Q1) The one that is not expected to show isomerism is:

a) $[Ni(NH_3)_2Cl_2]$

b) $[Ni(NH_3)_4(H_2O)_2]^{+2}$

c) $[pt(NH_3)_2Cl_2]$

d) $[Ni(en)_3]^{2+}$

Solution

$Ni(NH_3)_2Cl_2$ is expected to have $sp^3$ hybridization and tetrahedral geometry. Hence, it will not show isomerism.

$[Pt(NH_3)_2Cl_2]$ and $[Ni(NH_3)_4(H_2O)_2]^{2+}$ can show cis-trans isomerism.

$[Ni(en)_3]^{2+}$ will show optical isomerism.

Therefore, Option(a) is correct.

Q2) Match the type of interaction in column A with the distance dependence of their interaction energy in column B.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) ion-ion</td>
<td>a) $\frac{1}{r}$</td>
</tr>
<tr>
<td>ii) dipole-dipole</td>
<td>b) $\frac{1}{r^2}$</td>
</tr>
<tr>
<td>iii) London-dispersion</td>
<td>c) $\frac{1}{r^3}$</td>
</tr>
<tr>
<td></td>
<td>d) $\frac{1}{r^6}$</td>
</tr>
</tbody>
</table>

i) i-a, ii-c, iii-d

ii) i-a, ii-b, iii-d

iii) i-b, ii-d, iii-c

iv) i-a, ii-b, iii-c

**Solution**

(I) ion-ion interaction energy $\propto \frac{1}{r}$

(II) dipole-dipole interaction energy $\propto \frac{1}{r^3}$ for stationary molecules
dipole-dipole interaction energy $\propto \frac{1}{r^6}$ for rotating molecules

(III) London-dispersion energy $\propto \frac{1}{r^6}$

Hence, the correct combination is:
(I)-A, (II)-C, (III)-d

Therefore, **Option(a) is correct.**

Q3) The correct observation in the following reactions is:
Sucrose $\xrightarrow{\text{Glycosidic bond cleavage (hydrolysis)}} A + B \xrightarrow{\text{Seliwanoff reagent}}$

a) Gives no colour
b) Formation of Blue colour
c) Formation of Red colour
d) Formation of Violet colour

**Solution**
The reaction occurs as follows:

\[
\begin{align*}
\text{C}_{12}\text{H}_{22}\text{O}_{11} & \xrightarrow{140^\circ C} \text{C}_{6}\text{H}_{12}\text{O}_6 + \text{C}_{6}\text{H}_{12}\text{O}_6 \\
\text{Sucrose} & \rightarrow \text{Glucose} + \text{Fructose} \\
& \xrightarrow{\text{Seliwanoff's reagent}} \text{Red colour}
\end{align*}
\]

- Seliwanoff's test is useful to distinguish aldose and ketose sugars.
- Fructose gives red colour with Seliwanoff's reagent.

Therefore, **Option(3) is correct.**

---

Q4) Cost iron is used for the manufacture of:

a) pig iron, scrap iron and steel
b) wrought iron, pig iron and steel

c) wrought iron and steel

d) wrought iron and pig iron

**Solution**

Cast iron is prepared from pig iron and scrap iron. It is used to prepare wrought iron and steel.

Therefore, **Option(3) is correct.**

---

Q5) Consider the reaction sequence given below:

![Reaction sequence diagram](image)

which of the following statements is true:

a) changing the concentration of base will have no effect on reaction (1)

b) changing the base from $OH^-$ to $OR^-$ will have no effect on reaction (2)

c) changing the concentration of base will have no effect on reaction (2)

d) Doubling the concentration of base will double the rate of both the reactions
Solution
The reactions occur as follows:

\[ \text{OH}^- + \text{H}_2\text{O} \rightarrow \text{OH}^- + \text{H}_2\text{O} \]

\[ \text{OH}^- / \text{EtOH} \rightarrow \text{EtOH}^- \]

The \( S_N^1 \) rate of reaction depends on concentration of alkyl halide but not on nucleophile or base.

Therefore, Option(1) is correct.

---

Q 6) Amongst the following statements regarding absorption, those that are valid are:

a) \( \Delta H \) becomes less negative as absorption proceeds.

b) on a given absorbent, ammonia is absorbed more than nitrogen gas

c) on adsorption, the residual force acting along the surface of the adsorbent increases

d) with increase in temperature, the equilibrium concentration of adsorbate increases

Solution
(a) \( \Delta H \) becomes less negative as adsorption proceeds.

(b) As NH\(_3\) is more easily liquifiable, it is adsorbed to a greater extent than N\(_2\).

(c) On adsorption, the residual forces acting along the surface of the adsorbent decreases.

(d) With the increase in temperature, the equilibrium concentration of adsorbate decreases.
Thus, statements (a) and (b) are correct.

Therefore, **Option(2) is correct.**

---

Q7. The number of subshells associated with $n = 4$ and $m = -2$ quantum numbers is:

1) 2
2) 4
3) 8
4) 16

**Solution**

We have $n = 4$ and $m = -2$

As $m$ can take values from -1 to +1 and $l$ can take values from 0 to $(n-1)$.

Thus, possible combinations of $(n, l, m)$ are $(4, 3, -2)$ and $(4, 2, -2)$

Thus, 2 subshells are possible.

Therefore, **Option(1) is correct.**

---

Q8. The shape/structure of $[XeF_5]^-$ and $XeO_3F_2$ respectively are:

1) Triangular bipyramidal and pentagonal planar
2) Octahedral and square pyramidal
3) Pentagonal planer and trigonal bipyramidal

4) trigonal bipyramidal and trigonal bipyramidal

**Solution**
The structures are given below:

![Diagram of [XeF₆]⁺ and [XeO₃F₂] structures]

**Geometry:** Pentagonal bipyramidal

**Shape:** Pentagonal planar

**Geometry:** Trigonal bipyramidal

**Shape:** Trigonal bipyramidal

---

Q9 Three elements X, Y, and Z are in the 3rd period of the periodic table. The oxides of X, Y and Z, respectively, are basic, amphoteric and acidic. The correct order of the atomic numbers of X, Y and Z is:

1) Z < Y < X  2) Y < X < Z  3) X < Z < Y  4) X < Y < Z

**Solution**
As we move from left to right in a period, the acidic nature of oxide increases.
Thus, the correct order of atomic number is:
\[ Z > Y > X \]

Therefore, **Option(4) is correct.**

---

Q10 The major product of the following reaction is:

\[ \text{Conc. } HNO_2 + \text{Conc. } H_2SO_4 \]

1)  
2)  
3)  
4)  

**Solution**
The reaction occurs as follows:
-OH and CH₃ is electron donating group where -OH is stronger.
-NO₂ is an electron withdrawing group.
Due to strong donating tendency of -OH, attack of electrophile (-NO₂⁺) will be governed by -OH and -NO₂⁺ will attack at para position w.r.t -OH.

Therefore, Option(3) is correct.

Q11) If you spill a chemical toilet cleaning liquid on your hand, your first aid would be:
1) aqueous NH₃ 2) gaseous NaHCO₃
3) aqueous NaOH 4) Vinegar

Solution
Chemical toilet cleaning liquid contains acid and hence the first aid would be a weak base like NaHCO₃.

Therefore, Option(2) is correct.

Q12) Arrange the following labeled hydrogens in decreasing order of acidity:
1) c > b > a > d  2) b > a > c > d
3) b > c > d > a  4) c > b > d > a

**Solution**

Stable the anion, stronger the acid.

Thus, $K_a$: $b > c > d > a$

Anion of C is stabilized by -M effect of $\text{NO}_2$ and benzene but anion of d is only stabilized by -M effect of benzene.

Therefore, **Option(3) is correct.**

---

Q13  Two elements A and B have similar chemical properties. They don't form solid hydrogen carbonate but react with nitrogen to form nitrides. A and B, respectively, are:

1) Cs and Ba  2) Na and Rb
3) Li and Mg  4) Na and Ca

**Solution**

Li and Mg show diagonal relationship, they do not form solid hydrogen carbonate and react with nitrogen to form nitride.

Therefore, **Option(3) is correct.**
Q14 The size of a raw mango shrinks to a much smaller size when kept in a concentrated salt solution which one of the following process can explain this?

1) Reverse osmosis 2) Diffusion 3) Osmosis 4) Dialysis

Solution
Size of mango shrinks when it is kept in concentrated salt solution. This is due to osmosis in which the water molecules move out from the mango into the salt solution causing the mango to shrink.

Therefore, Option(3) is correct.

Q15 An organic compound 'A' (C₃H₁₀O) when treated with conc HI undergoes cleavage to yield precipitate with AgNO₃ where at 'C' tautomerizes to 'D'. 'D' gives positive iodoform test. 'A' could be?

1) \[
\begin{align*}
\text{CH}_3 - \text{C} - \text{H}_2 - \text{O} - \text{CH} &= \text{CH}_2
\end{align*}
\]
2) \[
\begin{align*}
\text{CH} &= \text{CH} - \text{CH} = \text{CH}_2
\end{align*}
\]
3) \[
\begin{align*}
\text{Cl} - \text{C} - \text{O} - \text{CH} &= \text{CH}_2
\end{align*}
\]
4) \[
\begin{align*}
\text{HC} &= \text{CH} - \text{C} - \text{O} - \text{CH} &= \text{CH}_2
\end{align*}
\]

Solution
The reactions occur as follows:
Q16. Two compounds A and B with some molecular formula (C3H6O) undergo Grignard's reactions with methylmagnesium bromide to give products C and D show the following chemical tests.

<table>
<thead>
<tr>
<th>Test</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceric ammonium nitrate test</td>
<td>Positive</td>
<td>Positive</td>
</tr>
<tr>
<td>Test</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>Lucas test</td>
<td>Turbidity obtained after five</td>
<td>Turbidity obtained immediately</td>
</tr>
<tr>
<td>Iodoform test</td>
<td>Positive</td>
<td>Negative</td>
</tr>
</tbody>
</table>

C and D respectively are:

\[
\begin{align*}
C &= \text{H}_2\text{C}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{OH} \\
D &= \text{H}_2\text{C}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{OH}
\end{align*}
\]

**Solution**

The reactions occur as follows:

\[1/2/3^\circ \text{ Alcohol} \xrightarrow{\text{CAN}} \text{ Blood Red Colour} \quad (+ve) \text{ Test.}\]

\[1^\circ \text{ R-OH} \xrightarrow{\text{Anhyd ZnOCh}} \text{ Instant Turbidity}\]

\[2^\circ \text{ R-OH} \xrightarrow{\text{conc HCl}} \text{ Turbidity after 5 mins.}\]

Q17. The molecular geometry of $SF_6$ is octahedral. What is the geometry of $SF_4$ including lone pairs of electrons (if any)?
(1) Trigonal Bipyramidal
(2) Square planar
(3) Tetrahedral
(4) Pyramidal

**Solution**
The geometry of $\text{SF}_6$ is given as octahedral as given below:

Further, the geometry of $\text{SF}_4$ is given as octahedral as given below:
Thus, the geometry of SF₄ including lone pair of electrons is **Trigonal bipyramidal**.

Therefore, **Option (1)** is correct.

---

**Q18.** The results given in the below were obtained during kinetic studies of the following reaction: \(2A + B \rightarrow C + D\)

<table>
<thead>
<tr>
<th>Experiment</th>
<th>((A)) molL(^{-1})</th>
<th>((B)) molL(^{-1})</th>
<th>((\text{initial rate})) molL(^{-1})min(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.1</td>
<td>0.1</td>
<td>(6.00 \times 10^{-3})</td>
</tr>
<tr>
<td>II</td>
<td>0.1</td>
<td>0.2</td>
<td>(2.40 \times 10^{-2})</td>
</tr>
<tr>
<td>III</td>
<td>0.2</td>
<td>0.1</td>
<td>(1.20 \times 10^{-2})</td>
</tr>
<tr>
<td>IV</td>
<td>(x)</td>
<td>0.2</td>
<td>(7.20 \times 10^{-2})</td>
</tr>
<tr>
<td>V</td>
<td>0.3</td>
<td>(y)</td>
<td>(2.880 \times 10^{-1})</td>
</tr>
</tbody>
</table>

\(x\) and \(y\) in the given table are respectively:

1) 0.4, 0.4
2) 0.4, 0.3
3) 0.3, 0.3
4) 0.3, 0.4

**Solution**

The rate law is given as:

\[
\text{Rate law} = k[A][B]^2
\]

**Case I:**
Thus, \[
\frac{7.2 \times 10^{-2}}{6 \times 10^{-3}} = \frac{k[X][2B]^2}{k[A][B]^2}
\]

Thus, \[
12 = \frac{[X] \times [4B]}{[A] \times [B]^2}
\]

\[\Rightarrow \frac{X}{A} = 3\]
\[\Rightarrow X = 3A\]
\[\Rightarrow X = 0.3\]

**Case II:**

Thus, \[
\frac{2.88 \times 10^{-1}}{6 \times 10^{-3}} = \frac{k[3A][Y]^2}{k[A][B]^2}
\]

\[\Rightarrow 48 = \frac{3Y^2}{B^2}\]

Thus, \[Y = 4B\]
\[Y = 0.4\]

Thus, X and Y in the given table are: 0.3 and 0.4 respectively.

Therefore, **Option(4) is correct.**

---

Q19. Simplified adsorption spectrum of there complexed \( (i), (ii) \) and \( (iii) \) of, \( M^{n+} \) are provided below; their \( \lambda_{max} \) values are marked as \( A, B, \) and \( C \) respectively.

The correct match between the complexed and their \( \lambda_{max} \) value is:
(i) \([\text{M(NCS)}_6]^{(-6+n)}\)

(ii) \([\text{MF}_6]^{(-6+n)}\)

(iii) \([\text{M(NH}_3)_6]^{n+}\)

1) \(A - ii, B - i, C - iii\)
2) \(A - ii, B - iii, C - i\)
3) \(A - i, B - ii, C - iii\)
4) \(A - iii, B - i, C - ii\)

Solution

(i) \([\text{M(NCS)}_6]^{(-6+n)}\): NCS is a medium filed ligand. Thus, splitting will be required medium amount of energy. Thus, \(\lambda_{\max}\) will be medium.

(ii) \([\text{MF}_6]^{(-6+n)}\): F is a weak field ligand. Thus, splitting will be low and low energy will be required. Thus, \(\lambda_{\max}\) will be highest.

(iii) \([\text{M(NH}_3)_6]^{n+}\): NH\(_3\) is strong filed ligand. Thus, splitting will be high and high energy will be required. Thus, \(\lambda_{\max}\) will be lower.

Thus, the correct sequence is:
A-(iii), B-(i), C-(ii)

Therefore, Option(4) is correct.
Q20. The major product obtained from $E_2$ elimination of $3\text{-bromo-2-Fluoropentane}$ is:

Solution
The reaction occurs as follows:
Q21. The oxidation states of transition metal atoms in $K_2Cr_2O_7$, $KMnO_4$ and $K_2FeO_4$, respectively are $X$, $Y$ and $Z$, the sum of $X$, $Y$ and $Z$ is _________.

Solution
In $K_2Cr_2O_7$, Cr is in +6, thus, $x = 6$

In $KMnO_4$, Mn is in +7, thus, $y = 7$

In $K_2FeO_4$, Fe is in +8, thus, $z = 6$
Thus, we have:

\[ x + y + z = 6 + 7 + 6 = 19 \]

Therefore, the correct answer is 19.

Q22. The work function of sodium metal is \( 4.41 \times 10^{-19} \, J \), if photons of wavelength 300 nm are incident on the metal, the Kinetic Energy of the ejected electrons will be \( (h = 6.63 \times 10^{-34} \, Js; c = 3 \times 10^8 \, ms) \)

\[ \times 10^{-21} \, J \]

Solution
We have:

\[ W_0 = 4.41 \times 10^{-19} \, J \]

\[ h\nu = h\nu_0 + K.E \]

Thus, we have:

\[ \frac{hc}{\lambda} = 4.41 \times 10^{-19} + K.E \]

\[ K.E = \frac{hc}{\lambda} - 4.41 \times 10^{-19} \]

\[ K.E = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{300 \times 10^{-9}} - 4.41 \times 10^{-19} \]

\[ K.E = 6.63 \times 10^{-34} \times 10^{15} - 4.41 \times 10^{-19} \]

\[ K.E = 222 \times 10^{-21} \, J \]

Thus, the correct answer is 222.
Q23. For the disproportionation reaction

\[ 2Cu^{+\text{aq}} \rightarrow Cu(s) + Cu^{2+\text{aq}}, \text{at 298K} \text{ in } K \text{ (where } K \text{ is the equilibrium Constant) is } \times 10^{-1} \]

Given

\[ E^{\circ}_{\text{Cu}^{2+\text{aq}}} = 0.16V, E^{\circ}_{\text{Cu}^{+\text{aq}}} = 0.52V, \frac{RT}{F} = 0.025 \]

Solution

We have given:

\[ \text{Cu}^{2+} \xrightarrow{0.16V} \text{Cu}^{+} \xrightarrow{0.52V} \text{Cu} \]

Thus, \( E^{\circ}_{\text{disproportionation}} = 0.52 - 0.16 = 0.36V \)

Now, we know:

\[ \Delta G = -nF E^{\circ} = -nRT \ln K \]

\[ \frac{RT}{F} \ln K = 1 \times 0.36 \]

\[ \ln K = \frac{0.36}{0.025} \]

Thus, \( \log K = 6.25 \)

Thus, \( K = 1.8 \times 10^6 \)

Q24. The heat of Combustion of ethanol into Carbon dioxide and water is \(-327K\text{cal at constant pressure . The heat evolved (in cal) at constant volume and 27}^\circ\text{C (if all gases behave ideally) is } \]

\( (R = 2calmol^{-1}K^{-1}) \)
Solution

The reaction occurs as follows:

\[ \text{C}_2\text{H}_5\text{OH} + \frac{7}{2}\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O} \]

\[ \Delta H = -327 \text{ kcal} \]

\[ \Delta n = 1.5 \]

Now,

\[ \Delta H = \Delta U + \Delta nRT \]

\[ \Delta U = \Delta H - \Delta nRT \]

\[ \Delta U = -327 + \frac{1.5 \times 2 \times 300}{1000} \]

\[ \Delta U = -326.1 \text{ kcal} \]

Therefore, correct answer is -326.1 kcal.

---

Q25. The ratio of the masses percentages of 'C' and 'H' and 'C' and 'O' of a saturated acyclic organic compound 'X' are 4:1 and 3:4 respectively. Then, the moles of oxygen gas required for complete combustion of two moles of organic compound 'X' is __________

Solution

We have

Mass ratio of C:H = 4:1

Mass ratio of C:O = 3:4

Thus, mass ratio of C:H:O = 12:3:16
Mass ratio of C:H:O = 1:3:1

Thus, empirical formula = CH₃O

Now, since (CH₃O)ₙ is saturated acyclic. Hence only possible value of n is 2.

Thus, the compound is C₂H₆O.

Now, the reaction occurs as follows:

\[ \text{C}_2\text{H}_6\text{O} + \frac{7}{2}\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O} \]

Thus, 7 moles of O₂ are required for combustion of 2 moles of the organic compound.

---

**SUBJECT - Mathematics**

**Total Questions - 21 out of 25**

---

1. Let \( A = \left\{ X = (x, y, z)^2 : Px = 0, \text{ and, } x^2 + y^2 + z^2 = 1 \right\} \), where \( P = \begin{pmatrix}
1 & 2 & 1 \\
-2 & 3 & -4 \\
1 & 9 & -1
\end{pmatrix} \) then Set A contains:

1) exactly two elements
2) is an empty set.
3) is a singleton set.
4) contains more than 2 elements.

Solution:
\[ P = \begin{bmatrix} 1 & 2 & 1 \\ -2 & 3 & -4 \\ 1 & 9 & -1 \end{bmatrix} \text{ and } X = [x, y, z]^T \]

\[ PX = 0 \]

\[ PX = \begin{bmatrix} 1 & 2 & 1 \\ -2 & 3 & -4 \\ 1 & 9 & -1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} \]

\[ x + 2y + z = 0 \]

\[-2x + 3y - 4z = 0 \]

\[ x + 9y = 2 = 0 \]

Only solution is \( x = 0, y = 0 \) and \( z = 0 \)

Hence \( x^2 + y^2 + z^2 = 0 \)

Therefore \( A \) is an empty set

---

2. Let \( f: \mathbb{R} \to \mathbb{R} \) be a function which satisfies \( f(x + y) = f(x) + f(y) \) for all \( x, y \in \mathbb{R} \), \( f(1) = 2 \), and \( g(n) = \sum_{k=1}^{n-1} f(k), n \in \mathbb{N} \)

\( g(n) = 20 \), then the value of \( n \) for which

1) 4
2) 5
3) 9
4) 20

Solution:
\[ f(x + y) = f(x) + f(y) \]
\[ f(1) = 2 \]
\[ g(x) = \sum_{k=1}^{n-1} f(k) \quad n \in \mathbb{N} \]
\[ g(n) = 20 \]
\[ f(1) = f(1) + f(0) \]
\[ f(2) = 2f(2) = 4 \]
\[ f(3) = 8f(2) + f(2) = 6 \]
\[ f(4) = 8 \]
\[ f(5) = f(3) + f(2) = 6 + 4 = 10 \]
\[ f(x) = 2x \]
\[ \Rightarrow 2 \times \frac{n(n+1)}{2} = 20 \]
\[ \Rightarrow 4 \times 5 = 20 \Rightarrow n = 4 \]

3. \( a, b, c \in \mathbb{R} \) non-zero and satisfies \( a^3 + b^3 + c^3 = 2 \) if the matrix

\[
A = \begin{pmatrix} a & b & c \\ b & c & a \\ c & a & b \end{pmatrix}
\]
satisfies \( A^T A = I \), then the value of abc can be:

1) \(-\frac{1}{3}\)
Solution:

\[ A = \begin{bmatrix} a & b & c \\ b & c & a \\ c & a & b \end{bmatrix} \]

\[ A^T = \begin{bmatrix} a & b & c \\ b & c & a \\ c & a & b \end{bmatrix} \]

\[ A \cdot A^T = I \]

\[
\begin{bmatrix}
a & b & c \\
b & c & a \\
c & a & b
\end{bmatrix} \times \begin{bmatrix}
a & b & c \\
b & c & a \\
c & a & b
\end{bmatrix} = \begin{bmatrix}
1 & 0 & 0 \\
0 & 1 & 0 \\
0 & 0 & 1
\end{bmatrix}
\]

\[
\begin{bmatrix}
 a^2 + b^2 + c^2 & ab + bc + ca & ab + bc + ca \\
ab + bc + ca & a^2 + b^2 + c^2 & ab + bc + ca \\
ab + bc + ca & ab + bc + ca & a^2 + b^2 + c^2
\end{bmatrix} = \begin{bmatrix}
1 & 0 & 0 \\
0 & 1 & 0 \\
0 & 0 & 1
\end{bmatrix}
\]

\[ \Rightarrow a^2 + b^2 + c^2 = 1 \text{ and } ab + bc + ca = 0 \]

\[ (a + b + c)^2 = 1 \Rightarrow (a + b + c) = \pm 1 \]

\[ a^3 + b^3 + c^3 = (a + b + c) [a^2 + b^2 + c^2 - ab - bc - ac] + 3abc \]

\[ 2 = 1 \times [\pm 1] + 3abc \]
4. Equation of normal to the curve \( y = (1 + x)^2 + \cos^2(\sin^{-1} x) \) at \( x = 0 \) is:

1) \( y + 4x = 2 \)
2) \( x + 4y = 8 \)
3) \( y = 4x + 2 \)
4) \( 2y + x = 4 \)

Solution:

\[
y = (1 + x)^2 + \cos^2(\sin^{-1} x)
\]

\[
\frac{dy}{dx} = 2(1 + x) + 2 \cos(\sin^{-1} x) \cdot (-\sin(\sin^{-1} x)) \cdot \frac{1}{\sqrt{1 - x^2}}
\]

\[
\frac{dy}{dx} \bigg|_{x=0} = 2
\]

Slope of normal

\[
\frac{dx}{dy} = \frac{1}{-2}
\]

\[
y - y_1 = -\frac{1}{2}(x - x_1)
\]

At \( x = 0, \ y = 2 \)

\[
y - 2 = -\frac{1}{2}(x - 0)
\]

\[
2y - 4 = -x
\]

5. Tautology?
(a) \((\sim q) \lor (p \land q) \rightarrow q\)
(b) \((\sim p) \land (p \lor q) \rightarrow q\)
(c) \((q \rightarrow p) \lor (p \rightarrow q)\)
(d) \((p \rightarrow q) \land (q \rightarrow p)\)

Solution:

Truth table of \((\sim p) \land (p \lor q) \rightarrow q\)

<table>
<thead>
<tr>
<th>p</th>
<th>q</th>
<th>(\sim p \land (p \lor q) \rightarrow q)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>F</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>T</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>T</td>
<td>F</td>
<td>T</td>
</tr>
</tbody>
</table>

6. Imaginary part of \((3 + 2\sqrt{-54})^{1/2} - (3 - 2\sqrt{-54})^{1/2}\) can be

1) 6
2) \(\sqrt{6}\)
3) \(-\sqrt{6}\)
4) \(-2\sqrt{6}\)

Solution:

\((3 + 2\sqrt{-54})^{1/2} - (3 - 2\sqrt{-54})^{1/2}\)

\((3 + 2 \cdot 3\sqrt{6}i)^{1/2} - (3 - 2 \cdot 3\sqrt{6}i)^{1/2}\)

\([3^2 + (\sqrt{6}i)^2 + 2 \cdot 3\sqrt{6}i]^{1/2} - [3^2 + (\sqrt{6}i)^2 - 2 \cdot 3\sqrt{6}i]^{1/2}\)
\[ 3 + \sqrt{6i} - 3 - \sqrt{6i} \]

\[ b_1 = \pm \sqrt{6} \text{ and } b_2 = \pm \sqrt{6} \]

So the value of \( b_1 + b_2 = 2\sqrt{6} \quad \text{or} \quad -2\sqrt{6} \quad \text{or} \quad 0 \]

7. For some \( \theta \in \left(0, \frac{\pi}{2}\right)\), if the eccentricity of the hyperbola \( x^2 - y^2 \sec^2 \theta = 10 \) is \( \sqrt{5} \) times the eccentricity of the ellipse \( x^2 \sec^2 \theta + y^2 = 5 \), then the length of the latus rectum of the ellipse is

1) \( \sqrt{30} \)
2) \( \frac{4\sqrt{5}}{3} \)
3) \( \frac{2\sqrt{5}}{7} \)
4) \( \frac{2\sqrt{5}}{6} \)

Solution:

Equation of hyperbola
\[ x^2 - \frac{y^2}{\cos^2 \theta} = 10 \]

Equation of ellipse
\[ \frac{x^2}{\cos^2 \theta} + y^2 = 5 \]
\[
\begin{align*}
\epsilon_h &= \sqrt{1 + \frac{\cos^2 \theta}{1}} , \quad \epsilon_e = \sqrt{1 - \frac{\cos^2 \theta}{1}} \\
1 + \cos^2 \theta &= 5 \sin^2 \theta \\
2 &= 6 \sin^2 \theta \\
\sin^2 \theta &= 1/3 \\
\text{LR of ellipse } &= \frac{2 \times \frac{2}{3} \times 5}{\sqrt{5}} = \frac{4}{3} \sqrt{5}
\end{align*}
\]

8. Let \( E^c \) denote the complement of an event \( E, E_1, E_2, E_3 \) be any pair wise independent events with \( P(E) > 0 \) and \( P(E_1 \cap E_2 \cap E_3) = 0 \) then

\[
P \left( \frac{E_2 \cap E_3}{E_1} \right)
\]

is equal to

1) \( P(E_3^c) - P(E_2^c) \),

2) \( P(E_3^c) - P(E_2) \),

3) \( P(E_2^c) - P(E_3) \),

4) \( P(E_3) - P(E_2^c) \),

Solution:

\[
P(\bar{E}_2 \cap \bar{E}_3 / E_1) = \frac{P(\bar{E}_2 \cap \bar{E}_3 \cap E_1)}{P(E_1)} = \frac{P(\bar{E}_2)P(\bar{E}_3)P(E_1)}{P(E_1)} = P(\bar{E}_2)P(\bar{E}_3)
\]

\[
= P(\bar{E}_2)\{1 - P(E_3)\} = P(\bar{E}_2) - P(\bar{E}_2)P(E_3)
\]

\[
= P(\bar{E}_2) - \{1 - P(E_2)\}P(E_3) = P(\bar{E}_2) - P(E_3) + P(E_2)P(E_3)
\]

now given that \( E_1, E_2, E_3 \) are independent and \( P(E_1 \cap E_2 \cap E_3) = 0 \)

\[
\Rightarrow P(E_1)P(E_2)P(E_3) = 0
\]
Q9 Area of an equilateral triangle inscribed in the parabola \( y^2 = 8x \) with one of its vertices on the vertex of this parabola is:

1) \( 128\sqrt{3} \)
2) \( 192\sqrt{3} \)
3) \( 64\sqrt{3} \)
4) \( 256\sqrt{3} \)

Solution:

Let the two vertices of the triangle be Q and R. Points Q and R will have the same x-coordinate = \( k \) (say)

Now in the right triangle PRT, right-angled at T.
\[
\tan 30^\circ = \frac{RT}{k} \Rightarrow \frac{1}{\sqrt{3}} = \frac{RT}{k} \Rightarrow RT = \frac{k}{\sqrt{3}} \Rightarrow R \left( k, \frac{k}{\sqrt{3}} \right)
\]

Now \( R \) lies on the parabola: \( y^2 = 4ax \)

\[
\Rightarrow \left( \frac{k}{\sqrt{3}} \right)^2 = 4a(k)
\]

\[
\Rightarrow \frac{k}{3} = 4a
\]

\[
\Rightarrow k = 12a
\]

Length of side of the triangle = \( 2(\text{RT}) = 2 \cdot \frac{k}{\sqrt{3}} = 2 \cdot \frac{(12a)}{\sqrt{3}} = 8\sqrt{3}a = 16\sqrt{3} \)

Area of Equilateral triangle is \( \frac{\sqrt{3}}{4} a^2 = 192\sqrt{3} \)

Q10 Sum of first 11 terms of an A.P. \( a_1, a_2, \ldots \) is 0 (\( a_1 \neq 0 \)), then the sum of the A.P. \( a_1, a_3, a_5, \ldots, a_{23} \) is \( ka_1 \) where \( k \) is equal to:

\[
\begin{array}{cccc}
121 & -121 & 72 & -72 \\
10 & 10 & 5 & 5 \\
\end{array}
\]

1) \( \frac{121}{10} \) 2) \( \frac{-121}{10} \) 3) \( \frac{72}{5} \) 4) \( \frac{-72}{5} \)

Solution:

\[
S_{11} = \frac{11}{2} (2a_1 + 10d) = 0
\]

\[
a_1 = -5d
\]
\[ S_{12} = \frac{12}{2} \(2a_1 + 22d\) \]
\[ = (a_1 + 11d) \times 12 \]
\[ = 6d \times 12 \]
\[ = 72d = -\frac{72}{5}a \]

Q11 Let \(f(x)\) is a quadratic polynomial such that \(f(-1) + f(-2) = 0\). If the roots of \(f(x) = 0\) is 3, then the other root lies in:
1) (-3, -1)
2) (0, 2)
3) (1, 3)
4) (-1, 0)

Solution:
\[ f(-1) + f(2) = 0 \]
\[ f(x) = ax^2 + bx + c \]
\[ a - b + c + 4a + 2b + c = 0 \]
\[ 5a + b + 2c = 0 - 0 \]
\[ f(3) = 0 \]

\[ \Rightarrow 9a + 3b + c = 0 \ldots (ii) \]
Equation (ii)-(i)
\[ 4 a + 2 b - c = 0 \]
\[ 4 a + 2 b + c = 2 c \]
\[ \Rightarrow f(2) = 2 \times f(0) \]
\[ \therefore \text{f}(0) \text{ and f}(-1) \text{ are of opposite signs} \]
Q12 S is sum of first 9 terms \((x + ka) + (x^2 + (k + 2)a) + (x^3 + (k + 4)a) + (x^4 + (k + 6)a) + \ldots\) where \(a \neq 0\) and \(x \neq 1\). If
\[
S = \frac{x^{10} - x + 45a(x - 1)}{x - 1}
\]
then \(k\) is?

1) 3  
2) 2  
3) -3  
4) -5

Solution:
\[
S = (x + ka) + (x^2 + (k + 2)a) + (x^3 + (k + 4)a) + \ldots
\]
\[
= (x + x^2 + x^3 + \ldots + x^9) + a[(k + (k + 2) + (k + 4) + \ldots + (k + 16))]
\]
\[
= \frac{x(x^9 - 1)}{(x - 1)} + a[9k + 72]
\]
\[
\therefore 9k + 72 = 45
\]
\[
k + 8 = 5
\]
\[
k = -3
\]
Option 3

Q13 If a curve \(y = f(x)\), passing through the points \((0,2)\) is the solution of the differential equation \(2x^2 \frac{dy}{dx} = (2xy + y^2)dx\), then \(f\left(\frac{1}{2}\right)\) is equal to
\[
\frac{1}{1 + \log_e 2}
\]

1) \(1 + \log_e 2\)  
2) \(1 + \log_e 2\)
\[
\begin{align*}
&3) \frac{-1}{1 + \log_e 2} \\
&4) \frac{1}{1 - \log_a 2}
\end{align*}
\]

Solution:

\[
2x^2 \, dy = (2xy + y^2) \, dx
\]

\[
\frac{dy}{dx} = \frac{2xy + y^2}{2x^2}
\]

\[
\frac{dy}{dx} = \frac{2 \left( \frac{y}{x} \right) + \left( \frac{y}{x} \right)^2}{2}
\]

\[
y = tx \\
y = tx \Rightarrow \frac{dy}{dx} = t + x \frac{dt}{dx}
\]

\[
t + x \frac{dt}{dx} = t + \frac{t^2}{2}
\]

\[
\Rightarrow \int \frac{2}{t^2} \, dt = \int \frac{2}{x} \, dx
\]

\[
\Rightarrow -\frac{2}{t} = \ln x + c
\]

\[
\Rightarrow -\frac{2}{2x} = \ln x + c
\]

\[
-\frac{2 \times 1}{y} = 0 + c \Rightarrow c = -1
\]

\[
\frac{2x}{y} = \ln x - 1
\]
at $x = -1/2$
\[
-2 \times \frac{1}{2} = \ln \left( \frac{1}{2} \right) - 1
\]
\[
-1 = \ln \left( \frac{1}{2} \right) - 1 \Rightarrow y = \frac{1}{1 - \ln 2}
\]
option 4

Q14 If the equation $\cos^4 \theta + \sin^4 \theta + \lambda = 0$ does have real solutions for $\theta$, then $\lambda$ lies in the interval:

1) $\left( -\frac{5}{4}, -1 \right)$
2) $\left( -\frac{1}{2}, -\frac{1}{4} \right)$
3) $\left[ -\frac{3}{2}, -\frac{5}{4} \right]$ 
4) $\left[ -1, -\frac{1}{2} \right]$

Solution:

$\cos^4 \theta + \sin^4 \theta + \lambda = 0$

\[
f(\theta) = \cos^4 \theta + \sin^4 \theta
\]
\[
= (\cos^2 \theta + \sin^2 \theta)^2 - 2 \sin^2 \theta \cos^2 \theta
\]
\[
= 1 - \frac{\sin^2 2\theta}{2}
\]
\[
\frac{\sin^2 2\theta}{2} \in \left[\frac{1}{2}, 1\right] \\
\therefore \lambda \in \left[-1, -\frac{1}{2}\right]
\]

Q15 Consider a region \( R = \{(x, y) \in \mathbb{R}^2 : x^2 \leq y \leq 4x\} \). If a line \( y = \alpha \) divided the region \( R \) into two equal parts, then which of the following is true?

1) \( 3\alpha^2 - 8\alpha + 8 = 0 \)
2) \( \alpha^2 - 6\alpha + 16 = 0 \)
3) \( \alpha^3 - 6\alpha^3 - 16 = 0 \)
4) \( 3\alpha^2 - 8\alpha^3 + 8 = 0 \)

Solution:

\[
x^2 \leq y \leq 2x
\]
\[ \int_0^\alpha \left( \sqrt{y} - \frac{y}{2} \right) dy = \frac{1}{2} \int_0^2 (2x - x^2) \, dx \]

\[ \frac{2}{3} y^{3/2} - \frac{y^2}{4} \bigg|_0^\alpha = \frac{1}{2} \left[ x^2 - \frac{x^3}{3} \right]_0^\alpha \]

\[ \Rightarrow \frac{2}{3} \alpha^{3/2} - \frac{\alpha^2}{4} = \frac{1}{2} \left[ 4 - \frac{8}{3} \right] \]

\[ \Rightarrow \frac{8\alpha^{3/2} - 3\alpha^2}{12} = \frac{1}{2} \times \frac{4}{3} \]

\[ \Rightarrow 8\alpha^{3/2} - 3\alpha^2 = 8 \]

\[ \lim_{x \to 0} \int \tan \left( \frac{\pi}{4} + x \right) \, dx \]

is equal to:

a) 2  b) 1  c) \( e^2 \)  d) \( e \)

Solution:

\[ \lim_{x \to 0} \tan \left( \frac{\pi}{4} + x \right)^{1/x} = \lim_{x \to 0} \left( \frac{\tan(\pi/4) + \tan x}{1 - \tan(\pi/4) \tan x} \right)^{1/x} \]

\[ = \lim_{x \to 0} \left( \frac{1 + \tan x}{1 - \tan x} \right)^{1/x} \]

\[ = \lim_{x \to 0} \left( 1 + \frac{2 \tan x}{1 - \tan x} \right)^{1/x} \]

\[ = e^{\lim_{x \to 0} \left( \frac{2 \tan x}{1 - \tan x} \right)^{1/x}} \]

\[ = e^2 \]
21) \[ y = \sum_{k=1}^{6} \cos^{-1}\left\{ \frac{3}{5} \cos kx - \frac{4}{5} \sin kx \right\} \]

Solution:

\[ y = \sum_{k=1}^{6} \cos^{-1}\left( \cos(kx + \alpha) \right) \]

where \( \cos \alpha = \frac{3}{5} \)

\[ = \sum_{k=1}^{6} (kx + \alpha) \]

\[ = \frac{6 \times 7 \times x}{2} + 6\alpha \]

\[ = 21x + 6\alpha \]

\[ \frac{dy}{dx} = 21 \]

---

22) Let \( \lfloor t \rfloor \) denote the greater integer less than or equal to \( t \). Then the value of \( \int_{1}^{2} |2x - [3x]| \, dx \) is ___

Solution:

\[ \int_{1}^{2} |2x - [3x]| \, dx \]
\[ \int_1^{4/3} |2x - 3| \, dx + \int_{4/3}^{5/3} |2x - 4| \, dx + \int_{5/3}^{6} |2x - 5| \, dx \]

\[ = \frac{2}{9} + \frac{3}{9} + \frac{4}{9} = 1 \]

---

23) If the variance of the terms in an increasing A.P. \( b_1, b_2, b_3, \ldots, b_4 \) is 90 then common difference of this A.P. is ___.

Solution:

\[ \sum \frac{(x_i - \mu)^2}{n} = 90 \]

\[ \mu = \frac{n}{2} [2a + 10d] = a + 5d \]

\[ \sum \frac{(x_i - \mu)^2}{n} = \sum \frac{x_i^2}{n} - \mu^2 \]

\[ = \frac{1}{n} \left( \frac{11}{6} \times 21 \right) a^2 + \frac{1}{6} \times 11 \times 11 \times d^2 + \frac{2ad \times 10 \times 11}{2 \times 11} \]

\[ = a^2 + \frac{10 \times 11}{6 \times 11} \times d^2 + 2ad \times 10 \times 11 \times \frac{1}{2 \times 11} - (a^2 + 25d^2 + 10ad) \]

\[ 10d^2 = 90 \]

\[ d = 3 \]

---

24) Let the position vector of point A and B be \( \hat{i} + \hat{j} + \hat{k} \) and \( 2\hat{i} - \hat{j} - 3\hat{k} \), respectively. A point 'p' divides the line segment AB internally in the ratio \( \alpha : 1(\alpha, \theta) \).

\[ \overrightarrow{OB} \cdot \overrightarrow{OP} - 3 \left| \overrightarrow{OA} \times \overrightarrow{OP} \right|^2 = 6, \alpha = \_ \]
25) For a positive integer \( n \) \( \left(1 + \frac{1}{x}\right)^4 \) is expanded in increasing power of \( x \), if three consecutive coefficient in this expansion are in the ratio 2 : 5 : 12, \( n = \) __

Solution:

\[
\frac{nC_{r-1}}{nC_r} = \frac{12}{5}
\]

\[
\frac{r}{n-r+1} = \frac{12}{5} \quad \text{(i)}
\]

\[
\frac{nC_r}{nC_{r+1}} = \frac{5}{2} \quad \text{(ii)}
\]

\[
\frac{r+1}{n-r} = \frac{5}{2}
\]

From equation (i) and (ii)

\[ n = 118 \]

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**SUBJECT - Physics**

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**Q-1**

A small point carrying some positive charge on it is redirected from the edge of the table. There is a uniform electric field in this region in the horizontal direction. Which of the following options then correctly describe the trajectory of the mass?

(where we have drawn schematically and are not to scale)
Ans-A

Solution:

\[ S_y = \frac{1}{2} gt^2 \]
\[ S_x = \frac{1}{2} \frac{qE}{m} t^2 \]

After certain time, \( S_x \) becomes constant but \( S_y \) keeps increasing

Q-2

4. In a hydrogen atom, the electron makes the transition from \((n + 1)^{th}\) level to the \(n^{th}\) level. If \( n \gg 1 \), the frequency of radiation emitted is proportional to

\[ \frac{1}{A-n} \]
\[ \frac{1}{B-n^4} \]
An energy gap, $\Delta E = h\nu$

Here, $h$ is Planck's constant 
therefore, 
Frequency=$\nu$

$$\nu = \frac{\Delta E}{h} = k \left[ \frac{1}{(n)^2} - \frac{1}{(n+1)^2} \right] \Rightarrow \nu = \frac{k(2n+1)}{n^2(n+1)^2}$$

Since $n \gg 1$ 
So $(n+1)^2 \approx n^2$

$$\Rightarrow \nu \propto \frac{1}{n^3}$$

Q-3

The uniform circular discs are rotating in the same direction around their common axis passing through their centers. The moment of inertia and angular velocity of the first disc are $0.1 \text{ kg.m}^2$ and $10 \text{ rad.s}^{-1}$ respectively, while those for the second one are $0.2 \text{ kg.m}^2$ and $5 \text{ rad.s}^{-1}$ respectively. At some instant, they get stuck together and start rotating as a single system about their common axis with some angular speed, the kinetic energy of the combined system is

$$\frac{1}{2} I \omega^2$$

A. $\frac{10}{3}$
B. $\frac{20}{3}$
Solution:

By angular momentum conservation

\[ I_1 \omega_1 + I_2 \omega_2 = (I_1 + I_2) \omega \]

\[ 0.1 \times 10 + 0.2 \times 5 = (0.3) \times \omega \]

\[ \omega = \frac{20}{3} \]

\[ K.E. = \frac{1}{2} I \omega^2 = \frac{1}{2} (0.1 + 0.2) \left( \frac{20}{3} \right)^2 = \frac{20}{3} J \]

---

Q-5: A single piece of wire carrying a current I is bent in the shape ABCDEF as shown where the rectangle ABCDA and AOEFA are perpendicular to each other. If the sides of the rectangles are of the length a and b then the magnitude and direction of magnetic moment of the loop ABCDEF.
\[ \sqrt{aabI}, \text{ along } \left( \frac{\hat{j}}{\sqrt{5}} + \frac{2\hat{k}}{\sqrt{5}} \right) \]
A-

\[ abI, \text{ along } \left( \frac{\hat{j}}{\sqrt{5}} + \frac{2\hat{k}}{\sqrt{5}} \right) \]
B-

\[ abI, \text{ along } \left( \frac{\hat{j}}{\sqrt{2}} + \frac{\hat{k}}{\sqrt{2}} \right) \]
C-

\[ \sqrt{2}abI, \text{ along } \left( \frac{\hat{j}}{\sqrt{2}} + \frac{\hat{k}}{\sqrt{2}} \right) \]
D-
Solution-

\[ M_1 = IA\hat{k} = Iab\hat{k} \]

and \[ M_2 = IA\hat{j} = Iab\hat{j} \]

\[ |M_{\text{net}}| = \sqrt{(M_1)^2 + (M_2)^2} = \sqrt{(I^2a^2b^2) + (I^2a^2b^2)} = \sqrt{2}Iab \]

And the direction of net magnetic moment is along \[ \vec{u} \] where \[ \vec{u} = \hat{i} + \hat{j} \]

So

\[ M_{\text{net}} = \sqrt{2}Iab\hat{u} = \sqrt{2}Iab \frac{\vec{u}}{|\vec{u}|} = \sqrt{2}Iab \frac{(\hat{k} + \hat{j})}{\sqrt{2}} \]

Q-4

An inductive coil has a resistance of 100 \( \Omega \). When an a.c. signal of frequency 1000 Hz is fed to the coil, the applied voltage leads the current by \( 45^0 \). What is the inductance of the coil?

A- 6.7 \( \times 10^{-7} \) H

B- 1.1 \( \times 10^{-1} \) H

C- 1.1 \( \times 10^{-5} \) H

D- 1.6 \( \times 10^{-3} \) H

Ans- D

Solution-
The applied voltage leads the current by $45^\circ$

i.e., $\frac{X_L}{R} = \tan 45^\circ$

$X_L = R$

$\Rightarrow 2 \times 3.14 \times 1000L = 100$

$\Rightarrow 6280L = 100$

$\Rightarrow L = \frac{25}{1570} = 0.01592 \cong 16mH$

Q-7-

In the following digital circuit, what will be the output at $Z$ when the input $(A,B)$ are $(1,0)$, $(0,0)$, $(1,1)$, $(0,1)$?

A- (1,0,1,1)

B- (0,1,0,0)

C- (0,0,1,0)

D- (1,1,0,1)

Ans- c
Q-8

If momentum $P$, area $A$, and time $T$ are taken to be fundamental quantities, then the dimensional formula for energy is:

A. $PA^{1/2}T^{-1}$
B. $P^2AT^{-2}$
C. $PA^{-1}T^{-2}$
D. $P^{1/2}AT^{-1}$

Ans-A

Solution-
Let energy,
\[ U \propto P^a A^b T^c \]
\[ U = k P^a A^b T^c \] \( \ldots (i) \)
where \( k \) is dimensionless constant of proportionality.

From (i)
\[ [ML^2 T^{-2}] = (MLT^{-1})^a (L^2)^b T^c = M^a L^{a+2b} T^{-a+c} \]

Applying the principle of homogeneity of dimensions, we get
\[ a = 1, \]
\[ a + 2b = 2 \Rightarrow b = \frac{2 - a}{2} = \frac{2 - 1}{2} = \frac{1}{2} \]
\[ -a + c = -2 \Rightarrow c = -2 + a = -2 + \frac{1}{2} = -\frac{3}{2} \]

\[ : \text{from} (i), U = k \left[P^1 A^{1/2} T^{-1}\right] \]

Q-12-

A 10\(\mu\)F capacitor is charged to a potential difference of 50V and is connected to another uncharged capacitor in parallel. Now the common potential difference becomes 20 volts. The capacitance of the second capacitor is

A-10\(\mu\)F
B- 30\(\mu\)F
C- 20\(\mu\)F
D-15\(\mu\)F

Ans-C

Solution-
Q-6

Potentiometer wire PQ of length 1m is connected to a standard cell E1. Another cell of E2 of emf 1.02v is connected with a resistance 'r' and with a switch 'S' as shown in the circuit diagram. When the switch S is open, the null position is obtained at a distance of 49 cm from Q. Calculate the potential gradient in the potentiometer wire is:-

A-0.02 V/cm
B-0.04 V/cm
C-0.03 V/cm
D-0.01 V/cm

Ans-

Length of potentiometer wire l = 1m
Emf of standard cell = E1
Emf of cell E2 = 1.02v/s
Given Null point from Q is 49 cm
Null point from P = 100 - 49 = 51cm = 0.51m
Potential gradient of the wire \( V = \frac{1.02}{0.51} \) \( V = 2V/m = 0.02V/cm \)

Q-9

The particle is moving 5 times as fast as an electron, the ratio of the \( \lambda \) of the particle to that of the electron is \( 1.878 \times 10^{-4} \), then the mass of the particle is close to
A- $9.7 \times 10^{-28}$ kg
B- $4.8 \times 10^{-27}$ kg
C- $1.2 \times 10^{-28}$ kg
D- $9.1 \times 10^{-31}$ kg

Ans- A

Solution-

$$\frac{\lambda_e}{\lambda_p} = \frac{\frac{h}{m_e v_e}}{\frac{h}{m_p v_p}}$$

It is given that -

$$\frac{\lambda_p}{\lambda_e} = 1.878 \times 10^{-4}$$

$m_e = 9.109 \times 10^{-31}$ kg

Also given that - $V_p = 5 V_e$

After putting the values -

$m_p = 9.7 \times 10^{-28}$ kg

Q-10-

The height $h$ at which the weight of a body will be the same as that at the same depth $h$ from the surface of the earth is:

$$\frac{R}{A}$$

A- 2
\[
\begin{align*}
&\sqrt{5}R - R \\
&\div 2 \\
C: \quad &\sqrt{3}R - R \\
&\div 2 \\
&\sqrt{5}R - 2R \\
&\div 2 \\
\text{Ans-B} \\
\text{Solution-} \\
\text{Since,} \\
\text{weight at height } h = \text{weight at depth } d \\
\text{So, } mg_h = mg_d \\
\text{So, } g_h = g_d \\
\text{So,} \\
\frac{g_o R^2}{(R + h)^2} = \frac{g_o (R - d)}{R} \\
\text{Where,} \\
g_o = \text{acceleration due to gravity at the surface of earth} \\
h = \text{height} \\
d = \text{Depth} \\
R = \text{Radius of the earth} \\
\text{On solving,}
\[
\frac{R^2}{(R + h)^2} = \frac{(R - d)}{R}
\]

\[\Rightarrow R^3 = (R^2 + h^2 + 2Rh)(R - d)\]

As \(h = d\) (Given)

On Solving this we get -

\[h^2 + hR - R^2 = 0\]

So,

\[\Rightarrow h = \frac{\sqrt{5}R - R}{2}\]

Q-11

A magnetic field of 0.3T is present in a region and a proton enters the region with velocity \(4 \times 10^5\) m/s making an angle of 60° with the field. If the proton completes 10 revolutions by the time it crosses the region as shown in the figure, then \(I\) is close to (mass of proton=\(1.67 \times 10^{-27}\) kg, charge of proton=\(1.6 \times 10^{-19}\) C)
A-0.22 m
B-0.44 m
C-0.88 m
D-0.11 m
Ans-C
Solution-

By equating centripetal and magnetic force on proton, we get -

\[ \frac{mv^2}{R} = qvBS\sin60^\circ \]

\[ m = 1.67 \times 10^{-27} \text{ kg} \]

\[ v = 4 \times 10^6 \text{ m/s} \]
\[ q = 1.6 \times 10^{-19} \text{ C} \]
\[ B = 0.3 \text{ T} \]

By putting above values, we get
\[ R = 0.0160695 \text{ m} \]

Now,
\[ v = \omega R \]

by putting the values of \( v \) and \( R \), we get 
\[ \omega = 24891875.91399 \text{ rad/s} \]

Now we can calculate time period -
\[ T = \frac{2\pi}{\omega} \]

So,
\[ T = 1.080707 \times 10^{-7} \text{ S} \]

Now,
Distance \( = n \times V \times T \)

Here \( n = 10 \)
\[ v = 4 \times 10^{5} \text{ m/s} \]

So,
\[ \frac{l}{\sin 60^\circ} = 10 \times 4 \times 10^{5} \]
From here -

\[ l = 0.88m \]