Ch. 4 NOTES ~ Formation of Compounds

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

I. Element Review

THE SEVEN DIATOMIC MOLECULES ("Super Seven"):
H_2 F_2 O_2 N_2 Cl_2 Br_2 I_2

THE METALLOIDS: B, Si, Ge, As, Sb, Te, Po, At

COMMON ELEMENTS TO KNOW (symbols and names):
Ag, Al, Ar, As, Au, B, Ba, Be, Bi, Br, C, Ca, Cl, Co, Cr, Cs, Cu, F, Fe, Fr, H, He, Hg, I, K, Kr, Li, Mg, Mn, N, Na, Ne, Ni, O, P, Pb, Ra, Rb, S, Sb, Si, Sr, Sn, U, W, Zn

II. Valence Electron Review

A. **Valence electrons**—the *electrons in the highest energy level* of at atom ("highest shell" or highest n)
   1) tells *how many are available for bonding*
   2) tells *how many e- will be gained or lost in forming ions*

GROUP #:	VALENCE # OUT OF 8:	USUALLY, WHEN FORMING IONS:
Group IA	1	loses 1
Group IIA	2	loses 2
Group IIIA	3	loses 3
Group IVA	4	can lose or gain
Group VA	5	gains 3
Group VIA	6	gains 2
Group VIIA	7	gains 1
Group VIIIA	8	does not form ions

B. Review electron dot diagrams (Lewis structures)

III. Atoms and Ions

A. *atomic neutrality: atoms are neutral (net charge of zero) # protons = # electrons*
B. **ion**—*a charged atom(s) or a charged group of atoms*
   1) formed by gain or loss of electrons
   2) **cation**— *a positive ion formed by losing electrons*
   3) **anion**— *a negative ion formed by gaining electrons*
      - *common ending is —IDE* (chloride, bromide, iodide...)
      - *ions of Group VIIA*, the halogens, are called *halide ions*

CP AN Cations Positive, Anions Negative "Cat People Are Nice"
YOU CAN'T LOSE OR GAIN PROTONS TO FORM AN ION !

   4) an ion has different properties than its element (Na atom vs. Na^+ ion)
   5) examples...

Q: Aluminum loses three electrons when its ion is formed. Write its symbol and charge. A: Al^{3+}

Q: Oxygen gains two electrons when its ion is formed. Write its symbol and charge. A: O^{2-}

IV. 4.1 Notes: The Variety of Compounds

** properties of individual elements may differ from their ions

** properties of individual elements may differ from the compounds they can form

NAME	SYMBOL	PHYSICAL STATE at room temp.	PROPERTIES
sodium	Na	solid	1) metal 2) silver-white 3) soft 4) reacts violently with H_2O and O_2
chlorine	Cl_2	gas	1) nonmetal 2) greenish 3) poisonous 4) stinging odor 5) disinfectant
sodium chloride	NaCl	solid	1) white crystals 2) soluble in water 3) important to cells 4) stable
carbon	C	solid	1) nonmetal 2) brown to black 3) main ingredient of charcoal and coal 4) burns at high temperatures 5) main component of organic chemicals
oxygen	O_2	gas	1) nonmetal 2) colorless 3) odorless 4) vital to living organisms
carbon dioxide	CO_2	gas	1) colorless 2) odorless 3) stable 4) dissolves in water
hydrogen	H_2	gas	1) nonmetal 2) flammable 3) colorless
oxygen	O_2	gas	1) nonmetal 2) colorless 3) odorless 4) vital to living organisms
water	H_2O	liquid	1) colorless 2) odorless 3) stable 4) vital to living organisms

4.2 Notes: *How elements form compounds*

V. **Octet Rule**
- A. *reactivity of atoms is based on achieving a complete octet (8/8)*
- B. *atoms in compounds tend to have a stable* **Noble Gas configuration**
- C. *exceptions* to the Octet Rule
  1) atoms of *transition metals*
  2) they achieve a **pseudo-Noble Gas configuration**
  3) examples: Ag^{+}, Cu^{+}, Au^{+}, Cd^{2+}, Hg^{2+}

VI. Ways to achieve a stable outer energy level
- A. *transferring of electrons* = **ionic bond**
- B. *sharing of electrons* = **covalent bond**

VII. Formation of **Ionic Compounds** *(electron transfer)*
- A. **ionic bond**—*a chemical attraction between positive ions (cation) and a negative ion (anion)*
- B. *total of positive charges = total of negative charges*
- C. **Noble Gas configurations** of both ions are achieved
- D. *electronegativity differences are large*
  1) the cation is not electronegative ("not greedy" or electropositive) and will let its electron(s) be taken
  2) the anion is more electronegative ("greedy") and will take the electron(s)
- E. **formula unit**— the *lowest whole-number ratio of ions* in an ionic compound
  1) do not use the term "molecule" to describe an ionic compound
  2) ionic compounds occur in *repeating units in their crystals*
- F. *crystalline solids*—a structure containing *3-D repeating patterns* of formula units
  1) crystals are arranged in a *positive-negative alternating setup*:

Na+	Cl-	Na+	Cl-	Na+	Cl-	Na+	Cl-	Na+	Cl-	Na+	Cl-
Cl-	Na+	Cl-	Na+	Cl-	Na+	Cl-	Na+	Cl-	Na+	Cl-	Na+
Na+	Cl-	Na+	Cl-	Na+	Cl-	Na+	Cl-	Na+	Cl-	Na+	Cl-
Cl-	Na+	Cl-	Na+	Cl-	Na+	Cl-	Na+	Cl-	Na+	Cl-	Na+

  2) examples of crystal shapes: SC, BCC, FCC, HCP…
  3) setup is called a **crystal lattice** which is hard and brittle
  4) *salt—any ionic compound,* not just sodium chloride

VIII. Cations and Anions in ionic compounds
- A. formation of **cations**
  1) the **octet rule** applies
  2) examples
     a) Sodium has one valence electron. It is easier for it to lose that one than it is to gain seven more to complete the "shell." It forms a 1+ ion, exposing its filled n = 2 shell.

$$Na \rightarrow Na^{+} + e^{-}$$

The sodium ion has the Noble Gas configuration of neon (10 e-), but it still has a nucleus with 11 protons, keeping it an ion of sodium.

b) Aluminum has three valence electrons. It is easier to lose three than to gain five. It forms a 3+ ion, exposing its filled n = 2 shell.

$Al \rightarrow Al^{3+} + 3e^-$

The aluminum ion has the Noble Gas configuration of neon (10 e-), but it still has a nucleus with 13 protons, keeping it an ion of aluminum.

B. formation of **anions**

1) the **octet rule** applies
2) *common ending is —IDE* (chloride, sulfide, oxide...)
3) examples

a) Chlorine has seven valence electrons. It only needs one more to achieve a Noble Gas configuration. It forms a 1- ion and has the configuration of argon.

$Cl + e^- \rightarrow Cl^-$

The chloride ion has the Noble Gas configuration of argon (18 e-), but it still has a nucleus with 17 protons, keeping it an ion of Cl.

b) Sulfur has six valence electrons. It only needs two more to achieve a Noble Gas configuration. It forms a 2- ion and has the configuration of argon.

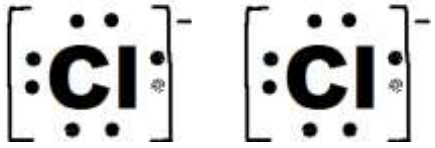
$S + 2\,e^- \rightarrow S^{2-}$

The sulfide ion has the Noble Gas configuration of argon (18 e-), but it still has a nucleus with 16 protons, keeping it an ion of S.

IX. Electron Dot Diagrams for Ionic Compounds

sodium atom chlorine atom → → sodium ion chloride ion

"sodium chloride"



aluminum atom chlorine atom → → aluminum ion chloride ions

"aluminum chloride"

(three chlorines are needed to balance the charges)

X. Formation of **Covalent Compounds** *(electron sharing)*

A. **single covalent bond**—a *sharing* of electrons between two atoms
   1) consists of *one electron from each partner*
   2) *weaker than an ionic bond*
   3) smaller difference in electronegativity between the bonding partners
   4) bonding will occur to achieve a Noble Gas valence configuration

B. **structural formula**—set of symbols showing the *arrangement* and *bonding patterns* of atoms

C. **molecule**—a covalent compound existing as *defined molecules, not formula units*

XI. Multiple Covalent Bonds: Double and Triple Bonds

A. **double covalent bond**—sharing *two pairs* of electrons

B. **triple covalent bond**—sharing *three pairs* of electrons

XII. Electron Dot Diagrams for Covalent Compounds

A. remember the octet rule (no lone electron dots when finished)

B. draw each electron dot diagram using the "A" group numbers

C. make the compound by combining the individual structures

D. examples

1) single bonds

single boron atom with three fluorines → **boron trifluoride**

2) double bonds

single O atom **single O atom** → **diatomic oxygen molecule**

3) triple bonds

2 nitrogen atoms → **diatomic nitrogen molecule**

XIII. Coordinate Covalent Bonds

A. **<u>coordinate covalent bond</u>**—a covalent bond consisting of *two electrons donated by a single atom*

3) achieves stable configurations
4) behaves as a normal covalent bond
5) shown by a long arrow

B. example

ammonia **hydrogen ion** → **OR** **ammonium ion**

XIV. Comparison of ionic and molecular compounds

Table: Comparison of characteristics

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