Limiting Reactant Challenges

1. **Reaction of Hydrogen and Oxygen to Form Water**

   - **Problem**: If 10 grams of hydrogen gas (H_2) react with 80 grams of oxygen gas (O_2), determine the limiting reagent and the amount of water (H_2O) produced.
   - **Solution**:
     - Moles of H_2 = 10 g / 2 g/mol = 5 moles
     - Moles of O_2 = 80 g / 32 g/mol = 2.5 moles
     - The balanced equation is $2H_2 + O_2 \rightarrow 2H_2O$
     - The mole ratio required is 2:1 (H_2). Therefore, H_2 is in excess, and O_2 is the limiting reagent.
     - Amount of H_2O produced = 2.5 moles of O_2 * 2 moles of H_2O / 1 mole of O_2 = 5 moles of H_2O
     - Mass of H_2O = 5 moles * 18 g/mol = 90 grams

2. **Combustion of Propane**

   - **Problem**: Determine the limiting reagent and the amount of CO_2 produced when 44 grams of propane (C_3H_8) combust with 160 grams of oxygen.
   - **Solution**:
     - Moles of C_3H_8 = 44 g / 44.1 g/mol = 1 mole
     - Moles of O_2 = 160 g / 32 g/mol = 5 moles
     - The balanced equation is $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$
     - The mole ratio required is 1:5 (C_3H_8). Therefore, O_2 is in excess, and C_3H_8 is the limiting reagent.
     - Amount of CO_2 produced = 1 mole of C_3H_8 * 3 moles of CO_2 / 1 mole of C_3H_8 = 3 moles of CO_2
     - Mass of CO_2 = 3 moles * 44 g/mol = 132 grams

3. **Synthesis of Ammonia**

   - **Problem**: Find the limiting reagent and the amount of NH_3 produced when 28 grams of nitrogen (N_2) react with 6 grams of hydrogen (H_2).
   - **Solution**:
     - Moles of N_2 = 28 g / 28 g/mol = 1 mole
     - Moles of H_2 = 6 g / 2 g/mol = 3 moles
     - The balanced equation is $N_2 + 3H_2 \rightarrow 2NH_3$
     - The mole ratio required is 1:3 (N_2). Therefore, N_2 is in excess, and H_2 is the limiting reagent.
     - Amount of NH_3 produced = 3 moles of H_2 * 2 moles of NH_3 / 3 moles of H_2 = 2 moles of NH_3
     - Mass of NH_3 = 2 moles * 17 g/mol = 34 grams

4. **Formation of Calcium Carbonate**

- **Problem**: If 40 grams of calcium oxide (CaO) react with 44 grams of carbon dioxide (CO_2), determine the limiting reagent and the amount of calcium carbonate ($CaCO_3$) formed.
- **Solution**:
  - Moles of CaO = 40 g / 56 g/mol = 0.714 moles
  - Moles of CO_2 = 44 g / 44 g/mol = 1 mole
  - The balanced equation is $CaO + CO_2 \rightarrow CaCO_3$
  - The mole ratio required is 1:1 (CaO
    $_2$). Therefore, CaO is the limiting reagent.
  - Amount of $CaCO_3$ produced = 0.714 moles of CaO * 1 mole of $CaCO_3$ / 1 mole of CaO = 0.714 moles of $CaCO_3$
  - Mass of $CaCO_3$ = 0.714 moles * 100 g/mol = 71.4 grams

5. **Decomposition of Potassium Chlorate**

- **Problem**: Determine the limiting reagent and the amount of KCl produced when 245 grams of potassium chlorate ($KClO_3$) decompose.
- **Solution**:
  - Moles of $KClO_3$ = 245 g / 122.5 g/mol = 2 moles
  - The balanced equation is $2KClO_3 \rightarrow 2KCl + 3O_2$
  - The mole ratio required is 2:2 ($KClO_3$
). Therefore, $KClO_3$ is the limiting reagent.
  - Amount of KCl produced = 2 moles of $KClO_3$ * 2 moles of KCl / 2 moles of $KClO_3$ = 2 moles of KCl
  - Mass of KCl = 2 moles * 74.5 g/mol = 149 grams

6. **Neutralization of Hydrochloric Acid with Sodium Hydroxide**

- **Problem**: If 50 grams of HCl react with 80 grams of NaOH, determine the limiting reagent and the amount of NaCl produced.
- **Solution**:
  - Moles of HCl = 50 g / 36.5 g/mol = 1.37 moles
  - Moles of NaOH = 80 g / 40 g/mol = 2 moles
  - The balanced equation is $HCl + NaOH \rightarrow NaCl + H_2O$
  - The mole ratio required is 1:1 (HCl
). Therefore, HCl is the limiting reagent.
  - Amount of NaCl produced = 1.37 moles of HCl * 1 mole of NaCl / 1 mole of HCl = 1.37 moles of NaCl
  - Mass of NaCl = 1.37 moles * 58.5 g/mol = 80.145 grams