Answer Key

Mathematics (25 Questions)

Q1. (B)	Q2. (A)	Q3. (D)	Q4. (C)	Q5. (D)
Q6. (D)	Q7. (B)	Q8. (B)	Q9. (A)	Q10. (B)
Q11. (B)	Q12. (D)	Q13. (B)	Q14. (B)	Q15. (D)
Q16. (B)	Q17. (A)	Q18. (C)	Q19. (B)	Q20. (B)
Q21. 9	Q22. 2	Q23. 17	Q24. 28	Q25. 2

Physics (25 Questions)

Q26. (A)	Q27. (C)	Q28. (A)	Q29. (B)	Q30. (B)
Q31. (B)	Q32. (C)	Q33. (A)	Q34. (D)	Q35. (A)
Q36. (D)	Q37. (B)	Q38. (D)	Q39. (B)	Q40. (A)
Q41. (B)	Q42. (A)	Q43. (C)	Q44. (A)	Q45. (C)
Q46. 8	Q47. 4	Q48. 4	Q49. 2	Q50. 6

Chemistry (25 Questions)

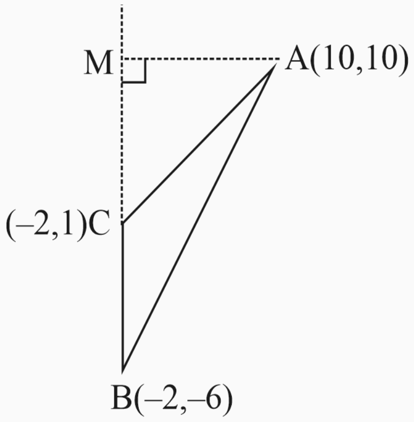
Q51. (D)	Q52. (B)	Q53. (D)	Q54. (D)	Q55. (B)
Q56. (C)	Q57. (B)	Q58. (B)	Q59. (B)	Q60. (D)
Q61. (B)	Q62. (B)	Q63. (D)	Q64. (C)	Q65. (A)
Q66. (D)	Q67. (B)	Q68. (D)	Q69. (D)	Q70. (A)
Q71. 36	Q72. 4200	Q73. 25	Q74. 4	Q75. 2

Solutions

Q1. Solution

Correct Answer: (B)

Let perpendicular bisector of AB is $3x+4y-20=0$ and perpendicular bisector of AC is $8x+6y-65=0$
$\Rightarrow$ Image of A w.r.t. $3x+4y-20=0$ is B and image of A w.r.t $\quad 8x+6y-65=0$ is C.



For B, $\frac{x-10}{3}=\frac{y-10}{4}=-2\left(\frac{30+40-20}{25}\right) \quad \Rightarrow \quad B \equiv(-2,-6)$ For
C, $\frac{x-10}{8}=\frac{y-10}{6}=-2\left(\frac{80+60-65}{100}\right) \quad \Rightarrow \quad C \equiv(-2,1)$ Area of $\triangle ABC=\frac{1}{2}(10+2)(1+6)=42 \quad \Rightarrow$
Required value $=6$

Q2. Solution
Correct Answer: (A)

Let the arithmetic series be $a_1, a_2, \dots, a_{2p}$ with first term a and common difference d.
The terms are $a, a+d, a+2d, \dots, a+(2p-1)d$.
The terms at odd places are $a_1, a_3, \dots, a_{2p-1}$.
These are $a, a+2d, a+4d, \dots, a+(2p-2)d$.
This is an arithmetic progression with p terms, first term $A = a$, and common difference $D = 2d$.
The sum of terms at odd places is $S_{odd} = \frac{p}{2}[2A + (p-1)D] = \frac{p}{2}[2a + (p-1)(2d)] = p[a + (p-1)d]$.
Given $S_{odd} = 20$.
So, $p[a + (p-1)d] = 20 \quad (1)$
The terms at even places are $a_2, a_4, \dots, a_{2p}$.
These are $a+d, a+3d, \dots, a+(2p-1)d$.
This is an arithmetic progression with p terms, first term $A' = a+d$, and common difference $D' = 2d$.
The sum of terms at even places is
$S_{even} = \frac{p}{2}[2A' + (p-1)D'] = \frac{p}{2}[2(a+d) + (p-1)(2d)] = p[a+d+(p-1)d] = p[a+pd]$.
Given $S_{even} = 24$.
So, $p[a+pd] = 24 \quad (2)$
The difference between the last term and the first term of the series is 7.
The last term is $a_{2p} = a + (2p-1)d$.
The first term is $a_1 = a$.
$a_{2p} - a_1 = (a + (2p-1)d) - a = (2p-1)d$.
Given $(2p-1)d = 7 \quad (3)$
Now, we solve the system of equations (1), (2), and (3).
From (1): $pa + p(p-1)d = 20$ and From (2): $pa + p^2d = 24$
Subtracting equation (1) from equation (2):
$(pa + p^2d) - (pa + p(p-1)d) = 24 - 20$
$p^2d - (p^2d - pd) = 4$
$pd = 4 \quad (4)$
Now we have two equations involving p and d:
1. $(2p-1)d = 7$
2. $pd = 4$

From equation (4), we can express d as $d = \frac{4}{p}$.
Substitute this expression for d into equation (3):
$(2p-1)\left(\frac{4}{p}\right) = 7$
$4(2p-1) = 7p$
$8p - 4 = 7p$
$8p - 7p = 4$
$p = 4$.

Q3. Solution

Correct Answer: (D)

Here $z^2 - z = |z|^2 + \frac{64}{|z|^5}$ ...(i) $\begin{aligned} &\Rightarrow \quad z^2 - z = \bar{z}^2 - \bar{z} \\ &\Rightarrow \quad (z-\bar{z})(z+\bar{z}-1) = 0 \end{aligned}$ ($\because z^2 - z$ is purely real number) $\Rightarrow \quad z = \bar{z}$ as $z + \bar{z} = 1$ is not possible $\left(\because x \neq \frac{1}{2}\right) \Rightarrow \quad z = x \therefore$ Equation (i), given as $x^2 - x - |x|^2 - \frac{64}{|x|^5} = 0 \quad \Rightarrow \quad x = -2 \therefore$ Only one solution

Q4. Solution

Correct Answer: (C)

Given $\vec{r} \times \vec{a} = \vec{b} \times \vec{a}$

$\Rightarrow \vec{r} \times \vec{a} - \vec{b} \times \vec{a} = 0$

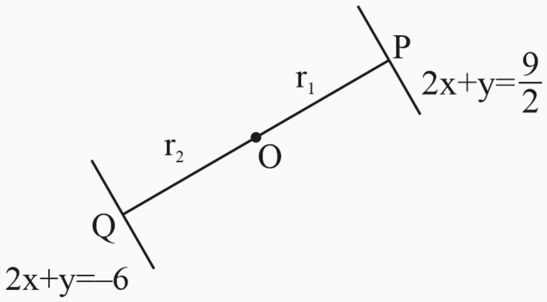
$\Rightarrow \quad (\vec{r} - \vec{b}) \times \vec{a} = 0 \Rightarrow (\vec{r} - \vec{b})$ is parallel/collinear to $\vec{a} \Rightarrow \quad \vec{r} - \vec{b} = p\vec{a}$

$\Rightarrow \vec{r} = b + p\vec{a} \quad \ldots$ (1) (Equation of the line) Similarly, $\vec{r} \times \vec{b} - \vec{a} \times \vec{b} = 0 \Rightarrow \vec{r} = a + s\vec{b}$ ... (2) (Equation of the line) The point of intersection of (1) and (2) gives $\vec{b} + p\vec{a} = \vec{a} + s\vec{b} \Rightarrow \vec{b}(1-s) + \vec{a}(p-1) = 0$ Since $\vec{a}$ and $\vec{b}$ are non collinear $\Rightarrow 1 - s = 0$ and $p - 1 = 0 \Rightarrow p = s = 1$ Hence point of intersection is $\vec{a} + \vec{b} = 3\hat{i} + \hat{j} - \hat{k}$.

Q5. Solution

Correct Answer: (D)

The line makes an angle of 60° with axis of x, m $= \sqrt{3}$ and passes through $P(\sqrt{3}, 0)$. Hence its parametric equation is $\frac{x-\sqrt{3}}{\cos 60^\circ} = \frac{y-0}{\sin 60^\circ} = r$ Solve with parabola $y^2 = x + 2$ and get a quadratic in r as



$3r^2 - 2r - (4\sqrt{3} + 8) = 0$

$\therefore r_1 r_2 = PA \cdot PB$

$= \dfrac{4\sqrt{3}+8}{3} = \dfrac{4(\sqrt{3}+2)}{3}$

Q6. Solution

Correct Answer: (D)

$\int_0^x \mathrm{f}(\mathrm{g}(\mathrm{t}))\mathrm{dt} = \frac{1}{2}\left(1 - \mathrm{e}^{-2\mathrm{x}}\right)$ differentiating both sides w.r.t. x $f(g(x)) = e^{-2x} \Rightarrow f'(g(x)) \cdot g'(x) = -2e^{-2x}$

Let $g(f(x)) = y$

$$\therefore x \cdot y \cdot (-2) \cdot e^{-2x} = e^{-2x} \cdot \frac{dy}{dx}$$

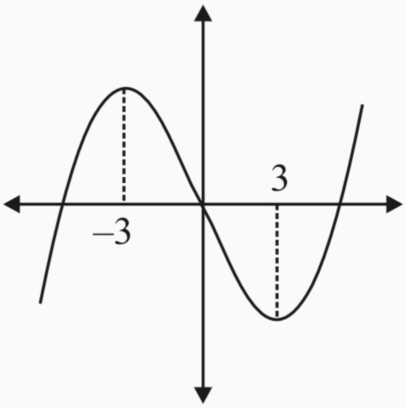
$$\Rightarrow \frac{dy}{dx} = -2yx \Rightarrow \frac{dy}{y} + 2x dx = 0$$

$$\Rightarrow \ell ny + x^2 = c \Rightarrow y = e^{c-x^2} \Rightarrow g(f(x)) = e^{-x^2}$$

$$\therefore h(x) = \frac{e^{-x^2}}{e^{-2x}} = e^{2x-x^2}$$

Q7. Solution

Correct Answer: (B)

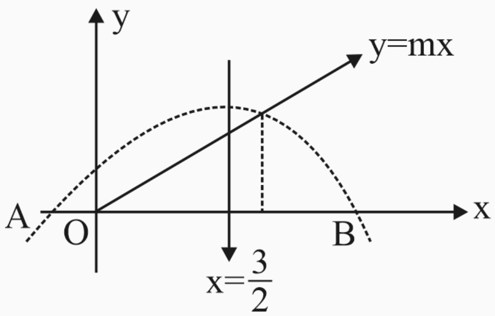


$f(x)=x^3-27x+k=0$
$f'(x)=3x^2-27 \Rightarrow f'(x)=0 \Rightarrow x=\pm 3$
$f''(x)=6x=0 \Rightarrow x=0$

2 roots integer $\Rightarrow 3^{\text{rd}}$ must be integer Possible cases $\rightarrow$ root $=0 \Rightarrow k=0$ (Not possible); Roots $\pm 1 \Rightarrow k=\pm 26$ (Not Possible) $\begin{aligned} & Qx^3-27x+26=0 \\ & (x-1)\left(x^2+x-26\right)=0\end{aligned}$ From $\pm 2 \Rightarrow k=\pm 46$ (Not possible) From $\pm 3 \Rightarrow k=\pm 54 \Rightarrow x^3-27x-54=(x-3)^2(x+6)$
$2=\pm 3 \Rightarrow 2=\pm 54; \Rightarrow k=\pm 54 \Rightarrow x^3-27x-54=(x+3)^2(x-6)$ Only possibility $k=\pm 54$

Q8. Solution

Correct Answer: (B)



Here, the curve is $x^2-4x=1-y$, ie, $(x-2)^2=-(y-5)$

It is a parabola whose vertex is $(2,5)$, axis is $x-2=0$ and $y \leq 5$ at every point of the curve. Also, when $x=0, y=1+4x-x^2$ gives $y=1$ So, the parabola cuts the y-axis at $(0,1)$ when $y=0, y=1+4x-x^2$ gives; $1+4x-x^2=0$ ie, $x^2-4x-1=0 \quad \therefore \quad x=\frac{4 \pm \sqrt{20}}{2}=2 \pm \sqrt{5}$ The parabola cut's x-axes $A(2-\sqrt{5}, 0) \& B(2+\sqrt{5}, 0) \therefore \quad$ The parabola cuts the x-axis at $A(2-\sqrt{5}, 0)$ and $B(2+\sqrt{5}, 0)$. The area enclosed by the lines $x=0, y=0, x=3/2$ and the curve $\begin{aligned} & =\int_0^{3/2} y d x=\int_0^{3/2}\left(1+4x-x^2\right) d x \\ & =\left(\frac{3}{2}+2 \cdot \frac{9}{4}-\frac{1}{3} \cdot \frac{27}{8}\right)=\frac{39}{8}\end{aligned}$ The area bounded by the lines $(y=mx, y=0$ and $x=3/2)=\int_0^{3/2} y d x=\int_0^{3/2} m x d x=\frac{9m}{8}$ According to questions, $\frac{9}{8} m=\frac{1}{2} \cdot \frac{39}{8} \quad \Rightarrow \quad m=13/6$

Q9. Solution

Correct Answer: (A)

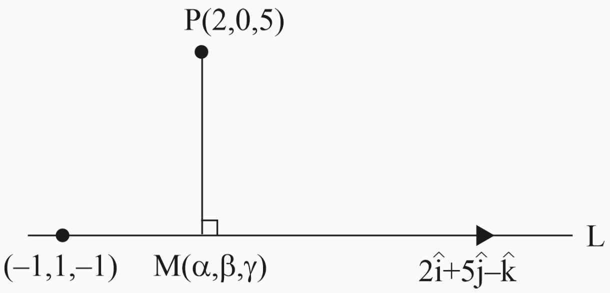
$$\because \frac{dx}{dy}+\frac{x^2}{y^2}-\frac{x}{y}+1=0$$

Let $\frac{x}{y}=t \Rightarrow x=ty \Rightarrow \frac{dx}{dy}=y\frac{dt}{dy}+t \quad \therefore y\frac{dt}{dy}+t+t^2-t+1=0 \Rightarrow \frac{dt}{t^2+1}=\frac{-dy}{y}$

$$\Rightarrow \tan^{-1}(t)+\ln y+C=0 \Rightarrow \tan^{-1}\left(\frac{x}{y}\right)+\ln y+C=0$$

Q10. Solution

Correct Answer: (B)



$L : \frac{x+1}{2}=\frac{y-1}{5}=\frac{z+2}{-1}=\lambda$ (let)

Let foot of perpendicular be $M(2\lambda-1, 5\lambda+1, -\lambda-1)$. Now, $\overrightarrow{PM} \perp (2\hat{i}+5\hat{j}-\hat{k})$

$\therefore PM \cdot (2\hat{i}+5\hat{j}-\hat{k})$

$$\Rightarrow \lambda=-\frac{1}{6} \Rightarrow (\alpha,\beta,\gamma) \equiv \left(-\frac{4}{3},\frac{1}{6},-\frac{5}{6}\right)$$

Q11. Solution

Correct Answer: (B)

The prime digits are $2,3,5,7$. If we fix 2 at first place, then other eleven places are filled by all four digits. So, total number of ways $=4^{11}$. Now sum of 2 consecutive digits is prime when consecutive digits are $(2,3)$ or $(2,5)$, then 2 will be fixed at all alternate places.

2		2		2		2		2		2	

So, favourable cases $=2^6$ $\therefore$ Required probability $=\frac{2^6}{2^{22}}=\frac{1}{2^{16}}$.

Q12. Solution

Correct Answer: (D)

For $f(x)$ to be defined

$(i)\ \left[2x^2-3\right]=-1,\ 0,1$

$\Rightarrow -1 \leq 2x^2-3<2 \Rightarrow 2 \leq 2x^2<5$

$\Rightarrow 1 \leq x^2<\frac{5}{2}$

$\Rightarrow \begin{cases}1 \leq x^2 \Rightarrow x \leq -1\ \ \&x \geq 1 \\ x^2<\frac{5}{2} \Rightarrow -\sqrt{\frac{5}{2}}<x<\sqrt{\frac{5}{2}}\end{cases}$

$-\sqrt{\frac{5}{2}}<x \leq -1 \& 1 \leq x<\sqrt{\frac{5}{2}} \ldots .\left(A\right)$

$(ii)\ x^2-5x+5>0$

$\Rightarrow x<\frac{5-\sqrt{5}}{2}$ or $x>\frac{5+\sqrt{5}}{2} \ldots(B)$

$(iii)\ \log_{\frac{1}{2}}\left(x^2-5x+5\right)>0$

$\Rightarrow x^2-5x+5<\left(\frac{1}{2}\right)^0$

$\Rightarrow x^2-5x+5<1 \Rightarrow x^2-5x+4<0$

$\Rightarrow 1<x<4 \ldots(C)$

From$(A),(B)$ and (C) , $1<x<\frac{5-\sqrt{5}}{2}$

,

Q13. Solution

Correct Answer: (B)

Given,

$x\sin\theta - 2y\cos\theta - az = 0$

$x + 2y + z = 0$

$-x + y + z = 0$

For the system to have a non-trivial solution,

$$\begin{vmatrix} \sin\theta & -2\cos\theta & -a \\ 1 & 2 & 1 \\ -1 & 1 & 1 \end{vmatrix} = 0$$

Expanding the above with respect to R_1 we get,

$\sin\theta(2-1) + 2\cos\theta(2) - a(3) = 0$

$\sin\theta + 4\cos\theta = 3a$

$\Rightarrow -\sqrt{1+16} \leq 3a \leq \sqrt{1+16}$

$\because$Range of $\text{asinx} + \text{bcosx}$ is $\left[-\sqrt{a^2+b^2},\ \sqrt{a^2+b^2}\right]$

$a \in \left[\frac{-\sqrt{17}}{3},\ \frac{\sqrt{17}}{3}\right]$

Integral values of a are $-1,\ 0,\ 1$.

Hence, a has 3 integral values.

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Q14. Solution

Correct Answer: (B)

The equation of first circle $(x-1)^2 + (y-3)^2 = r^2$ whose centre is $C_1(1,3)$ and radius $r_1 = r$ and equation of second circle $x^2 + y^2 - 8x + 2y + 8 = 0$ whose centre is $C_2(4,-1)$ and radius $r_2 = \sqrt{4^2 + 1^2 - 8} = \sqrt{17-8} = \sqrt{9} = 3$ Two circles intersect in two distinct points, then:

$$\begin{aligned} & |r_1 - r_2| < C_1C_2 < r_1 + r_2 && \Rightarrow \quad |r-3| < \sqrt{(4-1)^2 + (-1-3)^2} < r+3 \\ \Rightarrow \quad & |r-3| < \sqrt{9+16} < r+3 && \Rightarrow \quad |r-3| < 5 < r+3 \\ \Rightarrow \quad & |r-3| < 5 \text{ and } 5 < r+3 && \Rightarrow \quad 2 < r < 8 \Rightarrow r = 3, 5, 7 \end{aligned}$$

Q15. Solution

Correct Answer: (D)

Given ellipse $\frac{x^2}{8}+\frac{y^2}{4}=1$ Two points on the ellipse whose eccentric angles differ by $\frac{\pi}{2}$ are $P(2\sqrt{2}\cos\theta, 2\sin\theta)$ and $Q\left(2\sqrt{2}\cos\left(\theta+\frac{\pi}{2}\right), 2\sin\left(\theta+\frac{\pi}{2}\right)\right)$ or $Q(-2\sqrt{2}\sin\theta, 2\cos\theta)$

$\therefore (PQ)^2 = 8(\cos\theta+\sin\theta)^2+4(\sin\theta-\cos\theta)^2$

$= 12+4\sin 2\theta \leq 16$.

$\therefore (PQ)_{\max}=4.$

Q16. Solution

Correct Answer: (B)

$$\bar{x}=\frac{\sum x_i}{5}=\frac{24}{5}\Rightarrow\sum x_i=24$$

$$\sigma^2=\frac{\sum x_i^2}{5}-\left(\frac{24}{5}\right)^2\Rightarrow\frac{194}{25}$$

$$\Rightarrow\sum x_i^2=154\Rightarrow x_1+x_2+x_3+x_4=14$$

$$\Rightarrow x_5=10$$

:

$$\sigma^2=\frac{x_1^2+x_2^2+x_3^2+x_4^2}{4}-\frac{48}{4}=a$$

$$\Rightarrow x_1^2+x_2^2+x_3^2+x_4^2=4a+49\Rightarrow x_5^2=154-4a-49$$

$$\Rightarrow 100=105-4a\Rightarrow 4a=5\Rightarrow a=\frac{5}{4}$$

$$4a+x_5=5+10=15$$

Q17. Solution

Correct Answer: (A)

$$\mathrm{A}^{-5}=\begin{bmatrix}\sin^{10}\alpha & 0 & 0\\ 0 & \sin^{10}\beta & 0\\ 0 & 0 & \sin^{10}\gamma\end{bmatrix}\ \&\ \ \mathrm{A}^{-2}=\begin{bmatrix}\sin^{4}\alpha & 0 & 0\\ 0 & \sin^{4}\beta & 0\\ 0 & 0 & \sin^{4}\gamma\end{bmatrix}\ \&\text{ so on similarly,}$$

$$\mathbf{B}^{-5}=\begin{bmatrix}\cos^{10}\alpha & 0 & 0\\ 0 & \cos^{10}\beta & 0\\ 0 & 0 & \cos^{10}\gamma\end{bmatrix}\ \&\ \ \mathrm{B}^{-2}=\begin{bmatrix}\cos^{4}\alpha & 0 & 0\\ 0 & \cos^{4}\beta & 0\\ 0 & 0 & \cos^{4}\gamma\end{bmatrix}\ \&\text{ so on}$$

Now $\mathrm{C}=\mathrm{A}^{-5}+\mathrm{B}^{-5}+5\,\mathrm{A}^{-1}\,\mathrm{B}^{-1}\left(\mathrm{A}^{-3}+\mathrm{B}^{-3}\right)+10\,\mathrm{A}^{-2}\,\mathrm{B}^{-2}\left(\mathrm{A}^{-1}+\mathrm{B}^{-1}\right)$

$C_{11}=\cos^{10}\alpha+\sin^{10}\alpha+5\sin^2\alpha\cos^2\alpha\left(\sin^6\alpha+\cos^6\alpha\right)+10\sin^4\alpha\cos^4\alpha\left(\sin^2\alpha+\cos^2\alpha\right)$

$=\left(\cos^2\alpha\right)^5+{}^5C_1\left(\cos^2\alpha\right)^4\cdot\sin^2\alpha+{}^5\mathrm{C}_2\left(\cos^2\alpha\right)^3\left(\sin^2\alpha\right)^2+{}^5\mathrm{C}_3\left(\cos^2\alpha\right)^2\left(\sin^2\alpha\right)^3+{}^5\mathrm{C}_4\left(\cos^2\alpha\right)\left(\sin^2\alpha\right)^4+{}^5\mathrm{C}_5\left(\sin^2\alpha\right)^5$

$=\left(\cos^2\alpha+\sin^2\alpha\right)^5=1$

Similarly $\mathrm{C}_{22}=\mathrm{C}_{33}=1$

$$\therefore\quad \mathrm{C}=\begin{bmatrix}1&0&0\\0&1&0\\0&0&1\end{bmatrix}.,$$

Q18. Solution

Correct Answer: (C)

$$\vec{a}+\vec{b}=6\vec{p}-\vec{q}$$

We have $\Rightarrow \quad |\vec{a}+\vec{b}|=\sqrt{(6\vec{p}-\vec{q})^2}=\sqrt{36\vec{p}^2+\vec{q}^2-12\vec{p}\cdot\vec{q}}$ Similarly,

$$\sqrt{36(8)+9-12(2\sqrt{2})(3)\cos\frac{\pi}{4}}=\sqrt{225}=15$$

$$|\vec{a}-\vec{b}|=|4\vec{p}+5\vec{q}|=\sqrt{(4\vec{p}+5\vec{q})^2}$$

$$=\sqrt{16\vec{p}2+25\vec{q}^2+40\vec{p}\cdot\vec{q}}$$

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$$=\sqrt{19(8)+25(9)+40(2\sqrt{2})(3)\cos\frac{\pi}{4}}=\sqrt{617}$$

Q19. Solution

Correct Answer: (B)

$$\mathrm{E}=\sin 1^\circ \sin 3^\circ \sin 5^\circ \ldots \sin 89^\circ$$

$$\Rightarrow \frac{\sin 1^\circ \sin 2^\circ \sin 3^\circ \sin 4^\circ \ldots \sin 88^\circ \sin 89^\circ}{\sin 2^\circ \sin 4^\circ \ldots \sin 88^\circ}$$

$$\Rightarrow \frac{(\sin 2^\circ \sin 4^\circ \ldots \sin 88^\circ)\cdot \sin 45^\circ}{2^{44}\cdot(\sin 2^\circ \sin 4^\circ \cdot \sin 88^\circ)}\cdot \sin 45^\circ$$

$$=\frac{1}{2^{44}\cdot 2^{1/2}}$$

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$$\Rightarrow \mathrm{E}=\frac{1}{2^{\frac{89}{2}}}$$

$$\mathrm{E}^2=\frac{1}{2^{89}}$$

$$\frac{1}{\mathrm{E}^2}=2^{89}$$

Q20. Solution

Correct Answer: (B)

$$\lim_{x\to\infty}[x]=\lim_{x\to\infty}\frac{[x]x}{x}$$

$$=\lim_{x\to\infty}\frac{[x]x}{x}\cdot\lim_{x\to\infty}x=\lim_{x\to\infty}x\left(\text{as }\lim_{x\to\infty}\frac{[x]}{x}=1\right)$$

$$=\lim_{x\to\infty}\frac{x^n+x^{n-1}+1}{e^{[x]}}$$

$$=\lim_{x\to\infty}\frac{x^n+x^{n-1}+1}{e^x}$$

:

$$=\lim_{x\to\infty}\frac{1+\frac{n}{x}+\frac{1}{x^n}}{1+x+\frac{x^2}{2!}+..+\frac{x^n}{n!}+\frac{x^{n+1}}{(n+1)!}+\ldots}$$

$$=\lim_{x\to\infty}\frac{1+\frac{n}{x}+\frac{1}{x^n}}{\frac{1}{x^n}+\frac{1}{x^{n-1}}+\frac{1}{2x^{n-2}}+\ldots.+\frac{1}{n!}+\frac{x}{(n+1)!}+\frac{x^2}{(n+2)!}+\ldots}$$

$$=\frac{1+0+0}{0+0+..+0+\frac{1}{n!}}=\frac{1}{\infty}=0..$$

Q21. Solution

Correct Answer: 9

Shortest between skew lines

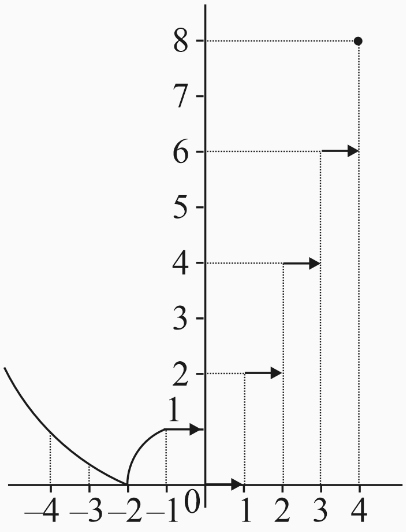
$\vec{r}=\vec{a}+\lambda\vec{p}$ and $\vec{r}=\vec{b}+\mu\vec{q}$ is given by

$$=\frac{|(\vec{b}-\vec{a})\cdot(\vec{p}\times\vec{q})|}{|\vec{p}\times\vec{q}|}$$

$$\Rightarrow SD=\frac{|(-2\hat{i}-3\hat{j}+\hat{k})\cdot\{(\hat{i}+2\hat{j}+3\hat{k})\times(-\hat{i}+2\hat{j}-2\hat{k})\}|}{|(\hat{i}+2\hat{j}+3\hat{k})\times(-\hat{i}+2\hat{j}-2\hat{k})|}$$

$$\Rightarrow d=\frac{9}{\sqrt{13}}\Rightarrow\sqrt{13}d=9$$

Q22. Solution
Correct Answer: 2

Graph of $f(x)$ is 

from fig. $f(x)$ is differentiable at $x=-3$, and $x=-1$ in $(-4,4)$ Check video solution for detailed explanation

Q23. Solution
Correct Answer: 17

$\lambda=\int_1^9\left(\frac{1}{2}+\sqrt{\frac{1}{4}+\log_3 x}\right)dx+\int_1^2 \frac{3^{x^2-[x]}}{3^{\{x\}}}dx$
$f(x)=3^{x^2-x}$
$f^{-1}(x)=\frac{1}{2}+\sqrt{\frac{1}{4}+\log_3 x}$
$\lambda=\int_1^9 f(x)dx+\int_1^2 f^{-1}(x)dx$
$\lambda=18-1=17$

Q24. Solution
Correct Answer: 28

$\sum\frac{12!}{(2a)!(2b)!(2c)!} \quad 2^a3^b5^c$
$\Rightarrow a+b+c=6$
number of solution $={}^{6+3-1}C_{3-1}={}^8C_2$
number of rational terms $=28$

Q25. Solution

Correct Answer: 2

x^2+2x+3

$\Rightarrow x^2+3=-2x$

$x^4+6x^2+9=4x^2$

$x^4+2x^2+9=0$

$\Rightarrow P_5+2P_3+9P_1=0$

$\dfrac{P_5+9P_1}{P_3}=-2$

Q26. Solution

Correct Answer: (A)

To find the dimensional formula for each physical quantity, we use their defining equations and the dimensional formulas of the fundamental quantities (Mass $[M]$, Length $[L]$, Time $[T]$, Electric Current $[A]$). (A) Gravitational Constant (G): Newton's Law of Gravitation states $F=G\frac{m_1m_2}{r^2}$. Dimensional formula of Force $[F]=[MLT^{-2}]$ Dimensional formula of mass $[m]=[M]$ Dimensional formula of distance $[r]=[L]$ So, $[G]=\frac{[MLT^{-2}][L^2]}{[M][M]}=[M^{-1}L^3T^{-2}]$. This matches (II). (B) Magnetic Field (B): The force on a current-carrying conductor in a magnetic field is $F=BIL\sin\theta$. Dimensional formula of Force $[F]=[MLT^{-2}]$ Dimensional formula of Current $[I]=[A]$ Dimensional formula of Length $[L]=[L]$ So, $[B]=\frac{[MLT^{-2}]}{[A][L]}=[MT^{-2}A^{-1}]$. This matches (IV). (C) Electric Field (E): The force on a charge in an electric field is $F=qE$. Dimensional formula of Force $[F]=[MLT^{-2}]$ Dimensional formula of Charge $[q]=[AT]$ (since current $I=q/t$, so $q=It$) So, $[E]=\frac{[MLT^{-2}]}{[AT]}=[MLT^{-3}A^{-1}]$. This matches (III). (D) Electric Potential (V): Electric potential is defined as work done per unit charge: $V=\frac{W}{q}$ Dimensional formula of Work $[W]=[ML^2T^{-2}]$ Dimensional formula of Charge $[q]=[AT]$ So, $[V]=\frac{[ML^2T^{-2}]}{[AT]}=[ML^2T^{-3}A^{-1}]$. This matches (I).

Q27. Solution

Correct Answer: (C)

$2\mathrm{kx}\sin\theta=2\ \mathrm{T}=\left(\dfrac{4\ \mathrm{m},\ \mathrm{m}_2}{\mathrm{m}_1+\mathrm{m}_2}\right)\mathrm{g}$

$\mathrm{kx}\dfrac{\sqrt{3}}{2}=\dfrac{2\times2\times3}{5}\times10$

$1000\times\dfrac{\mathrm{x}}{2}\times\sqrt{3}=8\times3$

$\dfrac{\mathrm{x}}{2}=\dfrac{\sqrt{3}}{125}\times100\ \mathrm{cm}$

$\dfrac{\mathrm{x}}{2}=\dfrac{\sqrt{3}}{5}\times4$

$\dfrac{\mathrm{P}}{2}=\dfrac{\mathrm{x}}{2}=\sqrt{3}\times0.8$

$\dfrac{\sqrt{3}\mathrm{P}}{1.6}=3$

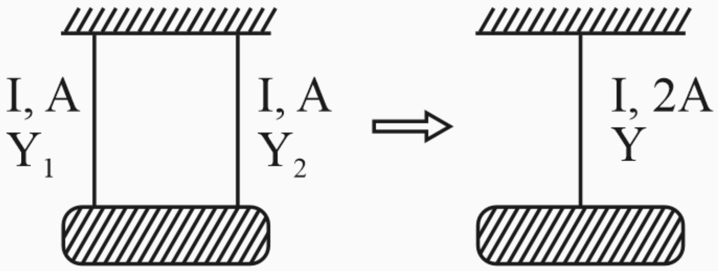
Q28. Solution

Correct Answer: (A)

Let, we connect 24 cells in n rows of m cells, then if I is the current in external circuit then $I=\frac{mE}{mr/n+R}$ For I to be maximum, $(\mathrm{mr}+\mathrm{nR})$ should be minimum. It is minimum for $R=\frac{mr}{n}$ So maximum current in external circuit is $I=\frac{mE}{2R}$ Here $\mathrm{R}=3, \mathrm{r}=0.5$, so equation (2) become $\frac{m}{n}=6$ so $\mathrm{n}=2,\ \mathrm{m}=12$

Q29. Solution

Correct Answer: (B)



Equivalent spring constant of a wire is given by

$$\mathrm{K}=\frac{\mathrm{YA}}{\mathrm{I}}$$
$$\mathrm{K}_{\mathrm{eq}}=\mathrm{K}_1+K_2$$
$$\text{or } \frac{Y(2\ \mathrm{A})}{I}=\frac{Y_1 A}{I}+\frac{Y_2 A}{I}$$
$$\text{or } \mathrm{Y}=\frac{Y_1+Y_2}{2}$$

Q30. Solution

Correct Answer: (B)

$eV=hc\left(\frac{1}{\lambda}-\frac{1}{\lambda_0}\right) \ldots \ldots .(1)\ e\frac{V}{3}=hc\left(\frac{1}{2\lambda}-\frac{1}{\lambda_0}\right) \ldots \ldots .(2)\ \frac{(1)}{(2)} \Rightarrow \lambda_0=4\lambda$

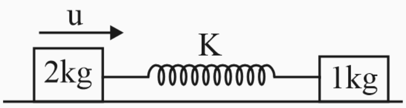
Q31. Solution

Correct Answer: (B)

The energy of an electron in the n-th stationary state of a hydrogen-like species is given by the Bohr model as: $E_n = -13.6\frac{Z^2}{n^2}$ eV, where Z is the atomic number and n is the principal quantum number. For two species to have the same electronic energy, the value of $\frac{Z^2}{n^2}$ must be the same for both. A) Hydrogen atom in its ground state and Li^{2+} ion in its first excited state. For Hydrogen atom (H) in ground state: $Z = 1$, $n = 1$. So, $\frac{Z^2}{n^2} = \frac{1^2}{1^2} = 1$. For Li^{2+} ion (Lithium has $Z = 3$) in its first excited state ($n = 2$): $\frac{Z^2}{n^2} = \frac{3^2}{2^2} = \frac{9}{4} = 2.25$. Since $1 \neq 2.25$, their energies are not the same. B) He^+ ion in its ground state and Be^{3+} ion in its first excited state. For He^+ ion (Helium has $Z = 2$) in its ground state ($n = 1$): $\frac{Z^2}{n^2} = \frac{2^2}{1^2} = \frac{4}{1} = 4$. For Be^{3+} ion (Beryllium has $Z = 4$) in its first excited state ($n = 2$): $\frac{Z^2}{n^2} = \frac{4^2}{2^2} = \frac{16}{4} = 4$. Since $4 = 4$, their energies are the same. C) Li^{2+} ion in its second excited state and He^+ ion in its ground state. For Li^{2+} ion (Lithium has $Z = 3$) in its second excited state ($n = 3$): $\frac{Z^2}{n^2} = \frac{3^2}{3^2} = \frac{9}{9} = 1$. For He^+ ion (Helium has $Z = 2$) in its ground state ($n = 1$): $\frac{Z^2}{n^2} = \frac{2^2}{1^2} = \frac{4}{1} = 4$. Since $1 \neq 4$, their energies are not the same. D) Be^{3+} ion in its ground state and hydrogen atom in its first excited state. For Be^{3+} ion (Beryllium has $Z = 4$) in its ground state ($n = 1$): $\frac{Z^2}{n^2} = \frac{4^2}{1^2} = \frac{16}{1} = 16$. For Hydrogen atom (H) in its first excited state ($n = 2$): $Z = 1$. So, $\frac{Z^2}{n^2} = \frac{1^2}{2^2} = \frac{1}{4} = 0.25$. Since $16 \neq 0.25$, their energies are not the same. Therefore, the pair of species and their respective states that possess the same electronic energy is given in option B.

Q32. Solution

Correct Answer: (C)



$\mathrm{kx} = \mu \mathrm{mg}$

$8\mathrm{x} = 0.8 \times 1 \times 10$

$\mathrm{x} = 1 + \frac{1}{2}\mathrm{kx}^2 + \mu \mathrm{mgx} = 0 + \frac{1}{2}\mathrm{mv}^2$

$\frac{1}{2} \times 8 \times 1^2 + 0.8 \times 2 \times 10 \times 1 = \frac{1}{2} \times 2 \times \mathrm{u}^2$

$4 + 16 = \mathrm{u}^2$

$\mathrm{u} = \sqrt{20}\ \mathrm{m/s}$

Q33. Solution

Correct Answer: (A)

The electromagnetic spectrum arranges different types of electromagnetic radiation based on their wavelength, frequency, and energy. The order of electromagnetic waves from shortest wavelength (highest frequency/energy) to longest wavelength (lowest frequency/energy) is as follows: Gamma rays (shortest wavelength) X-rays Ultraviolet Visible light Infrared Microwaves Radio waves (longest wavelength) Given the radiations: (P) Radio waves (Q) Visible light (R) Gamma rays (S) X-rays Arranging them in increasing order of their wavelength: 1. Gamma rays (R) have the shortest wavelength. 2. X-rays (S) have a longer wavelength than gamma rays. 3. Visible light (Q) has a longer wavelength than X-rays. 4. Radio waves (P) have the longest wavelength among the given options. Therefore, the increasing order of wavelength is: $\lambda_R < \lambda_S < \lambda_Q < \lambda_P$.

Q34. Solution
Correct Answer: (D)

For a magnetic dipole placed in a uniform magnetic field, the torque is given by $\vec{\tau} = \vec{M} \times \vec{B}$, and potential energy U is given as,

$U = -\vec{M} \cdot \vec{B} = -MB\cos\theta$

When $\vec{M}$ is in the same direction as $\vec{B}$ then $\vec{\tau} = 0$ and U is minimum = $-MB$ as $\theta = 0^o$.$\Rightarrow$ Stable equilibrium is (b).

When $\vec{M}$ the opposite direction of $\vec{B}$, then $\vec{\tau} = 0$ and U is max = $+MB$
As, $\theta = 180^o$ $\Rightarrow$Unstable equilibrium in (d)

Q35. Solution
Correct Answer: (A)

path difference $= \frac{yd}{D} = 900nm$ Condition for missing lines Path Difference $= \frac{(2n-1)\lambda}{2} \Rightarrow \lambda = \frac{2\Delta x}{2n-1}$ $\lambda = \frac{1800}{2\mathrm{n}-1}$
put n $= 1, 2, 3$ $\lambda = 1800$ nm, 600 nm, 360 nm

Q36. Solution
Correct Answer: (D)

Input power is 4 kW Efficiency is 90% $\therefore$ Output power $= 0.9 \times 4$ kW $= 3.6$ kW $3.6\mathrm{kIV} = i^2 R = 36 \times R$
or $R = \dfrac{3.6 \text{ kW}}{36} = \dfrac{3.6 \times 10^3 \text{ W}}{36}$
$= 10^2 \Omega = 100\Omega$

Q37. Solution
Correct Answer: (B)

The potential energy at depth is given by $U_1 = V_1 m = -\frac{GM}{2R^3}\left(3R^2 - \frac{R^2}{4}\right)m = -\frac{11GMm}{8R}$ The energy of satellite at a height R/2 is given by $E_2 = -\frac{GMm}{3R}$ $\therefore$ The work required $= E_2 - U_1 = \frac{25GMm}{24R}$

Q38. Solution
Correct Answer: (D)

$R_{\text{Bulb}} = \frac{V^2}{P} = \frac{1.5^2}{4.5} = 0.5\Omega$
$I_i = \frac{1.5}{0.5} = 3$ A
$I \simeq I_i = 3$ A $= \frac{\varepsilon}{0.5+\frac{5}{3}}$
$\varepsilon = 3\left(\frac{1}{2} + \frac{5}{3}\right)$
$= \frac{13}{2}$ volts.

Q39. Solution

Correct Answer: (B)

Here, $R = 5 \times 10^3 \Omega, V_i = 220V$; Zener voltage, $V_Z = 50$ V Load current, $I_L = \frac{V_Z}{R_L} = \frac{50}{20 \times 10^3}$ $= 2.5 \times 10^{-3}$ A Current through R, $I = \frac{220-50}{5 \times 10^3} = 34 \times 10^{-3} A \therefore I_z = 31.5 mA$ and $2I_z = 63 mA$

Q40. Solution

Correct Answer: (A)

$\mathrm{V} = \frac{\mathrm{K}}{\sqrt{\mathrm{T}}}, \mathrm{T} = \frac{\mathrm{PV}}{\mathrm{nR}}$ is put then $\mathrm{PV}^3 =$ constant (say k_1) $\therefore \Delta \mathrm{W} = \mathrm{PdV} = \int \frac{\mathrm{k}_1}{\mathrm{v}^3} \mathrm{dv} = \frac{-\mathrm{nR} \Delta \mathrm{T}}{2} = \frac{-5 \mathrm{R} \Delta \mathrm{T}}{2}$

$\Delta U = nCv\Delta T = (n_1 Cv_1 + n_2 Cv_2)\Delta T = \left(3 \times \frac{3R}{2} + 2 \times \frac{5R}{2}\right)\Delta T = \frac{19}{2} R\Delta T$

$\Delta Q = \Delta U + \Delta W = \frac{14 R\Delta T}{2} = 7R\Delta T\ C_{(\text{process})} = \frac{\Delta Q}{n\Delta T} = \frac{7R\Delta T}{5\Delta T} = \frac{7R}{5}$

Q41. Solution

Correct Answer: (B)

The electric field due to $\vec{P}_1$ at the position of $\vec{P}_2$ is $E_1 = \frac{KP_1}{r^3} \therefore$ force of inter action between the dipoles is

$$F = P_2 \left| \frac{dE_1}{dr} \right|$$

$$F = \frac{3kP_1P_2}{r^4}$$

Q42. Solution

Correct Answer: (A)

Mass of remaining portion $= \left(\pi R^2 - \frac{R^2}{4}\right) e$ Mass of triangular portion $= \frac{R^2}{4} e$

$$R^2 \left(\pi - \frac{1}{4}\right) ex = \frac{R^2}{4} e \quad \frac{2}{3} \left(\frac{R}{2}\right)$$

$$\Rightarrow x = \frac{R}{3(4\pi - 1)}$$

Q43. Solution

Correct Answer: (C)

For both the particle to collide at point, their time of fight should be same

$$T=\frac{2usin\theta}{g}=\frac{2(10)sin60}{10}=2\ \frac{\sqrt{3}}{2}$$

time of fight of particle thrown from above

$$t=\frac{\sqrt{2h}}{g}$$

equation we get,

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

h=15m

Q44. Solution

Correct Answer: (A)

Root-mean-square velocity of a gas is given by, $V_{RMS}=\sqrt{\frac{3RT}{M}}$, where R, T and M are universal gas constant, temperature and molecular mass of gas.

Now for gas A, $(V_{RMS})_{\mathrm{A}}=\sqrt{\frac{3RT_{\mathrm{A}}}{M_{\mathrm{A}}}}\ldots(1)$

For gas B, $(V_{RMS})_{B}=\sqrt{\frac{3RT_{\mathrm{B}}}{M_{\mathrm{B}}}}\ldots(2)$

Ratio of R.M.S. speed of A to B is given by,

$$\Rightarrow\frac{(V_{RMS})_A}{(V_{RMS})_B}=\frac{\sqrt{\frac{3RT_{\mathrm{A}}}{M_{\mathrm{A}}}}}{\sqrt{\frac{3RT_{\mathrm{B}}}{M_{\mathrm{B}}}}}$$

$$\Rightarrow\frac{(V_{RMS})_A}{(V_{RMS})_B}=\frac{\sqrt{\frac{T_{\mathrm{A}}}{M_{\mathrm{A}}}}}{\sqrt{\frac{T_{\mathrm{B}}}{M_{\mathrm{B}}}}}$$

$$\Rightarrow\frac{(\mathrm{V_{RMS}})_{\mathrm{A}}}{(\mathrm{V_{RMS}})_{\mathrm{B}}}=\frac{\sqrt{4\frac{T_{\mathrm{B}}}{M_{\mathrm{B}}}}}{\sqrt{\frac{T_{\mathrm{B}}}{M_{\mathrm{B}}}}}$$

$$\Rightarrow\frac{(V_{RMS})_A}{(V_{RMS})_B}=\sqrt{4}=2$$

Q45. Solution

Correct Answer: (C)

$x_L = \omega L = 100 \times 0.01 = 1\Omega$

$x_C = \frac{1}{\omega C} = \frac{1}{100 \times 4 \times 10^{-4}} = \frac{100}{4} = 25\Omega$

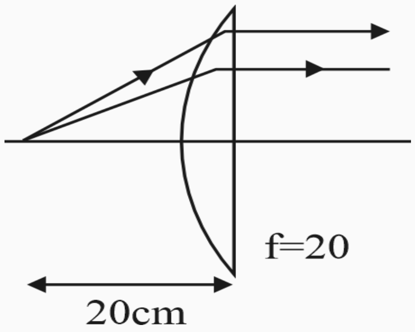
$Z = \sqrt{R^2 + (x_C - x_L)^2} = \sqrt{10^2 + (25-1)^2} = \sqrt{676}$

$\text{Iruns} = \frac{\text{Vruns}}{2} = \frac{520}{\sqrt{676}}\text{ A}$

$P_{\text{av}} = \text{Irms}\ {}^2 R = \frac{520^2}{676} \times 10 = 4000\text{ W} = 4\text{ kW}$

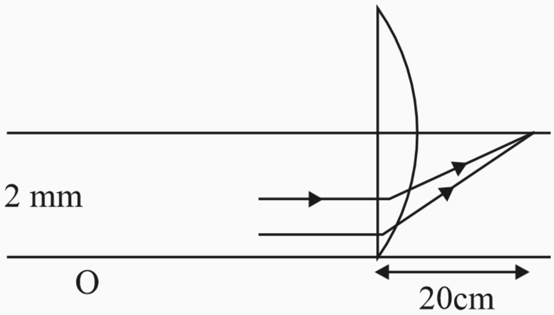
Q46. Solution

Correct Answer: 8



Now lens 1 and lens 2 has $f = 20$ cm.

Now for lens 2. p-axis is 2 mm above the given axis so image is at focus point



n = 40 cm;   m = 0.2 cm

so nm = 8

Q47. Solution

Correct Answer: 4

$v=|t-2|$

$v=0$ for $t=2\sec$

$\Rightarrow$ for $0<t<2$

$v=2-t$

$ds=(2-t)dt$

$s=\left(2t-\frac{t^2}{2}\right)^2$

$=2(2)-\frac{2^2}{2}$

$=2$ m

for $2<t<4$

$v=t-2$

$ds=\left(\frac{t^2}{2}\right)_2^4-2(t)_2^4$

$=\frac{1}{2}(16-4)-2(4-2)$

$=6-4=2$ m

$\Rightarrow s=4$ m

Q48. Solution

Correct Answer: 4

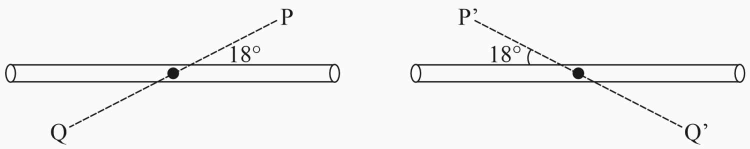


Figure-a Figure-b

The MI of rod about axis PQ figure(a) and MI of rod about axis $P'Q'$ figure (b) are same by symmetry.

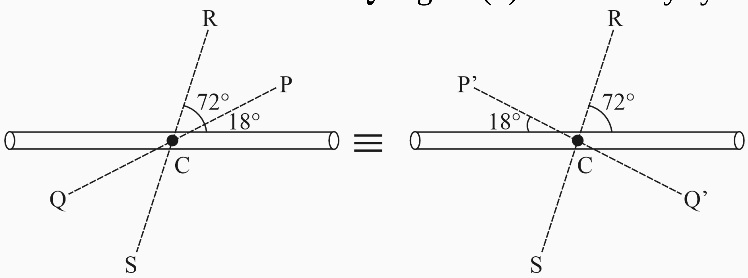


Figure-c Figure-d

$\therefore \quad \mathrm{I_{PQ}}+\mathrm{I_{RS}}=\mathrm{I_{P'}Q'}+\mathrm{I_{RS}}=\frac{mc^2}{12}$

Q49. Solution

Correct Answer: 2

For pipe A, second resonant frequency is third harmonic thus $\mathrm{f}=\frac{3V}{4L_A}$ For pipe B, second resonant frequency is second harmonic thus $\mathrm{f}=\frac{2V}{2L_B}$ Equating, $\frac{3V}{4L_A}=\frac{2V}{2L_B}\Rightarrow \mathrm{L_B}=\frac{4}{3}\,\mathrm{L_A}=\frac{4}{3}\cdot(1.5)=2$ m.

Q50. Solution

Correct Answer: 6

$$\phi = 3t(2-t) = 3\left(2t - t^2\right)$$

$$\varepsilon = \frac{d\phi}{dt} = 3(2-2t)$$

$$H = \int_0^2 \frac{9(2-2t)^2}{R} dt = 9\int_0^2 \left(1 + t^2 - 2t\right) dt \text{ because } \mathrm{R} = 4\Omega$$

$$H = 9\left[t + \frac{t^3}{3} - t^2\right]_0^2$$

$$= 9\left[2 + \frac{(2)^3}{3} - (2)^2\right] = 9\left[\frac{14}{3} - 4\right] = 9 \times \frac{2}{3} = 6$$

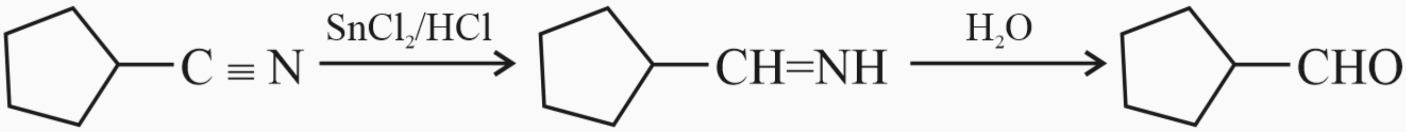
Q51. Solution

Correct Answer: (D)

$\because$ If CO_3^{2-}, SO_3^{2-} and SO_4^{2-} are present alongwith $BaCl_2$, these can also show white precipitate (as precipitate of all these are also white).

Q52. Solution

Correct Answer: (B)

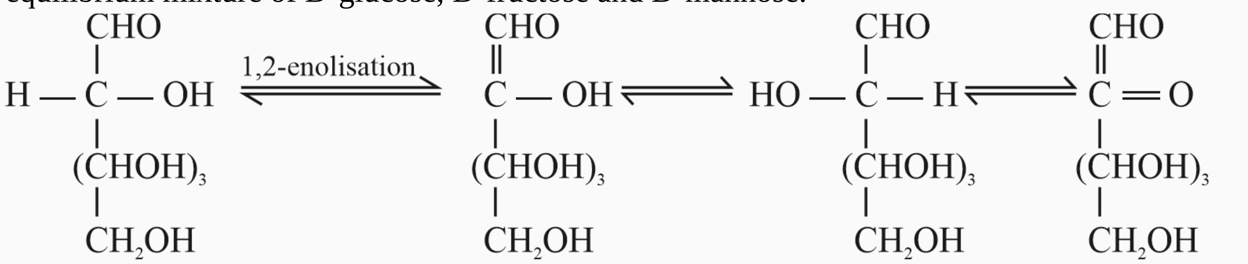


This is known as Stephen's reduction.

Q53. Solution

Correct Answer: (D)

When fructose is treated with dil. solution of an alkali, it undergoes reversible isomerization to form an equilibrium mixture of D-glucose, D-fructose and D-mannose.



D(+) Glucose Enediol D(+) Mannose D(–) Fructose

It is due to isomerisation that fructose reduces Tollen's reagent although it does not contain an- CHO group

Q54. Solution
Correct Answer: (D)

order of electron gain enthalpy $\mathrm{Cl} > \mathrm{F} > \mathrm{O}$ Second electron gain enthalpy for an element is always positive.

Q55. Solution
Correct Answer: (B)

(P) G.I ✓ Tautomerism ✓ Optical $\times$ (Q) G.I ✓ Tautomerism $\times(0\alpha - \mathrm{H})$ Optical ✓ (R) G.I ✓ Tautomerism ✓ Optical ✓ (S) $\mathrm{GI}\times$ Tautomerism ✓ Optical ✓

Q56. Solution
Correct Answer: (C)

Size decreases from left to right in 5f series due to actinide contraction.

Q57. Solution
Correct Answer: (B)

$\mathrm{Mg}^{2+} + 2\mathrm{OH}^{-} \rightleftharpoons \mathrm{Mg(OH)}_2$
$\mathrm{K}_{\mathrm{sp}} = \left[\mathrm{Mg}^{2+}\right]\left[\mathrm{OH}^{-}\right]^2$
$\left[\mathrm{OH}^{-}\right] = \sqrt{\frac{\mathrm{K}_{\mathrm{sp}}}{\left[\mathrm{Mg}^{2+}\right]}} = 10^{-4}$
$\therefore \mathrm{pOH} = 4$ and $\mathrm{pH} = 10$

Q58. Solution
Correct Answer: (B)

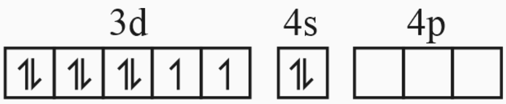
$Cr_{24} = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$ For s - orbital electrons $l + m = 0 \therefore 2+2+2+2+2+1+1 = 12$

Q59. Solution

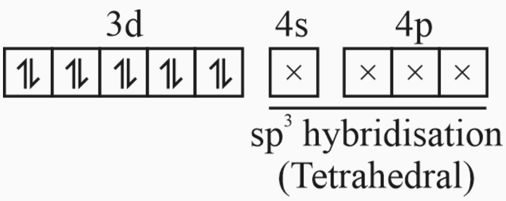
Correct Answer: (B)

1. $[Ni(CO)_4]$

$Ni(28) = [Ar]\ 3d^8 4s^2$



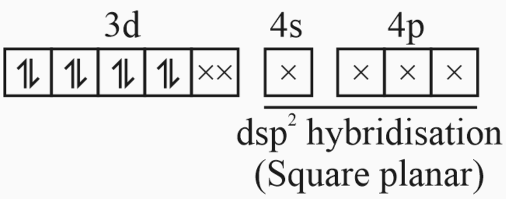
CO is strong field ligand which cause pairing of $3d$ electrons.



Hybridisation of Ni in $[Ni(CO)_4]$ is sp^3 and has tetrahedral geometry.

2. $[Ni(CN)_4]^{-2}$

$Ni^{2+}(26) = 3d^8$

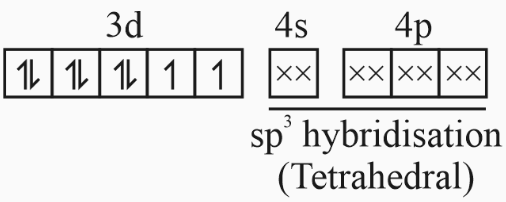


CN^- is strong field ligand which cause pairing in inner orbital.

Hybridisation of Ni in $[Ni(CN)_4]^{-2}$ is dsp^2 and has square planar geometry.

3. $[Ni(Cl_4)]^{-2}$

$Ni^{2+}(26) = 3d^8$



Cl^- is weak field ligand which cause pairing in outer orbital

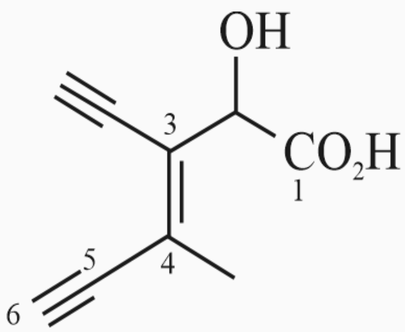
Hybridisation of Ni in $[Ni(Cl)_4]^{-2}$ is sp^3 and has tetrahedral geometry.

Q60. Solution

Correct Answer: (D)

The structure of the compound whose IUPAC name is 3-Ethyl-2-hydroxy-4-methyl hex-3-en-5-ynoic acid is as given below.

This structure contains one C=C bond and one C≡C bond. It also contains one −OH group and one −COOH group. One methyl and on ethyl substituents are present. The parent hydrocarbon contains 6 carbon atoms. So numbering starts from -COOH carbon.



3-ethynyl-2-hydroxy-4-methylhex-3-en-5-ynoic acid.

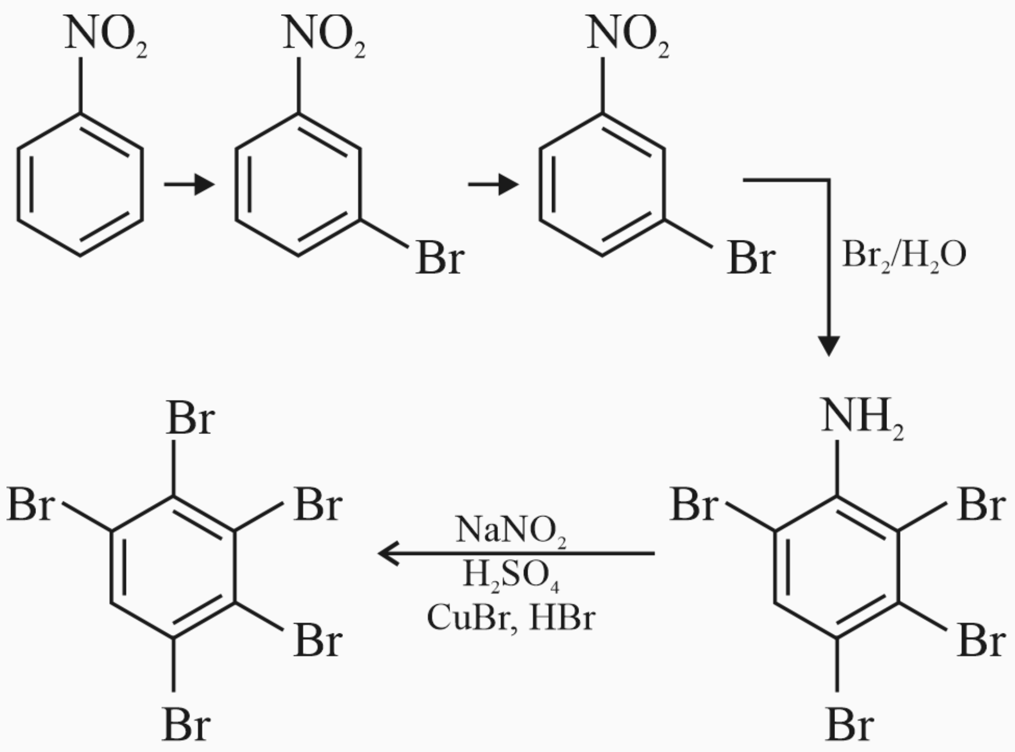
Q61. Solution

Correct Answer: (B)

To determine if a diatomic species is paramagnetic, we need to write its molecular orbital (MO) electronic configuration and check for the presence of unpaired electrons. Paramagnetic species have one or more unpaired electrons, while diamagnetic species have all electrons paired. The energy order of molecular orbitals differs for species with a total of 14 or fewer electrons compared to those with more than 14 electrons. For species with $\leq$ 14 electrons: $\sigma 1s < \sigma^* 1s < \sigma 2s < \sigma^* 2s < (\pi 2p_x = \pi 2p_y) < \sigma 2p_z < (\pi^* 2p_x = \pi^* 2p_y) < \sigma^* 2p_z$ For species with $>$ 14 electrons: $\sigma 1s < \sigma^* 1s < \sigma 2s < \sigma^* 2s < \sigma 2p_z < (\pi 2p_x = \pi 2p_y) < (\pi^* 2p_x = \pi^* 2p_y) < \sigma^* 2p_z$ (I) B_2: Total electrons = 5 (from B) + 5 (from B) = 10 electrons. MO configuration: $\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \pi 2p_x^1 \pi 2p_y^1$ There are two unpaired electrons in the degenerate $\pi 2p$ orbitals. Therefore, B_2 is paramagnetic. (II) C_2: Total electrons = 6 (from C) + 6 (from C) = 12 electrons. MO configuration: $\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \pi 2p_x^2 \pi 2p_y^2$ All electrons are paired. Therefore, C_2 is diamagnetic. (III) N_2^+: Total electrons = 7 (from N) + 7 (from N) - 1 (for + charge) = 13 electrons. MO configuration: $\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \pi 2p_x^2 \pi 2p_y^2 \sigma 2p_z^1$ There is one unpaired electron in the $\sigma 2p_z$ orbital. Therefore, N_2^+ is paramagnetic. (IV) O_2^-: Total electrons = 8 (from O) + 8 (from O) + 1 (for - charge) = 17 electrons. MO configuration: $\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p_z^2 \pi 2p_x^2 \pi 2p_y^2 \pi^* 2p_x^2 \pi^* 2p_y^1$ There is one unpaired electron in a $\pi^* 2p$ orbital. Therefore, O_2^- is paramagnetic. (V) NO: Total electrons = 7 (from N) + 8 (from O) = 15 electrons. MO configuration: $\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p_z^2 \pi 2p_x^2 \pi 2p_y^2 \pi^* 2p_x^1$ There is one unpaired electron in a $\pi^* 2p$ orbital. Therefore, NO is paramagnetic. The paramagnetic species are (I) B_2, (III) N_2^+, (IV) O_2^-, and (V) NO.

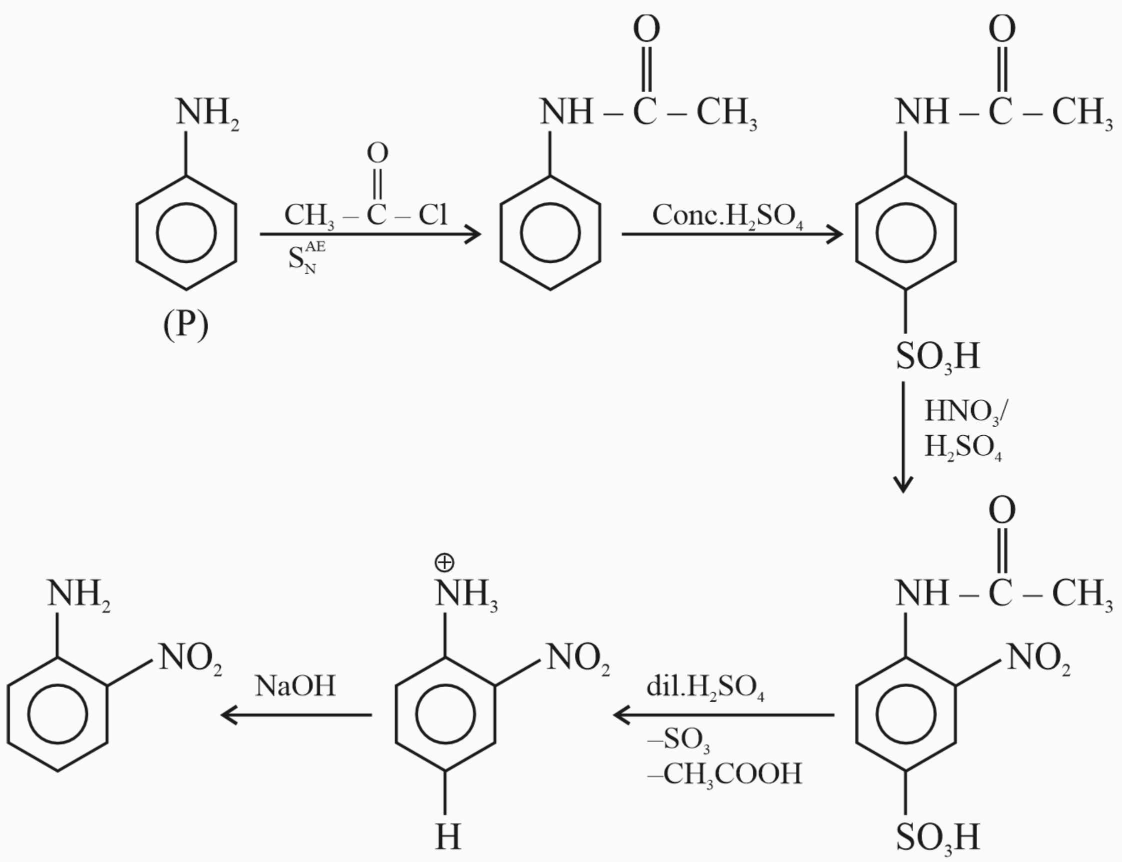
Q62. Solution

Correct Answer: (B)



Q63. Solution

Correct Answer: (D)



Q64. Solution

Correct Answer: (C)

Due to ortho effect, (III) and (I) are most acidic. If -OH group is present at p-position w.r.t. -COOH group, then it becomes less acidic.

Q65. Solution

Correct Answer: (A)

(P) Forms a minimum boiling azeotrope: A minimum boiling azeotrope is formed by solutions that show a large positive deviation from Raoult's law. In such solutions, the intermolecular forces between unlike molecules (A-B) are weaker than those between like molecules (A-A and B-B). This leads to higher vapor pressure and a lower boiling point than either pure component. Example: Ethanol and Water (2). When ethanol and water are mixed, the new hydrogen bonds formed are weaker than the hydrogen bonds in pure ethanol or pure water. This results in a positive deviation from Raoult's law and the formation of a minimum boiling azeotrope. So, (P) matches with (2). (Q) Exhibits negative deviation from Raoult's law: Negative deviation from Raoult's law occurs when the intermolecular forces between unlike molecules (A-B) are stronger than those between like molecules (A-A and B-B). This leads to lower vapor pressure and a higher boiling point than expected. Example: Chloroform and Acetone (3). Chloroform $(\mathrm{CHCl_3})$ and acetone $(\mathrm{CH_3COCH_3})$ form a hydrogen bond between the hydrogen atom of chloroform and the oxygen atom of acetone. This new intermolecular interaction is stronger than the individual dipole-dipole interactions in pure acetone or pure chloroform, leading to a negative deviation from Raoult's law. So, (Q) matches with (3). (R) Undergoes association in solution: Association in solution refers to the process where solute molecules combine to form larger aggregates, such as dimers, trimers, etc., typically through hydrogen bonding. This reduces the effective number of particles in the solution, leading to abnormal colligative properties. Example: Acetic acid in Benzene (4). Acetic acid $(\mathrm{CH_3COOH})$ molecules form dimers in non-polar solvents like benzene through hydrogen bonding. Two acetic acid molecules associate to form a cyclic dimer. So, (R) matches with (4). (S) Forms an ideal solution: An ideal solution is one that obeys Raoult's law over the entire range of concentrations. In an ideal solution, the intermolecular forces between A-A, B-B, and A-B molecules are nearly identical. There is no change in enthalpy or volume upon mixing. Example: Benzene and Toluene (1). Benzene and toluene are structurally similar non-polar compounds with similar intermolecular forces (London dispersion forces). When mixed, they form an ideal solution. So, (S) matches with (1).

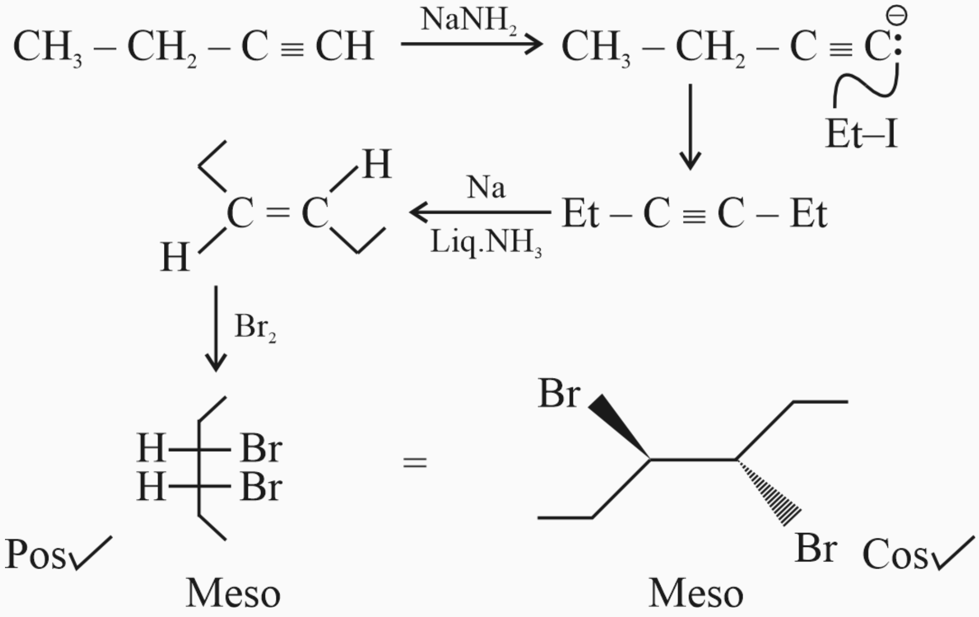
Q66. Solution

Correct Answer: (D)

$\mathrm{Ti^{3+}}$	$3\,\mathrm{d}^1$	1	$\sqrt{2}$
$\mathrm{Cu^{+}}$	$3\,\mathrm{d}^{10}$	0	0
$\mathrm{Ni^{2+}}$	$3\,\mathrm{d}^8$	2	$\sqrt{8}$
$\mathrm{Fe^{3+}}$	$3\,\mathrm{d}^5$	5	$\sqrt{35}$
$\mathrm{Mn^{2+}}$	$3\,\mathrm{d}^5$	5	$\sqrt{35}$
$\mathrm{Co^{2+}}$	$3\,\mathrm{d}^7$	3	$\sqrt{15}$

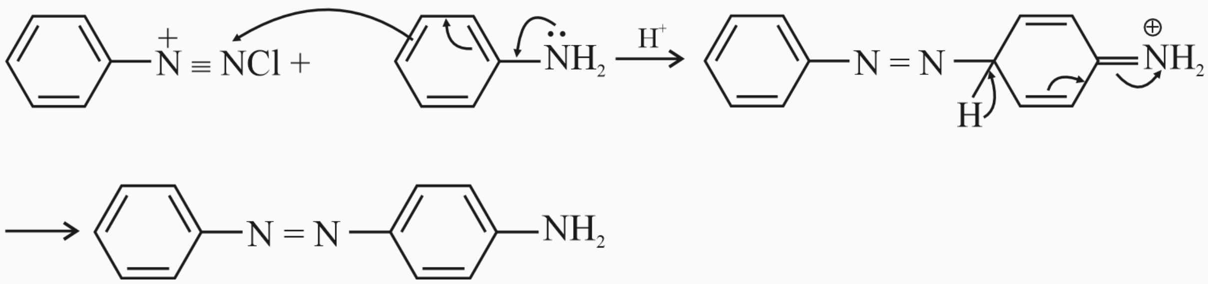
Q67. Solution

Correct Answer: (B)



Q68. Solution

Correct Answer: (D)



It is an electrophilic substitution reaction. Coupling reaction of aniline takes place at the para-position to NH_2 group in benzene nucleus gives azodye.

Q69. Solution

Correct Answer: (D)

If nitrogen or sulphur is also present in the compound, the sodium fusion extract is first boiled with concentrated nitric acid to decompose cyanide or sulphide of sodium formed during Lassaigne's test. These ions would otherwise interfere with the silver nitrate test for halogens.

$$NaCN + HNO_3 \rightarrow NaNO_3 + HCN$$

$$Na_2S + 2\,HNO_3 \rightarrow 2\,NaNO_3 + H_2S$$

Q70. Solution
Correct Answer: (A)

Haemoglobin is porphyrin complex of ferrous iron being coordinated to four nitrogen atoms and additionally coordinated to a water reversible by a molecule. The water molecule appears to be replaceable reversible by a molecule of oxygen to give oxyhaemoglobin.

$Fe^{2+}$is diamagnetic in the oxyhaemoglobin as unpaired electrons which exist here, couple antiferromagnetically, and gives diamagnetic property.

Q71. Solution
Correct Answer: 36

$\frac{\mathrm{dNx}}{\mathrm{dt}}=64\times\frac{\mathrm{dNy}}{\mathrm{dt}}$ at $\mathrm{t}=0$ after time $t\lambda_x\cdot N_x\cdot e^{-\lambda_x t}=\lambda_y\cdot N_y\cdot e^{-\lambda_y t}a$ On solving we get
$\lambda_x\cdot\mathrm{N_x}=\lambda_y\cdot\mathrm{N_y}\times 64$
$t=\frac{\ln 64}{\ln 2\left(\frac{1}{5}-\frac{1}{30}\right)}=36$ days

Q72. Solution
Correct Answer: 4200

$\Delta\mathrm{H_{process}}=\Delta\mathrm{H_{AB}}+\Delta\mathrm{H_{BC}}$

$=\mathrm{nC_P\Delta T}$ (along $\mathrm{BC\Delta T}=0$)

$=2\times\frac{7}{2}\times\mathrm{R}\times 600$

$=4200\ \mathrm{R}$

Q73. Solution
Correct Answer: 25

Given,
Mass of an organic compound $=0.20$ g
Mass of AgBr $=0.12$ g
Molecular mass of AgBr $=188\ \mathrm{g\ mol^{-1}}$
188 g of AgBr contains 80 g of bromine
$\therefore$ 0.12 g of AgBr will contain $=\frac{80}{188}\times 0.12$
$=0.05$ g of bromine
$\therefore$ Percentage of bromine $=\frac{0.05}{0.20}\times 100$
$=25\%$
Exact value is 25.53%, so we considered both 25 and 26 as correct answer

Q74. Solution

Correct Answer: 4

$$CH_3-\underset{\underset{O}{\|}}{C}-H$$

For Aldol α-h

Haloform $[CH_3-\underset{\underset{O}{\|}}{C}+$

$$CH_3-\underset{\underset{O}{\|}}{C}-CH_3$$

$$Ph-CH_2-\overset{\overset{O}{\|}}{C}-CH_3$$

Compound give Aldol & halo from $Ph-\underset{\underset{O}{\|}}{C}-Me$

Q75. Solution

Correct Answer: 2

$$\text{ppm} = \frac{\text{Mass of Ca in mg}}{\text{Volume of solution in litres}}$$

$$9.50 = \frac{\text{mass of Ca in mg}}{50 \times 10^{-3}}$$

Mass of Ca in mg $= 0.475\text{mg}$ Moles of Ca $= \frac{0.475 \times 10^{-3}}{40}$ Moles of Ca $=$ Moles of $Ca(NO_3)_2$ Mass of $Ca(NO_3)_2 = \frac{164 \times 0.475 \times 10^{-3}}{40} = 1.95 \times 10^{-3}$

$= 1.95\text{mg}$