The naming of chemical compounds (called "nomenclature") and the writing of chemical formulas is outlined in the following **Independent Study Unit**. This independent study unit is divided into sections (A, B, C, etc.) that describe how to name and write formulas for different types of "**inorganic**" chemical compounds. **Organic** chemistry, the chemistry of **carbon-containing** compounds, will be studied later in this course and in SCH 4UI. The successful completion of this unit will require a **dedicated effort**. After all, you are learning part of a "new language": The **"language of chemistry"**. Follow all the instructions carefully and check all solutions with the answers provided by your teacher. Be ready to name and write formulas for the sections indicated on the quiz/test schedule.

A. REGULAR BINARY COMPOUNDS

When writing the formula of a binary chemical compound...

When writing the formula for a chemical compound, you are usually given the name of the chemical compound. Use your Periodic Table to determine the symbol of each of the atoms in the chemical compound. How do these atoms combine to form a chemical compound? The following paragraph will help you understand how atoms combine to form ionic or covalent compounds. Additional information can be found in chapter 2.5 in your textbook.

The **oxidation state** (also called **oxidation number**) is the charge on the **ion** (***electrovalence***) during ionic bonding, **or**, the number of valence electron(s) an **atom** shares (***covalence***) during covalent bonding. In general, the oxidation state is often called the **combining capacity** or **valence** of an atom during chemical bonding. These terms refer to the number of electrons an atom gains or loses (ionic bonding) or shares (covalent bonding). If electrons are **lost** (**ionic bonding**) or partially lost or shared (**covalent bonding**), the oxidation state is **positive**. If electrons are **gained** or partially gained or shared, the oxidation state is **negative**.

1. **In Worksheet A1:** Place the **oxidation state** or charge on the ion or atom as a **superscript** to the right of each of the atom symbols in the left column and the top row.
Note: Use your Periodic Table or "Oxidation States" sheet to determine the oxidation state of an atom.

2. For each example (box) in Worksheet A1, determine the number of positive ion(s) or atom(s) required to combine with the negative ion(s) or atom(s) **in order that their charges add to zero (a neutral chemical compound results)**. The number of positive and negative atoms required are placed beside each symbol as **subscripts** and are **natural numbers** (see section 2.5 of your textbook for additional help).

3. Write the chemical formula (at the top of each box) for the combination of the *positive ion or atom (**"cation"**)* from the left column (written first in the formula) and the *negative ion or atom (**"anion"**)* along the top row (written second). The combination of ions or atoms must be a **reduced** whole number ratio. **Note: Use the completed examples in Worksheet A1 to help you get started.**

When writing the name of a binary chemical compound...

1. The name of the positive ion or atom is simply the name of the element from which the ion or atom is derived in the Periodic Table. The name of the negative ion or atom is found by dropping the last syllable of the element's name and adding the ending "ide".
(Note: For the negative ions or atoms of O, N, H, P, Se and Te, drop the last two syllables and add "ide".)

2. Name the ion in each box in the left column and the top row.

3. Write the name of each binary compound below the formula in the same box.
The cation or atom name is written first, the anion name is written second.

Worksheet A1

The following worksheet will help you learn to write chemical formulas and name chemical compounds. Use the instructions on the previous page to complete the table below. These instructions will also help you to complete Worksheet A2.

Anions - ➔ / Cations - ↓	**F^{-1}** **name: fluoride**	**O^{-2}** **name:**	**N^{-3}** **name:**	**C^{-4}** **name:**
Li^{+1} **name: lithium**	Li_1F_1 or LiF lithium fluoride	Li_2O_1 or Li_2O lithium oxide		
Be^{+2} **name: beryllium**	Be_1F_2 or BeF_2 beryllium fluoride	BeO (not Be_2O_2) beryllium oxide		
B^{+3} **name:**				
Na **name:**				
Mg **name:**				
Al **name:**				

***Note: Carbon compounds, where carbon is the cation, will be named **more correctly** in section D.

Worksheet A2 : More Binary Compounds

Use the rules described on page 1 to complete Worksheet A2. These are additional examples to practice writing names or formulae for regular binary compounds

chemical name	**chemical formula**	**chemical name**	**chemical formula**
sodium fluoride			NaI
lithium chloride			BeF_2
beryllium bromide			MgO
magnesium oxide			H_2O
boron iodide			Li_2S
aluminum sulfide			BCl_3
potassium oxide			Al_2O_3
calcium fluoride			K_2S
barium nitride			AgCl
cesium sulfide			$CaCl_2$
strontium oxide			BN
francium bromide			CsI

B. BINARY COMPOUNDS: MULTI-VALENT CATIONS

(Also known as multi-oxidation state cations)

A "**multi-valent cation**" is an element that can form more than one stable **POSITIVE** ion. The term "multi-valent" means the same as "**multi-oxidation state**". Different positive ions of the same element are formed when reacting under different conditions. Use your "Oxidation States" sheet (last page of booklet) and your Periodic Table to identify the "multi-valent cations". Use a hi-lighter to show which elements are "multi-valent cations". The "multi-valent cations" referred to in this section are **metal ions** found on the left side of the Periodic Table. There are **two different methods** which can be used to name chemical compounds containing a **multi-valent metal cation**.

"OUS - IC" METHOD

This is an **older method** for naming compounds containing a **multi-valent metal cation**. The suffix (last syllable) "ous" or "ic" is added to indicate which cation (higher or lower valence) is in the formula. Also, some cations are named using their **latin** names. List the multi-valent cations whose symbol is derived from their ***latin*** names (**see p. 92 of your textbook**):

_____

Writing chemical formulas using this method will be more easily understood by first learning how to **name** these formulas.

Rules to follow when using the ous-ic method:

1. Find the latin name of the cation in the chemical formula. Usually, the latin name for **Hg** and **Sb** are not used. **If the cation does not have a latin name, ignore this step.**

2. Remove the last syllable (usually "um" for the latin name) and add the suffix ("ous" or "ic") in its place. **Arsenic's** name remains **unchanged** when the higher oxidation state is used. For some elements, the last syllable is not removed (i.e., Co, Ni).

   The suffix "ous" indicates the lower oxidation state was used for the cation.
   The suffix "ic" indicates the higher oxidation state was used for the cation.

3. The anion name is written as you have done previously (ending with "ide").

chemical name	chemical formula	chemical name	chemical formula
ferrous oxide			Fe_2O_3
stannous chloride			$SnCl_4$
plumbous sulfide			PbS_2
cuprous bromide			$CuBr_2$
aurous iodide			AuI_3
mercurous fluoride			HgF_2

ROMAN NUMERAL METHOD (also called the "STOCK SYSTEM")

This method for naming chemical compounds is the **most widely used** and the **preferred** method for naming chemical compounds containing a **multi-valent metal cation**. This method is **NOT** used if the cation has only a single valence or oxidation state.

Rules to follow when using the Roman Numeral or Stock System method:

1. The English name of the multi-valent metal cation is written first.

2. A Roman numeral indicating the positive charge on the cation is written in brackets after the cation's name. **No space** is left between the cation name and the Roman numeral in brackets.

3. The anion name is written as you have done previously (ending with "ide").

chemical name	chemical formula	chemical name	chemical formula
copper(I) fluoride			CuF_2
manganese(II) oxide			MnO_2
nickel(II) chloride			$NiCl_3$
tin(II) sulfide			SnS_2
mercury(I) iodide			HgI_2

Worksheet B

Use the rules given on pages 4 and 5 to complete the table below.

chemical formula	"ous-ic" method name	Roman Numeral method name (Stock System name)
$SbCl_5$		
As_2O_3		
CoS		
Cu_2O		
Sn_3N_4		
Fe_2O_3		
	plumbic bromide	
	manganous oxide	
	ferrous fluoride	
	mercuric iodide	
	nickelous sulfide	
	stannous oxide	
		tin(IV) phosphide
		antimony(III) fluoride
		arsenic(V) sulfide
		lead(IV) oxide
		iron(III) carbide
		copper(II) chloride

C. BINARY COMPOUNDS: TWO NONMETALS

The Prefix Method

The Prefix method is another method used for naming binary compounds where the **nonmetal cation** is multi-valent. This method is usually used, or preferred, when naming **binary compounds containing two nonmetals**. A prefix is used to indicate the number of each cation **and** anion in the formula (i.e., "mono" means one; "di" =2; "tri" =3; "tetra" =4; "penta" =5; "hexa" =6; "hepta" =7; "octa" =8).

Rules to follow when using the Prefix Method:

1. Attach a prefix to the cation name (attached to the front of a word) indicating the number of cations in the chemical formula. **The prefix "mono-" is omitted from the name of the cation if it is the prefix required.**

2. A second prefix indicating the number of anions in the chemical formula is attached to the usual anion name.

3. The "o" or "a" ending of the prefix is omitted if the cation or anion name starts with an "o" or "a".

Worksheet C

Complete the following table using the Prefix method to name chemical formulas in the right column. Write chemical formulas for the chemical compounds given in the left column.

chemical name	chemical formula	chemical name	chemical formula
nitrogen monoxide			CO_2
silicon dioxide			As_2O_3
carbon monoxide			NO_2
sulfur trioxide			P_2O_5
phosphorus pentabromide			CBr_4
dinitrogen trioxide			SF_6
carbon tetrachloride			SeO_2

Worksheet D

Use the information above to complete the following table. Also, recall section C for naming the compounds with a non-metal cation and anion.

chemical name	chemical formula	chemical name	chemical formula
aluminum carbide			PN
lithium hydride			CO_2
sodium arsenide			Mg_3P_2
magnesium antimonide			H_2O
calcium nitride			N_2O_5

E. BINARY ACIDS

A **binary acid** is a binary chemical compound containing hydrogen as the cation and a nonmetal from Group 6 or 7 as the anion. These compounds can be named using the regular naming system for binary compounds (Section A) if they are gases. But, binary acids are usually found as clear, viscous liquids at room temperature and a different naming system is used when they are in this state. If the binary acid is in the liquid state, the prefix "hydro" and ending "ic" is added to the first syllable of the anion and this becomes the first part of the name. The word "acid" is included as the second part of the name.

Worksheet E

Use the above instructions and examples included in the below to name the binary acids in their liquid and gas form.

binary acid formula	**name of binary acid (liquid form)** (aqueous)	**name of gas (vapour form)**
HF		
HCl	hydrochloric acid	
HBr		
HI		hydrogen iodide
H_2S	hydrosulfuric acid	hydrogen sulfide
H_2Se	hydroselenic acid	selenide

F. DIATOMIC GASES

The following gases exist in nature in a diatomic form having the general chemical formula **"X_2"**. The names of these binary compounds are found by just using the element's name from the Periodic Table. HOF Br I N Cl

Name of diatomic gas	Formula for diatomic gas
hydrogen	
oxygen	
nitrogen	
fluorine	F_2
chlorine	
bromine	
iodine	

G. MONATOMIC GASES

The elements of Group 8A (Noble gases) exist in nature as monatomic gases. These gases are considered "inert" or unreactive under most conditions. Some may react under extreme pressures or temperatures. These elements are **not** binary chemical compounds, but you should know the names and formulas of these elements. Use your Periodic Table to determine the noble gas that is at the end of each period.

period	name of gas	formula or symbol
period 1		
period 2		
period 3		
period 4	krypton	
period 5		Xe
period 6		

H. BINARY COMPOUNDS: SUMMARY

Although all chemical compounds with multi-valent cations may be named using all three methods learned for this particular type of compound, there are **preferred method(s)** for naming each type of chemical compound. An **asterisk (*)** indicates the **preferred** method for the compounds summarized below. Chemical compounds having cations with only a single oxidation state only have one method for naming them.

chemical formula (metal and nonmetal)	**$CaCl_2$**	
chemical name		**boron oxide**

chemical formula (multi-valent metal)	MnO	Mn_2O_7
ous-ic method	**manganous oxide**	**manganic oxide**
Roman numeral method (*)		
Prefix method		

chemical formula (two nonmetals)	**P_2O_3**	**P_2O_5**
ous-ic name		
Roman numeral name		
Prefix name (*)		

chemical formula (binary acid)		
chemical name	**hydrochloric acid**	**hydrogen fluoride**

chemical formula (diatomic or monatomic gas)	**Br_2**	
chemical name (diatomic or monatomic gas)		**radon**

REVIEW WORKSHEETS

AA. BINARY COMPOUNDS - REGULAR

Write Formulas		Write Names	
1.	sodium chloride	26.	CaO
2.	calcium fluoride	27.	AgCl
3.	barium bromide	28.	Ca_3N_2
4.	lithium carbide	29.	H_2O
5.	silver iodide	30.	$SiBr_4$
6.	potassium oxide	31.	Al_2S_3
7.	aluminum bromide	32.	Ag_3N
8.	calcium nitride	33.	AlF_3
9.	radium oxide	34.	NaCl
10.	boron fluoride	35.	KBr
11.	hydrogen sulfide	36.	BaS
12.	rubidium hydride	37.	AlN
13.	cesium oxide	38.	BAs
14.	magnesium sulfide	39.	HBr (ℓ)
15.	calcium carbide	40.	$ZnCl_2$
16.	zinc oxide	41.	MgI_2
17.	potassium phosphide	42.	K_3N
18.	beryllium chloride	43.	HI (ℊ)
19.	aluminium arsenide	44.	$SrCl_2$
20.	boron iodide	45.	NaH
21.	silicon oxide	46.	SiF_4
22.	lithium nitride	47.	Ag_2O
23.	zinc nitride	48.	CaS
24.	francium sulfide	49.	Al_2O_3
25.	hydrogen oxide	50.	MgO

BB1. BINARY COMPOUNDS - "ous - ic" method			
Write Formulas		**Write Names**	
1.	auric iodide	26.	CuS
2.	aurous sulfide	27.	Cu_2S
3.	antimonic oxide	28.	HgBr
4.	antimonous chloride	29.	Fe_2O_3
5.	mercuric oxide	30.	FeO
6.	mercurous fluoride	31.	SnF_2
7.	plumbous arsenide	32.	SnF_4
8.	plumbic nitride	33.	$MnBr_7$
9.	stannic oxide	34.	MnO
10.	stannous fluoride	35.	$PbCl_2$
11.	ferric sulfide	36.	$PbCl_4$
12.	ferrous hydride	37.	Sb_2S_5
13.	nickelic oxide	38.	SbAs
14.	nickelous sulfide	39.	AsI_3
15.	cuprous carbide	40.	NiO
16.	cupric oxide	41.	CoN
17.	manganous phosphide	42.	FeF_2
18.	manganic chloride	43.	HgF_2
19.	mercurous arsenide	44.	$CuCl_2$
20.	cobaltic iodide	45.	Sn_3As_4
21.	arsenous oxide	46.	NiP
22.	antimonic nitride	47.	NiS
23.	arsenic nitride	48.	FeS
24.	cobaltous sulfide	49.	PbC
25.	plumbic oxide	50.	Hg_2O

BB2. BINARY COMPOUNDS - Roman numeral method

Write Formulas		Write Names	
1.	phosphorus(III) sulfide	26.	CuBr
2.	phosphorus(V) oxide	27.	Cu_2O
3.	antimony(V) chloride	28.	HgCl
4.	antimony(III) oxide	29.	Fe_2O_3
5.	mercury(II) fluoride	30.	FeS
6.	mercury(I) arsenide	31.	$SnBr_2$
7.	lead(II) nitride	32.	SnF_4
8.	lead(IV) oxide	33.	MnO_2
9.	tin(II) fluoride	34.	MnF_2
10.	tin(IV) sulfide	35.	PbI_2
11.	iron(III) hydride	36.	$PbCl_4$
12.	iron(II) oxide	37.	Sb_2O_5
13.	nickel(III) sulfide	38.	SbAs
14.	nickel(II) carbide	39.	AsF_5
15.	copper(I) oxide	40.	N_2O_5
16.	copper(II) phosphide	41.	CoAs
17.	manganese(II) chloride	42.	PBr_5
18.	manganese(VII) arsenide	43.	PF_3
19.	carbon(II) iodide	44.	SF_4
20.	carbon(IV) oxide	45.	SAs_2
21.	arsenic(III) nitride	46.	NiP
22.	sulfur(IV) chloride	47.	NiO
23.	arsenic(V) sulfide	48.	FeS
24.	cobalt(II) oxide	49.	PbC
25.	sulfur(VI) phosphide	50.	Hg_2S

CC. BINARY COMPOUNDS - prefix method

Write Formulas		Write Names	
1.	carbon dioxide	8.	CO_2
2.	carbon monoxide	9.	SiO_2
3.	sulfur dioxide	10.	SO_2
4.	sulfur trioxide	11.	NO_2
5.	carbon tetrachloride	12.	CO
6.	nitrogen dioxide	13.	CCl_4
7.	diphosphorus pentoxide	14.	P_2O_3

EE. BINARY COMPOUNDS - binary acids

Write Formulas		Write Names	
1.	hydrochloric acid	6.	H_2S (ℊ)
2.	hydrofluoric acid	7.	HCl (ℊ)
3.	hydrobromic acid	8.	HBr (ℓ)
4.	hydroiodic acid	9.	HF (ℓ)
5.	hydrosulfuric acid	10.	HI (ℊ)

FG. GASES - monatomic and diatomic

Write Formulas		Write Names	
1.	hydrogen gas	8.	He
2.	oxygen gas	9.	Ne
3.	nitrogen gas	10.	Ar
4.	fluorine gas	11.	Kr
5.	chlorine gas	12.	Xe
6.	bromine vapour	13.	Rn
7.	iodine vapour		