CHAPTER 5

# Nomenclature

## INTRODUCTION

In this chapter you will learn how to name ions and compounds. You will be asked to learn rules for naming ions and compounds, and you will need to memorize some names. Many of the problems at the end of this chapter have as their goal the application of the rules you will learn. Work on the naming problems until you have developed skill at naming chemical compounds.

## CHAPTER DISCUSSION

Many students look at nomenclature as memorizing the names of a seemingly endless list of chemicals, but this is simply not true. There are systematic rules for naming compounds. By knowing only a few rules you can name most any compound you will encounter in introductory chemistry.

For example, all the charges for the common, simple cations and anions in Table 5.1 of your text come from their placement on the periodic table (see Chapter 4 if this is unfamiliar to you).

Also, look at Table 5.2, the "common type II cations." What is the difference here? The difference is that these ions come from transition metals (not from the alkali or alkaline earth metals in the first two columns of the periodic table). These ions can have more than one stable charge, and we therefore have to specify which ion we are talking about. The Roman numeral is the charge, not the subscript. Therefore, the formula $Fe_2O_3$ should be read as "iron (III) oxide." Make sure to prove to yourself that it is indeed iron (III); that is, $Fe^{3+}$.

Notice this is different from NaCl. The name "sodium (I) chloride" is not so much wrong as it is redundant. The most stable charge for the sodium ion in a compound is 1+, and the most stable charge for the chloride ion in a compound is 1−. Therefore the only possible formula for "sodium chloride" is NaCl. However, the name "iron oxide" is incomplete because it could be referring to $Fe_2O_3$ [iron (III) oxide] or FeO [iron (II) oxide]. We use Roman numerals only when we have to for clarity.

The same goes for prefixes. For example, there is no reason to call $CaCl_2$ "calcium dichloride" because $CaCl_2$ is the only stable formula for an ionic compound made of calcium and chloride ions. Therefore, we can simply say "calcium chloride," and everyone knows that this means "$CaCl_2$." However, we cannot use the name "carbon oxide" because these are both nonmetals, meaning the compound is not made up of ions. There is no way from the name "carbon oxide" to know the formula (although we do know the compound is made from carbon and oxygen). Therefore we have to specify if it is carbon monoxide (CO) or carbon dioxide ($CO_2$), for example. The only way to make sure you can name compounds is to practice. Being able to name compounds requires you to have some rules memorized, but it also requires you to understand these rules.

## LEARNING REVIEW

1. Name the cations and anions below.
   a. $Cl^-$
   b. $Mg^{2+}$
   c. $Li^+$
   d. $Ba^{2+}$
   e. $N^{3-}$
   f. $O^{2-}$
   g. $F^-$
2. Name the following Type I binary compounds.
   a. KF
   b. CaS
   c. NaI
   d. $Li_3N$
   e. HCl
   f. $Al_2O_3$
   g. AgCl
   h. $MgF_2$
3. The following elements can all form more than one cation. How many cations form, and what is the charge on each of them?
   a. Cu
   b. Fe
   c. Sn
   d. Hg
   e. Pb
4. Name the following Type II binary compounds.
   a. $FeCl_3$
   b. $PbO_2$
   c. $CoI_2$
   d. $SnF_2$
   e. $Fe_2S_3$
   f. $Hg_2Br_2$

5. Name each of the compounds below.

   a. $CaBr_2$

   b. $PbS$

   c. $AlP$

   d. $FeS$

   e. $CoO$

   f. $MgCl_2$

6. Each of the compounds below has an *incorrect* name. Name each one correctly.

| | | |
|---|---|---|
| a. | KBr | potassium(I) bromide |
| b. | $Cu_2O$ | cupric oxide |
| c. | $PbS_2$ | lead(IV) sulfide(II) |
| d. | $Na_3P$ | sodium(III) phosphide |
| e. | $FeCl_3$ | iron chloride |

7. Name the following Type III binary compounds.

   a. $PCl_5$

   b. $CCl_4$

   c. $N_2O_3$

   d. $S_2F_{10}$

   e. $SO_2$

   f. $CO$

8. Name the following Type I, Type II, or Type III compounds.

   a. $KI$

   b. $NO_2$

   c. $FeCl_2$

   d. $Al_2O_3$

   e. $Cl_2O_7$

   f. $CaS$

9. What are the names of the polyatomic ions below?

   a. $HCO_3^-$

   b. $OH^-$

   c. $NH_4^+$

   d. $NO_2^-$

   e. $SO_4^{2-}$

   f. $CrO_4^{2-}$

10. The compounds below all contain polyatomic ions. Name each one.
    a. $K_2SO_4$
    b. $Fe(OH)_3$
    c. $NH_4NO_3$
    d. $Al_2(Cr_2O_7)_3$
    e. $Ca(CN)_2$
    f. $Mg_2(PO_4)_2$
    g. $NaMnO_4$
    h. $Cu(ClO_3)_2$
    i. $PbCO_3$
11. Check your knowledge of the common acids by naming the acids below.
    a. $H_2SO_4$
    b. HCN
    c. HBr
    d. $HNO_3$
    e. $H_2S$
    f. $HC_2H_3O_2$
12. From their names, write formulas for the compounds below.
    a. aluminum chloride
    b. cobalt(III) permanganate
    c. dinitrogen trioxide
    d. sulfur dioxide
    e. calcium nitrate
    f. silver chloride
    g. iron(II) acetate
    h. tin(IV) chlorite
    i. sodium sulfate
    j. lithium hydrogen carbonate
    k. mercury(II) dichromate

## ANSWERS TO LEARNING REVIEW

1. The ions in this problem are all monatomic ions. The cations all have the same name as the element while the anions all end in –ide.
    a. chloride
    b. magnesium
    c. lithium

d. barium
e. nitride
f. oxide
g. fluoride

2. Type I binary compounds form between a metal and a nonmetal.
   a. potassium fluoride
   b. calcium sulfide
   c. sodium iodide
   d. lithium nitride
   e. hydrogen chloride
   f. aluminum oxide
   g. silver chloride
   h. magnesium fluoride

3. Notice that these are all transition metal ions.
   a. $Cu^{+}$ $Cu^{2+}$
   b. $Fe^{2+}$ $Fe^{3+}$
   c. $Sn^{2+}$ $Sn^{4+}$
   d. $Hg_2^{2+}$ $Hg^{2+}$
   e. $Pb^{2+}$ $Pb^{4+}$

4. Type II binary compounds form between a metal that forms more than one cation and a nonmetal.
   a. iron(III) chloride
   b. lead(IV) oxide
   c. cobalt(II) iodide
   d. tin(II) iodide
   e. iron(III) sulfide
   f. mercury(I) bromide

5. The compounds are mixed Type I and Type II binary compounds.
   a. calcium bromide
   b. lead(II) sulfide
   c. aluminum phosphide
   d. iron(II) sulfide
   e. cobalt(II) oxide
   f. magnesium chloride

6.

a. Potassium forms only cations with 1+ charge, so potassium(I) bromide should be potassium bromide.

b. The formula $Cu_2O$ shows copper with a 1+ charge, which is named the copper(I) or cuprous ion. The correct name for this formula is copper(I) oxide or cuprous oxide.

c. The formula $PbS_2$ tells us that the charge on the lead ion is 4+, so the first part of the name, lead(IV), is correct. The sulfide ion has a 2– charge, but we do not use Roman numerals after the anion name. So the correct name for this compound is lead(IV) sulfide.

d. Sodium forms only cations with 1+ charge, so sodium(III) phosphide should be sodium phosphide.

e. The formula $FeCl_3$ tells us that iron has a 3+ charge. Because iron forms cations with more than one charge, the correct name would be iron(III) chloride.

7. Type III binary compounds form between nonmetals. The prefix that indicates ten atoms is *deca-*. This prefix is used in problem 7d.

a. phosphorus pentachloride

b. carbon tetrachloride

c. dinitrogen trioxide

d. disulfur decafluoride

e. sulfur dioxide

f. carbon monoxide

8. The compounds are a mixture of Type I, Type II and Type III compounds.

a. potassium iodide

b. nitrogen dioxide

c. iron(II) chloride

d. aluminum oxide

e. dichlorine heptoxide

f. calcium sulfide

9. If you have trouble naming these ions, go back and review the names again. You will need these names throughout your chemistry career.

a. bicarbonate

b. hydroxide

c. ammonium

d. nitrite

e. sulfate

f. chromate

10.

a. potassium sulfate
b. iron(III) hydroxide
c. ammonium nitrate
d. aluminum dichromate
e. calcium cyanide
f. magnesium phosphate
g. sodium permanganate
h. copper(II) chlorate
i. lead(II) carbonate

11.

a. sulfuric acid
b. hydrocyanic acid
c. hydrobromic acid
d. nitric acid
e. hydrosulfuric acid
f. acetic acid

12.

a. $AlCl_3$
b. $Co(MnO_4)_3$
c. $N_2O_3$
d. $SO_2$
e. $Ca(NO_3)_2$
f. $AgCl$
g. $Fe(C_2H_3O_2)_2$
h. $Sn(ClO_2)_4$
i. $Na_2SO_4$
j. $LiHCO_3$
k. $HgCr_2O_7$