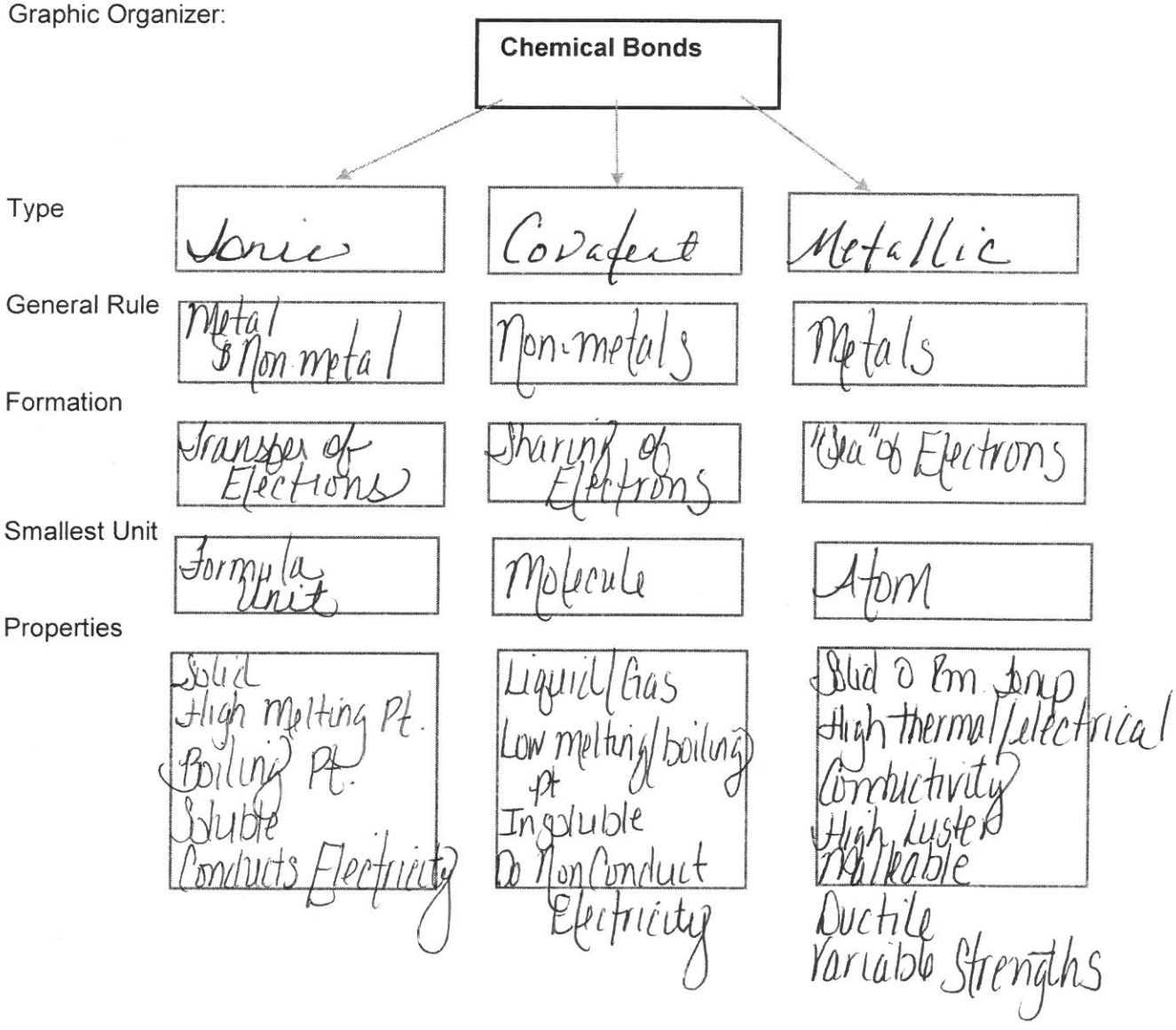
Name: Answer Key Date: _____ Period: ___

"Chemical Bonding"

1. What is a chemical bond? An attraction between atoms that enables the formation of compounds
2. Why do bonds form? Chemical bonds form so that atoms could become more stable
3. What are the three main types of chemical bonds? Ionic bonds, Covalent bonds and metallic bonds

Graphic Organizer:



I. Ionic Bonds are formed by the transfer of valence electrons, from a metal to a nonmetal. The metal atom will become a positive ion (cation), while the nonmetal atom will become a negative ion (anion). An ionic bond forms when the positive ions and negative ions attract each other (electrostatic attraction). Note: Even though we say a transfer of the valence electrons from metal atom to nonmetal atom, there's still some sharing. An ionic compound is made of ionic bonds between ions in a crystalline structure.

A. **Formation of Binary Ionic Compounds from main body elements - IA, IIA, IIIA, VA, VIA, VIIA** (not using transition metals yet, B group)

1. **Monatomic ion** – an ion consisting of a single atom.
   Examples: Ca^{+2} Na^{+1} Li^{+1}
2. **Binary ionic compound** – is composed of two different types of atoms. The first being a positive ion and the second a negative ion.
   Examples: $NaCl^{-}$ $Ca^{+2}Cl_2^{-}$ KCl^{-}

B. **Lewis Dot Diagram of the formation of a binary ionic compound**

Example 1: From groups IA and VIIA.

metal		**nonmetal**
lithium	and	chlorine

Lewis Dot Diagram: Li· ·Cl:

Show Transfer: Li· → $[Li]^{(+)}$ $:Cl:^{(-)}$

Formula: LiCl

- metal ion first
- subscripts tell how many of each ion
- nonmetal ion nect
- subscripts tell how many of each ion

Naming the Ionic Compound: Lithium Chloride

- name metal ion first (just the metal's name)
- Change ending on nonmetal **from -ine, -orus, -ygen etc.** (atom) to **–ide** (ion)

Example 2: From groups IA and VIIA.

metal		**nonmetal**
sodium	and	bromine

Lewis Dot Diagram:

Show Transfer:

Formula: Sodium Bromide

- metal ion first
- subscripts tell how many of each ion
- nonmetal ion nect
- subscripts tell how many of each ion

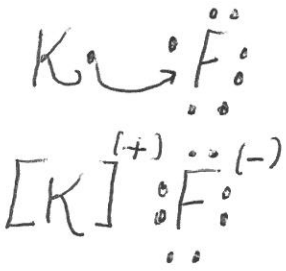
Naming the Ionic Compound: Potassium Fluoride

- name metal ion first (just the metal's name)
- Change ending on nonmetal **from -ine, -orus, -ygen etc.** (atom) to **–ide** (ion)

Example 3: From groups IA and VIIA.

metal		**nonmetal**
potassium	and	fluorine

You Do! (Draw Lewis Diagram, Show Transfer, Write Formula, Name Compound)



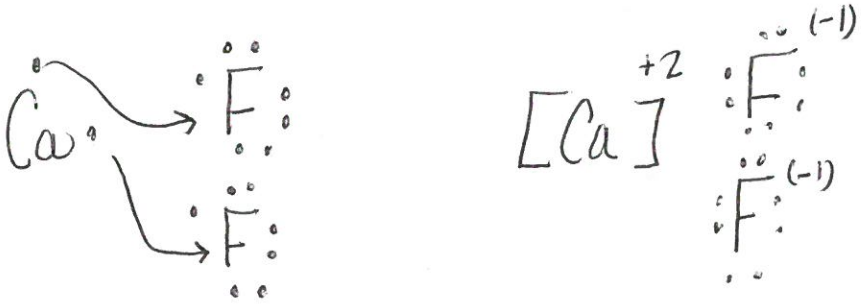
Potassium fluoride

Example 4: From groups IIA and VIIA.

metal		**nonmetal**
calcium	and	fluorine

Lewis Dot Diagram:

Show Transfer:



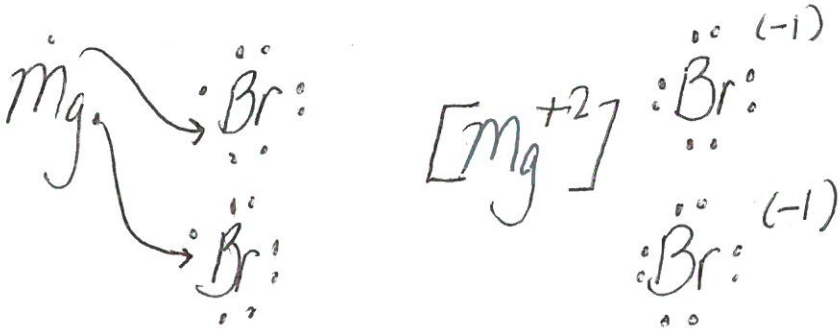
Formula: CaF_2

Naming the Ionic Compound: Calcium Fluoride

You Do! (Draw Lewis Diagram, Show Transfer, Write Formula, Name Compound)

Example 5: From groups IIA and VIIA.

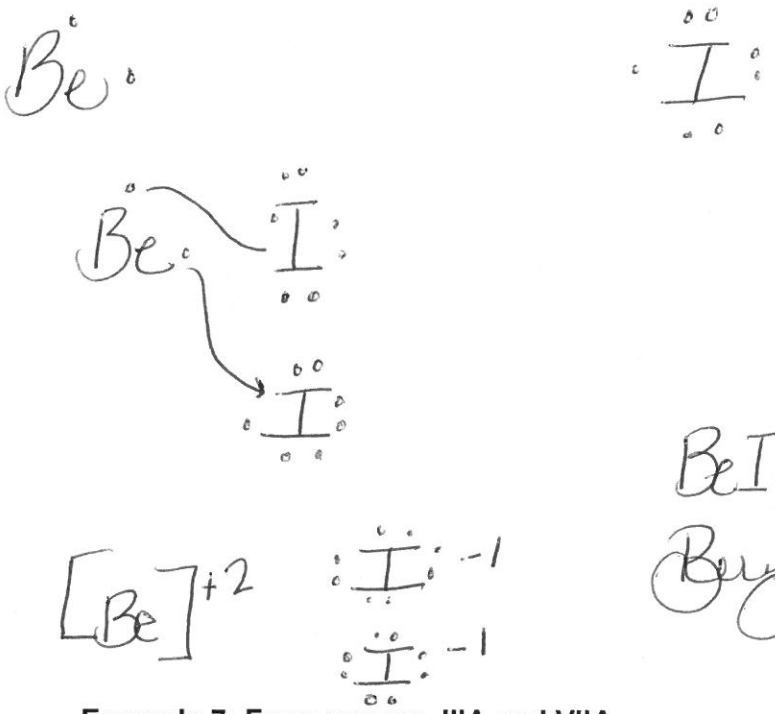
metal		**nonmetal**
magnesium	and	bromine



$MgBr_2$ Magnesium Bromide

Example 6: From groups IIA and VIIA.

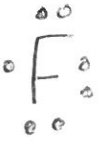
metal		**nonmetal**
beryllium	and	iodine



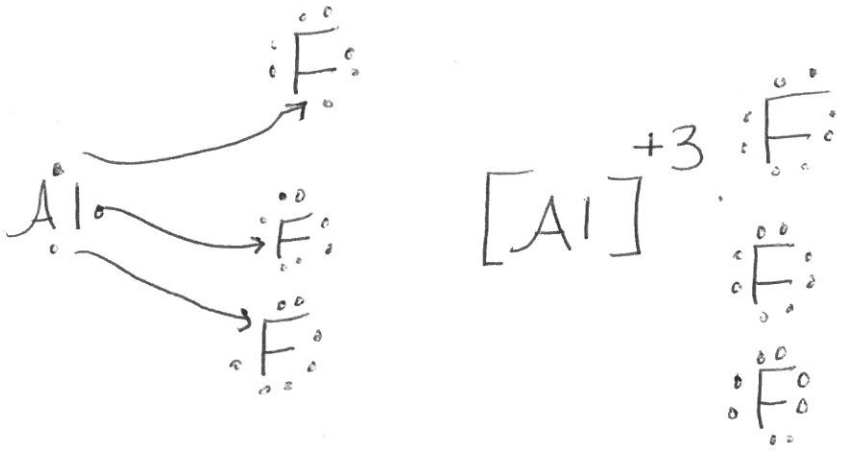
Example 7: From groups IIIA and VIIA.

metal		**nonmetal**
aluminum	and	fluorine

Lewis Dot Diagram:



Show Transfer:



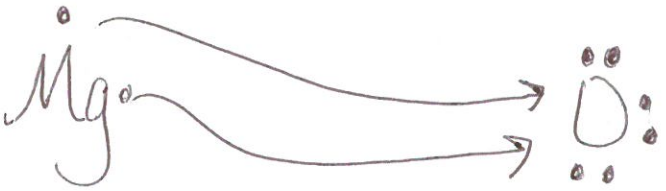
Formula: AlF_3

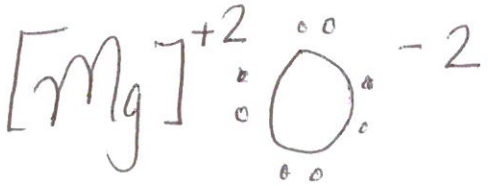
Naming the Ionic Compound: Aluminum Fluoride

You Do! (Draw Lewis Diagram, Show Transfer, Write Formula, Name Compound)

Example 8: From groups II A and VIA.

metal		**nonmetal**
magnesium	and	oxygen





MgO Magnesium Oxide

C. **Writing Ionic Formulas (Simplified)**

1. Here's a simpler way to write ionic formulas -------just **crisscross down** the **charge number** to get **how many of each ion. The charge becomes the subscript!**

Example 1: barium and chlorine

$Ba^{+2}Cl^{-1} \rightarrow BaCl_2$

YOU DO!

Example 2: sodium and oxygen $Na^{+1}O^{-2} \rightarrow Na_2O$

Example 3: aluminum and sulfur

Example 4: calcium and sulfur $Al^{+3}S^{-2} \rightarrow Al_2S_3$

$Ca^{+2}S^{-2} \rightarrow CaS$

What do you notice about the overall charge (net charge) on an ionic compound?

Neutral

D. **Group B Metals in Ionic Bonding**

1. Now, what about using transition metals (B group or 3-12) in a binary ionic compound? Remember any metal ion beyond group IIA are positive and have multiple charges (with a few exceptions – a few you will be responsible for memorizing – Ag^{+}, Zn^{2+}, Al^{3+}).

2. A Roman numeral in the name will tell you the charge of the metal ion that's beyond group IIA (Roman numerals are not used for the exceptions – Ag, Zn, Al).

   Example: The copper ion can come as Cu^{+} or Cu^{2+}

   copper(II) chloride is using Cu^{2+}

3. You can now write the formula for binary ionic compounds containing metals from beyond group IIA.

You Do! **Write the formula from the name. Remember to crisscross and reduce if applicable.**

a. iron(III) oxide (also known as rust) $Fe^{+3}O^{-2} \rightarrow Fe_2O_3$
b. iron(II) oxide $Fe^{+2}O^{-2} \rightarrow FeO$
c. manganese(III) phosphide $Mn^{+3}P^{-3} \rightarrow MnP$
d. zinc chloride (no Roman numeral in name, because it doesn't have multiple charges). $Zn^{+2}Cl^{-1} \rightarrow ZnCl_2$

4. You just wrote a formula from a name- let's go the other way now.

   Write the name from the formula

   Example: SnO_2^{-2} → Tin IV Oxide

   So this +4 / Net Charge (-4)

   The net charge on an ionic compound is 0.

   You need to do some math to figure out what charge is on Sn (it's a metal beyond IIA so we need to figure which charge was used).

   Can be +2 or +4 — Metal / Non-metal — $O_2 \rightarrow O^{-2}$ — O^{-2} → Net Charge −4

   +4 to balance −4 charge

   Example: CuO (don't crisscross back up to get the charge on Cu, because the subscripts were reduced).

   CuO^{-2} Copper II Oxide

   Cu^{+1}

   Cu^{+2}

   Nonmetal

   −2 So Cu must be +2

E. **Polyatomic Ions**

1. Ternary ionic compounds contain 3 different elements instead of binary ionic compounds, which contains 2.
2. Ternary ionic compounds contain a positive ion and a negative ion.
3. You must memorize the formulas and names of the common polyatomic ions we'll be using in class. Quiz _____.
4. A polyatomic ion is a group of atoms (covalently bonded together) that has a single charge, unlike a monatomic ion, which is a single atom with a charge. Polyatomic ions can be positive or negative like the monoatomic ions.
   → NH_4^+ is the only polyatomic cation.
5. Polyatomic ions act like a single unit with a charge.

F. **Writing formula from ionic compounds containing polyatomic ions.**

- Use parentheses around the polyatomic ion if you have more than one.
- Remember polyatomic ions act as a single unit with a charge.
- Determine charges, crisscross down, reduce if needed.

Example 1: calcium nitrate

$Ca^{+2}\ NO_3^{-1} \rightarrow Ca(NO_3)_2$

Criss Cross
Charges become subscript

Example 2: strontium carbonate

$Sr^{+2}\ CO_3^{-2} \rightarrow SrCO_3^{-2}$

Already Neutral
Write formula w/out charges

You Do!

a. ammonium nitrate $NH_4^+\ NO_3^- \rightarrow NH_4NO_3$
b. ammonium sulfide $NH_4^+ S^{-2} \rightarrow (NH_4)_2S$
c. copper(I) sulfate $Cu^{+1}\ SO_4^{-2} \rightarrow Cu_2SO_4$
d. lead(IV) carbonate $Pb^{+4} CO_3^{-2} \rightarrow Pb_2(CO_3)_4 \rightarrow Pb(CO_3)_2$
e. zinc sulfate $Zn^{+2} SO_4^{-2} \rightarrow ZnSO_4$
f. mercury(I) oxide $Hg^{+1} O^{-2} \rightarrow Hg_2O$
g. silver nitrate $Ag^{+1} NO_3^{-1} \rightarrow AgNO_3$
h. aluminum bicarbonate or aluminum hydrogen carbonate

$Al^{+3}(HCO_3)^{-1} \longrightarrow Al(HCO_3)_3$

G. **Naming ionic compounds from a formula containing a polyatomic ion.**

- Don't change the name of a polyatomic ion in a compound's name – just use its name.
- Identify the polyatomic ion in the formula – circle it.
- Name the cation (just name it) and anion (polyatomic –don't change name just name the polyatomic ion).

Example 1: $NaNO_3$ Sodium Nitrate

Example 2: $Ca(NO_3)_2$ Calcium Nitrate

You Do!

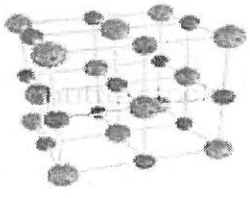
a. NH_4Cl Ammonium Chloride
b. $(NH_4)_2S$ Ammonium Sulfide
c. NH_4NO_3 Ammonium Nitrate

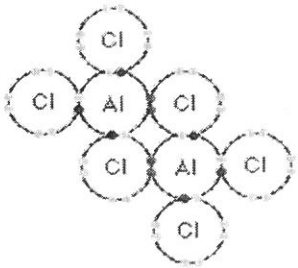
Don't forget to ask the question: Is the metal ion beyond IIA? If yes-use a Roman numeral in name. Use math to figure-out the charge for the Roman numeral.

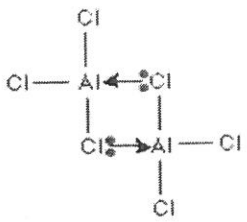
d. $Cu(NO_3)_2$ Copper II Nitrate
e. $Sn(CO_3)_2$ Tin IV Carbonate
f. $Pb(HCO_3)_2$ Lead II Bicarbonate OR Lead II Hydrogen Carbonate

II. Covalent Bonds are formed when valence electrons are shared between atoms. Covalent bonds are between non-metals. Each atom in the bond wants 8 valence electrons - Octet Rule (exception: 2 valence electrons in 1st energy level). A covalent bond contains a pairing of valence electrons. A single bond contains one pair of valence electrons. A double bond contains two pairs of valence electrons (total of 4 electrons) being shared between two atoms. A triple bond is three pairs of valence electrons (total of 6 electrons) being shared between two atoms. Covalent bonds make up molecular compounds. The smallest unit (representative unit) of a molecular compound is called a molecule, unlike the formula unit for ionic compounds.

Picture of representative units in an ionic compound verses a molecular compound.







A. **Lewis Dot Diagram of the Formation of a <u>Single Bond</u>.**

Example 1: **nonmetal** hydrogen and **nonmetal** hydrogen

Show Sharing with Lewis Dot Diagram: H· ·H → H:H

Structural Formula: (use lines to represent bonds)

- **single bond (2 electrons)**
- **double bond (4 electrons)**
- **triple bond (6 electrons)**

(Molecular) Formula:

Subscripts tell how many of each atom are in the molecule Hydrogen is a diatomic molecule that you memorized earlier in the year.

Lewis Dot Diagram of the Formation of a <u>Double Bond.</u>

Example 2: **nonmetal** oxygen and **nonmetal** oxygen

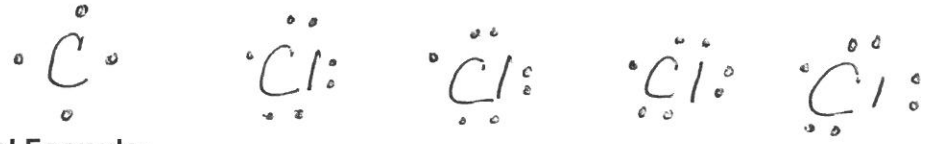
Lewis Dot Diagram of the Formation of a <u>Triple Bond.</u>

Example 3: **nonmetal** nitrogen and **nonmetal** nitrogen

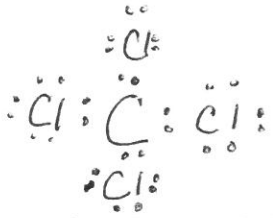
Lewis Dot for molecules that have <u>two or more different elements in the molecule.</u>

Example 4: **nonmetal** carbon and **nonmetal** chlorine

Show sharing with a Lewis Dot Diagram between carbon and chlorine:



Structural Formula:



Molecular Formula:

- **Carbon, or the least electronegative element is first in formula**
- **subscripts tell how many of each atom are in the molecule**

CCl_4

Naming (Nomenclature) of molecular compounds (except for the diatomic molecules).

- **Use prefixes in the name to indicate the number of atoms in the molecule.**
- **Don't use mono in the beginning of a name.**
- **You need to memorize the following prefixes:**

Name the molecule in #4. Carbon tetrachloride