Question 2:

When iron metal reacts with water vapor, solid Fe₃O₄ and hydrogen gas are formed.

a-) Write a balanced chemical equation for this reaction.

\[ 3 \text{Fe (s)} + 4 \text{H}_2 \text{O (g)} \rightarrow \text{Fe}_3\text{O}_4 (s) + 4 \text{H}_2 (g) \]

b-) How many grams of iron must react with excess water vapor to prepare 464g of Fe₃O₄.

\[
\frac{\text{MFe}_3\text{O}_4}{\text{MFe}} = \left[ 3 \times 55.85 + 4 \times 1 \right] \frac{\text{g}}{\text{mol}} = \frac{231.55 \text{g}}{\text{mol}}
\]

\[
\frac{n_{\text{Fe}_3\text{O}_4}}{n_{\text{Fe}}} = \frac{464 \text{g}}{231.55 \text{g}} = \frac{2 \text{ mol}}{1 \text{ mol}}
\]

\[
3 \text{ mol Fe} \quad \rightarrow \quad 1 \text{ mol Fe}_3\text{O}_4
\]

?? \quad \rightarrow \quad 2 \text{ mol Fe}_3\text{O}_4

\[
6 \text{ mol Fe}
\]

Mass of Fe = 6 mol Fe \times \frac{55.85 \text{g}}{1 \text{ mol Fe}} = 335.1 \text{g}
Question 3:

When hydrogen peroxide decomposes, oxygen is produced:

\[ 2 \text{H}_2\text{O}_2(aq) \rightarrow 2 \text{H}_2\text{O}(l) + \text{O}_2(g) \]

What volume of oxygen gas at 25°C and 1.0 atm is produced from the decomposition of 50.00 ml of a solution of hydrogen peroxide (d = 1.05 g/ml) that is 30.0% \text{H}_2\text{O}_2 by mass.

Mass of \text{H}_2\text{O}_2 = 50 \text{ml} \times \frac{1.05 \text{g}}{1 \text{ml}} = 52.5 \text{g}

Mass of \text{H}_2\text{O}_2 = 52.5 \text{g} \times \frac{\text{H}_2\text{O}_2}{100 \text{g} \text{sdn.}} = 157.5 \text{g}

\text{M}_{\text{H}_2\text{O}_2} = 34.02 \text{g/mol}

\text{mol} \text{H}_2\text{O}_2 = 157.5 \text{g} \times \frac{1 \text{mol}}{34.02 \text{g}} = 4.63 \text{mol}

\text{mol} \text{O}_2 = 0.463 \text{mol} \text{H}_2\text{O}_2 \times \frac{1 \text{mol O}_2}{2 \text{mol H}_2\text{O}_2} = 0.23 \text{mol}

\text{V}_{\text{O}_2} = \frac{\text{mol} \text{O}_2 \times R \times T}{P} = \frac{0.23 \text{mol} \times 0.0821 \text{atm} \cdot \text{mol} \cdot \text{K}}{1 \text{atm}} \times 298 \text{K}

= 5.63 \text{L}
Question 4

a) Write the four quantum numbers for the outermost three electrons of phosphorus.

*Hint*: You have to write the electron configuration and orbital diagram first.

Electron Configuration: $^1P \, 1s^2 \, 2s^2 \, 2p^6 \, 3s^2 \, 3p^3$

Orbital Diagram:

$$\begin{array}{cccc}
1s & 2s & 2p & 3s \\
(\uparrow\uparrow) & (\downarrow\uparrow) & (\uparrow) & (\downarrow) \\
3p & (\uparrow) & (\uparrow) & (\downarrow) \\
(\uparrow) & (\downarrow) & (\uparrow) & (\downarrow)
\end{array}$$

Four Quantum Numbers:

<table>
<thead>
<tr>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
</tr>
</thead>
<tbody>
<tr>
<td>$n$</td>
<td>$l$</td>
<td>$m_l$</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>-1</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>+1/2</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>+1/2</td>
</tr>
</tbody>
</table>

b) Write the abbreviated electron configuration for Fe$^{3+}$ and Te$^{2-}$.

Fe$^{3+}$: [Ar] 3d$^6$

Fe: [Ar] 4s$^2$ 3d$^6$

Te$^{2-}$: [Kr] 5s$^2$ 4d$^{10}$ 5p$^6$

Te: [Kr] 5s$^2$ 4d$^{10}$ 5p$^4$
Question 5:

A certain sample of aluminum requires 42 Joules to raise its temperature from 0°C to 37°C. How many moles of aluminum are in the sample? (The specific heat of aluminum is 0.90 J/g.K)

\[ q = m_{Al} \cdot c_{Al} \cdot \Delta T \]

\[ 42 \text{ J} = m_{Al} \times 0.90 \frac{\text{J}}{\text{g.K}} \times 37 \text{ K} \]

\[ m_{Al} = \frac{1.26 \text{ g}}{2.98 \text{ g/mol}} = 0.042 \text{ mol} \]
Question 6:

An aqueous solution of potassium iodide has a density of 1.55g/ml and is 4.65M.

Calculate,

a) Its molality

\[ \text{Original Conc. } = 4.65 \text{ M} \]  ORIGINALLY START WITH 1L of

1L soln. \( n_{KI} = 4.65 \text{ mol} \)

Mass of solution = 1L soln. \[ \frac{1.55 \text{ g}}{1 \text{ mol}} = 1.55 \text{ kg} \]

\[ m_{KI} = 4.65 \text{ mol} \times 1.55 \text{ kg/mol} = 0.772 \text{ kg} \]

Mass of solvent = (1.55 - 0.772) \text{ kg} = 0.778 \text{ kg} \]

\[ m_{KI} = \frac{n_{KI}}{\text{kg solvent}} = 4.65 \text{ mol} = 5.98 \text{ molal} \]

b) Mass percent of solute

\[ \text{Mass Percent of } KI = \frac{\text{Mass of } KI \times 100}{\text{Total mass of soln.}} \]

\[ = \frac{772 \text{ g}}{1.55 \times 10^3 \text{ g}} \times 100 = 49.8 \% \]

c) Mole fraction of solute

\[ X_{KI} = \frac{n_{KI}}{n_T} \]

\[ n_{KI} = 4.65 \text{ mol} \]

\[ n_{H_2O} = \frac{778.9 \text{ g}}{18.02 \text{ g/mol}} = 43.17 \text{ mol} \]

\[ X_{KI} = \frac{4.65 \text{ mol}}{4.65 + 43.17} \]

\[ X_{KI} = 0.097 \]

\[ 4.65 \text{ mol} = 0.097 \]

\[ 47.82 \text{ mol} \]
Question 7:

Carbon disulfide $\text{CS}_2$, has a normal boiling point of 46.5°C and has a vapor pressure of 400 mmHg at 28°C.

Calculate,

a-) Its heat of vaporization $\Delta H_{\text{vap}}$

\[
\ln \frac{P_2}{P_1} = \frac{\Delta H_{\text{vap}} \times \Delta T}{R \times (T_2 - T_1)}
\]

\[
\ln \frac{760}{400} = \frac{\Delta H_{\text{vap}} (319.5 - 301) K}{8.314 \times 319.5 K \times 301 K}
\]

$\Delta H_{\text{vap}} = 27.75 \text{ kJ/mol}$

b-) Its vapor pressure at 40°C

\[
\ln \frac{P_2}{P_1} = \frac{27.75 \text{ kJ} \times 10^3 \text{ J/mol} \times 12 \text{ K}}{8.314 \text{ J/}K\text{mol} \times 301 \text{ K} \times 313 \text{ K}}
\]

\[
\ln \frac{P_2}{400} = 4 \times 0.425 \quad \frac{P_2}{400 \text{ mmHg}} = e^{0.425}
\]

$\frac{P_2}{400 \text{ mmHg}} = 1.529$

$P_2 = 611.8 \text{ mmHg}$
Question 8:

10g of calcium hydroxide Ca(OH)$_2$ is dissolved in enough water to make 1L of solution.

a-) Calculate the hydrogen ion concentration and the pH value of the solution.

\[
\text{H}^+ \text{Ca(OH)}_2 = \frac{n \text{Ca(OH)}_2}{\text{liter of soln}}.
\]

\[
\text{Ca(OH)}_2 = \frac{10.9}{\left[40 + 2(17)\right]} \text{g/mol} = 74 \text{g/mol}
\]

\[
\text{H}^+ \text{Ca(OH)}_2 = \frac{0.135 \text{mol}}{1 \text{L}} = 0.135 \text{ M}
\]

\[
\text{Ca(OH)}_2(s) \rightarrow \text{Ca}^{2+}(aq) + 2\text{OH}^-(aq)
\]

\[
0.135 \text{ M} \quad 0.135 \text{ M} \quad 0.27 \text{ M}
\]

b-) Is the solution acidic or basic?

\[
\text{[OH}^-] = 0.27 \text{ M} \quad \frac{[H^+]}{[OH^-]} = \frac{1.0 \times 10^{-14}}{0.27} = 3.7 \times 10^{-14} \text{ M}
\]

\[
\text{pH} = -\log[H^+] = -\log(3.7 \times 10^{-14}) = 13.43
\]

b) \( \text{pH} > 7 \) \( \therefore \) The solution is \textit{BASIC}. 