Nomenclature IV
Compounds of Metals That Form More Than One Monatomic Ion

Most main group elements form only one stable ion (e. g., all members of Group 1 exist in their compounds as M^+ ions; all members of Group 2 exist in their compounds as M^{2+} ions; aluminum always exists in its compounds as an M^{3+} ion). Exceptions to the "rule" that "main group elements form only one stable ion" are found among the heavier elements of groups 13, 14, and 15. For instance, thallium and indium form both +1 and +3 ions (Tl^+ and Tl^{3+}; In^+ and In^{3+}). Likewise, tin and lead form both +2 and +4 ions (Sn^{2+} and Sn^{4+}; Pb^{2+} and Pb^{4+}).

In contrast to most main group elements, transition metals generally form several monatomic ions (notable exceptions are silver, which exists as Ag^+ in all of its common compounds, and zinc, which exists as Zn^{2+} in all of its common compounds). When a metal forms monatomic ions having a variety of charges, they are distinguished from one another by the placement of a Roman numeral in parentheses *immediately* after the name. This pattern of naming is illustrated below:

Cu^+	copper(I)	Fe^{2+}	iron(II)	Hg_2^{2+}	mercury(I)*
Cu^{2+}	copper(II)	Fe^{3+}	iron(III)	Hg^{2+}	mercury(II)

*note the unusual form of mercury(I); it is a dimeric ion, a combination of two Hg^+ ions

An earlier method for distinguishing pairs of ions such as Fe^{2+} and Fe^{3+} used the suffixes *–ous* and *–ic*, added to the root of the name (often the Latin name) of the metal, to indicate the ions of lower and higher charge, respectively. Thus, Fe^{2+} was called the "ferrous ion" and Fe^{3+} was called the "ferric ion". Although this method is still sometimes used today, it is too limited for systematic nomenclature and will not generally be used in this course.

All compounds, of course, must be electrically neutral. Thus, the charges on the cation and anion will determine the formula of the compound. Thus, iron forms two different sulfate compounds, iron(II) sulfate has the formula, $FeSO_4$ (the charge of a single SO_4^{2-} is balanced by the charge of a single Fe^{2+} ion). The total charge of three sulfate ions (–6) is balanced by the total charge of two iron(III) ions; thus, the formula of iron(III) sulfate is $Fe_2(SO_4)_3$.

Table IV.1 shows some of the charges commonly associated with ions of the first transition series. Note that almost all of them exhibit the +2 charge as well as one or more other possible charges.**

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
+2, +3	+2, +3, +4	+2, 3, +4, +5	+2, +3, +6	+2, +4, +7	+2, +3	+2, +3, +4	+2, +4	+1, +2	+2

**Note that compounds containing "ions" with "charges" of +4 or greater often exhibit significant covalent character. Thus, while lead(II) chloride is a typical ionic compound (crystalline solid that dissolves (albeit sparingly) in water to produce an electrolytic solution), lead(IV) chloride is an oily yellow liquid that decomposes upon contact with water. The Roman numeral in the name, lead(IV) chloride, is more properly an "oxidation number", rather than a charge. The IV indicates that the lead would be a Pb^{4+} ion *if* lead(IV) chloride were an ionic compound.

Exercises

1. Name the compounds identified below:

a. $Fe(CN)_2$
b. $Fe(CN)_3$
c. $MnCl_2$
d. MnO_2
e. CrO_3
f. $CrCl_2$
g. $Cr(OH)_3$
h. OsF_6
i. V_2O_5
j. Cu_2S
k. CuS
l. $CoCl_2$
m. $CoCl_3$
n. AuCl
o. $AuCl_3$
p. SnF_2
q. SnF_4
r. TiO_2
s. Ag_2S
t. Hg_2S

2. Give the correct formula for the compounds named below:

a. manganese(II) hydrogen sulfate
b. vanadium(III) chlorate
c. iron(II) sulfite
d. lead(II) dichromate
e. manganese(II) hydroxide
f. titanium(II) carbonate
g. tin(IV) nitrate
h. bismuth(I) chloride
i. nickel(II) sulfate
j. scandium(II) nitrite
k. copper(II) iodate
l. lead(II) chromate
m. vanadium(IV) chloride
n. cobalt(IV) iodide
o. tungsten(VI) oxide
p. mercury(II) perchlorate