

Ch. 9 NOTES ~ Chemical Bonding

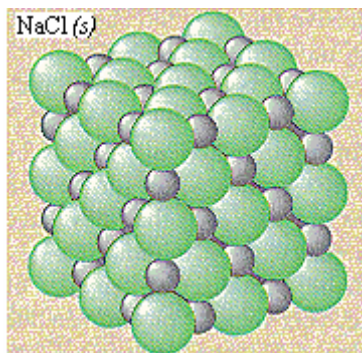
NOTE: Vocabulary terms are in **boldface and underlined**. Supporting details are in *italics*.

I. Review: Comparison of ionic and molecular compounds

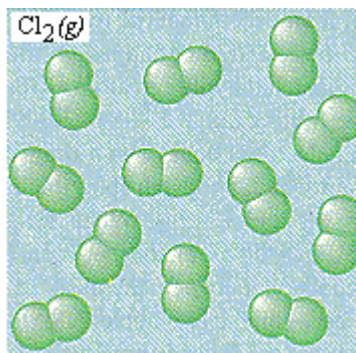
	<i>Molecular compounds</i>	<i>Ionic compounds</i>
Particles	<i>Molecules</i>	<i>Formula units</i> made of ions (cations & anions)
Elements	Nonmetals	Metals & nonmetals
Conductivity	Low “nonelectrolytes”	High (when molten or in aqueous solution) “ <i>electrolytes</i> ”
State at room temp.	Solid, liquid, or gas	Solid
Type of Bond	Polar or nonpolar <i>covalent</i>	<i>Ionic</i>
Misc.	Covalent compounds	<i>Salts</i>

II. Review of bonding

- A. **ionic bonding**—*chemical attraction between a positive ion (cation) and a negative ion (anion)*
- metals and nonmetals
 - **formula unit**—the *lowest whole-number ratio of ions* in an ionic compound
- B. **covalent bonding**—*electron sharing*
- nonmetals only
 - **molecule**—a covalent compound existing as *defined molecules, not formula units*
- a) **single covalent bond**—a *sharing of electrons between two atoms*
- a) consists of *one electron from each partner*
 - b) *weaker than an ionic bond*
- 2) **double covalent bond**—*sharing two pairs of electrons*
- 3) **triple covalent bond**—*sharing three pairs of electrons*



repeating formula units



molecules

III. Electronegativity

- A. **electronegativity**—the “*greediness*” of an atom for electrons when bonding
- B. group trends: electronegativity decreases from top to bottom
- C. periodic trends: electronegativity increases from left to right

D. $\Delta \text{EN} = \text{electronegativity differences}$ (more detailed than the textbook)

0.0 – 0.4	nonpolar covalent
0.4 – 1.0	moderately polar covalent
1.0 – 2.0	very polar covalent
> 2.0	ionic

Electronegativity Values

1 H 2.1																	2 He
3 Li 1.0	4 Be 1.5											5 B 2.0	6 C 2.5	7 N 3.0	8 O 3.5	9 F 4.0	10 Ne
11 Na 0.9	12 Mg 1.2											13 Al 1.5	14 Si 1.8	15 P 2.1	16 S 2.5	17 Cl 3.0	18 Ar
19 K 0.8	20 Ca 1.0	21 Sc 1.3	22 Ti 1.5	23 V 1.6	24 Cr 1.6	25 Mn 1.5	26 Fe 1.8	27 Co 1.8	28 Ni 1.8	29 Cu 1.9	30 Zn 1.6	31 Ga 1.6	32 Ge 1.8	33 As 2.0	34 Se 2.4	35 Br 2.8	36 Kr
37 Rb 0.8	38 Sr 1.0	39 Y 1.2	40 Zr 1.4	41 Nb 1.6	42 Mo 1.8	43 Tc 1.9	44 Ru 2.2	45 Rh 2.2	46 Pd 2.2	47 Ag 1.9	48 Cd 1.7	49 In 1.7	50 Sn 1.8	51 Sb 1.9	52 Te 2.1	53 I 2.5	54 Xe
55 Cs 0.7	56 Ba 0.9	71 Lu 1.3	72 Hf 1.3	73 Ta 1.5	74 W 1.7	75 Re 1.9	76 Os 2.2	77 Ir 2.2	78 Pt 2.2	79 Au 2.4	80 Hg 1.9	81 Tl 1.8	82 Pb 1.9	83 Bi 1.9	84 Po 2.0	85 At 2.2	86 Rn
87 Fr 0.7	88 Ra 0.9	103 Lr															

57 La 1.1	58 Ce 1.1	59 Pr 1.1	60 Nd 1.1	61 Pm 1.2	62 Sm 1.2	63 Eu 1.1	64 Gd 1.2	65 Tb 1.2	66 Dy 1.2	67 Ho 1.2	68 Er 1.2	69 Tm 1.2	70 Yb 1.2
89 Ac 1.1	90 Th 1.3	91 Pa 1.5	92 U 1.7	93 Np 1.3	94 Pu 1.3	95 Am 1.3	96 Cm 1.3	97 Bk 1.3	98 Cf 1.3	99 Es 1.3	100 Fm 1.3	101 Md 1.3	102 No 1.5

E. Examples

- E1) HF Classify the bond between H and F based on electronegativity differences.
4.0 – 2.1 = 1.9 very polar covalent
- E2) OF₂ Classify the bond between O and F based on electronegativity differences.
4.0 – 3.5 = 0.5 moderately polar covalent
- E3) Fe₂O₃ Classify the bond between Fe and O based on electronegativity differences.
3.5 – 1.8 = 1.7 very polar covalent

This gives you more detailed information about bond strength than just generalizing BI, BM, TI, etc...

IV. Polar Bonds and Polar Molecules

- A. **polar bond (polar covalent bond)**—a covalent bond with *unequal sharing* of electrons (unequal “pull” or preference)
- 1) a **polar molecule** has an *asymmetrical* molecular shape
 - 2) *partially positive* = δ^+ *partially negative* = δ^-
 - 3) because of the two ends, a polar molecule is also called a **dipole**
- B. **nonpolar covalent bond**—a covalent bond with *equal sharing of electrons*
- 1) examples: diatomic molecules
 - 2) symmetrical molecular shape
- C. Every element has an electronegativity value assigned to it.
Electronegativity differences determine bond strength.



NONPOLAR molecule



POLAR molecule (a dipole)

V. Intermolecular Attractions

- A. *intermolecular attractions*—forces *between molecules* (not bonds)
- B. categories
- 1) **van der Waals forces**—*weak* intermolecular attractions
 - a) **dispersion forces** (also called *London forces*)
 - the *weakest* force between molecules
 - between *two nonpolar* molecules
 - b) **dipole interactions** (also called *dipole-dipole forces*)
between *two polar* molecules
 - 2) **hydrogen bonds**—an attraction between hydrogen and an unshared pair of an electronegative element on a neighboring molecule
 - a) shown as a dotted line between molecules
 - b) not an actual bond between atoms
 - c) *strongest* intermolecular force

VI. Molecular Shape: VSEPR Theory

- A. **VSEPR theory** = *Valence Shell Electron Pair Repulsion* theory
- B. valence electrons repel themselves as far apart as possible

- C. VSEPR predicts 3-D geometric shapes of molecules based on the numbers of bonding and nonbonding pairs on the central atom
 D. a double or a triple bond is treated as one main bonding “arm”
 E. electron dot diagrams (Lewis structures) are used to predict models’ shapes

“right, left, up, down, top all the way around.”

3 5			
2	SYMBOL	1	
6		8	
4 7			
K •	• Ca •	• Al •	• C •
one unshared e- 1 bond can form	two unshared e- 2 bonds can form	three unshared e- 3 bonds can form	four unshared e- 4 bonds can form
• N •	• O •	• Cl •	• Ar •
three unshared e- one nonbonding pair 3 bonds can form	two unshared e- 2 nonbonding pairs 2 bonds can form	one unshared e- 3 nonbonding pairs 1 bond can form	NO unshared e- 4 nonbonding pairs NO bonds can form

VSEPR SHAPES

# BONDING PAIRS OF CENTRAL ATOM	# NONBONDING PAIRS OF CENTRAL ATOM	SHAPE	BOND ANGLE
2	0	linear	180°
2	1	angular (bent)	~120°
2	2	angular (bent)	109.5°
3	0	trigonal planar (triangular planar)	120°
3	1	pyramidal (trigonal pyramidal)	<109.5°
4	0	tetrahedral	109.5°
5	0	trigonal bipyramidal	90° & 120°
6	0	octahedral	90°

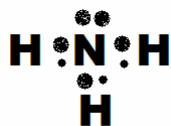
F. examples

E4) What is the shape of a BF₃ molecule?



The central atom is B, which has 3 bonding and 0 nonbonding pairs. (3,0) = trigonal planar

E5) What is the shape of an NH_3 molecule?



The central atom is N, which has 3 bonding pairs and 1 nonbonding pair. (3,1) = pyramidal

VSEPR MODELS

