1. If 25.0 g of hydrogen sulphide reacts with 50.0 g of potassium permanganate to produce potassium sulphate, manganese (IV) oxide and hydrogen gas.

   a) Write the balanced chemical equation for this reaction.
   \[ \text{H}_2\text{S} + 2 \text{KMnO}_4 \rightarrow \text{K}_2\text{SO}_4 + 2\text{MnO}_2 + \text{H}_2 \]

   b) Determine which reactant is limiting and which is in excess.
   \[ \text{moles ratio} \]
   \[ \frac{25.0 \text{ g H}_2\text{S}}{34.1 \text{ g/mol} \times \text{L/mol}} = 0.733 \text{ mol} \]
   \[ \frac{50.0 \text{ g KMnO}_4}{158.0 \text{ g/mol} \times \text{L/mol}} = 0.316 \text{ mol} \]
   \[ \frac{0.733 \text{ mol H}_2\text{S}}{2 \text{ mol KMnO}_4} = 0.366 \text{ mol KMnO}_4 \]
   \[ \text{mole ratio} \]
   \[ \frac{0.316 \text{ mol KMnO}_4}{0.733 \text{ mol H}_2\text{S}} = \frac{1}{2} \]

   c) What mass of the excess reactant will be left over at the end of the reaction?
   \[ \text{mole excess} = 0.733 \text{ mol} - 0.316 \text{ mol} \]
   \[ \text{mass excess} = 0.733 \text{ mol} \times 34.1 \text{ g/mol} \times \frac{1}{2} \]
   \[ = 19.6 \text{ g} \]

   d) What mass of manganese (IV) oxide will be produced?
   \[ 0.316 \text{ mol KMnO}_4 \times \frac{2 \text{ mol MnO}_2}{2 \text{ mol KMnO}_4} = 0.316 \text{ mol MnO}_2 \]
   \[ = 27.5 \text{ g} \]

   e) If all the potassium sulphate produced were dissolved in 1.5 L of water what would be the concentration of the potassium sulphate solution?
   \[ 0.316 \text{ mol KMnO}_4 \times \frac{1 \text{ mol K}_2\text{SO}_4}{2 \text{ mol KMnO}_4} = 0.158 \text{ mol K}_2\text{SO}_4 \]
   \[ [\text{K}_2\text{SO}_4] = \frac{0.158 \text{ mol}}{1.5 \text{ L}} = 0.11 \text{ M} \]

2. If 9.25 g of zinc are reacted with 100 mL of 1.00 M HCl, then zinc chloride and hydrogen gas are formed.

   a) Write a balanced chemical equation for this reaction.
   \[ \text{Zn} + 2 \text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2 \]

   b) Show which reactant is in excess and which is the limiting factor.
   \[ 9.25 \text{ g Zn} \div 65.4 \text{ g/mol} = 0.141 \text{ mol Zn} \]
   \[ 0.100 \text{ L} \times 1.00 \text{ M HCl} = 0.100 \text{ mol HCl} \]
   \[ \text{mole ratio} \]
   \[ \frac{0.141 \text{ mol Zn}}{0.100 \text{ mol HCl}} = \frac{1}{2} \]

   c) Calculate the mass of zinc chloride that should be formed from the limiting factor.
   \[ 0.0500 \text{ mol ZnCl}_2 \times \frac{136.4 \text{ g/mol}}{2 \text{ mol ZnCl}_2} = 6.82 \text{ g} \]

   d) Calculate the volume of hydrogen gas that should be formed at STP.
   \[ 0.0500 \text{ mol H}_2 \times \frac{1 \text{ mol H}_2}{2 \text{ mol HCl}} = 0.0500 \text{ mol H}_2 \]
   \[ 0.0500 \text{ mol H}_2 \times \frac{22.44 \text{ L/mol}}{9.82 \text{ g/mol}} = 1.12 \text{ L} \]

   e) What volume of hydrogen gas would be formed if the percentage yield is 89%?
   \[ \frac{X \text{ L}}{1.12 \text{ L}} \times 100\% = 89\% \]
   \[ X = 0.997 \text{ L} \]
3. Gold dissolves in the acid mixture known as aqua regia according to the following reaction:

\[ \text{Au} + \text{HNO}_3 + 3 \text{HCl} \rightarrow \text{AuCl}_3 + \text{NO} + 2 \text{H}_2\text{O} \]

a) If you had 1.25 mg of gold, what volume of 18 M HNO₃ would you need to react with the gold, assuming excess HCl is available?

\[
\begin{align*}
1.25 \times 10^{-3} \text{ g Au} & \div 197.0 \text{ g/mol} \times 6.02 \times 10^{23} \text{ mol Au} \times \\
6.35 \times 10^{-6} \text{ mol Au} & \div 1 \text{ mol Au} = 6.35 \times 10^{-7} \text{ mol HNO}_3 \\
V & = \frac{n}{M} = \frac{6.35 \times 10^{-7} \text{ mol}}{18 \text{ M}} = 3.5 \times 10^{-7} \text{ L}
\end{align*}
\]

b) How many grams of gold (III) chloride would be produced?

\[
6.35 \times 10^{-6} \text{ mol Au} \times \frac{1 \text{ mol AuCl}_3}{1 \text{ mol Au}} = 6.35 \times 10^{-6} \text{ mol AuCl}_3 \\
6.35 \times 10^{-6} \text{ mol} \times 303.5 \text{ g/mol} = 1.93 \times 10^{-3} \text{ g AuCl}_3
\]

4. Phosphorus pentachloride decomposes to produce phosphorus trichloride and chlorine gas.

a) Write a balanced chemical equation for this reaction.

\[ \text{PCl}_5 \rightarrow \text{PCl}_3 + \text{Cl}_2 \]

b) If you react 18.5 grams of phosphorus pentachloride, what mass of phosphorus trichloride should be produced?

\[
18.5 \text{ g PCl}_5 \div 208.5 \text{ g/mol} = 0.0887 \text{ mol PCl}_5 \\
0.0887 \text{ mol PCl}_5 \times \frac{1 \text{ mol PCl}_3}{1 \text{ mol PCl}_5} = 0.0887 \text{ mol PCl}_3 \\
0.0887 \text{ mol PCl}_3 \times 137.5 \text{ g/mol} = 12.2 \text{ g PCl}_3
\]

5. Glucose, \( C_6H_{12}O_6 \), can be converted to ethanol, \( CH_3CH_2OH \), and \( CO_2 \) gas by fermentation.

a) Write a balanced chemical equation for the reaction.

\[
C_6H_{12}O_6 \rightarrow 2CH_3CH_2OH + 2CO_2
\]

b) If 1.00 kg of glucose was used, what would be the concentration of the ethanol if 20.0 L of ethanol was produced?

\[
1.00 \times 10^3 \text{ g glucose} \div 180 \text{ g/mol} = 5.56 \text{ mol glucose} \\
5.56 \text{ mol glucose} \times \frac{2 \text{ mol ethanol}}{1 \text{ mol glucose}} = 11.1 \text{ mol ethanol} \\
\text{[ethanol]} = \frac{11.1 \text{ mol}}{20.0 \text{ L}} = 0.556 \text{ M}
\]

6. When hydrogen is exposed to a flame, it combusts to form water.

a) Write a balanced chemical equation for this reaction.

\[
2 \text{H}_2 + \text{O}_2 \rightarrow 2 \text{H}_2\text{O}
\]

b) If you had 22.4 mL of hydrogen gas at STP, how many grams of water would be produced?

\[
22.4 \times 10^{-3} \text{ L} \div 22.4 \text{ L/mol} = 1.00 \times 10^{-3} \text{ mol H}_2 \\
1.00 \times 10^{-3} \text{ mol H}_2 \times \frac{2 \text{ mol H}_2\text{O}}{2 \text{ mol H}_2} = 1.00 \times 10^{-3} \text{ mol H}_2\text{O} \\
1.00 \times 10^{-3} \text{ mol} \times 18.0 \text{ g/mol} = 0.018 \text{ g H}_2\text{O}
\]