SNC 2PI NAMING COMPOUNDS

AND FORMULA WRITING

PRACTICE WORKBOOK

I: BINARY COMPOUNDS

Binary compounds contain only **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 provide a clue to the charge of its ion.

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 charges 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 showing the transfer of electrons. It works!!

Practice Table #1: Finding Charges on Ions

Element	Group #	Ion	Element	Group #	Ion
Li	**1**	Li^{+1}	**F**	**17**	F^{-1}
Mg			**S**		
Al			**N**		
Be			**Br**		
Na			**P**		

Practice Table #2: Writing Formulas of Regular Ionic Compounds

Metal	Non-metal	Compound	Metal	Non-metal	Compound
Na	**Br**		**Al**	**Cl**	
Mg	**Br**		**B**	**O**	
Al	**Br**		**Ca**	**N**	
Li	**S**		**K**	**O**	
Ca	**S**		**Na**	**P**	
B	**S**		**Al**	**O**	
K	**N**		**Mg**	**S**	
Be	**N**		**B**	**P**	
Al	**N**		**Na**	**Cl**	
Li	**O**		**Ca**	**F**	

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			
calcium phosphide			
magnesium oxide			
potassium chloride			
beryllium sulfide			
barium nitride			
aluminum sulfide			
lithium phosphide			
potassium sulfide			
boron oxide			
calcium fluoride			

B: 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 $\mathbf{Fe^{2+}}$ ion OR an $\mathbf{Fe^{3+}}$ 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 #4: Writing Formulas with Transition Metals

Compound Name	Metal Ion	Non-metal Ion	Formula
gold (I) chloride			
nickel (III) sulfide			
cobalt (II) oxide			
iron (III) phosphide			
mercury (IV) fluoride			
nickel (II) nitride			
gold (III) sulfide			
copper (I) oxide			

Naming Compounds:

When we name a transition metal ionic compound, we MUST include the charge on the metal ion (in brackets). Because we cannot use the periodic table to predict the charge on transition metal cations, we need a way to figure out this charge, using the **formula** of the compound. This technique is called the **reverse crossover**.

Eg. Co_2O_3 - the two elements involved here are cobalt and oxygen, so the name will be **cobalt ( ) oxide**

- **however**, we still need to find the **charge** on the cobalt ion to put in the brackets

$Co_2 \quad O_3$ - if we put a bit of space between the two parts of the compound, it makes it easier to show the **reverse crossover**
- now, just cross the **subscript** of each element UP to become the **charge** of the opposite element

- this gives you the charges on each ion, which shows that oxygen has a 2- charge, and cobalt has a 3+ charge
- we **must** check that the non-metal has the correct charge, and indeed according to the periodic table, oxygen will have a 2- charge

Therefore the name of this compound is **cobalt (III) oxide**. Other than the brackets, all other naming rules for ionic compounds stay the same.

Why is it important to check the charge on the non-metal ion?

Eg. FeO

If we use reverse crossover to find the charge on the iron ion here, we see:

Fe O - the charge on iron appears to be 1+, and on oxygen is 1–

However, when we check, we find that oxygen MUST have a 2- charge. Therefore we must **multiply** the charge on the oxygen by 2 to bring it up to the necessary 2- value. BUT if multiply one charge, we must multiply the other, bringing the iron ion up to a 2+ charge.

Therefore the name of the compound is **iron (II) oxide**.

Practice Table #5: Naming Ionic Compounds with Transition Metals

Formula	Reverse Crossover Predicted Charges			Name
	Metal Ion	Non-Metal Ion	Actual Charge of Non-Metal Ion	
CoS	+1	-1	-2	Cobalt (II) sulfide **
NiO				
HgI_4				
FeF_2				
Fe_2O_3				
$CuCl_2$				
HgF_2				
CoN				
NiP				
FeS				
Cu_2O_3				

** NOTE: The charges had to be corrected from 1 to 2, because the correct charge on a sulfur ion is 2-!!

B: Molecular Compounds

Molecular compounds ALWAYS contain two non-metal elements.

Writing Formulas:

The formulas of molecular 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.

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**.

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)

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 #6: 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			**SO_2**
sulfur trioxide			**NO**
carbon tetrachloride			**SiS_2**
diarsenic trioxide			**PO_3**
phosphorus pentabromide			**PF_3**
nitrogen dioxide			**CBr_4**
sulfur hexafluoride			**NCl_3**
selenium dioxide			**SiO_3**
dinitrogen tetroxide			**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 5.2, on p. 159.

Polyatomic Ions to Memorize:

NAME	FORMULA
ammonium	$(NH_4)^{+1}$
hydroxide	$(OH)^{-1}$
nitrate	$(NO_3)^{-1}$
carbonate	$(CO_3)^{-2}$
sulfate	$(SO_4)^{-2}$
phosphate	$(PO_4)^{-3}$
hydrogen carbonate	$(HCO_3)^{-1}$
hydrogen sulfate	$(HSO_4)^{-1}$

Writing Formulas:

Since these are ionic compounds, we use ALL the same rules that applied to the other ionic compounds, such as crossover and reverse crossover (for transition metal 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^{-1},…. 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 copper (II) nitrate?

Cu^{2+} NO_3^-

CROSSOVER!

$Cu(NO_3)_2$ is the correct formula for copper (II) 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 #7:   Writing Formulas with Polyatomic Ions

Compound Name	Positive Ion	Negative Ion	Formula
sodium carbonate	Na^{+1}	CO_3^{-2}	Na_2CO_3
calcium nitrate			
manganese (V) sulfate			
aluminum hydrogen carbonate			
potassium phosphate			
beryllium hydroxide			
gold (I) hydrogen sulfate			
ammonium chloride			
nickel (II) phosphate			
mercury (I) 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 $CoPO_4$?

Cobalt is a transition metal, so we must use reverse crossover to determine its charge.

Co_1 $(PO_4)_1$ Here, there is ONE phosphate ion, so the number that we cross up will be 1, NOT 4

This gives phosphate a charge of –1. BUT we know that it has a charge of –3, so we must **multiply** both charges by 3 to correct them. This gives the name

cobalt (III) phosphate

Practice Table #8: Naming Compounds with Polyatomic Ions

FORMULA	NAME OF COMPOUND
$Fe(OH)_2$	
$CaCO_3$	
NH_4Cl	
$LiHCO_3$	
$Al(NO_3)_3$	
$Be_3(PO_4)_2$	
$Cu(HSO_4)_2$	
$(NH_4)_3N$	

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			
			NiS	
				calcium nitrate
				nitrogen trifluoride
				gold (III) iodide
			CoF_2	
K	HSO_4^-			
			KCl	
				copper (II) hydroxide
			$HgSO_4$	
			CO	
			Fe_2O_3	
				lead (IV) sulfate