Outline

- Chemical Bonding
- Ionic Compounds
- Covalent Compounds
- Bond Energy Length
- Electronegativity and Bond Polarity

Chemical Bonding

Ionic bonds…

electrons “transferred” between metal and nonmetal atoms

hold collection of ions together

Covalent bonds…

electrons are “shared” between nonmetal atoms

hold individual molecules together

Metallic bonds…

electrons “pool” between metal atoms

hold collection of atoms together

Ionic Compounds

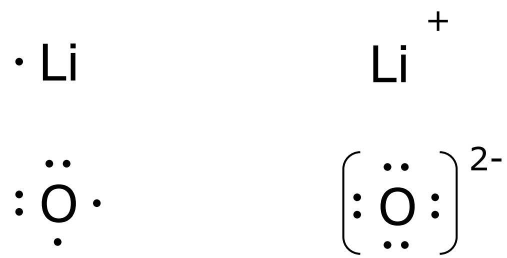
Atoms represented as Lewis Symbols…

…element symbol and valence electrons (as dots)

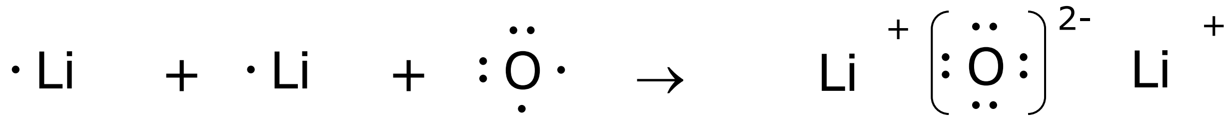
…“complete level” given by 0 or 8 electrons

lithium (I)

oxygen (VI)



Ions combine to form compound…



Attraction between oppositely charged ions is ionic bond

Energy change to produce gaseous ions from an ionic solid is lattice energy

Indicates strength of attraction of ions in solid state

LiF	1047 kJ/mol
LiCl	828 kJ/mol
LiBr	787 kJ/mol
LiI	732 kJ/mol

Lattice energies are predicted using Born-Haber cycle…

Consider: $Li(s) + {}^{1}/_{2}F_2(g) \rightarrow LiF(s)$ $\Delta H_f^o = -616$ kJ

$Li(s)$	$\rightarrow$	$Li(g)$	$\Delta H = 161$ kJ	Sublimation
$Li(g)$	$\rightarrow$	$Li^+(g) + e^-$	$\Delta H = 521$ kJ	Ionization
${}^{1}/_{2}F_2(g)$	$\rightarrow$	$F(g)$	$\Delta H = 77$ kJ	Dissociation
$F(g) + e^-$	$\rightarrow$	$F^-(g)$	$\Delta H = -328$ kJ	Electron Affinity
$Li^+(g) + F^-(g)$	$\rightarrow$	$LiF(s)$	$\Delta H =$???? kJ	-(Lattice Energy)
$Li(s) + {}^{1}/_{2}F_2(g)$	$\rightarrow$	$LiF(s)$	$\Delta H = -616$ kJ	Formation!

-(Lattice Energy) = -616 kJ – 161 kJ – 521 kJ – 77 kJ + 328 kJ

= -1047 kJ

Lattice Energy = +1047 kJ

Lattice energy strengths depend on:

1. Ion charges

   the larger the charges, the greater the attraction between the ions:

   LiF (MP = 845 ^{o}C) BeO (MP = 2530 ^{o}C)

2. Ion sizes

   the smaller the ions, the closer they can get, and the greater their attraction:

   NaCl (MP = 801 ^{o}C) KCl (MP = 770 ^{o}C)

Covalent Compounds

Composed of discrete molecules

Atoms share electrons to obtain stable, complete outer shells

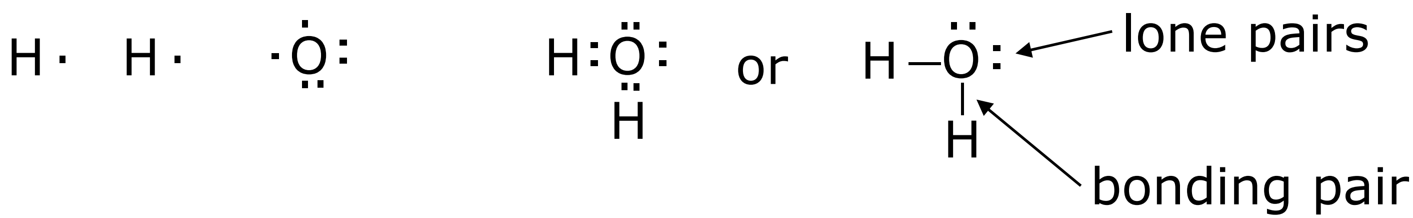
Localized Electron Model… bonds between atoms formed from electron pairs in atomic orbitals

Lewis Structures

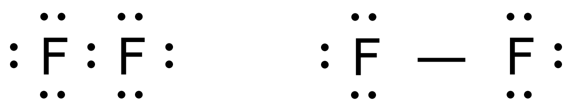
Bonding can be represented using electron dot notation, if each atom achieves a complete outer shell (octet, or duet for H)

Water

H_2O



Fluorine, F_2



single bond

Oxygen, O_2

double bond

Nitrogen, N_2

triple bond

Bond Energy and Length

Bond Order

The number of shared electron pairs of electrons

Bond Energy

The energy needed to break a bond

Bond Length

The distance between the nuclei of 2 bonding atoms

	F_2	O_2	N_2
Bond Order	1	2	3
Bond Energy (kJ/mol)	154	495	941
Bond Length (nm)	0.142	0.121	0.110

Consider the following bonds:

H – F, H – Cl, H – Br

Which is the strongest? H – F (568 kJ/mol)

Which is the weakest? H – Br (366 kJ/mol)

Which is the shortest? H – F (0.092 nm)

Which is the longest? H – Br (0.141 nm)

Bond energies can be used to approximate the reaction energy change, ΔH_{rxn}:

$$\Delta H_{rxn} = E_{\text{bonds broken}} - E_{\text{bonds formed}}$$

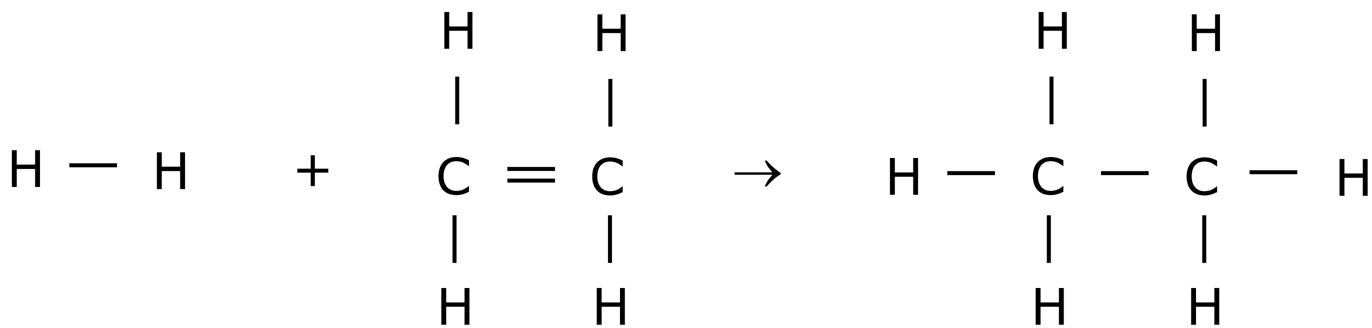
Determine ΔH_{rxn} for: $O_2(g) + 2F_2(g) \rightarrow 2OF_2(g)$

Bond Energies:		
	O = O	499 kJ/mol
	F – F	157 kJ/mol
	O – F	190. kJ/mol

Broken: 1 mol (499 kJ/mol) + 2 mol (157 kJ/mol) = 813 kJ
Formed: 4 mol (190. kJ/mol) = 760. kJ

ΔH_{rxn} = 813 kJ – 760. kJ = <u>53 kJ</u>

Determine ΔH_{rxn} for: $H_2(g) + C_2H_4(g) \rightarrow C_2H_6(g)$



H – H	436 kJ/mol	C – C	347 kJ/mol
C – H	414 kJ/mol	C = C	620. kJ/mol

Broken: 1 (436 kJ) + 4 (414 kJ) + 1 (620. kJ) = 2712 kJ

Formed: 6 (414 kJ) + 1 (347 kJ) = 2831 kJ

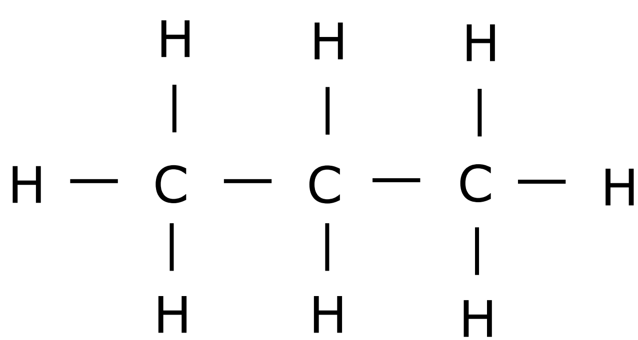
ΔH_{rxn} = 2712 kJ – 2831 kJ = -119 kJ

Determine ΔH_{rxn} for: $C_3H_8(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$

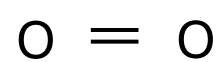
C – H	414 kJ/mol	O = O	499 kJ/mol
C – C	347 kJ/mol	C = O	799 kJ/mol
H – O	460 kJ/mol		

Balanced Equation: $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

C_3H_8:



O_2:



Problem Cont'd…

CO_2: O ═ C ═ O

H_2O: H — O — H

Broken:

8 (414 kJ) + 2 (347 kJ) + 5 (499 kJ) = 6501 kJ

Formed:

6 (799 kJ) + 8 (460 kJ) = 8474 kJ

ΔH_{rxn} = 6501 kJ – 8474 kJ = <u>-1973 kJ</u>

Electronegativity and Bond Polarity

Electronegativity (EN)

An atom's attraction for shared electrons

Highest: F (4.0) Lowest: Fr (0.7)

Indicates the type of bonding between atoms

EN Difference	Bonding
< 0.4	Nonpolar Covalent
0.4 – 1.7	Polar Covalent
> 1.7	Ionic

A bond between two atoms with same EN’s is a nonpolar covalent bond because bonding e^-’s are shared equally

Nonpolar covalent bonds have 0% ionic character

Cl – Cl	Br – Br
3.0 3.0	2.8 2.8

A bond between two atoms with different EN’s is a polar covalent bond because bonding e^-’s are not shared equally

Polar covalent bonds have 1% to 49% ionic character

H – Cl	H – Br
2.1 3.0	2.1 2.8
$\delta+$ $\delta-$	$\delta+$ $\delta-$

A polar bond is dipolar, has a dipole moment

A dipole moment arrow shows the positive and negative ends of the bonds, and the magnitude of the polarity

H – Cl　　　　　　H – Br


A bond between two atoms with very different EN’s is an ionic bond because e-’s are transferred

Ionic bonds have 50% or more ionic character

Na – Cl

0.9　3.0

Na^+　Cl^-