

SCIENCE AND ENGINEERING MATERIALS

Interatomic Bonding

by

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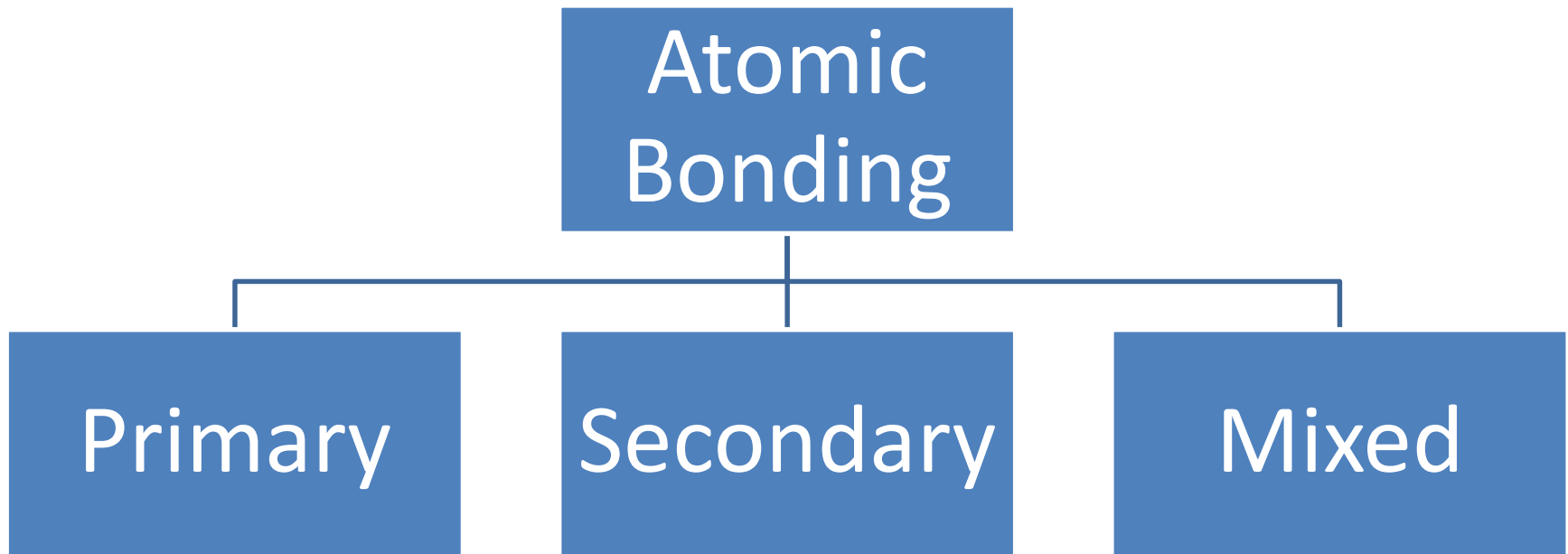


Chapter Description

- Learning Objectives
 - Describe ionic, covalent, metallic, Van Der Waals and mixed bonds and note the differences between them
 - Explain the relation between atomic bonding and material properties
 - Note what materials exhibit each of the bonding types



Atomic Bonding



Atomic Bonding: Ionic Bonding

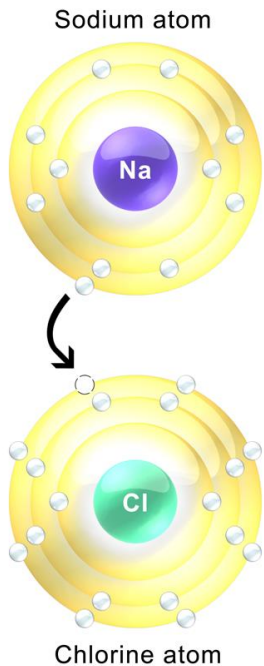
- Result of electron transfer from one atom to another
- Formed between highly electropositive (metallic) elements and highly electronegative (nonmetallic) elements
- Due to coulombic attraction
- Producing cations and anions
- Nondirectional: +ve species attract –ve species in all direction → ions stacked together in a solid



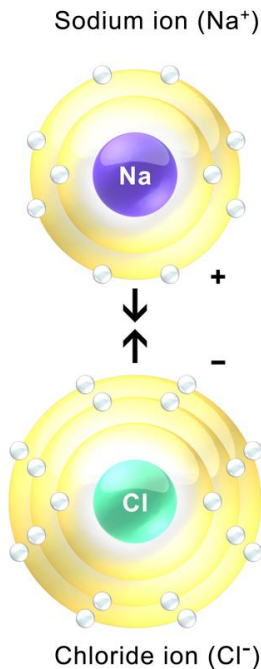
Atomic Bonding: Primary bonding

Ionic Bonding

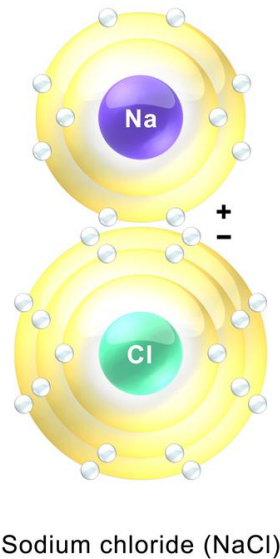
A Formation of ions



B Attraction between opposite charges



C Formation of an ionic compound



Formation of an Ionic Bond

Source: [BruceBlaus](#); [Wikimedia](#)

Poor Electrical conductivity; the electrical charge is transferred by the movement of entire ion. Because of their size do not move as easy as electrons

Brittle; During mechanical force → electrostatic repulsion between molecules, leads to disruption of lattice structure



Atomic Bonding: Primary bonding

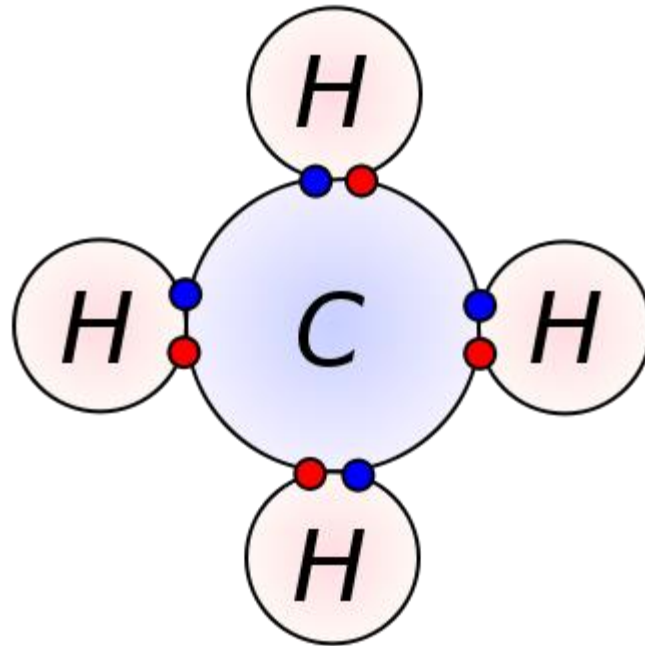
Covalent Bonding

- Cooperative sharing of valence electrons between two adjacent atoms (atoms with small differences in electronegativity and close to each other in periodic table)
- Highly directional
- Poor electrical and thermal conductivity
- For electron to move and carry current covalent bond must be broken (required high temperature or voltage)



Atomic Bonding: Primary bonding

Covalent Bonding



- Electron from hydrogen
- Electron from carbon

Source: [DynaBlast](#); [Wikimedia](#)



Atomic Bonding: Primary bonding

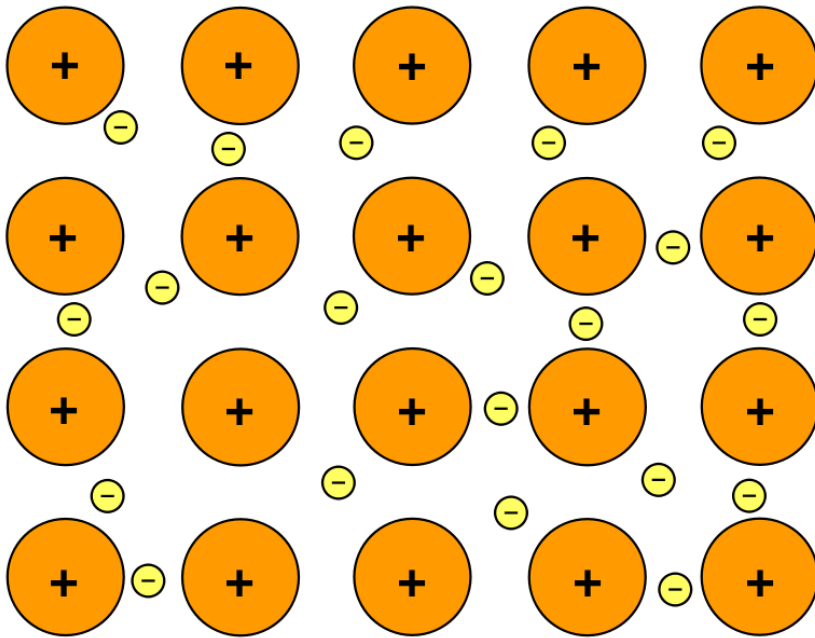
Metallic Bonding

- Occurs in solid metals
- Involves e^- sharing: Valence e^- attracted to the nuclei of neighboring atoms (delocalized e^-) → electron cloud
- Non-directional: atoms are packed together in a systematic pattern or crystalline structure
- Example: Al give 3 electrons to form a sea of electron



Atomic Bonding: Primary bonding

Metallic Bonding



Source: [Muskid](#); [Wikimedia](#)

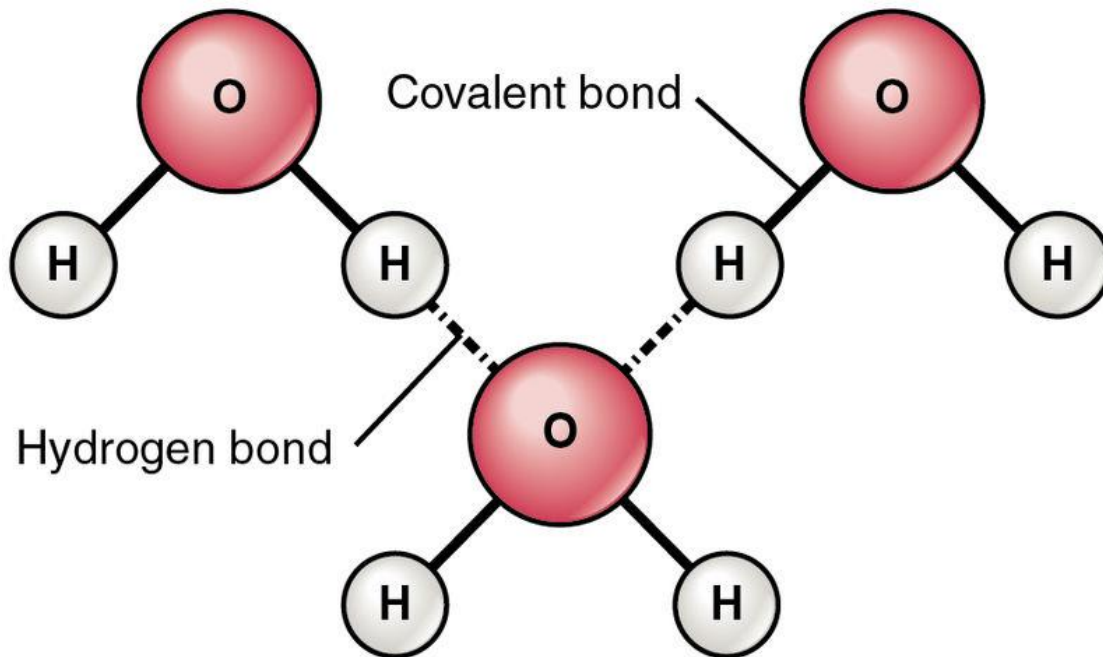
- Graphical depiction of metallic bonding. Note the metal *ion cores* is surrounded by *sea* of free electrons

Atomic Bonding: Secondary bonding

- Involves weak attraction between atoms
- Electron transfer/sharing **does not** take place
- Arises from interaction between dipoles
 - Fluctuating dipoles
 - Permanent dipoles (molecule induced)
- Examples:
 - Van der Waal's bonding
 - Hydrogen bonding



Atomic Bonding: Secondary bonding



- Hydrogen bonding between water molecules
- Heating water may break the hydrogen bonding between molecule (secondary bond), but much higher energy is needed to break covalent bonding (primary bond) joining hydrogen and oxygen.

Source: [OpenStax College](#); [Wikimedia](#)



Atomic Bonding: Mixed bonding

- Ionic-covalent – semiconducting compounds such as GaAs, ZnSe
- Metallic-covalent – occurs in transition metals (Ti, Fe) → high T_{melt}
- Metallic-ionic – occurs in intermetallic compounds (NaZn_{13} , Al_9Co_3 , $\text{Fe}_5\text{Zn}_{21}$)



Conclusion of The Chapter

- There are three types of atomic bonding
 - Primary bonding
 - Secondary bonding
 - Mixed bonding
- Three types of primary bonding
 - Ionic bonding
 - Covalent bonding
 - Metallic
- Two types of secondary bonding
 - Fluctuating dipoles
 - Permanent dipoles



References

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- [3] Smith, W. F. & Hashemi, J. Foundations of Materials Science & Engineering, McGraw Hill, 0071256903
- [4] Askeland, D. R. The Science and Engineering of Materials, Chapman & Hall, 412539101



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