Chapter 5: Calculations and the Chemical Equation

- 5.1 The Mole Concept and Atoms
  - **The Mole and Avogadro's Number**
    - atomic mass unit (amu) - unit of measure for the mass of atoms.
      - carbon-12 assigned the mass of exactly 12 amu
      - 1 amu = 1.66×10^{-24} g
      - periodic table gives atomic weights in amu.
    - Chemists usually work with much larger quantities.
      - It is more convenient to work with grams than amu.
    - To make the connection we must define the **mole**.
    - The mole is abbreviated mol.
    - Avogadro's number = 1 mol of atoms = 6.022×10^{23} atoms of an element
    - A mole is simply a unit that defines an amount of something
      - Just as a dozen defines 12
      - Just as a gross defines 144
    - **Molar mass** - The mass in grams of 1 mole of atoms.
    - What is the molar mass of carbon? 12.01 g/mol
    - This means if you counted out a mole of Carbon atoms (i.e, 6.022×10^{23} of them) they would have a mass of 12.01 g.
    - The average mass of **one atom** of an element in **amu** is numerically equivalent to the mass of **one mole** of an element expressed in **grams**.
      - That is, 1 atom F is 19.00 amu and 1 mole of F is 19.00 g. Or,
      - 19.00 amu/atom F and 19.00 g/mole F
- 5.2 Compounds
  - The Chemical Formula
    - **Chemical Formula** - a combination of symbols of the various elements that make up the compound.
    - **Formula unit** - the smallest collection of atoms that provide two important pieces of information
      - the identity of the atoms and
      - the relative number of each type of atom
    - Let's look closely at the following formulas:
    - H_2O, NaCl, $Fe(CN)_3$, $(NH4)_3PO_4$, $CuSO_4.5H_2O$
      - This is an example of a **hydrate** - compounds containing one or more water molecules as an integral part of their structure.
- 5.3 The Mole Concept Applied to Compounds
  - **Formula weight** - the sum of the atomic weights of all atoms in the compound, as represented by its formula.
    - expressed in amu
  - Molar mass applies to compounds also.
  - **What is the formula weight of H_2O?**
    - 16.00 amu + 2(1.008 amu) = 18.02 amu
  - **What is the molar mass of H_2O?**

        - 18.02 g/mol H_2O
    - When calculating the formula weight (or molar mass of an ionic compound, use the smallest unit of the crystal)
- 5.4 The Chemical Equation and the Information It Conveys
    - A Recipe For Chemical Change
    - **Chemical Equation** - shorthand notation of a chemical reaction.
    - **Reactants** - (starting materials) - the substances that undergo change in the reaction.
    - **Products** - substances produced by the reaction.
    - **Law of Conservation of Mass** - matter cannot be either gained or lost in the process of a chemical reaction.
        - The total mass of products must equal the total mass of the reactants.
    - We know that a chemical equation represents a chemical change. The following is evidence for a reaction:
        - Release of a gas.
            - CO_2 is released when acid is placed in a solution containing CO_3^{2-} ions.
            - H_2 is released when Na is placed in water.
        - Formation of a solid (precipitate.)
            - A solution containing Ag^+ ions is mixed with a solution containing Cl^- ions.
        - Heat is produced or absorbed (temperature changes)
            - Acid and base are mixed together
        - The color changes
        - Light is absorbed or emitted
        - Changes in the way the substances behave in an electrical or magnetic field
        - Changes in electrical properties.
- 5.5 Balancing Chemical Equations
    - Consider the following reaction:
        - **hydrogen reacts with oxygen to produce water**
    - Write the above reaction as a chemical equation.
    - You probably wrote the following:
        - $H_2 + O_2 \rightarrow H_2O$
    - Don't forget the diatomic elements.
    - Is the law of conservation of mass obeyed as written? NO!
    - Balancing chemical equations uses **coefficients** to ensure that the law of conservation of mass is obeyed.
    - You may not change subscripts!
    - WRONG: $H_2 + O_2 \rightarrow H_2O_2$
- 5.6 Calculations Using the Chemical Equation
    - We will learn in this section to calculate quantities of reactants and products in a chemical reaction.
    - Need a **balanced** chemical equation for the reaction of interest.
    - Keep in mind that the **coefficients** represent the number of **moles** of each substance in the equation.

- **Theoretical and Percent Yield**
  - **Theoretical yield** - the maximum amount of product that can be produced
    - Pencil and paper yield
  - **Actual yield** - the amount produced when the reaction is performed
    - Laboratory yield
  - **Percent yield**: actual yield divided by theoretical yield X 100