

Lecture 4 — Covalent Bonding

Michael Brodskiy

Professor: J. Adams

January 15, 2025

- Electron Sharing in Covalent Bonds
 - Covalent bonds form when atoms share electrons to achieve a stable electron configuration (octet rule)
 - Key Characteristics
 - * Localized Electrons:
 - Shared electrons are concentrated in the bond region between two nuclei
 - * Directionality:
 - Covalent bonds are directional, determining the geometry of molecules and lattices
- Octet Rule
 - Atoms tend to share, gain, or lose electrons to achieve a stable configuration with eight valence electron configuration
 - Covalent bonding enables atoms to fulfill this rule by sharing electrons
 - Exceptions to the Octet Rule
 - * Expanded Octets: Elements like phosphorus (P) or sulfur (S) can have more than eight valence electrons
 - * Electron Deficiency: Atoms have fewer than 8 electrons in their valence shell
 - * Deviations occur due to varying atomic size, electron configurations, or bonding needs
 - * Odd-Electron Molecules (Radicals): Molecules with unpaired electrons, resulting in an incomplete octet
- Bond Types
 - Single: Longest bond length and lowest bond energy
 - Double: Shorter and stronger than single bonds

- Triple: Shortest bond length and highest bond energy
- Covalent Networks
 - Solids where atoms are connected in a continuous, 3D lattice through covalent bonds
 - Distinguished from molecular solids, which consist of discrete molecules
- Covalent Polymers
 - Polymers are large molecules made up of repeating units (monomers) joined by covalent bonds
 - Backbone of the polymer chain is typically a carbon-based structure, providing stability and flexibility
- Molecular Orbital Theory
 - A theory that explains covalent bonding by combining atomic orbitals to form molecular orbitals that are spread over the entire molecule
 - Electrons are delocalized and occupy molecular orbitals, rather than being confined to individual bonds
 - Principles:
 - * Constructive and Destructive Interference: Atomic Orbitals combine to form bonding (low energy) and anti-bonding (high energy) molecular orbitals
 - * Electron Filling: Molecular orbitals are filled from lower to highest energy levels, following the Pauli exclusion principle and Hund's rule
 - * Delocalization: Explains electron behavior in systems like graphene and benzene
- Hybridization
 - A concept that explains how atomic orbitals mix to form new hybrid orbitals that are suitable for bonding
 - Ensures maximum overlap and stronger bonds