Naming Ionic Compounds

What are the structural units that make up ionic compounds and how are they named?

Why?

When working in chemistry, it is often convenient to write a chemical in symbols. For example we might write down the substance table salt as NaCl. In talking about chemistry however, it is a bit tacky to say "en-ay see-ell" when we want to refer to a substance. Also, in formal writing we should use the name of the compound rather than its symbols. Therefore we need to learn how to say the proper names of ionic substances.

Model 1 – Ion Charges for Selected Elements

1	H^+										
2	Li^+	Be^{2+}							N^{3-}	O^{2-}	F^{1-}	
3	Na^+	Mg^{2+}	Transition elements				Al^{3+}		P^{3-}	S^{2-}	Cl^{1-}	
4	K^+	Ca^{2+}	Fe^{2+} Fe^{3+}	Ni^{2+} Ni^{3+}	Cu^+ Cu^{2+}	Zn^{2+}					Br^{1-}	
5	Rb^+	Sr^{2+}			Ag^{1+}			Sn^{2+} Sn^{4+}			I^{1-}	
6		Ba^{2+}				Hg_2^{2+} Hg^{2+}		Pb^{2+} Pb^{4+}				

Cations → ← Anions

1. Based on the information in Model 1:
   a. Identify three elements that form only one cation.

   b. Identify three elements that form only one anion.

   c. Identify three elements that form more than one cation.

   d. In what region of the periodic table are these "multiple ion" elements usually located?

2. Consider the ions of potassium (K) and sulfur (S). Write chemical formulas for all possible ionic compounds involving these ions, using the simplest ratio(s) of potassium (K) and sulfur (S). Keep in mind that the sum of the charges in an ionic compound must equal zero.

3. Consider the ions of iron (Fe) and sulfur (S). Write chemical formulas for all possible ionic compounds involving these ions, using the simplest ratio(s) of iron (Fe) and sulfur (S). Keep in mind that the sum of the charges in an ionic compound must equal zero.

Model 2 – Ionic Compound Names (Metals that form one ion)

$NaCl$	Sodium chloride	Zn_3P_2	Zinc phosphide
CaS	Calcium sulfide	Al_2O_3	Aluminum oxide
Ag_2S	Silver sulfide	$SrCl_3$	Strontium chloride

4. Circle the symbol for the metal in each of the compounds in Model 2.
5. Which element comes first in the name and formula of the compounds in Model 2—the metal or the nonmetal?
6. Use the table of ions in Model 1 to answer the following questions:
   a. In the compound zinc phosphide, what is the charge on the zinc ion?
   b. In the compound zinc phosphide, what is the charge on the phosphide ion?
7. Explain why a 3 to 2 ratio of ions is necessary for the compound zinc phosphide.
8. The compound carbon dioxide has a name that gives you a hint as to how many oxygen atoms are in the compound. Is there anything in the name "zinc phosphide" that indicates there are three zinc and two phosphorus ions in the formula unit?
9. Is there any other ratio of zinc and phosphorus ions that could exist? For instance, could you have Zn_2P or ZnP_2? Explain your answer.
10. Explain why you don't need to specify the number of ions in the compound when you are naming ionic substances like those in Model 2.
11. Model 2 is labeled "Metals that form one ion." What other metals that also form only one ion could be included in the Model 2 list? Model 1 may be helpful in this regard.
12. Describe how the names of the nonmetal elements in Model 2 are changed when they are in their anion forms.
13. Name the following ionic compounds using what you learned from Model 2.

Li_2O MgF_2 Al_2S_3 K_3N

14. Provide the chemical formula for each of the following ionic compounds.

Barium chloride Magnesium oxide

15. Consider the two chemical formulas you wrote in Question 3 for compounds of iron and sulfur. Would the name "iron sulfide" be sufficient to uniquely identify either of those compounds? Explain.

Read This!

When the metal in an ionic compound always forms an ion with the same charge, you need not indicate that charge as part of the compound name. However, some atoms have the ability to form more than one type of ion. This can make naming confusing. You can't simply refer to a compound of copper and oxygen as "copper oxide." People won't know which compound you are referring to—CuO or Cu_2O.

Model 3 – Ionic Compound Names (Metals that form multiple ions)

Cu_2O	Copper(I) oxide	PbO	Lead(II) oxide
CuO	Copper(II) oxide	PbO_2	Lead(IV) oxide
SnF_2	Tin(II) fluoride	$FeCl_2$	Iron(II) chloride
SnF_4	Tin(IV) fluoride	$FeCl_3$	Iron(III) chloride

16. Model 3 is labeled "Metals that form multiple ions." What other metals that form multiple ions could be included in Model 3? Model 1 may be helpful in this regard.

17. Describe the most obvious difference between the names in Model 3 and those in Model 2.

18. The Roman numerals in the name tell you _____ of the CATION / ANION.

19. Keeping in mind that the sum of the charges in an ionic compound must equal zero, use the chemical formulas in Model 3 to answer the following questions:

a. Identify the charge on the copper cations in copper(I) oxide and copper(II) oxide, respectively.

b. Identify the charge on the iron cations in iron(II) chloride and iron(III) chloride, respectively.

20. Identify the charge for the metal in the following:

$NiCl_2$ _____ $NiCl_3$ _____ PbO_2 _____

21. Fill in the table below using what you've learned from Model 3.

Compound	Charge on Cation	Name of the Compound
$PbCl_4$	Pb^{4+}	Lead(IV) chloride
Fe_2O_3		
SnO		
$CuBr_2$		

22. For each of the compounds in the table below, determine the type of metal in the compound and then name the compound using the correct naming method.

	Metal forms only one ion	Metal forms multiple ions	Name
$CaBr_2$			
MgO			
Ag_3N			
$SnCl_2$			
CuF_2			
K_3P			
Zn_3N_2			
HgO			

Model 4 – Traditional Names for Ionic Compounds

Metals that form one ion		Metals that form multiple ions-	
NaCl	Sodium chloride	Cu_2O	Cuprous oxide
CaS	Calcium sulfide	CuO	Cupric oxide
Ag_2S	Silver sulfide	SnF_2	Stannous fluoride
Zn_3P_2	Zinc phosphide	SnF_4	Stannic fluoride

Traditionally, ionic compounds with metals that form multiple ions did not use Roman numerals in their name. Compare the names in Model 4 to the naming in Model 3.

23. Do the "-ous" and "-ic" endings in the compound names in Model 4 refer to a particular metal ion charge? Explain.

24 Examine the traditional ion names shown below for selected metals. Write a rule for using the "-ous" and "-ic" endings for metal ions.

Cu^{2+} cupric	Fe^{3+} ferric	Sn^{4+} stannic	Pb^{4+} plumbic
Cu^{1+} cuprous	Fe^{2+} ferrous	Sn^{2+} stannous	Pb^{2+} plumbous