Liquids and Solids

Chemistry 30 AP – Ms. Hayduk

Ion Formation

- **Ion**: an atom that becomes charged by gaining or losing electrons to become isoelectronic with a noble gas

Ionic Bonds

- Electrostatic attraction between positive and negatively charged ions
- Very strong (strength of attraction based on Coulomb's Law)
- Formed between metal cations and non-metal anions

Strength of Ionic Bonds

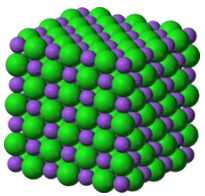
- Recall Coulomb's Law:

$$F = \frac{kq_1q_2}{d^2}$$

- Stronger attractions for:
  - Ions with higher charge
  - Smaller ions (decreased distance between nuclei)
- Strength affects properties like melting point and solubility

Structure of Ionic Solids

- Ions arrange in crystal lattice structure to minimize repulsive forces and maximum attractive forces



Lattice Energy

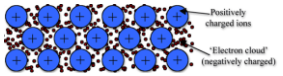
- Measures stability of ionic solid – energy required to separate one mole of ionic solid into gaseous ions
- Based on bond strength

Thinking Activity

$Mg(OH)_2$ has a lattice energy of 2900 kJ/mol. $Sr(OH)_2$ has a lattice energy of 2300 kJ/mol. Explain this difference.

Metallic Bonds

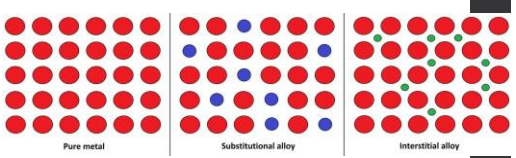
- Metals form lattices of positive ions where valence electrons move freely (delocalized)
- "Electron sea model"



Alloys

- Substitutional: host metal atoms replaced by another metal with atoms of similar size
- Interstitial: smaller metal atoms fit in between the host metal atoms
- Why alloys?
  - Generally stronger than pure metals
  - Alters the structure of the metal to reduce corrosion, change conductivity/melting point, etc.

Alloys



Covalent Network Solids

- Strong bonds between many similar non-metal atoms to form a "giant molecule"
- Examples: diamond, graphene, silicon
- Semiconductors:
  - n-type doping – replace atoms in covalent solid with higher valence atoms (increase negative charge)
  - p-type doping – replace with lower valence atoms (increase positive charge)

Summary: Types of Solids

Network	Metallic	Molecular	Ionic
Atomic			
Atom	Atom	Molecule	Ion
Hard High MP Insulator	Wide range of properties	Low MP Insulator	Hard High MP Insulator

Example: Types of Solids

Classify each of the following substances according to the type of solid it forms:

1. Gold
2. Carbon dioxide
3. Lithium fluoride
4. Diamond

Intramolecular Forces

- Types of bonds formed WITHIN a substance:
  - Covalent (polar/non-polar)
  - Ionic
  - Metallic
- Depends on types of atoms (metal/non-metal) present and their periodic properties

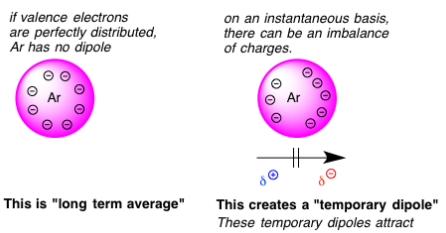
Intermolecular Forces

- Explains forces between particles (atoms, ions or molecules)
- Can be between identical particles (within a sample of water) or two different particles (salt in water)
- **All intermolecular forces are weaker than intramolecular forces**

London Dispersion Forces

- Caused by *instantaneous dipoles* caused by electron movement in a particle
- Weak forces that exist for <u>all</u> particles
- Increases in strength with size of particles (more electrons) and when shape of particles allows them to be closer together
- Predominant force in non-polar substances/mixtures

London Dispersion Forces

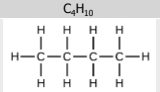
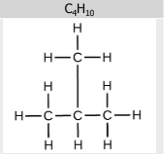


Example 1: London Dispersion

At room temperature, explain why fluorine and chlorine are gases, bromine is a liquid and iodine is a solid.

Example 2: London Dispersion

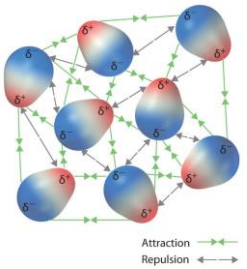
Explain.

Butane	Isobutane
C_4H_{10}	C_4H_{10}
	
BP -0.4°C	BP -11.8°C

Dipole-Dipole Forces

- Occurs between polar molecules (permanent dipoles)
- Formed by attraction between partial positive and negative charges
- Larger dipoles (more EN diff) = stronger force

Dipole-Dipole Forces

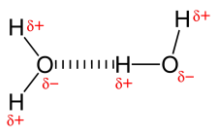


Example: Dipole-Dipole Forces

Which of H_2 and HCl would you expect to have a higher boiling point? Why?

Hydrogen Bonding Forces

- Occurs for polar molecules with hydrogen atom covalently bonded to oxygen, nitrogen or fluorine – VERY polar bond
- Similar to dipole-dipole, but stronger



Strength of IMFs

For similar-sized molecules:

Most	hydrogen bonding
	dipole-dipole
Least	London disperson

Everything has LDFs, but these are insignificant if DDFs or HBFs also exist

Example: Identifying IMFs

What type of intermolecular forces govern each of the following substances?

CH_3OH (methanol)

CH_4 (methane)

CH_3Cl (chloromethane)

Which would most likely exist as a liquid at room temperature?