

## Chapter 2 Supplemental Homework Nomenclature and Formula Writing

### Objective

The purpose of this assignment is to gain practice in using chemical nomenclature for naming compounds and writing chemical formulas.

### Discussion

Chemical nomenclature is the system of names used to distinguish compounds from each other and the rules needed to devise these names. In the early history of chemistry there was no system for naming compounds. Early names included quicksilver, blue vitriol, Glauber's salt, gypsum, sal ammoniac and laughing gas. As chemistry grew, it became clear that the "anything goes" system was not acceptable. Without a system for naming compounds, coping with the multitude of known substances would be a hopeless task.

A systematic set of rules for naming compounds is available for use by scientists. These rules, known as IUPAC rules, have been formulated by the nomenclature committees of the International Union of Pure and Applied Chemistry (IUPAC). The committees of the international scientific organization meet periodically to revise and update the nomenclature rules to accommodate any newly discovered types of compounds. The flow chart on the next page provides a summary of the nomenclature rules for inorganic compounds.

A chemical formula gives a great deal of information about a particular compound. By reading a chemical formula, one can tell what elements are present in the substance and the number of atoms of each element in a formula unit of a particular compound. A formula unit is the smallest uncharged particle formed by the bonding of two or more ions or atoms.

There are a few simple rules to follow when writing formulas:

1. The formula contains the symbols of all elements in a compound.
2. Each symbol represents one atom of an element.
3. Subscripts are used to indicate more than one atom of an element in a molecule or formula unit.
4. Parentheses enclose polyatomic ions occurring more than once in a formula unit and subscripts following parentheses indicate the quantity of the group in the formula unit. Parentheses do NOT enclose polyatomic ions unless they occur at least twice in the unit.
5. Formulas do NOT show how atoms are arranged in a molecule.
6. In a neutral compound, the sum of the positive and negative charges equals zero. The charges of the ions are NOT included in the formula.

Every compound has its own CHEMICAL FORMULA and its own NAME. The nomenclature (naming systems) for IONIC and COVALENT compounds are different.

## IONIC COMPOUNDS

These consist of any positive ion (except  $H^+$ ) combined with any negative ion. If  $H^+$  is the positive ion, the compound is an ACID (once again, hydrogen plays by its own rules.)

- The positive ion (cation) may be a metal (such as  $Na^+$ ) or a polyatomic ion (such as  $NH_4^+$ ).
- The negative ion (anion) may be a non-metal ion (such as  $Cl^-$ ) or a polyatomic ion (such as  $SO_4^{2-}$  or  $NO_3^-$ ).

All names follow the same general format: cation is cited first & anion is cited second.

### Case 1 – Ionic Compounds: Fixed Charge Metal + Non-metal

Name format: Metal Name + Anion Name

- Metal is always named first (name unchanged)
- Anion named second

Examples:       $KBr$       potassium bromide  
                   $AlCl_3$      aluminum chloride  
                   $Li_3N$       lithium nitride

Note: The name does NOT indicate how many of each atom. Everyone has memorized their ions, so they know how many are needed to create a compound with zero net charge.

1. Write formulas for the following cations:

barium ion  $Ba^{2+}$     aluminum ion  $Al^{3+}$     potassium ion  $K^+$

2. Write formulas for the following anions:

bromide  $Br^-$     nitride  $N^{3-}$     iodide  $I^-$     oxide  $O^{2-}$     sulfide  $S^{2-}$

3. Name the following compounds:

$SrI_2$     strontium iodide                       $Ca_3N_2$     calcium nitride  
 $K_2O$     potassium oxide                       $Al_2O_3$     aluminum oxide  
 $Ba_3N_2$     barium nitride                       $Na_3P$     sodium phosphide

4. Give formulas for the following compounds – refer to the periodic table only.

potassium phosphide     $K_3P$                       calcium iodide                       $CaI_2$   
strontium chloride       $SrCl_2$                       magnesium nitride                       $Mg_3N_2$   
zinc bromide               $ZnBr_2$                       lithium sulfide                       $Li_2S$

## Case 2 – Ionic Compounds: Transition Metal + Non-metal

Name format: Metal Name + Roman Numeral + Anion Name

In general, it is NOT possible to use the periodic table to predict what ions are formed by transition metals. You need to know the charge of the anions to determine the charge of most transition metals.

For transition metals that form two ions, the naming system is as follows:

### Modern System:

- Metal is always first (name unchanged)
- A Roman numeral in parentheses indicating the charge on the metal ion  
There are 3 transition metals that do NOT require a Roman Numeral:  $\text{Ag}^+$ ,  $\text{Zn}^{2+}$  &  $\text{Cd}^{2+}$ .
- Non-metal with the ending changed to -IDE

Examples	$\text{FeF}_2$	iron(II) fluoride
	$\text{SnO}_2$	tin(IV) oxide
	$\text{Cu}_3\text{P}$	copper(I) phosphide

### Old System:

- -ous ending refers to the ion with lower charge
- -ic ending refers to the ion with higher charge

### Examples

$\text{Fe}^{2+}$	ferrous	$\text{Fe}^{3+}$	ferric	$\text{Cr}^{2+}$	chromous	$\text{Cr}^{3+}$	chromic
$\text{Cu}^+$	cuprous	$\text{Cu}^{2+}$	cupric	$\text{Sn}^{2+}$	stannous	$\text{Sn}^{4+}$	stannic
$\text{Pb}^{2+}$	plumbous	$\text{Pb}^{4+}$	plumbic				

$\text{FeF}_2$	ferrous fluoride
$\text{SnO}_2$	stannic oxide
$\text{Cu}_3\text{P}$	cuprous phosphide

5. Name the following compounds using Modern and Old Names if applicable.

	Modern Name (use Roman Numerals)	Old Name (use '-ic' or "-ous")
$\text{SnCl}_2$	<u>tin(II) chloride</u>	<u>stannous chloride</u>
$\text{FeBr}_3$	<u>iron(III) bromide</u>	<u>ferric bromide</u>
$\text{Cu}_3\text{N}$	<u>copper(I) nitride</u>	<u>cuprous nitride</u>

6. Give formulas for the following compounds.

chromium(III) oxide	<u><math>\text{Cr}_2\text{O}_3</math></u>	stannous fluoride	<u><math>\text{SnF}_2</math></u>
ferrous iodide	<u><math>\text{FeI}_2</math></u>	zinc nitride	<u><math>\text{Zn}_3\text{N}_2</math></u>
cupric bromide	<u><math>\text{CuBr}_2</math></u>	cobalt(II) oxide	<u><math>\text{CoO}</math></u>

### Case 3 – Ionic Compounds: Polyatomic Ions as the Cation or Anion

Name format: Cation Name + Anion Name

Now we will introduce the polyatomic cations and anions. Notice that the format for each name remains the same. We still list the cation name first and the anion name second. If the cation is a variable charge metal, then we must continue indicating the charge with a Roman numeral.

#### Examples

$(\text{NH}_4)_2\text{SO}_4$	ammonium sulfate
$\text{FeO}$	iron(II) oxide
$\text{Fe}_2\text{O}_3$	iron(III) oxide
$\text{AgNO}_3$	silver nitrate

7. Give the names for the following ionic compounds.

$\text{NH}_4\text{Cl}$  ammonium chloride

$\text{NaHCO}_3$  sodium bicarbonate

$\text{Ca}(\text{OH})_2$  calcium hydroxide

$\text{AlPO}_4$  aluminum phosphate

$\text{AgNO}_3$  silver nitrate

$\text{Sn}(\text{CO}_3)_2$  tin(IV) carbonate

8. Give the chemical formula for the following ionic compounds.

Copper(II) cyanide  $\text{Cu}(\text{CN})_2$

Chromium(III) carbonate  $\text{Cr}_2(\text{CO}_3)_3$

Tin(IV) bisulfate  $\text{Sn}(\text{HSO}_4)_4$

Ammonium hydroxide  $\text{NH}_4\text{OH}$

Zinc bromide  $\text{ZnBr}_2$

## COVALENT COMPOUNDS – two or more non-metals

When non-metal atoms **share** electrons with other non-metal atoms, they form **covalent (molecular) compounds**. We shall learn the nomenclature for binary covalent compounds. A binary covalent compound is a compound formed by only two elements.

### Case 4 – Binary Covalent Compounds

Name format: Greek prefix + 1<sup>st</sup> Non-metal + Greek Prefix + 2<sup>nd</sup> Non-metal prefix + "ide"

- The less electronegative atom is first and assumes the position of the 'cation.'
- The more electronegative atom is last and gets an -IDE ending.
- The number of each atom is specified with a Greek prefix.

The Greek prefixes you need to know are:

1 is mono-	2 is di-	3 is tri-	4 is tetra-	5 is penta-
6 is hexa-	7 is hepta-	8 is octa-	9 is nona-	10 is deca-

- Note:
1. When there is only one atom of the first element, the mono prefix is omitted.
  2. When oxygen requires a prefix, the last vowel of the prefix is omitted if it is an 'a'

Examples	NF <sub>3</sub>	nitrogen trifluoride
	I <sub>2</sub> S	diiodine monosulfide
	P <sub>4</sub> O <sub>10</sub>	tetraphosphorus decoxide

You must memorize these very important common names.

H <sub>2</sub> O (water)	NH <sub>3</sub> (ammonia)	CH <sub>4</sub> (methane)	H <sub>2</sub> O <sub>2</sub> (hydrogen peroxide)
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9. Name the following compounds.

N <sub>2</sub> O <sub>4</sub>	<u>dinitrogen tetroxide</u>	PCl <sub>5</sub>	<u>phosphorus pentachloride</u>
SO <sub>2</sub>	<u>sulfur dioxide</u>	SO <sub>3</sub>	<u>sulfur trioxide</u>
CS <sub>2</sub>	<u>carbon disulfide</u>	Br <sub>2</sub> O <sub>7</sub>	<u>dibromine heptoxide</u>
CO	<u>carbon monoxide</u>	P <sub>2</sub> O <sub>5</sub>	<u>diphosphorus pentoxide</u>

10. Give formulas for the following compounds.

iodine pentabromide	<u>IBr<sub>5</sub></u>	chlorine dibromide	<u>ClBr<sub>2</sub></u>
oxygen difluoride	<u>OF<sub>2</sub></u>	carbon tetrachloride	<u>CCl<sub>4</sub></u>
sulfur hexafluoride	<u>SF<sub>6</sub></u>	iodine heptafluoride	<u>IF<sub>7</sub></u>

## Case 5 - Diatomic Molecules

Several common non-metal elements exist as diatomic molecules. The element name refers to the diatomic molecule. For example, hydrogen refers to  $H_2$  and oxygen refers to  $O_2$ . If we mean the atom, we say atomic hydrogen or atomic oxygen.

11. List the 7 elements that exist as diatomic molecules:  $H_2$   $N_2$   $F_2$   $O_2$   $I_2$   $Cl_2$   $Br_2$

12. Write the chemical formula for the underlined names of the gases.

Ar Dry air contains about 79% nitrogen and 21% oxygen, with small amounts of carbon dioxide, neon, and argon. Polluted air may contain small amounts of sulfur dioxide, sulfur trioxide, nitrogen dioxide, dinitrogen monoxide, chlorine, ammonia, methane and carbon monoxide.

$N_2$        $O_2$        $CO_2$       Ne

$Cl_2$        $NH_3$        $CH_4$        $CO$        $SO_2$        $SO_3$        $NO_2$        $N_2O$

13. Write the chemical name for the chemical formulas in the following paragraph.

Probably the most important element found uncombined in nature is  $O_2$ .  $O_2$  is quite reactive, forming compounds with the halogens  $F_2$ ,  $Cl_2$ ,  $Br_2$ , and  $I_2$ .  $O_2$  forms two compounds with  $H_2$ . Following the usual rules of nomenclature, the most common oxide of hydrogen ( $H_2O$ ) would be name dihydrogen monoxide.  $O_2$  forms a series of compounds with  $N_2$ , many of which are atmospheric pollutants, including  $NO$ ,  $N_2O$ ,  $NO_2$ ,  $N_2O_4$ , and  $N_2O_5$ .

$O_2$  = oxygen

$F_2$  = fluorine

$Cl_2$  = chlorine

$Br_2$  = bromine

$I_2$  = iodine

$H_2$  = hydrogen

$N_2O_5$  = dinitrogen pentoxide

$NO$  = nitrogen monoxide

$N_2O$  = dinitrogen monoxide

$NO_2$  = nitrogen dioxide

$N_2O_4$  = dinitrogen tetroxide

Now Put it All Together

14. Write the chemical name for each formula.

$BaCl_2$  barium chloride

$F_2$  fluorine

$N_2$  nitrogen

$LiNO_3$  lithium nitrate

$N_2O_5$  dinitrogen pentoxide

$OF_2$  oxygen difluoride

$NiCl_4$  nickel (IV) chloride

$P_4S_3$  tetraphosphorus trisulfide

$Fe_2O_3$  iron (III) oxide

$AuF_3$  gold (III) fluoride

$PbBr_2$  lead (II) bromide

$Cr(CN)_3$  chromium (III) cyanide

$Cu_2O$  copper (I) oxide

$Sn(SO_4)_2$  tin (IV) sulfate

$CuSO_4$  copper (II) sulfate

$SO_2$  sulfur dioxide

$Cr(CH_3CO_2)_3$  chromium (III) acetate

$Sr_3(PO_4)_2$  strontium phosphate

$ZnCO_3$  zinc carbonate

$Cl_2$  chlorine

$KClO_2$  potassium hypochlorite ( $KClO$ )

$CO_2$  carbon dioxide

\*  
 $KClO_2$   
 $CO_2$   
 oops ;)

15. Write the formula for the following compounds.

iron(II) nitrate  $\text{Fe}(\text{NO}_3)_2$

lithium sulfide  $\text{Li}_2\text{S}$

zinc phosphide  $\text{Zn}_3\text{P}_2$

silver bicarbonate  $\text{AgHCO}_3$

sulfur hexafluoride  $\text{SF}_6$

chromium(III) sulfate  $\text{Cr}_2(\text{SO}_4)_3$

ammonium acetate  $\text{NH}_4\text{CH}_3\text{CO}_2$  or  $\text{NH}_4\text{C}_2\text{H}_3\text{O}_2$

copper(II) phosphate  $\text{Cu}_3(\text{PO}_4)_2$

chromium(III) hydroxide  $\text{Cr}(\text{OH})_3$

tetranitrogen hexoxide  $\text{N}_4\text{O}_6$

iodine  $\text{I}_2$

nitrogen trichloride  $\text{NCl}_3$

magnesium carbonate  $\text{MgCO}_3$

oxygen  $\text{O}_2$

gold(III) nitrite  $\text{Au}(\text{NO}_2)_3$

ammonium nitrate  $\text{NH}_4\text{NO}_3$

tin(IV) sulfite  $\text{Sn}(\text{SO}_3)_2$

aluminum phosphate  $\text{AlPO}_4$