Chapter #2: Atoms and Elements

2.1 Imaging and Moving Individual Atoms

- Atom is the smallest unit of an element.
- Gerd Binning and Heinrich Rohrer developed a scanning tunneling microscope (STM) to see atoms.
- Microscope work by having an electrode scan over the surface of the matter and measuring the tunneling current between the electrode and surface.
    - Tunneling current is sensitive to distance so it moves up and down to accommodate individual atoms. (Moves up as it goes over atom and moves down when it goes over gap between atoms)
    - Measure the up and down movement to see individual atoms.
- Later STM was also able to pick up and move atoms.

2.2 Early Ideas of Atoms and Matter

- Leucippus and Democritus proposed that matter was composed of small indivisible particles called atoms
- Atoms exist in different shape and size.
- John Dalton latter revisited this theory to offer evidence.

2.3 Atomic Theories

The Law of Conservation of Mass

- Matter is not created or destroyed in chemical reactions.
    - Mass of substances in reaction do not change.
- Particles rearrange in reaction but amount is conserved because atoms are indestructible.

The Law of Definite Proportions

- Same compounds have the same proportions of constituent elements.
    - Same ratio between elements for same compound.
- Compounds have definite proportion because atoms occur in a definite ratio.

The Law of Multiple Proportions

- Two elements can combine to form more than one type of compound.

Dalton and the *Atomic Theory*

1. An element is composed of tiny indivisible particles called atoms.
2. All atoms of the same element has the same properties.
3. Atoms combine in ratios to form compounds.
4. Atoms of one element cannot change to atom of another. For chemical reactions, atoms change the way they are bound together.

2.4 Discovery of Electron

Cathode Rays

- Electrical charge of atoms result in electrostatic forces between them.
- Area around atom where electrostatic force exist is called an electric field.
- J.J Thompson discovered electrons through cathode ray experiments where he found that a particle that originate from the cathode carries an negative charge.

- He applied electrical voltage to anode and cathode and found cathode rays travel from cathode to anode.

Millikan's Oil Drop Experiment

- Millikan found the charge of a single electron through the oil drop experiment.
    - He used an atomizer to make the oil into fine droplets and allow it to fall and acquire electrons. Ionizing radiation bombard the chamber to produce electrons. Then he creates an electrical field with metal plates and measures the strength of the field to determine the negative charge of the droplet. Then assuming the charge of each drop is whole-number multiple of the electron's charge, a single electron charge is determined.
- Each electron has a charge of -1.60*10^-19.

2.5 Structure of the Atom

- Since atoms are neutral and there are negative charges within them, there must be positive charges that neutralize the negative charge.
    - J.J Thomson proposed that there are negative electrons distributed in a positive background. (plum pudding model)
- Rutherford performed the gold foil experiment which discovered the nucleus of atoms.
    - If the atom was like J.J Thomson's model then the alpha particles that is beamed through the gold foil will pass straight through with minimum deflection.
    - Some particles deflected greatly and some bounced straight back in the experiment.
- Rutherford's nuclear theory included:

1. Most of an atom's mass and positive charge is in the nucleus.
2. Most of atom's volume is empty space and in the space is tiny negative electrons.
3. There is an equal amount of positive and negative particles that neutralize the atom.

- Chadwick introduced neutrons to explain the extra mass to an atom.
- Nucleus of atom contains most of the mass.

2.6 Subatomic Particles

- Masses of element is expressed in atomic mass unit (amu).
    - The mass of one proton or one neutron is 1 amu.
- Electrons have a charge of -1 and protons are +1.
- If there are imbalances in charge, it will try to neutralize quickly.

Differentiation Between Elements

- The element is defined by the number of protons it contains.
    - Number of protons is also the atomic number.

Isotopes

- All element have the same number of protons but may have different number of neutrons.
- Percentages of the relative amount of different isotopes that occur naturally in a sample is called natural abundance.
- Mass of an element is the sum of protons and neutrons.

Ions

- Atoms lose or gain electrons to become ions.

- If atom gains an electron it becomes negatively charged, if it loses an electron, it becomes positively charged.
    - Positive ions are cations and negative ions are anions.

2.7 The Periodic Law

- Periodic law is when elements are arranged in increasing mass, certain sets of properties recur periodically.
- Metals are on left side and middle, non-metal on right side, and metalloid dividing the two.
    - Metalloids exhibit mixed properties. (semi-conductor)
- Transition metal's properties are hard to predict based on position in periodic table.
- Alkali metals (Group 1) are highly reactive metals.
- Alkaline earth metals (Group 2) is very reactive but not as reactive as alkali metals.
- Halogens (Group 7) are highly reactive nonmetals.
- Nobel gases (Group 8) are mainly unreactive.

Ions in Periodic Table

- Metals tend to gain electrons while nonmetals tend to lose electrons.
- Group 1 lose one electron to form +1.
- Group 2 lose two electrons to form +2.
- Group 6 gain 2 electrons to form -2.
- Group 7 gain 1 electron to form -1.

2.8 Atomic Mass

- Atomic mass is the average mass for the element from all isotopes.
- There may be more of a certain isotope than others.
- Use calculation:

$$\sum \text{(percentage of isotope)} * \text{(mass of isotope)}$$

Mass Spectrometry

- Measures mass of atoms and the percent abundances.
- Atoms are first vaporized and injected into the instrument.
- Then it is ionized by bombarding the sample with electrons to create positive ions.
- Ions are accelerated with electric field into a magnetic field.
- The amount of deflection by the magnetic field is based on their mass.
- It is then detected by a detector and the signal is recorded.
- It can be used to identify unknown molecules in a sample.

2.9 Molar Mass

Mole

- A unit to keep counting atoms more manageable.
    - 1 mole = 6.022*10^23 (Avogadro's Number)
- Mass of 1 mole of atoms is the molar mass.
    - Molar mass = Atomic mass