1. The cyanide process of gold extraction involves leaching out gold from its ore with CN\(^-\) in the presence of Q in water to form R. Subsequently, R is treated with T to obtain Au and Z. Choose the correct option(s).

   (1) T is Zn
   (2) R is \([\text{Au(CN)}_4]^\text{3-}\)
   (3) Z is \([\text{Zn(CN)}_4]^\text{2-}\)
   (4) Q is \(O_2\)

   Ans. (1, 3, 4)
Sol. $4\text{Au}(s) + 8\text{CN}^-(aq) + 2\text{H}_2\text{O}(aq) + \text{O}_2(g) \rightarrow 4[\text{Au(CN)}_2]^-(aq) + 4\text{OH}^-(aq)$ \hspace{1cm} (Q)

$2[\text{Au(CN)}_2]^-(aq) + \text{Zn}(s) \rightarrow [\text{Zn (CN)}_4]^2-(aq) + 2\text{Au}(s)$ \hspace{1cm} (R)

2. Which of the following reactions produce(s) propane as a major product?

1. $\text{CH}_3\text{CH}_2\text{CH}_2\text{COONa} + \text{H}_2\text{O} \xrightarrow{\text{electrolysis}} \text{n-hexane}$

2. $\text{CH}_3\text{CH}_2\text{CH}_2\text{COONa} \xrightarrow{\text{NaOH, CaO, } \Delta} \text{CH}_3\text{CH}_2\text{CH}_3$

3. $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl} + \text{Zn, dil. HCl} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_3$

4. $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br} + \text{Zn} \xrightarrow{\text{dehalogenation}} \text{CH}_3\text{CH}_2\text{CH}_3$

Ans. (2,3)

Sol. $\text{CH}_3 - \text{CH}_2 - \text{CH}_2\text{CO}_2\text{Na} + \text{H}_2\text{O} \xrightarrow{\text{electrolysis}} \text{n-hexane}$

$\text{CH}_3 - \text{CH}_2 - \text{CH}_2\text{CO}_2\text{Na} \xrightarrow{\text{NaOH + CaO, } \Delta} \text{CH}_3 - \text{CH}_2 - \text{CH}_3$

$\text{CH}_3 - \text{CH}_2 - \text{CH}_2\text{Cl} + \text{Zn} \rightarrow \text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{ZnCl} \xrightarrow{\text{dil. HCl}} \text{CH}_3\text{CH}_2\text{CH}_3$

3. The ground state energy of hydrogen atom is $-13.6$ eV. Consider an electronic state $\Psi$ of He$^+$ whose energy, azimuthal quantum number and magnetic quantum number are $-3.4$ eV, 2 and 0 respectively. Which of the following statement(s) is(are) true for the state $\Psi$?

1. It has 2 angular nodes
2. It has 3 radial nodes
3. It is a 4d state
4. The nuclear charge experienced by the electron in this state is less than 2e, where $e$ is the magnitude of the electronic charge.

Ans. (1,3)

Sol. 

$\# \ -3.4 \ = \ \frac{-13.6 \times 4}{n^2}$

$n = 4$

$\# \ \ell = 2$

$\# \ m = 0$

Angular nodes $= \ell = 2$

Radial nodes $= (n - \ell - 1) = 1$

$n \ \ell = 4d$ state
4. Choose the correct option(s) that give(s) an aromatic compound as the major product.

(1) \[
\text{苯} + \text{Cl}_2 (\text{excess}) \xrightarrow{\text{UV, } 500K} \text{(Non aromatic)}
\]

(2) \[
\text{H}_3\text{C} - \text{Br} \xrightarrow{i) \text{ alc. KOH, } ii) \text{NaNH}_2, \text{iii) red hot iron tube, } 873K} \text{CH}_3 - \text{C} \equiv \text{CH} \xrightarrow{\text{Red hot iron tube, } 873K} \text{(Aromatic)}
\]

(3) \[
\text{Br} \xrightarrow{\text{NaOEt}} \text{(Substitution product)} + \text{(Elimination product)} \xrightarrow{\text{Dimerise}} \text{(Non aromatic)}
\]

(4) \[
\text{NaOMe} \xrightarrow{} \text{Na}^+ + \text{MeOH} \text{(Aromatic ion)}
\]

Ans. (2, 4)

Sol. (1) \[
\text{苯} + \text{Cl}_2 (\text{excess}) \xrightarrow{\text{UV, } 500K} \text{(Non aromatic)}
\]

(2) \[
\text{H}_3\text{C} - \text{Br} \xrightarrow{i) \text{ alc. KOH, } ii) \text{NaNH}_2, \text{iii) red hot iron tube, } 873K} \text{CH}_3 - \text{C} \equiv \text{CH} \xrightarrow{\text{Red hot iron tube, } 873K} \text{(Aromatic)}
\]

(3) \[
\text{Br} \xrightarrow{\text{NaOEt}} \text{(Substitution product)} + \text{(Elimination product)} \xrightarrow{\text{Dimerise}} \text{(Non aromatic)}
\]

(4) \[
\text{NaOMe} \xrightarrow{} \text{Na}^+ + \text{MeOH} \text{(Aromatic ion)}
\]
5. Consider the following reactions (unbalanced)

\[
\text{Zn} + \text{hot conc. } \text{H}_2\text{SO}_4 \rightarrow \text{G} + \text{R} + \text{X}
\]

\[
\text{Zn} + \text{conc. } \text{NaOH} \rightarrow \text{T} + \text{Q}
\]

\[
\text{G} + \text{H}_2\text{S} + \text{NH}_4\text{OH} \rightarrow \text{Z} \text{ (a precipitate)} + \text{X} + \text{Y}
\]

Choose the correct option(s).

(1) The oxidation state of Zn in T is +1

(2) Bond order of Q is 1 in its ground state

(3) Z is dirty white in colour

(4) R is a V-shaped molecule

Ans. (2,3,4)

Sol. Zn + 2H\textsubscript{2}SO\textsubscript{4} \text (Hot and conc.) \rightarrow \text{ZnSO}_4 + \text{SO}_2 \uparrow + 2\text{H}_2\text{O} 

\text{(G)} \quad \text{(R)} \quad \text{(X)} 

Zn + 2\text{NaOH} \text{(conc.)} \rightarrow \text{Na}_2\text{ZnO}_2 + \text{H}_2 \uparrow 

\text{(T)} \quad \text{(Q)} 

\text{ZnSO}_4 + \text{H}_2\text{S} + 2\text{NH}_4\text{OH} \rightarrow \text{ZnS} \downarrow + 2\text{H}_2\text{O} + (\text{NH}_4)_2\text{SO}_4 

\text{(Z)} \quad \text{(X)} \quad \text{(Y)} 

6. With reference to \textit{aqua regia}, choose the correct option(s).

(1) Reaction of gold with \textit{aqua regia} produces NO\textsubscript{2} in the absence of air

(2) \textit{Aqua regia} is prepared by mixing conc. HCl and conc. HNO\textsubscript{3} in 3:1 (v/v) ratio

(3) Reaction of gold with \textit{aqua regia} produces an anion having Au in +3 oxidation state

(4) The yellow colour of \textit{aqua regia} is due to the presence of NOCl and Cl\textsubscript{2}

Ans. (2,3,4)

Sol. (1) Au + HNO\textsubscript{3} + 4HCl \rightarrow \text{AuCl}_4^\oplus + \text{H}_2\text{O}^+ + \text{NO} + \text{H}_2\text{O}

(2) \textit{Aqua regia} = 3\text{HCl}(conc.) + \text{HNO}_3(conc.)

(3) \text{AuCl}_4^\oplus is produced

(4) Yellow colour of \textit{aqua regia} is due to it's decomposition into NOCl(orange yellow) and Cl\textsubscript{2}(greenish yellow).
7. Choose the correct option(s) from the following

(1) Natural rubber is polyisoprene containing trans alkene units

(2) Nylon-6 has amide linkages

(3) Cellulose has only α-D-glucose units that are joined by glycosidic linkages

(4) Teflon prepared by heating tetrafluoroethene in presence of a persulphate catalyst at high pressure

Ans. (2,4)

Sol. 1. Natural rubber is polyisoprene containing cis alkene units

2. Nylon-6 has amide linkage

\[
\begin{align*}
&\text{HN} - (\text{CH}_2)_3 - \text{C}_n^\text{O} \\
&\text{O}
\end{align*}
\]

3. Cellulose has only β-D glucose units.

4. \( \text{F}_2\text{C} = \text{CF}_2 \xrightarrow{\text{Persulphate}} \{\text{CF}_2 - \text{CF}_2\}_n \)

8. Choose the correct option(s) for the following reaction sequence

Consider Q, R and S as major products

\[
\begin{align*}
\text{MeO} & \xrightarrow{\text{CHO}} \text{MeO} \\
\text{CHO} & \xrightarrow{\text{MeO}} \text{CHO} \\
\text{CHO} & \xrightarrow{\text{MeO}} \text{CHO}
\end{align*}
\]

(1) MeO

(2) MeO

(3) MeO

(4) MeO
Ans. (2,4)

Sol.  

SECTION-2 : (Maximum Marks: 18)

- This section contains SIX (06) questions. The answer to each question is a NUMERICAL VALUE.
- For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places, truncate/round-off the value to Two decimal places.
- Answer to each question will be evaluated according to the following marking scheme:
  - Full Marks : +3 If ONLY the correct numerical value is entered.
  - Zero Marks : 0 In all other cases.

1. The decomposition reaction $2\text{N}_2\text{O}_3(g) \rightarrow 2\text{N}_2\text{O}_4(g) + \text{O}_2(g)$ is started in a closed cylinder under isothermal isochoric condition at an initial pressure of 1 atm. After $Y \times 10^3$ s, the pressure inside the cylinder is found to be 1.45 atm. If the rate constant of the reaction is $5 \times 10^{-4}$ s$^{-1}$, assuming ideal gas behavior, the value of $Y$ is ___  

Ans. (2.30)
Sol. 

\[ 2N_2O_3(g) \overset{\Delta}{\longrightarrow} 2N_2O_4(g) + O_2(g) \] at constant V, T

\[
t = 0 \quad 1 \\
t = y \times 10^3 \text{ sec} \quad (1 - 2P) \quad 2P \quad P \\
P_{t} = (1 + P) = 1.45 \\
P = 0.45 \text{ atm}
\]

\[
(2K)t = 2.303 \log \left( \frac{1}{1-2P} \right)
\]

\[
(2 \times 5 \times 10^{-4}) \times y \times 10^3 = 2.303 \log \frac{1}{0.1}
\]

\[
y = 2.303 = 2.30
\]

2. Total number of isomers, considering both structural and stereoisomers, of cyclic ethers with the molecular formula C₄H₈O is ___

Ans. (10.00)

Sol.

\[
\begin{align*}
(1) & \quad \text{(R + S)} \\
(2) & \quad \text{O} \\
(3) & \quad \text{O} \\
(1) & \quad \text{(R + S)} \\
(2) & \quad \text{O} \\
(3) & \quad \text{O}
\end{align*}
\]

3. The amount of water produced (in g) in the oxidation of 1 mole of rhombic sulphur by conc. HNO₃ to a compound with the highest oxidation state of sulphur is ___

(Given data: Molar mass of water = 18 g mol⁻¹)

Ans. (288.00)

Sol. 

\[ S_8 + 48 \text{ HNO}_3 \rightarrow 8\text{H}_2\text{SO}_4 + 48\text{NO}_2 + 16\text{H}_2\text{O} \]

1 mole of rhombic sulphur produce 16 mole of H₂O i.e. 288 gm of H₂O
4. Total number of *cis* N–Mn–Cl bond angles (that is, Mn–N and Mn–Cl bonds in *cis* positions) present in a molecule of *cis*-[Mn(en)$_2$Cl$_2$] complex is ____ (*en* = NH$_2$CH$_2$CH$_2$NH$_2$)  

Ans. (6.00)

**Sol.**

Number of cis (Cl—Mn—N) = 6

5. Total number of hydroxyl groups present in a molecule of the major product P is ___

**Ans. (6.00)**

**Sol.**

total 6 –OH group present in a molecule of the major product.
6. The mole fraction of urea in an aqueous urea solution containing 900 g of water is 0.05. If the density of the solution is 1.2 g cm\(^{-3}\), the molarity of urea solution is ___.

(Given data: Molar masses of urea and water are 60 g mol\(^{-1}\) and 18 g mol\(^{-1}\), respectively)

**Ans. (2.98 or 2.99)**

**Sol.**

\[
X_{\text{urea}} = 0.05 = \frac{n}{n + 50}
\]

\[19n = 50\]

\[n = 2.6315\]

\[
V_{\text{sol}} = \frac{(2.6315 \times 60 + 900)}{1.2} = 881.5789 \text{ ml}
\]

\[
\text{Molarity} = \frac{2.6315 \times 1000}{881.5789} = 2.9849
\]

Molarity = 2.98 M

---

**SECTION–3 : (Maximum Marks : 12)**

- This section contains **TWO (02)** List-Match sets.
- Each List-Match set has **Two (02)** Multiple Choice Questions.
- Each List-Match set has two lists: **List-I** and **List-II**
- **List-I** has **Four** entries (I), (II), (III) and (IV) and **List-II** has **Six** entries (P), (Q), (R), (S), (T) and (U)
- **FOUR** options are given in each Multiple Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.
- Answer to each question will be evaluated according to the following marking scheme:
  - **Full Marks** : +3 If ONLY the option corresponding to the correct combination is chosen.
  - **Zero Marks** : 0 If none of the options is chosen (i.e., the question is unanswered);
  - **Negative Marks** : −1 In all other cases

1. **Answer the following by appropriately matching the lists based on the information given in the paragraph**

Consider the Bohr's model of a one-electron atom where the electron moves around the nucleus. In the following List-I contains some quantities for the \(n\)\(^{th}\) orbit of the atom and List-II contains options showing how they depend on \(n\).

<table>
<thead>
<tr>
<th>List-I</th>
<th>List-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>(I) Radius of the (n)(^{th}) orbit</td>
<td>(P) (\propto n^{-2})</td>
</tr>
<tr>
<td>(II) Angular momentum of the electron in the (n)(^{th}) orbit</td>
<td>(Q) (\propto n^{-1})</td>
</tr>
<tr>
<td>(III) Kinetic energy of the electron in the (n)(^{th}) orbit</td>
<td>(R) (\propto n^0)</td>
</tr>
<tr>
<td>(IV) Potential energy of the electron in the (n)(^{th}) orbit</td>
<td>(S) (\propto n^1)</td>
</tr>
<tr>
<td></td>
<td>(T) (\propto n^2)</td>
</tr>
<tr>
<td></td>
<td>(U) (\propto n^{1/2})</td>
</tr>
</tbody>
</table>

Which of the following options has the correct combination considering List-I and List-II?

(1) (II), (R)  (2) (I), (P)  (3) (I), (T)  (4) (II), (Q)

**Ans. (3)**
\[ r = 0.529 \times \frac{n^2}{z} \Rightarrow r \propto n^2 \Rightarrow (I) \ (T) \]

\[ mvr = \frac{nh}{2\pi} \Rightarrow (mvr) \propto n \Rightarrow (II) \ (S) \]

\[ KE = +13.6 \times \frac{z^2}{n^2} \Rightarrow KE \propto n^{-2} \Rightarrow (III) \ (P) \]

\[ PE = -2 \times 13.6 \times \frac{z^2}{n^2} \Rightarrow PE \propto n^{-2} \Rightarrow (IV) \ (P) \]

2. Answer the following by appropriately matching the lists based on the information given in the paragraph

Consider the Bohr's model of a one-electron atom where the electron moves around the nucleus. In the following List-I contains some quantities for the \( n^{th} \) orbit of the atom and List-II contains options showing how they depend on \( n \).

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</tr>
<tr>
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<td>(Q)</td>
</tr>
<tr>
<td>(III)</td>
<td>(R)</td>
</tr>
<tr>
<td>(IV)</td>
<td>(S)</td>
</tr>
</tbody>
</table>

Which of the following options has the correct combination considering List-I and List-II?

(1) (III), (S)  (2) (IV), (Q)  (3) (IV), (U)  (4) (III), (P)

Ans. (4)

Sol. Same as 1 (Section-3)
3. Answer the following by appropriately matching the lists based on the information given in the paragraph.

List-I includes starting materials and reagents of selected chemical reactions. List-II gives structures of compounds that may be formed as intermediate products and/or final products from the reactions of List-I.

<table>
<thead>
<tr>
<th>List-I</th>
<th>List-II</th>
</tr>
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<tbody>
<tr>
<td>(I)</td>
<td>(P)</td>
</tr>
<tr>
<td>(II)</td>
<td>(Q)</td>
</tr>
<tr>
<td>(III)</td>
<td>(R)</td>
</tr>
<tr>
<td>(IV)</td>
<td>(S)</td>
</tr>
<tr>
<td></td>
<td>(T)</td>
</tr>
</tbody>
</table>

Which of the following options has correct combination considering List-I and List-II?

(1) (III), (S), (R)  
(2) (IV), (Q), (R)  
(3) (III), (T), (U)  
(4) (IV), (Q), (U)  

Ans. (2)
3. **Sol.**

\[
\begin{align*}
\text{Cl} & \xrightarrow{\text{KCN}} \text{CN} \xrightarrow{\text{H}_2\text{O}^+, \Delta} \text{CO}_2\text{H} \\
\text{CH}_3 & \quad \text{CH}_3 \\
\end{align*}
\]

\[
\begin{align*}
\text{LiAlH}_4 & \xrightarrow{\text{Conc. H}_2\text{SO}_4} \text{OH} \\
\text{CH}_2 & \quad \text{OH} \\
\end{align*}
\]

**III, T, Q, R**

\[
\begin{align*}
\text{CO}_2\text{Me} & \xrightarrow{\text{LiAlH}_4, \text{Conc. H}_2\text{SO}_4} \text{OH} \\
\text{CH}_3 & \quad \text{CH}_2\text{OH} \\
\end{align*}
\]

**IV, Q, R**

4. **Answer the following by appropriately matching the lists based on the information given in the paragraph**

List-I includes starting materials and reagents of selected chemical reactions. List-II gives structures of compounds that may be formed as intermediate products and/or final products from the reactions of List-I.

<table>
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<tr>
<th><strong>List-I</strong></th>
<th><strong>List-II</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>(I) [ \text{CN} ] i) DlBAL-H ii) dil, HCl iii) \text{NaBH}_4 iv) conc. \text{H}_2\text{SO}_4</td>
<td>(P) [ \text{CHO} ]</td>
</tr>
<tr>
<td>(II) [ \text{CO}_2\text{H} ] i) O\text{}_3 ii) Zn, H\text{}_2\text{O} iii) \text{NaBH}_4 iv) conc. \text{H}_2\text{SO}_4</td>
<td>(Q) [ \text{OH} ]</td>
</tr>
<tr>
<td>(III) [ \text{Cl} ] CO\text{CH}_3 i) \text{KCN} ii) \text{H}_2\text{O}^+, \Delta iii) \text{LiAlH}_4 iv) conc. \text{H}_2\text{SO}_4</td>
<td>(R) [ \text{O} ]</td>
</tr>
</tbody>
</table>
Which of the following options has correct combination considering List-I and List-II?

(1) (I), (Q), (T), (U)  
(2) (II), (P), (S), (U)  
(3) (II), (P), (S), (T)  
(4) (I), (S), (Q), (R)

Ans. (2)

Sol.

I, Q, R

II, P, S, U