Chapter 2: The Composition and Structure of the Atom

- 2.1 Matter and Structure
  - Understanding the structure of the atom will help to understand the properties of the elements.
  - Keep in mind that these, as all theories, are subject to constant refinement. The picture of the atom isn't final.
- 2.2 Composition of the Atom
  - **Atom** – the basic structural unit of an element.
    - The smallest unit of an element that retains the chemical properties of that element.
  - **Radioactive Decay** – certain kinds of atoms can "split" into smaller particles and release large amounts of energy.
  - Atoms consist of three **primary** particles.
    - Electrons
    - Protons
    - Neutrons
  - **Nucleus** – small, dense, positively charged region in the center of the atom. Contains:
    - Protons – positively charged particles
    - Neutrons – uncharged particles
  - Surrounding the nucleus is a diffuse region of negative charge populated by:
    - Electrons – negatively charged particles
  - **Atomic Number** – the number of protons in an atom
  - **Mass Number** – sum of the number of protons and neutrons
  - **Isotopes** – atoms of the same element having different masses.
    - Contain same number of protons
    - Contain different numbers of neutrons
    - Isotopes of the same element have identical chemical properties
    - Some isotopes are radioactive
  - **Atomic Mass** – the weighted average of the masses of the isotopes that make up an element.
  - The **weighted average** is an average corrected by the relative amounts of each isotope present in nature.
    - Chlorine consists of chlorine-35 and chlorine-37 in a 3:1 ratio.
    - Calculate the atomic mass of naturally occurring chlorine if 75.77% of chlorine atoms are chlorine-35 and 24.23% of chlorine atoms are chlorine-37.

      Step 1: Convert the percentage to a decimal fraction

      Step 2: Multiply the decimal fraction by the mass of that isotope to obtain the isotope contribution to the atomic mass.

      Step 3: Sum to get the weighted average atomic mass of chlorine.

- 2.2 Composition of the Atom
  - **Ion** – electrically charged particles that result from the gain or loss of one or more electrons by the parent atom.
  - **Cation** – positively charged.
    - Results from the loss of electrons
  - **Anion** – negatively charged.
    - Results from the gain of electrons
- 2.3 Development of the Atomic Theory
  - **Dalton's Atomic Theory** – the first experimentally based theory of atomic structure of the atom.
    - John Dalton
    - Early 1800's
  - Much of Dalton's Theory is still regarded as correct today. (See starred items
  - <u>Postulates of Dalton's Atomic Theory</u>
    - All matter consists of tiny particles called atoms.*
    - An atom cannot be created, divided, destroyed, or converted to any other type of atom.
    - Atoms of a particular element have identical properties.
    - Atoms of different elements have different properties.*
    - Atoms of different elements combine in simple whole-number ratios to produce compounds (stable aggregates of atoms).*
    - Chemical change involves joining, separating, or rearranging atoms.*
- **Subatomic Particles: Electrons, Protons, and Neutrons**
  - Electrons were the first subatomic particles to be discovered using the cathode ray tube.
  - Protons were the next particle to be discovered.
    - Protons have the same size charge but opposite in sign.
    - Proton is 1837 times as heavy as an electron.
  - Neutrons
    - Postulated to exist in 1920's but not demonstrated to exist until 1932.
    - Almost the same mass as the proton.
- **The Nucleus**
  - The initial ideas of the atom did not have a "nucleus"
  - "Plum Pudding Model"
  - Earnest Rutherford's "Gold Foil Experiment" led to the understanding of the nucleus.
  - Most of the atom is empty space.
  - Most of the mass is located in a small, dense region.
- 2.4 The Relationship between Light and Atomic Structure
  - Spectroscopy – absorption or emission of light by atoms.
    - Used to understand the electronic structure.
  - To understand the electronic structure, we must first understand light and **electromagnetic radiation**.
  - **Emission spectrum** – light emitted when a substance is excited by an energy source.

        - The emission-spectrum of hydrogen leads to the modern understanding of the electronic structure of the atom.
- 2.5 The Bohr Atom
    - Initial understanding of the atom by Niels Bohr
    - Electrons exist in fixed energy levels surrounding the nucleus. The quantization of energy.
    - Promotion of an electron occurs as it absorbs energy. The excited state.
    - Energy is released as the electron travels back to lower levels. Relaxation.
    - **Orbit** – what Bohr called the fixed energy levels.
    - **Ground state** – the lowest possible energy state an electron can occupy.
    - The orbits are also identified using "quantum numbers": 1, 2, 3, …
    - When the electron relaxes (c) the energy released is observed as a single wavelength of light.
- 2.6 Modern Atomic Theory
    - Bohr's model of the atom when applied to atoms with more than one electron failed to explain their line spectra.
    - One major change from Bohr's model is that electrons do <u>not</u> move in orbits.
    - **Atomic orbitals** – regions in space with a high probability of finding an electron.
    - Electrons move rapidly within the orbital giving a high electron density in that region.