1 Stoichiometry

1.1 Stoichiometry

Stoichiometry is the measurement and calculation of the amounts of reactants and products in chemical reactions.

Balanced chemical equations represent the relationship between the number of moles of reactants and the number of moles of products.

Mole ratio is the conversion factor for any two reactants or products in a chemical reaction.

Mole to Mole Problems

- 1. Write the balanced equation
- 2. Write the strategy (molar road map)
- 3. Set up the correct calculation

Stoichiometry Road Map - Grams of A \leftrightarrow Moles of A \leftrightarrow moles of B \leftrightarrow grams of B

Exercise - Iron reacts with carbon dioxide to form iron(III) oxide and carbon monoxide. How many moles of carbon dioxide are needed to produce 2.2 moles of iron(III) oxide? (6.6 mol CO_2)

Exercise - How many grams of magnesium chloride are produced when 0.500 moles of magnesium reacts with an excess of hydrochloric acid? (47.6 g $MgCl_2$)

Exercise - How many moles of zinc sulfate are produced when 4.55 g of zinc reacts with an excess of sulfuric acid? ($0.0696 \text{ mol } ZnSO_4$)

Exercise - Calcium carbonate reacts with phosphoric acid to produce calcium phosphate, carbon dioxide, and water. Calculate the number of grams of CO_2 formed when 0.47 g of water is produced. (1.1 g CO_2)

1.2 Percent Yield, Limiting Reactant, & Gas and Solution Stoichiometry

- Stoichiometric calculations are based on ideal reactions.
- Many reactions do not go to completion and not as much product is produced as expected.

There are two different yields:

Theoretical Yield: what stoichiometry predicts.

Actual Yield: What is actually produced and measured in the lab.

Percent Yield:

% yield =
$$\frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

Exercise - What is the percent yield for the reaction

$$Cl_2 + 2KBr \rightarrow 2KCl + Br_2$$

in which 214 g of chlorine react with an excess of potassium bromide to produce 412 g of bromine? (85.4%) The limiting reactant is the chemical that is used up first in a chemical reaction. It limits the amount of product that can be made.

The other reactant(s) is/are called the excess reactant(s).

If you are given the amounts of both reactants and asked to predict the amounts of products, you must base your answer on the limiting reactant.

Exercise - The balanced equation for the reaction between 50.0 g of silicon dioxide and 50.0 g of carbon is

$$SiO_2 + 3C \rightarrow SiC + 2CO$$

Assuming the reaction is 100% efficient, what is the excess reactant and how much in excess is it? (Carbon, 20.0 g)

We can also involve gases in stoichiometry:

- Liters are used for a gas as STP
- STP means "standard temperature and pressure", which we'll define as 0°C and 1 atm
- Use 22.4 L/mol. This applies to ANY GAS AT STP.

Exercise - How many liters of 3.4 M copper(II) sulfate are needed to react fully with 2.00 grams of zinc? (0.0090 L CuSO₄)

Exercise - How many atoms of oxygen are there in a 3.0 mole sample of Mg(ClO₃)₂? $(1.1 \times 10^{25} \text{ atoms})$