r^4} \quad .....(\mathrm{i})$

and according to second postulate, $mvr = \frac{nh}{2\pi} \quad .....(\mathrm{ii})$

Combining equations (i) and (ii), we get $r = \frac{4\pi^2e^2km}{n^2h^2}$

Total energy is given by,$E = K + U = \frac{1}{2}mv^2 + \left(\frac{-Ke^2}{3r^3}\right) = \frac{Ke^2}{2r^3} - \frac{Ke^2}{3r^3} = \frac{Ke^2}{6r^3}$

As we can see that, $r \propto \frac{1}{n^2}$ and E $\propto \frac{1}{r^3}$

So, E will be directly proportional to n^6

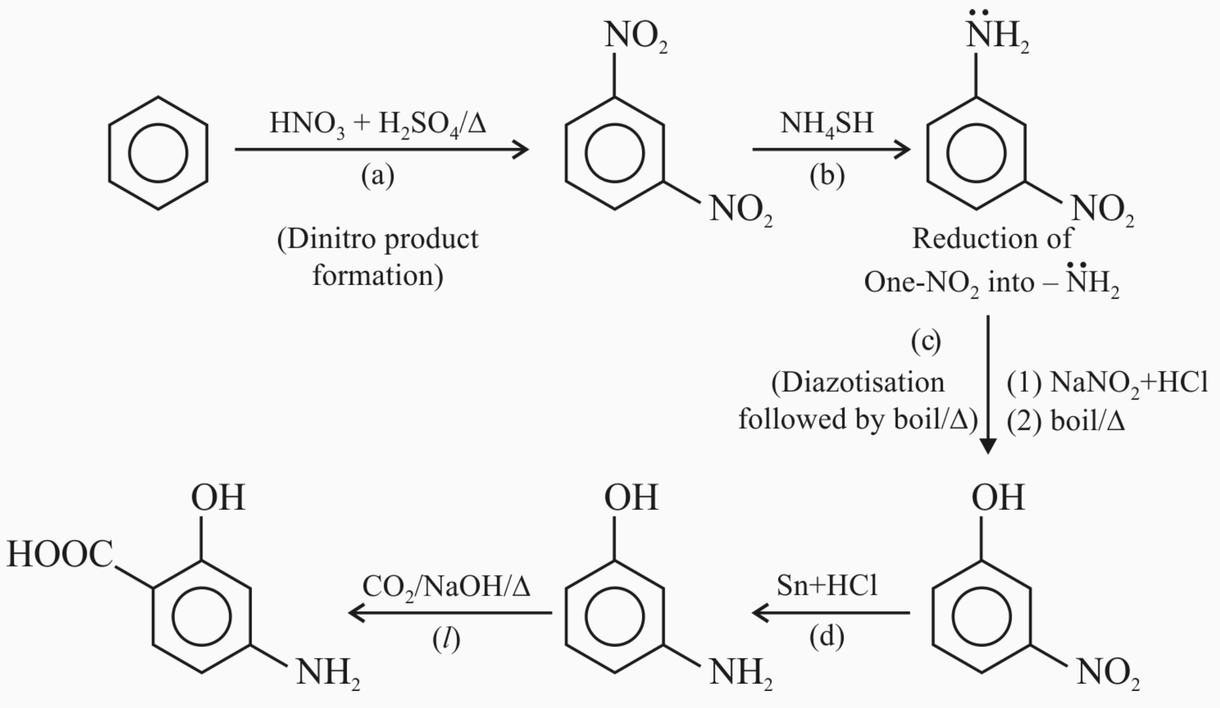
$\therefore\ E \propto n^6$

And as, $r \propto m$ and $E \propto \frac{1}{r^3}$

So, E is inversly proportional to m^3, that is $E \propto m^{-3}$

Q59. Solution

Correct Answer: (B)



Q60. Solution

Correct Answer: (C)

Essential amino acids are those that cannot be synthesized by the human body and must be obtained from the diet. Non-essential amino acids can be synthesized by the body.Let's classify each amino acid given: - **(P) Tryptophan:** Essential amino acid. - **(Q) Glutamine:** Non-essential amino acid. - **(R) Methionine:** Essential amino acid. - **(S) Asparagine:** Non-essential amino acid. - **(T) Valine:** Essential amino acid. Therefore, the essential amino acids from the list are Tryptophan (P), Methionine (R), and Valine (T). This corresponds to option (C).

Q61. Solution

Correct Answer: (B)

The cathode is the electrode where reduction takes place. In an electrolytic cell, the species with the highest (most positive) standard reduction potential will be preferentially reduced at the cathode. The species present in the aqueous solution are $\mathrm{Au^{3+}}$, $\mathrm{Cu^{2+}}$, $\mathrm{Zn^{2+}}$, $\mathrm{Na^{+}}$, and water ($\mathrm{H_2O}$).Let's list the standard reduction potentials for these species: - For $\mathrm{Au^{3+}}$: $\mathrm{Au^{3+}(aq) + 3e^- \rightarrow Au(s)}$; $\mathrm{E^\theta = +1.50\ V}$ - For $\mathrm{Cu^{2+}}$: $\mathrm{Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)}$; $\mathrm{E^\theta = +0.34\ V}$ - For water (in neutral solution): $\mathrm{2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)}$; $\mathrm{E^\theta \approx -0.41\ V}$ (given) - For $\mathrm{Zn^{2+}}$: $\mathrm{Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)}$; $\mathrm{E^\theta = -0.76\ V}$ - For $\mathrm{Na^{+}}$: $\mathrm{Na^{+}(aq) + e^- \rightarrow Na(s)}$; $\mathrm{E^\theta = -2.71\ V}$ Arranging these reduction potentials in decreasing order: $\mathrm{+1.50\ V(Au^{3+}) > +0.34\ V(Cu^{2+}) > -0.41\ V(H_2O) > -0.76\ V(Zn^{2+}) > -2.71\ V(Na^{+})}$ Based on this order, the species will be reduced at the cathode in the following sequence: - $\mathrm{Au^{3+}}$ ions will be reduced first to deposit gold metal. - After all $\mathrm{Au^{3+}}$ ions are consumed, $\mathrm{Cu^{2+}}$ ions will be reduced to deposit copper metal. - After all $\mathrm{Cu^{2+}}$ ions are consumed, water will be reduced to evolve hydrogen gas. - $\mathrm{Zn^{2+}}$ and $\mathrm{Na^{+}}$ ions have even lower reduction potentials than water, so they will not be reduced as long as water is present and can be reduced. Therefore, gold will deposit first, followed by copper, and then hydrogen gas will evolve.The final answer is $\boxed{\mathrm{B}}$.

Q62. Solution

Correct Answer: (A)

The third period contains eight elements: sodium, magnesium, aluminium, silicon, phosphorus, sulphur, chlorine, and argon. The first two, sodium and magnesium, are members of the s-block of the periodic table, while the others are members of the p-block. The oxide of magnesium is ionic, aluminium oxide is amphoteric and the giant molecule is the oxide of silicon hence, the order of atomic numbers is $\mathrm{A < B < C}$.

Q63. Solution

Correct Answer: (A)

The dipole moment of a molecule is the vector sum of the individual bond dipoles and the dipole moment due to any lone pairs. Both NH_3 and NF_3 have a trigonal pyramidal geometry with a lone pair on the central nitrogen atom. 1. **Electronegativity Differences:** * In NH_3: Nitrogen (electronegativity ≈ 3.0) is more electronegative than hydrogen (electronegativity ≈ 2.2). Therefore, the N-H bond dipoles point from hydrogen towards nitrogen. * In NF_3: Fluorine (electronegativity ≈ 4.0) is more electronegative than nitrogen (electronegativity ≈ 3.0). Therefore, the N-F bond dipoles point from nitrogen towards fluorine. 2. **Contribution of Lone Pair:** In both molecules, the lone pair on the nitrogen atom contributes a dipole moment that points away from the nitrogen atom, along the axis of the lone pair. 3. **Vector Sum in NH_3:** * The three N-H bond dipoles point towards the nitrogen atom. * The lone pair dipole also points in the same general direction as the resultant of the N-H bond dipoles (away from the base of the pyramid, towards the apex where the lone pair resides). * These two contributions (bond dipoles and lone pair dipole) add up constructively, resulting in a relatively large net dipole moment for NH_3 (approx. 1.47 D). 4. **Vector Sum in NF_3:** * The three N-F bond dipoles point away from the nitrogen atom, towards the fluorine atoms. * The lone pair dipole points away from the nitrogen atom (towards the apex). * In this case, the resultant of the N-F bond dipoles points in the opposite direction to the lone pair dipole. These two contributions largely oppose each other, leading to a significant cancellation. * As a result, NF_3 has a much smaller net dipole moment (approx. 0.23 D). Therefore, NH_3 has a higher dipole moment than NF_3 because in NH_3, the bond dipoles and the lone pair dipole are in the same general direction, whereas in NF_3, the bond dipoles largely oppose the lone pair dipole. The correct option is A.

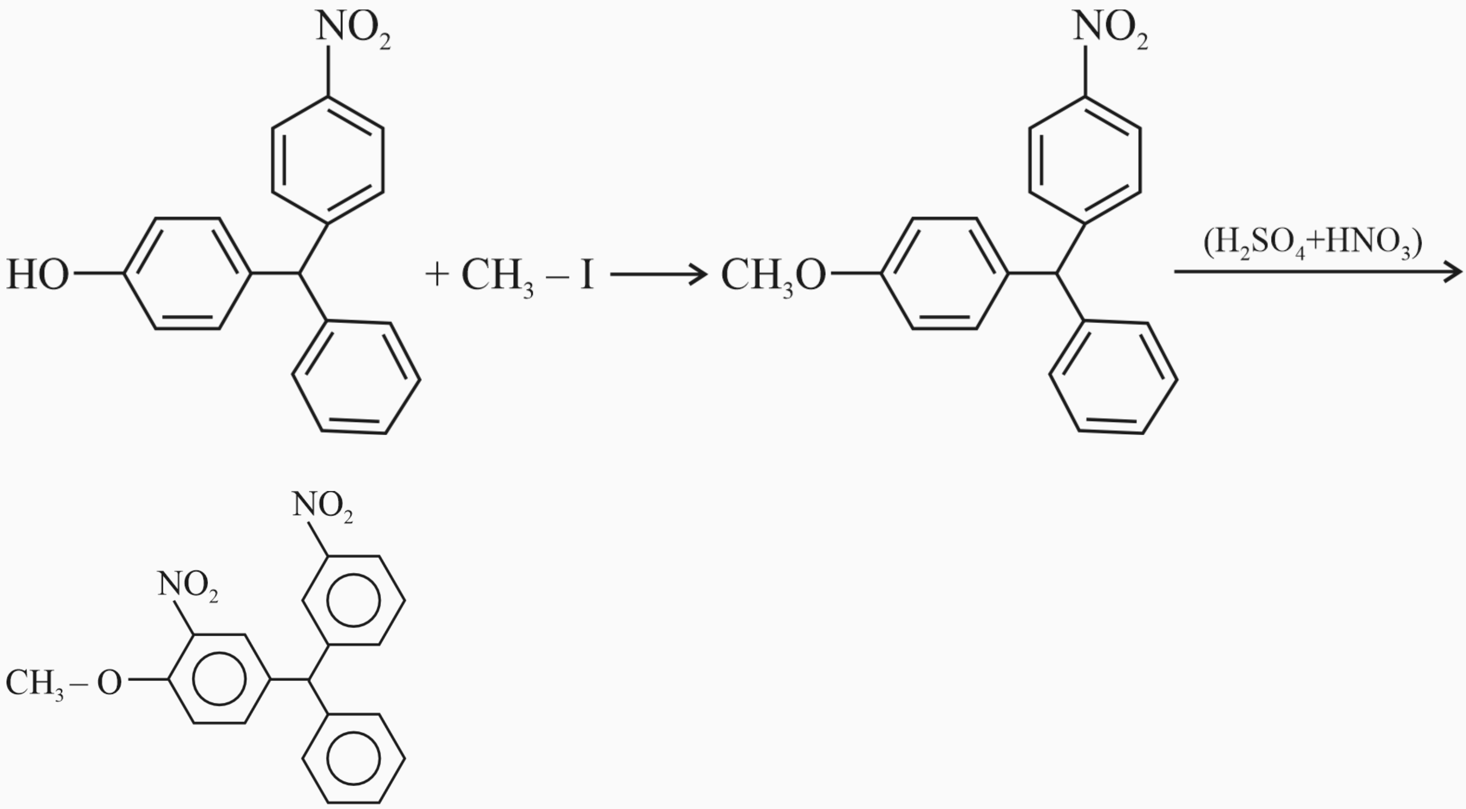
Q64. Solution

Correct Answer: (B)

B atom after losing outermost electron acquires noble gas configuration (stable configuration). It is difficult to remove the next electron from $\mathrm{B}^{+}\left(1s^2,\ 2s^2\ 2p^6\right)$ ion.

Q65. Solution

Correct Answer: (D)



Q66. Solution

Correct Answer: (C)

$$CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH=O + O=CH-CH_2-CH_2-CH_2-\underset{\underset{O}{\|}}{C}-OH$$

$$\Big\uparrow \begin{array}{l}(1)\ O_3 \\ (2)\ Zn/H_2O\end{array}$$

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

(i) It is not $\beta-\gamma$ undaturated acid (ii) Mol. formula of x is $\Rightarrow C_{14}H_{26}O_2$ (iii) It shows GI (iv) It do not shows O.I. hence not form enantiomeric-pair

Q67. Solution

Correct Answer: (A)

The Heisenberg Uncertainty Principle requires $\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$.

Given $\Delta x = \Delta p$, substitution yields $(\Delta p)^2 \geq \frac{h}{4\pi}$.

Since $\Delta p = m \cdot \Delta v$, we substitute to obtain $m^2(\Delta v)^2 \geq \frac{h}{4\pi}$.

The minimum uncertainty occurs at equality: $(\Delta v)^2 = \frac{h}{4\pi m^2}$.

Taking square roots gives $\Delta v = \frac{1}{2m}\sqrt{\frac{h}{\pi}}$.

Final answer: $\boxed{\text{A}}$

Q68. Solution

Correct Answer: (C)

$Cr_2O_7^{2-} + 6I^- + 14H^+ \rightarrow 2Cr^{3+} + 3I_2 + 7H_2O$ Given: Volume of $K_2Cr_2O_7$ solution = 50 mL = 0.050 L Concentration of $K_2Cr_2O_7$ solution = 0.05 M Moles of $K_2Cr_2O_7$ = Molarity × Volume (in L) Moles of $K_2Cr_2O_7$ = 0.05 mol/L × 0.050 L = 0.0025 mol From the balanced equation, 1 mole of $Cr_2O_7^{2-}$ reacts with 6 moles of I^-. Since $K_2Cr_2O_7$ provides $Cr_2O_7^{2-}$ and KI provides I^-, we can use the mole ratio directly. Moles of KI required = 6 × Moles of $K_2Cr_2O_7$ Moles of KI required = 6 × 0.0025 mol = 0.015 mol Statement (A) is **correct**. In $Cr_2O_7^{2-}$, the oxidation state of Cr is +6. In Cr^{3+}, the oxidation state of Cr is +3. The change in oxidation state per Cr atom is $6 - 3 = 3$. Since there are two Cr atoms in $Cr_2O_7^{2-}$, the total change in oxidation state (n-factor) for $Cr_2O_7^{2-}$ is $2 \times 3 = 6$. Equivalent weight = $\frac{\text{Molecular weight}}{\text{n-factor}}$ Equivalent weight of $K_2Cr_2O_7$ = $\frac{\text{Molecular weight}}{6}$ Statement (B) says the equivalent weight is $\frac{\text{Molecular weight}}{3}$, which is **incorrect**. From the balanced equation, 1 mole of $Cr_2O_7^{2-}$ produces 3 moles of I_2. Moles of I_2 produced = 3 × Moles of $K_2Cr_2O_7$ Moles of I_2 produced = 3 × 0.0025 mol = 0.0075 mol Statement (C) is **correct**. From the balanced equation, 1 mole of $Cr_2O_7^{2-}$ requires 14 moles of H^+. Moles of H^+ required = 14 × Moles of $K_2Cr_2O_7$ Moles of H^+ required = 14 × 0.0025 mol = 0.035 mol Sulfuric acid (H_2SO_4) is a strong acid and provides 2 moles of H^+ ions per mole of H_2SO_4. Moles of H_2SO_4 required = $\frac{\text{Moles of H}^+}{2} = \frac{0.035\text{ mol}}{2} = 0.0175$ mol Volume of H_2SO_4 solution = $\frac{\text{Moles}}{\text{Molarity}} = \frac{0.0175\text{ mol}}{0.2\text{ M}} = 0.0875$ L Converting to mL: 0.0875 L × 1000 mL/L = 87.5 mL Statements (A) and (C) are correct.

Q69. Solution

Correct Answer: (A)

Assertion I: True Statement: Partition chromatography separates components based on their differential distribution between a mobile liquid phase and a stationary liquid phase, which is often coated on an inert solid. Correct Reasoning: This is exactly how partition chromatography works. - A liquid stationary phase is coated on a solid support. - A liquid mobile phase flows over it. - Components separate based on different partition coefficients between the two liquid phases. - Hence, Assertion I is true. Assertion II: False Statement: In paper chromatography, the paper's cellulose structure acts as the primary stationary phase. Why this is incorrect: - In paper chromatography, the stationary phase is NOT cellulose itself. - The true stationary phase is the thin layer of water adsorbed on the cellulose fibers. - Cellulose only provides support for this water layer; it does NOT act as the stationary phase. Thus, the student's statement assumes cellulose is the stationary phase - this is conceptually wrong. Therefore, Assertion II is false.

Q70. Solution

Correct Answer: (B)

$$\mathrm{C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O + 1367KJ}$$
$$\mathrm{C + O_2 \rightarrow CO_2 + 393KJ}$$
$$\mathrm{H_2 + \frac{1}{2}O_2 \rightarrow H_2O + 285KJ}$$

$\therefore$ Heat of combustion of ethylalcohol $=$ Total heat formation of products - Total heat of formation of reactants

$$-1367 = \left[2\left(\Delta H_{f_{\mathrm{CO_2}}}\right) + 3\left(\Delta H_{f_{\mathrm{H_2O}}}\right)\right] - \left[\left(\Delta H_{f_{\mathrm{C_2H_5OH}}}\right) + \left(\Delta H_{f_{O_2}}\right)\right]$$
$$-1367 = [2(-373) + (-285)] - \left[\Delta H_{f_{C_2\mathrm{H_5OH}}} + \text{ Zero }\right]$$
$$-1367 = [-786 - 855] - \left[\Delta H_{f_{C_2\mathrm{H_5OH}}}\right]$$
$$-1367 = [-1641] - \left[\Delta H_{f_{C_2\mathrm{H_5OH}}}\right]$$
$$\therefore \Delta H_{f_{C_2\mathrm{H_5OH}}} = -1641 + 1367 = -274\mathrm{KJ}$$

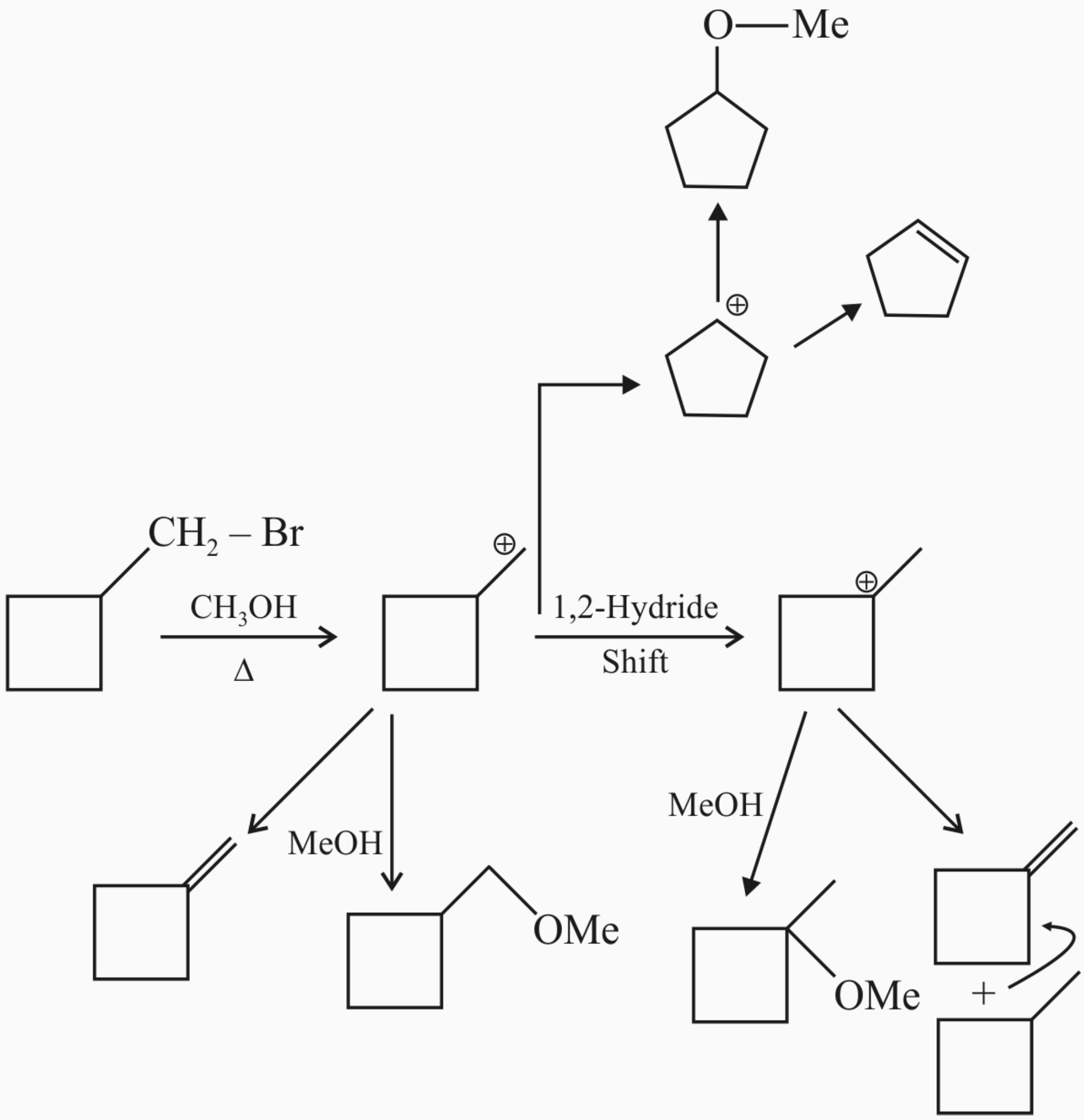
Q71. Solution

Correct Answer: 5

I $\longrightarrow$ application of Huckel's rule of periphery electrons. Total no. of periphery electrons participating in aromatic character is 18 IV $\longrightarrow$ 14πe$^-$- aromatic V $\longrightarrow$ non-aromatic VI $\longrightarrow$ Anti-aromatic VII $\longrightarrow$ non-aromatic VIII $\longrightarrow$ Anti-aromatic $\begin{array}{c}\text{IX} \longrightarrow \text{ aromatic } 10\pi\mathrm{e}^- \\ \text{X} \longrightarrow \text{ aromatic } 6\pi\mathrm{e}^-\end{array}$

Q72. Solution

Correct Answer: 6



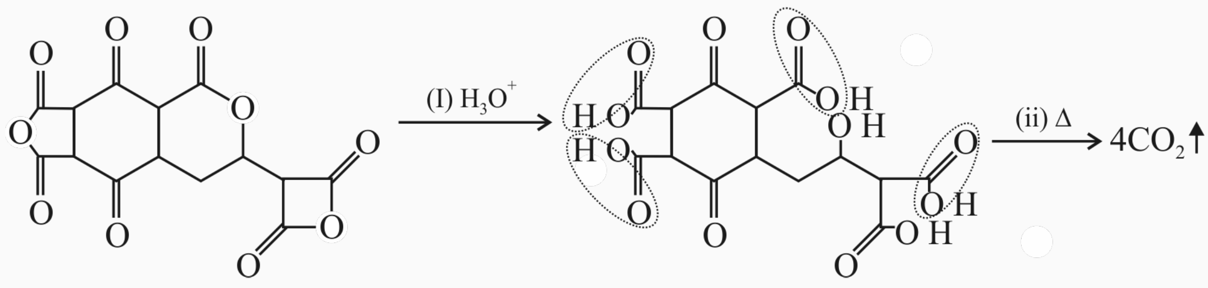
Q73. Solution

Correct Answer: 6

1. Potassium hexacyanochromate(III) ($K_3[Cr(CN)_6]$): Yellow * Oxidation state of Cr: $3(+1) + Cr + 6(-1) = 0 \Rightarrow Cr = +3$. * Cr^{3+} electron configuration: $[Ar]3d^3$. * For a d^3 system in an octahedral field, the electrons will occupy the t_{2g} orbitals singly. Thus, $t_{2g}^3 e_g^0$. * Number of unpaired electrons (n) = 3. * Spin-only magnetic moment (μ_1) = $\sqrt{3(3+2)} = \sqrt{15} \approx 3.87$ B.M. * Color: Yellow (included in the sum). **2. Sodium hexacyanoferrate(II) ($Na_4[Fe(CN)_6]$): Yellow** * Oxidation state of Fe: $4(+1) + Fe + 6(-1) = 0 \Rightarrow Fe = +2$. * Fe^{2+} electron configuration: $[Ar]3d^6$. * For a d^6 low-spin octahedral complex (CN^- is a strong field ligand), all electrons pair up in the t_{2g} orbitals. Thus, $t_{2g}^6 e_g^0$. * Number of unpaired electrons (n) = 0. * Spin-only magnetic moment (μ_2) = $\sqrt{0(0+2)} = 0$ B.M. * Color: Yellow (included in the sum). **3. Potassium hexacyanomanganate(II) ($K_4[Mn(CN)_6]$): Pale yellow** * Oxidation state of Mn: $4(+1) + Mn + 6(-1) = 0 \Rightarrow Mn = +2$. * Mn^{2+} electron configuration: $[Ar]3d^5$. * For a d^5 low-spin octahedral complex (CN^- is a strong field ligand), four electrons pair up in the t_{2g} orbitals, and one remains unpaired. Thus, $t_{2g}^5 e_g^0$. * Number of unpaired electrons (n) = 1. * Spin-only magnetic moment (μ_3) = $\sqrt{1(1+2)} = \sqrt{3} \approx 1.73$ B.M. * Color: Pale yellow (included in the sum). **4. Hexamminecobalt(III) chloride ($[Co(NH_3)_6]Cl_3$): Yellow-orange** * Oxidation state of Co: $Co + 6(0) + 3(-1) = 0 \Rightarrow Co = +3$. * Co^{3+} electron configuration: $[Ar]3d^6$. * For a d^6 low-spin octahedral complex (NH_3 is a strong field ligand for Co^{3+}), all electrons pair up in the t_{2g} orbitals. Thus, $t_{2g}^6 e_g^0$. * Number of unpaired electrons (n) = 0. * Spin-only magnetic moment (μ_4) = $\sqrt{0(0+2)} = 0$ B.M. * Color: Yellow-orange (included in the sum). **5. Potassium hexacyanoferrate(III) ($K_3[Fe(CN)_6]$): Red** * Oxidation state of Fe: $3(+1) + Fe + 6(-1) = 0 \Rightarrow Fe = +3$. * Fe^{3+} electron configuration: $[Ar]3d^5$. * For a d^5 low-spin octahedral complex (CN^- is a strong field ligand), four electrons pair up in the t_{2g} orbitals, and one remains unpaired. Thus, $t_{2g}^5 e_g^0$. * Number of unpaired electrons (n) = 1. * Spin-only magnetic moment (μ_5) = $\sqrt{1(1+2)} = \sqrt{3} \approx 1.73$ B.M. * Color: Red (NOT included in the sum). Now, sum the magnetic moments for the complexes exhibiting yellow, pale yellow, or yellow-orange color: Sum = $\mu_1 + \mu_2 + \mu_3 + \mu_4$ Sum = $3.87 + 0 + 1.73 + 0 = 5.60$ B.M. Rounding to the nearest integer, the sum is 6 B.M. The final answer is $\boxed{6}$

Q74. Solution

Correct Answer: 4



Q75. Solution

Correct Answer: 20

$$K_{In} = \frac{[H^+]_{eq}[I_n^-]_{eq}}{[HI_n]_{eq}}$$

$$\Rightarrow -\log K_{In} = -\log [H^+]_{eq} - \log \frac{[I_n^-]_{eq}}{[HI_n]_{eq}}$$

$$\Rightarrow PK_{In} + \log \frac{[I_n^-]_{eq}}{[HI_n]_{eq}} = PH$$

$$\Rightarrow 6 + \log \frac{[I_n^-]_{eq}}{[HI]_{eq}} = 5.4$$

$$\begin{array}{llll} & HI_n & \rightleftharpoons H^+ & +In^{\ominus} \\ T = 0 & Co & & \\ t = t_{eq} & Co - x & & x \end{array}$$

$$\Rightarrow \log \frac{[I_n^-]_{eq}}{[HI_n]_{eq}} = -0.6 = \log \frac{1}{4}$$

$$\Rightarrow \frac{[I_n^-]_{eq}}{[HI_n]_{eq}} = \frac{1}{4}$$

$$\Rightarrow \frac{x}{Co - x} = \frac{1}{4}$$

$$\Rightarrow 4x = Co - x$$

$$\Rightarrow 5x = Co$$

$$\Rightarrow x = \frac{Co}{5}$$

$$\Rightarrow \frac{x}{Co} = \frac{1}{5}$$

$$\% \text{ dissociation } = \frac{1}{5} \times 100\% = 20\%$$