Fundamentals of Atomic Structure

Fundamental Chemical Laws

- Law of Conservation of Mass-mass is neither created or destroyed (Lavoisier)
- Law of Definite Proportions-a given compound always contains exactly the same proportion of elements by mass (Proust)
- Law of Multiple Proportions-when two elements from a series of compounds, the ratios of the masses of the second element that combine with 1 gram of the first element can always be reduced to small whole numbers (Dalton)

(See sample exercise 2.1 on page 42)

Dalton's Atomic Theory

- Each element is made up of tiny particles called atoms.
- The atoms of a given element are identical; the atoms of different elements are different in some fundamental way.
- Chemical compounds are formed when atoms of different elements combine with each other. A given compound always has the same relative numbers and types of atoms.
- Chemical reactions involve reorganization of the atoms-changes in the way they are bound together. The atoms themselves are not changed in a chemical reaction.

Subatomic Particles

- The electron was discovered by J.J. Thomson through his study of the cathode-ray tube.
- His studies also resulted in the determination of the charge-to-mass ratio of an electron.
- $e/m = -1.76 \times 10^{8}$ C/g
- A new atomic model was developed called the plum pudding model.
- In 1909, Robert Millikan performed an experiment using charged oil drops which allowed him to determine the magnitude of the electron's charge (1.60×10^{-19} C).
- This led directly to the determination of the mass of an electron (9.11×10^{-31} kg).

The Nuclear Atom

- Rutherford's Gold Foil experiment resulted in the determination that the atom is mostly empty space with a small, dense, positively charged center (nucleus).
- The electrons move around the nucleus at a distance that is large relative to the nuclear radius.
- This model of the atom is also referred to as the planetary model.

Discovery of the Proton and Neutron

- A positively charged particle equal in magnitude to the electron was discovered by Goldstein. This particle is 1837 times larger in mass than the electron (1.67×10^{-27} kg) and is called a proton.
- Chadwick, in 1932, discovered the existence of a particle having no charge and almost equal in mass to the proton. (1.67×10^{-27} kg) This particles is called the neutron.
- See page 50 for a comparison of three subatomic particles.

Representing Atomic Structure

- The atomic number (Z) is equal to the number of protons.
- Since atoms are neutral, the number of protons equals the number of electrons.
- The mass number (A) is equal to the number of protons and neutrons. (This number is approximately equal to the mass of the atom).
- The number of neutrons can be determined by subtracting the atomic number from the mass number.
- Isotopes are atoms of the same element that have different masses due to differing numbers of neutrons.

Ions

- An atom that gains electrons forms a negative ion called an anion.
- An atom that loses electrons forms a positive ion called a cation.

Introduction to the Periodic Table

- The periodic table is organized by increasing atomic number.
- Horizontal rows are called periods.
- Vertical columns are called groups.
- Elements within the same group have similar chemical properties.

Organization of the Periodic Table

- Metals are found on the left side of the table and share the following properties:
  1) tend to be solids at room temperature
  2) have luster
  3) malleable and ductile
  4) react with acids
  5) conduct heat and electricity
  6) lose electrons and form positive ions

Organization of the Periodic Table

- Nonmetals are found on the upper right side of the table and share the following properties:

  1) tend to be liquids and gases at room temperature

  2) are dull

  3) are brittle

  4) are nonconductors

  5) don’t react with acids

  6) gain electrons and form negative ions.

Organization of the Periodic Table

- Metalloids are elements that have properties of both metals and nonmetals.
- Metalloids are located along the diagonal line dividing the metals from the nonmetals.

Organization of the Periodic Table

- Group 1A: alkali metals
- Group 2A: alkaline earth metals
- Group 7A: halogens
- Group 8A: noble gases