

## Naming and Writing Chemical Formulas

A **Chemical Formula** is a type of notation made with numbers and chemical symbols. Ex:  $C_6H_{12}O_6$

A chemical formula has 2 purposes.

- 1) To indicate the elements present.
- 2) To indicate the amounts of elements present.

In other words, "what's there, and in what amounts".

The term **compound** describes 2 or more different elements chemically bonded.

**Describe: compound** \_\_\_\_\_

The term **diatomic element** describes 2 atoms of the same element chemically bonded.

**Describe: diatomic element** \_\_\_\_\_

**Subscripts** are whole numbers placed after an atomic symbol or polyatomic ion, at the bottom, to indicate how many of the preceding item is present. If no subscript is present it is assumed to mean "1".

Ex:  $H_2O$  means there are 2 hydrogen atoms and 1 oxygen atom.

Ex:  $C_6H_{12}O_6$  means there are 6 carbon atoms, 12 hydrogen atoms, and 6 oxygen atoms.

Ex:  $Ca(NO_3)_2$  means there is 1 calcium and 2 of the polyatomic ion nitrate ( $NO_3$ )

**How many of each type of atom are in  $CBr_4$ ?** \_\_\_\_\_

A **molecular formula** indicates the total number of atoms of each element required to form a molecule. Remember! A molecule is a group of covalently bonded atoms (nonmetals only). **NO METALS IN MOLECULES!!!**

**Describe: molecule** \_\_\_\_\_

Ex:  $C_4H_{10}$  means that there are 4 carbon atoms and 10 hydrogen atoms in the molecule.

Ex:  $C_2H_2$  means that there are 2 carbon atoms and 2 hydrogen atoms in the molecule.

An **empirical formula** shows the simplest (lowest) whole number ratio of atoms in a compound.

**Describe: empirical formula** \_\_\_\_\_

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## How to convert a molecular formula to an empirical formula?

**Divide all the subscripts by the largest common denominator.**

Ex: molecular formula  $C_4H_8$

The largest common denominator is 4.  $C \frac{4}{4}$   $H \frac{8}{4}$

The resulting empirical formula is  $CH_2$

Ex:  $C_6H_{12}O_6$  is the molecular formula for glucose. However, its simplest whole # ratio of subscripts is  $CH_2O$ . Notice, the subscript ratio is the same, but for an actual molecule of glucose there must be 6 carbon atoms, 12 hydrogen atoms, and 6 oxygen atoms.

$C \frac{6}{6}$   $H \frac{12}{6}$   $O \frac{6}{6}$

Therefore; the empirical formula for glucose is  $CH_2O$ .

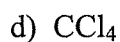
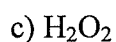
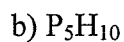
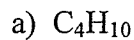
It is possible for a compound to have the same empirical and molecular formula.

**Ex:**  $CH_4$  is both the molecular and empirical formula of methane.

**Is it possible for a compound to have the same empirical and molecular formula?** \_\_\_\_\_

**Provide an example:** \_\_\_\_\_

Determine the empirical formulas of the following: **SHOW WORK!** .



**Polyatomic Ions** Along with simple ions such as  $Na^+$  and  $Cl^-$ , there are **polyatomic ions** such as  $NO_3^-$  (nitrate ion) and  $SO_4^{2-}$  (sulfate ion). Polyatomic ions are groups of covalently bonded atoms that have a charge and behave as a normal ion. The sum of the oxidation #s in a polyatomic ion is equal to the charge of the polyatomic ion. In regents chemistry, if an ionic compound has more than 2 different elements it contains a polyatomic ion!

Table E contains the names, formulas, and charges of many polyatomic ions.

Describe: polyatomic ion \_\_\_\_\_

\_\_\_\_\_

What will the sum of the oxidation #s in a polyatomic ion be equal to? \_\_\_\_\_

\_\_\_\_\_

What table contains the names, formulas, and charges of many polyatomic ions? \_\_\_\_\_

\_\_\_\_\_

**Ionic Compounds (+ and - ions)** exist as repeating geometric structures (crystals). Recall your  $NaCl$  marshmallow structures.

Ionic compounds do not exist as molecules.

Do ionic compounds exist as molecules? \_\_\_\_\_

## The formulas for ionic compounds must always be empirical!

Even the smallest grain of table salt, (NaCl), sodium chloride, contains countless numbers of sodium ions and chloride ions. It would not make sense to represent sodium chloride as  $\text{Na}_{10000000000}\text{Cl}_{10000000000}$ . There is no independent molecule of NaCl. Therefore; only empirical formulas can be written for ionic compounds.

**Oxidation states (numbers)** are possible charges an atom can attain when it becomes an ion. Oxidation #s are used to determine the ratio of elements in a compound. Remember! Oxidation numbers can be found in the upper right of an element's box on the periodic table.

## The sum of the oxidation #s in a compound must be 0.

The sum of the oxidation #s in a compound must be \_\_\_\_\_.

How to **write a chemical formula**. In a compound the sum of the oxidation #s must equal 0.

What does this mean? Elements have oxidation numbers. Some are + and some are -. For elements that have more than 1 oxidation #, use the top oxidation # unless indicated otherwise.

Ex: **NaCl**, Na has a +1 oxidation # and Cl has a -1 oxidation #. Together the sum is 0.  
Notice; the elements are in a 1:1 ratio.

Ex: **CaO**, Ca has a +2 oxidation # and O has a -2 oxidation #. Together the sum is 0.  
Notice; the elements are in a 1:1 ratio.

Ex: **MgF<sub>2</sub>**, Mg has an oxidation # of +2. F has an oxidation # of -1, but there are 2 Fs.  
Together the sum is 0.  
Notice: the elements are in a 1:2 ratio.

Ex: **H<sub>2</sub>O**, H has a +1 oxidation # and O has a -2 oxidation #.  
Together the sum is 0.  
Notice; the elements are in a 2:1 ratio.

## Many different ratios are possible!

## When writing chemical formulas the metallic element goes first.

Ex: NaCl, MgO, CuCl<sub>2</sub>, AgBr

If no metals are present, the more metallic element goes first (least electronegative element) or closest to the lower left of the periodic table.

Ex: H<sub>2</sub>O, CCl<sub>4</sub>, and SO<sub>2</sub>

When writing a formula, which element goes first? \_\_\_\_\_

Write the formulas for the following combinations of elements. .

Look up the symbols for the elements in Table S. Please!

Don't forget the sum of the oxidation #s in a compound must = 0.

a) strontium and sulfur

b) barium and chlorine

c) sodium and fluorine

d) oxygen and magnesium

e) bromine and zinc

f) oxygen and hydrogen

g) hydrogen and chlorine

h) zirconium and iodine

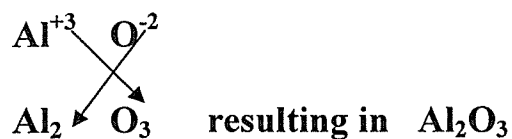
**Crossover Method** The crossover method allows us to write formulas and ensure the correct ratio of elements in a compound if it is not obvious as in the previous page.. This method uses the oxidation # of the first element or polyatomic ion as the subscript of the other. Next, it uses the oxidation # of the second element or polyatomic ion as the subscript of the first. There are no negative subscripts. Only use the absolute value of an oxidation # as a subscript.

Remember! If it is an ionic compound the formula must be reduced to empirical. Charges are not shown in the final chemical formula.

Are charges shown in a final chemical formula? \_\_\_\_\_

Confused? ☹ Don't worry. We'll look at some examples.

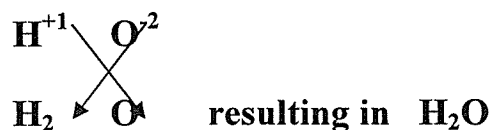
Ex: Write the formula of the compound of aluminum and oxygen.



Ex: Write the formula of the compound of zinc and chlorine.



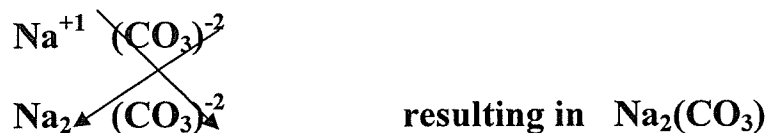
Ex: Write the formula of the compound containing hydrogen and oxygen.



Ex: How does sodium combine with the polyatomic ion carbonate?

First, look up the formula and charge of carbonate in Table E.

Always put your polyatomic ions in parenthesis. The charge goes outside the parenthesis.



Ex: How does aluminum combine with the polyatomic ion carbonate?

First, look up the formula and charge of carbonate in Table E.  
Always put your polyatomic ions in parenthesis. The charge goes outside the parenthesis.



**Produce the correct formulas for the following.** . Don't be afraid to look at Table E to figure out the formulas and charges for polyatomic ions.

a) calcium combines with chlorine

b) calcium combines with phosphate

c) zirconium combines with nitrogen

d) sulfur combines with oxygen

e) ammonium combines with nitrate

f) magnesium combines with phosphate

g) gallium combines with thiosulfate

**Binary Compound** describes a compound composed of 2 different elements in any ratio.

Exs:  $\text{H}_2\text{O}$ ,  $\text{CH}_4$ ,  $\text{SO}_2$ ,  $\text{Fe}_2\text{O}_3$ ,  $\text{N}_2\text{O}_5$ , and  $\text{Al}_2\text{O}_3$ .

**Describe: binary compound** \_\_\_\_\_

**Naming binary compounds** Say the full name of the first element, then change the name of the second element to end in “**ide**”.

Any naming question may include the acronym **IUPAC** which is the naming system used in regents chemistry. It stands for **I**nternational **U**nion of **P**ure and **A**ppplied **C**hemists.

Binary compound names end with “**ide**”.

If a compound name ends in “**ide**” it is usually a binary compound.

**Exception! There are 3 polyatomic ions that have names ending in “ide”. Polyatomic ions are not compounds.**

**Cyanide ( $\text{CN}^-$ ), hydroxide ( $\text{OH}^-$ ), and peroxide ( $\text{O}_2^{-2}$ )**

**List the 3 polyatomic ions that end with “ide”.** \_\_\_\_\_

**Are polyatomic ions compounds?** \_\_\_\_\_

Example binary compounds:

$\text{NaCl}$  sodium chloride

$\text{Na}_2\text{O}$  sodium oxide

$\text{KCl}$  potassium chloride

$\text{KI}$  potassium iodide

**When naming compounds, if the first element has more than 1 choice of oxidation #, the oxidation # must be indicated in the name.**

This involves the **Stock System**.

The stock system uses **Roman Numerals** to indicate oxidation #s when the first element in the compound has more than 1 choice of + oxidation #. Look at the periodic table.

**Examples of elements with more than 1 choice of + oxidation #.**

			+2
+2	+2	+3	+1
$\text{Pb}^{+4}$	$\text{Fe}^{+3}$	$\text{Cr}^{+6}$	$\text{Cu}^{+2}$
.	.	.	.
.	.	.	.
		.	

**The Roman numeral only applies to the first element in the compound.**

**Roman Numerals:**

I – 1

II – 2

III – 3

IV – 4

V – 5

VI – 6

VII – 7

The Roman numerals will only be used in word names of compounds. They are never used in chemical formulas.

**Are Roman Numerals used in chemical formulas?** \_\_\_\_\_

The Roman numeral in parenthesis indicates the element's oxidation number.  
The Roman numeral is not the subscript!

**Is a Roman numeral ever used as a subscript?** \_\_\_\_\_

Lead (II)

Pb<sup>+2</sup>

Iron (III)

Fe<sup>+3</sup>

Chromium (VI)

Cr<sup>+6</sup>

Tin (IV)

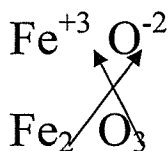
Sn<sup>+4</sup>

Nitrogen (V)

N<sup>+5</sup>

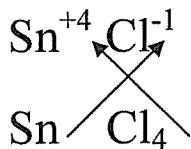
**Since the name of a compound that starts with an element with more than 1 choice of + oxidation number must reveal the oxidation #, the crossover method may be used backwards.**

**Ex: What is the name of Fe<sub>2</sub>O<sub>3</sub>**



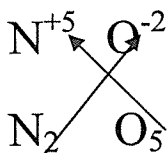
**Name: Iron (III) oxide**

Ex: What is a correct name for  $\text{SnCl}_4$



**Name: Tin (IV) chloride**

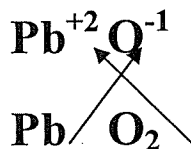
Ex: What is a correct IUPAC name for  $\text{N}_2\text{O}_5$ ?



**Name: Nitrogen (V) oxide**

The crossover method is just a method to get the right answer. Always double check to make sure the oxidation # you have chosen is actually makes sense.

**A Chem regents example of this is to name:  $\text{PbO}_2$**



If you named it lead (II) oxide you would be wrong. Since oxygen only has an oxidation # of -2, lead, Pb, must have an oxidation # of +4.

Therefore; the correct name is **lead (IV) oxide**.

**When you are asked to name a compound:**

"If there is any doubt in your mind, use the Roman numeral designation of charge as part of the name. It is never wrong to do so, even though it may sometimes be unnecessary."

**Name the following compounds:**

a) PbO

b) CrCl<sub>6</sub>

c) NiCl<sub>2</sub>

d) MnPO<sub>4</sub>

## **Naming compounds that contain polyatomic ions.**

Remember! If an ionic compound contains more than 2 different elements it contains a polyatomic ion.

In regents chemistry polyatomic ions will always be at the end of a chemical formula, except for ammonium (NH<sub>4</sub>)<sup>+1</sup>,

**Say the full name of the first element (use the Roman numeral if required).**

**Next, say the full name of the polyatomic ion.**

**If the compound begins with ammonium (NH<sub>4</sub>)<sup>+1</sup>, say ammonium followed by the rest of the compound.**

Don't guess at polyatomic ion names and charges. Look them up in Table E.

**We must remember that the sum of the oxidation #s in a compound must be 0.**

### **Examples:**

Fe<sub>2</sub>(CO<sub>3</sub>)<sub>3</sub>                  Iron (III) carbonate

Na<sub>2</sub>CO<sub>3</sub>                      Sodium carbonate

NH<sub>4</sub>NO<sub>3</sub>                      Ammonium nitrate

NH<sub>4</sub>Cl                         Ammonium chloride

CuSO<sub>4</sub>                         Copper (II) sulfate

Name the following compounds. .

a)  $\text{NH}_4\text{Br}$

b)  $\text{NaOH}$

c)  $\text{AgNO}_3$

d)  $\text{MgCO}_3$

e)  $\text{Fe}(\text{OH})_2$

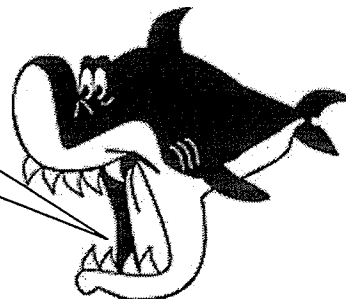
f)  $(\text{NH}_4)_2(\text{Cr}_2\text{O}_7)$

## Important!

**Don't name a compound until you know if the first element needs a Roman numeral!** (has more than 1 positive oxidation #)

You won't know by just looking.

Open up the  
reference table!  
It doesn't bite



You will need to check the periodic table to see if the first element has more than 1 choice of oxidation #.

## Common Names

Some compounds have common names that are not based on a naming system.

You need to know their names for the chemistry reagents.

$\text{H}_2\text{O}$	water
$\text{NH}_3$	ammonia
$\text{C}_6\text{H}_{12}\text{O}_6$	glucose
$\text{CH}_4$	methane
$\text{CO}_2$	carbon dioxide
$\text{SO}_2$	sulfur dioxide

Additionally:

**Organic Chemistry** is the study of carbon compounds.

When you study the topic of **Organic Chemistry** there is a special naming system for many carbon compounds.

2