Chemical Bonding 4.1

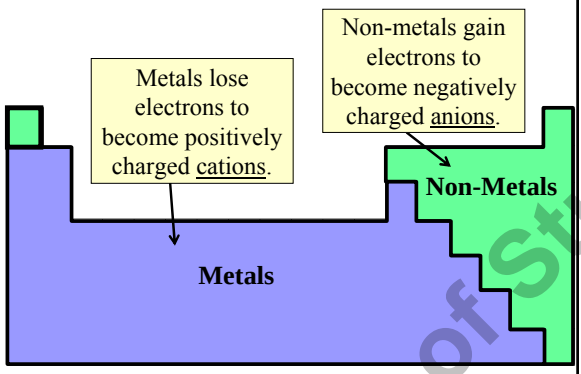
Octet Rule
Ionic Bonding
Lattice Energy
Covalent Bonding

The Octet Rule

Elements tend to gain, lose, or share electrons to acquire a full octet.

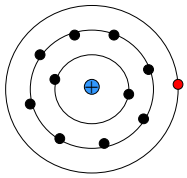
- In $n = 1$ a full octet consists of 2 electrons.
  - There is only one 1s orbital.
- From $n = 2$ to $n = 7$, a full octet consists of 8 electrons.
  - A full s-orbital and a full p subshell.

The Formation of Ions



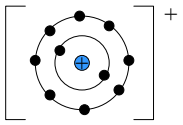
Electron Configurations of Ions

Na
Incomplete Octet



$1s^2\ 2s^2\ 2p^6\ 3s^1$
$= [Ne]\ 3s^1$

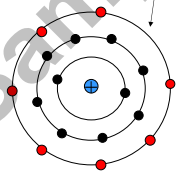
Na^+
Complete Octet
Lost the electron from $n = 3$ to acquire a full octet



$1s^2\ 2s^2\ 2p^6$
$= [Ne]$

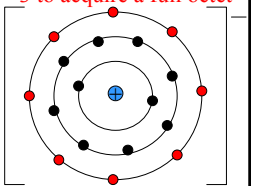
Electron Configurations of Ions

Cl
Incomplete Octet



$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$
$= [Ne]\ 3s^2\ 3p^5$

Cl^-
Complete Octet
Gained an electron in $n = 3$ to acquire a full octet



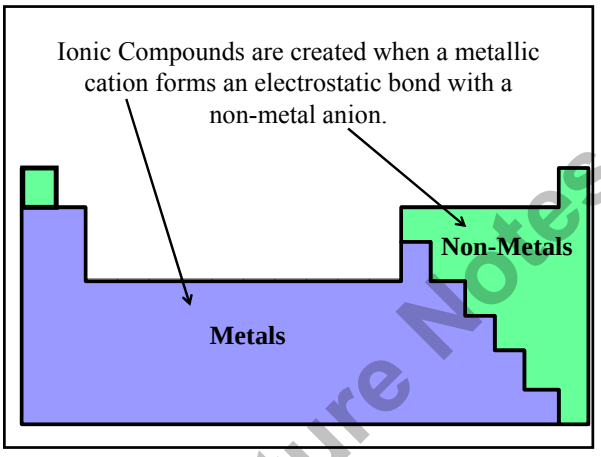
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$
$= [Ne]\ 3s^2\ 3p^6 = [Ar]$

The charges on ions are usually related to the group they're in.

Group 1A → +1 (H can also be –1)
Group 2A → +2
d-block → +1 to +4 (it's hard to predict)
Group 3A → +3 (Tl can also be +1)
Group 4A → +4 (Sn and Pb can also be +2)
Group 5A → -3 non-metals, +3 and +5 metals
Group 6A → -2
Group 7A → -1

d-block cations

- These elements lose electrons from their highest s-sublevel first before losing from their d-sublevel.
- Ex) Iron may form 2 types of ions.
  - Fe [Ar] $4s^2$ $3d^6$
  - Fe^{2+} [Ar] $3d^6$ → Lost electrons from 4s
  - Fe^{3+} [Ar] $3d^5$ → Lost electrons from 4s and one in 3d.



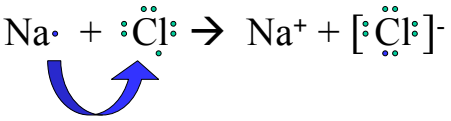
Ionic Bonding Defined

1) Metals transfer electrons to non-metals, and the two form bonds due to the electrostatic attractions between them.

or

2) Cations (metal ions) and anions (non-metal ions) form electrostatic bonds based on opposite charges.
   - Cations and anions may be polyatomic

Ionic Bonding



Lattice Energy

- The energy required to break one mole of a solid ionic compound into its individual gaseous ions.
- This requires a lot of energy as ionic bonds are very strong.
  - Very Endothermic
- Conversely, putting a lattice together is Very Exothermic

Lattice Energy

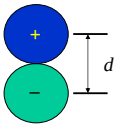
$NaCl_{(s)} \rightarrow Na^+_{(g)} + Cl^-_{(g)}$ $\Delta H_{lattice} = +788$ kJ/mol

$Na^+_{(g)} + Cl^-_{(g)} \rightarrow NaCl_{(s)}$ $\Delta H = -788$ kJ/mol

Factors Affecting Lattice Energy

Electrostatic Equation

Derived from Coulomb's Law



$$E = \frac{KQ_1Q_2}{d}$$

$K = 8.99 \times 10^9$ Jm/C^2

d = distance between ionic centers

Q = the charge of a single ion

Ex) Trends in Lattice Energy

Ex) Which compound from each set has the highest melting temperature? Why?

1) LiF LiI

2) $MgCl_2$ MgO

3) NaF MgI_2

Properties of Ionic Solids

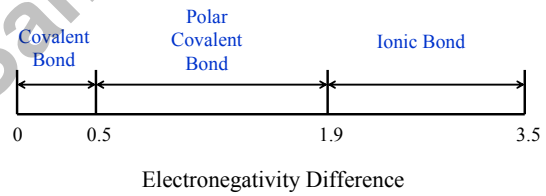
- **High Lattice Energy**
  - High melting point
- **Cleaves along planes**
  - Brittle 3D structure
  - Ions line up in a repetitive pattern.
- **Ions**
  - Most are soluble in polar solvents.
  - Conduct electricity when molten or dissolved in a polar solvent
    - The higher the concentration of ions in a solution, the higher the electrical conductivity.

Covalent Bonds

One atom shares electrons with another atom so that both acquire full octets.

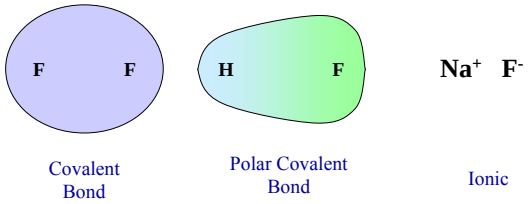
Occurs between two non-metals

Electronegativity and Bond Polarity

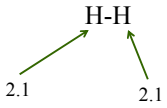


Electronegativity Difference

Types of Bonds

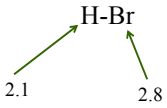


Determining Bond Type



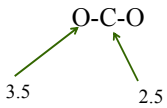
Electronegativity difference = 0.0

Determining Bond Type



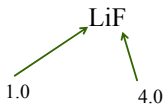
Electronegativity difference = 0.7

Determining Bond Type



Electronegativity difference = 1.0

Determining Bond Type



Electronegativity difference = 3.0

Molecular Compounds Defined

Molecules:

- Two or more non-metals bonded together to form a compound.
- Bonds between atoms are covalent or polar covalent.