I: BINARY COMPOUNDS

Binary compounds contain **two** different elements. Binary compounds may be **ionic** or **molecular** compounds. We have different rules for each of these.

A: Regular Ionic Compounds

Regular ionic compounds ALWAYS contain a metal element from group 1, 2 or 13, and a non-metal element.

Writing Formulas:

To write the **formula** of this type of compound, we must first determine the CHARGE that each element will have when it forms a stable ion. Remember, the **group number** of the element will tell us the charge its ion will have.

Practice Table #1: Finding Charges on Ions

Element	Group #	Ion	Element	Group #	Ion
Li	1	Li^{+1}	F	17	F^{-1}
Mg	2	Mg^{+2}	S	16	S^{-2}
Al	13	Al^{+3}	N	15	N^{-3}
Be	2	Be^{+2}	Br	17	Br^{-1}
Na	1	Na^{+1}	P	15	P^{-3}

Once we know the charge on each element, we then use the **crossover rule** to find the **formula** of the compound they will form.

Eg. Find the formula of the compound formed from Li and P.

Solution: Li is in group 1, so its charge will be +1
P is in group 15, so its charge will be –3

So: Li^{+1} P^{-3} "cross over" the value of the charges but not the sign to find the formula

Li_3P [notice that we do not show the "1", it is understood to be there]

You can check this by modeling the transfer of electrons we learned previously. It works!!

Practice Table #2: Writing Formulas of Regular Ionic Compounds

Metal	Non-metal	Compound	Metal	Non-metal	Compound
Na	Br	$NaBr$	Al	Cl	$AlCl_3$
Mg	Br	$MgBr_2$	B	O	B_2O_3
Al	Br	$AlBr_3$	Ca	N	Ca_3N_2
Li	S	Li_2S	K	O	K_2O
Ca	S	Ca_2S_2 CaS	Na	P	Na_3P
B	S	B_2S_3	Al	O	Al_2O_3
K	N	K_3N	Mg	S	Mg_2S_2 MgS
Be	N	Be_3N_2	B	P	B_3P_3 BP
Al	N	Al_3N_3 AlN	Na	Cl	$NaCl$
Li	O	Li_2O	Ca	F	CaF_2

Please Note: The subscripts of ionic compounds must be the lowest ratio.
Example: Mg_2O_2 reduces to become MgO

Naming Compounds:

A regular ionic compound has a very simple name. We simply take the name of the **metal element** and follow it with the name of the **non-metal element**, with the ending changed to **–ide**.

Eg. NaCl = sodium and chlorine → sodium chlor**ide**

That's it! Go back to Practice Table #2 and write the NAME of each compound under its formula. Notice that NO capital letters are used in the name.

Practice Table #3: Chemical Names and Formulas of Regular Ionic Compounds

Chemical Name	Metal Ion	Non-metal Ion	Chemical Formula
sodium fluoride	Na^{+1}	F^{-1}	NaF
boron iodide			BI_3
calcium phosphide			Ca_3P_2
magnesium oxide	Mg^{+2}	O^{-2}	MgO ?
potassium chloride			KCl
beryllium sulfide			BeS
barium nitride	Ba^{+2}	N^{-3}	Ba_3N_2
aluminum sulfide			Al_2S_3
lithium phosphide			Li_3P
potassium sulfide			K_2S
boron oxide			B_2O_3
calcium fluoride			CaF_2

B: Molecular Compounds

Molecular compounds ALWAYS contain two non-metal elements.

Writing Formulas:

The formulas of covalent compounds often cannot be predicted. We understand covalent bonding, but many non-metals bond in unexpected combinations. You will always be given the NAME or the FORMULA of the compound.

Memorize !!

If you are given the name of the compound, you need to be able to write its formula. We use **prefixes** to indicate how many atoms of each element are in the compound.

PREFIX	NUMBER	PREFIX	NUMBER
mono	**1**	**tetra**	**4**
di	**2**	**penta**	**5**
tri	**3**	**hexa**	**6**

NOTES:

1. The prefix **mono** is never used with the **first element** in the compound.
2. The prefixes **mono, tetra, penta, and hexa** LOSE their final o or a when placed in front of oxygen.
3. The ending of the second element is again changed to **–ide**.

Binary compound

Eg. What are the formulas of the following compounds?

carbon **mon**ox**ide** CO (the molecule contains 1 atom of carbon – see note 1, and one atom of oxygen – see note 2)

diphosphorus **penta**brom**ide** P_2Br_5 (2 atoms of phosphorus and 5 atoms of bromine)

NO CROSSOVER

Naming Compounds:

To determine the name of a covalent compound, simply apply the prefixes to the two elements that make up the compound.

Eg. What are the names of the following compounds?

CO_2 carbon **di**ox**ide** (the molecule contains 1 atom of carbon – see note 1, and 2 atoms of oxygen)

N_2O_3 **di**nitrogen **tri**ox**ide** (2 atoms of nitrogen and 3 atoms of oxygen)

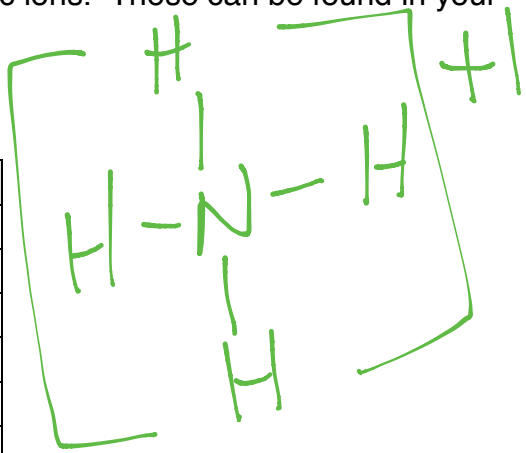
Practice Table #4: Names and Formulas of Molecular Compounds

Complete the table with the names or formulas needed.

Chemical Name	Formula	Chemical Name	Formula
nitrogen monoxide	NO		SCl_2
silicon dioxide		sulfur dioxide	SO_2
sulfur trioxide			NO
carbon tetrachloride	CCl_4		SiS_2
diarsenic trioxide			PO_3
phosphorus pentabromide	PBr_5		PF_3
nitrogen dioxide			CBr_4
sulfur hexafluoride		nitrogen trichloride	NCl_3
selenium dioxide			SiO_3
dinitrogen tetroxide	N_2O_4		PCl_3
sulfur dioxide			CS_2

II: COMPOUNDS CONTAINING POLYATOMIC IONS

Some **ionic compounds** are **NOT binary**. They contain AT LEAST three elements. In this situation, the compound contains one (or both) ion which is **polyatomic** (many atoms). You **must memorize** the names, formulas and charges of EIGHT polyatomic ions. These can be found in your text in Table 4.7, on p. 161.



Polyatomic Ions to Memorize:

NAME	FORMULA
ammonium	NH_4^+
hydroxide	OH^-
nitrate	NO_3^-
carbonate	CO_3^{2-}
sulfate	SO_4^{2-}
phosphate	PO_4^{3-}
hydrogen carbonate	HCO_3^-
hydrogen sulfate	HSO_4^-

Writing Formulas:

Since these are ionic compounds, we use ALL the same rules that applied to the other ionic compounds. One NEW thing is the use of **brackets** whenever we need **more than one** of these polyatomic ions in the compound.

Eg 1 What is the formula of **lithium hydroxide**?

We know that lithium forms a 1+ ion, and hydroxide is OH^-, SO:

Li^+ OH^- The charges are equal but opposite -no crossover is needed.

SO… LiOH is the correct formula for lithium hydroxide

Eg 2 What is the formula of Magnesium nitrate?

Mg^{2+} NO_3^- CROSSOVER!

$Mg(NO_3)_2$ is the correct formula for Magnesium nitrate

Notice the use of brackets around the **whole** nitrate ion. This is important, since we can then put the two **outside** the bracket to show that this compound needs two complete nitrate ions.

Practice Table #5: Writing Formulas with Polyatomic Ions

Compound Name	Positive Ion	Negative Ion	Formula
sodium carbonate	Na^+	CO_3^{2-}	Na_2CO_3
calcium nitrate			
barium sulfate			
aluminum hydrogen carbonate	Al^{+3}	HCO_3^{-1}	$Al(HCO_3)_3$
potassium phosphate			
beryllium hydroxide			
lithium hydrogen sulfate			
ammonium chloride			
sodium phosphate			
potassium sulfate			
ammonium carbonate			

Naming Compounds:

Again, we use all the same rules for naming ionic compounds when we are using these polyatomic ions. Notice that other than ammonium (a positive ion), the other (negative ions) names all end in **–ate**.

Eg 1 What is the name of $Ca(NO_3)_2$?

Calcium is a regular metal, so we just call this compound **calcium nitrate**. Notice that again, the positive ion name goes first, followed by the negative ion name. We **do not** change the ending to –ide, since **nitrate** is already the proper name for the ion.

Eg 2 What is the name of Li_3PO_4?

Li PO_4 Here, there is ONE phosphate ion, so the number that we cross up will be 1, NOT 4

This gives phosphate a charge of –3 and lithium +1.

Practice Table #6: Naming Compounds with Polyatomic Ions

FORMULA	NAME OF COMPOUND
$Mg(OH)_2$	
$CaCO_3$	
NH_4Cl	
$LiHCO_3$	
$Al(NO_3)_3$	
$Be_3(PO_4)_2$	
$KHSO_4$	
$(NH_4)_3N$	

III: Ionic Compounds with the Transition Metals

The Transition metals are unusual because many of them are able to form several **different** ions. For example, iron may form an **Fe^{2+}** ion OR an **Fe^{3+}** ion, depending on what it is bonding with. This means that we cannot PREDICT the charge on the ion when we see it in a compound.

We use a special system that allows us to know what charge is on the ion. We actually put the charge into the name! We write the charge as a **Roman numeral**, and put it in **brackets** after the name of the metal.

Eg. iron (II) chloride - in this case, iron has formed an Fe^{2+} ion
copper (I) oxide - here, copper has formed a Cu^{+} ion

Writing Formulas:

The bracket system makes it very easy to find the formulas of transition metal compounds, since we are given the charge on the metal ion! We only have to predict the charge on the non-metal as usual, using the periodic table. We then use the crossover rule as usual to get the formula.

Eg. copper (II) chloride - here, copper has a 2+ charge, as indicated in the brackets

So: Cu^{2+} Cl^{-} (predicted from the periodic table)
Crossover!
Formula: $CuCl_2$

Practice Table #7: Writing Formulas with Transition Metals

Compound Name	Metal Ion	Non-metal Ion	Formula
gold (I) chloride	Au^{+1}	Cl^{-1}	$AuCl$
nickel (III) sulfide			
cobalt (II) oxide			
iron (III) phosphide			
mercury (IV) fluoride			
nickel (II) nitride			
gold (III) sulfide			
copper (I) oxide			

Review: Naming Chemical Compounds

Element #1 (or ion and charge)	Element #2 (or ion and charge)	Type of Compound	Formula	Name
Be^{2+}	F^{-}	ionic	BeF_2	beryllium fluoride
			NaCl	
				nickel (III) oxide
			Cl_2O	
Na^{+}	CO_3^{-2}			
			Na_3PO_4	
				calcium chloride
NH_4^{+}	F^{-1}			
K^{+}	OH^{-1}			
				calcium nitrate
				nitrogen trifluoride
				gold (III) iodide
			$Mg(NO_3)_2$	
K^{+}	HSO_4^{-}			
			KCl	
				copper (II) hydroxide
				sulfur dioxide
			CO	
				nickel (II) nitrate
				lead (IV) sulfate