Answer Key

Mathematics (25 Questions)

Q1. (B)	Q2. (A)	Q3. (B)	Q4. (C)	Q5. (B)
Q6. (B)	Q7. (A)	Q8. (D)	Q9. (C)	Q10. (D)
Q11. (B)	Q12. (C)	Q13. (B)	Q14. (D)	Q15. (B)
Q16. (D)	Q17. (D)	Q18. (B)	Q19. (A)	Q20. (C)
Q21. 41	Q22. 1	Q23. 3	Q24. 2	Q25. 2

Physics (25 Questions)

Q26. (A)	Q27. (C)	Q28. (A)	Q29. (C)	Q30. (D)
Q31. (C)	Q32. (D)	Q33. (D)	Q34. (A)	Q35. (C)
Q36. (D)	Q37. (C)	Q38. (D)	Q39. (B)	Q40. (D)
Q41. (B)	Q42. (D)	Q43. (D)	Q44. (B)	Q45. (C)
Q46. 5	Q47. 8	Q48. 3	Q49. 6	Q50. 200

Chemistry (25 Questions)

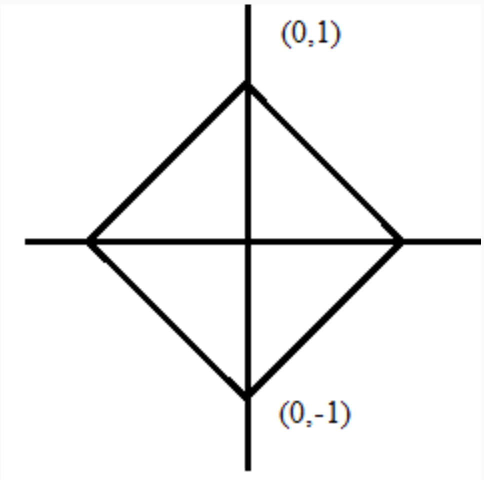
Q51. (B)	Q52. (C)	Q53. (A)	Q54. (A)	Q55. (A)
Q56. (C)	Q57. (D)	Q58. (C)	Q59. (D)	Q60. (B)
Q61. (D)	Q62. (A)	Q63. (B)	Q64. (D)	Q65. (A)
Q66. (A)	Q67. (B)	Q68. (D)	Q69. (D)	Q70. (A)
Q71. 4	Q72. 720	Q73. 724	Q74. 7	Q75. 393

Solutions

Q1. Solution

Correct Answer: (B)

Clearly $|z+i|+|z-i|=2$ is a line segment from $(0,1)$ to $(0,-1)$ and
$|z+\bar{z}|+|z-\bar{z}|=2$
$|x|+|y|=1$
Clearly there are two points of intersection.



Q2. Solution

Correct Answer: (A)

$\because |A|=3$

$$B=\begin{bmatrix} a_{11} & \frac{1}{2}a_{12} & \frac{1}{4}a_{13} \\ 2a_{21} & a_{22} & \frac{1}{2}a_{23} \\ 4a_{31} & 2a_{32} & a_{33} \end{bmatrix}$$

$$|B|=8\begin{vmatrix} a_{11} & \frac{1}{2}a_{12} & \frac{1}{4}a_{13} \\ a_{21} & \frac{1}{2}a_{22} & \frac{1}{4}a_{23} \\ a_{31} & \frac{1}{2}a_{32} & \frac{1}{4}a_{33} \end{vmatrix}=\begin{vmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{vmatrix}=|A|=3$$

$$\left|\left(B^T\right)^{-1}\right|=\frac{1}{|B^T|}=\frac{1}{|B|}=\frac{1}{3}$$

Q3. Solution

Correct Answer: (B)

$\operatorname{Arg}(z_1)=\frac{\pi}{6} \Rightarrow \quad \sin\left(\frac{\pi}{4}+\arg z_1\right)+\cos\left(\frac{3\pi}{4}-\arg z_1\right)=\frac{1}{\sqrt{2}} \therefore \quad |\sqrt{2}z-3+2i|=|z|\frac{1}{\sqrt{2}}$ or $\left|\frac{z-\frac{3-2i}{\sqrt{2}}}{z}\right|=\frac{1}{2}$ which represents a circle.

Q4. Solution

Correct Answer: (C)

Given $A-1=xA2+yA+zI$

$$A^{-1}=I=xA^3+yA^2+zA \quad \ldots(1)$$

$$A^2=\begin{bmatrix}2&1&1\\1&1&1\\1&1&2\end{bmatrix}\begin{bmatrix}2&1&1\\1&1&1\\1&1&2\end{bmatrix}\begin{bmatrix}6&4&5\\4&3&4\\5&4&6\end{bmatrix}$$

$$A^3=\begin{bmatrix}6&4&5\\4&3&4\\5&4&6\end{bmatrix}\begin{bmatrix}2&1&1\\1&1&1\\1&1&2\end{bmatrix}\begin{bmatrix}21&15&20\\15&11&15\\20&15&21\end{bmatrix}$$

Now using $\mathrm{xA}^3+y\mathrm{A}^2+\mathrm{zA}=I$

$$\begin{bmatrix}21x&15x&20x\\15x&11x&15x\\20x&15x&21x\end{bmatrix}+\begin{bmatrix}6y&4y&5y\\4y&3y&4y\\5y&4y&6y\end{bmatrix}+\begin{bmatrix}2z&z&z\\z&z&z\\z&z&2z\end{bmatrix}=\begin{bmatrix}1&0&0\\0&1&0\\0&0&1\end{bmatrix}$$

Comparing the diagonal elements

$21x+6y+2z=1 \quad \ldots(1)$

$11x+3y+z=1 \quad \ldots(2)$

$21x+6y+2z=1 \quad \ldots(3)$

$2\times(2)-(1)$ gives $\quad x=1$

$3y+z=-10 \quad \ldots(4)$

Comparing, a12

$15x+4y+z=0$

$4y+z=-15 \quad \ldots(5)$

for (4) & (5) $\quad y=-5$ and $z=5$

$x+y+z=1+(-5)+5=1$

Q5. Solution

Correct Answer: (B)

Consider the numbers $a/2, a/2, b/3, b/3, b/3, c/4, c/4, c/4, c/4$ using A.M. $\geq$ G.M. we get

$\frac{a+b+c}{9}\geq\left(\frac{a^2b^3c^4}{2^{10}3^3}\right)^{1/9}$

$\Rightarrow$ maximum value of $a^2b^3c^4$ is $2^{10}\times3^3$

Hence $x=10$ and $y=3$

$\therefore \log_{10}\left(x^y\right)=\log_{10}\left(10^3\right)=3$

Q6. Solution
Correct Answer: (B)

$1, 4, 7 \ldots\ldots 298$
$\mathrm{Tn} = 3\mathrm{n} - 2$
$\mathrm{n} = 1$ to 100
$2, 4.\ 6 \ldots\ldots 300$
$\mathrm{Tm} = 2\ \mathrm{m}$
$\mathrm{m} = 1$ to 150
For $3\mathrm{n} - 2 = 2\ \mathrm{mn}$ must be even $\mathrm{n} = 2.4 \cdot 6 \ldots\ldots\ldots 100$

Q7. Solution
Correct Answer: (A)

We have $F(x) = \frac{x^3}{3} + (a-3)x^2 + x - 13$

$\therefore$ For $\mathrm{F(x)}$ to have negative point of local minimum, the equation $\mathrm{F'(x)} = 0$ must have two distinct negative roots.

Now, $F'(x) = x^2 + 2(a-3)x + 1$

$\therefore$ Following condition(s) must be satisfied simultaneously.

(i) Discriminant > 0;

(ii) Sum of roots < 0;

(iii) Product of roots > 0

Now, $\mathrm{D} > 0$

$\Rightarrow 4(a-3)^2 > 4$
$\Rightarrow (a-3)^2 - 1 > 0$
$\Rightarrow (a-2)(a-4) > 0$
$\therefore a \in (-\infty, 2) \cup (4, \infty) \ldots (i)$

Also $-2(a-3) < 0$

$\Rightarrow \mathrm{a} - 3 > 0$
$\Rightarrow \mathrm{a} > 3 \ldots (ii)$

And product of $\mathrm{root(s)} = 1 > 0 \forall \mathrm{a} \in \mathrm{R}$

$\therefore\ \text{(i)} \cap \text{(ii)} \cap \text{(iii)}$
$\Rightarrow a \in (4, \infty) \ldots (iii)$

Hence sum of value(s) of $a = 5 + 6 + 7 + \ldots\ldots\ldots + 100 = 5040$

Q8. Solution

Correct Answer: (D)

$\mathrm{F}\left(x\right)=\int_x^{x^2+\frac{x}{3}} 2\cos^2 t dt$

$\mathrm{F}'\left(x\right)=2\cos^2\left(x^2+\frac{\pi}{3}\right)\cdot 2x+2\cos^2 x$

$\mathrm{F}''\left(x\right)=4\cos^2\left(x^2+\frac{\pi}{3}\right)+4x\cdot 2\cos\left(x^2+\frac{\pi}{3}\right)$

$\left(-\sin\left(x^2+\frac{\pi}{3}\right)\right)+4\left(\cos x\right)\left(-\sin x\right)\ldots.\left(i\right)$

Given that area $=\mathrm{F}'(a)+2$

$\Leftrightarrow \int_0^a f\left(x\right)dx=\mathrm{F}'\left(a\right)+2$

Differentiating with respect to a, we get

$f(a)=\mathrm{F}''(a)$

Substituting $a=0$, we get

$\Rightarrow f(0)=\mathrm{F}''(0)$

$=4\cos^2\frac{\pi}{3}$

$=4\left(\frac{1}{4}\right)=1$

Q9. Solution

Correct Answer: (C)

Given integral $I=\int_{\frac{3\pi}{4}}^{\pi}\sin x-1\left[\frac{4x}{\pi}\right]\cdot dx$

We known that $\sin x$ lies between -1 to 1 and we can split the values of $\sin x$ between -1 to 0 and 0 to 1 .

If $0/\!/ \sin x''1$ then $[\sin x]=0$ for $x\in[0,\pi]$

Then,

$$\mathrm{I}=\int_{\frac{3\pi}{4}}^{\pi}[\sin x]dx+\int_{\frac{3\pi}{4}}^{\pi}\left[\frac{4x}{\pi}\right]\cdot dx$$

If $\frac{3\pi}{4}\leq x\leq\pi$ then $\frac{4}{x}\times\frac{3\pi}{4}\leq\frac{4\pi}{\pi}\leq\frac{4}{\pi}\times\pi$

$\Rightarrow \quad 3\leq\frac{4x}{\pi}\leq 4$

So, $\left[\frac{4x}{\pi}\right]=3$

$$I=\int_{\frac{3\pi}{4}}^{\pi}(0)dx+3\int_{\frac{3\pi}{4}}^{\pi}dx$$

$$I=0+4[x]_{\frac{3\pi}{4}}^{\pi}=3\left(\pi-\frac{3\pi}{4}\right)=\frac{3\pi}{4}$$

Q10. Solution

Correct Answer: (D)

The shortest distance between two lines $\overrightarrow{r} = \overrightarrow{a_1} + \lambda\overrightarrow{b_1}$ and $\overrightarrow{r} = \overrightarrow{a_2} + \mu\overrightarrow{b_1}$ is given by

$$\left|\frac{\left(\overrightarrow{b_1}\right)\times\left(\overrightarrow{a_2}-\overrightarrow{a_1}\right)}{\overrightarrow{b_1}}\right|$$

Given equation of lines

$$\overrightarrow{r} = \hat{i} + 2\hat{j} - 4\widehat{k} + \lambda\left(2\hat{i} + 3\hat{j} + 6\widehat{k}\right),\ \overrightarrow{r} = 3\hat{i} + 3\hat{j} - 5\widehat{k} + \mu\left(2\hat{i} + 3\hat{j} + 6\widehat{k}\right)$$

Comparing with the standard form, we get

$$\overrightarrow{a_1} = \hat{i} + 2\hat{j} - 4\widehat{k},\ \overrightarrow{a_2} = 3\hat{i} + 3\hat{j} - 5\widehat{k},\ \overrightarrow{b_1} = 2\hat{i} + 3\hat{j} + 6\widehat{k}$$

$$\left(\overrightarrow{a_2} - \overrightarrow{a_1}\right) = \left(3\hat{i} + 3\hat{j} - 5\widehat{k}\right) - \left(\hat{i} + 2\hat{j} - 4\widehat{k}\right)$$
$$= \left(3\hat{i} - \hat{i}\right) + \left(3\hat{j} - 2\hat{j}\right) + \left(-5\widehat{k} + 4\widehat{k}\right) = 2\hat{i} + \hat{j} - \widehat{k}$$

Now, $\overrightarrow{b_1} \times \left(\overrightarrow{a_2} - \overrightarrow{a_1}\right) = \begin{vmatrix} \hat{i} & \hat{j} & \widehat{k} \\ 2 & 3 & 6 \\ 2 & 1 & -1 \end{vmatrix}$

$$\Rightarrow \left[\hat{i}\left(-3-6\right) - \hat{j}\left(-2-12\right) + \widehat{k}\left(2-6\right)\right] = -9\hat{i} + 14\hat{j} - 4\widehat{k}$$

Magnitude of $\overrightarrow{b_1}$

$$= \sqrt{2^2 + 3^2 + 6^2} = 7$$

The shortest distance is given by

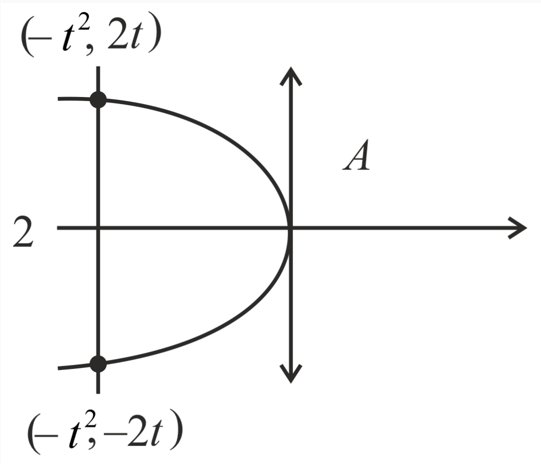
$$= \left|\frac{-9\hat{i} + 14\hat{j} - 4\widehat{k}}{7}\right| = \frac{\sqrt{293}}{7}$$

Hence, the value of K is 7.

Q11. Solution
Correct Answer: (B)

The given equation can be written as
$(ydx - xdy) + x\sqrt{xy}(x+y)dx + y\sqrt{xy}(x+y)dy = 0$
$\Rightarrow \quad (ydx - xdy) + (x+y)\sqrt{xy}(xdx + ydy) = 0$
$\Rightarrow \quad \frac{ydx - xdy}{y^2} + \left(\frac{x}{y} + 1\right) \cdot \sqrt{\frac{x}{y}} d\left(\frac{x^2+y^2}{2}\right) = 0$
$\Rightarrow \quad d\left(\frac{x}{y}\right) + d\left(\frac{x^2+y^2}{2}\right)\left(\frac{x}{y} + 1\right)\sqrt{\frac{x}{y}} = 0$
$\Rightarrow \quad d\left(\frac{x^2+y^2}{2}\right) + \frac{d\left(\frac{x}{y}\right)}{\left(\frac{x}{y}+1\right)\cdot\sqrt{\frac{x}{y}}} = 0$
Integrating both the sides, we get
$\Rightarrow \quad \frac{x^2+y^2}{2} + 2\tan^{-1}\sqrt{\frac{x}{y}} = C$.

Q12. Solution
Correct Answer: (C)



Let $P\left(-t^2, 2t\right)$ & $Q\left(-t^2, -2t\right)$

R divides in the ratio $2:1$

$\left(\frac{-2t^2 - t^2}{2+1}, \frac{-4t+2t}{2+1}\right)$

$\left(-t^2, \frac{2}{3}t\right)$

$x = -t^2$

$y = -\frac{2}{3}t$

$\therefore \ 9y^2 = 4t^2$

$\Rightarrow 9y^2 = -4x$

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Q13. Solution

Correct Answer: (B)

$S_1 > 0 \Rightarrow 2\cos^2\theta + 3\cos\theta - 2 > 0$

$(2\cos\theta - 1)(\cos\theta + 2) > 0$

$\cos\theta > \dfrac{1}{2}$

$\therefore \quad \theta \in \left[0, \dfrac{\pi}{3}\right) \cup \left(\dfrac{5\pi}{3}, 2\pi\right]$ `

given $\theta = \dfrac{n\pi}{6} \Rightarrow \theta = \dfrac{\pi}{6}, \dfrac{11\pi}{6}, \dfrac{12\pi}{6}$

$\therefore \quad n \in \{1, 11, 12\}$

Q14. Solution

Correct Answer: (D)

Any point on the first line is $(4r + k\ , 2\ r + 1, r - 1)$, and any point on the second line is $(r' + k + 1\ , -r', 2r' + 1)$for some values of r and r'. The lines are intersecting if these two points coincide i.e $4r + k = r' + k + 1, 2r + 1 = -r', \mathrm{r} - 1 = 2r' + 1$ for some r and r'

$\Rightarrow \quad 4r - r' = 1\ , 2\ r + r' = -1, r - 2r' = 2$

Now, $4r - r' = 1\ , 2\ r + r' = -1 \ \Rightarrow \ r = 0, r' = -1$ which satisfy r -2 $r' = 2$.

$\Rightarrow$ The given lines are intersecting for all real values of k. `

Q15. Solution

Correct Answer: (B)

$\overrightarrow{OG_1} \cdot \overrightarrow{BG_2} = 0$

$\Rightarrow \dfrac{\vec{a} + \vec{b} + \vec{c}}{3} \cdot \dfrac{a + \vec{c} - 3\vec{b}}{3} = 0$

$\Rightarrow a^2 + c^2 - 3b^2 + 2\vec{a} \cdot \vec{c} - 2\vec{b} \cdot \vec{c} - 2\vec{a} \cdot \vec{b} = 0$

Now, $|\vec{c} - \vec{a}|^2 = b^2, |\vec{c} - \vec{b}| = a^2$ and $|\vec{a} - \vec{b} - | = c^2$

$2\vec{a} \cdot \vec{c} = a^2 + c^2 - b^2, 2\vec{b} \cdot \vec{c}$

$= b^2 + c^2 - a^2, 2\vec{a} \cdot \vec{b} a^2 b^2 - c^2$

Putting in the above result, we get

$2a^2 + 2c^2 - 6b^2 = 0 \quad \Rightarrow \frac{a^2 + c^2}{b^2} = 3$.

Q16. Solution

Correct Answer: (D)

We have, $\sum_{i=1}^{n}\left(x_i+1\right)^2=11n\ldots\ldots\ldots(\mathrm{i})$
and $\sum_{i=1}^{n}\left(x_i-1\right)^2=7n\ldots(\mathrm{ii})$
Adding (i) and (ii) , we get
$2\sum_{i=1}^{n}\left(x_i^2+1\right)=18n\Rightarrow\sum_{i=1}^{n}\left(x_i^2+1\right)=9n$
$\Rightarrow\sum_{i=1}^{n}x_i^2+n=9n\Rightarrow\sum_{i=1}^{n}x_i^2=8n$
$\Rightarrow\frac{\sum_{i=1}^{n}x_i^2}{n}=8$
Subtracting (i) and (ii), we get
$4\sum_{i=1}^{n}x_i=4n\Rightarrow\sum_{i=1}^{n}x_i=n\Rightarrow\frac{\sum_{i=1}^{n}x_i}{n}=1$
Now, variance $=\frac{1}{n}\left[\sum_{i=1}^{n}x_i^2\right]-\left[\frac{\sum_{i=1}^{n}x_i}{n}\right]^2=8-1=7:$

Q17. Solution

Correct Answer: (D)

Let ravish reaches place of meeting at 7 hours x minutes and B reaches place of meeting at 7 hours y minutes.

Then,

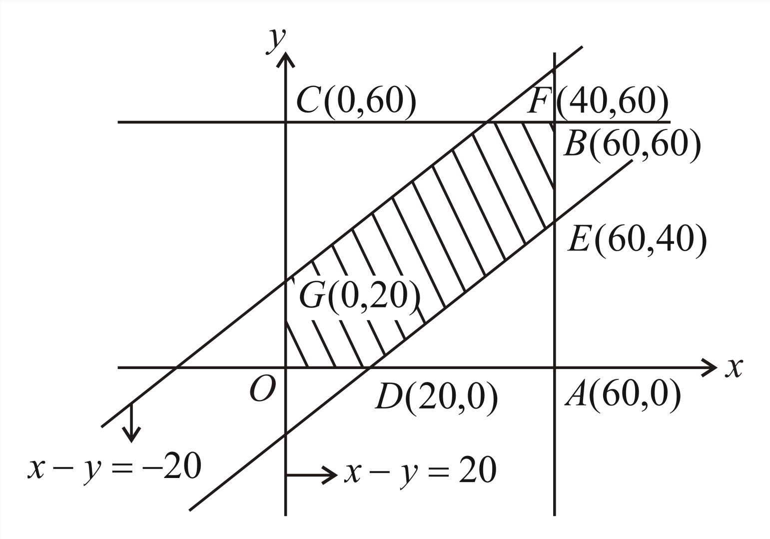
$0 \leq x \leq 60$

$0 \leq y \leq 60$

Condition for meeting to happen.

$|x-y| \leq 20$

Then,



Total area

$= \operatorname{ar}(OABCO) = 60 \times 60 = 3600$

Favourable area

$= \operatorname{ar}(ODBEFG)$

$= \operatorname{ar}(OABCO) - (A_1 + A_2)$

$= 3600 - \left\{\frac{1}{2} \times 40 \times 40 + \frac{1}{2} \times 40 \times 40\right\}$

$= 2000$

Hence, required probability is

$= \frac{2000}{3600} = \frac{5}{9}$

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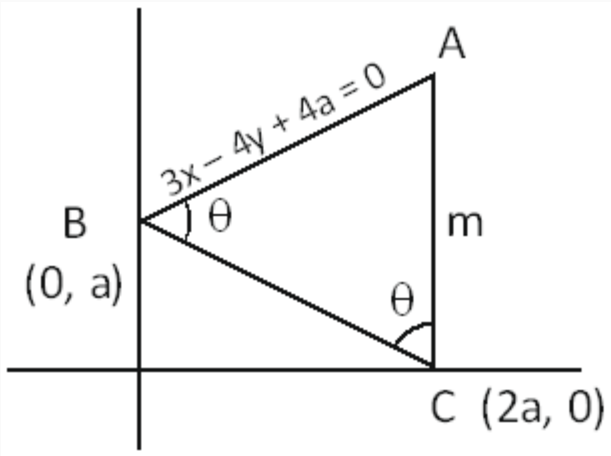
Q18. Solution
Correct Answer: (B)

$y=\tan^{-1}\frac{1}{1+x+x^2}+\tan^{-1}\frac{1}{x^2+3x+3}+\ldots+2n$ terms
$=\tan^{-1}\frac{(x+1)-x}{1+x(1+x)}+\tan^{-1}\frac{(x+2)-(x+1)}{1+(x+1)(x+2)}+\ldots\ldots$ (2n terms)
$=\tan^{-1}(x+1)-\tan^{-1}x+\tan^{-1}(x+2)-\tan^{-1}(x+1)+\ldots+\tan^{-1}(x+2n)-\tan^{-1}(x+(2n-1))$
$=\tan^{-1}(x+2n)-\tan^{-1}x$
$y(0)=\tan^{-1}(2n)$.

Q19. Solution
Correct Answer: (A)

Since $\sin^2 18^\circ$ and $\cos^2 36^\circ$ are the roots of a quadratic equation. $\therefore$ Sum of roots $=\sin^2 18^\circ+\cos^2 36^\circ$ $=\left(\frac{\sqrt{5}-1}{4}\right)^2+\left(\frac{\sqrt{5}+1}{4}\right)^2=\frac{5+1-2\sqrt{5}}{16}+\frac{5+1+2\sqrt{5}}{16}=\frac{12}{16}=\frac{3}{4}$ and product of roots $=\sin^2 18^\circ\cdot\cos^2 36^\circ$ $=\left(\frac{\sqrt{5}-1}{4}\right)^2\left(\frac{\sqrt{5}+1}{4}\right)^2=\left(\frac{5-1}{4\times 4}\right)^2=\left(\frac{1}{4}\right)^2=\frac{1}{16}$ Required equation whose roots are $\sin^2 18^\circ$ and $\cos^2 36^\circ$, is $x^2-(\text{ sum of roots })x+(\text{ product of roots })=0\Rightarrow\quad x^2-\frac{3}{4}x+\frac{1}{16}=0\Rightarrow\quad 16x^2-12x+1=0\sim$

Q20. Solution
Correct Answer: (C)



Let, $\angle ABC=\angle ACB=\theta$ and slope of $AC=m$
Slope of $BC=-\frac{1}{2}$
Slope of $AB=\frac{3}{4}$
Now, $\tan(\angle ABC)=\tan(\angle \mathrm{ACB})$
$\Rightarrow\frac{\frac{3}{4}-\left(-\frac{1}{2}\right)}{1+\left(\frac{3}{4}\right)\left(-\frac{1}{2}\right)}=\frac{-\frac{1}{2}-m}{1+\left(-\frac{1}{2}m\right)}$
$\Rightarrow 2=\frac{-\frac{1}{2}-m}{1-\frac{m}{2}}\Rightarrow 2-m=-\frac{1}{2}-m\Rightarrow m=$not defined
$\Rightarrow$ equation of AC is $x=2a$:

Q21. Solution
Correct Answer: 41

Since $3.14 < \pi < 3.142, 1.57 < \pi/2 < 1.571$
Thus, $\left[\frac{\pi}{2}+\frac{n}{100}\right]=1$ for $n=0,1,2,\ldots,42$
Thus, largest natural number n for which $E < 43$ is 41.

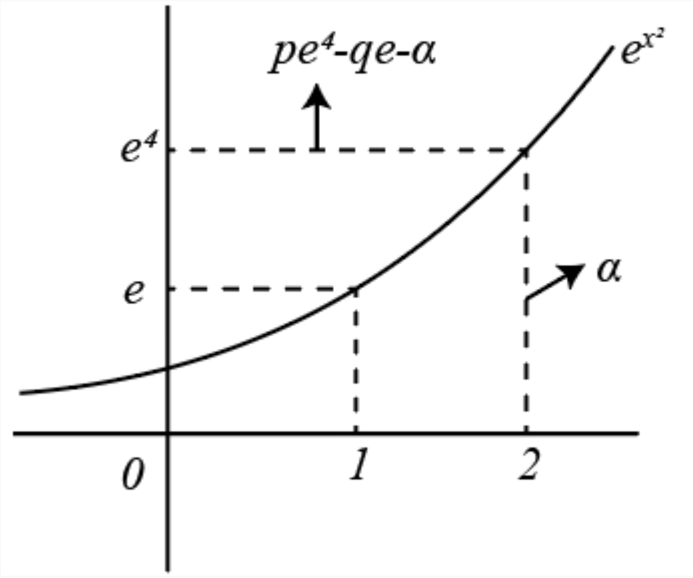
Q22. Solution
Correct Answer: 1

$\because \mathrm{A^T|A|B = A|B|B^T}$
Taking determinant on both sides, we get,
$\mathrm{\left|A^T\right||A||B| = |A||B|\left|B^T\right|}$
$\Rightarrow \mathrm{|A|} = 2$
Now, $\left|\mathrm{AB^{-1}adj}\left(\mathrm{A^TB}\right)^{-1}\right|$
$\left|\mathrm{A}\right| \times \frac{1}{\mathrm{|B|}} \times \frac{1}{\mathrm{|adj(A^TB)|}}$
$\mathrm{|A|} \times \frac{1}{\mathrm{|B|}} \times \frac{1}{\mathrm{|A^TB|^2}} = \frac{\mathrm{|A|}}{\mathrm{|B|^3|A|^2}} = \frac{1}{16}$

i.e. $4\mathrm{K} = \frac{1}{4} = 0.25$

$16\mathrm{K} = 1$

Q23. Solution
Correct Answer: 3



$y = e^{x^2} \rightarrow \quad \ln y = x^2 \Rightarrow x = \sqrt{\ln y}$
$\int_1^2 e^{x^2} \cdot dx + \int_e^{e^4} \sqrt{\ln x} \cdot dx = \cancel{\alpha} + pe^4 - qe - \cancel{\alpha}$
$2e^4 - e = pe^4 - qe$
$p = 2; q = 1 \Rightarrow p + q = 3$

Q24. Solution

Correct Answer: 2

Dividing the given d.e by $y^2 \cos x, -\frac{1}{y^2}\frac{dy}{dx} + \sec x \cdot \frac{1}{y} = 1 - \sin x$

$\frac{d}{dx}\left(\frac{1}{y}\right) + \sec x \cdot \left(\frac{1}{y}\right) = 1 - \sin x$

Linear d.e with I.F. $= \exp \int \sec x dx = \sec x + \tan x$

Solution, $\frac{\sec x + \tan x}{y} = \int \frac{(1-\sin x)(1+\sin x)dx}{\cos x} = \int \cos x dx = \sin x + c$

$x = 0, y = 1 \Rightarrow c = 1$

$\therefore \quad y = \frac{\sec x + \tan x}{\sin x + 1} = \sec x, y\left(\frac{\pi}{3}\right) = 2.$

Q25. Solution

Correct Answer: 2

$$\left.\begin{array}{l}17k \pm 1\\ 17k \pm 2\\ 17k \pm 3\end{array}\right|\downarrow$$

$$\begin{aligned}&= (204+2)^{1753}\\ &= 204k + 2^{1753}\end{aligned}$$

$$\begin{aligned}\frac{2^{1753}}{17} &= \frac{2^1 \times 2^{1752}}{17}\\ &= 2 \times (16)^{438}\\ &= 2 \times (17-1)^{438}\\ &= 2(17k+1)\\ &= 34k + 2\\ \text{Rem } &= 2\end{aligned}$$

Q26. Solution

Correct Answer: (A)

Dimensions of $E = \left[\mathrm{ML^2\,T^{-2}}\right]$

Dimensions of $G = \left[\mathrm{M^{-1}\,L^3\,T^{-2}}\right]$

Dimensions of $I = \left[\mathrm{MLT^{-1}}\right]$

And dimension of $M = [\mathrm{M}]$

$\therefore$ Dimensions of $\frac{GIM^2}{E^2} = \frac{\left[\mathrm{M^{-1}\,L^3\,T^{-2}}\right]\left[\mathrm{MLT^{-1}}\right]\left[\mathrm{M^2}\right]}{\left[\mathrm{ML^2\,T^{-2}}\right]^2}$

$= [\mathrm{T}]$

$=$ Dimensions of time

Q27. Solution

Correct Answer: (C)

$T_{\text{mean}} = \frac{53+52+55+54+51}{5} = 53\text{sec.}$

$$\left.\begin{array}{l}\Delta T_1 = T_{\text{mean}} \sim T_1 = 0 \\ \Delta T_2 = 1\text{sec} \\ \Delta T_3 = 2\text{sec} \\ \Delta T_4 = 1\text{sec} \\ \Delta T_5 = 2\text{sec}\end{array}\right\}$$

$$\Delta T_{\text{mean}} = \frac{0+1+2+1+2}{5}$$

$$= \frac{6}{5} = 1.2 \text{ sec.}$$

Q28. Solution

Correct Answer: (A)

By third's law of motion $v^2 = u^2 + 2as$

$$v^2 - u^2 = -2\left(\frac{F}{m}\right) \cdot s$$

$$-u^2 = -2\frac{F}{m} \cdot s$$

$$u^2 = \frac{2F \cdot s}{m}$$

$$\text{or} \quad m = \frac{2F \cdot s}{u^2} \Rightarrow m \propto s$$

$s_2 = ?$

Given $s_1 = x$ $m_1 = m$

$m_2 = m \times 25\% + m$

Now, $\frac{m_1}{m_2} = \frac{s_1}{s_2}$

$$\frac{m}{m \times \frac{25}{100} + m} = \frac{x}{s_2}$$

$$s_2 = \frac{x \times m\left(\frac{100+25}{100}\right)}{m}$$

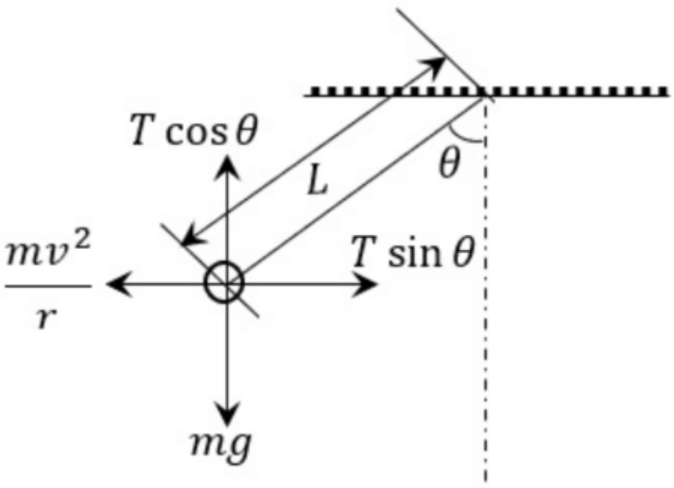
$$s_2 = \frac{125}{100}x$$

$$s_2 = 1.25x$$

Q29. Solution

Correct Answer: (C)

Consider the figure below:



$$T\cos\theta = mg \quad ....(1)$$

$$T\sin\theta = \text{centripetal force} \quad ....(2)$$

On taking the ratio of equation (1) and (2):

Centripetal force $= \mathrm{mg}\tan\theta$

From geometry, $\tan\theta = \frac{\mathrm{r}}{\sqrt{\mathrm{L}^2-\mathrm{r}^2}}$

$\therefore$ Centripetal force $= \frac{\mathrm{mgr}}{\sqrt{\mathrm{L}^2-\mathrm{r}^2}}$

Q30. Solution

Correct Answer: (D)

From the work-energy principle for the given system,

$$-\frac{1}{2}kx^2 - \mu mgx = 0 - \frac{1}{2}mv^2$$

$$\Rightarrow \quad v = \frac{4}{10}, \quad \text{so } N = 4$$

Q31. Solution

Correct Answer: (C)

$\because$ Escape velocity from a planet,

$v_e = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2GM}{R^2}R}$

$= \sqrt{2gR}$ ..... (i)

Acceleration due to gravity,

$g = \frac{GM}{R^2} = \frac{G\frac{4}{3}\pi R^3 \cdot \rho}{R^2} = \frac{4}{3}G\pi R\rho$

$\therefore$ Radius $R = \frac{3g}{4\pi G\rho}$ ..... (ii)

From Equations. (i) and (ii), we get

$v_e = \sqrt{2g \cdot \frac{3g}{4\pi G\rho}} = \sqrt{\frac{3}{2}\frac{g^2}{\pi G\rho}}$

Thus, $v_e \propto \frac{g}{\sqrt{\rho}}$

$\therefore \quad \frac{v_{e_1}}{v_{e_2}} = \frac{g_1}{\sqrt{\rho_1}} \times \frac{\sqrt{\rho_2}}{g_2} = \frac{5}{2} \times \frac{1}{\sqrt{2}}$

$\left(\text{given, } \frac{g_1}{g_2} = \frac{5}{2} \text{ and } \frac{\rho_1}{\rho_2} = 2:1\right)$

$= \frac{5}{2\sqrt{2}}$

Q32. Solution

Correct Answer: (D)

Temperature at 'a' $= \mathrm{T_0} = \frac{\mathrm{PV}}{\mathrm{R}}$

At (a) $\mathrm{T_0} = \frac{\mathrm{P_0V_0}}{\mathrm{R}}$

At (c) $\mathrm{T_C} = \frac{(2\mathrm{P_0})(4\mathrm{V_0})}{\mathrm{R}} = 8\mathrm{T_0}$

$\Delta\mathrm{U} = \mathrm{nC_V}(\mathrm{T_f} - \mathrm{T_i}) = \frac{3}{2}\mathrm{R}(8\mathrm{T_0} - \mathrm{T_0})$

$\Delta\mathrm{U} = \frac{21\,\mathrm{RT_0}}{2} = 10.5\,\mathrm{RT_0}$

Q33. Solution

Correct Answer: (D)

$\gamma_{\text{mix}} = \frac{\frac{\mu_1\gamma_1}{\gamma_1-1} + \frac{\mu_2\gamma_2}{\gamma_2-1}}{\frac{\mu_1}{\gamma_1-1} + \frac{\mu_2}{\gamma_2-1}}$

$= \frac{1\times\frac{5}{3}}{\left(\frac{5}{3}-1\right)} + \frac{1\times\frac{7}{5}}{\left(\frac{7}{5}-1\right)}$

$= \frac{3}{2} = 1.50$

Q34. Solution
Correct Answer: (A)

First calculate the energy needed for $1\ $ kg ice at -20°C to become water at 0°C,

$$Q_1 = m_1 C_1 \Delta t + m_1 L$$

$$Q_1 = \left\{1 \times \left(2.09 \times 10^3\right) \times (20)\right\} + \left\{1 \times \left(334.4 \times 10^3\right)\right\}$$

$$Q_1 = 376200 \text{ J}$$

Energy released by $2\ $ kg of water to decrease its temperature from 90°C to 0°C,

$$Q_2 = m_2 C_2 \Delta t$$

$$Q_2 = 2 \times \left(4.18 \times 10^3\right) \times (90 - 0)$$

$$Q_2 = 752400 \text{ J}$$

As we can observe that $Q_2 > Q_1$, so the complete ice will melt and $Q_2 - Q_1$ energy will remain in the system which will increase the temperature of the system. Suppose the final temperature of the system will be t then,

$$Q_2 - Q_1 = (m_1 + m_2) C (t - 0)$$

$$752400 - 376200 = (1 + 2) \times \left(4.18 \times 10^3\right) \times t$$

$$t = 30^{\circ}\text{C}.$$

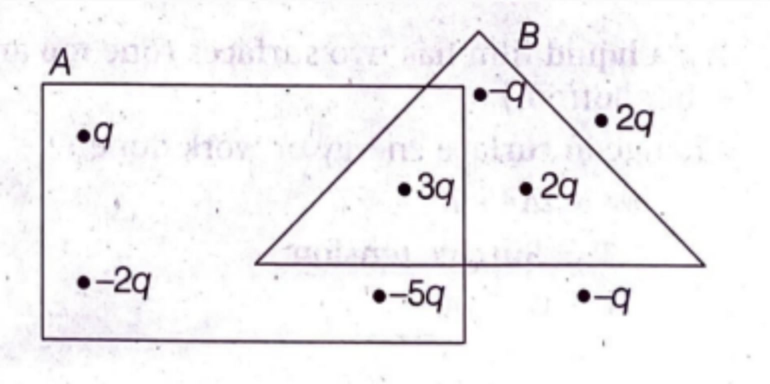
Q35. Solution
Correct Answer: (C)

$E_1 = \frac{1}{2} k x^2, E_2 = \frac{1}{2} k y^2$
$E = \frac{1}{2} k (x + y)^2 = \frac{1}{2} k x^2 + \frac{1}{2} k y^2 + kxy = E_1 + E_2 + 2\sqrt{E_1 E_2} = 2 + 8 + 2\sqrt{16} = 18J$

Q36. Solution

Correct Answer: (D)

The distribution of charges on two Gaussian surfaces A and B are shown below



Flux through a closed surface, $\phi = \frac{q_{\text{net}}}{\varepsilon_0}$

q_{net} = net charge enclosed by the surface

Here, $(q_{\text{net}})_A$ = charge enclosed by surface

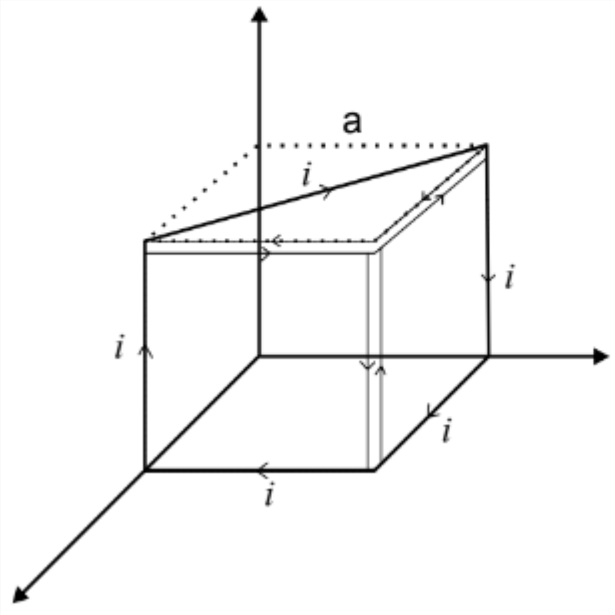
$A = q + 3q - 2q - 5q = -3q$

And $(q_{\text{net}})_B = -q + 3q + 2q = 4q$

So, $\frac{\phi_A}{\phi_B} = \frac{-3q/\varepsilon_0}{4q/\varepsilon_0} = \frac{-3}{4}$

Q37. Solution

Correct Answer: (C)



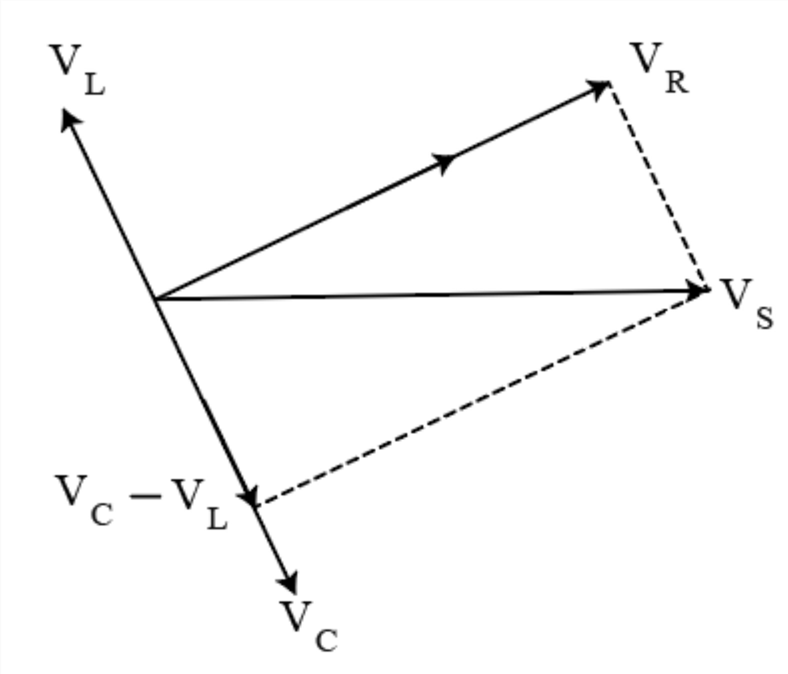
Here $\vec{M} = -ia^2\hat{i} - i\dfrac{a^2}{2}\hat{j} - ia^2\hat{k}$

$\vec{M} = -ia^2\left(\hat{i} + \dfrac{\hat{j}}{2} + \hat{k}\right) \Rightarrow |\vec{M}| = \dfrac{3}{2}ia^2$

$= \dfrac{3}{2} \times 3 \times 1 \quad |\vec{M}| = \dfrac{9}{2}$ amphere - meter ^{2}

Q38. Solution
Correct Answer: (D)

(1) Applied e.m.f. and potential difference across resistance are in same phase $(\times)$
(2) Applied e.m.f. and potential difference at inductor coil have phase difference of $\frac{\pi}{2}$ $(\times)$
(3) Potential difference at capacitor and inductor have phase difference of $\frac{\pi}{2}$. $(\times)$
(4) Potential difference across resistance and capacitor have phase difference of $\frac{\pi}{2}$. $(\checkmark)$
$\tan\phi = \frac{x_C - x_L}{R}$



Q39. Solution
Correct Answer: (B)

$$B_0 = \frac{E_0}{C} = \frac{150}{3 \times 10^8} = 5 \times 10^{-7}$$
$f = 30\text{MHz} = 30 \times 10^6\ \text{Hz}$
$\omega = 60\pi \times 10^6\ \text{Hz},\ \text{K} = \frac{\omega}{\text{C}} = \frac{\text{x}}{5}$
as $\hat{\text{C}} = \overrightarrow{\text{E}} \times \overline{\text{B}}$
So, direction of $\overrightarrow{\text{B}}$ is along z-axis.
Thus, $\overrightarrow{\text{B}} = \left(5 \times 10^{-7}\right) \sin\left[\frac{\pi}{5}\text{x} - 6 \times 10^7 \pi \text{t}\right] \hat{\text{z}}$

Q40. Solution

Correct Answer: (D)

Firstly find out distance of retina from his eye lens i.e., image distance in first case (we are assuming distance between eye lens and retina is not changing which is not true practically we are taking that liberty to make problem more mathematically convenient. However it doesn't effect base line of problem)

$\frac{1}{\mathrm{v}}-\frac{1}{-25}=\frac{1}{f_1}$

$\frac{1}{\mathrm{v}}+\frac{1}{25}=\frac{1}{f_1}$

for second case image distance should be same

$\frac{1}{\mathrm{v}}+\frac{1}{50}=\frac{1}{f_2}$

$\Rightarrow \quad \frac{1}{25}-\frac{1}{50}=\frac{1}{f_1}-\frac{1}{f_2}$

$\Rightarrow \quad \frac{1\mathrm{cm}^{-1}}{50}=\frac{1}{f_1}-\frac{1}{f_2}=\mathrm{P}_1-\mathrm{P}_2=2\mathrm{D}$

Let power of his eye lens in two cases are (Pe)1, (Pe)2 respectively

$\mathrm{P}_1=(2.5+(\mathrm{P}_\mathrm{e})_1)$

$\mathrm{P}_2=(2.5+(\mathrm{P}_\mathrm{e})_2)$

$\Rightarrow \quad \mathrm{P}_1-\mathrm{P}_2=(\mathrm{P}_\mathrm{e})_1-(\mathrm{P}_\mathrm{e})_2$

= 2

So loss in power is 2D so he should use additional power of 2D i.e. 4.5D

Q41. Solution

Correct Answer: (B)

Assertion and Reason are both correct and reason is not the correct explanation of assertion. Check video solution for detailed explanation.

Q42. Solution
Correct Answer: (D)

Given, energy of hydrogen atom in ground state $= -|E|$ and $n_A = 3$
$\therefore$ Energy of electrons in excited state, n_A
$(E)_{n_A} = \frac{-|E|}{n_A^2}$
Energy of electrons in excited state, n_B
$= (E)_{nB} = \frac{-(E)}{n_B^2}$
When sample absorbs the photon of energy, $\frac{|E|}{12}$, then its electrons reaches from energy state n_A to energy state n_B.

$$\text{Hence, } (E)_{n_B} - (E)_{n_A} = \frac{|E|}{12}$$

$$\frac{-|E|}{n_B^2} - \left\{\frac{-|E|}{n_A^2}\right\} = \frac{|E|}{12}$$

$$\frac{-1}{n_B^2} + \frac{1}{n_A^2} = \frac{1}{12} \Rightarrow -\frac{1}{n_B^2} = \frac{1}{12} - \frac{1}{n_A^2}$$

$$= \frac{1}{12} - \frac{1}{9} \Rightarrow -\frac{1}{n_B^2} = -\frac{1}{36}$$

$$\Rightarrow \quad n_B^2 = 36$$

$$\therefore \quad n_B = 6$$

Q43. Solution
Correct Answer: (D)

$$\begin{aligned} Y &= \overline{A + \bar{A}B} \\ &= \bar{A} \cdot \overline{\bar{A}B} \\ &= \bar{A} \cdot (A + \bar{B}) \\ &= A \cdot \bar{A} + \bar{A} \cdot \bar{B} \\ &= 0 + \overline{A + B} \\ &= \overline{A + B} \end{aligned}$$

"NOR"

Q44. Solution

Correct Answer: (B)

Since, the pass axes of two polarisers P_1 and P_2 were kept such that the incident unpolarised beam of intensity I_0 gets completely blocked.

This means that both polarisers were kept cross (perpendicular of their pass axes) to each other. When third polariser P_3 is introduced between P_1 and P_2 such that the angle between the pass axes of P_1 and P_3 is 60°, i.e. $\theta_1 = 60^{\circ}$.

intensity of polarised light emerging from first polaroid, $I_1 = \frac{I_0}{2}$

Intensity of polarised light (I_3) emerging from polaroid P_3 is given by law of Malus, i.e.,

$$I_3 = I_1 \cos^2 \theta,$$
$$= \frac{I_0}{2} \cos^2 60 = \frac{I_0}{2} \frac{1}{4}$$
$$I_3 = \frac{I_0}{8}$$

Now, the angle between pass axis of P_3 and P_2, $\theta_2 = 90^{\circ} - 60^{\circ} = 30^{\circ}$

$\therefore$ Intensity of polarised light emerging from lost (second) polaroid P_2.

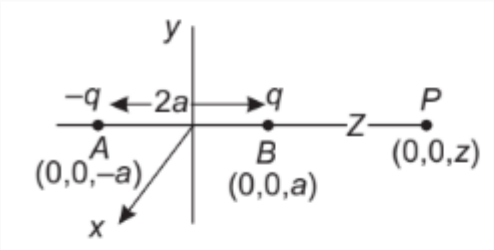
$I_2 = I_3 \cos^2 30^{\circ} = \frac{I_0}{8} \cdot \frac{3}{4} = \frac{3I_0}{32}$

Q45. Solution

Correct Answer: (C)

Potential at P due to $(+q)$ charge

$V_1 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{(z-a)}$



Potential at P due to $(-q)$ charge

$V_2 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{-q}{(z+a)}$

Total potential at P due to (AB) electric dipole

$$V = V_1 + V_2$$
$$= \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{(z-a)} - \frac{1}{4\pi\varepsilon_0} \frac{q}{(z+a)}$$
$$= \frac{q}{4\pi\varepsilon_0} \frac{(z+a-z+a)}{(z-a)(z+a)}$$

$\Rightarrow \quad V = \frac{2qa}{4\pi\varepsilon_0(z^2-a^2)}$

Q46. Solution

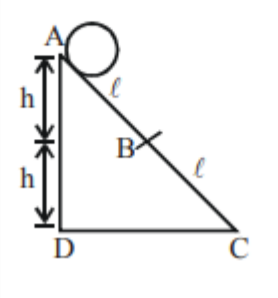
Correct Answer: 5

$$\mathrm{mgh}=\frac{1}{2}\mathrm{mv}^2+\frac{1}{2}\frac{\mathrm{mR}^2}{2}\omega^2 \quad 2\mathrm{mgh}=\frac{1}{2}\mathrm{mv}_{\mathrm{f}}^2+\frac{1}{2}\frac{\mathrm{mR}^2}{2}\omega^2 \quad \mathrm{mgh}=\frac{1}{2}\mathrm{mv}_{\mathrm{f}}^2-\frac{1}{2}\mathrm{mv}^2$$

$\therefore$ Ratio

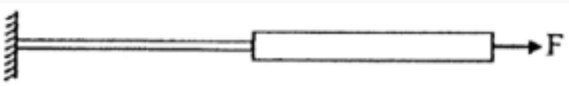
$$\mathrm{mgh}=\frac{3}{4}\mathrm{mv}^2 \quad 2\mathrm{mgh}=\frac{1}{2}\mathrm{mv}_{\mathrm{f}}^2+\mathrm{mgh}-\frac{1}{2}\mathrm{mv}^2 \quad \frac{1}{2}\mathrm{mv}_{\mathrm{f}}^2=\frac{5}{3}\mathrm{mgh}$$

$$=\frac{\frac{1}{2}\mathrm{mv}_{\mathrm{f}}^2}{\frac{1}{2}\frac{\mathrm{mv}^2}{2}}=\frac{\frac{5}{3}\mathrm{mgh}}{\frac{1}{4}\frac{4}{3}\mathrm{mgh}}=5$$



Q47. Solution

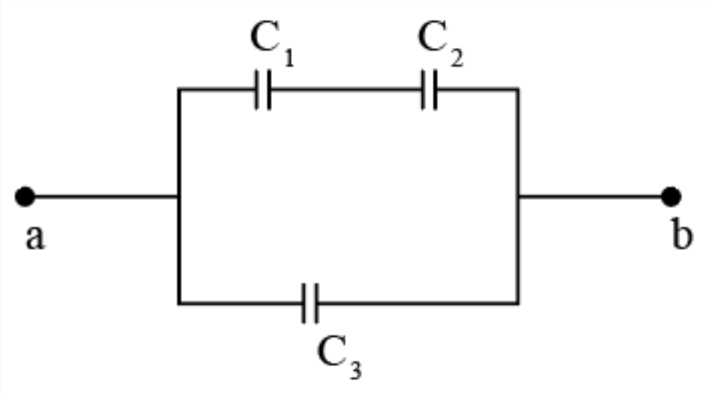
Correct Answer: 8



$$\frac{\mathrm{F}}{\mathrm{A}_1}=\mathrm{y}\frac{\Delta\ell_1}{\ell}$$
$$\frac{\mathrm{F}}{\mathrm{A}_2}=\mathrm{y}\frac{\Delta\ell_2}{\ell}$$
$$\Delta_{\prime_i}+\Delta_{\eta_2}=10\ \mathrm{mm}$$
$$\frac{\mathrm{F}\ell}{\mathrm{A}_1\mathrm{y}}+\frac{\mathrm{F}\ell}{4\ \mathrm{A}_1\mathrm{y}}=10\ \mathrm{mm}\Rightarrow\frac{\mathrm{F}\ell}{\mathrm{A}_1\mathrm{y}}=8\ \mathrm{mm}$$

Q48. Solution

Correct Answer: 3



$\mathrm{C}_1 \equiv \mathrm{C}_2 = \mathrm{C}_3 = \mathrm{C}$

Capacitor $\mathrm{C}_1 \& \mathrm{C}_2$ are in series.

$C_{12} = \frac{C_1 C_2}{C_1 + C_2} = \frac{C^2}{2C} = \frac{C}{2}$

Now C_{12} \& C_3 are in parallel,

$\therefore \mathrm{C}_\mathrm{T} = \mathrm{C}_{12} + \mathrm{C}_3$

$= \dfrac{\mathrm{C}}{2} + \mathrm{C} = \dfrac{3\mathrm{C}}{2}$

C is given as $C = \frac{A\epsilon_0}{d}$

$\therefore$ Capacitance of system,

$\mathrm{C} = \frac{3\,\mathrm{A}\in_0}{2\,\mathrm{d}}$

Q49. Solution

Correct Answer: 6

Heat produced in a resistor

$H = i^2\, R\, t = \frac{V^2}{R} t$

in case of parallel combination voltage is same so

$\therefore\; H \propto \frac{1}{R}$

Ratio of heat dissipated,

$\frac{H_1}{H_2} = \frac{3}{4}$

$\Rightarrow \frac{H_1}{H_2} = \frac{R_2}{R_1} \Rightarrow \frac{R_2}{R_1} = \frac{3}{4}$

$\because\;\; R_1 = G$

Therefore, Equation (i) becomes,

$R_2 = \frac{3}{4} G$

Q50. Solution
Correct Answer: 200

$\mathrm{N} = qvB$

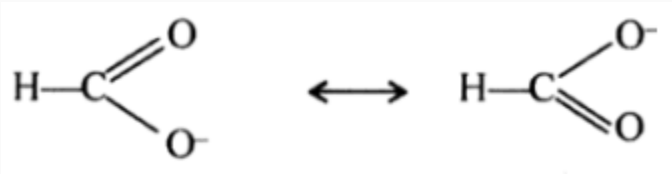
$$-\mu\mathrm{qvB} = \frac{\mathrm{mdv}}{\mathrm{dt}} = \mathrm{mv}\frac{\mathrm{dv}}{\mathrm{dS}}$$
$\mu\mathrm{qBS} = \mathrm{mv}$

$\mathrm{S} = \frac{3\times10^{-6}\times4}{0.3\times10^{-6}\times0.2} = 200\ \mathrm{m}$

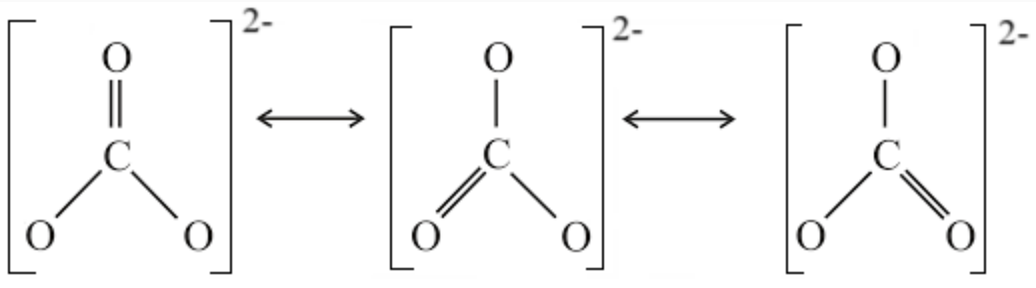
Q51. Solution
Correct Answer: (B)

The boiling point of an azeotropic mixture of water and ethyl alcohol is less than that of theoretical value of water and alcohol mixture. Hence, the mixture shows positive deviation from Raoult's law.
Positive deviations from Raoult's law are noticed when
(i) Exp. vaue of vapour pressure of mixture is more than calculated value.
(ii) Exp. value of boiling point of mixture is less than calculated value.
(iii) $\Delta\mathrm{H}_{\text{mixing}} = +\mathrm{ve}$
(iv) $\Delta\mathrm{V}_{\text{mixing}} = +\mathrm{ve}$

Q52. Solution
Correct Answer: (C)

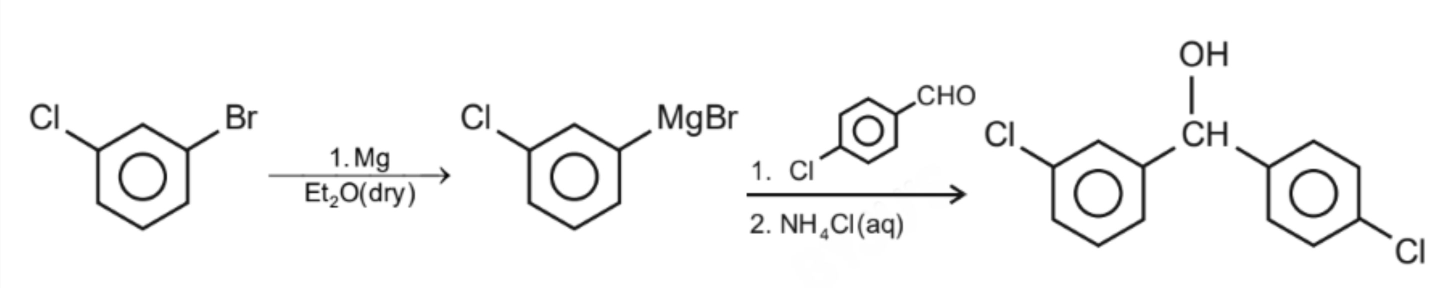


B.O. $= \frac{2+1}{2} = 1.5$



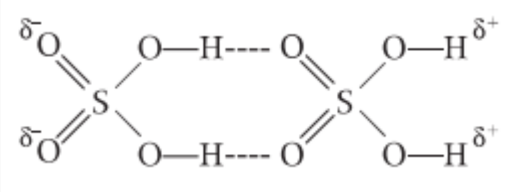
B.O. $= \frac{2+1+1}{3} = \frac{4}{3} = 1.33$
$\mathrm{C}-\mathrm{O}$ bond length in HCOO^{-} is less than $\mathrm{C}-\mathrm{O}$ bond length in CO_3^{2-}

Q53. Solution
Correct Answer: (A)



Q54. Solution
Correct Answer: (A)

H_2SO_4 involves H-bonding due to which it is less volatile.



Q55. Solution
Correct Answer: (A)

More the electropositivity of central atom, the more basic is the oxide and more electronegative central atom, more acidic is the oxide.
As we know, the electronegativity is the property of the element to attract electrons pairs. Hence, acidic character of the oxides "decreases down the group" because the electronegativity decreases down the group.
Electronegativity decreases down the group because the "distance between the nucleus and valences shell electron increases. Hence, acidic nature of oxides increases left to right and decreases from top to bottom.

Q56. Solution
Correct Answer: (C)

(A) Atomic radius does not decrease regularly down the group due to d - and f -block contraction. Hence, this statement is incorrect.
(B) & (C) check video solution for details.
(D) Compounds of boron, like boric acid (H_3BO_3), exhibit significant $p\pi - p\pi$ character due to boron's small size and its ability to form strong π-overlap. This statement is correct.
(E) Boron shows a diagonal relationship with silicon, resulting in similar chemical behavior, such as the formation of covalent compounds, acidic oxides, and tetrahedral structures like BF_4 and SiF_4. This statement is correct.
Correct Answer: (C), (D), and (E) only.

Q57. Solution
Correct Answer: (D)

n represents the principal quantum number, i.e., shell number.

l represents the azimuthal quantum number which gives an idea about the sub-shell in which electron is present.

m represents the magnetic quantum number which gives an idea about the shape and orientation of orbitals.

For orbital A,

$\mathrm{n}=3,\ \mathrm{l}=2,\ \mathrm{m}=0$, so, it is $3\mathrm{d}_{\mathrm{xz}}$ orbital.

For orbital B,

$\mathrm{n}=3,\ \mathrm{l}=1,\ \mathrm{m}=0$, so, it is $3\mathrm{p}_{\mathrm{y}}$ orbital.

More the value of $\mathrm{n}+\mathrm{l}$, more is the energy of an orbital. So, energy of $3\mathrm{d}\ >\ 3\mathrm{p}$.

Lobes of given $\mathrm{p}-$orbital lies on $\mathrm{y}-$axis, so, probability of finding electron density in B is zero along $\mathrm{x}-\mathrm{z}$ plane.

The electron density in d_{xz} orbital is along the lobes oriented at 45° to both x & $\mathrm{z}-$axes.

The formula for finding:

Radial nodes $=\mathrm{n}-\mathrm{l}-1$

Angular nodes $=\mathrm{l}$.

Thus, for the orbital in B:

Radial nodes $=3-1-1=1$

Angular nodes $=1$.

Q58. Solution
Correct Answer: (C)

$2\mathrm{Au}^{3+}+6\mathrm{e}^{-}\longrightarrow 2\mathrm{Au}, \Delta G^{\circ}=-6\times 1.52F\ldots$ (i)
$3\mathrm{Au}^{3+}+6\mathrm{e}^{-}\longrightarrow 3\mathrm{Au}^{+}, \Delta G^{\circ}=-6\times 1.36\ \mathrm{F}\ldots$ (ii)
For the reaction
$3\mathrm{Au}^{+}\longrightarrow 2\mathrm{Au}+\mathrm{Au}^{3+}, \Delta G^{\circ}=\text{(i)}-\text{(ii)}$
$=8.16F-9.12F=-0.96\ \mathrm{F}$ (negative)

Q59. Solution

Correct Answer: (D)

$CH_3CH = CH_2$ to $CH_3CH_2CH_2Cl$ in the presence of HCl in a peroxide is not feasible as peroxide/kharash effect is not observed for HCl and HI.

$\underset{\substack{| \\ Cl}}{CH_3CH} - \underset{\substack{| \\ Cl}}{CH_2}$ to $CH_3C \equiv CH$ using KOH/Δ is not feasible as this reaction would give an alkene which when treated with sodamíde gives alkyne.

Thus, I and III are not feasible.

Q60. Solution

Correct Answer: (B)

Copper, Silver, Aurum and Roentgenium belong to IB.

Down the group, the atomic radius increases, so, the nuclear force of attraction decreases and the metallic character increases.

Q61. Solution

Correct Answer: (D)

(A) $[Na_2Zn(OH)_4] + H_2S \rightarrow ZnS \downarrow + 2NaOH + 2H_2O$

(B)

$3Hg \downarrow + 3HgS \downarrow + 12HCl + 4HNO_3 \rightarrow 6HgCl_2 + 3S \downarrow + 4NO \uparrow + 8H_2O$

$S \downarrow + 6HCl + 2HNO_3 \rightarrow SO_4^{2-} + 6Cl^{-1} + 8H^+ + 2NO \uparrow$

(D)

$Fe^{3+} + 2S_2O_3^{2-} \rightarrow [Fe(S_2O_3)_2]^{-1}$ (violet colouration)

$[Fe(S_2O_3)_2]^{-1} + Fe^{3+} \rightarrow 2Fe^{2+} + S_4O_6^{2-}$

Q62. Solution

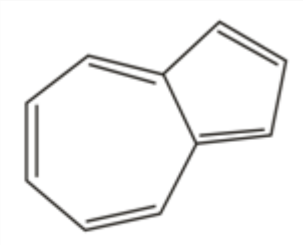
Correct Answer: (A)

Bond energy $\propto \frac{1}{Bond\ length}$

Bond length order in carbon halogen bonds arein the order of C – F < C – Cl < C – Br < C – I Hence, Bond energy order C – F > C – Cl > C – Br > C – I

Q63. Solution

Correct Answer: (B)

I 

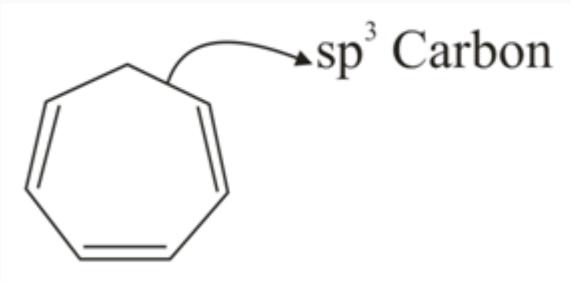
The compound is an example of polycyclic, non-benzenoid fused rings. Here, the aromaticity is defined by Craig's rule.

Craig's rule states that if a molecule contains $c - axis$, then the count total of number of bonds(N) can be calculated with the value of $\mathrm{N} - 1$.

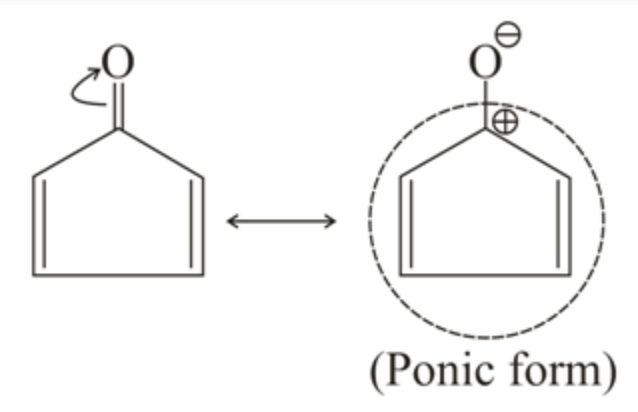
If $\mathrm{N} - 1 =$ even, the compound is aromatic.

Here,

$\mathrm{N} = 5$ and $\mathrm{N} - 1 = 4$. So, the compound is aromatic

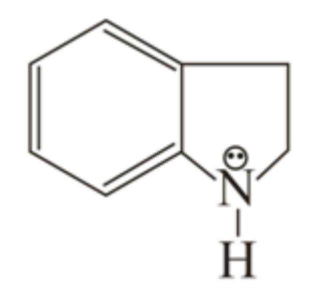
II 

- The sp^3 carbon atom restricts the configuration of $\pi \mathrm{e}^-$. Hence, the structure is non aromatic.

III 

- Does not follow Huckel's rule.
- Cyclic structure (yes)
- Planer structure (yes)
- $\left(4\,\mathrm{ne}^2\right)\pi\mathrm{e}^-(\mathrm{No})$

The structures have $\left(4\mathrm{n}\pi\mathrm{e}^-\right)$ where $\mathrm{n} = 1$. So, the structure is antiaromatic.

IV 

The Indole structure has $10\pi e^{-}$, and followed Huckel's rule.

$(4\,ne^{2})\pi e = 10$

$4n\pi e = 8$

$n = 2$

So, the structure is aromatic.

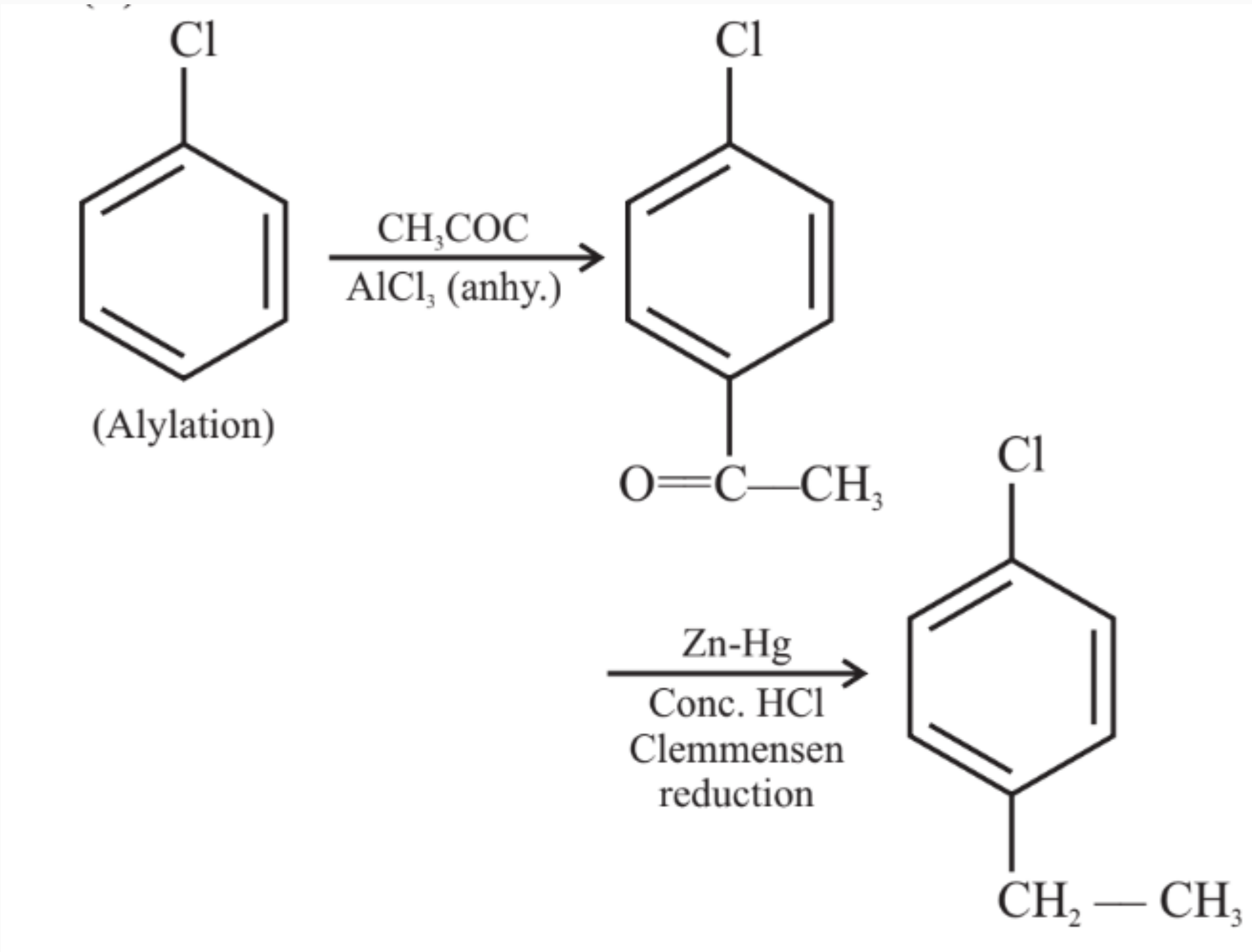
V 

Counting πe^{-}, we get $= 4\pi e^{-}$, and hence, the structure is antiaromatic.

- Cyclic
- Planer
- $4n\pi e^{-}$

Q64. Solution

Correct Answer: (D)

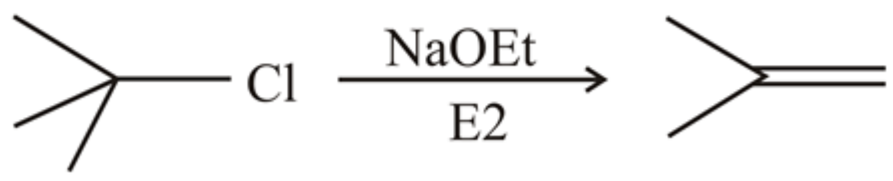


Q65. Solution

Correct Answer: (A)

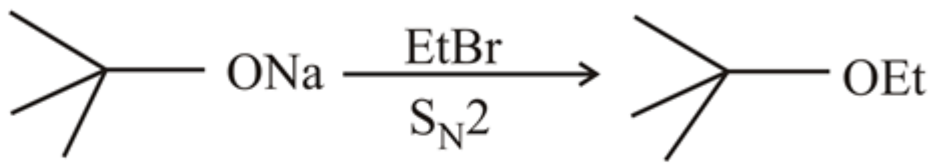
P: NaOEt

P is dehydrohalogenation of haloalkanes to give alkenes in the presence of a strong base like NaOEt.



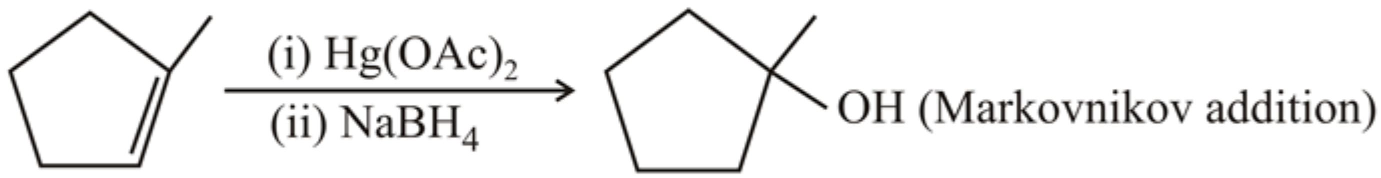
Q: EtBr

Q is Williamson ether synthesis which is an organic reaction, forming an ether from an organohalide (EtBr) and an alkoxide. Thus, Q matches with EtBr which is an organohalide.



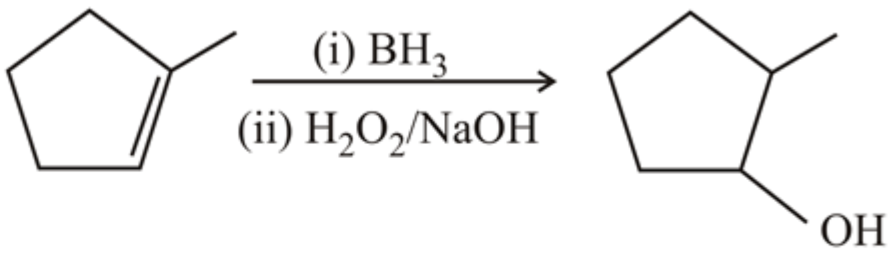
R: $Hg(OAc)_2;\ NaBH_4$

In R, the reagent used to produce alcohol from alkene by Markovnikov's rule is $Hg(OAc)_2;\ NaBH_4$



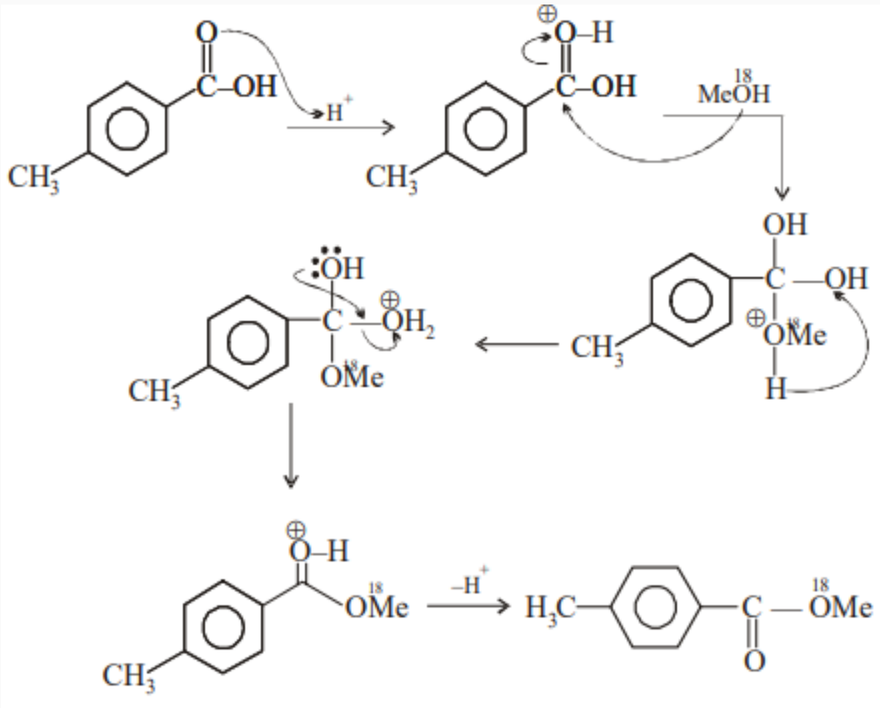
S: $BH_3;\ H_2O_2/\ NaOH$

S is hydroboration oxidation which is an anti-Markovnikov's reaction, which converts an alkene into alcohol. The process results in the syn-addition of hydrogen and anti-addition of a hydroxyl group, where the double bond has been. The reagent used is $BH_3;\ H_2O_2/\ NaOH$.



Q66. Solution

Correct Answer: (A)



Q67. Solution

Correct Answer: (B)

Titration of iodine (I_2) by thiosulphate solution $\left(S_2O_3^{2-}\right)$ follows the reaction:

$2S_2O_3^{2-} + I_2 \rightarrow 2I^- + S_4O_6^{2-}$

In the presence of starch, free iodine present in the solution imparts blue colour to the solution.

End point marks the completion of reaction, that is, at this point all the iodine present in the solution is reduced to iodide ions by thiosulphate solution.

So, due to the absence of free iodine in the solution, the solution turns colourless.

Thus, the end point is indicated by colour change in the solution from blue to colourless.

Q68. Solution

Correct Answer: (D)

Nucleosides are the structural subunit of nucleic acids such as DNA and RNA. A nucleoside, composed of a nucleobase, is either a pyrimidine (cytosine, thymine or uracil) or a purine (adenine or guanine), a five carbon sugar which is either ribose or deoxyribose. The base connected to sugar at position. Nucleotides are building blocks of nucleic acids DNA and RNA. Nucleotides are composed of a nitrogenous base, a five-carbon sugar (ribose or deoxyribose), and at least one phosphate group. Thus, a nucleoside plus a phosphate group yields a nucleotide.

Q69. Solution
Correct Answer: (D)

Tert-butyl carbocation is more stable than benzyl carbocation. 9 alpha hydrogen stability dominates over resonance due to benzene ring.

Q70. Solution
Correct Answer: (A)

The solution must contain Ni^{2+} as it forms a complex with DMG giving $[Ni(DMG)_2]$ which is red in colour.

Q71. Solution
Correct Answer: 4

$\mathrm{N_2O_4\ (g) \rightleftharpoons 2NO_2\ (g)}$
Molar concentration of $[\mathrm{N_2O_4}] = \frac{9.2}{92} = 0.1\ \mathrm{mol/L}$
In the equilibrium state,
(When 50% dissociation occurs)
$[\mathrm{N_2O_4}] = 0.05\ \mathrm{M}$
$[\mathrm{NO_2}] = 0.1\ \mathrm{M}$
$\because \mathrm{K_c} = \frac{[\mathrm{NO_2}]^2}{[\mathrm{N_2O_4}]}$
$\therefore \mathrm{K_c} = \frac{0.1\times0.1}{0.05} = 0.2$

Q72. Solution
Correct Answer: 720

To calculate the work done, we neet to know the final temperature.
$\mathrm{T_1 = 300\ K, P_1 = 1\ atm, n = 2\ mole\ , P_2 = 2\ atm,\ V_1 = \frac{nRT_1}{P_1}}$
$\mathrm{w = \Delta Y = nC_v\,(T_2 - T_1) = -P_2\,(V_2 - V_1)}$
For a monatomic gas, $\mathrm{C_v = \frac{3}{2}R}$
$\Rightarrow \quad \mathrm{\frac{3}{2}nR\,(T_2 - T_1) = -P_2\,(V_2 - V_1)}$
$$\mathrm{\frac{3}{2}nR\,(T_2 - T_1) = -P_2\left(nR\frac{T_2}{P_2} - nR\frac{T_1}{P_1}\right)}$$
$$\mathrm{\frac{3}{2}(T_2 - T_1) = -T_2 + \frac{P_2}{P_1} \Rightarrow T_2 = \frac{2}{3}\left(\frac{P_2}{P_1} + \frac{3}{2}\right)T_1}$$
$\mathrm{T_2 = 0.4(2 + 1.5)300 = 420\ K}$
Work done, $\mathrm{W = nC_v\Delta T = 2 \times \frac{3}{2}R \times (420 - 300)}$
$\mathrm{\Rightarrow W = 2 \times \frac{3}{2} \times 2 \times 120 = 720cal}$

Q73. Solution

Correct Answer: 724

$\Delta T_f = iK_f m$ (i = 1 for non-electrolyte)

$2 = 0.76 \times \frac{n}{\frac{100}{1000}}$

$n = \frac{2}{7.6}$

Relative lowering in vapour pressure $= X_B$ (mole fraction of solute)

$\frac{\Delta P}{P_A^0} = \frac{2/7.6}{100/18}$

$\frac{\Delta P}{760} = \frac{36}{760}$

$\Delta P = 36$

$P = 760 - 36$

$P = 724$ mm of Hg

Q74. Solution

Correct Answer: 7

$$\frac{k_1}{k_2} = \frac{A_1}{A_2} e\left(\frac{Ea_2 - Ea_1}{1000}\right)$$

$$100 = \frac{1}{10} e^{\left(\frac{Ba_2 - Ba_2}{1000}\right)}$$

$$1000 = e^{\left(\frac{\left(Ea_2 - Ea_{a_1}\right.}{1000}\right)}$$

$$\ln 10^3 = \left(\frac{Ba_i - Ea_1}{1000}\right)$$

$$\frac{3 \ln 10 \times 1000}{1000} = (Ea_2 - Ea_1)$$

Q75. Solution

Correct Answer: 393

Given:

Weight of the substance C_3H_7N, which was analysed for $N_2 = 2$ g

Molar mass of $C_3H_7N = 57$ g

By Dumas method, the estimation of nitrogen,

$C_3H_7N \rightarrow \frac{1}{2}N_2$

By applying the mole-mole analysis,

$1\ \text{mol}\ C_3H_7N = 57\ \text{g}\ \text{of}\ C_3H_7N$

And 1 mol of C_3H_7N gives $\frac{1}{2}\text{mol}\ \ \text{of}\ N_2$

$\Rightarrow \frac{2}{57}$ mol of $C_3H_7N \rightarrow \frac{1}{2} \times \frac{2}{57}$ mol of N_2

Moles of nitrogen gas evolved $= \frac{1}{57}\ \text{mol}\ N_2$

Now, at NTP, the volume of 1 mol substance $= 22400\ \text{mL}$

$\Rightarrow$Volume of $\frac{1}{57}$ mol of N_2 $\text{at}\ \ \text{NTP}\ (\text{mL}) = \frac{1}{57} \times 22400\ = 393\ \text{mL}$

Hence, the volume of nitrogen evolved at NTP from 2 g $C_3H_7N = 393\ \text{mL}$