Naming Simple Compounds

Binary Ionic Compounds (Type I)

Binary ionic compounds contain a positive ion (cation) always written first in the formula and a negative ion (anion). In naming these compounds, the following rules apply:

1. The cation $(+)$ is always named first and the anion $(-)$ second.
2. A monatomic (meaning "one-atom") cation takes its name from the name of the element. For example, Na^+ is called sodium.
3. A monatomic anion is named by taking the root of the element name and adding –ide. Thus, the Cl^- ion is called chloride.

Some common monatomic ions are listed in the following table:

Cation	Name	Anion	Name
H^+	Hydrogen	H^-	Hydride
Li^+	Lithium	F^-	Fluoride
Na^+	Sodium	Cl^-	Chloride
K^+	Potassium	Br^-	Bromide
Cs^+	Cesium	I^-	Iodide
Ag^+	Silver	O^{2-}	Oxide
Be^{2+}	Beryllium	S^{2-}	Sulfide
Mg^{2+}	Magnesium	N^{3-}	Nitride
Ca^{2+}	Calcium	P^{3-}	Phosphide
Ba^{2+}	Barium		
Zn^{2+}	Zinc		
Cd^{2+}	Cadmium		
Al^{3+}	Aluminum		

Example 1
Name each binary compound.

a) CsF

b) $AlCl_3$

c) LiH

Formulas from Names

It is equally important to be able to determine the chemical formula for a compound from its name. To do so, follow the steps below:

1. Determine the charges of the ions that the compound is made of.
2. Determine how many of the cation and how many of the anion would be needed to make the total charge of the compound zero.
3. Write the symbol for the cation first, followed by a subscript that indicates how many of the cation are in the compound.
4. Write the symbol for the anion second, followed by a subscript that indicates how many of the anion are in the compound.

Example 2
Given the following names, write the formula for each compound:

a) calcium chloride

b) potassium iodide

c) calcium oxide

d) aluminum sulfide

Binary Ionic Compounds (Type II)

In Type I compounds, the metal present forms only a single type of cation. For example, sodium is always Na^+. However, there are many metals that form more than one type of cation and thus form more than one type of ionic compound with a given anion. For example, the compound $FeCl_2$ contains Fe^{2+} ions, and the compound $FeCl_3$ contains Fe^{3+} ions.

Note: Metals that form more than one cation are called **polyvalent metals**. Some common polyvalent metals are listed in the table to the right.

When naming compounds that contain a polyvalent metal, the charge on the metal ion must be specified. To do this, we include a Roman numeral in the name of the metal that indicates its charge.

For example, the compound $FeCl_2$ is called iron(II) chloride, while the compound $FeCl_3$ is called iron(III) chloride.

Ion	Name
Fe^{3+}	Iron(III)
Fe^{2+}	Iron(II)
Cu^{2+}	Copper(II)
Cu^{+}	Copper(I)
Co^{3+}	Cobalt(III)
Co^{2+}	Cobalt(II)
Sn^{4+}	Tin(IV)
Sn^{2+}	Tin(II)
Pb^{4+}	Lead(IV)
Pb^{2+}	Lead(II)
Hg^{2+}	Mercury(II)
Hg_2^{2+}	Mercury(I)

Example 3
Write the name for each of the following compounds:

a) $CuCl$

b) HgO

c) Fe_2O_3

Elements that form only one cation do not need to be identified by a Roman numeral. Common metals that do not require Roman numerals are Group 1 and Group 2 metals, silver, aluminum, and zinc.

Example 4
Given the following names, write the formula for each compound:

a) manganese(IV) oxide

b) lead(II) chloride

Ionic Compounds with Polyatomic Ions

Many ionic compounds contain **polyatomic ions**, which are ions made up of more than one atom. The table below lists the formulas and the charges for several common polyatomic ions.

Ion	Name	Ion	Name
NH_4^+	ammonium	IO_4^-	periodate
NO_2^-	nitrite	$C_2H_3O_2^-$	acetate
NO_3^-	nitrate	$H_2PO_4^-$	dihydrogen phosphate
HSO_4^-	hydrogen sulfate	CO_3^{2-}	carbonate
OH^-	hydroxide	HSO_3^-	hydrogen sulfite
CN^-	cyanide	SO_3^{2-}	sulfite
MnO_4^-	permanganate	SO_4^{2-}	sulfate
HCO_3^-	hydrogen carbonate	$S_2O_3^{2-}$	thiosulfate
ClO^-	hypochlorite	O_2^{2-}	peroxide
ClO_2^-	chlorite	CrO_4^{2-}	chromate
ClO_3^-	chlorate	$Cr_2O_7^{2-}$	dichromate
ClO_4^-	perchlorate	HPO_4^{2-}	hydrogen phosphate
BrO_3^-	bromate	PO_4^{3-}	phosphate
IO_2^-	iodite	AsO_4^{3-}	arsenate
IO_3^-	iodate	SCN^-	thiocyanate

Notice that several sets of anions contain an atom of a given element with different numbers of oxygen atoms (e.g. SO_3^{2-} and SO_4^{2-}). These anions are called **oxyanions**. In such sets, the name of the one with fewer oxygen atoms ends in *–ite* and the name of the one with more oxygen atoms ends in *–ate*. When more than two oxyanions make up a set, *hypo–* (less than) and *per–* (more than) are used as prefixes to name the members with the fewest and the most oxygen atoms, respectively.

To name polyatomic ionic compounds:

1. The cation $(+)$ is always named first and the anion $(-)$ second.
2. A monatomic (meaning "one-atom") cation takes its name from the name of the element. A polyatomic cation uses the name of the polyatomic ion.
3. A monatomic anion is named by taking the root of the element name and adding –ide. A polyatomic anion uses the name of the polyatomic ion.

Example 5
Write the name for each of the following compounds:

a) Na_2SO_4

b) KH_2PO_4

c) $Fe(NO_3)_3$

d) $Mn(OH)_2$

e) Na_2SO_3

f) Na_2CO_3

Example 6
Given the following names, write the formula for each compound:

a) sodium hydrogen carbonate

b) cesium perchlorate

c) sodium hypochlorite

d) potassium bromate

Worksheet

1. How does the sum of the charges on the positive ions compare to the sum of the charges on the negative ions in ionic compounds?

2. Calculate the sum of the ionic charges in the compound Al_2O_3. Show your calculation.

3. Draw a Bohr diagram to show the electron transfer that occurs when magnesium and fluorine form the compound magnesium fluoride.

4. Write the formulas for the compounds formed by the following combinations of elements:

   a) lithium and fluorine
   b) calcium and bromine
   c) sodium and nitrogen
   d) aluminum and nitrogen

5. Name each of the compounds in question 4.

6. Write the formulas for the following compounds:

   a) sodium iodide
   b) beryllium fluoride
   c) magnesium oxide
   d) aluminum sulfide

7. Write the names for the following compounds:

   a) KCl
   b) Na_3P
   c) CaF_2

8. Write the formulas for the following compounds:

   a) copper(I) bromide
   b) copper(II) bromide
   c) iron(II) sulfide

9. Write the names for the following compounds:

   a) $SnCl_2$
   b) $SnCl_4$
   c) $PbBr_2$

10. Write the formula and name of the compound formed by each of the following combinations of ions. (Note that some of these ions will require the use of Roman numerals in the names.)

    a) Fe^{+3} and O^{-2}
    b) Ca^{+2} and F^{-}
    c) Cu^{+} and S^{-2}

11. In mining, some minerals are referred to as ferrous. What metallic element is present in these compounds? (Hint: Look at the letters that begin the word.)

12. In your own words, explain what is meant by the term "polyatomic ion." Give two examples.

13. Write the formulas for the following compounds:

    a) sodium phosphate
    b) calcium sulfate
    c) potassium chlorate
    d) aluminum hydroxide
    e) beryllium nitrate
    f) magnesium hydrogen carbonate (magnesium bicarbonate)
    g) nickel carbonate

14. Write the names for the following compounds:

    a) K_2CO_3
    b) Na_2SO_4
    c) $Al(HCO_3)_3$
    d) $AgNO_3$

15. Why is ammonium nitrate (NH_4NO_3) not written as $N_2H_4O_3$?

16. Give the names and formulas of the compounds formed by an ammonium ion and

    a) a chloride ion.
    b) a sulfate ion.