Al-Mustaqbal University
Department of Techniques of Fuel and Energy Engineering
First stage
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Stoichiometric of chemical analysis

What is Stoichiometric analysis

Stoichiometric analysis is a method used in chemistry to determine the quantitative relationship between reactants and products in chemical reactions. It relies on the concept of stoichiometry, which is the calculation of the amounts of substances involved in chemical reactions based on their relationships defined by balanced chemical equations.

Key Concepts of Stoichiometric Analysis:

1. **Balanced Chemical Equation**: Stoichiometric analysis starts with a balanced chemical equation. A balanced equation ensures that the number of atoms for each element is the same on both sides of the equation, reflecting the law of conservation of mass.
2. **Mole Ratios**: The coefficients in a balanced chemical equation represent the mole ratios between the reactants and products. These ratios are used to convert between moles of different substances involved in the reaction.
3. **Conversion of Units**: Stoichiometric analysis often involves converting between different units such as mass, volume, and moles. This is done using the molar mass of substances, the ideal gas law for gases, or Avogadro's number for molecules.
4. **Limiting Reactant**: Stoichiometric analysis is especially useful for identifying the **limiting reactant**—the reactant that will be completely

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consumed first, determining the maximum amount of product that can be formed.

5. **Theoretical and Actual Yield**: Stoichiometric calculations can also be used to find the **theoretical yield**, which is the maximum amount of product expected from a reaction. This can then be compared to the **actual yield**, the amount of product obtained experimentally, to calculate the **percent yield**.

Steps Involved in Stoichiometric Analysis:

1. **Write the Balanced Chemical Equation**:
   The first step is to write a balanced chemical equation for the reaction. The coefficients in the balanced equation are the mole ratios that will be used in calculations.
2. **Convert Given Quantities to Moles**:
   Convert the given quantities (whether in grams, liters, or molecules) to moles. Use the molar mass for solids and liquids or the ideal gas law (at STP) for gases.
3. **Use Mole Ratios**:
   Use the mole ratios from the balanced equation to convert from moles of one substance to moles of another. The mole ratio is derived from the coefficients in the balanced chemical equation.
4. **Convert Moles to Desired Units**:
   Convert the moles of the desired substance to the required unit (grams, liters,

molecules, etc.). For example, if you need the mass of a product, multiply the number of moles of the product by its molar mass.

Types of Stoichiometric Calculations:

1. **Mole-to-Mole Calculation**:
   This involves converting moles of one substance to moles of another, using the mole ratio from the balanced equation.

   Example:
   In the reaction:

$$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O$$

   If you have 2 moles of H_2, the mole ratio shows that it will produce 2 moles of H_2O.

2. **Mass-to-Mass Calculation**:
   This involves converting the mass of one substance to moles, using its mola mass, then using the mole ratio from the balanced equation, and finally converting back to mass.

   Example:
   In the reaction:

$$2Na + Cl_2 \rightarrow 2NaCl$$

To determine how many grams of sodium chloride (NaCl) will be produced from 10 grams of sodium (Na), follow these steps:

- Convert sodium (Na) from grams to moles.
- Use the mole ratio to find the moles of NaCl.
- Convert moles of NaCl to grams.

3. **Volume-to-Volume Calculation (for Gases)**:
   When dealing with gases at Standard Temperature and Pressure (STP), you can use the mole ratio from the balanced equation to convert volumes.

Example:
In the reaction:

$$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O$$

If you have 5 liters of hydrogen gas (H_2) at STP, you can use the mole ratio to find how many liters of oxygen (O_2) are needed.

4. **Limiting Reactant Calculation**:
   Stoichiometry is essential in determining the **limiting reactant**, which is the substance that runs out first and limits the amount of product that can be formed.

Example:

In a reaction:

$$4Fe + 3O_2 \rightarrow 2Fe2Fe_2O_3$$

If you have 5 moles of iron and 3 moles of oxygen, you use stoichiometry to determine which reactant is limiting.

5. **Percent Yield Calculation**:

   Stoichiometry helps calculate the **theoretical yield** of a reaction (how much product is expected to be produced), which can be compared to the **actual yield** (the amount of product actually obtained) to find the percent yield.

Formula for Percent Yield:

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

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