1st

J/mole

Types of Bonds

- Bond Energy - energy required to break a bond KJ/mole
- Bonds form when the system can achieve the lowest possible energy by behaving that way.
- Ionic bonds form when (2 steps):
  1. an atom has an attraction for the electrons of another atom & pulls the electrons off.
  2. there is a strong mutual attraction of the oppositely charged particles
- The energy of interaction between a pair of ions is calculated using **COULOMB'S LAW**.

$$E = k\frac{Q_1 Q_2}{r^2}$$

E → Force of attraction or repulsion

k → proportionality constant

Q → charges of the particles

r → distance between the ion centers

- Coulomb's law can also be used to determine the repulsive energy of two like-charged ions. E will be (+).

$$-E = \frac{(+)(-)}{+r^2}$$ ↑ energy is released

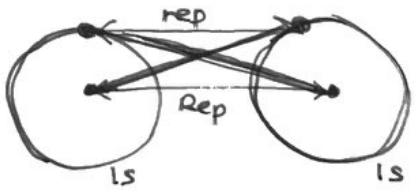
$$+E = \frac{(+)(+)}{+r^2}$$ ↑ energy absorbed (required)

- It is easy to see how a bonding force develops between two different types of atoms that react to form oppositely charged ions. How does a bonding force develop between two identical atoms?

Ex. Two hydrogen atoms → H_2 Under what conditions is the molecule favored over the separate atoms?

2 unfavorable potential energy terms: $p^+ - p^+$ repulsion
$e^- - e^-$ repulsion

1 favorable potential energy term: $p^+ - e^-$ attraction



A bond will form if the system can lower its total energy in the process.

- The distance between the atoms where the energy is at a minimum is called the bond length.

- Study figure 8.7 on page 307.
  The electrons reside primarily in the space between the 2 nuclei where they are attracted simultaneously by both nuclei.

- The type of bonding in which electrons are shared by nuclei is called covalent bond.

- The ability of an atom in a molecule to attract electrons to itself is called electronegativity.

- Nonpolar covalent bond (H–H) result when two of the same atom are bonded to each other and the two atoms share the electrons equally because they have identical electronegativity. (Br–Br)

- Polar covalent bond result from unequal sharing of the electrons due to differences in electronegativity. (H–Cl)

- When two atoms with very different electronegativities interact, electron transfer can occur resulting in the formation of ions → cannot share

- A molecule with a center of positive charge and a center of negative charge is said to be a dipole or to have a dipole moment.
  polar molecules

- A dipole moment can be represented two ways:

HCl

H:Cl:

delta

δ+ H—Cl: δ−

HCl is a dipole.

δ delta
partial
or
incomplete

polar molecule → H—Cl:

H⁺—Cl:⁻

polar bond

- When a nonmetal reacts with another nonmetal, they share electrons in a way that completes the valence electron configurations of both atoms. Both atoms gain a noble gas configuration. This is called a covalent bonds.

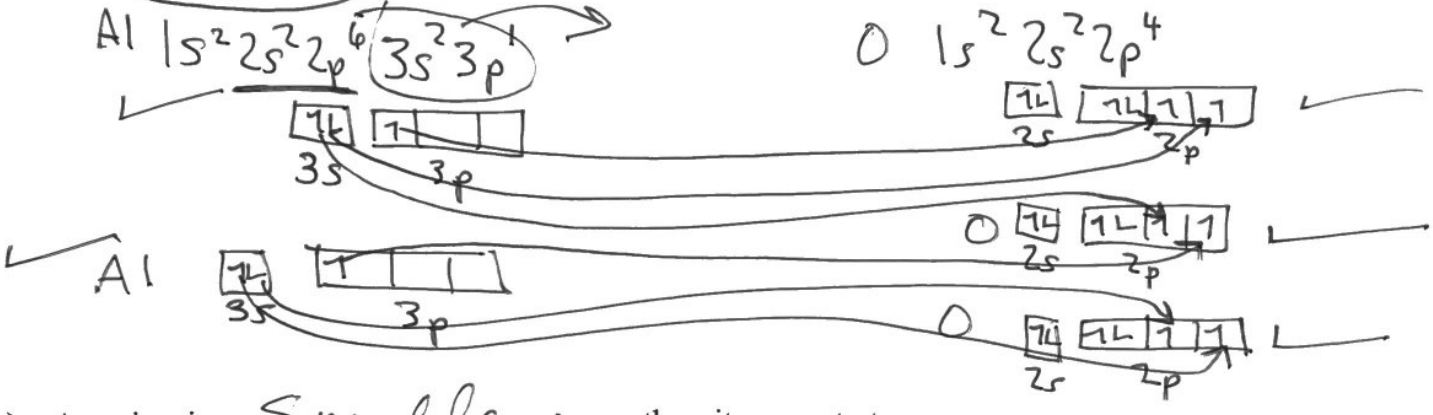
(1st)

- Covalent bonds can be classified as polar or nonpolar.

- When a nonmetal reacts with a metal, the more electronegative nonmetal takes electrons from the metal creating a positive and a negative ion. The oppositely charged ions are attracted to one another creating an ionic bond. The ions form so that the negative ion gains enough electrons to give it an octet (a full s and p in the highest energy level). In other words, it will have the electron configuration of the next higher noble gas. The positive ion will lose all of its valence electrons giving it the electron configuration of the next lower noble gas.

- To predict the formula of an ionic compound, just remember that chemical compounds are electrically neutral. This means they have the same number of (+) and (-) charges.

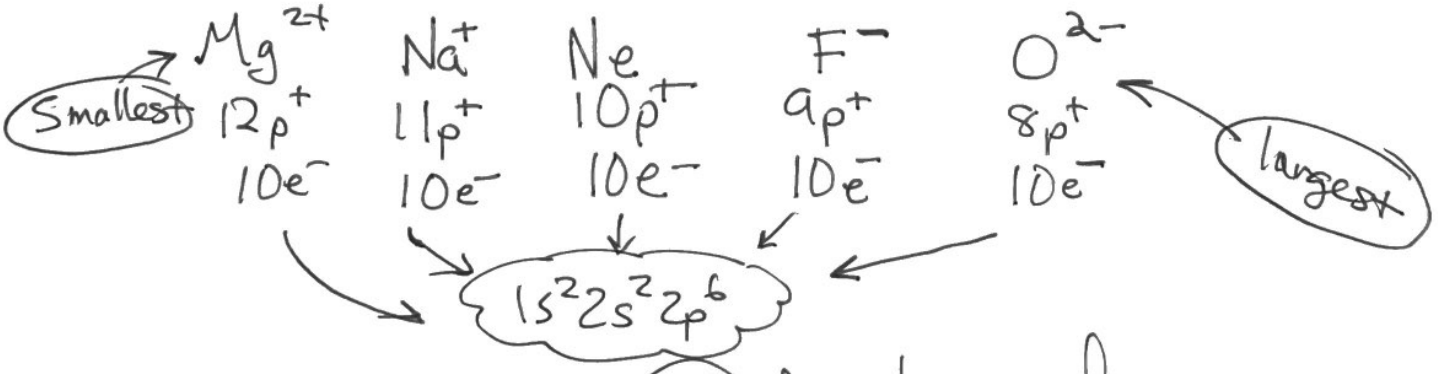
Al_2O_3 → formula unit



- A cation is smaller than its parent atom. ← e⁻ out # the p⁺

- An anion is larger than its parent atom. → less effective nuclear charge, e⁻–e⁻ repulsion

- Isoelectronic particles (~~ions~~ particles) are ~~ions~~ that contain that contain the same number of electrons – have the same electron configuration.



How do the sizes of these ions vary and why? Nuclear charge ↑ nuclear charge, ↓ distance of e's from nucleus

Read 8.2
Study p305 Born-Haber Cycle
Q 21-28

The Formation of Ionic Solids

Operational definition of ionic compounds: any compound that conducts an electric current when melted. → ions can flow

Ionic solids form because the aggregated oppositely charged ions have a lower energy state than the individual elements.

metal ← $M^{+1}X^{-1}$ → diatomic element

Creating an Ionic Compound $LiF_{(s)}$

Energy changes involved in the formation of an ionic solid: (remember: a negative energy sign represents energy released and a positive energy sign represents energy taken in by the system)

Enthalpy = change in heat content

ΔH → change in heat content

1) Endothermic – Sublimation of metallic solid

Enthalpy of sublimation

$M_{(s)} \rightarrow M_{(g)}$ / $Li_{(s)} \rightarrow Li_{(g)}$ $\Delta H_{sub} = +161\ kJ/mol$ *

(+ → endothermic)

2) Endothermic – Ionization of the gaseous metal atom (Removal of the I_1 electron requires the first ionization energy of the metal.)

First Ioniz. Energy IE_1

$M_{(g)} \rightarrow M^+_{(g)} + e^-$ / $Li_{(g)} \rightarrow Li^+_{(g)} + e^-$ $IE_1 = +520\ kJ/mol$ *

(+ → endothermic)

3) Endothermic – Break the diatomic halogen molecule apart

Bond Energy 154 kJ/mole

$\frac{1}{2}X_{2(g)} \rightarrow X_{(g)}$ / $\frac{1}{2}F_{2(g)} \rightarrow F_{(g)}$ B.E. = +77 kJ/½ mole *

4) Exothermic – Form ions of halogen. (Energy released is the electron affinity value for the halogen and has a negative value.)

1st electron affinity

$X_{(g)} + e^- \rightarrow X^-_{(g)}$ / $F_{(g)} + e^- \rightarrow F^-_{(g)}$ E.a. = −328 kJ/mole *

(− → exothermic)

5) Exothermic – As ions come together, energy is released. This is called the lattice energy.

$M^+_{(g)} + X^-_{(g)} \rightarrow MX_{(s)}$ / $Li^+_{(g)} + F^-_{(g)} \rightarrow LiF_{(s)}$ LE = −1047 kJ/mol *

(− → exothermic)

Overall Equation:

$Li_{(s)} + \frac{1}{2}F_{2(g)} \rightarrow LiF_{(s)}$

Enthalpy of Reaction → ΔH_r ΔH_f ← Enthalpy of formation

$\Delta H_r = \Delta H_f = -617\ kJ/mol$

Lattice energy is the change in energy when gaseous ions are packed together to form an ionic solid. Also defined as the energy released when an ionic solid is formed from its ions.

Figure 8.6 Study the energy diagram. Look at the energy required for the endothermic steps versus the lattice energy.

Partial ionic character of ionic bonds:

There are probably no totally ionic bonds. Compounds with more than 50% ionic character are considered to be ionic solids. So, we need to use an **operational definition for ionic solids**

- Any solid that conducts electricity when molten = ionic solid

Covalent Bonds

Bond length –

Page 325 Table 8.3 Table of Bond Lengths

As the number of bonds between two atoms increases, the bond length _____.

Single covalent bonds

Double covalent bonds

Triple covalent bonds