Answer Key

Mathematics (25 Questions)

Q1. (D)	Q2. (B)	Q3. (D)	Q4. (B)	Q5. (B)
Q6. (A)	Q7. (B)	Q8. (C)	Q9. (A)	Q10. (D)
Q11. (D)	Q12. (D)	Q13. (B)	Q14. (B)	Q15. (A)
Q16. (C)	Q17. (D)	Q18. (D)	Q19. (D)	Q20. (A)
Q21. 7	Q22. 10	Q23. 7	Q24. 6	Q25. 4

Physics (25 Questions)

Q26. (A)	Q27. (A)	Q28. (C)	Q29. (A)	Q30. (B)
Q31. (D)	Q32. (A)	Q33. (B)	Q34. (B)	Q35. (B)
Q36. (C)	Q37. (D)	Q38. (C)	Q39. (A)	Q40. (A)
Q41. (D)	Q42. (D)	Q43. (C)	Q44. (A)	Q45. (D)
Q46. 2	Q47. 4	Q48. 180	Q49. 47	Q50. 8

Chemistry (25 Questions)

Q51. (A)	Q52. (C)	Q53. (A)	Q54. (C)	Q55. (A)
Q56. (B)	Q57. (A)	Q58. (A)	Q59. (A)	Q60. (C)
Q61. (D)	Q62. (B)	Q63. (D)	Q64. (B)	Q65. (A)
Q66. (B)	Q67. (B)	Q68. (B)	Q69. (C)	Q70. (C)
Q71. 5	Q72. 20	Q73. 84	Q74. 3	Q75. 3

Solutions

Q1. Solution

Correct Answer: (D)

Sum of roots $= \operatorname{tr}(\mathrm{A}) = 5$ product of roots $= |\mathrm{A}|$ Characterstic equation is $x^2 - 5x + |A|$ since

$f(\mathrm{~A}) = \mathrm{A}^2 + \mathrm{aA} + 3\mathrm{I} \therefore \mathrm{a} = -5$, and $|\mathrm{A}| = 3$ consider $\mathrm{A} = \begin{bmatrix} \mathrm{p} & \mathrm{s} \\ \mathrm{r} & \mathrm{q} \end{bmatrix}$ where $\mathrm{p} + \mathrm{q} = 5, \mathrm{pq} - \mathrm{rs} = 3$

$\operatorname{adj} \mathrm{A} = \begin{bmatrix} \mathrm{q} & -\mathrm{s} \\ -\mathrm{r} & \mathrm{p} \end{bmatrix}$ $(\operatorname{adj} \mathrm{A})^2 = \begin{bmatrix} \mathrm{q} & -\mathrm{s} \\ -\mathrm{r} & \mathrm{p} \end{bmatrix} \begin{bmatrix} \mathrm{q} & -\mathrm{s} \\ -\mathrm{r} & \mathrm{p} \end{bmatrix} = \begin{bmatrix} \mathrm{q}^2 + \mathrm{rs} & -\mathrm{s}(\mathrm{p} + \mathrm{q}) \\ -\mathrm{r}(\mathrm{p} + \mathrm{q}) & \mathrm{p}^2 + \mathrm{rs} \end{bmatrix}$

$\operatorname{tr}\left((\operatorname{adj} A)^2 + (a+1) \operatorname{adj} A + 3I\right) = \mathrm{p}^2 + \mathrm{q}^2 + 2\mathrm{rs} - 4[\mathrm{p} + \mathrm{q}] + 3(1+1)$

$(p+q)^2 - 2(pq - rs) - 4(p+q) + 6 \Rightarrow 25 - 6 - 20 + 6 = 5$

Q2. Solution

Correct Answer: (B)

$A \times \times \times \times \times = \frac{5!}{2!}$ $\quad ED \times \times \times \times = 4!$

$D \times \times \times \times \times = \frac{5!}{2!}$ $\quad EEA \times \times \times = 3!$ rank is 181

$EA \times \times \times \times = 4!$ $\quad EED \times \times \times = 3!$

$EENADU = 1$

Q3. Solution

Correct Answer: (D)

$\left({}^{19}c_0 \left(x^3\right)^{19} + {}^{19}c_1 \left(px^2 + 2x - 5\right)\left(x^3\right)^{18} + \ldots\right)$

$\left({}^8c_0 x^{16} + {}^8c_1 (qx - 41) x^{14} + \ldots\right)\left({}^6c_0 x^{24} + {}^6c_1 \left(-x^3 + x - 1\right) x^{20} + \ldots\right)$ Comparing the coefficient of x^{96}

$= x^{97} + 391 x^{96} + a_{95} x^{95} + \ldots$

$19p + 8q - 6 = 391$

$\Rightarrow 19p + 8q = 397$ Let $q = 19\lambda + k, 0 \leq k < 19$

we get $p = \dfrac{397 - 8(19\lambda + k)}{19} = 21 - 8\lambda - 2\dfrac{(4k+1)}{19}$ For minimum +ve value of $p, \lambda = 1$ and $p = 7$

$\dfrac{4k+1}{19}$ must be integer $\Rightarrow k = 14, p = 15 - 8\lambda$

Q4. Solution

Correct Answer: (B)

The given lines are $L_1 : \frac{x-2}{1} = \frac{y+1}{2} = \frac{z-3}{-1}$ and $L_2 : \frac{x+1}{2} = \frac{y-1}{\alpha} = \frac{z}{1}$. For line L_1, we can identify a point $A(2, -1, 3)$ and its direction vector $\vec{b_1} = \hat{i} + 2\hat{j} - \hat{k}$. For line L_2, we can identify a point $C(-1, 1, 0)$ and its direction vector $\vec{b_2} = 2\hat{i} + \alpha\hat{j} + \hat{k}$. First, find the vector $\vec{AC}$ connecting a point on L_1 to a point on L_2: $\vec{AC} = C - A = (-1-2)\hat{i} + (1-(-1))\hat{j} + (0-3)\hat{k} = -3\hat{i} + 2\hat{j} - 3\hat{k}$. $\vec{b_1} \times \vec{b_2} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 2 & -1 \\ 2 & \alpha & 1 \end{vmatrix}$ $= \hat{i}(2\cdot 1 - (-1)\cdot\alpha) - \hat{j}(1\cdot 1 - (-1)\cdot 2) + \hat{k}(1\cdot\alpha - 2\cdot 2) = (2+\alpha)\hat{i} - (1+2)\hat{j} + (\alpha-4)\hat{k}$ $= (2+\alpha)\hat{i} - 3\hat{j} + (\alpha-4)\hat{k}$ $(\vec{AC})\cdot(\vec{b_1}\times\vec{b_2}) = (-3)(2+\alpha) + (2)(-3) + (-3)(\alpha-4)$ $= -6 - 3\alpha - 6 - 3\alpha + 12 = -6\alpha$ $|\vec{b_1}\times\vec{b_2}| = \sqrt{(2+\alpha)^2 + (-3)^2 + (\alpha-4)^2}$ $= \sqrt{(4+4\alpha+\alpha^2) + 9 + (\alpha^2 - 8\alpha + 16)} = \sqrt{2\alpha^2 - 4\alpha + 29}$ The formula for the shortest distance (SD) between two skew lines is $SD = \frac{|(\vec{AC})\cdot(\vec{b_1}\times\vec{b_2})|}{|\vec{b_1}\times\vec{b_2}|}$. We are given that the shortest distance is $\frac{3}{\sqrt{14}}$. So, $\frac{|-6\alpha|}{\sqrt{2\alpha^2-4\alpha+29}} = \frac{3}{\sqrt{14}}$ $\frac{6|\alpha|}{\sqrt{2\alpha^2-4\alpha+29}} = \frac{3}{\sqrt{14}}$ $\frac{2|\alpha|}{\sqrt{2\alpha^2-4\alpha+29}} = \frac{1}{\sqrt{14}}$ $\frac{(2\alpha)^2}{2\alpha^2-4\alpha+29} = \frac{1}{14}$ $\frac{4\alpha^2}{2\alpha^2-4\alpha+29} = \frac{1}{14}$ $14(4\alpha^2) = 1(2\alpha^2 - 4\alpha + 29)$ $56\alpha^2 = 2\alpha^2 - 4\alpha + 29$ $54\alpha^2 + 4\alpha - 29 = 0$ We need to find the sum of all permissible values of α. For a quadratic equation $ax^2 + bx + c = 0$, the sum of the roots is given by $-\frac{b}{a}$. In this equation, $a = 54$, $b = 4$, and $c = -29$. Sum of permissible values of $\alpha = -\frac{4}{54} = -\frac{2}{27}$. The final answer is $-\frac{2}{27}$

Q5. Solution

Correct Answer: (B)

$P(A) = 2(B) \Rightarrow \quad P(B) = \frac{1}{3}$ $P(A) = \frac{2}{3}$

Required Probability $= \frac{\frac{1}{3}\cdot\frac{4}{7}}{\frac{2}{3}\cdot\frac{3}{5} + \frac{1}{3}\cdot\frac{4}{7}} = \frac{10}{31}$.

Q6. Solution

Correct Answer: (A)

$$\int e^{\sin x}\left(\frac{5+\cos^2 x}{(2-\sin x)\sqrt{3+\cos^2 x}}\right)\cos x dx$$

put $\sin x = t$

$$\int e^t\left(\frac{6-t^2}{(2-t)\sqrt{4-t^2}}\right)dt$$

$$\int e^t\left(\frac{4-t^2}{(2-t)\sqrt{4-t^2}}+\frac{2}{(2-t)\sqrt{4-t^2}}\right)dt$$

$$\int e^t\left(\sqrt{\frac{2+t}{2-t}}+\frac{2}{(2-t)^{3/2}(2+t)^{1/2}}\right)dt$$

If $g(t)=\sqrt{\frac{2+t}{2-t}}$

$$g'(t)=\frac{2}{(2-t)^{3/2}(2+t^2)^{1/2}}$$

$$e^t\sqrt{\frac{2+t}{2-t}}+c$$

$$f(x)=e^{\sin x}\sqrt{\frac{2+\sin x}{2-\sin x}}+c$$

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

$$f(x)=e^{\sin x}\sqrt{\frac{2+\sin x}{2-\sin x}}$$

$$f\left(\frac{\pi}{2}\right)=\sqrt{3}e$$

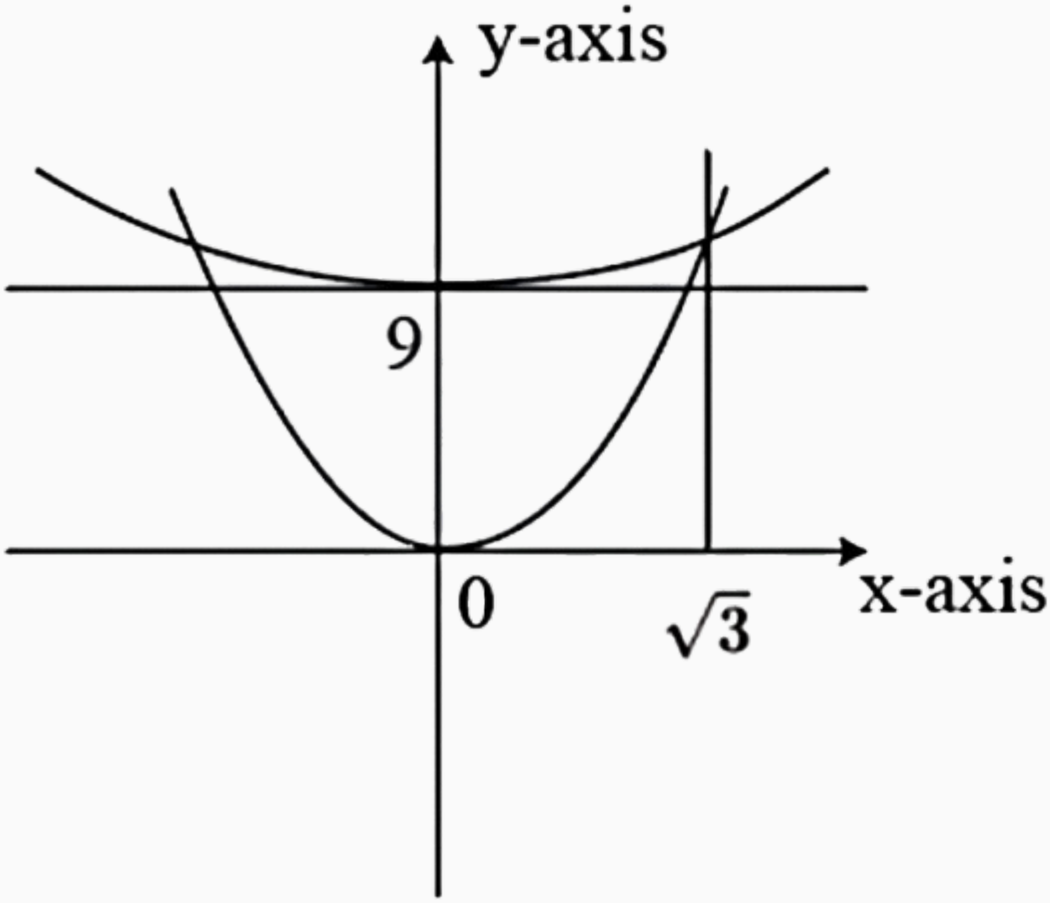
Q7. Solution

Correct Answer: (B)

$x^2=\frac{y}{5}, x^2=\frac{1}{2}(y-9)$

Area $=2 \int_0^{\sqrt{3}}\left[\left(2 x^2+9\right)-\left(5 x^2\right)\right] d x$

$=2 \int_0^{\sqrt{3}}\left(9-3 x^2\right) d x=18 x-2 x^3=18 \sqrt{3}-6 \sqrt{3}=12 \sqrt{3}$



Q8. Solution

Correct Answer: (C)

We have $\tan^{-1} x + \cot^{-1} x = \sin^{-1} x + \cos^{-1} x$, which is true for all x $\in [-1, 1]$ So, number of integral

$$\vec{c} = |\vec{a} \times \vec{b}|\vec{a} + (\vec{a} \cdot \vec{b})\vec{b}, |\vec{a}| = 1 = |\vec{b}|$$

$$\vec{a} \wedge \vec{b} = \frac{\pi}{6}$$

$$\therefore |\vec{a} \times \vec{b}| = (1)(1)\sin\frac{\pi}{6} = \frac{1}{2}\vec{a} \cdot \vec{b} = (1)(1)$$

$$\frac{\sqrt{3}}{2} = \frac{\sqrt{3}}{2}$$

$$\Rightarrow \vec{c} = \frac{1}{2}\vec{a} + \frac{\sqrt{3}}{2}\vec{b}$$

$$\Rightarrow |2\vec{c}|^2 = |\vec{a} + \sqrt{3}\vec{b}|^2$$

values of x $= 3$. $\Rightarrow 4|\vec{c}|^2 = 1 + 3 + 2\sqrt{3}\left(\frac{\sqrt{3}}{2}\right) = 7$

$$\therefore 4|\vec{c}|^2 = 7$$

$$\text{Let } I = \int_{-\pi/2}^{\pi/2} \frac{\ln(\sec x)}{(2013)^{\sin x} + 1} dx$$

So,

$$\left[\frac{1}{(2013)^{\sin x} + 1} + \frac{1}{(2013)^{-\sin x} + 1}\right] dx$$

$$= -\int_0^{\pi/2} \ell \ln(\cos x) dx = \frac{\pi}{2}\ell n2$$

$$\therefore k = 2$$

Q9. Solution

Correct Answer: (A)

The given parabola is $x^2 = -4y$. Comparing this with the standard form $x^2 = -4ay$, we find $a = 1$. The focus of the parabola is $\mathrm{F}(0, -a) = (0, -1)$. The equation of the directrix is $y = a$, so $y = 1$. Let $\mathrm{P}(x_1, y_1) = (4, -4)$. Since M is the foot of the perpendicular from P to the directrix $y = 1$, the coordinates of M are $(x_1, 1) = (4, 1)$. For a parabola $x^2 = -4ay$, a point on the parabola can be represented parametrically as $(2at, -at^2)$. For $\mathrm{P}(4, -4)$ and $a = 1$, we have $2t = 4 \Rightarrow t = 2$. Also, $-t^2 = -4$, which gives $t^2 = 4$, so $t = \pm 2$. Thus, $t = 2$ for point P. Since PQ is a focal chord, if P corresponds to parameter t, then Q corresponds to parameter $-1/t$. So, for Q, the parameter is $t' = -1/2$. The coordinates of Q are $(2a(-1/t), -a(-1/t)^2) = (2(1)(-1/2), -(1)(-1/2)^2) = (-1, -1/4)$. Since N is the foot of the perpendicular from Q to the directrix $y = 1$, the coordinates of N are $(x_Q, 1) = (-1, 1)$. Now we have the vertices of the quadrilateral PQMN: $\mathrm{P}(4, -4)$ $\mathrm{Q}(-1, -1/4)$ $\mathrm{M}(4, 1)$ $\mathrm{N}(-1, 1)$ Notice that PM and QN are vertical line segments (both perpendicular to the directrix $y = 1$). Thus, PM is parallel to QN. This means PQMN is a trapezoid. The lengths of the parallel sides are: Length of $\mathrm{PM} = |y_P - y_M| = |-4 - 1| = |-5| = 5$. Length of $\mathrm{QN} = |y_Q - y_N| = |-1/4 - 1| = |-5/4| = 5/4$. The height of the trapezoid is the perpendicular distance between the lines $x = 4$ (containing PM) and $x = -1$ (containing QN), which is the difference in their x-coordinates: Height $= |x_P - x_Q| = |4 - (-1)| = |5| = 5$. The area of a trapezoid is given by $\frac{1}{2} \times (\text{sum of parallel sides}) \times (\text{height})$. Area of $\mathrm{PQMN} = \frac{1}{2} \times (\mathrm{PM} + \mathrm{QN}) \times (\text{distance between PM and QN})$ Area $= \frac{1}{2} \times (5 + \frac{5}{4}) \times 5$ Area $= \frac{1}{2} \times (\frac{20+5}{4}) \times 5$ Area $= \frac{1}{2} \times \frac{25}{4} \times 5$ Area $= \frac{125}{8}$. Thus, the area of the quadrilateral PQMN is $\frac{125}{8}$.

Q10. Solution

Correct Answer: (D)

Given $\vec{c} = (2\vec{a} \times \vec{b}) - 3\vec{b}$

$\vec{b} \cdot \vec{c} = \vec{b} \cdot \{(2\vec{a} \times \vec{b}) - 3\vec{b}\}$

$\vec{b} \cdot \vec{c} = -3|\vec{b}|^2 \quad \ldots.(1)$

now $|\vec{a} \times \vec{b}|^2 = \vec{a}^2\vec{b}^2 - (\vec{a} \cdot \vec{b})^2$

$= 16 - 4 = 12$

and $\vec{c}^2 = ((2\vec{a} \times \vec{b}) - 3\vec{b})^2$

$|\vec{c}|^2 = 4|\vec{a} \times \vec{b}|^2 + 9\vec{b}^2 - \underbrace{6\vec{b} \cdot (2\vec{a} \times \vec{b})}_{\text{zero}}$

$= 48 + 144 = 192$

$|\vec{c}|^2 = 8\sqrt{3}$

Now, $\cos\theta = \frac{\vec{b} \cdot \vec{c}}{|\vec{b}||\vec{c}|} = \frac{-3|\vec{b}|^2}{|\vec{b}||\vec{c}|} = \frac{-3|\vec{b}|}{|\vec{c}|} = \frac{-3(4)}{8\sqrt{3}} = \frac{-\sqrt{3}}{2}$ Hence

$\vec{b} \wedge \vec{c} = \frac{5\pi}{6}$ Ans.

Q11. Solution

Correct Answer: (D)

$M=\lim_{x\to\infty}\left(-\frac{3}{2}\left(\frac{1}{3}-\frac{x^2}{x^2+1}\right)\right)^{x^2}$ $\frac{1}{3}-\frac{x^2}{x^2+1}=\frac{1(x^2+1)-3x^2}{3(x^2+1)}=\frac{x^2+1-3x^2}{3(x^2+1)}=\frac{1-2x^2}{3(x^2+1)}$ $-\frac{3}{2}\left(\frac{1-2x^2}{3(x^2+1)}\right)=-\frac{1}{2}\left(\frac{1-2x^2}{x^2+1}\right)=\frac{-(1-2x^2)}{2(x^2+1)}=\frac{2x^2-1}{2(x^2+1)}$ $M=\lim_{x\to\infty}\left(\frac{2x^2-1}{2x^2+2}\right)^{x^2}$ This limit is of the indeterminate form 1^{∞}, because as $x\to\infty$: Base: $\lim_{x\to\infty}\frac{2x^2-1}{2x^2+2}=\lim_{x\to\infty}\frac{2-1/x^2}{2+2/x^2}=\frac{2}{2}=1$ Exponent: $\lim_{x\to\infty}x^2=\infty$ For a limit of the form $\lim_{x\to a}(f(x))^{g(x)}$ where $f(x)\to 1$ and $g(x)\to\infty$, the value is $e^{\lim_{x\to a}g(x)(f(x)-1)}$. Here, $f(x)=\frac{2x^2-1}{2x^2+2}$ and $g(x)=x^2$. $f(x)-1=\frac{2x^2-1}{2x^2+2}-1=\frac{2x^2-1-(2x^2+2)}{2x^2+2}=\frac{-3}{2x^2+2}$ $\lim_{x\to\infty}g(x)(f(x)-1)=\lim_{x\to\infty}x^2\left(\frac{-3}{2x^2+2}\right)=\lim_{x\to\infty}\frac{-3x^2}{2x^2+2}=\lim_{x\to\infty}\frac{-3}{2+2/x^2}=\frac{-3}{2+0}=-\frac{3}{2}$ $M=e^{-3/2}$ $\log_e M=\log_e(e^{-3/2})=-\frac{3}{2}$ $\frac{\log_e M}{2+\log_e M}=\frac{-3/2}{2+(-3/2)}=\frac{-3/2}{4/2-3/2}=\frac{-3/2}{1/2}=-3$.

Q12. Solution

Correct Answer: (D)

Given,

$\mathrm{F(mn)=f(m)\cdot f(n)}$

Put $\mathrm{m}=1$, then $\mathrm{f(1\cdot n)=f(1)\cdot f(n)\Rightarrow f(1)=1}\quad\{f(n)\neq 0\}$

Put $\mathrm{m}=\mathrm{n}=2$

$\mathrm{f(4)=f(2)\cdot f(2)}$

If $f(2)=1$, then $f(4)=1$ and if $f(2)=2$, then $f(4)=4$

Put $\mathrm{m}=2,\ \mathrm{n}=3$

$f(6)=f(2)\cdot f(3)$

If $f(2)=1$, then $f(3)$ can be any value between 1 to 7

If $f(2)=2$, then $f(3)$ can be 1 or 2 or 3

$\mathrm{f(5),\ f(7)}$ can take any value from $\{1,2,\ldots,7\}$

So, total number of function $=(1\times 1\times 7\times 1\times 7\times 1\times 7)+(1\times 1\times 3\times 1\times 7\times 1\times 7)$

$=490$

,

Q13. Solution

Correct Answer: (B)

$$\frac{A_n}{A'_n}=\frac{a_1+(k-1)d_1}{a_2+(k-1)d_2}=\frac{2k-3}{3k+1}$$
put $\mathrm{k}=33$
$$\frac{\mathrm{a}_1+32\ \mathrm{d}_1}{\mathrm{a}_2+32\ \mathrm{d}_2}=\frac{2(33)-3}{3(33)+1}=\frac{63}{100}$$
$$\frac{\mathrm{a}_1+32\ \mathrm{d}_1}{\mathrm{a}_2+32\ \mathrm{d}_2}=\frac{63}{100}$$
$$\frac{2\mathrm{a}_1+64\ \mathrm{d}_1}{2\mathrm{a}_2+64\ \mathrm{d}_2}=\frac{63}{100}$$
$$\frac{\mathrm{S}_{65}}{\mathrm{S}_{65}}=\frac{63}{100}$$
$\therefore \mathrm{a}=63,\ \mathrm{b}=100$

Q14. Solution

Correct Answer: (B)

$\mathrm{P}(3\lambda+5-\lambda+7\quad \lambda-2), \mathrm{Q}(-3\mu+5\quad 2\mu+3\quad 4\mu+6)$
Drs of $\mathrm{PQ}(3\lambda+3\mu+8,-\lambda-2\mu+4,\lambda-4\mu-8)$
$$\frac{3\lambda+3\mu+8}{2}=\frac{-\lambda-2\mu+4}{7}=\frac{\lambda-4\mu-8}{-5}$$
$\Rightarrow \lambda=\mu=-1$
$\therefore P(2,8,-3)Q(0,1,2)$
$\therefore PQ^2=4+49+25=78$

Q15. Solution

Correct Answer: (A)

We must have $\begin{vmatrix} x & 1 & 2 \\ f(x) & 3 & x^2 \\ 5x & 6 & 1 \end{vmatrix}=0$
$\therefore x\left(3-6x^2\right)-1\left(f(x)-5x^3\right)+2(6f(x)-15x)=0$
$\therefore f(x)=\dfrac{x^3+27x}{11} \quad \Rightarrow f'(x)=\dfrac{3x^2+27}{11}>0 \forall x \in R$

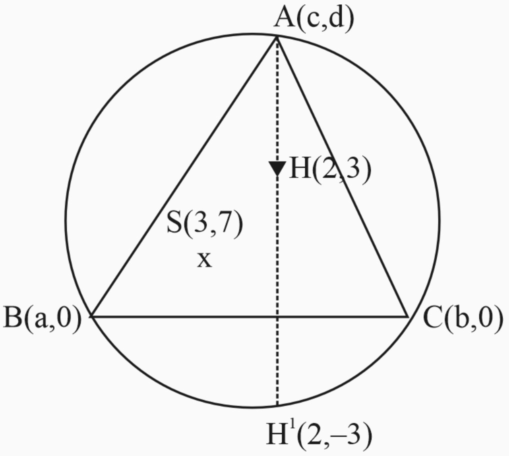
Q16. Solution

Correct Answer: (C)

$$\frac{2xydy-y^2dx}{x^2}+xdy+ydx=0$$
$$d\left(\frac{y^2}{x}+xy\right)=0$$
$\Rightarrow y^2+x^2y=2x$

Q17. Solution

Correct Answer: (D)



$H^1S = R = \sqrt{109}$

$G = \left(4, \dfrac{17}{3}\right)$

$\dfrac{a+b+c}{3} = 4 \Rightarrow a+b+c = 12$

$\dfrac{d}{3} = \dfrac{17}{3} \Rightarrow d = 17$,

$SB = \sqrt{109} \Rightarrow a = 5 \pm \sqrt{60}$

$\therefore B = (5-\sqrt{60}, 0), C = (5+\sqrt{60}, 0)$

$a+b+c = 4 \times 3 = 12$

$10 + C = 12$

$\text{C} = 2$

Q18. Solution

Correct Answer: (D)

Given : $2\cos x + 2\cos 2x + \sin 2x + 2\cos x \sin 2x = 2\sin x$

$2\cos x + 2\cos 2x + 2\sin x\cos x + (\sin 3x - \sin x) = 0$

$2\cos x + 2\cos 2x + 2\sin x\cos x + 2\cos 2x\sin x = 0$

$2\cos x(1+\sin x) + 2\cos 2x(1+\sin x) = 0$

$(1+\sin x)(2\cos x + 2\cos 2x) = 0$

$2(1+\sin x)(\cos x + \cos 2x) = 0$

$2(1+\sin x)2\cos\left(\dfrac{3x}{2}\right)\cdot\cos\left(\dfrac{x}{2}\right) = 0$

$\Rightarrow \sin x = -1 \Rightarrow x = 2n\pi + \dfrac{3\pi}{2}$

$x = \dfrac{-\pi}{2}$ are solution in $[-\pi, \pi]$

$\cos\dfrac{3x}{2} = 0 \Rightarrow \dfrac{3x}{2} = (2n+1)\dfrac{\pi}{2}$

$x = (2n+1)\dfrac{\pi}{3} \quad \dfrac{\pi}{3}, \dfrac{-\pi}{3}, \pi, -\pi$ All

$\cos\dfrac{x}{2} = 0, \Rightarrow x = (2n+1)\pi = \pi, -\pi$

solutions $= x = \left\{-\pi, \frac{-\pi}{2}, \frac{-\pi}{3}, \frac{\pi}{3}, \pi\right\}$ 5 solutions. .

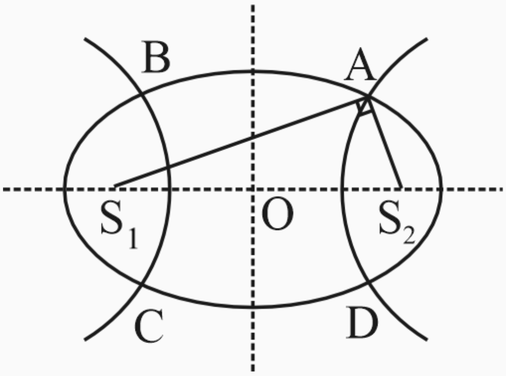
Q19. Solution

Correct Answer: (D)

$z_1 : z+(\sqrt{3}+i)t-i=0$ and $\arg(z_1)=\frac{\pi}{4} \Rightarrow \operatorname{Re}(z_1)=\frac{\sqrt{3}}{2}(\sqrt{3}+1)$ and
$z_2=z+\left(\frac{\sqrt{3}+i}{\sqrt{3}}\right)\lambda-i=0 \Rightarrow \operatorname{Re}(z_2)=-\frac{\sqrt{3}+1}{2}$ Hence area of
$\triangle ABC=\frac{1}{2}\times 1\times\left(\frac{\sqrt{3}+1}{2}\right)(\sqrt{3}+1)=\frac{\sqrt{3}+2}{2}$. ~

Q20. Solution

Correct Answer: (A)



$AS_1+AS_2=2a=10$
$AS_2-AS_1=2A=6$
$AS_2=8\ \&\ A_1=2\ \&\ S_1S_2=\sqrt{68}$

for ellipse $2a_1=2\sqrt{17} \Rightarrow e_1=\dfrac{\sqrt{17}}{5}$:

for hyperbola $2Ae_2=2\sqrt{17} \Rightarrow e_2=\dfrac{\sqrt{17}}{3}$

Q21. Solution

Correct Answer: 7

Check video solution for simple method to solve this question Let $N=\left((7)^{77}\right)^{77}$. We need to find the remainder when N is divided by 10, which is equivalent to finding the last digit of N. We will use the concept of cyclicity of the last digits of powers. First, let's observe the pattern of the last digits of powers of 7:
$7^1=7 \implies$ last digit is 7 $7^2=49 \implies$ last digit is 9 $7^3=343 \implies$ last digit is 3
$7^4=2401 \implies$ last digit is 1 $7^5=16807 \implies$ last digit is 7 The pattern of the last digits of powers of 7 is $7,9,3,1$, which repeats every 4 powers. The cycle length is 4. To find the last digit of 7^E, we need to determine the remainder of the exponent E when divided by the cycle length (which is 4). In this problem, the exponent is $E=77^{77}$. We need to calculate $77^{77} \pmod 4$. First, let's find the remainder of the base of the exponent, 77, when divided by 4: $77=4\times 19+1$ So, $77=1 \pmod 4$. Now, we can substitute this into the exponent calculation: $77^{77}=1^{77} \pmod 4$ $77^{77}=1 \pmod 4$. This result tells us that the exponent 77^{77} can be written in the form $4k+1$ for some integer k. Therefore, the last digit of $\left((7)^{77}\right)^{77}$ will be the same as the last digit of 7^1, which is 7. Thus, when $\left((7)^{77}\right)^{77}$ is divided by 10, the remainder is 7.

Q22. Solution

Correct Answer: 10

Let the given set be $S=\{1,2,3,4\}$. A binary relation P is defined on S such that for any $a,b\in S$, aPb if and only if $b=a+1$. We need to find the ordered pairs in P. For $a=1$, $b=1+1=2$. Since $2\in S$, $(1,2)\in P$. For $a=2$, $b=2+1=3$. Since $3\in S$, $(2,3)\in P$. For $a=3$, $b=3+1=4$. Since $4\in S$, $(3,4)\in P$. For $a=4$, $b=4+1=5$. Since $5\notin S$, there is no pair starting with $a=4$. So, the relation $P=\{(1,2),(2,3),(3,4)\}$. k is the total number of ordered pairs in P. From the above, $k=3$. A relation P on a set S is reflexive if for every $a\in S$, $(a,a)\in P$. The set $S=\{1,2,3,4\}$. For P to be reflexive, it must contain the pairs $(1,1),(2,2),(3,3),(4,4)$. The current relation $P=\{(1,2),(2,3),(3,4)\}$ does not contain any of these pairs. Therefore, the minimum number of additional ordered pairs required to make P a reflexive relation is $p=4$. A relation P on a set S is symmetric if for every $(a,b)\in P$, (b,a) must also be in P. The current relation $P=\{(1,2),(2,3),(3,4)\}$. - For $(1,2)\in P$, we need $(2,1)$ to be in P. - For $(2,3)\in P$, we need $(3,2)$ to be in P. - For $(3,4)\in P$, we need $(4,3)$ to be in P. None of these required pairs are currently in P. Therefore, the minimum number of additional ordered pairs required to make P a symmetric relation is $q=3$.
$k+p+q=3+4+3=10$.

Q23. Solution

Correct Answer: 7

The given equation $x^2-5|x|+6=|\lambda-2|$ will have four distinct roots if the above equation in $|x|$ has two distinct positive roots. This implies $|\lambda-2|<6$
$\Rightarrow -6<\lambda-2<6 \Rightarrow -4<\lambda<8$.
$\therefore$ the highest positive integral value of λ is 7.

Q24. Solution

Correct Answer: 6

$$f(x)=x\ln x+x-\int_1^x \frac{f(t)dt}{t\ln t}$$

$\therefore f'(x)=\frac{x}{x}+\ln x+1-\frac{f(x)}{x\ln x}$ $\therefore f'(x)=\frac{f(x)}{x\ln x}=2+\ln x$ This is linear differentiable equation. I.

$$\Rightarrow \frac{dy}{dx}+\frac{y}{x\ln x}-2+\ln x$$

F $=e^{\int\frac{dx}{x\ln x}}=e^{\ln(\ln x)}=\ln x$ Solution is $y\ln x=\int(2+\ln x)\ln x dx$

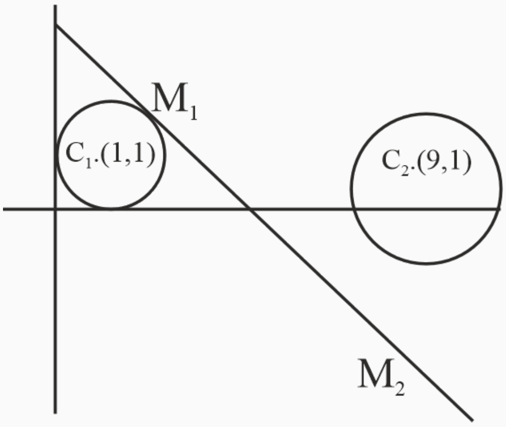
$\therefore y\ln x=\int\left(\ln^2 x+2\ln x\right)dx=x\ln^2 x+C$ Put x = 1 get

C = 0 $y\ln x=x\ln^2 x$

$\therefore \quad y=f(x)=x\ln x$

$\therefore f'(x)=\frac{1}{x} \quad \Rightarrow f'(e)+f''\left(\frac{1}{4}\right)=(1+\ln e)+4 \quad =2+4=6$

Q25. Solution
Correct Answer: 4

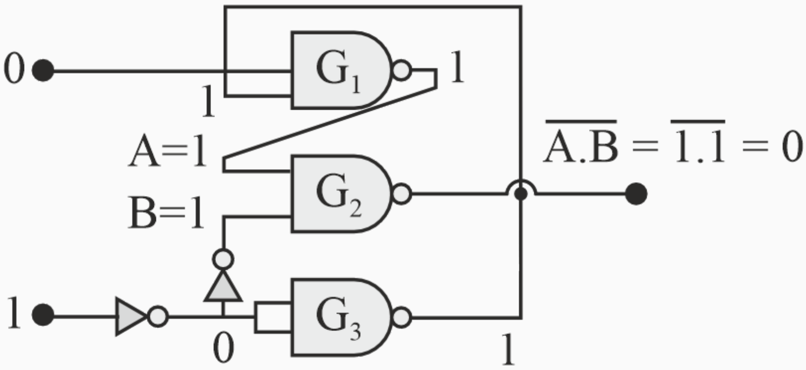


$S_1 : x^2 + y^2 - 2x - 2y + 1 = 0 \quad C_1(1,1)$
$r_1 = 1$
$S_2 : x^2 + y^2 - 18x - 2y + 78 = 0 \quad C_2(9,1)$
$r_2 = 2$
$C_1 M_1 \geq r_1$
$\frac{|3+4-\lambda|}{5} \geq 1$
$|7-\lambda| \geq 5$
$7 - \lambda \geq 5$ or $\lambda - 7 \geq 5$
$\lambda \leq 2$ (reject) or $\lambda \geq 12$
similarly $C_2 M_2 \geq r_2$
$\frac{|27+4-\lambda|}{\sqrt{3^2+4^2}} \geq 2$
$31 - \lambda \geq 10, \lambda \leq 21$

Hence $12 \leq \lambda \leq 21$ It is given that there should be no common point with circles, so we will not include 12 and 21. Possible values of λ are $\{13, 14, 15, \ldots\ldots, 20\}$ $2k = 8$
$k = 4$

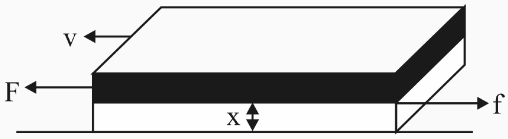
Q26. Solution
Correct Answer: (A)

Lower NOT gate inverts input to zero. NOT gate from NAND gate inverts this output to 1 upper NAND gate converts this input 1 and input 0 to 1. Thus $A = 1$ and $B = 1$ become inputs of NAND gate giving final output as zero. Choice A is correct.



Q27. Solution

Correct Answer: (A)



$magnitude\ of\ viscous\ force\ f = \eta A \frac{\mathrm{d}v}{\mathrm{d}x}$

velocity is constant so net force =0

$F - f = 0 \Rightarrow F = f \Rightarrow F = \eta A \frac{\mathrm{d}v}{\mathrm{d}x} \Rightarrow \eta = \frac{F}{A\frac{\mathrm{d}V}{\mathrm{d}X}}$

$\therefore\ \eta = \frac{10^{-2}}{(10^{3}\times10^{-4})\left(\frac{6\times10^{-2}}{6\times10^{-3}}\right)}$

$= \frac{10^{-2}\times6\times10^{-3}}{10^{-1}\times6\times10^{-2}}$

$= 10^{-2}\mathrm{Nsm}^{2} = 0.1$ poise

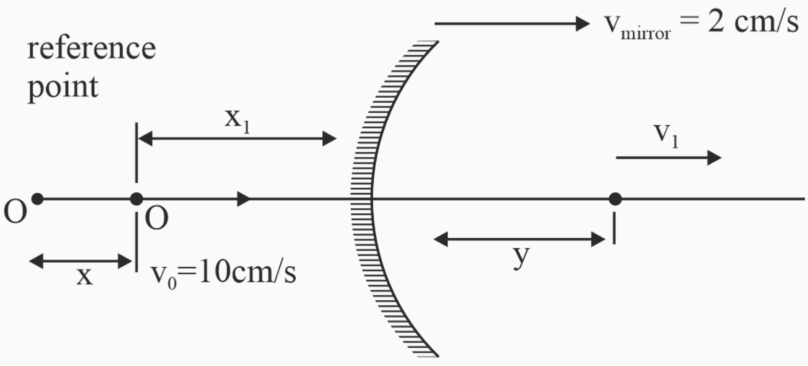
Q28. Solution

Correct Answer: (C)

Immediately after cutting the string reaction force at the hinge A is $\frac{mg}{4}$. So it should be $\frac{mg}{4}$, before cutting the string also for no change. That implies that tension in the string is $T = \frac{3mg}{4}$ Now taking torque about the hinge, $mg \times \frac{L}{2} = \frac{3mg}{4} \times x \Rightarrow \frac{2L}{3}$

Q29. Solution

Correct Answer: (A)



$$\frac{1}{y} + \frac{1}{-x_1} = \frac{1}{10}$$

$$\frac{1}{y} - \frac{1}{10} = \frac{1}{10} \Rightarrow y = 5 \text{ cm}$$

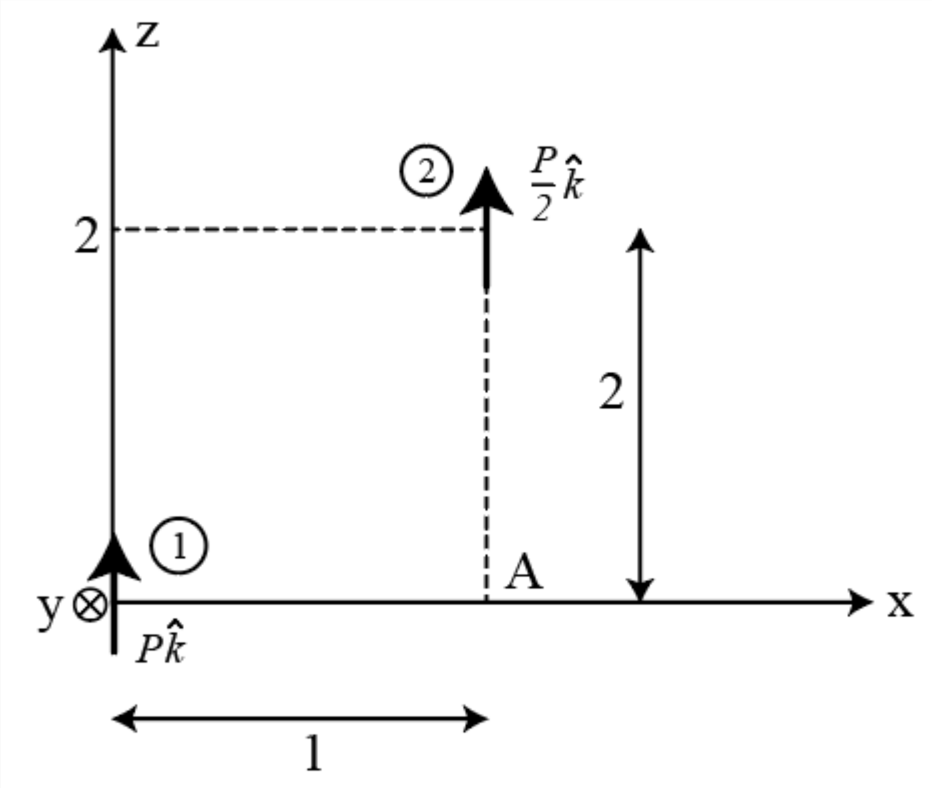
$$\frac{dx}{dy} = 10 \text{ cm/s}, \frac{d(x + x_1)}{dt} = 2 \text{ cm/s}$$

$$\frac{dy}{dt} = v_1 = 2$$

$$\frac{dy}{dt} = \left(\frac{y^2}{x_2}\right)\frac{dx_1}{dt} \Rightarrow v_1 - 2 = \left(\frac{5}{10}\right)^2(-8) \Rightarrow v_1 = 0$$

Q30. Solution

Correct Answer: (B)



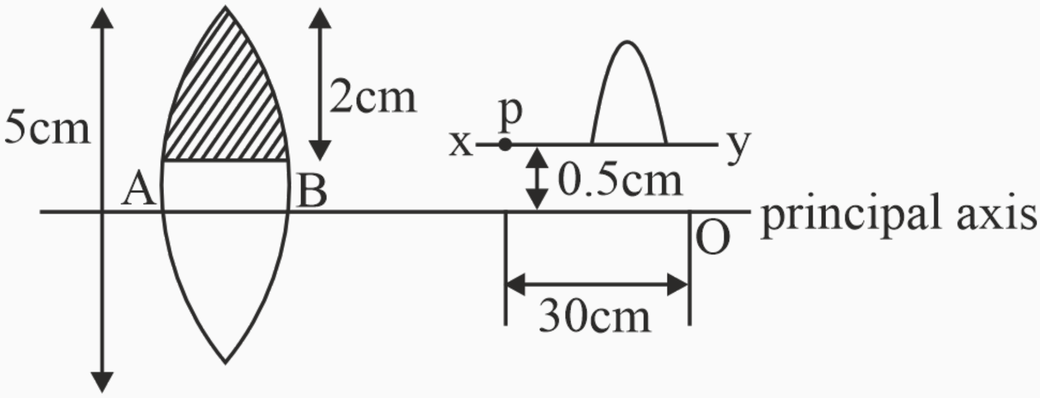
$$\overrightarrow{E_1} = \left(\frac{1}{4\pi\epsilon_0}\right)\frac{(-P\hat{k})}{13}$$

$$\overrightarrow{E_2} = \left(\frac{1}{4\pi\epsilon_0}\right)\frac{2(P/2)\hat{k}}{2^3}$$

$$\overrightarrow{E_{\text{res}}} = \overrightarrow{E_1} + \overrightarrow{E_2}$$

$$= -\frac{7P\hat{k}}{32\pi\epsilon_0}$$

Q31. Solution
Correct Answer: (D)



$\frac{h_1}{h_o} = \frac{f}{u+f}$

$h_o = \frac{20}{(-30)+20} \times 0.5$

$h_o = -1 \text{ cm}$

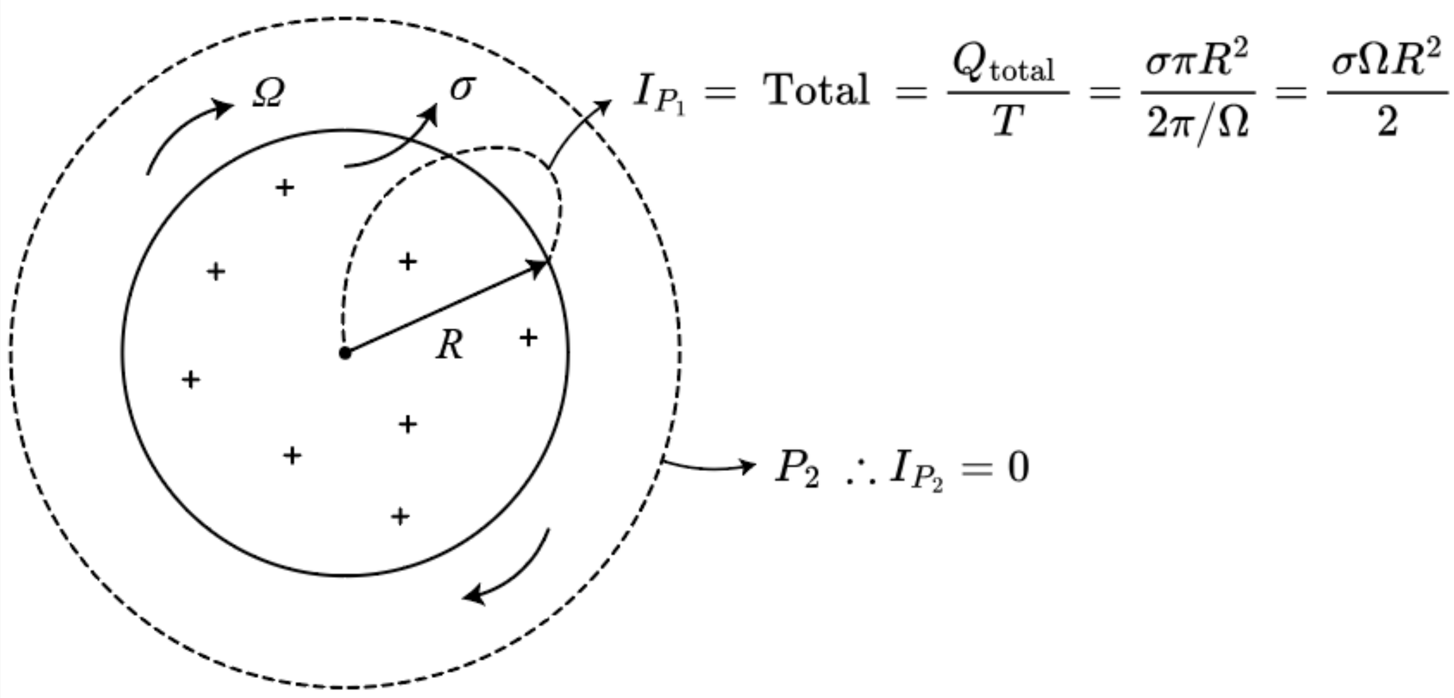
so image will be formed 1.5 cm below xy line.

Q32. Solution
Correct Answer: (A)

Let's evaluate each statement: (I) An extensive property's value is directly proportional to the size or amount of the system. This statement is **correct**. Extensive properties are those that depend on the amount of matter in the system, such as mass, volume, internal energy, entropy, and number of moles. (II) Pressure (P), temperature (T), and specific volume (v) are examples of intensive properties. This statement is **correct**. Intensive properties are independent of the amount of matter in the system. Pressure and temperature are classic examples. Specific volume ($v = V/m$, where V is volume and m is mass) is also an intensive property because it is the ratio of two extensive properties, making it independent of the system's size. (III) Internal energy (U), entropy (S), and number of moles (n) are intensive properties. This statement is **incorrect**. Internal energy (U), entropy (S), and number of moles (n) are all *extensive* properties. Their values depend on the size or amount of the system. For example, if you double the amount of a system, its internal energy, entropy, and number of moles will also double. Based on the evaluation, statements (I) and (II) are correct. Therefore, the correct option is A.

Q33. Solution

Correct Answer: (B)



To determine the value of $I_{P_1} - I_{P_2}$, we need to calculate I_{P_1} and I_{P_2} separately. Consider a thin annular ring of radius r and thickness dr on the disk. The charge dq on this ring is: $dq = \sigma \cdot (\text{area of the ring}) = \sigma(2\pi r dr)$ This charge rotates with angular velocity Ω. The time period of rotation is $T = \frac{2\pi}{\Omega}$. The current dI due to this rotating annular ring is the charge passing a point per unit time: $dI = \frac{dq}{T} = \frac{\sigma(2\pi r dr)}{2\pi/\Omega} = \sigma\Omega r dr$ $I_{P_1} = \int_0^R \sigma\Omega r dr = \sigma\Omega \int_0^R r dr = \sigma\Omega \left[\frac{r^2}{2}\right]_0^R$ $I_{P_1} = \frac{1}{2}\sigma\Omega R^2$ Loop P_2 is a large circular path concentric with the disk and completely surrounds it. The term "net current passing through the area bounded by loop P_2" refers to the current that *pierces* the surface enclosed by the loop, as used in Ampere's Law ($\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{\text{enclosed}}$). In this scenario, the charges are moving in circular paths *within* the plane of the disk, which is the surface bounded by P_2. They are not *passing through* or *piercing* this surface. For any given point on the surface, the charges are moving tangentially to the surface, not perpendicularly through it. Therefore, the net current *passing through* the area bounded by loop P_2 is zero. $I_{P_2} = 0$ $I_{P_1} - I_{P_2} = \frac{1}{2}\sigma\Omega R^2 - 0 = \frac{1}{2}\sigma\Omega R^2$

Q34. Solution

Correct Answer: (B)

The fringe width (β) in Young's double-slit experiment is given by the formula: $\beta = \frac{\lambda D}{d}$ Where: λ is the wavelength of the light used. D is the distance between the slits and the screen. d is the distance between the two slits. The problem states that all other experimental parameters are kept constant, which means D and d remain the same for both light sources. Therefore, the fringe width (β) is directly proportional to the wavelength (λ) of the light: $\beta \propto \lambda$ We know that green light has a longer wavelength than violet light. The approximate range of wavelengths for visible light is: Violet light: 380-450 nm Green light: 495-570 nm Since $\lambda_{\text{green}} > \lambda_{\text{violet}}$, it follows that $\beta_{\text{green}} > \beta_{\text{violet}}$. Thus, the fringe width produced by green light will be larger than that produced by violet light. The final answer is $\boxed{B}$

Q35. Solution
Correct Answer: (B)

As the initial speed of the coil is v, then initially it will have some kinetic energy (KE).

When the coil will start entering the magnetic field, the magnetic force will start acting on it. It will be given by,

$F = Bbv$ (in opposite to velocity)

$\Rightarrow -a = \frac{Bbv}{m}$, here a is the acceleration.

$\Rightarrow -v\frac{\mathrm{d}v}{\mathrm{d}x} = \frac{Bbv}{m} \Rightarrow \frac{\mathrm{d}v}{\mathrm{d}x} = -\frac{Bb}{m}$

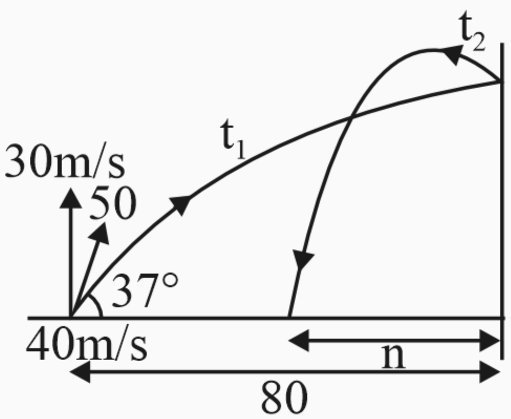
The slope will be negative and constant.

Again when all the loop will enter the magnetic field, the flux will become constant, so the velocity will become constant.

Now when the loop will start coming out, again the flux will start changing. In this case, the slope will be negative and constant.

Again when the full loop come out, then there will not be any change in flux and the velocity will remain same.

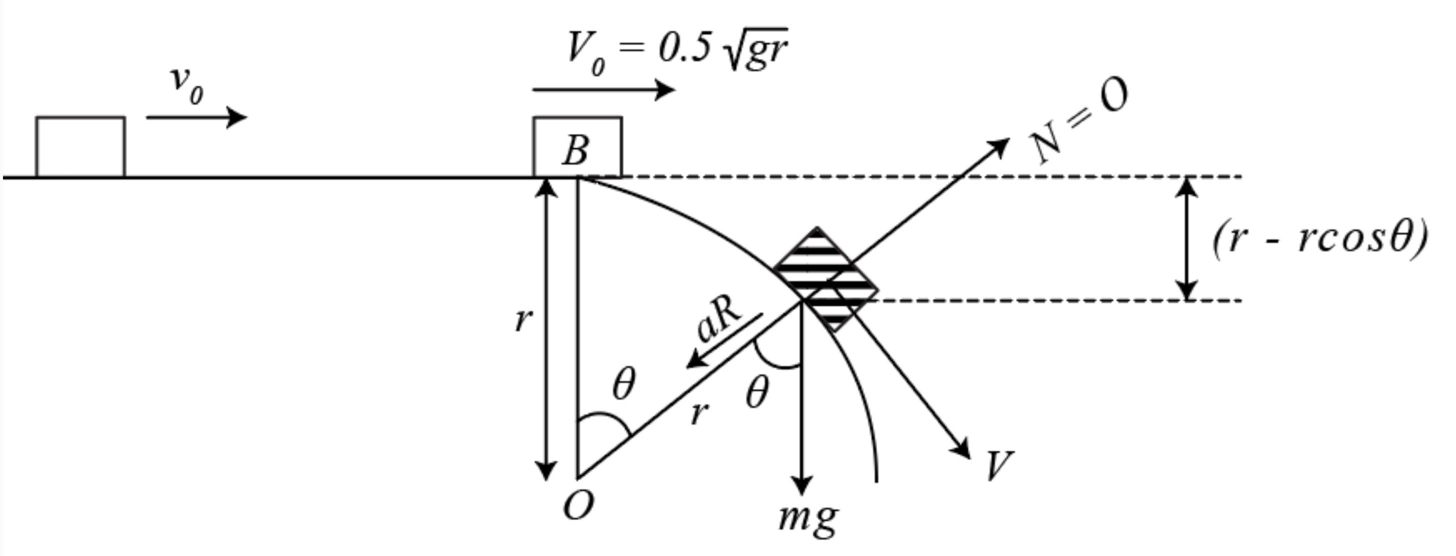
Q36. Solution
Correct Answer: (C)



After first collision : $\mathrm{v_y} = 30 - \mathrm{gt}; \mathrm{v_x} = -20\hat{i}; t_1 = \frac{80}{40} = 2\mathrm{sec}; \mathrm{t_2} = \mathrm{T} - \mathrm{t_1} = 4\mathrm{sec}$ Before second collision : $v_x = -20\hat{i}; \mathrm{x} = 20 \times 4 = -80\ \mathrm{m}; \mathrm{v_y} = 10 - 10\,(\mathrm{t_2}) = -30\hat{j}$ After second collision : $v_x = -20\hat{i}; v_y = +15\hat{j}$ $\quad$ Range $= 60$ m Net: $60\ \mathrm{m} + 80\ \mathrm{m} = 140\ \mathrm{m}$

Q37. Solution

Correct Answer: (D)



$\frac{1}{2}mv^2 = \frac{1}{2}mv_0^2 + mg(r - r\cos\theta)$

$mv^2 = mv_0^2 + 2mgr(1 - \cos\theta)$

$mg\cos\theta - x^0 = \frac{mv^2}{r}$

$mgr\cos\theta = mv_0^2 + 2mgr - 2mgr\cos\theta$

$3mgr\cos\theta = 0.25mgr + 2mgr$

$\cos\theta = \frac{2.25}{3} = \frac{3}{4}$

$\theta = \cos^{-1}\left(\frac{3}{4}\right)$

Q38. Solution

Correct Answer: (C)

$T = 2\pi\sqrt{\frac{M}{k}}$

$T' = 2\pi\sqrt{\frac{M+m}{k}}$

$\Rightarrow \frac{5T}{3} = 2\pi\sqrt{\frac{M+m}{k}}$

Dividing Eq. (i) by (ii), we have

$\therefore \frac{3}{S} = \sqrt{\frac{M}{M+m}}$

$\frac{9}{25} = \frac{M}{M+m}$

$\Rightarrow 9M + 9m = 25M$

$\Rightarrow 16M = 9m$

$\frac{m}{M} = \frac{16}{9}$

Q39. Solution

Correct Answer: (A)

Since, $V_L = V_C = V_R \therefore X_L = X_C = R$ and $V = V_R = 10$ V when capacitor is short circuited

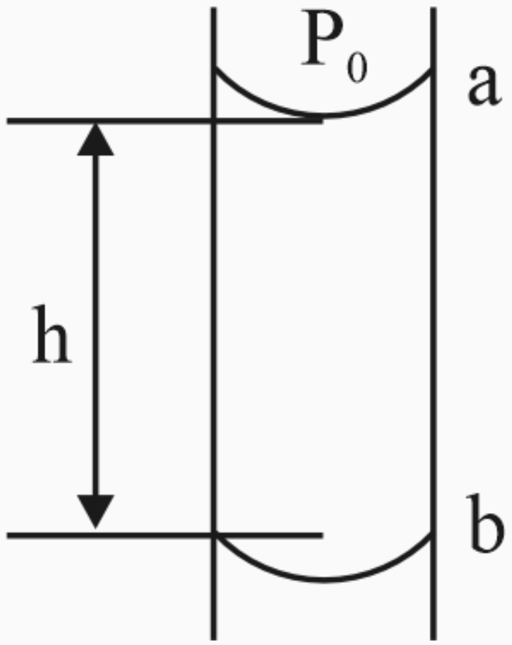
$i = \frac{10}{\sqrt{R^2 + X_L^2}} = \frac{10}{\sqrt{2}R}(\text{ as } X_L = R)$

$V_L = iX_L = \left(\frac{10}{\sqrt{2}R}\right)R = \frac{10}{\sqrt{2}}$ V

Q40. Solution
Correct Answer: (A)

Let's determine the dimensional formula for each physical quantity: 1. Momentum (A): Momentum (p) is defined as the product of mass (m) and velocity (v). $p = mv$ Dimensions of mass $[M] = [M^1]$ Dimensions of velocity $[v] = [L^1T^{-1}]$ So, dimensions of momentum $[p] = [M^1L^1T^{-1}]$. This matches List-II (II). 2. Strain (B): Strain is defined as the ratio of change in dimension to the original dimension (e.g., $\frac{\Delta L}{L}$, $\frac{\Delta V}{V}$). Since it is a ratio of two quantities with the same dimensions, strain is dimensionless. Dimensions of strain $= [M^0L^0T^0]$. This matches List-II (I). 3. Gravitational Constant (G) (C): From Newton's Law of Universal Gravitation, the force (F) between two masses (m_1, m_2) separated by a distance (r) is given by: $F = G\frac{m_1m_2}{r^2}$ Rearranging for G: $G = \frac{Fr^2}{m_1m_2}$ Dimensions of force $[F] = [M^1L^1T^{-2}]$ Dimensions of distance $[r] = [L^1]$ Dimensions of mass $[m] = [M^1]$ So, dimensions of $G = \frac{[M^1L^1T^{-2}][L^1]^2}{[M^1][M^1]} = \frac{[M^1L^3T^{-2}]}{[M^2]} = [M^{-1}L^3T^{-2}]$. This matches List-II (III). 4. Planck's Constant (h) (D): From the energy of a photon, $E = h\nu$, where E is energy and ν is frequency. Rearranging for h: $h = \frac{E}{\nu}$ Dimensions of energy $[E] = [M^1L^2T^{-2}]$ (e.g., from work done = force $\times$ distance) Dimensions of frequency $[\nu] = [T^{-1}]$ So, dimensions of $h = \frac{[M^1L^2T^{-2}]}{[T^{-1}]} = [M^1L^2T^{-1}]$. This matches List-II (IV).

Q41. Solution
Correct Answer: (D)



$$P_a = P_0 - \frac{2T}{r}$$

$$P_b = P_0 - \frac{2T}{r} + hdg$$

As $P_b - P_0 = \frac{2T}{r}$

$$\frac{4T}{r} = hdg$$

or $h = \frac{4T}{rdg} = \frac{4 \times 0.075}{\left(\frac{1}{2} \times 10^{-3}\right)\left(1 \times 10^3\right)10}$ m

$= 0.6 \times 10^{-1}$ m $= 6$ cm

Q42. Solution

Correct Answer: (D)

Stoping potential 1.1V i.e. $KE_{\max} = 1.1\text{eV}$

$$h\nu = w_0 + KE_{\max} \qquad \lambda = 4000A^0$$
$$\frac{12400}{4000} = w_0 + 1.1\text{eV} \qquad w_0 = 2\text{eV}$$
$$\lambda_0 = \frac{12400}{2} = 6200A^0 = 620 \text{ nm}$$

Q43. Solution

Correct Answer: (C)

The given relation is $K = \frac{A^3B}{C^2\sqrt{D}}$. To find the maximum percentage error in K, we use the rule for propagation of errors for quantities combined by multiplication, division, and powers. If a quantity K is given by $K = A^xB^yC^zD^w$, then the maximum fractional error is given by: $\frac{\Delta K}{K} = |x|\frac{\Delta A}{A} + |y|\frac{\Delta B}{B} + |z|\frac{\Delta C}{C} + |w|\frac{\Delta D}{D}$ And the maximum percentage error is: $\frac{\Delta K}{K} \times 100\% = |x|\left(\frac{\Delta A}{A} \times 100\%\right) + |y|\left(\frac{\Delta B}{B} \times 100\%\right) + |z|\left(\frac{\Delta C}{C} \times 100\%\right) + |w|\left(\frac{\Delta D}{D} \times 100\%\right)$ In our case, $K = A^3B^1C^{-2}D^{-1/2}$.
$\frac{\Delta A}{A} \times 100\% = 2\%$ $\frac{\Delta B}{B} \times 100\% = 1\%$ $\frac{\Delta C}{C} \times 100\% = 4\%$ $\frac{\Delta D}{D} \times 100\% = 3\%$
$\frac{\Delta K}{K} \times 100\% = |3|(2\%) + |1|(1\%) + |-2|(4\%) + |-1/2|(3\%)$
$\frac{\Delta K}{K} \times 100\% = 3(2\%) + 1(1\%) + 2(4\%) + \frac{1}{2}(3\%)$ $\frac{\Delta K}{K} \times 100\% = 6\% + 1\% + 8\% + 1.5\%$
$\frac{\Delta K}{K} \times 100\% = 16.5\%$ Thus, the maximum percentage error in the calculated value of K is 16.5%.

Q44. Solution

Correct Answer: (A)

For adiabatic process, $\mathrm{TV}^{-1} = \text{constant}$

$$T\left(\frac{m}{\rho}\right)^{\gamma-1} = \text{constant}$$
$$\frac{T}{\rho^{\gamma-1}} = \text{constant}$$
$$\rho \propto T^{y/(\gamma-1)} \Rightarrow \frac{1}{\gamma-1} = 3 \Rightarrow \gamma = 4/3$$
$$f = \frac{2}{\gamma-1} = \frac{2}{\left(\frac{4}{3}-1\right)} = 6$$

Q45. Solution
Correct Answer: (D)

The given force varies with distance

Therefore, work done,

$W = \int_0^{x=5} F.\,dx$

$= \int_0^5 \left(7 - 2x + 3x^2\right)\, dx$

$= \left[7x - \frac{2x^2}{2} + \frac{3x^3}{3}\right]_0^5$

$= \left[7 \times 5 - (5)^2 + (5)^3 - 0\right]$

$= 135 \text{ J}$

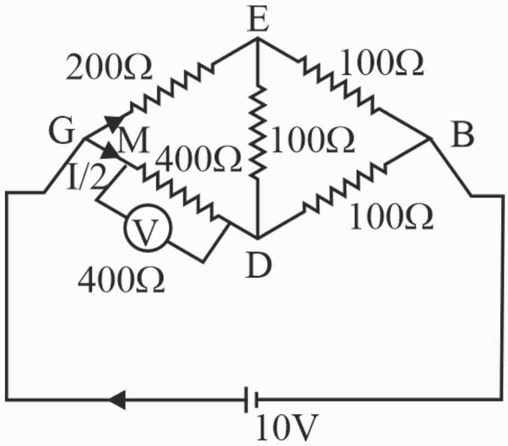
Q46. Solution
Correct Answer: 2

In the velocity selector, the charged particles pass undeflected, which means the electric force (F_E) and the magnetic force (F_B) on the particle are equal in magnitude and opposite in direction. The electric force is given by $F_E = qE$, and the magnetic force is given by $F_B = qvB$, where q is the charge, E is the electric field strength, v is the velocity of the particle, and B is the magnetic field strength. For undeflected motion: $qE = qvB$ $v = \frac{E}{B}$ Given $E = 5 \times 10^4 \text{ N/C}$ and $B = 0.25 \text{ T}$. $v = \frac{5 \times 10^4 \text{ N/C}}{0.25 \text{ T}} = 20 \times 10^4 \text{ m/s} = 2 \times 10^5 \text{ m/s}$ After exiting the selector, the particles enter a region with only the magnetic field $B = 0.25 \text{ T}$ and follow a circular trajectory with radius $r = 4 \text{ cm} = 0.04 \text{ m}$. In this case, the magnetic force provides the centripetal force required for circular motion. The centripetal force is given by $F_c = \frac{mv^2}{r}$, where m is the mass of the particle. $qvB = \frac{mv^2}{r}$ We need to find the charge-to-mass ratio, q/m. Rearranging the equation: $\frac{q}{m} = \frac{v}{Br}$ Substitute the values of v, B, and r: $\frac{q}{m} = \frac{2 \times 10^5 \text{ m/s}}{(0.25 \text{ T})(0.04 \text{ m})}$ $\frac{q}{m} = \frac{2 \times 10^5}{0.01} = 2 \times 10^5 \times 100 = 2 \times 10^7 \text{ C/kg}$ The magnitude of the charge-to-mass ratio is $2 \times 10^7 \text{ C/kg}$. Comparing this to the form $y \times 10^7 \text{ C/kg}$, the value of y is 2. The final answer is $\boxed{2}$

Q47. Solution

Correct Answer: 4

We can redraw the circuit as The equivalent resistance between G and D is $\mathrm{R}_{\mathrm{GD}}=\frac{400 \times 400}{400+400}=200 \Omega$



Since $\frac{R_{GE}}{R_{GD}}=\frac{R_{EB}}{R_{DB}}$ $\therefore$ It is a case of balanced wheatstone bridge. The equivalent resistance across G and B is $\mathrm{R}_{\mathrm{GB}}=\frac{300 \times 300}{300+300}=150 \Omega$ Current $I=\frac{V}{R_{GB}}=\frac{10}{150}=\frac{1}{15}$ Amp Since $R_{GEB}=R_{GDB}$, the current is divided at G into two equal parts. The current $\mathrm{I}/2$ further divides into two equal parts at M. Therefore the potential difference across the voltmeter. $\frac{1}{4} \times 400=\frac{1}{15} \times 100=\frac{20}{3}$ volt $\begin{gathered}20/3=5\ \mathrm{K}/3 \\ \mathrm{K}=4\end{gathered}$

Q48. Solution

Correct Answer: 180

$q=CV$
$\frac{\mathrm{d}q}{\mathrm{dt}}=C \frac{\mathrm{d}v}{\mathrm{dt}}$
$=20 \times 10^{-6} \times 3$
Conduction current $=60\ \mu\mathrm{A}$
Displacement current $=\varepsilon_0 \frac{\mathrm{d}\phi_e}{\mathrm{dt}}$
$=\varepsilon_0 \frac{A}{d} \frac{\mathrm{dV}}{\mathrm{dt}}$
$=60\ \mu\mathrm{A}$

$M=60, N=60$
$M+2N=180$

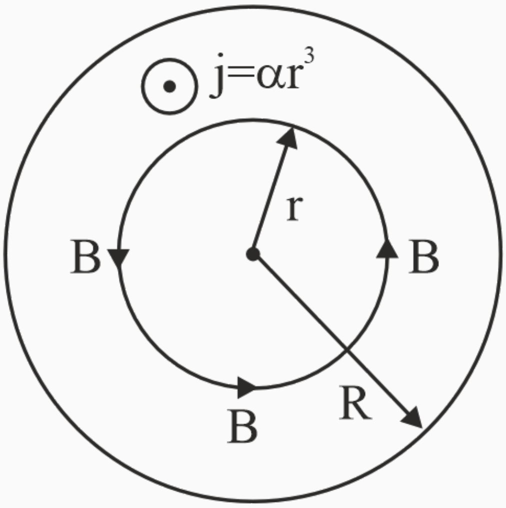
Q49. Solution

Correct Answer: 47

Let the pipe have a uniform mass per unit length λ. The total length of the pipe is L. It is rotated about one of its ends (pivot) in a horizontal plane with a constant angular velocity ω. Consider a small element of the pipe of length dr at a distance r from the pivot. The mass of this element is $dm = \lambda dr$. The centripetal force required for this element to rotate is $dF = dm \cdot a_c = (\lambda dr) \cdot (\omega^2 r)$. The tension $T(x)$ in the pipe at a point located at a distance x from the pivot is the sum of all centripetal forces required for the segment of the pipe from x to L. This means the tension at x must provide the centripetal force for all the mass elements further away from the pivot than x. $T(x) = \int_x^L dF = \int_x^L (\lambda dr)(\omega^2 r)$ $T(x) = \lambda\omega^2 \int_x^L r dr$ $T(x) = \lambda\omega^2 \left[\frac{r^2}{2}\right]_x^L$ $T(x) = \lambda\omega^2 \left(\frac{L^2}{2} - \frac{x^2}{2}\right)$ $T(L/4) = \lambda\omega^2 \left(\frac{L^2}{2} - \frac{(L/4)^2}{2}\right)$ $T(L/4) = \lambda\omega^2 \left(\frac{L^2}{2} - \frac{L^2}{16\cdot 2}\right)$ $T(L/4) = \lambda\omega^2 \left(\frac{L^2}{2} - \frac{L^2}{32}\right)$ $T(L/4) = \lambda\omega^2 \left(\frac{16L^2}{32} - \frac{L^2}{32}\right)$ $T(L/4) = \lambda\omega^2 \left(\frac{16L^2 - L^2}{32}\right)$ $T(L/4) = \frac{15}{32}\lambda\omega^2 L^2$ The problem states that the tension is $\frac{p}{q}\lambda\omega^2 L^2$. By comparing this with our result, we have: $\frac{p}{q} = \frac{15}{32}$ Thus, $p = 15$ and $q = 32$. $p + q = 15 + 32 = 47$.

Q50. Solution

Correct Answer: 8



$$B2\pi r = \mu_0 \int_0^r j2\pi r dr$$

When r $\leq$ R $Br = \dfrac{\mu_0 \alpha r^5}{5}$

$$B = \frac{\mu_0 \alpha r^4}{5}, r \leq R$$

$$B2\pi r = \mu_0 \int_0^R j2\pi r dr$$

$$Br = \mu_0 \int_0^R \alpha r^3 r dr$$

$$Br = \frac{\mu_0 \alpha R^5}{5}$$

when r > R $\therefore B = \dfrac{\mu_0 \alpha R^5}{5r}, r > R$

at $r = \dfrac{R}{2}, B_1 = \dfrac{\mu_0 \alpha R^4}{80}$

at $r = 2R, B_2 = \dfrac{\mu_0 \alpha R^4}{10}$

$$\therefore \frac{B_2}{B_1} = 8$$

Q51. Solution

Correct Answer: (A)

a) Lassaigne's test is used to identify the elements N,S,P and halogens b) Cu(II)O is used to identify 'Carbon' c) $\mathrm{AgNO_3}$ is used to identify halogen specifically d) $2\mathrm{Na}^{+}+\mathrm{S}^{-2} \rightarrow \mathrm{Na}_2\ \mathrm{S} \xrightarrow{\mathrm{CH_3COOH}} \mathrm{H}_2\ \mathrm{S} \xrightarrow{\mathrm{pb(CH_3COO)_2}} PbS \downarrow$ (black)

Q52. Solution

Correct Answer: (C)

$C \quad 85.7\% \quad \frac{85.7}{12}=7.14 \quad 1$

$H \quad 14.3\% \quad \frac{14.3}{1}=14.3 \quad 2$

$\mathrm{CH_2}$ (Empirical Eormula)

Empirical mass $=14\ \mathrm{g/mol}$

density of gas $=\dfrac{PM}{RT}$

$M=\dfrac{dRT}{P}=\dfrac{1.95\times 0.0821\times 350}{1}$

$M=56\ \mathrm{g/mol}$

Q53. Solution

Correct Answer: (A)

In all complexes, Nickel is in the +2 oxidation state. The electronic configuration of Ni is $[Ar]3d^8 4s^2$. The electronic configuration of Ni^{2+} is $[Ar]3d^8$. I. $[Ni(en)_3]^{2+}$: 'en' (ethylenediamine) is a strong field, bidentate ligand. With 3 bidentate ligands, the coordination number is 6, leading to an **octahedral** geometry. II. $[Ni(H_2O)_6]^{2+}$: H_2O is a weak field, monodentate ligand. With 6 monodentate ligands, the coordination number is 6, leading to an **octahedral** geometry. III. $[NiCl_4]^{2-}$: Cl^- is a weak field, monodentate ligand. With 4 monodentate ligands, $Ni(II)$ (d^8) typically forms a **tetrahedral** complex with weak field ligands. IV. $[Ni(CN)_4]^{2-}$: CN^- is a very strong field, monodentate ligand. With 4 strong field ligands, $Ni(II)$ (d^8) typically forms a **square planar** complex.

Spectrochemical series (relevant ligands): $Cl^- < H_2O < en < CN^-$ (increasing ligand field strength). **For** d^8 system: **Octahedral (Oh):** The electron configuration is $t_{2g}^6 e_g^2$. This is always low spin for d^8. Since 'en' is a stronger ligand than H_2O, $\Delta_o(en) > \Delta_o(H_2O)$. Therefore, $|CFSE(en)| > |CFSE(H_2O)|$. **Tetrahedral (Td):** The electron configuration is $e^4 t_2^4$. Since Cl^- is a very weak ligand, $\Delta_t(Cl^-)$ is small, making this CFSE value the least negative (closest to zero). **Square Planar (SP):** For d^8 strong field complexes, square planar geometry is highly favored due to a very large CFSE. The electron configuration is $(d_{z^2})^2(d_{xz})^2(d_{yz})^2(d_{xy})^2$. The highest energy $d_{x^2-y^2}$ orbital remains empty. The CFSE for d^8 square planar is significantly larger in magnitude than for octahedral or tetrahedral. Therefore, in ascending order of CFSE (from least negative to most negative): $[NiCl_4]^{2-} < [Ni(H_2O)_6]^{2+} < [Ni(en)_3]^{2+} < [Ni(CN)_4]^{2-}$ III < II < I < IV

Q54. Solution

Correct Answer: (C)

Assertion is true but reason is false. Ions of inert electrolytes are not involved in any electrochemical change until they react chemically with the electrolytes in the two half-cells.

Q55. Solution

Correct Answer: (A)

The graphs are for logarithmic form of arrhenius equation for which we have the following relation,

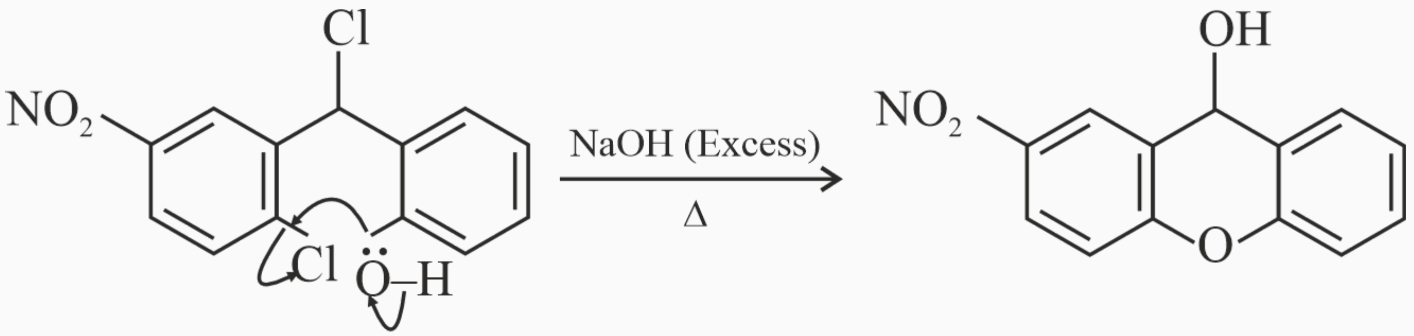
$\ln\ k\ =\ \ln\ A\ -\ \left(\frac{E}{R}\right)\frac{1}{T}\text{intercept}\ =\ \ln\ A;\text{slope}\ =\ -\frac{E}{R}.$

From the given graphs, we can observe that,

$\ln\left(A_I\right)\ >\ \ln\left(A_{II}\right)\ \Rightarrow A_I\ >\ A_{II}\left|\frac{-E_I}{R}\right|\ >\left|\frac{-E_{II}}{R}\right|\ \Rightarrow E_I\ >\ E_{II}$

Q56. Solution

Correct Answer: (B)



The Cl atom which is attached with benzene ring replaces easily due to presence of $-NO_2$ group at p-position w.r.t. Cl.

Q57. Solution
Correct Answer: (A)

The skeletal equation is,

$$\mathrm{Mn^{3+}(aq) \longrightarrow Mn^{2+}(aq) + MnO_2(s) + H^+(aq)}$$

Reduction half reaction

$$\mathrm{Mn^{3+}(aq) + e^- \longrightarrow Mn^{2+}} \qquad \text{....(i)}$$

Oxidation half reaction

$$\mathrm{Mn^{3+}(aq) \longrightarrow \overset{+4}{Mn}O_2 + e^-} \qquad \text{....(ii)}$$

Balance charge by adding $4H^+$ to RHS and then balance O atoms by adding $2H_2O$ to LHS

$$\mathrm{Mn^{3+}(aq) + 2H_2O(l) \longrightarrow MnO_2(s) + e^- + 4H^+(aq)} \qquad \text{....(iii)}$$

By adding (i) and (iii) we get

$$\mathrm{2Mn^{3+}(aq) + 2H_2O(l) \longrightarrow Mn^{2+} + MnO_2(s) + 4H^+(aq)}$$

This represents the final balanced redox reaction (disproportionation reaction).

Q58. Solution
Correct Answer: (A)

The given sparingly soluble compound is $\mathrm{Ga_3(PO_4)_5}$. When this compound dissociates in water, it forms $\mathrm{Ga^{5+}}$ and $\mathrm{PO_4^{3-}}$ ions. The dissociation equilibrium can be written as: $\mathrm{Ga_3(PO_4)_5}(s) \rightleftharpoons 3\mathrm{Ga^{5+}}(aq) + 5\mathrm{PO_4^{3-}}(aq)$ Let 's' be the molar solubility of $\mathrm{Ga_3(PO_4)_5}$. According to the stoichiometry of the dissociation: The concentration of $\mathrm{Ga^{5+}}$ ions at equilibrium will be $3s$. The concentration of $\mathrm{PO_4^{3-}}$ ions at equilibrium will be $5s$. The solubility product constant, $\mathrm{K_{sp}}$, is defined as the product of the concentrations of the ions, each raised to the power of its stoichiometric coefficient in the balanced dissociation equation. So, for $\mathrm{Ga_3(PO_4)_5} : \mathrm{K_{sp}} = [\mathrm{Ga^{5+}}]^3[\mathrm{PO_4^{3-}}]^5$ $\mathrm{K_{sp}} = (3s)^3(5s)^5$ $\mathrm{K_{sp}} = (3^3 \cdot s^3) \cdot (5^5 \cdot s^5)$ $\mathrm{K_{sp}} = (27 \cdot s^3) \cdot (3125 \cdot s^5)$ $\mathrm{K_{sp}} = (27 \times 3125) \cdot s^{(3+5)}$ $\mathrm{K_{sp}} = 84375 \cdot s^8$ $s = \left(\frac{\mathrm{K_{sp}}}{84375}\right)^{\frac{1}{8}}$

Q59. Solution

Correct Answer: (A)

To classify the given coordination compounds, we need to check two conditions for each: whether they are homoleptic and if their central metal ion has an odd number of d-electrons. 1. Homoleptic Complex: A complex is homoleptic if it has only one type of ligand. It is heteroleptic if it has more than one type of ligand. 2. Odd Number of d-electrons: Determine the oxidation state of the central metal ion and then its electronic configuration to count the d-electrons. (P) $[\mathrm{Ti(H_2O)_6}]^{3+}$ Homoleptic/Heteroleptic: Only $\mathrm{H_2O}$ ligands are present, so it is homoleptic. Oxidation State of Ti: Let the oxidation state of Ti be x. $\mathrm{H_2O}$ is a neutral ligand (charge = 0). $x + 6(0) = +3 \implies x = +3$. So, Ti is in the +3 oxidation state. d-electron Count: Titanium (Ti) has atomic number 22. Its ground state electronic configuration is $[\mathrm{Ar}]3d^2 4s^2$. For Ti^{3+}, three electrons are removed (two from $4s$ and one from $3d$). The electronic configuration of Ti^{3+} is $[\mathrm{Ar}]3d^1$. Number of d-electrons = 1 (odd). (Q) $[\mathrm{Fe(CN)_6}]^{4-}$ Homoleptic/Heteroleptic: Only CN^- ligands are present, so it is homoleptic. Oxidation State of Fe: Let the oxidation state of Fe be x. CN^- is a ligand with charge -1. $x + 6(-1) = -4 \implies x - 6 = -4 \implies x = +2$. So, Fe is in the +2 oxidation state. d-electron Count: Iron (Fe) has atomic number 26. Its ground state electronic configuration is $[\mathrm{Ar}]3d^6 4s^2$. For Fe^{2+}, two electrons are removed from $4s$. The electronic configuration of Fe^{2+} is $[\mathrm{Ar}]3d^6$. Number of d-electrons = 6 (even). (R) $[\mathrm{MnCl_4}]^{2-}$ Homoleptic/Heteroleptic: Only Cl^- ligands are present, so it is homoleptic. Oxidation State of Mn: Let the oxidation state of Mn be x. Cl^- is a ligand with charge -1. $x + 4(-1) = -2 \implies x - 4 = -2 \implies x = +2$. So, Mn is in the +2 oxidation state. d-electron Count: Manganese (Mn) has atomic number 25. Its ground state electronic configuration is $[\mathrm{Ar}]3d^5 4s^2$. For Mn^{2+}, two electrons are removed from $4s$. The electronic configuration of Mn^{2+} is $[\mathrm{Ar}]3d^5$. Number of d-electrons = 5 (odd). (S) $[\mathrm{Cr(NH_3)_5Br}]^{2+}$ Homoleptic/Heteroleptic: Contains two different types of ligands ($\mathrm{NH_3}$ and Br^-), so it is heteroleptic. Oxidation State of Cr: Let the oxidation state of Cr be x. $\mathrm{NH_3}$ is neutral (charge = 0), Br^- has charge -1. $x + 5(0) + 1(-1) = +2 \implies x - 1 = +2 \implies x = +3$. So, Cr is in the +3 oxidation state. d-electron Count: Chromium (Cr) has atomic number 24. Its ground state electronic configuration is $[\mathrm{Ar}]3d^5 4s^1$. For Cr^{3+}, one electron is removed from $4s$ and two from $3d$. The electronic configuration of Cr^{3+} is $[\mathrm{Ar}]3d^3$. Number of d-electrons = 3 (odd). (T) $[\mathrm{Ni(CO)_4}]$ Homoleptic/Heteroleptic: Only CO ligands are present, so it is homoleptic. Oxidation State of Ni: Let the oxidation state of Ni be x. CO is a neutral ligand (charge = 0). $x + 4(0) = 0 \implies x = 0$. So, Ni is in the 0 oxidation state. d-electron Count: Nickel (Ni) has atomic number 28. Its ground state electronic configuration is $[\mathrm{Ar}]3d^8 4s^2$. For $\mathrm{Ni}(0)$, the configuration is $[\mathrm{Ar}]3d^8 4s^2$. The d-electron count is 8 (even). Therefore, only compounds (P) and (R) satisfy both conditions.

Q60. Solution

Correct Answer: (C)

Let's analyze each thermodynamic identity: A) The heat absorbed at constant pressure is equal to the change in enthalpy, i.e., $dq_P = dH$. According to the first law of thermodynamics, $dU = dq + dW$. For a process at constant pressure, if only P-V work is considered, $dW = -PdV$. So, $dU = dq - PdV$. Rearranging, $dq = dU + PdV$. Enthalpy (H) is defined as $H = U + PV$. Differentiating H: $dH = dU + PdV + VdP$. At constant pressure ($dP = 0$), $dH = dU + PdV$. Comparing this with $dq_P = dU + PdV$, we find $dq_P = dH$. This statement is $\mathbf{correct}$. B) The heat absorbed at constant volume is equal to the change in internal energy, i.e., $dq_V = dU$. According to the first law of thermodynamics, $dU = dq + dW$. For a process at constant volume ($dV = 0$), the work done $dW = -PdV = 0$. Therefore, $dU = dq_V$. This statement is $\mathbf{correct}$. C) For a system at constant temperature, the change in Gibbs free energy with pressure is given by $\left(\frac{\partial G}{\partial P}\right)_T = -V$. The Gibbs free energy (G) is defined as $G = H - TS$. We also know that $H = U + PV$. Substituting H into the Gibbs free energy definition: $G = U + PV - TS$. To find the differential of G, we differentiate this expression: $dG = dU + PdV + VdP - TdS - SdT$. For a reversible process, from the first law of thermodynamics, $dU = dq_{rev} + dW_{rev}$. For P-V work, $dW_{rev} = -PdV$, and for reversible heat transfer, $dq_{rev} = TdS$. So, $dU = TdS - PdV$. Substitute this expression for dU into the dG equation: $dG = (TdS - PdV) + PdV + VdP - TdS - SdT\ dG = VdP - SdT$. From this fundamental equation for dG, we can identify the partial derivatives: $\left(\frac{\partial G}{\partial P}\right)_T = V$ (when temperature T is constant, $dT = 0$). $\left(\frac{\partial G}{\partial T}\right)_P = -S$ (when pressure P is constant, $dP = 0$). The given identity is $\left(\frac{\partial G}{\partial P}\right)_T = -V$. This statement is $\mathbf{incorrect}$. D) The molar heat capacity at constant pressure is defined as $C_P = \left(\frac{\partial H}{\partial T}\right)_P$. Heat capacity ($C$) is generally defined as the amount of heat required to raise the temperature by one degree, $C = \frac{dq}{dT}$. At constant pressure, we know $dq_P = dH$. Therefore, the heat capacity at constant pressure is $C_P = \left(\frac{\partial H}{\partial T}\right)_P$. This statement is $\mathbf{correct}$. Therefore, the incorrect thermodynamic identity is C.

Q61. Solution

Correct Answer: (D)

In amylo pectin, $\alpha - 1, 4$ and $\alpha - 1, 6$ linkage that provides the attachment point for another chain.

Q62. Solution

Correct Answer: (B)

The energy of an electron in a hydrogen atom (a one-electron system) depends solely on its principal quantum number, n. This means that all orbitals within the same principal energy level (i.e., having the same n value) are degenerate, regardless of their azimuthal quantum number (l) or magnetic quantum number (m_l). Let's analyze the given options: A) $2s, 2p_x, 3s$: The principal quantum numbers are $n = 2$ for $2s$ and $2p_x$, but $n = 3$ for $3s$. Since the n values are not all the same, these orbitals are not degenerate. B) $3p_y, 3d_{xy}, 3s$: The principal quantum numbers for all these orbitals are $n = 3$. Since they all have the same principal quantum number, they are degenerate in a hydrogen atom. C) $1s, 2s, 3s$: The principal quantum numbers are $n = 1$ for $1s$, $n = 2$ for $2s$, and $n = 3$ for $3s$. Since the n values are different, these orbitals are not degenerate. D) $4s, 4p_z, 5d_{z^2}$: The principal quantum numbers are $n = 4$ for $4s$ and $4p_z$, but $n = 5$ for $5d_{z^2}$. Since the n values are not all the same, these orbitals are not degenerate. Therefore, the set of orbitals $3p_y, 3d_{xy}, 3s$ represents a degenerate group for a hydrogen atom. The final answer is $\boxed{B}$.

Q63. Solution

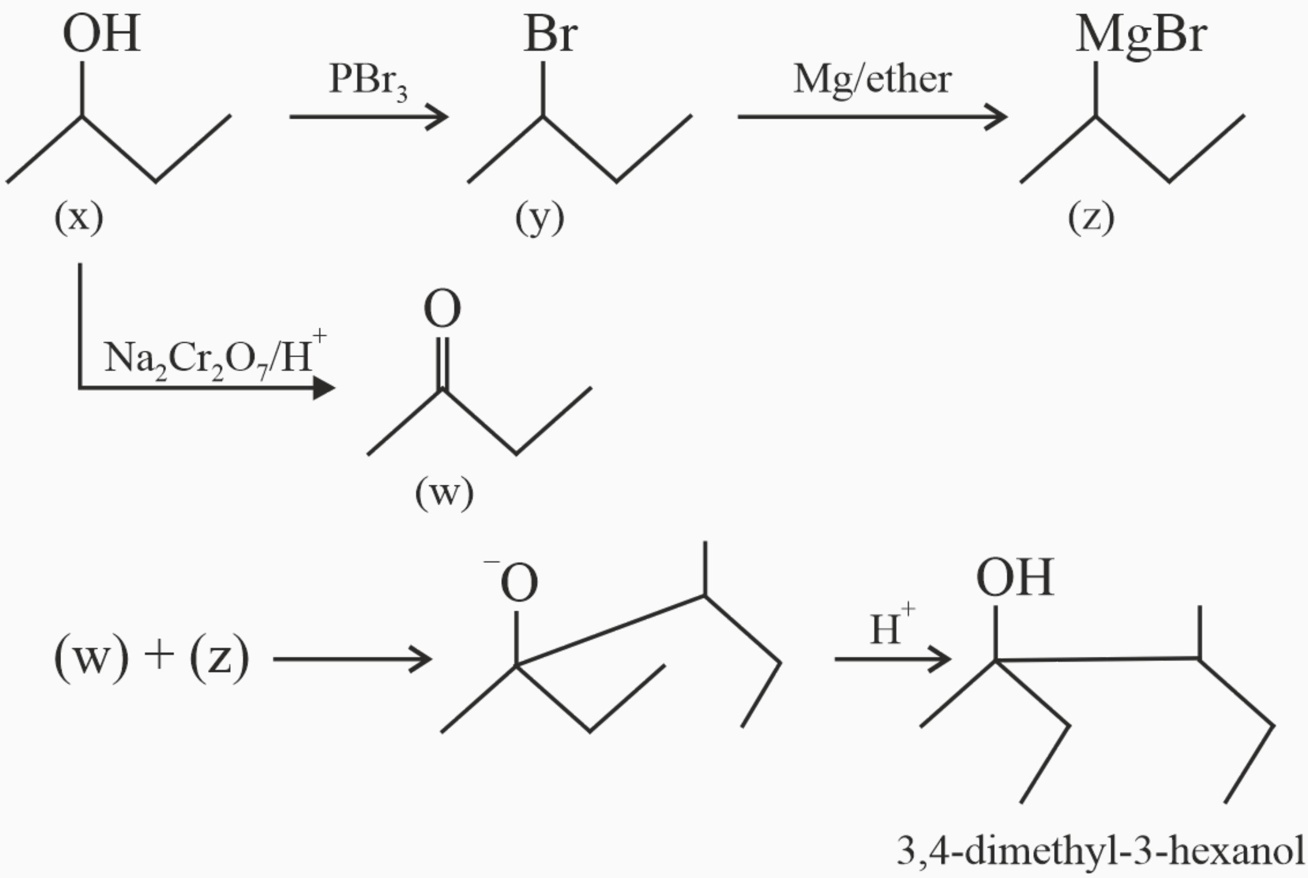
Correct Answer: (D)

Atomic Number	Ionization Enthalpy (kJ/mol)		
	I_1	I_2	I_3
n	1579	3374	6043
n + 1	2075	3952	6125
n + 2	493	4562	6907
n + 3	739	1451	7731

By observing the values of I_1, I_2 & I_3 for atomic number $(\mathrm{n}+2)$, it is observed that $\mathrm{I}_2 \gg \mathrm{I}_1$. This indicates that number of valence shell electrons is 1 and atomic number $(\mathrm{n}+2)$ should be an alkali metal. Also for atomic number $(\mathrm{n}+3), \mathrm{I}_3 \gg \mathrm{I}_2$. This indicates that it will be an alkaline earth metal which suggests that atomic number $(\mathrm{n}+1)$ should be a noble gas & atomic number (n) should belong to Halogen family. Since $\mathrm{n}<10$; hence $\mathrm{n}=9$ (F atom) Note: $\mathrm{n}=1$ (H atom) cannot be the answer because it does not have $I_2 \& I_3$ values.

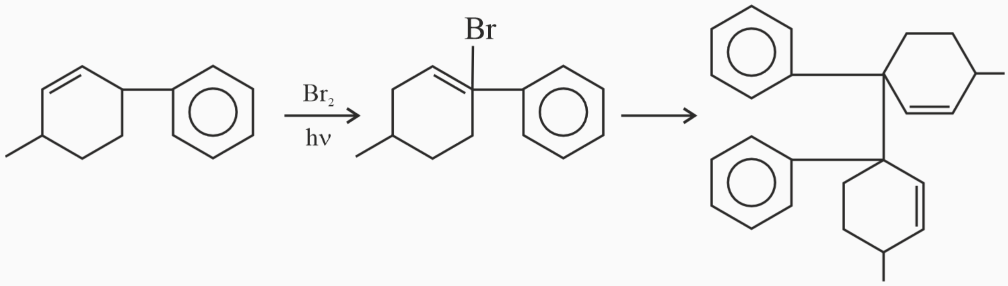
Q64. Solution

Correct Answer: (B)



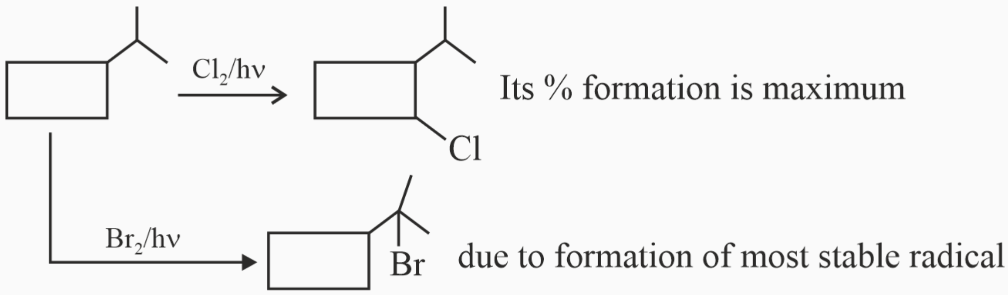
Q65. Solution

Correct Answer: (A)



Q66. Solution

Correct Answer: (B)



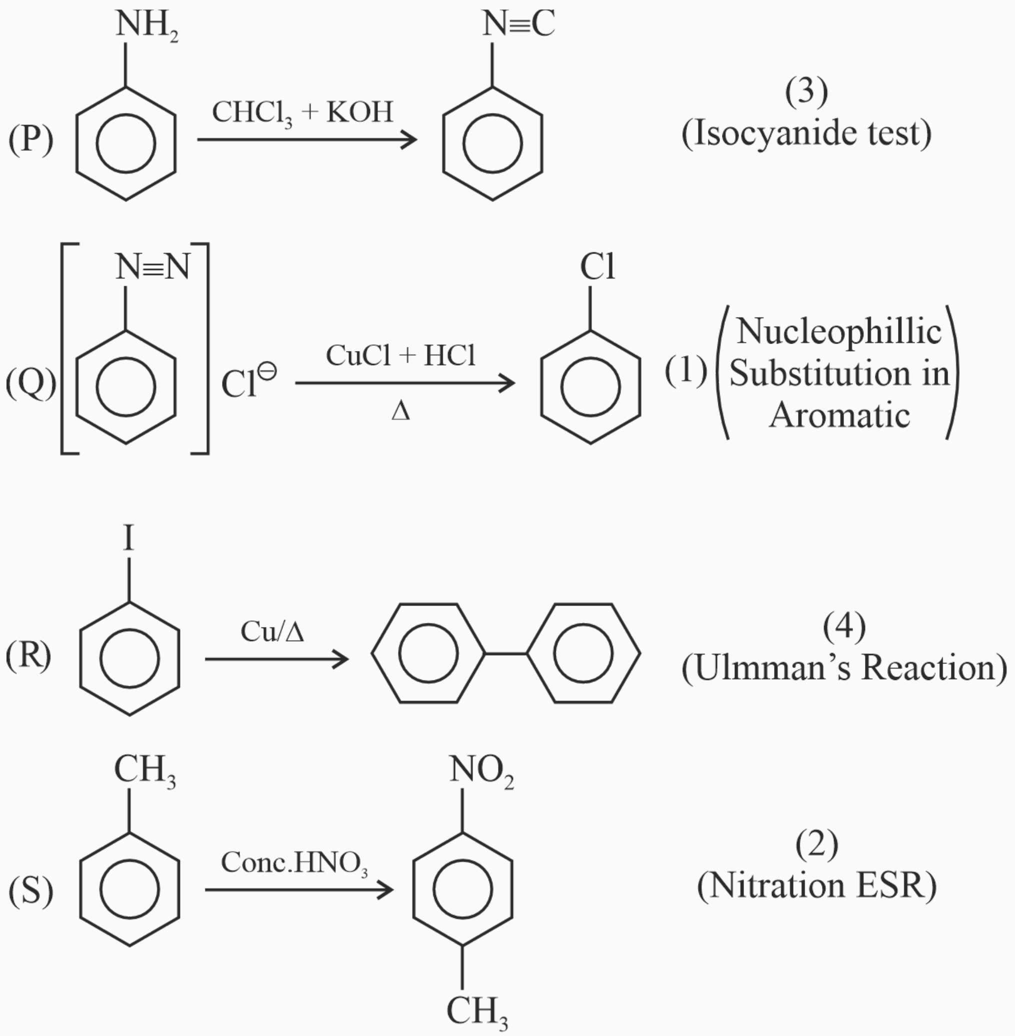
Q67. Solution

Correct Answer: (B)

+M effect of $-\mathrm{NH}-\mathrm{CH}_3 > +\mathrm{M}$ of $-\mathrm{O}-\mathrm{CH}_3$ group disperse the charge of carbocation, hence increases the stability $-\mathrm{CH}_3$ group +HC and +IE so it will disperse the charge loss than $-\mathrm{NH}-\mathrm{CH}_3, -\mathrm{O}-\mathrm{CH}_3$ group. Whereas $-\mathrm{NO}_2$ group show -M and -1 effect due to which positive charge on the carbocation increases, hence stability decreases.

Q68. Solution

Correct Answer: (B)



Q69. Solution

Correct Answer: (C)

The reactions are $4NaCl + K_2Cr_2O_7 + 6H_2SO_4 \rightarrow \underset{\text{(Red vapours)}}{2CrO_2Cl_2} + 4NaHSO_4 + 2KHSO_4 + 3H_2O$

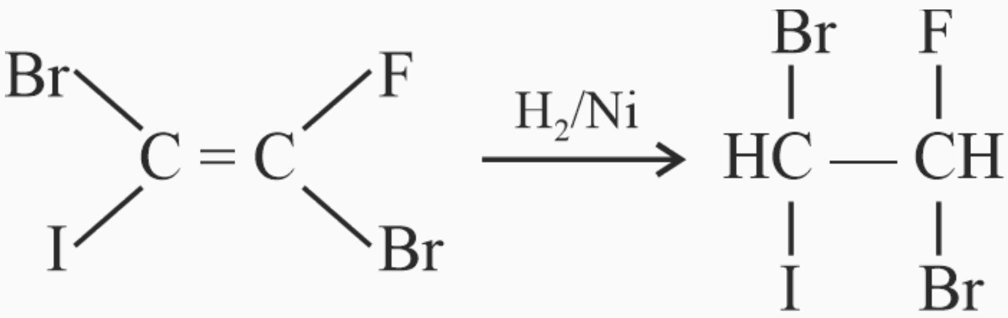
$\underset{\text{chromyl chloride}}{CrO_2Cl_2} + 4NaOH \rightarrow \underset{\text{yellow solution}}{Na_2CrO_4} + 2NaCl + 2H_2O$

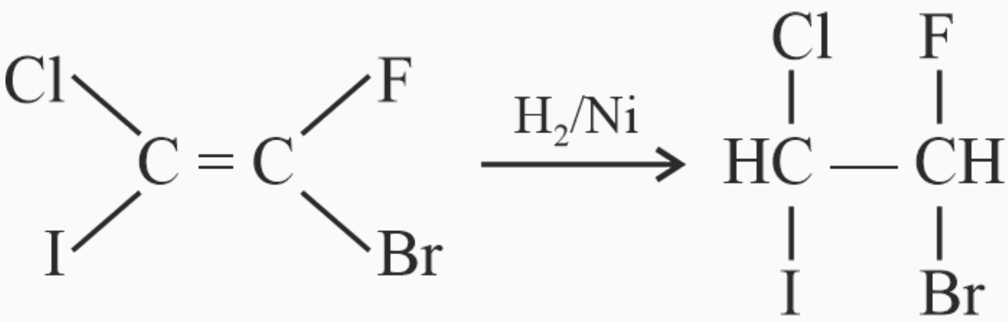
Q70. Solution
Correct Answer: (C)

Nitrogen is an element of Group 15 with atomic number 7. Its electronic configuration is $1s^2 2s^2 2p^3$. In its valence shell (n=2), it has only s and p orbitals. It can form three covalent bonds by sharing its three unpaired p-electrons. Additionally, it can use its lone pair of electrons in the 2s orbital to form one coordinate bond. Therefore, the maximum covalency of Nitrogen is 4 (e.g., in $\mathrm{NH_4^+}$ ion). Nitrogen cannot expand its octet beyond 4 because of the absence of vacant d-orbitals in its valence shell. Phosphorus, on the other hand, is also in Group 15 but has vacant 3d-orbitals in its valence shell. This allows phosphorus to expand its octet and exhibit a covalency of 5 (e.g., in $\mathrm{PCl_5}$) or even 6 (e.g., in $\mathrm{PCl_6^-}$). Regarding the bond strength, the $\mathrm{N-N}$ single bond is significantly weaker than the $\mathrm{P-P}$ single bond. This is primarily due to the small atomic size of Nitrogen. When two small nitrogen atoms are bonded together, the non-bonding lone pairs of electrons on each nitrogen atom are in close proximity. This leads to significant inter-electronic repulsion between these lone pairs, which destabilizes the $\mathrm{N-N}$ single bond and makes it weaker. For phosphorus, due to its larger atomic size, the lone pairs are further apart, and the inter-electronic repulsion is much less, resulting in a stronger $\mathrm{P-P}$ single bond. Thus, option C correctly states the maximum covalency of Nitrogen and the primary reason for the weaker $\mathrm{N-N}$ bond.

Q71. Solution

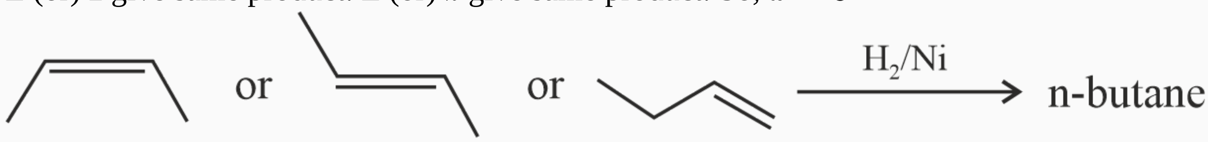
Correct Answer: 5

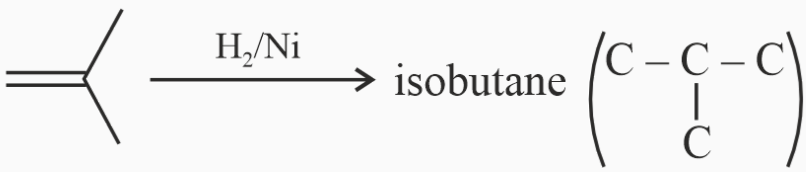




E (or) z give same product.

E (or) z give same product. E (or) z give same product. So, $x = 3$





$Y = 2$

$\therefore X + Y = 5$

Q72. Solution

Correct Answer: 20

a mole

$Li_2CO_3(s) \longrightarrow Li_2O(s) + CO_2(g)$ $(a+b) \times 44 = 22 \quad \Rightarrow \quad a + b = 0.5$

a mole $\quad$ b mole $\quad a \times 74 + b \times 84 = 38$

$MgCO_3(s) \longrightarrow MgO(s) + CO_2(g)$ $a = 0.4 : b = 0.1$

b mole

$\%MgCO_3 = \frac{0.1}{0.4+0.1} \times 100 = 20\%$

Q73. Solution

Correct Answer: 84

$$C_2H_6(\mathrm{~g})+\frac{7}{2}O_2(\mathrm{~g}) \longrightarrow 2CO_2(\mathrm{~g})+3H_2O(\ell)$$
$$\Delta H_t^{\circ}=\sum \Delta H_f^{\circ}(\text{ Products })-\sum \Delta H_f^{\circ}(\text{ Reactants })$$
$$-1564.25=[2 \times(-395)+3 \times(-286)]-[\Delta H_f^{\circ} C_2H_6]$$
$$\Delta H_f^{\circ} C_2H_6=-83.75 \mathrm{~kJ} \mathrm{~mol}^{-1}$$

Q74. Solution

Correct Answer: 3

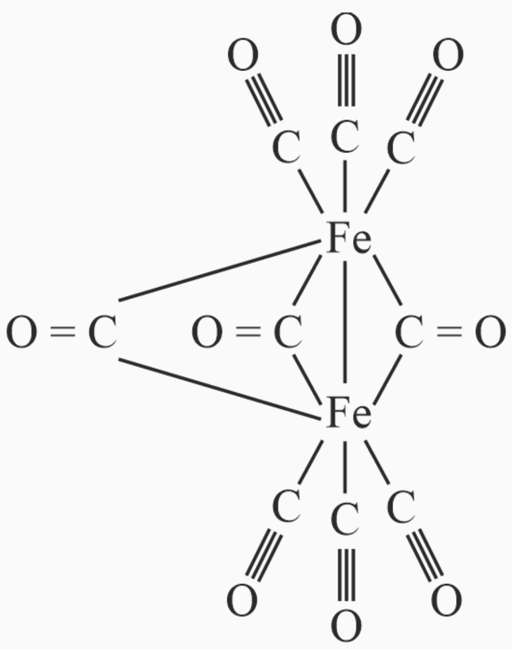
To determine the molecular structure of each species, we apply the VSEPR (Valence Shell Electron Pair Repulsion) theory. This involves identifying the central atom, counting its valence electrons, forming bonds with surrounding atoms, and then determining the number of lone pairs and bond pairs (electron domains) around the central atom. Based on the total number of electron domains, we can predict the electron geometry and subsequently the molecular geometry. 1. SO_2 (Sulfur Dioxide): Central atom: S Valence electrons on S: 6 Bonds with O: S forms two double bonds with two oxygen atoms. (Each double bond counts as one electron domain for VSEPR). Lone pairs on S: $6-(2 \times 2)=2$ electrons, so 1 lone pair. Electron domains: 2 bond pairs + 1 lone pair = 3. Electron geometry: Trigonal planar. Molecular geometry: Bent. 2. NO_2 (Nitrogen Dioxide): Central atom: N Valence electrons on N: 5 Total valence electrons: $5+(2 \times 6)=17$. This is a radical. Bonds with O: N forms one double bond and one single bond with oxygen atoms. There is also one unpaired electron on N. Electron domains: 2 bond pairs + 1 unpaired electron (which acts similarly to a lone pair in terms of repulsion) = 3. Molecular geometry: Bent. 3. O_3 (Ozone): Central atom: O Valence electrons on central O: 6 Bonds with O: Central O forms one double bond and one single bond with the other two oxygen atoms. Lone pairs on central O: $6-(2+1)=3$ electrons, so 1 lone pair (after considering resonance). Electron domains: 2 bond pairs + 1 lone pair = 3. Electron geometry: Trigonal planar. Molecular geometry: Bent. 4. ICl_2^- (Dichloriodide ion): Central atom: I Valence electrons on I: 7 Charge: -1 (add 1 electron) Total electrons for I: $7+1=8$ Bonds with Cl: I forms two single bonds with two chlorine atoms. Lone pairs on I: $8-(2 \times 1)=6$ electrons, so 3 lone pairs. Electron domains: 2 bond pairs + 3 lone pairs = 5. Electron geometry: Trigonal bipyramidal. Molecular geometry: Linear (the three lone pairs occupy the equatorial positions, and the two Cl atoms occupy the axial positions). 5. $SnCl_2$ (Tin(II) Chloride): Central atom: Sn Valence electrons on Sn: 4 Bonds with Cl: Sn forms two single bonds with two chlorine atoms. Lone pairs on Sn: $4-(2 \times 1)=2$ electrons, so 1 lone pair. Electron domains: 2 bond pairs + 1 lone pair = 3. Electron geometry: Trigonal planar. Molecular geometry: Bent. 6. H_2S (Hydrogen Sulfide): Central atom: S Valence electrons on S: 6 Bonds with H: S forms two single bonds with two hydrogen atoms. Lone pairs on S: $6-(2 \times 1)=4$ electrons, so 2 lone pairs. Electron domains: 2 bond pairs + 2 lone pairs = 4. Electron geometry: Tetrahedral. Molecular geometry: Bent. 7. CO_2 (Carbon Dioxide): Central atom: C Valence electrons on C: 4 Bonds with O: C forms two double bonds with two oxygen atoms. Lone pairs on C: $4-(2 \times 2)=0$ electrons, so 0 lone pairs. Electron domains: 2 bond pairs + 0 lone pairs = 2. Electron geometry: Linear. Molecular geometry: Linear. 8. BeH_2 (Beryllium Hydride): Central atom: Be Valence electrons on Be: 2 Bonds with H: Be forms two single bonds with two hydrogen atoms. Lone pairs on Be: $2-(2 \times 1)=0$ electrons, so 0 lone pairs. Electron domains: 2 bond pairs + 0 lone pairs = 2. Electron geometry: Linear. Molecular geometry: Linear. The molecules/ions with a linear molecular structure are ICl_2^-, $CO_{2'}$ and BeH_2. Therefore, there are 3 such species. The final answer is $\boxed{3}$.

Q75. Solution

Correct Answer: 3

In the molecular structure of $Fe_2(CO)_9$, The difference between the number of triply bonded $C \equiv O$ units and doubly bonded $C = O$ units are shown below by structure:

The molecular structure of $Fe_2(CO)_9$ is



$$
\begin{array}{lcc}
\text{Triply bonded } (C \equiv O) \text{ units} & = & 6 \\
\text{Doubly bonded } (C = O) \text{ units} & = & 3 \\
 & & \text{----------} \\
\text{Difference} & = & 3
\end{array}
$$

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