CHM138H1 - Introductory Chemistry

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Contents

1 Atomic Structure

Atoms consist of a nucleus containing protons and neutrons, surrounded by electrons in various energy levels (orbitals).

1.1 Subatomic Particles

- **Proton**: Positively charged particle in the nucleus.
- **Neutron**: Neutrally charged particle in the nucleus.
- **Electron**: Negatively charged particle in orbitals around the nucleus.

1.2 Isotopes

Isotopes are atoms with the same number of protons but different numbers of neutrons. Example:

$$^{12}\mathrm{C},\ ^{13}\mathrm{C},\ ^{14}\mathrm{C}$$

2 Quantum Mechanics and Orbitals

Electrons occupy orbitals, regions of space where the probability of finding an electron is highest.

2.1 Quantum Numbers

- **Principal quantum number** n: Energy level (shell).
- **Azimuthal quantum number** l: Orbital shape (subshell).
- **Magnetic quantum number** m_l: Orientation of the orbital.
- **Spin quantum number** m_s: Spin direction of the electron.

3 Periodic Trends

Elements in the periodic table exhibit trends in properties like atomic radius, ionization energy, and electronegativity.

3.1 Atomic Radius

The atomic radius increases down a group and decreases across a period.

3.2 Ionization Energy

The energy required to remove an electron. It decreases down a group and increases across a period.

4 Chemical Bonding

Atoms form bonds to achieve stable electron configurations.

4.1 Ionic Bonding

Occurs between metals and non-metals, involving the transfer of electrons. Example: NaCl.

4.2 Covalent Bonding

Involves the sharing of electron pairs between atoms. Example: H_2O.

5 Molecular Geometry

The 3D arrangement of atoms in a molecule is determined by VSEPR (Valence Shell Electron Pair Repulsion) theory.

5.1 VSEPR Theory

Predicts molecular shape based on electron pair repulsion. Example shapes:

- Linear: 180° bond angles (CO_2).
- Trigonal planar: 120° bond angles (BF_3).
- Tetrahedral: 109.5° bond angles (CH_4).

6 Thermodynamics

The study of energy changes in chemical reactions.

6.1 First Law of Thermodynamics

Energy cannot be created or destroyed, only transferred or converted.

6.2 Enthalpy

The heat content of a system at constant pressure. The change in enthalpy (ΔH) during a reaction can be exothermic (releases heat) or endothermic (absorbs heat).

7 Equilibrium

In a reversible reaction, the system reaches equilibrium when the rates of the forward and reverse reactions are equal.

7.1 Le Chatelier's Principle

If a system at equilibrium is disturbed, it will shift to counteract the disturbance.

8 Acids and Bases

Acids donate protons (H^+), while bases accept protons.

8.1 pH Scale

The pH scale measures the acidity or basicity of a solution:

$$\text{pH} = -\log[\text{H}^+]$$

8.2 Buffers

A buffer solution resists changes in pH when small amounts of acid or base are added.

9 Kinetics

Chemical kinetics is the study of the rates of chemical reactions.

9.1 Rate Laws

The rate of a reaction depends on the concentration of reactants:

$$\text{Rate} = k[\text{A}]^m[\text{B}]^n$$

where k is the rate constant, and m and n are the reaction orders.

10 Electrochemistry

Electrochemistry deals with the relationship between electricity and chemical reactions.

10.1 Redox Reactions

Reduction involves the gain of electrons, while oxidation involves the loss of electrons.

10.2 Galvanic Cells

A galvanic cell generates electrical energy from spontaneous redox reactions.