

# Part C: Naming & Formula of Multivalent Ionic Compounds

April 10, 2019 1:45 PM

multiple different ion charges

## PART C: NAMING & FORMULA OF MULTIVALENT IONIC COMPOUNDS

Have a look at your periodic table, can you find any elements that have more than one ion charge? List an example below:

$Cu^+$ ,  $Cu^{2+}$ ,  $Co^{2+}$ ,  $Co^{3+}$ ,  $Ti^{3+}$ ,  $Ti^{4+}$ ,  $Fe^{2+}$ ,  $Fe^{3+}$

can be  $Cu^+$  ← copper(I) ion  
 $Cu^{2+}$  ← copper(II) ion

**Multivalent metals** are metals that can form more than one type of ion. For

example, copper can form an ion with a +1 or a +2 charge.

That means that copper can give up either 1 or 2 electrons when forming an ionic compound with a non-metal ion.

### 1. FROM COMPOUND NAME --> CHEMICAL FORMULA

When we name multivalent metals we need a way of distinguishing what ion charge of the multivalent metals is involved.

Metal Ion Charge	Roman Numeral
1+	I
2+	II
3+	III
4+	IV
5+	V
6+	VI
7+	VII

For this we use Roman Numerals

- $Ni^{2+}$  or nickel(II) ion called "nickel two" and shows the nickel ion has an ion charge of 2+.
- $Ni^{3+}$  or nickel(III) ion is called "nickel three" and shows the nickel ion has an ion charge of 3+.

For example, the name chromium(III) chloride tells you that that chromium ion in the compound is  $Cr^{3+}$  not  $Cr^{2+}$  ion ← could be either b/c chromium is multivalent... but the (III) tells us which

When we write the chemical formula for an ionic compound containing a multivalent metal, the same steps we have already learned still apply.

swap + drop.

You can use the charge balancing method or the criss cross method.

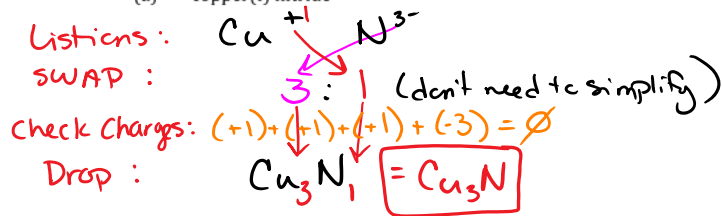
The only thing that is new is that we will see a Roman Numeral in the name of the compound telling us which ion charge is involved.

## Writing Formulas of Compounds Containing a Multivalent Metal

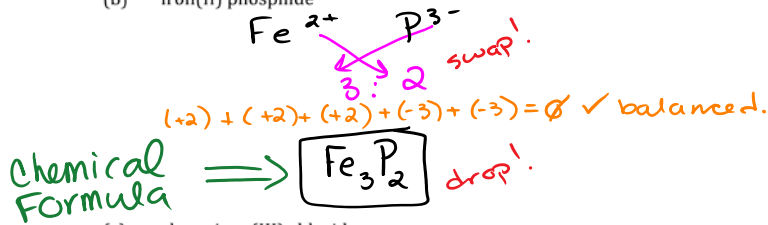
Steps	Examples	
	manganese(IV) sulfide	cobalt(III) oxide
1. Identify each ion and its charge.	$Mn^{+4}$ $S^{-2}$	$Co^{+3}$ $O^{-2}$
2. Determine the total charges needed to balance positive with negative.	$(+4) + (+4) + (-2) + (-2) + (-2) + (-2) = 0$ <i>(swap!)</i> $2 : 4$	$(+3) + (+3) + (-2) + (-2) + (-2) = 0$ $2 : 3$
3. Note the ratio of positive ions to negative ions.	$(+4) + (-2) + (-2) = 0$ $1 : 2$	$(+3) + (-2) + (-2) = 0$ $1 : 2$
4. Use subscripts to write the formula. A "1" is not shown in the subscripts.	$Mn_2S_4 = MnS_2$ <i>(drop!)</i>	$Co_2O_3$ <i>"little numbers" subscripts.</i>

### PRACTICE

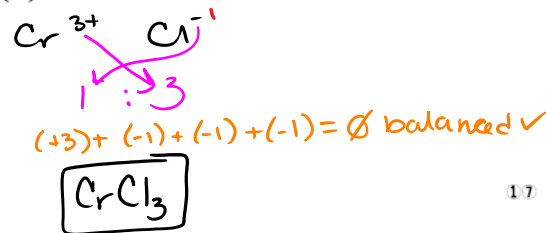
(a) copper(I) nitride



(b) iron(II) phosphide



(c) chromium (III) chloride



# Homework

## ASSIGNMENT #4: Writing formulas of Ionic Compounds with MULTIVALENT ions

This assignment is to be completed below in the space provided.

HW  
April 15

### Practice Problems

1. Write the formulas of the following compounds containing multivalent metals.

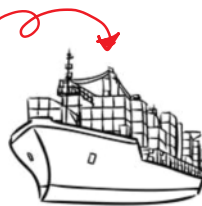
- |                           |                                    |
|---------------------------|------------------------------------|
| (a) manganese(II) oxide   | <u>MnO</u>                         |
| (b) manganese(IV) oxide   | <u>MnO<sub>2</sub></u>             |
| (c) chromium(II) bromide  | <u>CrBr<sub>2</sub></u>            |
| (d) chromium(III) bromide | <u>CrBr<sub>3</sub></u>            |
| (e) lead(IV) chloride     | <u>PbCl<sub>4</sub></u>            |
| (f) iron(III) phosphide   | <u>FeP</u>                         |
| (g) tin(II) sulfide       | <u>SnS</u>                         |
| (h) tin(II) nitride       | <u>Sn<sub>3</sub>N<sub>2</sub></u> |
| (i) mercury(II) fluoride  | <u>HgF<sub>2</sub></u>             |
| (j) tin(IV) nitride       | <u>Sn<sub>3</sub>N<sub>4</sub></u> |
| (k) copper(I) iodide      | <u>CuI</u>                         |
| (l) copper(II) iodide     | <u>CuI<sub>2</sub></u>             |
| (m) Iron (II) iodide      | <u>FeI<sub>2</sub></u>             |
| (n) Nickel (III) sulfide  | <u>Ni<sub>2</sub>S<sub>3</sub></u> |
| (o) Iron (II) fluoride    | <u>FeF<sub>2</sub></u>             |
| (p) Copper (II) chloride  | <u>CuCl<sub>2</sub></u>            |
| (q) Tin (IV) oxide        | <u>SnO<sub>2</sub></u>             |
| (r) Titanium (IV) oxide   | <u>TiO<sub>2</sub></u>             |

## 2. FROM CHEMICAL FORMULA --> COMPOUND NAME

### Naming an Ionic Compound with a Multivalent Metal

The compound  $\text{Fe}_2\text{O}_3$  is the main source of iron in the making of steel, which is used for things like cutlery to shipping freighters.

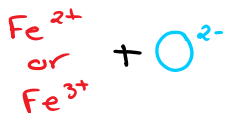
Pure  $\text{Fe}_2\text{O}_3$  is reddish in colour and is used as a pigment in some paints.



What is the name of  $\text{Fe}_2\text{O}_3$ ?

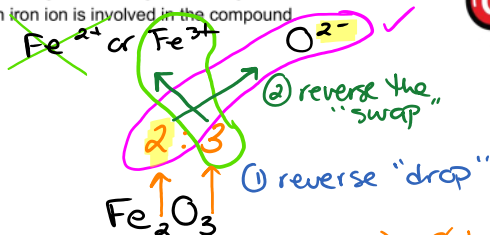
*Fe is multivalent  
 $\text{Fe}^{2+}$  or  $\text{Fe}^{3+}$*

Step 1: Identify the ions.

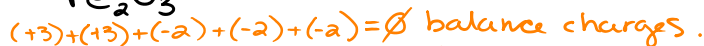


Step 2: "Reverse Swap + drop"

Work backwards using either charge balancing or criss cross methods to determine which iron ion is involved in the compound.

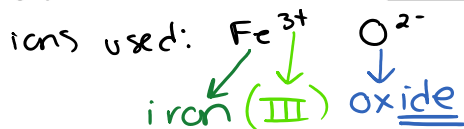


Step 3:



Write the name of the compound using a Roman Numeral to indicate the charge of the multivalent metal ion.

Don't forget you still need to name the non-metal with a "-ide" ending!



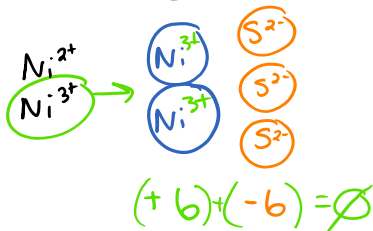
**NAMING Ionic Compounds that Contain a Multivalent Metals:** (reverse "swap and drop")

Naming Ionic Compounds Containing a Multivalent Metal		
Steps	Examples	
1. Identify the metal.	① $Au_3N$	② $PdS_5$
2. Verify that it can form more than one kind of ion by checking the periodic table.	$Au^+$ or $Au^{3+}$	$Pd^{2+}$ or $Pd^{4+}$
3. Determine the ratio of the ions in the formula.	$Au_3N_1$	$Pd_1S_5$
4. Note the charge of the negative ion from the periodic table.	N is always $N^{3-}$	$S^{2-}$
5. The positive and negative charges must balance out. Determine what the charge needs to be on the metal ion to balance the negative ion.	$Au^+$ $Au^+$ $N^{3-}$ $Au^+$ $(+1)+(+1)+(+1)+(-3) = 0$	$Pd^{4+}$ $S^{2-}$ $S^{2-}$ $(+4)+(-2)+(-2) = 0$
6. Write the name of the compound.	$Au^+ N^{3-}$ <u>gold(I)nitride</u>	<u>Palladium(IV)sulfide</u>

**PRACTICE**

Each of these compounds contains a multivalent metal ion. That means that the name of the metal ion will contain a Roman numeral, which you will need to determine. Write the names of the following compounds.

- (a)  $PbF_4$  lead(IV) fluoride
- (b)  $FeI_2$  iron(II) iodide
- (c)  $HgI_2$  mercury(II) iodide
- (d)  $Hg_3N_2$  mercury(III) nitride
- (e)  $Fe_2O_3$  iron(III) oxide
- (f)  $Sn_3P_4$  tin(IV) phosphide
- (g)  $MnS$  manganese(II) sulfide
- (h)  $MnS_2$  manganese(IV) sulfide
- (i)  $VCl_5$  vanadium(V) chloride
- (j)  $Ni_3S_2$  nickel(III) sulfide



**Homework**

**ASSIGNMENT #5: Naming Ionic Compounds with MULTIVALENT ions**  
This assignment is to be completed below in the space provided.

Example: Write the names of the following:

- $FeCl_3$  ( $Fe^{3+}$ ) iron (III) chloride
- $CuCl$  ( $Cu^+$ ) copper (I) chloride
- $SnF_4$  ( $Sn^{4+}$ ) tin (IV) fluoride
- $PbCl_2$  ( $Pb^{2+}$ ) lead (II) chloride
- $Fe_2S_3$  ( $Fe^{3+}$ ) iron (III) sulfide

for multivalent ions, the name MUST indicate what the  $\oplus$  ion charge is.

1. Write the names of the compounds with the following ions:
- a.  $Co^{3+}$  and  $O^{2-}$  cobalt (III) oxide
  - b.  $Cu^+$  and  $Br^-$  copper (I) bromide
  - c.  $Cu^{2+}$  and  $Cl^-$  copper (II) chloride
  - d.  $Mn^{4+}$  and  $S^{2-}$  manganese (IV) sulfide

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- c.  $\text{Cu}^{2+}$  and  $\text{Cl}^-$       copper (II) chloride  
 d.  $\text{Mn}^{4+}$  and  $\text{S}^{2-}$       manganese (IV) sulfide

2. Write the **names** of the following compounds. Each contains an ion of a multivalent metal.

- a.  $\text{FeO}$       iron (II) oxide  
 b.  $\text{Cu}_3\text{N}$       copper (I) nitride  
 c.  $\text{SnS}_2$       tin (IV) sulfide  
 d.  $\text{Sn}_3\text{N}_2$       tin (II) nitride  
 e.  $\text{Ni}_2\text{S}_3$       nickel (III) sulfide  
 f.  $\text{MoCl}_3$       molybdenum (III) chloride  
 g.  $\text{PbF}_4$       lead (IV) fluoride  
 h.  $\text{TiS}_2$       ~~tin~~ titanium (IV) sulfide

3. Write the **chemical formula** for the following compounds.

- a. lead (IV) chloride       $\text{PbCl}_4$   
 b. lead (II) sulfide       $\text{PbS}$