Name _____ Chemistry ___/___/___

Writing Formulas for Compounds with Multivalent Cations

Part I: Common Naming System

Today we will start to use the transition metals in constructing ionic compounds. Find iron on your periodic table. Note that directly above the symbol Fe, the numbers 2 & 3 are written. These numbers are the cationic charges that iron can have when it forms an ionic compound. Look at some of the other elements that also have more than one charge.

When elements have more than one charge, it is important that we distinguish which charge is being used. We will do this in the way we name the ion. Today we will start by using the common naming system.

Metal Ions with More than One Ionic Charge

Formula	Stock Name	Common Name
Au^{1+}	Gold(I) ion	Aurous ion
Au^{3+}	Gold(III) ion	Auric ion
Co^{2+}	Cobalt(II) ion	Cobaltous ion
Co^{3+}	Cobalt(III) ion	Cobaltic ion
Cu^{1+}	Copper(I) ion	Cuprous ion
Cu^{2+}	Copper(II) ion	Cupric ion
Fe^{2+}	Iron(II) ion	Ferrous ion
Fe^{3+}	Iron(III) ion	Ferric ion
$(Hg_2)^{2+}$	Mercury(I) ion	Mercurous ion
Hg^{2+}	Mercury(II) ion	Mercuric ion
Ni^{2+}	Nickel(II) ion	Nickelous ion
Ni^{3+}	Nickel(III) ion	Nickelic ion
Pb^{2+}	Lead(II) ion	Plumbous ion
Pb^{4+}	Lead(IV) ion	Plumbic ion
Sn^{2+}	Tin(II) ion	Stannous ion
Sn^{4+}	Tin(IV) ion	Stannic ion

Antoine Laurent Lavoisier (1743-94) reformed chemistry in the late 1700's with his publication of Méthode de nomenclature chimique in 1787 (along with three co-authors) and Traité élémentaire de Chimie in 1789. He is known as the "**Father of Modern Chemistry**."

Two typical names of chemicals up to this point in history are "foliated earth of tartar" and "phlogisticated vitriolic acid." There were hundreds of such names. One goal of the Méthode was to create chemical names based on the chemical composition.

Lavoisier's solution, which will be studied in this lesson, was to use different suffixes to indicate differences in composition. Specifically, the use of "-ous" and "-ic" will be studied.

Here is what the IUPAC currently says about this naming system: "The following systems are in use but not recommended: The system of indicating valence by means of the suffixes -ous and -ic added to the root of the name of the cation may be retained for elements exhibiting not more than two valences."

When using the Common Naming System, you should refer to the chart on the left. Its also on the back of your periodic table.

The steps here are exactly as they were last class when we used polyatomic ions, except we need to use the above chart to look up the symbol and charge for the name used.

Let's try this one. Write the formula for **ferric oxide**

Description of Action	Action
1. Use your chart to find the symbol and charge for the given common name. Write the symbol and charge for this ion.	**1.** Fe^{3+}
2. To the right of the cation, write the anion and its charge.	**2.** Fe^{3+} O^{2-}
3. Cross each element's oxidation number to the lower right side of the other element's symbol.	**3.** Fe^{3+} O^{2-} **Result:** Fe_{2-} O_{3+}
4. Remove all (+) signs, (-) signs and ones.	**4.** Fe_2O_3
5. Reduce if necessary. Remember, if you are using a polyatomic ion, DO NOT touch anything in the parenthesis.	**5. Not Necessary:** Fe_2O_3
6. If you are using a polyatomic ion and there is no number outside of the parenthesis, you can remove the parenthesis.	**6. No polyatomic ions:** Fe_2O_3

Now you try it. Write the formula for **cobaltic phosphate**

Description of Action	Action
1.	**1.**
2.	**2.**
3.	**3.**
4.	**4.**
5.	**5.**
6.	**6.**

More Practice: Write the formulas for each of the following.

1. cuprous chloride
2. cobaltic phosphite
3. nickelous nitride
4. ferrous oxide
5. stannic borate
6. plumbic silicate
7. aurous citrate
8. mercurous peroxide
9. ferric dichromate
10. cupric amide
11. stannous oxalate
12. cobaltous fluoride
13. ferrous sulfate
14. plumbous carbide
15. auric selenate

Part II: The Stock System

The second type of naming you will learn about today is called the Stock system or Stock's system. It was designed by Alfred Stock (German chemist 1876-1946), and first published in 1919. In his own words, he considered the system to be “simple, clear, immediately intelligible, capable of the most general application."

In 1924, a German commission recommended Stock's system to be adopted with some changes. For example, $FeCl_2$, which would have been named iron(2)-chloride according to Stock's original idea, became iron(II) chloride in the revised proposal. In 1934, Stock approved of the Roman numerals, but felt it better to keep the hyphen and drop the parenthesis. This suggestion has not been followed, but the Stock system remains in use worldwide.

Example #1: Write the formula for copper(II) chloride.

Description of Action	Action
1. Write the symbol for the given cation name.	**1.** Cu
2. Use the number in parenthesis as the cations charge. Write it to the top right of the cation's symbol.	**2.** Cu^{2+}
3. To the right of the cation's symbol and charge, write the anion and its charge.	**3.** Cu^{2+} Cl^{1-}
4. Cross each element's oxidation number to the lower right side of the other element's symbol.	**4.** Cu^{2+} Cl^{1-} **Result:** Cu_{1-} Cl_{2+}
5. Remove all (+) signs, (-) signs and ones.	**5.** $CuCl_2$.
6. Reduce if necessary. Remember, if you are using a polyatomic ion, DO NOT touch anything in the parenthesis.	**6. Not necessary:** $CuCl_2$
7. If you are using a polyatomic ion and there is no number outside of the parenthesis, you can remove the parenthesis.	**7. No polyatomic ions:** $CuCl_2$

Fill in the information below to determine the formula for: **iron(III) citrate**

Description of Action	Action
1.	**1.**
2.	**2.**
3.	**3.**
4.	**4.**
5.	**5.**
6.	**6.**
7.	**7.**

More Practice: Write the formulas for each of the following compounds. They all use Stock's system.

1. nickel(II) sulfide
2. lead(IV) bromide
3. iron (II) bicarbonate
4. mercury(II) phosphate
5. tin(II) nitrate
6. copper(I) hydroxide
7. antimony(V) sulfite
8. chromium(III) acetate
9. tin(IV) selenate
10. lead(II) oxide
11. chromium(III) oxide
12. cobalt(III) sulfate

Homework: Write the formulas for each of the following compounds. All versions of naming are used (binary ionic compounds, polyatomic compounds, compounds using the Common naming system and compounds using the Stock naming system).

1. iron(III) oxide
2. calcium sulfide
3. nickel(III) iodide
4. rubidium nitrate
5. mercuric oxide
6. cupric chloride
7. lead(IV) chlorate
8. aluminum sulfite
9. potassium nitride
10. iron(III) hydrogen sulfate
11. ferric carbonate
12. magnesium citrate
13. lead(II) phosphite
14. iron(II) dichromate
15. cuprous hydroxide
16. copper(II) thiosulfate
17. lithium chloride
18. cupric bicarbonate
19. nickel(II) nitrate
20. silver cyanide
21. calcium chlorate
22. ammonium sulfate
23. aluminum chlorate
24. zinc sulfite
25. tin(IV) chloride
26. zinc selenate
27. antimony(V) chloride
28. sodium phosphate
29. silver sulfide
30. silver hypochlorite

Part III: Naming Ionic Compounds with Multivallent Cations

There are a lot of steps in this one. This is the most complicated process, review it closely and carefully.

Example #1: Name **$FeSO_4$**

Description of Action	Action
1. Name the cation.	**1. iron**
2. Check your periodic table to see if the element has more than one charge. If it does, write empty parenthesis after the cation's name.	**2.** Yes, iron has charges of 2+ or 3+ **iron( )**
3. Name the anion. Leave the parenthesis blank.	**3. iron( ) sulfate**
4. Look at your formula. If they are not already written, put parenthesis around any polyatomic ions.	**4.** Fe (SO_4) Sulfate is polyatomic, so I put parenthesis around it. Iron is not polyatomic, so it does not need parenthesis.
5. Write the anion's charge to the top right of its symbol, outside of the parenthesis	**5.** Fe $(SO_4)^{2-}$
6. Multiply the anion's **charge** and the anion's **subscript**. If the anion is polyatomic, use the subscript outside of the parenthesis. If there is no number written, we must assume it is one.	**6.** For this formula we would **multiply** 2- (charge) x 1 (subscript). 2 x 1 = **2**
7. Divide the **result** by the **subscript** of the cation. Again, if there is no number written, assume the subscript is one.	**7.** Our result was (2) and there is no subscript for Fe, so we would divide 2 ÷ 1 = **2**
8. Your new result is the roman numeral to put in parenthesis after the cation's name. Be sure to check your periodic table to verify that the number you use is valid.	**8. iron(II) sulfate**
9. Since iron(II) is also known as ferrous, you can also write the common name. Either is acceptable.	**9. ferrous sulfate**

Example #2: Name Cu_3PO_3 **YOU MUST WRITE BOTH THE DESCRIPTION AND THE ACTION!!!!!**

Description of Action	Action
1.	**1.**
2.	**2.**
3.	**3.**
4.	**4.**
5.	**5.**
6.	**6.**
7.	**7.**
8.	**8.**
9.	**9.**

Homework: Write the correct name for the following compounds:

1. HgF_2
2. $NaCl$
3. $Ca(MnO_4)_2$
4. $FeHPO_4$
5. $RbClO_4$
6. $BeCO_3$
7. ZnO
8. $Mg(HCO_3)_2$
9. $B(OH)_3$
10. $Sn_3(PO_3)_2$
11. NH_4IO
12. $SrCO_3$
13. $ZnCl_2$
14. $Ba_3(PO_3)_2$
15. AgH_2PO_4
16. Fe_2O_3
17. Hg_2Cl_2
18. CoF_3
19. $Fe(NO_2)_2$
20. K_2SO_4
21. $Ba(HSO_4)_2$
22. $Sn(HCO_3)_4$
23. $NaMnO_4$
24. Ag_2O
25. KF
26. $Pb(ClO_2)_2$
27. $CaSO_4$
28. Cu_2CrO_4
29. $Ca(ClO_4)_2$
30. AlI_3