

Basic Chemistry Concepts



Lecture Notes on Stoichiometric Calculations and Related Concepts

Stoichiometric Calculations

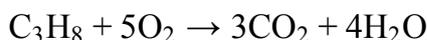
Definition: Stoichiometry is the calculation of reactants and products in chemical reactions. It is based on the balanced chemical equation and the conservation of mass.

Key Steps in Stoichiometric Calculations:

1. Write and Balance the Chemical Equation:

- Ensure the number of atoms of each element is the same on both sides of the equation.

Example:



2. Convert Masses to Moles:

- Use molar masses of reactants to convert given masses to moles.

3. Use Mole Ratios:

- Use the coefficients from the balanced equation to set up mole ratios.

4. Calculate Moles of Desired Substance:

- Use mole ratios to calculate the moles of the product or another reactant.

5. Convert Moles Back to Mass:

- Convert the moles of the desired substance back to grams if needed.

Limiting Reactant

Definition: The limiting reactant (or limiting reagent) is the reactant that is completely consumed in a reaction, determining the maximum amount of product that can be formed.

Steps to Identify the Limiting Reactant:

1. Calculate the Moles of Each Reactant:

- Convert the given masses of reactants to moles.

2. Use Stoichiometry to Find Required Moles:

- Determine the mole ratio from the balanced equation.

3. Compare the Calculated Moles:

- The reactant that produces the least amount of product is the limiting reactant.

Example:

For the reaction: $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$

- If 5 moles of N_2 and 12 moles of H_2 are available:
 - 5 moles N_2 requires $5 \times 3 = 15$ moles of H_2 .
 - Only 12 moles H_2 are available, so H_2 is the limiting reactant.

Yield of Reaction**Theoretical Yield:**

- **Definition:** The maximum amount of product that can be produced from a given amount of reactants, calculated using stoichiometry.
- **Calculation:** Based on the limiting reactant.

Actual Yield:

- **Definition:** The amount of product actually obtained from a reaction.
- **Measurement:** Determined experimentally.

Percent Yield:

- **Definition:** The ratio of the actual yield to the theoretical yield, expressed as a percentage.
- **Formula:**

$$\text{Percent Yield} = \left(\frac{\text{Actual Yield}}{\text{Theoretical Yield}} \right) \times 100$$

Example:

If the theoretical yield of a reaction is 10 grams and the actual yield is 8 grams:

$$\text{Percent Yield} = \left(\frac{8 \text{ g}}{10 \text{ g}} \right) \times 100 = 80\%$$

Example Problem

Given the reaction: $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$

1. Calculate the theoretical yield of water when 4 grams of H_2 react with 16 grams of O_2 :

- Molar mass of $\text{H}_2 = 2 \text{ g/mol}$
- Moles of $\text{H}_2 = \frac{4 \text{ g}}{2 \text{ g/mol}} = 2 \text{ moles}$
- Molar mass of $\text{O}_2 = 32 \text{ g/mol}$
- Moles of $\text{O}_2 = \frac{16 \text{ g}}{32 \text{ g/mol}} = 0.5 \text{ moles}$
- Reaction ratio: 2 mol H_2 : 1 mol O_2

O_2 is the limiting reactant

- Theoretical yield of H_2O : 2 moles $\text{O}_2 \rightarrow 2 \times 2 = 4 \text{ moles H}_2\text{O}$

- Mass of H₂O: $4 \times 18 \text{ g/mol} = 72 \text{ g}$

2. Determine the actual yield and percent yield if 68 grams of H₂O were produced:

- Actual yield = 68 grams
- Theoretical yield = 72 grams
- Percent yield:

$$\text{Percent Yield} = \left(\frac{68}{72}\right) \times 100 \approx 94.44\%$$

Summary

- **Stoichiometric Calculations:** Convert between masses and moles using balanced equations.
- **Limiting Reactant:** Determines the maximum product formed.
- **Theoretical Yield:** Maximum calculated product.
- **Actual Yield:** Measured product.
- **Percent Yield:** Efficiency of a reaction, comparing actual to theoretical yields.

These notes provide a comprehensive understanding of stoichiometry, limiting reactants, and reaction yields, essential for mastering chemical reaction calculations.