Salt Lake Community College, Chemistry Department

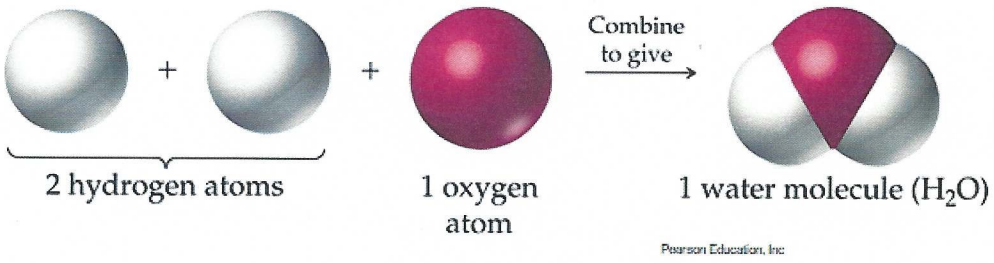
Chem 1110 Workshop 6

Topic: Covalent Compounds

Objective:

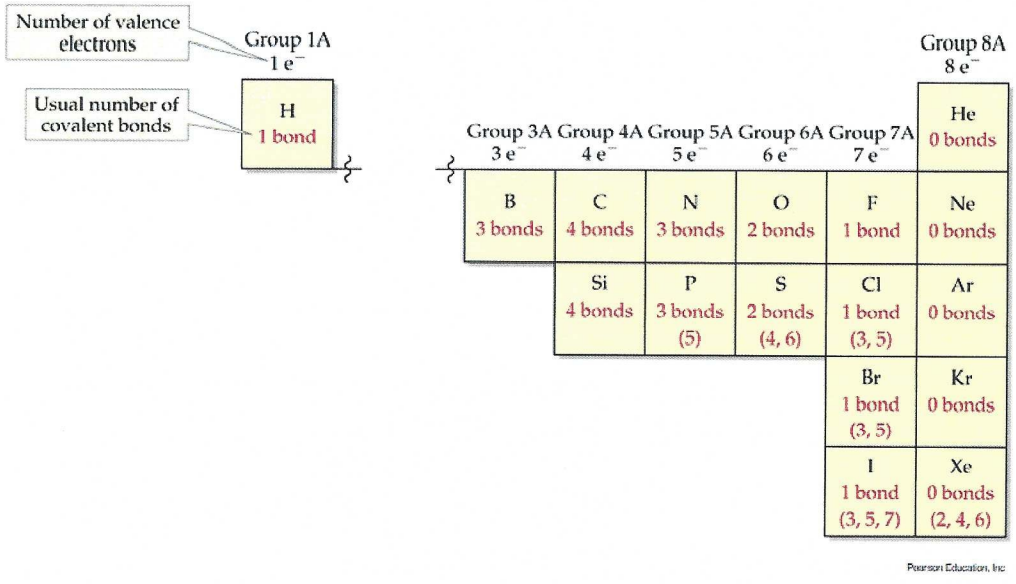
- Molecular Compounds and Covalent Bonds
- Covalent bonds and the periodic table
- Drawing Lewis Structures and the Shapes of Molecules
- Polar and Non-polar Covalent Bonds and Electronegativity
- Polar and Non-polar Molecules
- Naming Binary Molecular Compounds

Molecular compounds: usually combinations of nonmetals, H_2O



Molecule: A group of atoms held together by covalent bonds

Covalent bonds and the Periodic Table:



Numbers of covalent bonds are typically formed by main group elements to achieve octet configurations.

Drawing Lewis Structures and the Shapes of Molecules

A. Lewis structures: show bonds between atoms and the presence of unpaired electrons
B. Drawing Lewis structures of molecules Rules:

1. Sum the valence electrons from all the atoms in the molecule (**do not forget to add or subtract electrons based on the overall charge).
2. Determine the central atom (This will usually be the largest number of bonds/ or the first named atom in the molecular formula **except H atom)
3. Place the central atom (using its chemical symbol) and attach each of the peripheral atoms to it using a bonding pair of electrons written as a line.
4. Give each peripheral atom an octet of electrons (8 electrons) written as pairs of dots (except H – it follows the duet rule).
5. Any remaining electrons go on the central atom, even if doing this gives the central atom more than an octet of electrons.

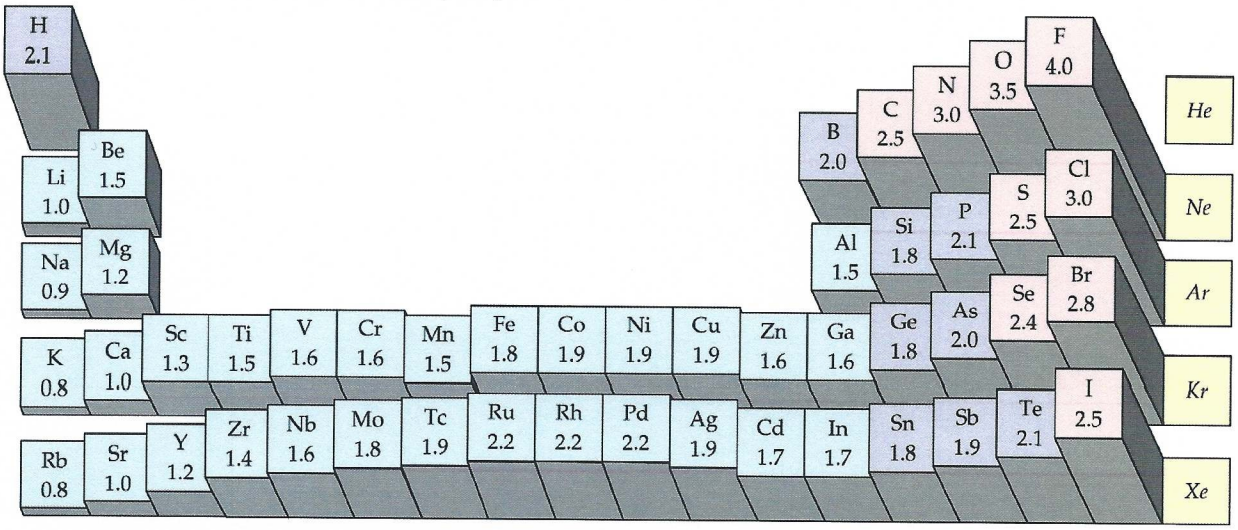
C. **Valence shell electron-pair repulsion Model:** It is a method predicting molecular shape by noting how many electrons charge clouds surround atoms and assuming that the clouds orient as far away from one another as possible.

The mutual repulsion of pairs of electrons cause them to arrange themselves as far apart spatially as possible

total pairs	bonding pairs	nonbonding pairs	geometry	example
2	2	0	linear	BeH_2
3	3	0	trigonal planar	BF_3
	2	1	bent	NO_2
4	4	0	tetrahedral	CH_4
	3	1	pyramidal	NH_3
	2	2	bent	H_2O

Polar and non-polar covalent bonds:

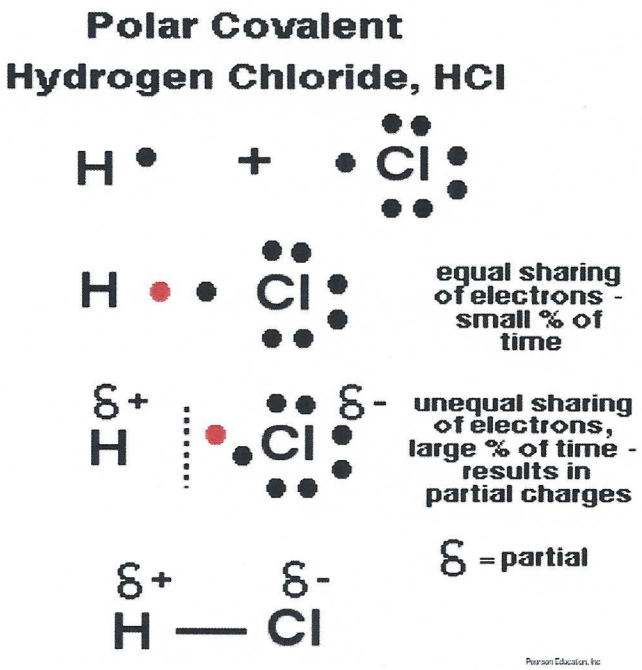
1. Electronegativity: Electronegativity is the tendency of an atom to attract electrons to itself (0-4).



2. F is the most electronegative atom in the periodic table (Electronegative value= 4.0)
3. Cs the least electronegative atom (Electronegative value = 0.7)
4. To determine the type of **bond between two atoms**, you can use the electronegativity difference:

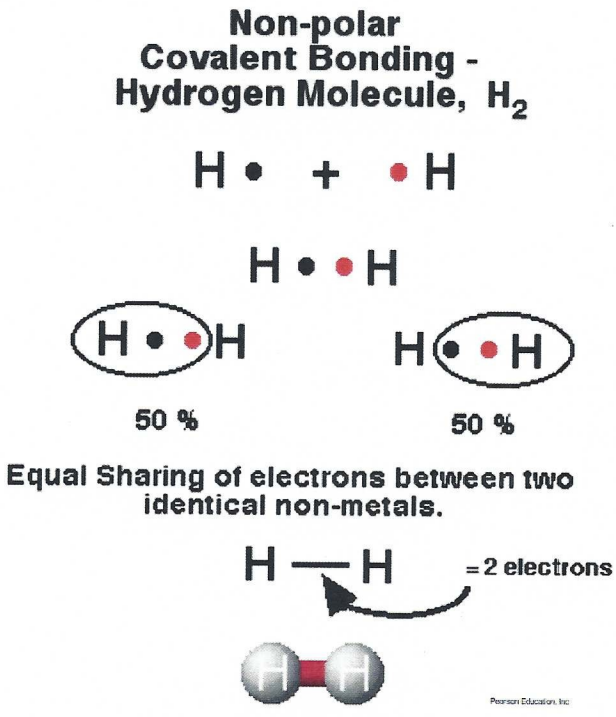
<0.5	nonpolar covalent
0.5 – 1.9	polar covalent
>2.0	ionic

A. Polar covalent bonds - bonding electrons are not shared equally due to differences in electronegativity between the bonding atoms



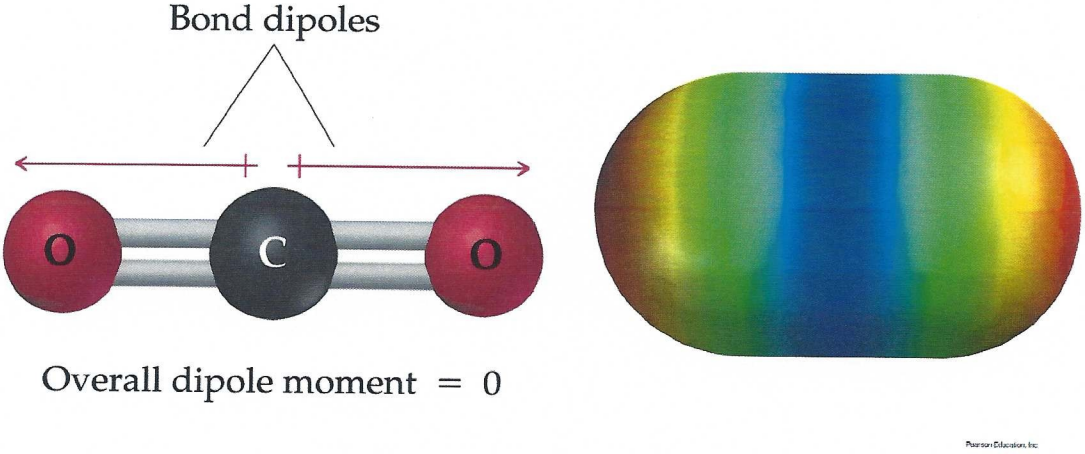
Nonpolar covalent bonds:

1. If the bonding atoms are the same (for example, H_2, N_2, O_2, F_2, etc.) the bonding atoms are shared equally (50%/50%)



Polar and Nonpolar Molecules

2. When there is a difference in electronegativity between two atoms, then the bond between them is polar.
3. It is possible for a molecule to contain polar bonds, but not be polar. For example, the bond dipoles in CO_2 cancel each other because CO_2 is linear.
4. Exceptions: highly symmetric molecules with polar bonds may be nonpolar.



Naming Binary Molecular Compounds:

prefixes (mono-, di-, tri-, tetra-, penta-, hexa-, hepta-, octa-, nona-, deca-) are used to indicate the number of atoms of each element (mono- is never used with the first element)

Practice Problems:

1. Classify each of these following compounds as an ionic or covalent compound

(a) N_2O→ nonmetal+ nonmetal= Covalent compound

(b) $CaCl_2$ →metal + nonmetal= Ionic compound

2. For each of the following molecules, give the total number of valence electrons, draw the Lewis structure, give the molecular shape, calculate the electronegativity difference, and identify the type of bond.

Chemical Formula	Total Number of valence electrons	Lewis Structure	Molecular Shape	Electronegativity difference	Type of bond (Polar or non-polar)
HCl	1+7=8e⁻		linear	3.0 − 2.1 = 0.9	Polar Covalent bond
CO_2	4+2(6)=16e⁻		linear	2.5 − 2.1 = 0.4	Non-polar covalent bond
CH_2O	4+2+6=12e⁻		trigonal pyramidal	C−H = 2.5−2.1=0.4 C−O = 3.5−2.5=1.0	→ Non-Polar covalent → Polar covalent bond
CO	4+6=10e⁻		linear	3.5−2.5=1.0	Polar covalent bond
NH_4^+	5+4=9−1 8e⁻		tetrahedral	3.0 − 2.1 = 0.9	Polar covalent
HCN	1+4+5=10e⁻		linear	H−C = 2.5−2.1=0.4 C−N = 3.0−2.5=0.5	→ nonpolar covalent bond → Polar covalent bond.
CH_3CH_2OH	C=8 H=6 O=6 /20e⁻		1- tetrahedral 2- tetrahedral 3- Bent	C−H = 2.5−2.1=0.4 O−H = 3.5−2.1=1.4 C−O = 3.5−2.5=1.0	→ nonpolar covalent bond → Polar covalent bond → polar covalent bond

4. Name the following binary molecular compounds:

Binary Molecular Compound	Name

CO	Carbon monoxide
P_4O_{10}	Tetraphosphrous decoxide
Cl_2O	Dichlorine monoxide
N_2O_4	Dinitrogen tetroxide
SO_3	Sulfur trioxide
SO_2	Sulfur dioxide

2. Classify each of these following compounds as polar or nonpolar molecules

(a) NH_3 → polar

(b) CH_4 → nonpolar

(c) CH_3Cl → polar