Focus

- Identification and calculations with limiting reagent
- Calculation of how much of excess reactant remains after reaction
- Application of Stoichiometry
  - Determination of a compounds formula through combustion reaction
  - Determination of compounds in mixtures

Reactions Involving a LIMITING REACTANT

- In a given reaction, there is not enough of one reagent to use up the other reagent completely.
- The reagent in short supply LIMITS the quantity of product that can be formed.

LIMITING REACTANTS

Reactants: 2 NO(g) + O₂ (g) → 2 NO₂(g)
Limiting reactant = NO₂
Excess reactant = O₂
LIMITING REACTANTS

The amount (mass or mole) of the product formed depends on the amount of the Limiting reagent.

Problem
If 75g of O$_2$ is mixed with 75g of NH$_3$ to produce nitrogen oxide (NO) and water, determine which of the reagents is limiting and hence calculate the amount of NO produced in grams.

Ans:

Step 1
Write a balance equation for the reaction

$$4\text{NH}_3 (g) + 5\text{O}_2 (g) \rightarrow 4\text{NO} (g) + 6\text{H}_2\text{O} (g)$$

Step 2
Convert the masses of the reactants to moles

$$75\text{g} \times \frac{1\text{ mol NH}_3}{17.03\text{g}} = 4.40\text{ mol NH}_3$$

$$75\text{g} \times \frac{1\text{ mol O}_2}{32.00\text{g}} = 2.31\text{ mol O}_2$$
LIMITING REACTANTS

Step 3
Compare the stoichiometric ratio to calculated mole ratio of reactants to determine limiting reactant.

From the balanced equation:

$$4\text{NH}_3 (g) + 5\text{O}_2 (g) \rightarrow 4\text{NO} (g) + 6\text{H}_2\text{O} (g)$$

The stoichiometric ratio of the reactants is:

$$\text{stoichiometric factor} = \frac{4 \text{ mol NH}_3}{5 \text{ mol O}_2} = 0.8$$

If exp. mole ratio > stoic. ratio, the reactant in the numerator is in excess therefore, reactant in the denominator is the LIMITING REACTANT

If exp. mole ratio < stoic. ratio, the reactant in the denominator is in excess therefore, reactant in the numerator is the LIMITING REACTANT

ANS:
exp. mole ratio > stoic. Ratio, therefore NH$_3$ is in excess. O$_2$ is the limiting reactant

Step 5 (Optional)
Calculate the amount of product formed using the stoichiometric factor that relates the limiting reagent and the product

$$2.3 \text{ mol O}_2 \times \frac{4 \text{ mol NO}}{5 \text{ mol O}_2} \times \frac{30 \text{ g NO}}{1 \text{ mol NO}} = 55.2 \text{ g NO}$$
LIMITING REACTANTS

Calculating how much of the excess reactant remains after the reaction is complete?

How much of the excess reactant, NH₃, remained after the reaction?

Step 1: First find how much NH₃ was required

Step 2: Then find how much NH₃ is in excess.

Calculating Amount of Excess Reactant Remaining After a Reaction
Applications of Stoichiometry: Combustion Analysis of Hydrocarbons

If 0.115 g of a hydrocarbon with formula C<sub>x</sub>H<sub>y</sub> is reacted with excess oxygen to produce 0.379 g of CO<sub>2</sub> and 0.1035 g of H<sub>2</sub>O, what is the empirical formula of C<sub>x</sub>H<sub>y</sub>?

C<sub>x</sub>H<sub>y</sub> + some oxygen → 0.379 g CO<sub>2</sub> + 0.1035 g H<sub>2</sub>O

Step 1: First, recognize that all C in CO<sub>2</sub> and all H in H<sub>2</sub>O is from C<sub>x</sub>H<sub>y</sub>.
1. Calculate moles of C in CO<sub>2</sub>
2. Calculate moles of H in H<sub>2</sub>O
Applications of Stoichiometry: Combustion Analysis of Hydrocarbons

Step 2: Find mol ratio of H/C to find values of x and y in C\textsubscript{x}H\textsubscript{y}.

\[ C\textsubscript{x}H\textsubscript{y} + \text{some oxygen} \rightarrow 0.379 \text{ g CO}_2 + 0.1035 \text{ g H}_2\text{O} \]

Problem: Styrene, the building block of polystyrene, is a hydrocarbon, a compound consisting only of C and H. If 0.438g of styrene is burned in oxygen and produces 1.481g of CO\textsubscript{2} and 0.303g of H\textsubscript{2}O, what is the empirical formula of styrene?
Applications of Stoichiometry: Combustion Analysis of Hydrocarbons

Applications of Stoichiometry: Analysis of Mixtures

Problem:
At higher temperatures NaHCO₃ is converted quantitatively to Na₂CO₃

2 NaHCO₃(s) → Na₂CO₃(s) + CO₂(g) + H₂O(g)

Heating a 0.7184g sample of impure NaHCO₃ gives 0.4724g of Na₂CO₃. What was the mass percent of NaHCO₃ in the original 0.7184g sample?
Applications of Stoichiometry:
Analysis of Mixtures