

Answer Key

Mathematics (25 Questions)

| | | | | |
|----------|----------|----------|----------|----------|
| Q1. (A) | Q2. (C) | Q3. (D) | Q4. (D) | Q5. (D) |
| Q6. (D) | Q7. (B) | Q8. (C) | Q9. (D) | Q10. (A) |
| Q11. (C) | Q12. (C) | Q13. (C) | Q14. (A) | Q15. (B) |
| Q16. (A) | Q17. (A) | Q18. (B) | Q19. (C) | Q20. (B) |
| Q21. 3 | Q22. 24 | Q23. 67 | Q24. 8 | Q25. 61 |

Physics (25 Questions)

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|----------|----------|-----------|----------|----------|
| Q26. (C) | Q27. (D) | Q28. (D) | Q29. (C) | Q30. (A) |
| Q31. (B) | Q32. (D) | Q33. (C) | Q34. (C) | Q35. (B) |
| Q36. (A) | Q37. (D) | Q38. (D) | Q39. (D) | Q40. (A) |
| Q41. (C) | Q42. (B) | Q43. (B) | Q44. (B) | Q45. (A) |
| Q46. 12 | Q47. 8 | Q48. 1200 | Q49. 3 | Q50. 80 |

Chemistry (25 Questions)

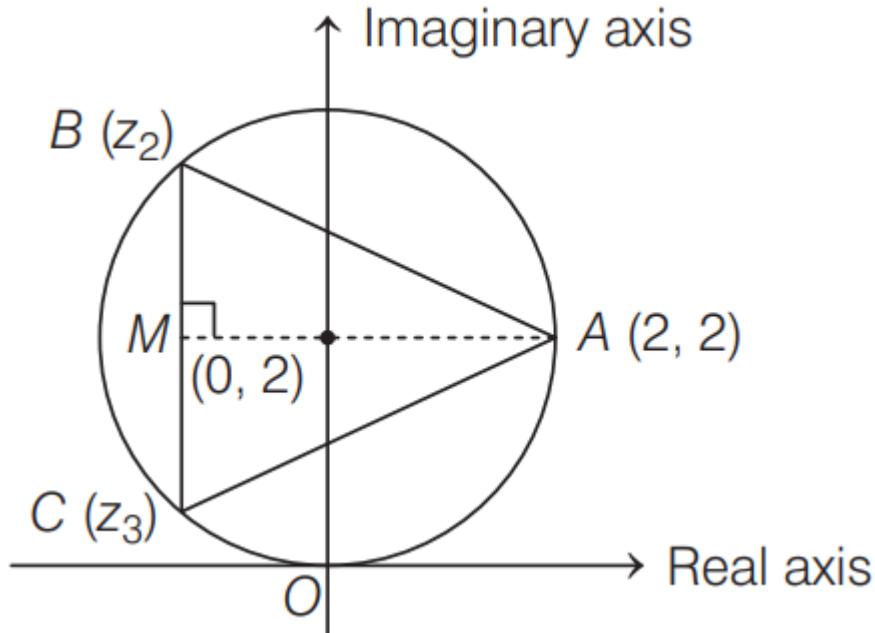
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|----------|----------|----------|----------|----------|
| Q51. (C) | Q52. (B) | Q53. (D) | Q54. (A) | Q55. (D) |
| Q56. (B) | Q57. (A) | Q58. (C) | Q59. (D) | Q60. (D) |
| Q61. (D) | Q62. (D) | Q63. (B) | Q64. (C) | Q65. (D) |
| Q66. (C) | Q67. (B) | Q68. (B) | Q69. (D) | Q70. (C) |
| Q71. 815 | Q72. 30 | Q73. 139 | Q74. 24 | Q75. 3 |

Solutions

Q1. Solution

Correct Answer: (A)

According to given information $|z - 2i| = 2$ is a circle having centre is $(0, 2)$ and radius is 2 .



If the area of $\triangle ABC$ is maximum the triangle must be equilateral triangle and point M is the mid point of BC , where M is the foot of perpendicular of point A ($z_1 = 2 + 2i$) on BC .

\therefore Sum of the imaginary parts of z_2 and z_3 is twice of the imaginary part of $M = 2 \times 2 = 4$.

Q2. Solution**Correct Answer: (C)**

Given that

$$f(2x^2 - 1) = 2x^3 f(x) \dots (\text{i})$$

Replacing x by $-x$ in (i), we get

$$f(2(-x)^2 - 1) = 2(-x)^3 f(-x)$$

$$\Rightarrow f(2x^2 - 1) = -2x^3 f(-x) \dots (\text{ii})$$

From equations (i) and (ii), we get

$$f(x) = \frac{f(2x^2 - 1)}{2x^3} \text{ and } f(-x) = \frac{f(2x^2 - 1)}{-2x^3}$$

$$\text{So, } f(-x) = -f(x)$$

i.e., $f(x)$ is an odd function.

$$\text{So, } f(0) = 0.$$

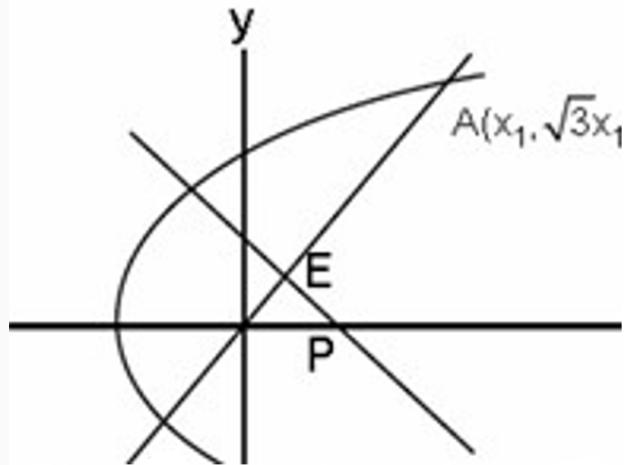
As even order derivative of odd function will also be odd function.

$$f^{(2010)}(0) = 0$$

Q3. Solution

Correct Answer: (D)

$F(0, 0)$, equation of straight line through points A and B will be $y = \sqrt{3}x$. Substitute it into the equation of the parabola. We get $3x^2 - 8x - 16 = 0$ If roots are x_1 and x_2 then, $x_1 + x_2 = \frac{8}{3}$ and $x_1x_2 = -\frac{16}{3}$ now $A(x_1, \sqrt{3}x_1)$ and $B(x_2, \sqrt{3}x_2)$ then mid point AB is $E\left(\frac{x_1+x_2}{2}, \sqrt{3}\left(\frac{x_1+x_2}{2}\right)\right) = \left(\frac{4}{3}, \frac{4}{\sqrt{3}}\right)$ Equation of



perpendicular bisector is $y - \frac{4}{\sqrt{3}} = -\frac{1}{\sqrt{3}}(x - \frac{4}{3})$

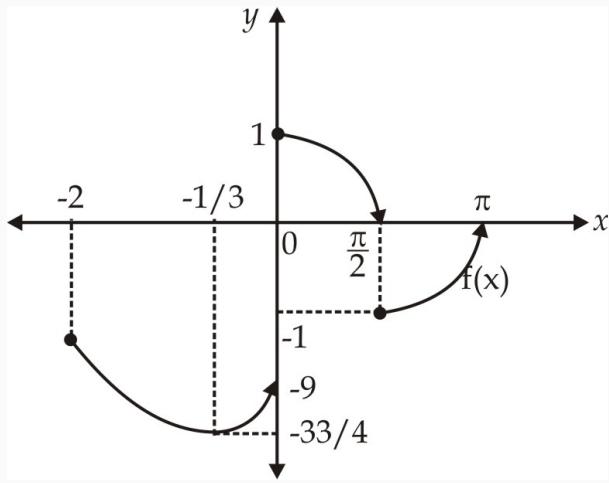
$$\Rightarrow \sqrt{3}y - 4 = -x + \frac{4}{3} \text{ Hence } P \text{ is } \left(\frac{16}{3}, 0\right)$$

$$\ell = \frac{16}{3} \Rightarrow \frac{3}{2}\ell = 8.$$

Q4. Solution**Correct Answer: (D)**

$$f'(x) = \begin{cases} 3x^2 + 2x - 10 & , -2 \leq x < 0 \\ \cos x & , 0 < x < \frac{\pi}{2} \\ -\sin x & , \frac{\pi}{2} \leq x < \pi \end{cases}$$

Draw the graph of $y = f'(x)$

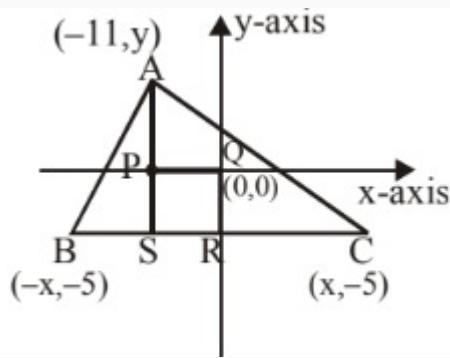


The graph of $f'(x)$ changes its sign negative to positive about $x = 0$ and positive to negative about $x = \frac{\pi}{2}$.

$\therefore x = 0$ is the point of local minima and $x = \frac{\pi}{2}$ is the point of local maxima.

Q5. Solution

Correct Answer: (D)



Let $Q(0, 0)$, $P(-11, 0)$, $R(0, -5)$ and $S(-11, -5)$

Since R is mid point of BC .

Let $B(-x, -5)$ then C is $(x, -5)$.

Also $A(-11, y)$ for some y .

Now BP is an altitude, perpendicular to

$$AC \Rightarrow m_{BP} \cdot m_{AC} = -1$$

$$\text{or } \left(\frac{5}{x-11}\right) \left(\frac{y+5}{-11-x}\right) = -1$$

$$\text{or } 5(y+5) = (x+11)(x-11) \dots (1)$$

Also Q is equidistant from A & C ,

$$\text{so } y^2 + 121 = x^2 + 25 \dots (2)$$

From (1) & (2), we get

$$5y + 25 = (y^2 + 96) - 121$$

$$\text{or } y^2 - 5y - 50 = 0 \text{ gives } y = 10, 5$$

But $y = -5$ is not possible

$$\text{Hence } y = 10 \Rightarrow x = 14$$

$$\therefore BC = 2x = 28$$

Q6. Solution

Correct Answer: (D)

Let $A = (0, 0)$, $B = (4, 0)$, $C(0, 3)$

Circum centre S is $(2, 3/2)$ and circum radius $= \frac{5}{2}$

$$\text{Equation of } S \text{ is } (x-2)^2 + (x-3/2)^2 = \frac{25}{4} \dots \dots (1)$$

$$\text{If circle } S_1 \text{ and } S \text{ touch internally } \Rightarrow \sqrt{(r_1-2)^2 + (r_1-3/2)^2} = |r_1 - 5/2|$$

$$\Rightarrow r_1^2 - 2r_1 = 0 \Rightarrow r_1 = 2$$

If S_2 is having radius r_2 and touching AB and AC \Rightarrow centre of $S_2 = (r_2, r_2)$

$$S_2 \text{ touches } S \text{ externally } \Rightarrow (r_2-2)^2 + (r_2-3/2)^2 = (r_2 + 5/2)^2$$

$$\Rightarrow r_2^2 - 12r_2 = 0 \Rightarrow r_2 = 12 \Rightarrow r_1r_2 = 24$$

Q7. Solution**Correct Answer: (B)**

Given, $(fog)(x) = x$ and $f(x) = 2x + \cos x + \sin^2 x$

So, $g(x)$ is the inverse of $f(x)$

$$\Rightarrow 1 + (2n - 1)\pi = 2x + \cos x + \sin^2 x$$

$$\Rightarrow 1 + (2n - 1)\pi = 2x + \cos x + 1 - \cos^2 x$$

$$\Rightarrow 2x + \cos x - \cos^2 x = (2n - 1)\pi$$

$$\text{Now, } n = 1 \Rightarrow x = \frac{\pi}{2}$$

$$n = 2 \Rightarrow x = \frac{3\pi}{2}$$

$$n = 3 \Rightarrow x = \frac{5\pi}{2}$$

$$\vdots \quad \vdots \quad \vdots$$

$$n = n \Rightarrow x = (2n - 1)\frac{\pi}{2}$$

$$\text{So, } \sum_{n=1}^{99} g(1 + (2n - 1)\pi) = \frac{\pi}{2} + \frac{3\pi}{2} + \frac{5\pi}{2} + \dots \text{ upto 99 terms}$$

$$= \frac{\pi}{2} (1 + 3 + 5 + \dots \text{ upto 99 terms})$$

$$= (99)^2 \frac{\pi}{2}$$

Q8. Solution**Correct Answer: (C)**

$$\omega^{r_1} + \omega^{r_2} + \omega^{r_3} = 0 \quad \{1 + \omega + \omega^2 = 0\}$$

$$r_1 \qquad \qquad r_2 \qquad \qquad r_3$$

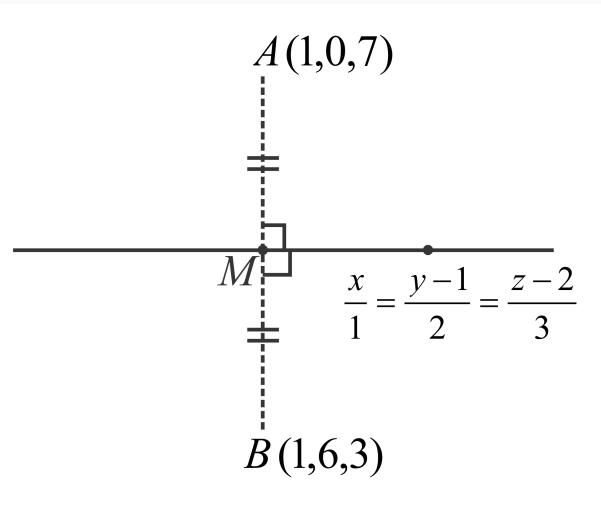
$$\downarrow \qquad \qquad \downarrow \qquad \qquad \downarrow$$

$$3 \text{ or } 6 \qquad 1 \text{ or } 4 \qquad 2 \text{ or } 5$$

$$\text{required prob.} = \frac{2 \times 2 \times 2 \times 3}{6^3} = \frac{2}{9}$$

Q9. Solution**Correct Answer: (D)**

Mid – point of AB is $M(1, 3, 5)$.



Which lies on $\frac{x}{1} = \frac{y-1}{2} = \frac{z-2}{3}$

$$\text{as } \frac{1}{1} = \frac{3-1}{2} = \frac{5-2}{3} \Rightarrow 1 = 1 = 1$$

Hence, statement II is true

Also, directions ratios of AB is $(1-1, 6-0, 3-7) \equiv (0, 6, -4) \dots (1)$

and direction ratios of straight line is

$$(1, 2, 3) \dots (2)$$

The two lines are perpendicular, if

$$0(1) + 6(2) + (-4)(3) = 12 - 12 = 0$$

Hence, statement I is true and statement II is true and statement II is a correct explanation for statement I.

Q10. Solution

Correct Answer: (A)

$$\text{Given, } \frac{\sin^{-1} x^2 + \cos^{-1} x}{\cos^{-1} x^2 + \sin^{-1} x} = -3$$

$$\Rightarrow \sin^{-1} x^2 + \cos^{-1} x = -3 \cos^{-1} x^2 - 3 \sin^{-1} x$$

$$\Rightarrow \sin^{-1} x^2 + 3 \cos^{-1} x^2 + \cos^{-1} x + 3 \sin^{-1} x$$

$$x = 0 \Rightarrow \pi + 2 \cos^{-1} x^2 + 2 \sin^{-1} x = 0$$

$$\Rightarrow \cos^{-1} x^2 + \sin^{-1} x = \frac{-\pi}{2}$$

Since, $0 \leq \cos^{-1} x^2 \leq \frac{\pi}{2}$ and

$$\frac{-\pi}{2} \leq \sin^{-1} x \leq \frac{\pi}{2}$$

So, $\cos^{-1} x^2 = 0 \Rightarrow x = \pm 1$ and

$$\sin^{-1} x = \frac{-\pi}{2} \Rightarrow x = -1.$$

\therefore Only solution is $x = \alpha = -1$.

$$\text{Hence, } \frac{\sec^{-1} \alpha - \tan^{-1} \alpha}{\cot^{-1} \alpha - \operatorname{cosec}^{-1} \alpha} =$$

$$\frac{\sec^{-1}(-1) - \tan^{-1}(-1)}{\cot^{-1}(-1) - \operatorname{cosec}^{-1}(-1)} = \frac{\frac{\pi}{4}}{\frac{3\pi}{4} + \frac{\pi}{2}} = \frac{\frac{5\pi}{4}}{\frac{5\pi}{4}}$$

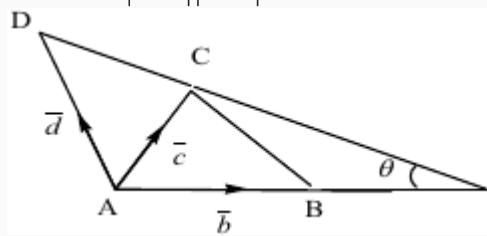
Q11. Solution

Correct Answer: (C)

Let $AC = \lambda \Rightarrow AB = 5\lambda$ and $AD = 3\lambda$

$$\overline{AB} = \bar{b}, \overline{AC} = \bar{c}, \overline{AD} = \bar{d}$$

$$\cos \theta = \frac{\overline{BA} \cdot \overline{CD}}{|\overline{BA}| |\overline{CB}|}$$

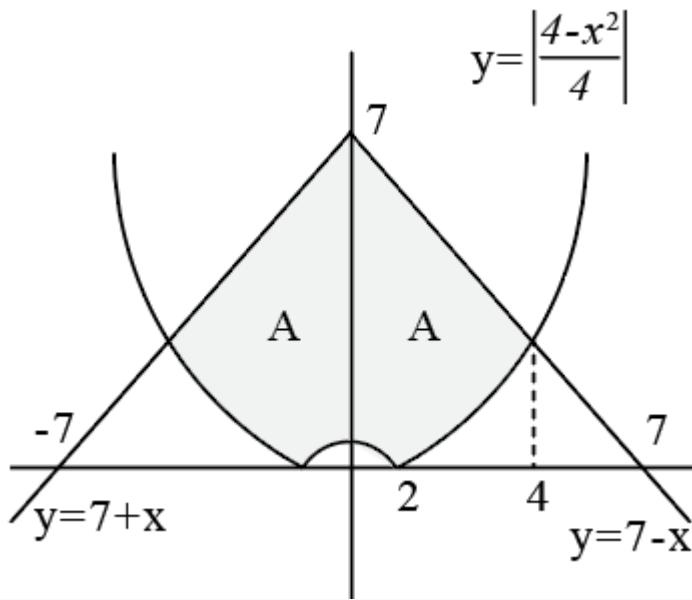


$$\begin{aligned} &= \frac{-\bar{b}(\bar{d} - \bar{c})}{|\bar{b}| |\bar{c} - \bar{d}|} \\ &= \frac{\bar{d} \cdot \bar{b} - \bar{b} \cdot \bar{c}}{5\lambda \cdot \sqrt{7}\lambda} \\ &= \frac{10\lambda^2}{5\sqrt{7}\lambda^2} \end{aligned}$$

$$\theta = \cos^{-1} \left(\frac{2}{\sqrt{7}} \right)$$

Q12. Solution

Correct Answer: (C)



Required Area = 2 A

$$A = \int_0^2 \left[7 - x - \left(\frac{4 - x^2}{4} \right) \right] dx + \int_2^4 \left[(7 - x) - \left(\frac{x^2 - 4}{4} \right) \right] dx,$$

$$\Rightarrow A = 16$$

∴ Ans : 32 sq. units

Q13. Solution

Correct Answer: (C)

α, β are roots of $x^2 + \alpha x + \beta = 0$

$$\Rightarrow \alpha + \beta = -\alpha \text{ and } \alpha\beta = \beta \Rightarrow \alpha = 1, \beta = -2$$

$$\text{Now, } ||x + 2| - 1| < 1$$

$$\Rightarrow -1 < |x + 2| - 1 < 1$$

$$\Rightarrow 0 < |x + 2| < 2$$

$$\Rightarrow -2 < x + 2 < 2, x + 2 \neq 0$$

$$\Rightarrow -4 < x < 0, x \neq -2$$

$$\Rightarrow x \in (-4, -2) \cup (-2, 0)$$

So, there are two integral values of x , i.e. $-3, -1$

Q14. Solution

Correct Answer: (A)

$x = 1$ satisfies the equation

$$(a - 3b)x^2 + (2b + 5a)x + (b - 6a) = 0 \therefore x = 1 \text{ is a root of the equation}$$

Now $T_m = \frac{1}{n}, T_n = \frac{1}{m}$ Let A&D be first term and common difference respectively of the AP then $A + (m-1)D = \frac{1}{n} \dots (i)$

$$A + (n-1)D = \frac{1}{m} \dots (ii) \Rightarrow D = \frac{1}{mn}, A = \frac{1}{mn} \therefore T_{mn} = \frac{1}{mn} + (mn-1)\frac{1}{mn} = 1$$

Q15. Solution**Correct Answer: (B)**

2 coins can be both 10 rupee coins, both 5 rupee coins or one 5 rupee coin and one 10 rupee coin

So, expected value

$$\begin{aligned} &= \frac{^{10}C_2}{^{15}C_2} \times 20 + \frac{^5C_2}{^{15}C_2} \times 10 + \frac{^{10}C_1 \cdot ^5C_1}{^{15}C_2} \times 15 = \frac{3}{7} \times 20 + \frac{2}{21} \times 10 + \frac{10}{21} \times 15 \\ &= \frac{350}{21} = \frac{50}{3} \end{aligned}$$

i.e. $\lambda = \frac{50}{3}$

Hence, $\frac{9\lambda}{4} = 37.5$

.

Q16. Solution**Correct Answer: (A)**

$$\begin{aligned} f(x) &= \cos x - \int_0^x (x-t)f(t)dt \\ \Rightarrow f(x) &= \cos x - x \int_0^x f(t)dt + \int_0^x t f(t)dt \\ (\text{differentiating w.r.t. } x \text{ by Leibnitz's Rule}) \\ \Rightarrow f'(x) &= -\sin x - xf(x) - \int_0^x f(t)dt + xf(x) \\ \Rightarrow f'(x) &= -\sin x - \int_0^x f(t)dt \\ (\text{again differentiating w.r.t. } x) \\ \Rightarrow f''(x) &= -\cos x - f(x) \\ \Rightarrow f''(x) + f(x) &= -\cos x \end{aligned}$$

Q17. Solution

Correct Answer: (A)

$$I = \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \frac{x^2 \cos x}{1+e^{-x}} dx \dots (i)$$

$$I = \frac{\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \frac{(-\frac{\pi}{2} + \frac{\pi}{2} - x)^2 \cdot \cos(-\frac{\pi}{2} + \frac{\pi}{2} - x)}{1+e^{(-\frac{\pi}{2} + \frac{\pi}{2} + x)}} dx}{\dots \left[\int_a^b f(x) dx = \int_a^b f(a+b-x) dx \right]}$$

$$= \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \frac{x^2 \cos x}{1+e^x}$$

Adding equation (i) and (ii), we get

$$2I = \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \left(\frac{x^2 \cos x}{1+e^x} + \frac{x^2 \cos x}{1+e^{-x}} \right) dx$$

$$2I = \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} x^2 \cos x \left[\frac{1}{1+e^x} + \frac{1}{1+e^{-x}} \right] dx$$

$$2I = \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} x^2 \cos x \left[\frac{1}{1+e^x} + \frac{e^x}{e^x + 1} \right] dx$$

$$\therefore 2I = \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} x^2 \cdot \cos x dx$$

$$\therefore 2I = 2 \int_0^{\frac{\pi}{2}} x^2 \cos x dx$$

$$\therefore \left[\int_{-a}^a f(x) dx = 2 \int_0^a f(x) dx \right]$$

if $f(x)$ is even function

$$\therefore I = \int_0^{\frac{\pi}{2}} x^2 \cos x \cdot dx$$

$$= \left[x^2 \cdot \sin x - 2 \int x \cdot \sin x dx \right]_0^{\frac{\pi}{2}}$$

$$= \left[x^2 \sin x - 2 \left(-x \cos x + \int \cos x dx \right) \right]_0^{\frac{\pi}{2}},$$

$$= \left[x^2 \sin x + 2x \cos x - 2 \sin x \right]_0^{\frac{\pi}{2}}$$

$$= \left(\frac{\pi^2}{4} - 2 \sin \frac{\pi}{2} - 0 + 0 - 0 \right)$$

$$= \frac{\pi^2}{4} - 2$$

Q18. Solution**Correct Answer: (B)**

$$\frac{a_{n-1}a_{n+1}-a_n^2}{2a_{n-1}\cdot a_n} = \frac{1}{n(n^2-1)} \Rightarrow \frac{a_{n+1}}{a_n} - \frac{a_n}{a_{n-1}} = \frac{2}{n(n+1)(n-1)} = \frac{(n+1)-(n-1)}{n(n+1)(n-1)}$$

$$\frac{a_{n+1}}{a_n} - \frac{a_n}{a_{n-1}} = \frac{1}{n(n-1)} - \frac{1}{n(n+1)}$$

$$\frac{a_n}{a_{n-1}} - \frac{a_{n-1}}{a_{n-2}} = \frac{1}{(n-1)(n-2)} - \frac{1}{(n-1)n}$$

$$\frac{a_3}{a_2} - \frac{a_2}{a_1} = \frac{1}{2} - \frac{1}{3}$$

$$\frac{a_{n+1}}{a_n} - \frac{a_2}{a_1} = \frac{1}{2} - \frac{1}{n(n+1)}$$

$$\frac{a_{n+1}}{a_n} = \frac{3}{2} - \left(\frac{1}{n} - \frac{1}{n+1} \right)$$

$$S = \sum_{k=2}^{2000} \frac{a_{k+1}}{a_k} = \sum_{k=2}^{2000} \frac{3}{2} - \left(\frac{1}{k} - \frac{1}{k+1} \right)$$

$$S = \frac{3}{2} \times 1999 - \left[\frac{1}{2} - \frac{1}{3} + \frac{1}{3} - \dots + \frac{1}{2000} - \frac{1}{2001} \right]$$

$$= \frac{3 \times 1999}{2} - \frac{1}{2} + \frac{1}{2001}$$

$$= \frac{5997 - 1}{2} + \frac{1}{2001}$$

$$S = 2998 + \frac{1}{2001}$$

$$[S] = 2998$$

Q19. Solution**Correct Answer: (C)**

Three digits occur twice each

$$\frac{6!}{2!2!2!} \times 10 = 900$$

Two digits occur three each

$$\frac{6!}{3!3!} \times 10 = 200$$

One digit occurs four times and the other twice $2 \times \frac{6!}{4!2!} \times 10 = 300$

Finally all digits are the same. There are 5 such numbers.

Thus the total number of admissible numbers is $900 + 200 + 300 + 5 = 1405 \sim$

Q20. Solution**Correct Answer: (B)**

$$|x| + |y| \leq \frac{1}{2}$$

$$\text{If } x = y, \quad 2|x| \leq \frac{1}{2}, -\frac{1}{4} \leq x \leq \frac{1}{4}$$

$\therefore (x, x) \notin R \quad \forall x \in \text{real no.}$

$\therefore R$ is not reflexive

$$\text{If } |x| + |y| \leq \frac{1}{2} \Rightarrow |y| + |x| \leq \frac{1}{2}$$

$$\therefore (x, y) \in R \Rightarrow (y, x) \in R$$

$\therefore R$ is symmetric

$$\text{If } |x| + |y| \leq \frac{1}{2} \text{ and } |y| + |z| \leq \frac{1}{2} \Rightarrow |x| + |z| \leq \frac{1}{2}$$

$\therefore R$ is not transitive.

Q21. Solution**Correct Answer: 3**

$$f(x) = \frac{1}{2} - x + \frac{1}{2}[2x] - \frac{1}{2}[1 - 2x] \text{ for } x \in [0, 1], 2x \in [0, 2] \text{ and } 2x \text{ takes integer values } 0, 1, 2 \text{ at } x = 0, \frac{1}{2}, 1$$

Also for $x \in [0, 1]$; $(1 - 2x) \in [-1, 1]$ and $(1 - 2x)$ takes integer values $-1, 0, 1$ at $x = 1, \frac{1}{2}$ and 0 respectively.

So, we shall break the interval $[0, 1]$ at $x = 1$

$$\therefore f(x) = \begin{cases} \frac{1}{2} - 0 + 0 - \frac{1}{2}; & x = 0 \\ \frac{1}{2} - x + \frac{1}{2}(0) - \frac{1}{2}(0); & 0 < x < \frac{1}{2} \\ \frac{1}{2} - \frac{1}{2} + \frac{1}{2}(1) - \frac{1}{2}(0); & x = \frac{1}{2} \\ \frac{1}{2} - x + \frac{1}{2}(1) - \frac{1}{2}(-1); & \frac{1}{2} < x < 1 \\ \frac{1}{2} - 1 + \frac{1}{2}(2) - \frac{1}{2}(-1); & x = 1 \\ 0; & x = 0 \end{cases}$$

$$\Rightarrow f(x) = \begin{cases} \frac{1}{2} - x; & 0 < x < \frac{1}{2} \\ \frac{1}{2}; & x = \frac{1}{2} \\ \frac{3}{2} - x; & \frac{1}{2} < x < 1 \\ 1; & x = 1 \end{cases}$$

$\therefore f(x)$ is discontinuous at $x = 0, \frac{1}{2}$ and 1 and

$$f'(x) = \begin{cases} -1; & 0 < x < \frac{1}{2} \\ -1; & \frac{1}{2} < x < 1 \end{cases}$$

$\Rightarrow f(x)$ is non-differentiable and discontinuous at $x = 0, \frac{1}{2}$ and 1 i.e., at 3 points.

Q22. Solution**Correct Answer: 24**

$$A^T = A, B^T = -B$$

$$(A+B)(A-B) = (A-B)(A+B)$$

$$\Rightarrow A^2 - AB + BA - B^2 = A^2 + AB - BA - B^2$$

$$\Rightarrow AB = BA \dots \dots \text{(i)}$$

$$\text{Now, } (AB)^T = B^T A^T = -BA = -AB = (-1)^k AB$$

$\Rightarrow k$ is an odd number

$$\Rightarrow k = 3, 5, 7, 9$$

$$\text{Sum} = 24$$

Q23. Solution**Correct Answer: 67**

$$\begin{aligned} \text{Let } S &= \sum_{k=0}^{100} \left(\frac{k}{k+1} \right) \left({}^{100}C_k \right) = \sum_{k=0}^{100} \left(\frac{k+1-1}{k+1} \right)^{100} C_k \\ &= \sum_{k=0}^{100} {}^{100}C_k - \sum_{k=0}^{100} \frac{1}{k+1} {}^{100}C_k \\ &= 2^{100} - \frac{1}{101} \sum_{k=0}^{100} \frac{101}{k+1} C_k \\ &= 2^{100} - \frac{1}{101} \sum_{k=0}^{100} {}^{101}C_{k+1} \\ &= 2^{100} - \frac{1}{101} (2^{101} - 1) \\ &= \frac{101 \cdot 2^{100} - 2^{101} + 1}{101} = \frac{99 \cdot 2^{100} + 1}{101} \end{aligned}$$

$$\text{So, } a = 99, b = 1, c = 101$$

$$\text{Hence, } \left(\frac{a+b+c}{3} \right)_{\text{least}} = 67$$

Q24. Solution**Correct Answer: 8**

$$a_1 e_1 = a_2 e_2$$

$$PF_1^2 + PF_2^2 = 4a_1^2 e_1^2 \dots (1) \text{ Using Pythagoras theorem}$$

$$\text{Given } PF_1 + PF_2 = 2a_1 \dots (2)$$

From Eqns. (1) and (4)

$$[PF_1 + PF_2] = 2a_2 \dots (3)$$

$$(2)^2 + (3)^2 \Rightarrow 2 [PF_1^2 + PF_2^2] = 24 (a_1^2 + a_2^2) \dots (4)$$

$$\therefore \frac{1}{e_1^2} + \frac{1}{e_2^2} = 2$$

$$2(a_1^2 + a_2^2) = 4a_1^2 e_1^2 \quad \text{Let } \frac{1}{e_1} = \sqrt{2} \cos \theta, \frac{1}{e_2} = \sqrt{2} \sin \theta$$

$$a_1^2 + a_2^2 = 2(a_1^2 e_1^2)$$

$$\therefore 1 + \left(\frac{a_2}{a_1} \right)^2 = 2e_1^2$$

$$1 + \left(\frac{e_1}{e_2} \right)^2 = 2e_1^2$$

$$\therefore E = 9e_1^2 + e_2^2 = \frac{9}{2} \times \sec^2 \theta + \frac{1}{2} \operatorname{cosec}^2 \theta$$

$$= \frac{1}{2} [9(1 + \tan^2 \theta) + 1 + \cot^2 \theta]$$

$$= \frac{1}{2} [10 + 9 \tan^2 \theta + \cot^2 \theta] \text{ minimum value} = 6 \text{ using AM} \geq \text{GM}$$

$$\therefore E_{\min.} = 8$$

Q25. Solution

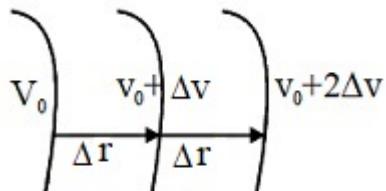
Correct Answer: 61

We have $(\overrightarrow{OP})^2 = (e^t + e^{-t})^2 (\overrightarrow{a})^2 + (e^t - e^{-t})^2 + 2(e^t + e^{-t})(e^t - e^{-t})(\overrightarrow{a} \cdot \overrightarrow{b})$
 $\left((\overrightarrow{a})^2 = |\overrightarrow{a}|^2 = 9, (\overrightarrow{b})^2 = |\overrightarrow{b}|^2 = 16 \text{ and } \overrightarrow{a} \cdot \overrightarrow{b} = |\overrightarrow{a}| |\overrightarrow{b}| \cos \frac{2\pi}{3} \right)$
 $\Rightarrow |\overrightarrow{OP}|^2 = 9(e^t + e^{-t})^2 + 16(e^t - e^{-t})^2 + 2(e^{2t} - e^{-2t}) \cdot 3 \cdot 4 \cdot \left(-\frac{1}{2}\right) = 13e^{2t} + 37e^{-2t} - 14$
 $\Rightarrow |\overrightarrow{OP}|_{\min}^2 = 2\sqrt{13 \times 37} - 14$
 $= 2\sqrt{481} - 14$
 $\Rightarrow a = 481, b = 7$

Q26. Solution

Correct Answer: (C)

Check video solution for detailed explanation



$$E = -\frac{\Delta V}{\Delta r}$$

$\therefore \Delta v$ and Δr are constant

$E = \text{constant}$

$$E = \frac{Kq}{r^2} = c$$

$$\Rightarrow q \propto r^2$$

$$\therefore q = \int_0^r \rho 4\pi r^2 dr$$

$$\Rightarrow \rho \propto \frac{1}{r}$$

Q27. Solution

Correct Answer: (D)

Quality (Wave form) of sound distinguish the different sources of sound from each other

So, assertion is false but, reason is true.

Q28. Solution**Correct Answer: (D)**

For RC charging circuit,

$$\text{Charging current, } I = \frac{E}{R} e^{-\frac{t}{RC}}$$

Taking log both sides,

$$\log I = \log\left(\frac{E}{R}\right) - \frac{t}{RC}$$

Slope of the given graph will be $(-\frac{1}{RC})$.

When R is doubled, slope of the curve decreases. Also at $t = 0$, the current will be less. Graph Q represents the best.

Q29. Solution**Correct Answer: (C)**

For dispersion without deviation

$$\delta_1 + \delta_2 = 0$$

$$(\mu_1 - 1)A_1 + (\mu_2 - 1)A_2 = 0$$

$$A_2 = -\frac{(\mu_1 - 1)A_1}{(\mu_2 - 1)}$$

Substituting the given values, we get

$$A_2 = -\frac{(1.5 - 1)5^\circ}{(1.75 - 1)} = -\frac{10^\circ}{3}$$

The negative sign shows that the two prisms must be joined in opposition.

Q30. Solution**Correct Answer: (A)**

Force on an electron in an electric field E in between the plates can be given as:

$$F = eE$$

Here, the electric field between the plates will be,

$$E = \frac{V}{d}$$

Substituting these values we get:

$$F = e \frac{V}{d}$$

From Newton's second law, let the acceleration of electron be a , then,

$$ma = \frac{eV}{d}$$

$$\Rightarrow a = \frac{eV}{md} \dots (1)$$

Applying the second equation of motion, the electron was initially at rest,

$d = 0 \times t + \frac{1}{2}at^2$; where t is time taken to reach the electron in the upper plate.

$$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2md^2}{eV}}.$$

Q31. Solution**Correct Answer: (B)**

$$K = \frac{1}{2}mv^2$$

$$v^2 = \frac{98 \times 2}{2} = 98$$

$$h = \frac{v^2}{2g} = \frac{98}{2 \times 9.8} = 5$$

$$K_1 = \frac{1}{2}mv^2 = \frac{1}{2}m \times 2gh$$

$$\therefore \frac{K_2}{K_1} = \frac{h_2}{h_1}$$

$$\text{Given } K_2 = \frac{K_1}{2}$$

$$\therefore \frac{K_2}{2K_1} = \frac{h_2}{5}$$

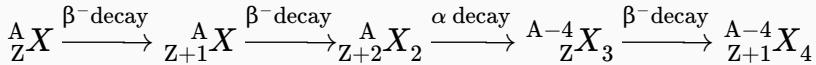
$$\therefore h_2 = 2.5 \text{ m}$$

Q32. Solution**Correct Answer: (D)**

In α -decay (${}^4_2\text{He}$) mass number decreases by 4

and atomic number decreases by 2.

In β^- - decay ($n \rightarrow p^+ + e^-$) mass number remains same while atomic number increases by 1.

**Q33. Solution****Correct Answer: (C)**

$$\mu_g \sin \theta_c = \mu_1 \sin 90^\circ$$

$$\text{Or } \mu_g \sin \theta_c = 1$$

When water is poured,

$$\mu_w \sin r = \mu_s \sin \theta_c \text{ or } \mu_w \sin r = 1$$

$$\text{Again, } \mu_a \sin \theta = \mu_w \sin r$$

$$\text{Or } \mu_a \sin \theta = 1$$

$$\text{Or } \sin \theta = 1 \text{ or } \theta = 90^\circ$$

Q34. Solution**Correct Answer: (C)**

If M is molecular mass of the gas, then from

$$M(C_p - C_v) = R$$

$$M = \frac{8.31}{210} = 0.0392$$

If ρ is density of the gas at NTP, then mass of 1 m^3 of gas at NTP = $\rho \text{ kg}$

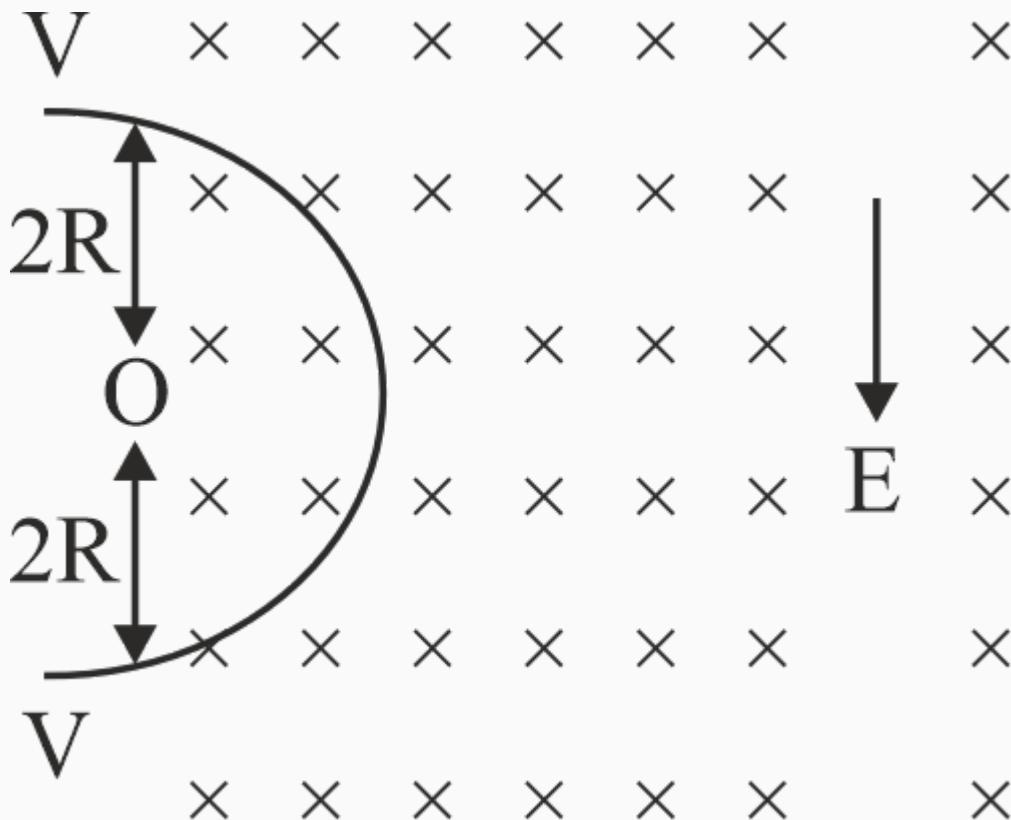
\therefore Mass of $22.4 \text{ L} (= 22.4 \times 10^{-3} \text{ m}^3)$ of gas at NTP = $\rho \times 22.4 \times 10^{-3} \text{ kg}$, which is the molecular mass of the gas

$$\therefore \rho \times 22.4 \times 10^{-3} = 0.0392$$

$$\rho = \frac{0.0392}{22.4 \times 10^{-3}} = 1.75 \text{ kg m}^{-3}$$

Q35. Solution

Correct Answer: (B)



$$\text{Radius of the circle, } r = \frac{mv}{Bq}$$

$$\therefore \text{Equation of line, } y = \frac{2mv}{Bq} = 2R$$

$$\text{Time period, } T = \frac{2\pi m}{Bq}$$

$$t = \frac{\pi m}{Bq} = \frac{T}{2}$$

\therefore Angular momentum of charged particle about origin

$$L = mv y + mv y = 2mv y$$

$$= 2mv \times 2R$$

$$= 4mv \times \frac{mv}{Bq} = \frac{4m^2v^2}{Bq}$$

From velocity selector,

$$v = \frac{E}{B}$$

$$\therefore L = \frac{4m^2E^2}{qB^3}$$

Q36. Solution

Correct Answer: (A)

If we connect the battery across A and C, then no current will flow in the resistances between B and F and between H and D. So they can be removed. Thus,

$$R_{eq} = \frac{3R}{4}$$

Q37. Solution**Correct Answer: (D)**

Velocity of efflux at section (4) is $v = \sqrt{2gh}$ Applying Bernoulli's equation between section (3) and (4)

$$\begin{aligned} P_3 + \frac{1}{2}\rho v_3^2 &= P_4 + \frac{1}{2}\rho v_4^2 \Rightarrow P_3 + \frac{1}{2}\rho(2\sqrt{2gh})^2 = P_0 + \frac{1}{2}\rho(\sqrt{2gh})^2 \\ &\Rightarrow P_3 = P_0 - 3\rho gh. \end{aligned}$$

Q38. Solution**Correct Answer: (D)**

$$V_1 = \frac{\omega}{k} \quad V_2 = \frac{\omega}{3k}$$

$$\Rightarrow 3V_2 = V_1$$

$$3 \frac{1}{\sqrt{\mu_{r_2} \epsilon_{r_2}}} = \frac{1}{\sqrt{\mu_{r_1} \epsilon_{r_1}}}$$

$$\Rightarrow \frac{\epsilon_{r_2}}{\epsilon_{r_1}} = 9 \frac{\mu_{r_1}}{\mu_{r_2}} = \frac{9}{4} = 2.25$$

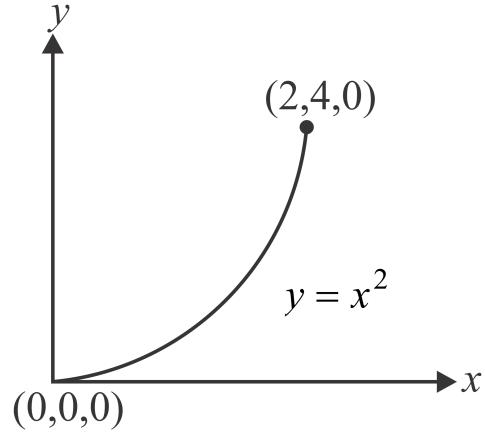
Q39. Solution**Correct Answer: (D)**

Given that

$$\text{force } \vec{F} = (3xy - 5z)\hat{j} + 4z\hat{k}$$

Initial point (0, 0, 0)

Final point (2, 4, 0)

Work done by the variable force is, $W = \int \vec{F} \cdot d\vec{r}$.

$$\vec{F} = (3xy - 5z)\hat{j} + 4z\hat{k}$$

$$= (3xy)\hat{j}$$

$$y = x^2$$

$$dy = 2xdx$$

$$dw = F_x dx + F_y dy$$

$$= 0 + (3xy)dy$$

$$= 3x \times x^2 \times 2xdx$$

$$w = 6 \int_0^2 x^4 dx = 6 \cdot \left(\frac{x^5}{5} \right)_0^2 = \frac{192}{5} \text{ J}$$

Q40. Solution**Correct Answer: (A)**

From the figure, the top wire shorts the section containing $2R$ and $4R$, so no current flows through them. Hence the external load seen by the battery is only R . Power delivered to the external circuit: $P = \left(\frac{E}{R+4}\right)^2 R = \frac{E^2 R}{(R+4)^2}$

$$\text{Maximize w.r.t. } R : \frac{d}{dR} \left(\frac{R}{(R+4)^2} \right) = 0 \Rightarrow R = 4\Omega$$

$$R = 4\Omega$$

Q41. Solution

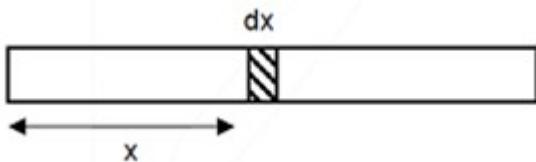
Correct Answer: (C)

Statement (A): Correct With increase in temperature, viscosity of liquids decreases due to weakening of intermolecular forces, while viscosity of gases increases due to increased momentum transfer between molecules.

Statement (B): Incorrect Water does not wet an oily glass because the adhesive force between water and oil is less than the cohesive force of water, not because the cohesive force of oil is less. Statement (C): Incorrect A liquid wets a solid surface only when the angle of contact is less than 90° , not greater than 90° .

Q42. Solution

Correct Answer: (B)



$$X_{cm} = \frac{1}{M} \int_0^{\ell} x \cdot dM$$

$$dM = \rho \cdot dx = \left(a + b\left(\frac{x}{\ell}\right)^2 \right) \cdot dx$$

$$x_{cm} = \frac{\int x dM}{\int dm} = \frac{\int x \rho dx}{\int \rho dx} = \frac{\int_0^{\ell} x \left(a + \frac{bx^2}{\ell^2}\right) dx}{\int_0^{\ell} \left(a + \frac{bx^2}{\ell^2}\right) dx}$$

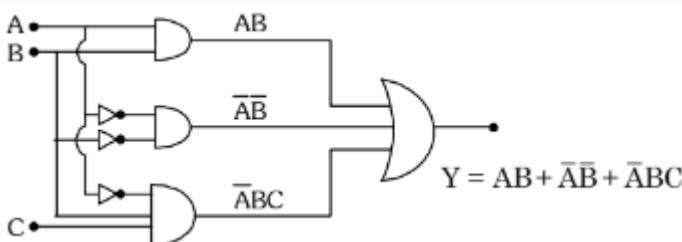
$$= \frac{a\left(\frac{x^2}{2}\right)_0^{\ell} + \frac{b}{\ell^2}\left(\frac{x^4}{4}\right)_0^{\ell}}{a(x)_0^{\ell} + \frac{b}{\ell^2}\left(\frac{x^3}{3}\right)_0^{\ell}}$$

$$= \frac{a\frac{\ell^2}{2} + b\frac{\ell^2}{4}}{a\ell + \frac{b\ell}{3}} = \frac{(2a+b)}{(3a+b)} \frac{\ell}{4} \times 3$$

$$= \frac{3\ell}{4} \left(\frac{2a+b}{3a+b} \right)$$

Q43. Solution

Correct Answer: (B)



Q44. Solution

Correct Answer: (B)

No. of molecules = area under AB

$$= \frac{(6+4)10^3}{2} \times (800 - 600) = 10^6$$

Q45. Solution

Correct Answer: (A)

We know that, angular momentum,

$$mvr = \frac{nh}{2\pi} \Rightarrow 2\pi r = n\left(\frac{h}{mv}\right) \text{ According to de broglie's wavelength, } \lambda = \frac{h}{mv}$$

$$\Rightarrow 2\pi r = n\lambda$$

Where r is the radius of the orbit, λ is the de Broglie wavelength and n represents integral quantisation for standing wave(electron)

$$\therefore \lambda = \frac{2\pi r}{n} = \frac{4 \times 10^{-9}}{2} = 2 \times 10^{-9} \text{ m}$$

Q46. Solution

Correct Answer: 12

$$\text{Fringe width, } \beta = \frac{\lambda D}{d} \quad \dots (i)$$

where, D : distance between screen and slit

d : distance between two slits

when a film of thickness t and refractive index μ is placed over one of the slit, the fringe pattern is shift by distance S and is given by $S = \frac{(\mu-1)tD}{d} \quad \dots (ii)$

$$\text{Given: } S = 10 \beta \quad \dots (iii)$$

From equations (i), (ii) and (iii), we get

$$\frac{(\mu-1)+D}{d} = 10 \frac{\lambda D}{d}$$

$$\Rightarrow \mu - 1 = \frac{10\lambda}{t} = \frac{10 \times 6000 \times 10^{-9}}{3 \times 10^{-3}} \text{ cm}$$

$$\Rightarrow \mu - 1 = 0.2$$

$$\Rightarrow \mu = 1.2$$

Q47. Solution

Correct Answer: 8

$$\text{As, } [MLT^{-2}] = [L^{2a}] [L^b T^{-b}] [M^c L^{-3c}] = [M^c L^{2a+c-3c} T^{-b}]$$

Comparing powers of M, L and T , we get

$$c = 1, 2a + b - 3c = 1, -b = -2 \text{ or } b = 2$$

$$2a + 2 - 3(1) = 1$$

$$\Rightarrow 2a = 2$$

$$\text{or } a = 1$$

Q48. Solution**Correct Answer: 1200**

$$\text{Least count} = \frac{\text{Pitch}}{\text{Number of division on circuit scale}} = \frac{0.5}{50} \\ = 0.01 \text{ mm}$$

$$\text{Now, diameter of ball} = (2 \times 0.5) + (2.5 - 5)(0.01) = 1.2 \text{ mm}$$

Q49. Solution**Correct Answer: 3**

Given, mass of disc = m

Radius of disc = a

Angular speed = ω

Moment of inertia of the disc, $I = \frac{1}{2}ma^2$

Initial angular momentum, $L_i = I \times \omega = \frac{1}{2}ma^2\omega$

Let ω' be the angular momentum of the disc when the particle of mass m is attached at the rim.

Final angular momentum, $L_f = I\omega' + mav'$

$$= \frac{1}{2}ma^2\omega' + ma^2\omega'$$

$$[\because v' = \omega'a]$$

Applying conservation of angular momentum,

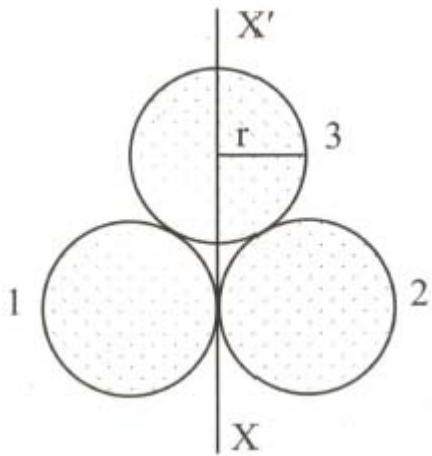
$$L_i = L_f$$

$$\frac{1}{2}ma^2\omega = \frac{1}{2}ma^2\omega' + ma^2\omega'$$

$$\Rightarrow \omega' = \frac{\omega}{3}$$

Q50. Solution

Correct Answer: 80



Using parallel axes theorem,

$$I_1 = \frac{2}{3}mr^2 + mr^2 \text{ and } I_1 = I_2$$

$$I_3 = \frac{2}{3}m^2$$

M.I. of system about XX' is

$$I = I_1 + I_2 + I_3$$

$$= 2\left(\frac{2}{3}mr^2 + mr^2\right) + \frac{2}{3}mr^2$$

$$= 4mr^2 = 4 \times 2 \times (10 \times 10^{-2})^2$$

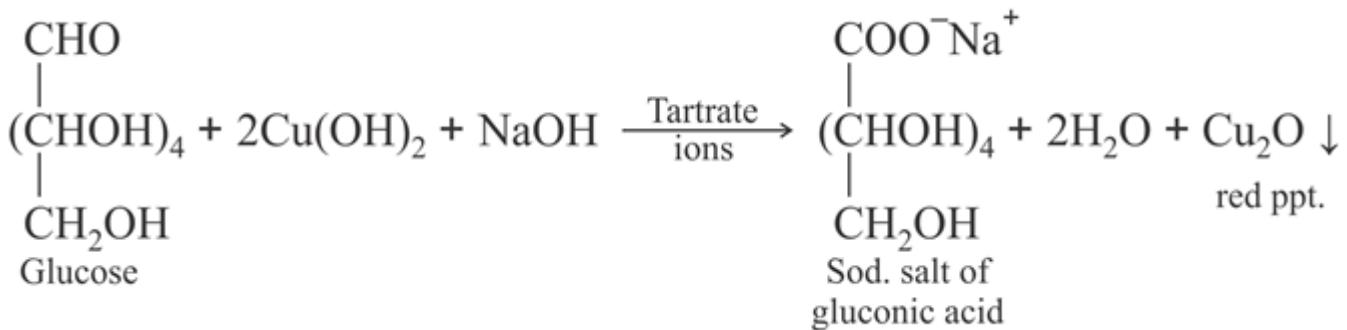
$$= 8 \times 10^{-2}$$

$$\therefore I = 80 \text{ gm}^2$$

Q51. Solution**Correct Answer: (C)**

Statement I is correct because tollen's reagent and fehling's solution is mild oxidising agent which oxidised of glucose into gluconic acid and it's convert Cu^{+2} into $\text{Cu}^{+1}(\text{Cu}_2\text{O})$ which is of reddish brown colour

Statement II is incorrect because glucose on reaction with Fehling's solution gives reddish brown precipitate of Cu_2O and no CuO is formed.

**Q52. Solution****Correct Answer: (B)**

These four can reduce tollen's reagent.

1. D-glucose
2. D-fructose (α -hydroxy ketone)
3. $\text{CH}_3 - \text{CHO}$
6. $\text{H} - \overset{\text{O}}{\underset{\parallel}{\text{C}}} - \text{OH}$

Q53. Solution**Correct Answer: (D)**

(i) The ionic radius of lanthanoids follow the following relation:

$$\text{Ionic radius} \propto \frac{1}{\text{atomic number}}$$

Atomic number (Z) for Pr = 59

Atomic number (Z) for Sm = 62

Atomic number (Z) for Dy = 66

and has ionic radii for positive ions as given below:

$$\text{Pr}^{3+} = 1.013\text{\AA}$$

$$\text{Sm}^{3+} = 0.964\text{\AA}$$

$$\text{Dy}^{3+} = 0.908\text{\AA}$$

Thus, statement (i) is not correct.

(ii) Element Eu ($Z = 63$) can exist in (+)2 and (+)3 oxidation state.

\therefore (+) 3 oxidation state is the most common oxidation state for lanthanoids.

Thus, (+) 2 oxidation state oxides oxidises to (+) 3 easily and Eu^{2+} can act as strong reducing agent.

Hence, the statement (II) is correct.

(iii) The electronic configuration for

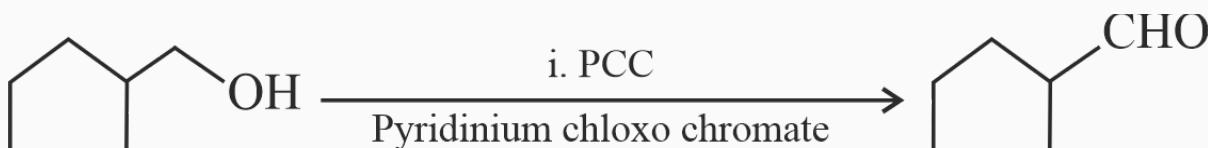
$$(\text{Pu}), (Z = 94) = 5f^6 6d^0 7s^2$$

Therefore, it can use maximum of $6 + 2 = 8$ electrons.

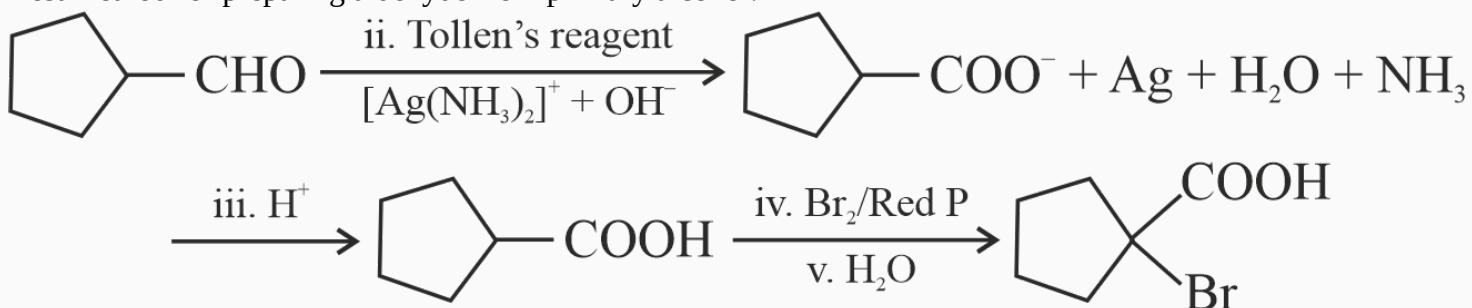
Thus, can show +7 oxidation state.

Thus, statement (III) is also correct.

Hence, option (d) is the correct answer.

Q54. Solution**Correct Answer: (A)**

Best method for preparing aldehyde from primary alcohol.

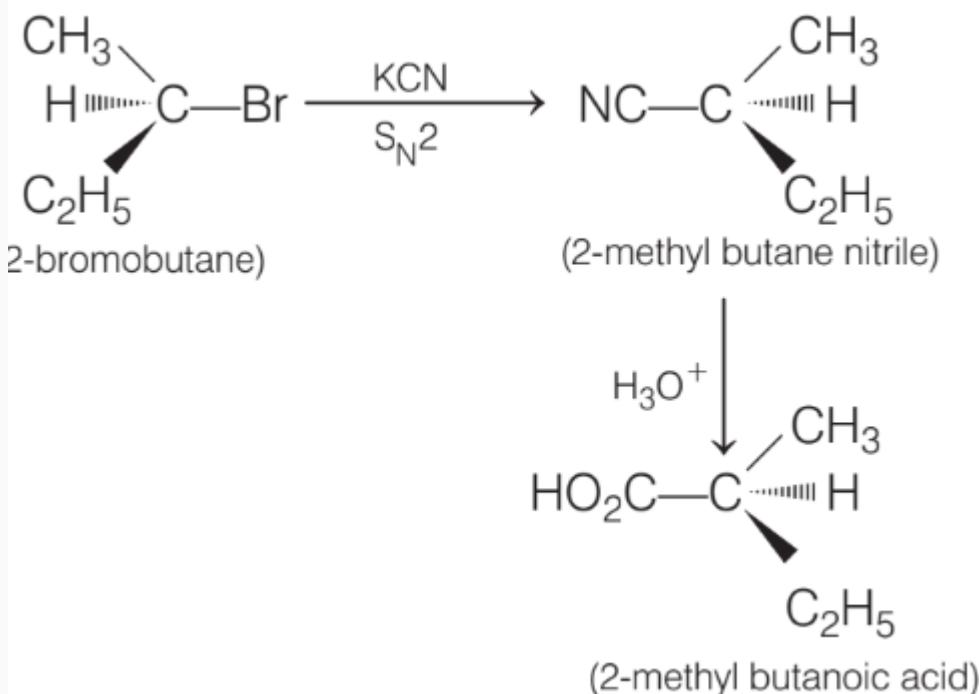


Q55. Solution**Correct Answer: (D)**

All three given carbocations are 2° carbocations. There is $+I$ and $+M$ effect due to OCH_3 that stabilise carbocation in (II). There is - I effect due to COCH_3 that destabilizes carbocation in (I). Order of stability will be $II > I > III$

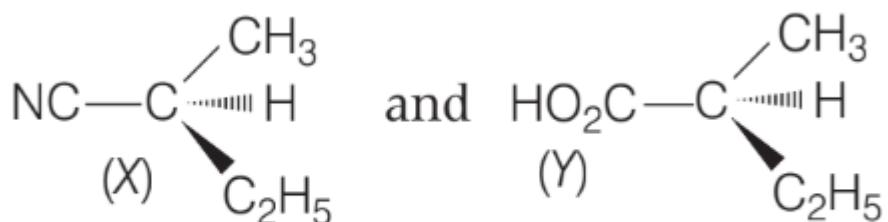
Q56. Solution**Correct Answer: (B)**

The given reaction occurs as follows :



In the above reaction, 2° haloalkane reacts with KCN via $\text{S}_{\text{N}}2$ mechanism due to less steric hinderance and we get 2-methyl butane nitrile (X) with inversion in structure.

On hydrolysis of (X), we get 2-methyl butanoic acid (Y) having inverted structure as that of haloalkane. Thus,



and option (b) is the correct answer.

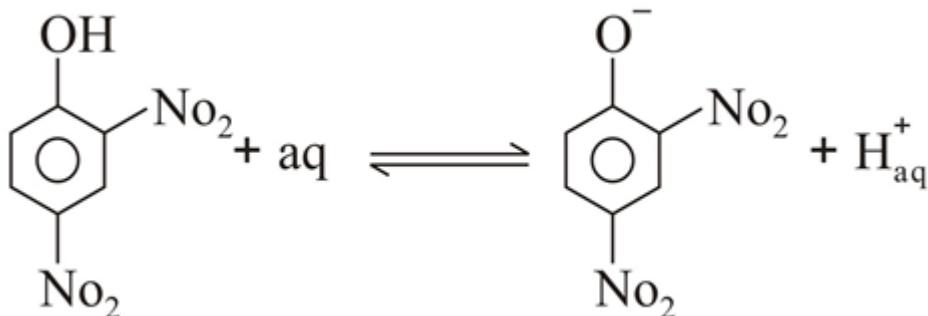
Q57. Solution**Correct Answer: (A)**

The four lobes of $d_{x^2-y^2}$ orbital are lying along x and y axes, so, density in XY plane can't be zero.

The two lobes of d_{z^2} orbital are lying along z axis, and contain a ring of negative charge surrounding the nucleus in xy plane. So, the density in XY plane is non-zero.

2s orbitals have one spherical node, where the electron density is zero.

In $2p_x$ orbital, both the lobs lie along x axis. Hence, the density in yz plane is zero, thus it is the nodal plane.

Q58. Solution**Correct Answer: (C)**

$$pH = pK_a + \log \frac{[C. \text{Base}]}{[\text{acid}]} \quad (\text{C. Base} = \text{Conjugate base})$$

$$5 = 4 + \log \frac{[C. \text{Base}]}{[\text{acid}]}$$

$$\log \frac{[C. \text{Base}]}{[\text{acid}]} = 1$$

$$\therefore \frac{[C. \text{Base}]}{[\text{acid}]} = \frac{[\text{Dissociated ions}]}{[\text{undissociated acid}]} = 10$$

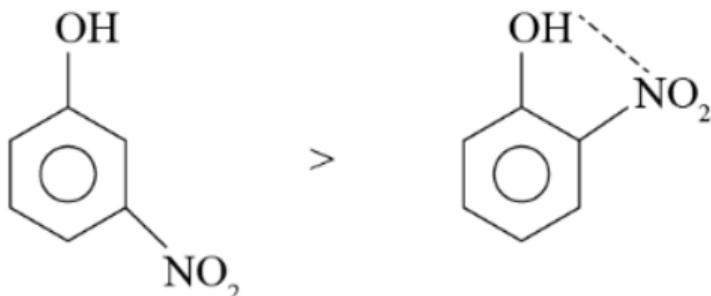
Q59. Solution**Correct Answer: (D)**

Here option D is correct while rest are incorrect as follows

(A) $T_2 > D_2 > H_2$ [BP \propto mol. wt.]

(B) n-pentane $>$ neo-pentane [BP \propto VWf \propto contact area $\propto \frac{1}{\text{Branching}}$]

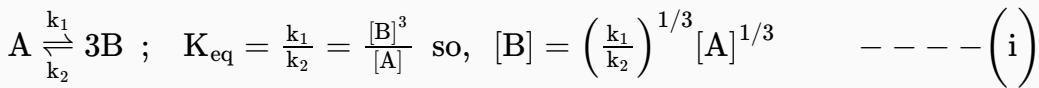
(C) Xe $>$ Ar $>$ He [BP \propto mol. wt.]



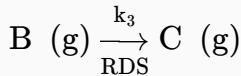
(D) Intermolecular H-bonding Intramolecular H-bonding

Q60. Solution**Correct Answer: (D)**

H_2S is more acidic than H_2O . It is due to the fact that $\text{H} - \text{S}$ bond is weaker than $\text{H} - \text{O}$ bond.

Q61. Solution**Correct Answer: (D)**

Now,



$$\therefore \text{Rate} = k_3[\text{B}] = k_3 \left(\frac{k_1}{k_2}\right)^{\frac{1}{3}} [\text{A}]^{\frac{1}{3}} \quad \text{---(i)}$$

As we know that Rate Law expression,

Rate = K (reactant concentration)ⁿ where, K = rate constant n = order of reaction

\therefore Here from (i), we can write

$$\text{Rate} = k[\text{A}]^{\frac{1}{3}}$$

where, $k = k_3 \left(\frac{k_1}{k_2}\right)^{\frac{1}{3}}$ = equivalent rate constant

$$\text{A } e^{-E_a/RT} = \text{A}_3 e^{-E_{a3}/RT} \left[\frac{\text{A}_1 e^{-E_{a1}/RT}}{\text{A}_2 e^{-E_{a2}/RT}} \right]^{\frac{1}{3}}$$

$$\text{A } e^{-E_a/RT} = \text{A}_3 \left(\frac{\text{A}_1^{\frac{1}{3}}}{\text{A}_2^{\frac{1}{3}}} \right) e^{\left(-E_{a3} - \frac{E_{a1}}{3} + \frac{E_{a2}}{3}\right) \left(\frac{1}{RT}\right)}$$

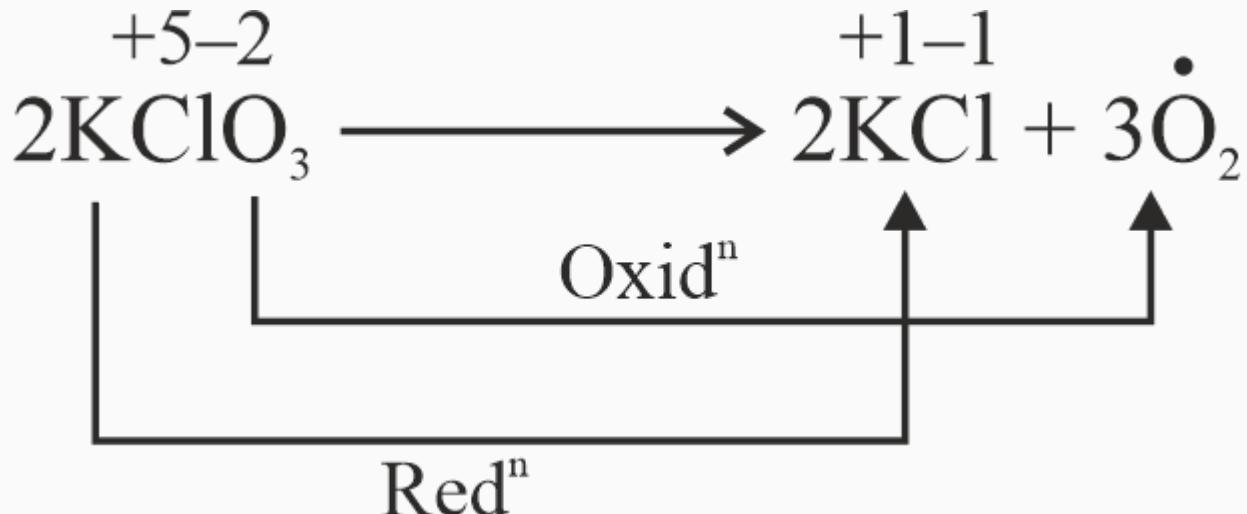
Comparing powers of exponential terms,

$$-E_a = -E_{a3} + \left(\frac{-E_{a1} + E_{a2}}{3} \right)$$

$$E_a = E_{a3} + \left(\frac{E_{a1} - E_{a2}}{3} \right)$$

$$E_a = 40 + \frac{180}{3} - \frac{90}{3} = 40 + 60 - 30 = 70 \text{ KJ mol}^{-1}$$

Hence, the overall activation energy of the reaction is 70 KJ mol^{-1}

Q62. Solution**Correct Answer: (D)**

(i, ii, iii and iv) all are false statement

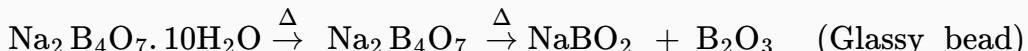
Correct Option: A, B, C, D (All Options are correct)

Q63. Solution**Correct Answer: (B)**Equation of CO_2 evolved = 0.1 = moles of CO_2 evolved1mol NaCl gives $\frac{1}{2}$ mol of Cl_2

0.2 mol of NaCl means it is 11.7 grams of sodium chloride. this gives 0.1 mole of chlorine

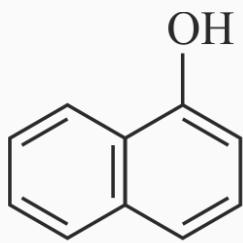
Q64. Solution**Correct Answer: (C)**

On heating borax, the colourless glassy bead is formed which consists of sodium metaborate and boric anhydride.

This glassy bead forms a blue coloured metaborate with cobalt giving $\text{Co}(\text{BO}_2)_2$.

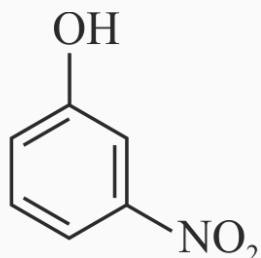
Q65. Solution

Correct Answer: (D)



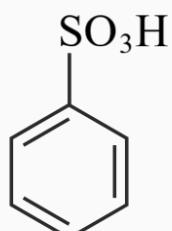
PKa 9.31

(i)



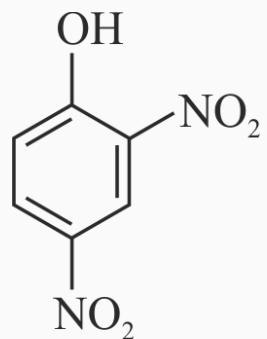
PKa 8.28

(ii)



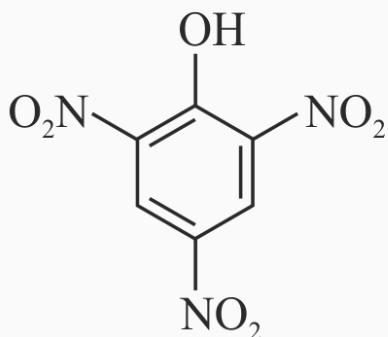
PKa 7.15

(iii)



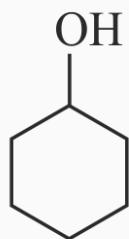
PKa 3.96

(iv)



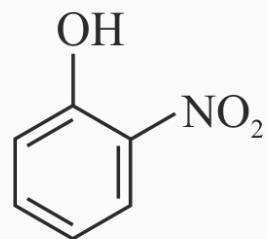
PKa 0.38

(v)



PKa 18

(vi)



PKa 7.12

(vii)

Q66. Solution**Correct Answer: (C)**

Relative lowering of vapour pressure,

$$\frac{p^\circ - p_s}{p^\circ} = x_A$$

$$= \frac{\frac{w_A}{m_A}}{\frac{w_A}{m_A} + \frac{w_B}{m_B}}$$

(where, w_A and m_A are the mass and molar mass of solute and w_B and m_B are the mass and molar mass of water.)

$$0.02 = \frac{\frac{x}{60}}{\frac{x}{60} + \frac{90}{18}}$$

$$0.02 = \frac{\frac{x}{60}}{\frac{x}{60} + 5}$$

$$\therefore \frac{1}{0.02} = \frac{\frac{x}{60} + 5}{\frac{x}{60}}$$

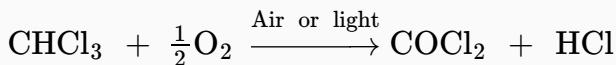
$$50 = 1 + \frac{5 \times 60}{x}$$

$$49 = \frac{300}{x}$$

$$x = \frac{300}{49} = 6 \text{ g}$$

Q67. Solution**Correct Answer: (B)**

CHCl_3 is stored in dark-coloured bottles and properly closed to keep air out because, in the presence of air and light, it oxidises to phosgene.



A small amount of ethanol is added in CHCl_3 to convert phosgene into non-poisonous diethyl carbonate.

In the carbylamine reaction, an intermediate dichlorocarbene is formed. When a primary amine reacts with KOH and chloroform, it eliminates hydrogen from the amine producing isocyanide and water.

**Q68. Solution****Correct Answer: (B)**

Freezing point and melting point is same for a pure substance i.e $T_A = T_B$. At freezing point entropy increases rapidly. $\Delta S = +ve$ favourable factor. $\Delta G = -ve$ spontaneous. $\Delta U = -ve$ favourable process.

Q69. Solution**Correct Answer: (D)**

Ionization Energy:

Energy required to remove an electron from atoms or ions is called ionization energy.

Ionization energy is inversely proportional to size.

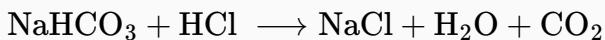
S^{2-} has the largest size and hence, has the lowest ionisation energy

Q70. Solution**Correct Answer: (C)**

In acidic medium $KMnO_4$ undergoes redox reaction with $H_2C_2O_4$ and HNO_2 and converted into Mn^{2+} .

Q71. Solution**Correct Answer: 815**

$$\begin{aligned}2C(s) + H_2(g) &\longrightarrow C_2H_2(g) (H - C \equiv C - H) \\ \Rightarrow B \cdot E(H_2) + \Delta B \cdot E(H_2) + \Delta H_{\text{sub}}(C) - B \cdot E(C - H) \times 2 + B \cdot E(C \equiv C) \Delta H_{\text{rxn}} \\ \Rightarrow 330 + 1410 - [350 \times 2 + x] &= 225 \Rightarrow x = 815\end{aligned}$$

Q72. Solution**Correct Answer: 30**

So moles of $NaHCO_3$ (Pure) used = moles of HCl

$$= 0.1 \times 5 \times 10^{-3}$$

$$\begin{aligned}\text{So weight of pure } NaHCO_3 \text{ used} &= 0.1 \times 5 \times \\ 10^{-3} \times 84 \text{ grams} &= 0.042 \text{ grams}\end{aligned}$$

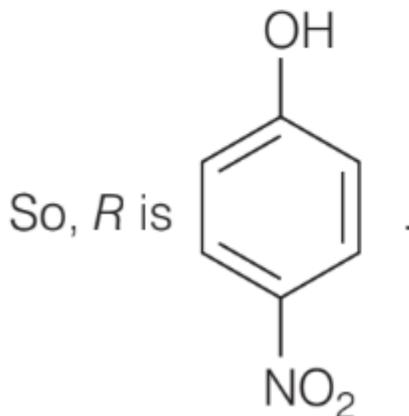
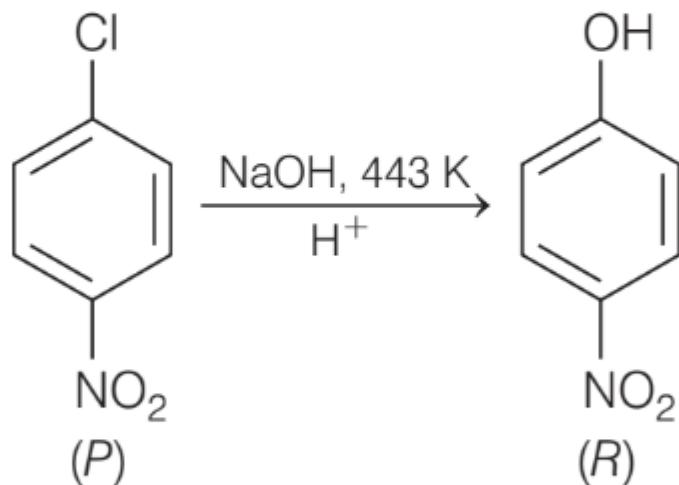
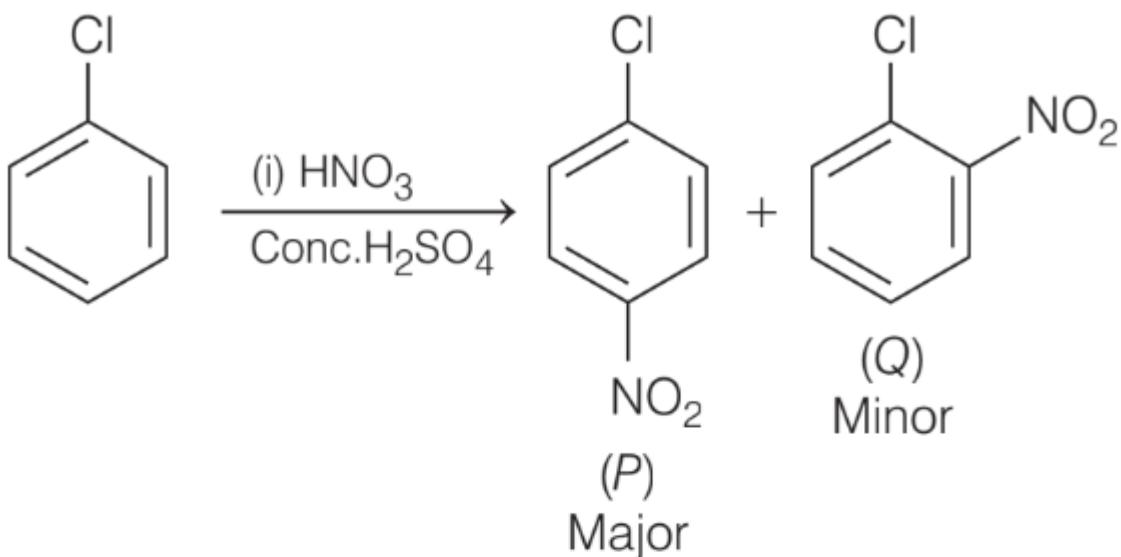
$$\% \text{Purity} = \frac{\text{Mass of pure substance}}{\text{Total mass of sample}}$$

$$\% \text{ Purity of tablet} = \frac{0.042}{0.14} \times 100 = 30\%$$

Q73. Solution

Correct Answer: 139

Chlorobenzene undergoes nitration reaction *p*-nitrochlorobenzene as a major product. It further 4-nitrophenol.



Q74. Solution**Correct Answer: 24**

For anhydrous salt

| Element | Al | K | S | O |
|--------------|-------------------|-------------------|-------------------|-------------------|
| Atomic ratio | $\frac{10.5}{27}$ | $\frac{15.1}{39}$ | $\frac{24.8}{32}$ | $\frac{49.6}{16}$ |
| | 0.39 | 0.39 | 0.78 | 3.10 |

Empirical formula of anhydrous salt = KAlS_2O_8

E.F mass of Anhydrous salt = 258 g/mol

$$\text{Mass of Moisture} = 258 \times \frac{45.6}{54.4} = 216 \text{ g}$$

$$= \frac{216}{18} \approx 12 \text{ mole}$$

Empirical formula of Anhydrous salt $\text{KAlS}_2\text{O}_8 \cdot 12\text{H}_2\text{O}$ E F Mass = $258 + 216 = 474$ g/Empirical formula mass

$$n = \frac{\text{Mole Mass}}{\text{E.F. Mass}} = \frac{948}{474} = 2$$

Molecular Formula = $\text{K}_2\text{Al}_2\text{S}_4\text{O}_{16} \cdot 24\text{H}_2\text{O}$

$$= \text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$$

Q75. Solution**Correct Answer: 3**

$$\lambda_{X^-}^0 \approx \lambda_{Y^-}^0$$

$$\Rightarrow \lambda_{H^+}^0 + \lambda_{X^-}^0 \approx \lambda_{H^+}^0 + \lambda_{Y^-}^0$$

$$\Rightarrow \lambda_{HX}^0 \approx \lambda_{HY}^0 \dots(i)$$

$$\text{Also, } \frac{\lambda_m}{\lambda_m^0} = \alpha$$

$$\text{So } \lambda_m(HX) = \lambda_m^0 \alpha_1 \text{ and } \lambda_m(HY) = \lambda_m^0 \alpha_2$$

(Where α_1 and α_2 are degree of dissociation of HX and HY respectively)

Now, given that

$$\lambda_m(HY) = 10 \lambda_m(HX)$$

$$\Rightarrow \lambda_m^0 \alpha_2 = 10 \times \lambda_m^0 \alpha_1$$

$$\alpha_2 = 10 \alpha_1 \dots(ii)$$

$$K_a = \frac{C\alpha^2}{1-\alpha}, \text{ But } \alpha \ll 1, \text{ therefore } K_a = C\alpha^2$$

$$\Rightarrow \frac{K_a(HX)}{K_a(HY)} = \frac{0.01\alpha_1^2}{0.1\alpha_2^2} = \frac{0.01}{0.1} \times \left(\frac{1}{10}\right)^2 = \frac{1}{1000}$$

$$\Rightarrow [\log(K_a(HX)) - \log(K_a(HY))] = -3$$

$$\Rightarrow pK_a(HX) - pK_a(HY) = 3$$