Chemical Bonds

Compound: A substance composed of two or more elements united chemically in definite proportions.

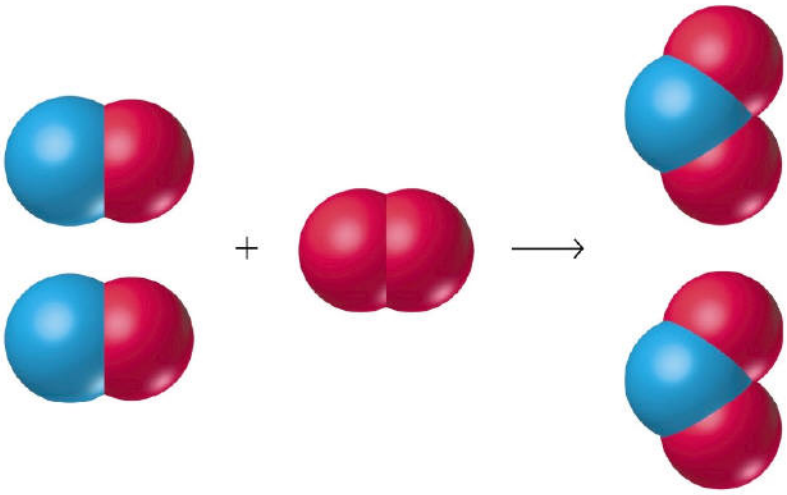
Molecule: A chemical combination of two or more atoms.

Chemical bonds: A strong attractive force that exists between atoms in a molecule.

Chemical reaction: Processes in which one or more substances are converted into other substances; also called chemical change.

Example of a chemical reaction:

$2\ NO + O_2 \rightarrow 2\ NO_2$



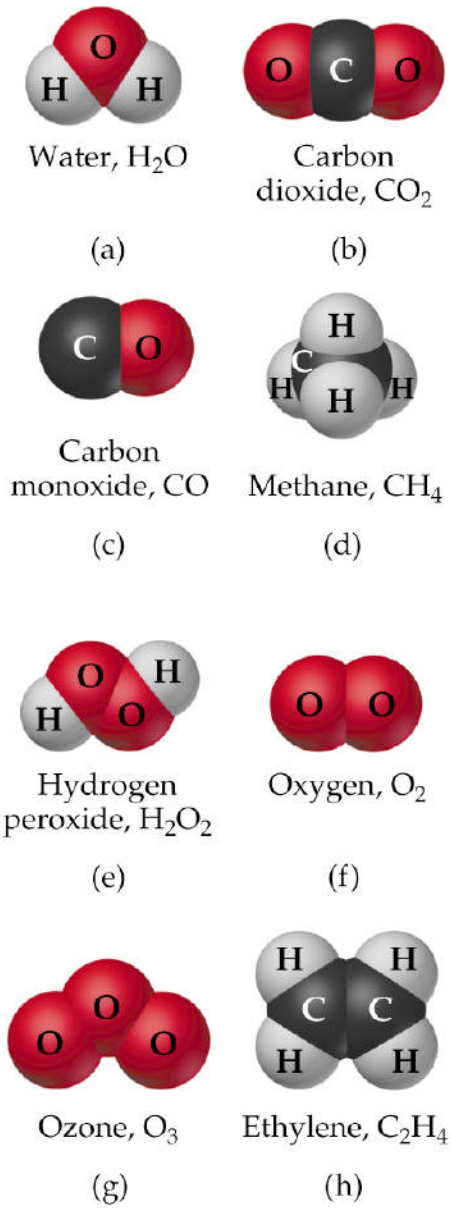
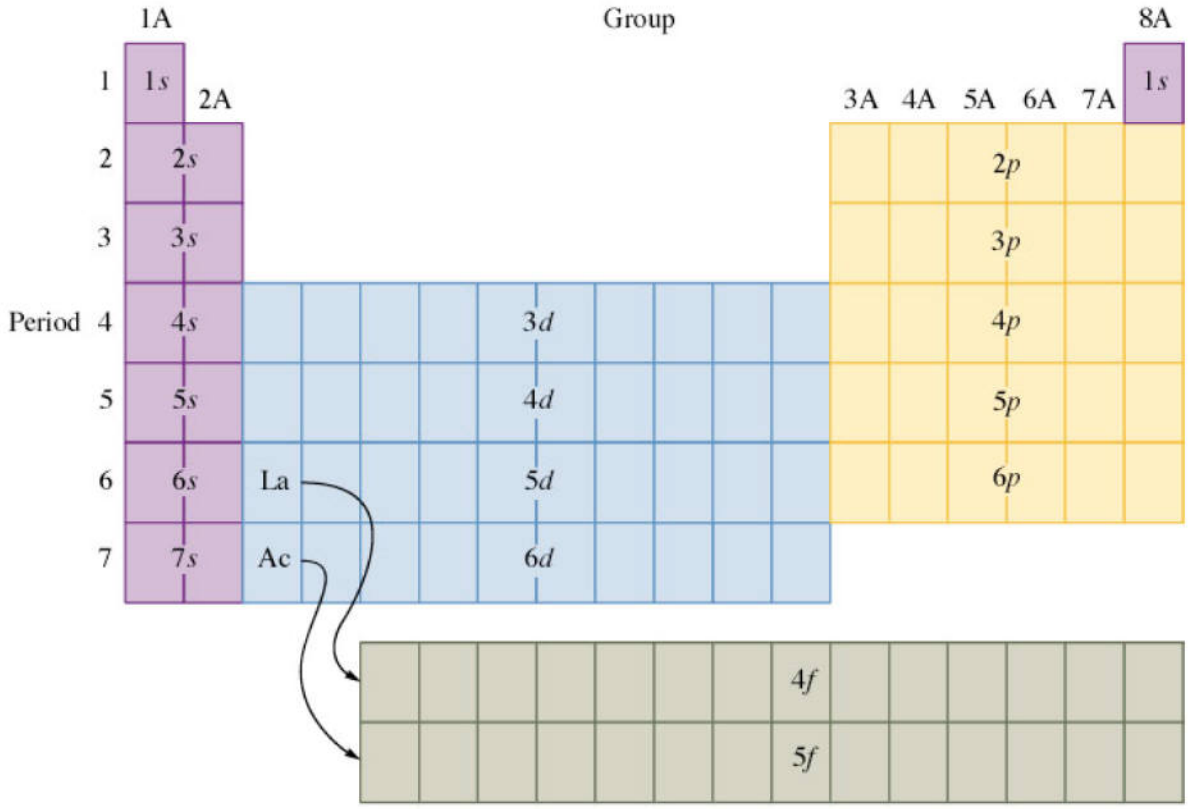


Figure on the left taken from Zumdahl, *Chemistry* and the picture on the right Figure taken from BLB *Chemistry; The Central Science*

Valence Electrons: those electrons in the atom's outermost shell and are responsible for determining the atom's chemistry.



Picture taken from Zumdahl, *Chemistry*

The number of valence electrons that an atom has is equal to the group number.

Noble Gases: Members of group 8A in the periodic table.

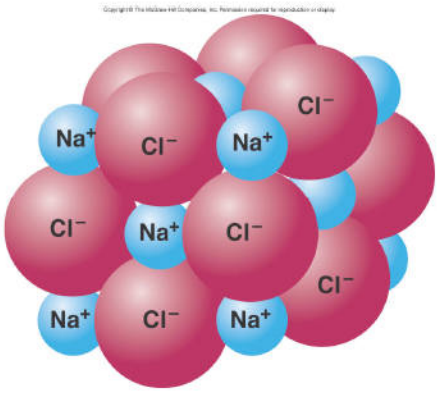
Stable Valence Electron Configurations:

Element	1st Energy level	2nd Energy level	3rd Energy level	4th Energy level
He	2 electrons			
Ne	2 electrons	8 electrons		
Ar	2 electrons	8 electrons	8 electrons	
Kr	2 electrons	8 electrons	18 electrons	8 electrons

Octet Rule: A rule stating that bonded atoms tend to possess or share a total of eight valence-shell electrons.

Any atom surround by eight valence electrons is very stable; similar in stability to the noble gases.

Classes of Chemical Compounds:



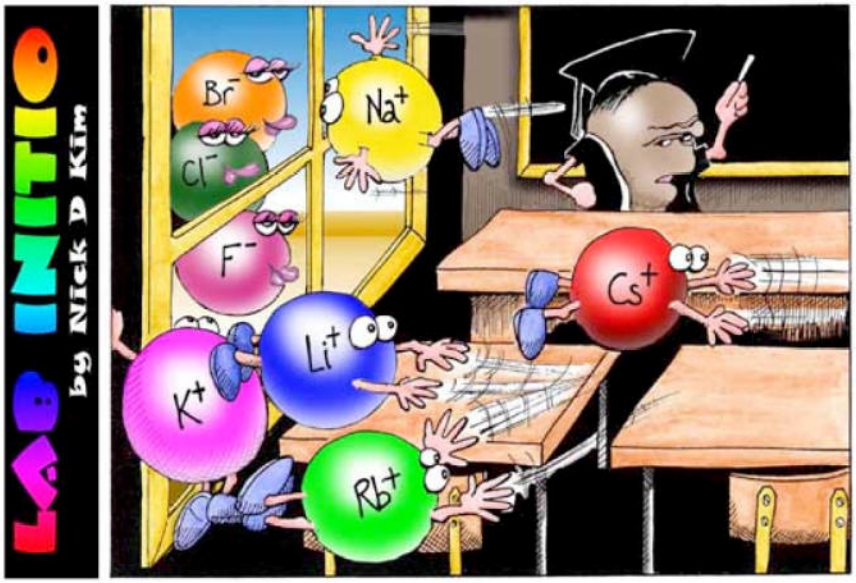
Ionic Compounds: A compound composed of cations and anions, held together by electrostatic attractions.

Ions: Electrically charged atom or groups of atoms; ions can be positively or negatively charged, depending on whether electrons are lost (positive) or gained (negative) by the atom.

Cation: A positively charged ion.

Anion: A negatively charged ion.

Electrostatic forces: The "glue" that holds ionic compounds together, opposite charges attract.



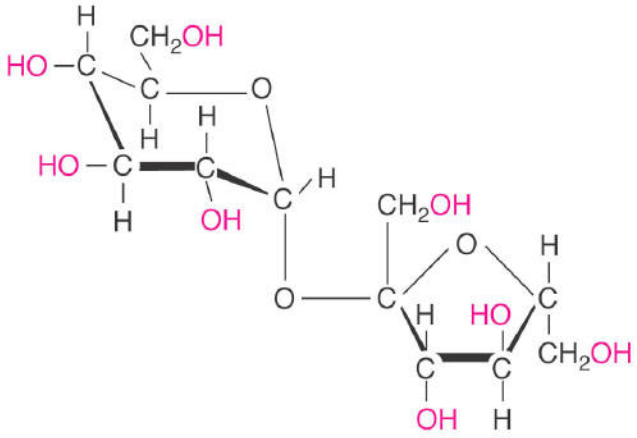
"Perhaps one of you gentlemen would mind telling me just what it is outside the window that you find so attractive...?"

Picture taken from (http://www.linuxgrrls.org/%7Enick/li/li166.jpg)

Covalent compounds: Formed by the sharing of valence electrons through covalent bonds.

Covalent bonds: A bond formed between two or more atoms by sharing electrons.

Molecular structure for sucrose, a covalent compound.



Lewis Dot Symbols: The chemical symbol for an element with a dot for each valence electron; also called electron-dot symbol.

TABLE 8.1 Lewis Symbols

Element	Electron Configuration	Lewis Symbol	Element	Electron Configuration	Lewis Symbol
Li	$[He]2s^1$	Li·	Na	$[Ne]3s^1$	Na·
Be	$[He]2s^2$	·Be·	Mg	$[Ne]3s^2$	·Mg·
B	$[He]2s^22p^1$	·$\dot{B}$·	Al	$[Ne]3s^23p^1$	·$\dot{Al}$·
C	$[He]2s^22p^2$	·$\dot{C}$·	Si	$[Ne]3s^23p^2$	·$\dot{Si}$·
N	$[He]2s^22p^3$	·$\dot{N}$:	P	$[Ne]3s^23p^3$	·$\dot{P}$:
O	$[He]2s^22p^4$	:$\dot{O}$:	S	$[Ne]3s^23p^4$	:$\dot{S}$:
F	$[He]2s^22p^5$	·$\ddot{F}$:	Cl	$[Ne]3s^23p^5$	·$\ddot{Cl}$:
Ne	$[He]2s^22p^6$	:$\ddot{Ne}$:	Ar	$[Ne]3s^23p^6$	:$\ddot{Ar}$:

Table taken from BLB; *Chemistry the Central Science*.

Example: Write Lewis symbols for the following elements: N, P, As, Al, and I.

Ionic Compounds:

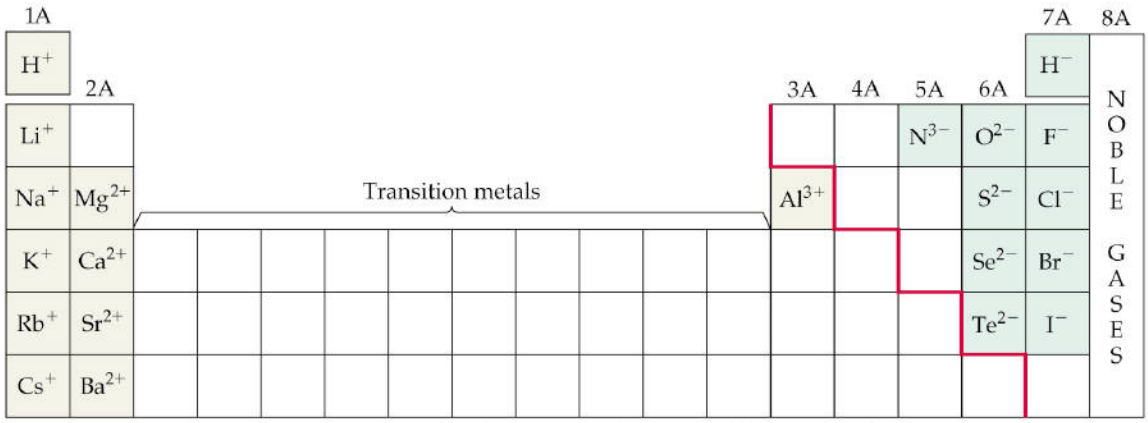


Figure taken from *BLB's Chemistry; The Central Science*; 9th edition.

Table 5.5

Comparison of a Sodium Atom with a Sodium Ion

Sodium Atom	Sodium Ion
Na	Na^+
11 protons	11 protons
11 electrons	10 electrons
Net charge: zero	***Net*** charge: +1

Table 5.6

Comparison of a Chlorine Atom with a Chloride Ion

Chlorine Atom	Chloride Ion
Cl	Cl^-
17 protons	17 protons
17 electrons	18 electrons
Net charge: zero	***Net*** charge: −1

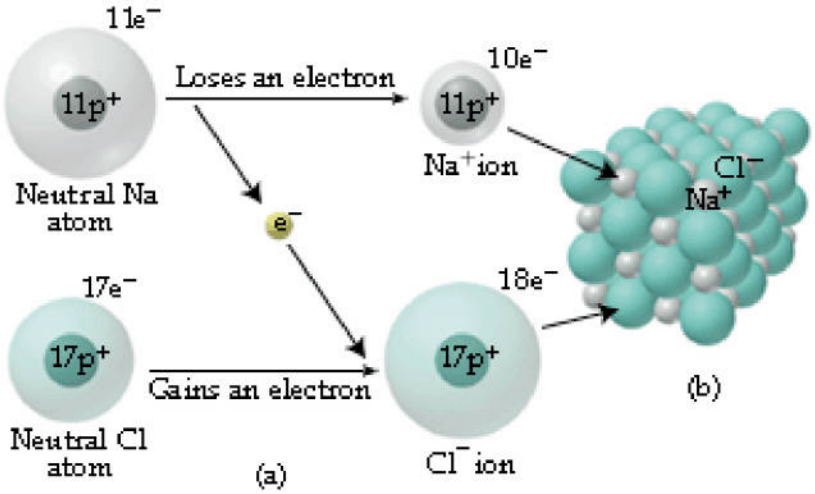


Figure taken from BLB's *Chemistry; The Central Science*

Ionic Bond: The attraction between cations and anions that hold the compound together.

Chemical Formula: A notation that uses chemical symbols with numerical subscripts to convey the relative proportions of atoms of the different elements in a substance.

Example: Give the chemical formula for the ionic compound formed between:

a) Magnesium and Sulfur
b) Calcium and Chlorine
c) Aluminum and Oxygen

Crossover Method: Used to predict the formula for an ionic compound.

Summary for ionic compounds:

- Comprised between a metal and a nonmetal.
- Held together by electrostatic attraction…NO BONDS!
- Use the crossover method to help predict chemical formulas for ionic compounds.

Covalent Compounds:

Covalent compounds are formed through the sharing of electrons so that each atom is surrounded by 8 valence electrons.

This is accomplished by forming covalent bonds.

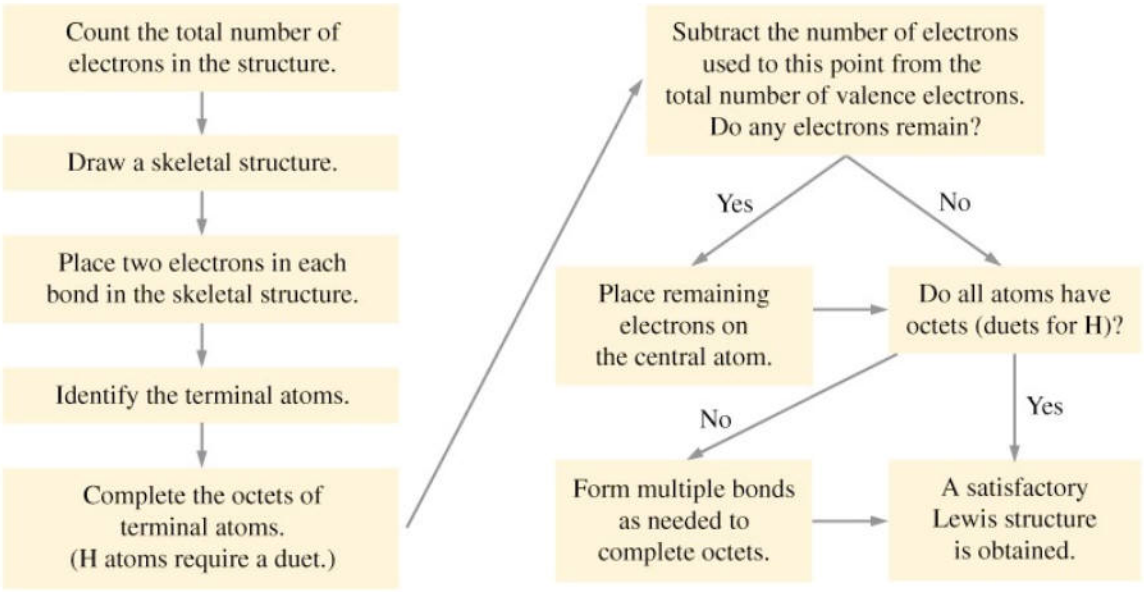
Single Bond: A covalent bond involving one electron pair.

Double Bond: A covalent bond involving two electron pairs.

Triple Bond: A covalent bond involving three electron pairs.

Lewis Dot Structures: A representation of covalent bonding in a molecule that is drawn using Lewis symbols. Shared electron pairs are shown as lines, and unshared electron pairs are shown as pairs of dots. Only the valence-shell electrons are shown.

Guidelines for writing Lewis Dot Structures:



Picture taken from PHH; *General Chemistry*.

Example: Write the Lewis Dot Structures for the following compounds: CH_4, BF_3, SO_2, CO, CH_3CH_2OH, and SO_4^{2-}.

Isomers: Compounds whose molecules have the same overall composition but different structures.

Example: $C_4H_{10}O$, Butanol and Diethyl ether.

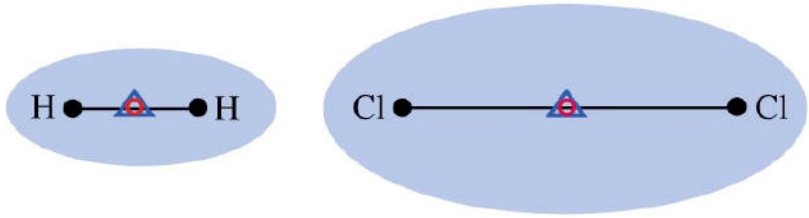
Physical Properties of Butanol and Diethyl ether:

Property	Butanol	Diethyl ether
Molecular Formula	$C_4H_{10}O$	$C_4H_{10}O$
Molecular Weight	74.12 g/mol	74.12 g/mol
Boiling Point	117.7 °C	34.6 °C
Density	0.810 g/mL	0.706 g/mL

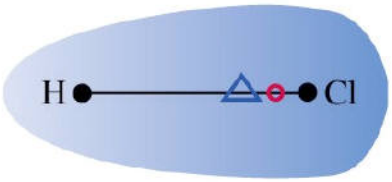
Equal Sharing vs. Unequal Sharing:

Polar: Means a separation of charge in a molecule. Polar molecules contain a region of positive charge and a region of negative charge.

Nonpolar Covalent Bond: A covalent bond in which the electrons are shared equally.



(a) Nonpolar covalent bonds



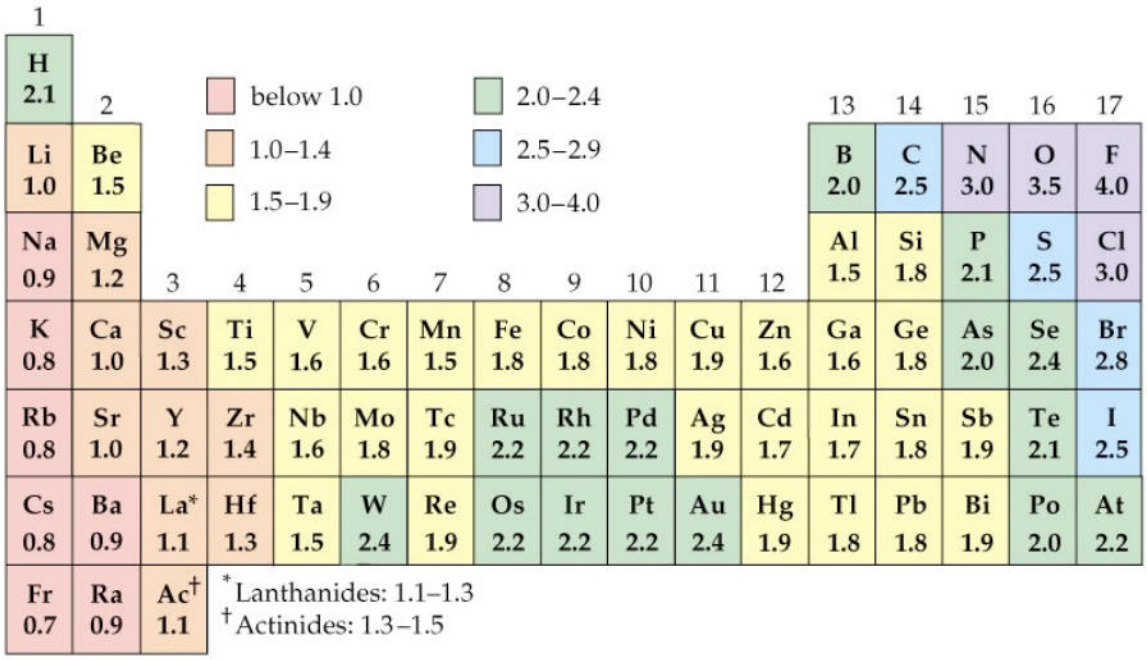
(b) Polar covalent bond

● = Atomic nucleus
△ = Center of positive charge
○ = Center of negative charge

Picture taken from PHH; *General Chemistry*; 8th edition

Polar Covalent Bond: A covalent bond in which the electrons are not shared equally.

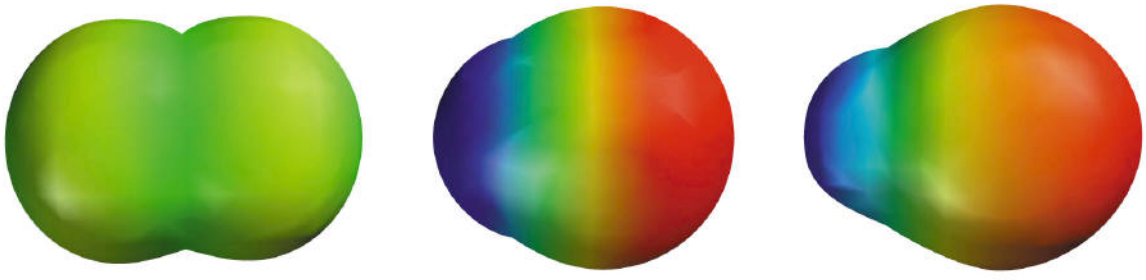
Electronegativity: A measure of the ability of an atom that is bonded to another atom to attract electrons to itself.



Picture taken from PHH; *General Chemistry*

Dipole: A molecule with one end having a slight negative charge and the other end having a slight positive charge, a polar molecule.

Dipole moment: A measure of the separation between the positive and negative charges in polar molecules.



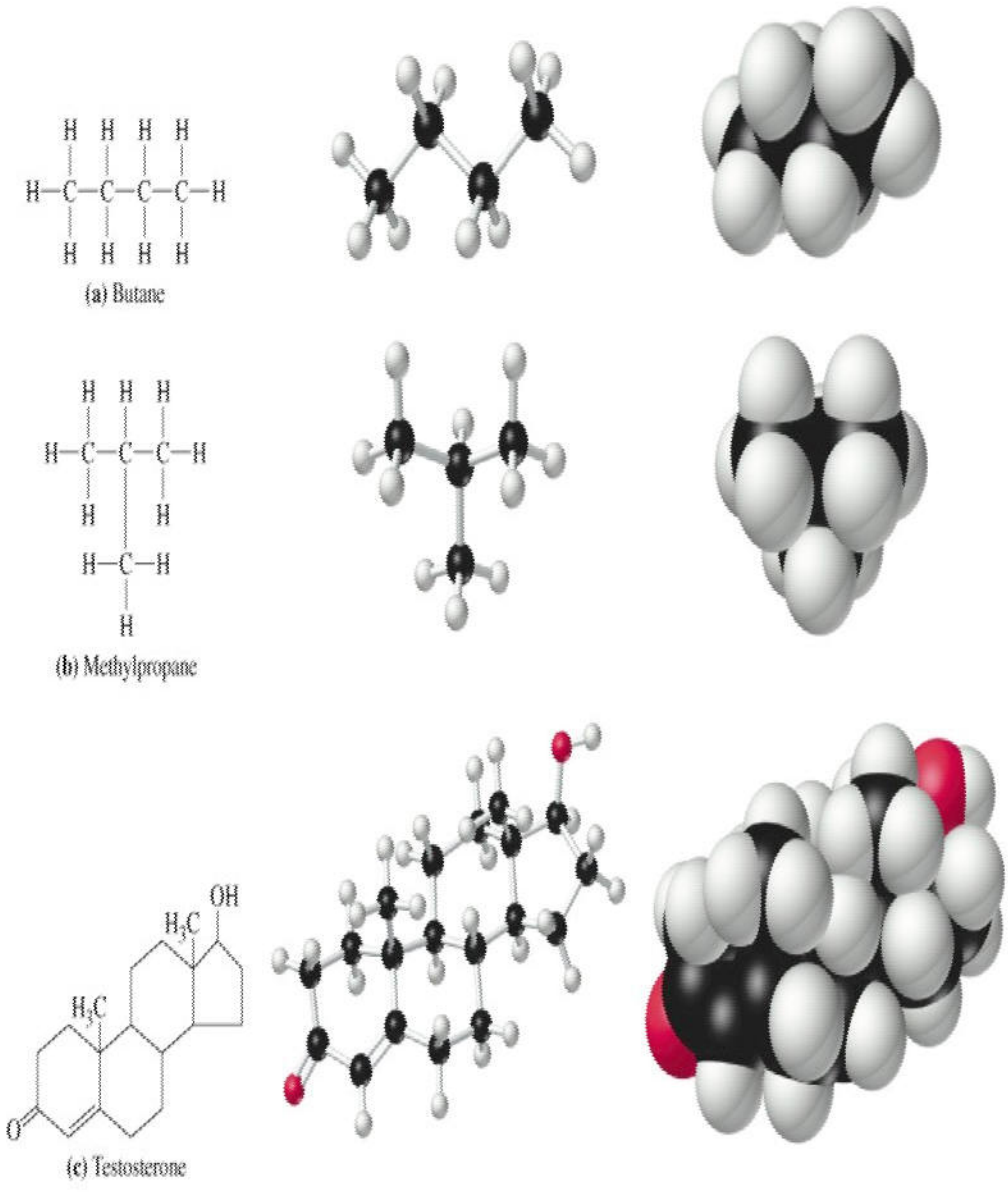
F_2 HF LiF

Picture taken from BLB; *Chemistry, The Central Science*

Structures:

Structural formulas: A formula that shows not only the number and kinds of atoms in the molecule but also the arrangement of the atoms.

Types of Models Used to Represent Structures:

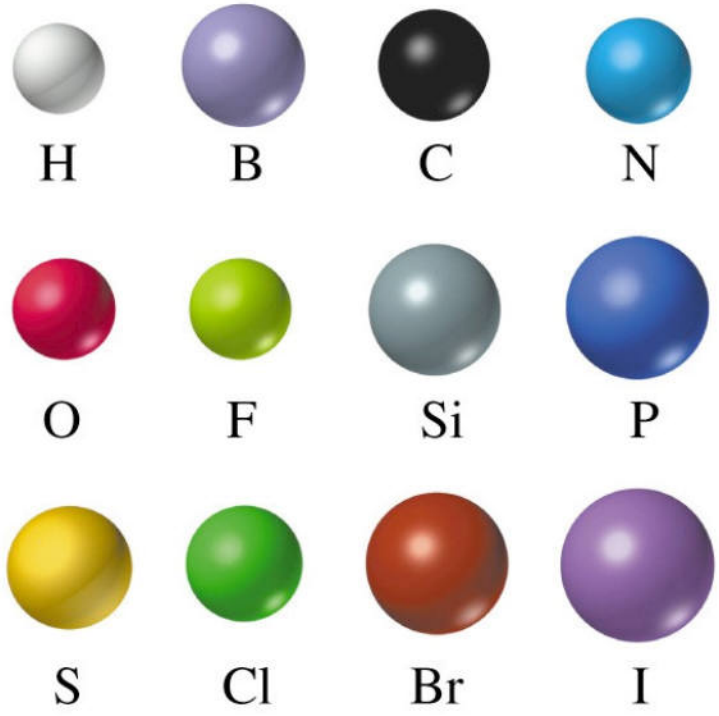


Picture taken from PHH; *General Chemistry*

Space-Filling Models: Depicts what the molecule would look like if the atoms were scaled up in size.

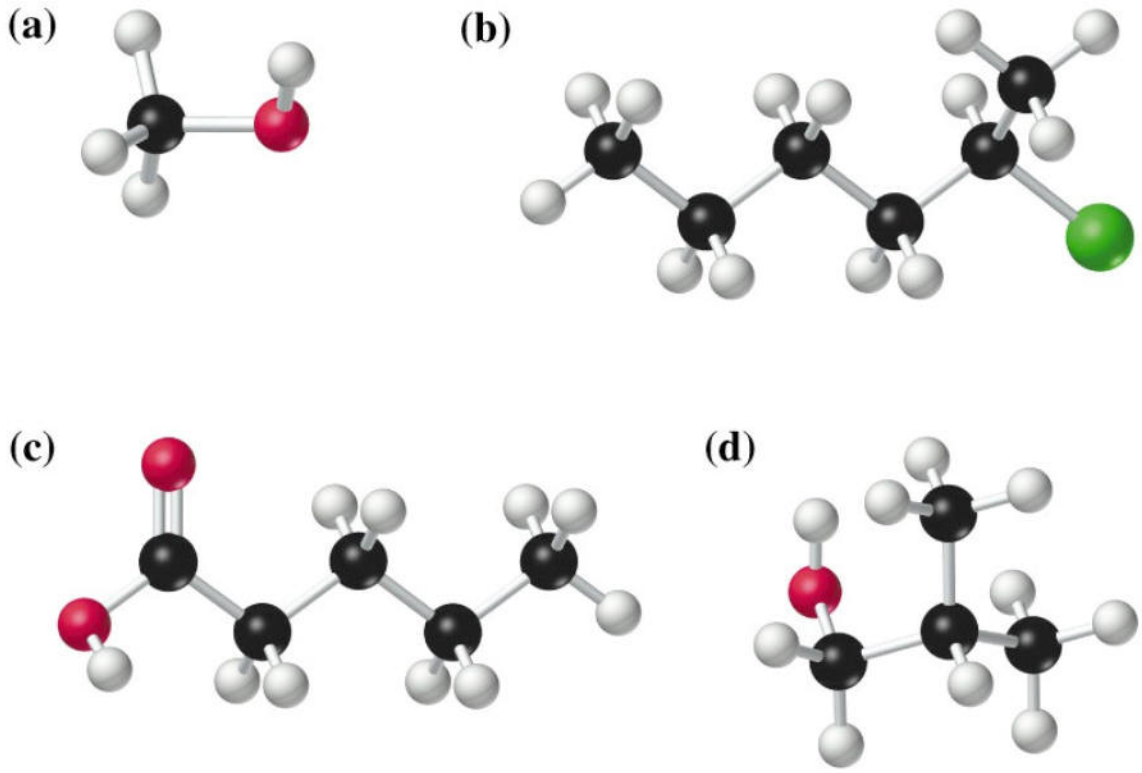
Ball-and-Stick Model: Shows the atoms as spheres and the bonds as sticks, and they accurately represent the angles at which the atoms are attached to one another within the molecule.

Line Art: Assumes that any point of connection between lines is a carbon atom that contains sufficient bonded hydrogen atoms to achieve the four bonds necessary for carbon.



Picture taken from PHH; *General Chemistry*

Example: Give the condensed structural formula and the molecular weight of the molecule whose ball-and-stick model is shown. Refer to the color scheme on the previous overhead.



Picture taken from PHH; *General Chemistry*

One Last Example: Below is the line art structure for aspirin. Predict the chemical formula for aspirin.