

## 3.5: Ionic Nomenclature

### Learning Objectives

- To use the rules for naming ionic compounds

After learning a few more details about the names of individual ions, you will be a step away from knowing how to name ionic compounds. This section begins the formal study of nomenclature, the systematic naming of chemical compounds.

### Naming Ions

The name of a monatomic cation is simply the name of the element followed by the word *ion*. Thus,  $\text{Na}^+$  is the sodium ion,  $\text{Al}^{3+}$  is the aluminum ion,  $\text{Ca}^{2+}$  is the calcium ion, and so forth.

We have seen that some elements lose different numbers of electrons, producing ions of different charges. Iron, for example, can form two cations, each of which, when combined with the same anion, makes a different compound with unique physical and chemical properties. Thus, we need a different name for each iron ion to distinguish  $\text{Fe}^{2+}$  from  $\text{Fe}^{3+}$ . The same issue arises for other ions with more than one possible charge.

There are two ways to make this distinction. In the simpler, more modern approach, called the **Stock system**, an ion's positive charge is indicated by a roman numeral in parentheses after the element name, followed by the word *ion*. Thus,  $\text{Fe}^{2+}$  is called the iron(II) ion, while  $\text{Fe}^{3+}$  is called the iron(III) ion. This system is used only for elements that form more than one common positive ion. We do not call the  $\text{Na}^+$  ion the sodium(I) ion because (I) is unnecessary. Sodium forms only a  $1+$  ion, so there is no ambiguity about the name *sodium ion*.

Table 3.5.1: The Common System of Cation Names

Element	Stem	Charge	Name
iron	ferr-	2+	ferrous ion
		3+	ferric ion
copper	cupr-	1+	cuprous ion
		2+	cupric ion
tin	stann-	2+	stannous ion
		4+	stannic ion
lead	plumb-	2+	plumbous ion
		4+	plumbic ion
chromium	chrom-	2+	chromous ion
		3+	chromic ion
gold	aur-	1+	aurous ion
		3+	auric ion

The second system, called the **common system**, is not conventional but is still prevalent and used in the health sciences. This system recognizes that many metals have two common cations. The common system uses two suffixes (*-ic* and *-ous*) that are appended to the stem of the element name. The *-ic* suffix represents the greater of the two cation charges, and the *-ous* suffix represents the lower one. In many cases, the stem of the element name comes from the Latin name of the element. Table 3.5.1 lists the elements that use the common system, along with their respective cation names.

The name of a monatomic anion consists of the stem of the element name, the suffix *-ide*, and then the word *ion*. Thus, as we have already seen,  $\text{Cl}^-$  is “chlor-” + “-ide ion,” or the chloride ion. Similarly,  $\text{O}^{2-}$  is the oxide ion,  $\text{Se}^{2-}$  is the selenide ion, and so forth. Table 3.5.2 lists the names of some common monatomic ions.

Table 3.5.2: Some Monatomic Anions

Ion	Name
$\text{F}^-$	fluoride ion
$\text{Cl}^-$	chloride ion
$\text{Br}^-$	bromide ion
$\text{I}^-$	iodide ion
$\text{O}^{2-}$	oxide ion
$\text{S}^{2-}$	sulfide ion
$\text{P}^{3-}$	phosphide ion
$\text{N}^{3-}$	nitride ion

The polyatomic ions have their own characteristic names, as discussed earlier.

#### ✓ Example 3.5.1

Name each ion.

- $\text{Ca}^{2+}$
- $\text{S}^{2-}$
- $\text{SO}_3^{2-}$
- $\text{NH}_4^+$
- $\text{Cu}^+$

#### Answer a

the calcium ion

#### Answer b

the sulfide ion (from Table 3.5.2)

#### Answer c

the sulfite ion

#### Answer d

the ammonium ion

#### Answer e

the copper(I) ion or the cuprous ion (copper can form cations with either a 1+ or 2+ charge, so we have to specify which charge this ion has)

#### ? Exercise 3.5.1

Name each ion.

- $\text{Fe}^{2+}$
- $\text{Fe}^{3+}$
- $\text{SO}_4^{2-}$
- $\text{Ba}^{2+}$
- $\text{HCO}_3^-$

#### Answer a

the iron (II) or ferrous ion

**Answer b**

the iron (III) or ferric ion

**Answer c**

the sulfate ion

**Answer d**

the barium ion

**Answer e**

the bicarbonate ion or hydrogen carbonate ion

**✓ Example 3.5.2**

Write the formula for each ion.

- a. the bromide ion
- b. the phosphate ion
- c. the cupric ion
- d. the magnesium ion

**Answer a**

$\text{Br}^-$

**Answer b**

$\text{PO}_4^{3-}$

**Answer c**

$\text{Cu}^{2+}$

**Answer d**

$\text{Mg}^{2+}$

**? Exercise 3.5.2**

Write the formula for each ion.

- a. the fluoride ion
- b. the carbonate ion
- c. the ferrous ion
- d. the potassium ion

**Answer a**

$\text{F}^-$

**Answer b**

$\text{CO}_3^{2-}$

**Answer c**

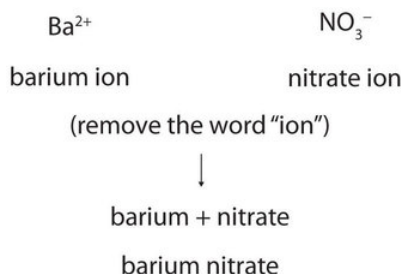
$\text{Fe}^{2+}$

**Answer d**

$\text{K}^+$

## Naming Compounds

Now that we know how to name ions, we are ready to name ionic compounds. We do so by placing the name of the cation first, followed by the name of the anion, and dropping the word *ion* from both parts. For example, what is the name of the compound whose formula is  $\text{Ba}(\text{NO}_3)_2$ ?



The compound's name does not indicate that there are two nitrate ions for every barium ion. You must determine the relative numbers of ions by balancing the positive and negative charges.

If you are given a formula for an ionic compound whose cation can have more than one possible charge, you must first determine the charge on the cation before identifying its correct name. For example, consider  $\text{FeCl}_2$  and  $\text{FeCl}_3$ . In the first compound, the iron ion has a 2+ charge because there are two  $\text{Cl}^-$  ions in the formula (1- charge on each chloride ion). In the second compound, the iron ion has a 3+ charge, as indicated by the three  $\text{Cl}^-$  ions in the formula. These are two different compounds that need two different names. By the Stock system, the names are iron(II) chloride and iron(III) chloride. If we were to use the stems and suffixes of the common system, the names would be ferrous chloride and ferric chloride, respectively.

### ✓ Example 3.5.3

Name each ionic compound, using both Stock and common systems if necessary.

- $\text{Ca}_3(\text{PO}_4)_2$
- $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$
- $\text{KCl}$
- $\text{CuCl}$
- $\text{SnF}_2$

#### Answer a

calcium phosphate

#### Answer b

ammonium dichromate (the prefix *di-* is part of the name of the anion)

#### Answer c

potassium chloride

#### Answer d

copper(I) chloride or cuprous chloride

#### Answer e

tin(II) fluoride or stannous fluoride

### ? Exercise 3.5.3

Name each ionic compound, using both Stock and common systems if necessary.

- $\text{ZnBr}_2$
- $\text{Fe}(\text{NO}_3)_3$
- $\text{Al}_2\text{O}_3$

d.  $\text{CuF}_2$

e.  $\text{AgF}$

**Answer a**

zinc bromide

**Answer b**

iron (III) nitrate or ferric nitrate

**Answer c**

aluminum oxide

**Answer d**

copper (II) fluoride or cupric fluoride

**Answer e**

silver fluoride

Figure 3.5.1 is a synopsis of how to name simple ionic compounds.

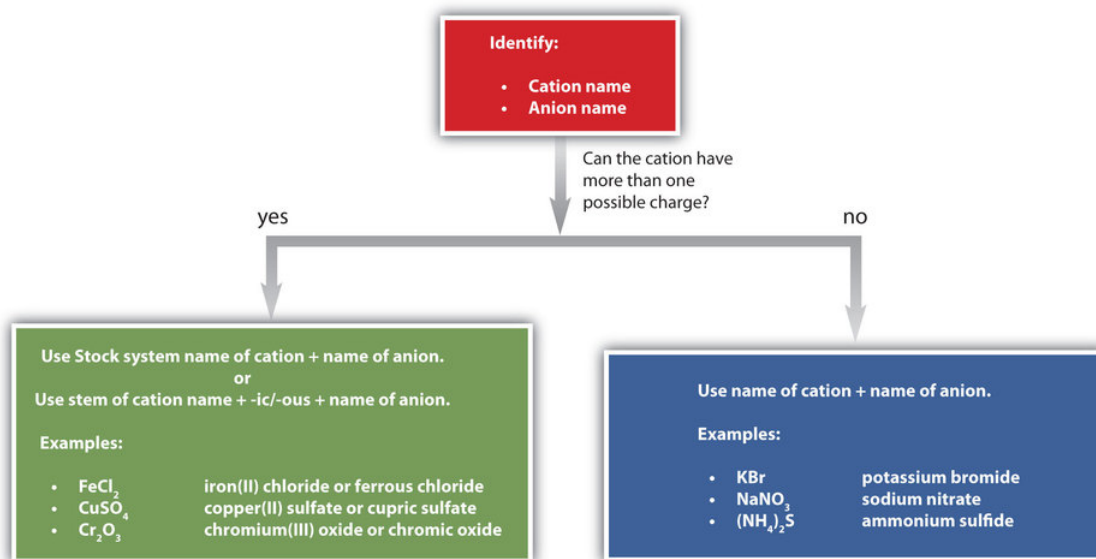


Figure 3.5.1: A Guide to Naming Simple Ionic Compounds. Follow these steps to name a simple ionic compound.

Identify the cation name and the anion name. If the cation can have more than one possible charge, either use the Stock system name of the cation and name of the anion, or use the stem of the cation name and -ic/-ous and the name of the anion. Examples of this would be  $\text{FeCl}_2$ , which is iron(II) chloride or ferrous chloride,  $\text{CuSO}_4$ , which is copper(II) sulfate or cupric sulfate, and  $\text{Cr}_2\text{O}_3$ , which is chromium(III) oxide or chromic oxide. If the cation can not have more than one possible charge, use the name of the cation and the name of the anion. Examples of this would be  $\text{KBr}$ , which is potassium bromide,  $\text{NaNO}_3$ , which is sodium nitrate, and  $(\text{NH}_4)_2\text{S}$ , which is ammonium sulfide.

## KEY TAKEAWAY

- Each ionic compound has its own unique name that comes from the names of the ions.

## EXERCISES

- Briefly describe the process for naming an ionic compound.
- In what order do the names of ions appear in the names of ionic compounds?
- Which ionic compounds can be named using two different systems? Give an example.
- Name each ion.

- a.  $\text{Ra}^{2+}$
- b.  $\text{P}^{3-}$
- c.  $\text{H}_2\text{PO}_4^-$
- d.  $\text{Sn}^{4+}$

5. Name each ion.

- a.  $\text{Cs}^+$
- b.  $\text{As}^{3-}$
- c.  $\text{HSO}_4^-$
- d.  $\text{Sn}^{2+}$

6. Name the ionic compound formed by each pair of ions.

- a.  $\text{Na}^+$  and  $\text{Br}^-$
- b.  $\text{Mg}^{2+}$  and  $\text{Br}^-$
- c.  $\text{Mg}^{2+}$  and  $\text{S}^{2-}$

7. Name the ionic compound formed by each pair of ions.

- a.  $\text{K}^+$  and  $\text{Cl}^-$
- b.  $\text{Mg}^{2+}$  and  $\text{Cl}^-$
- c.  $\text{Mg}^{2+}$  and  $\text{Se}^{2-}$

8. Name the ionic compound formed by each pair of ions.

- a.  $\text{Na}^+$  and  $\text{N}^{3-}$
- b.  $\text{Mg}^{2+}$  and  $\text{N}^{3-}$
- c.  $\text{Al}^{3+}$  and  $\text{S}^{2-}$

9. Name the ionic compound formed by each pair of ions.

- a.  $\text{Li}^+$  and  $\text{N}^{3-}$
- b.  $\text{Mg}^{2+}$  and  $\text{P}^{3-}$
- c.  $\text{Li}^+$  and  $\text{P}^{3-}$

10. Name the ionic compound formed by each pair of ions. Use both the Stock and common systems, where appropriate.

- a.  $\text{Fe}^{3+}$  and  $\text{Br}^-$
- b.  $\text{Fe}^{2+}$  and  $\text{Br}^-$
- c.  $\text{Au}^{3+}$  and  $\text{S}^{2-}$
- d.  $\text{Au}^+$  and  $\text{S}^{2-}$

11. Name the ionic compound formed by each pair of ions. Use both the Stock and common systems, where appropriate.

- a.  $\text{Cr}^{3+}$  and  $\text{O}^{2-}$
- b.  $\text{Cr}^{2+}$  and  $\text{O}^{2-}$
- c.  $\text{Pb}^{2+}$  and  $\text{Cl}^-$
- d.  $\text{Pb}^{4+}$  and  $\text{Cl}^-$

12. Name the ionic compound formed by each pair of ions. Use both the Stock and common systems, where appropriate.

- a.  $\text{Cr}^{3+}$  and  $\text{NO}_3^-$
- b.  $\text{Fe}^{2+}$  and  $\text{PO}_4^{3-}$
- c.  $\text{Ca}^{2+}$  and  $\text{CrO}_4^{2-}$
- d.  $\text{Al}^{3+}$  and  $\text{OH}^-$

13. Name the ionic compound formed by each pair of ions. Use both the Stock and common systems, where appropriate.

- a.  $\text{NH}_4^+$  and  $\text{NO}_3^-$
- b.  $\text{K}^+$  and  $\text{Cr}_2\text{O}_7^{2-}$
- c.  $\text{Cu}^+$  and  $\text{CO}_3^{2-}$
- d.  $\text{Na}^+$  and  $\text{HCO}_3^-$

14. Give two names for each compound.

- a.  $\text{Al}(\text{HSO}_4)_3$
- b.  $\text{Mg}(\text{HSO}_4)_2$

15. Give two names for each compound.

- a.  $\text{Co}(\text{HCO}_3)_2$
- b.  $\text{LiHCO}_3$

## Answers

1. Name the cation and then the anion but don't use numerical prefixes.
2. the cation name followed by the anion name
3. Ionic compounds in which the cation can have more than one possible charge have two naming systems.  $\text{FeCl}_3$  is either iron(III) chloride or ferric chloride (answers will vary).
4.
  - a. the radium ion
  - b. the phosphide ion
  - c. the dihydrogen phosphate ion
  - d. the tin(IV) ion or the stannic ion
5.
  - a. the cesium ion
  - b. the arsenide ion
  - c. the hydrogen sulfate ion
  - d. the tin(II) ion or the stannous ion
6.
  - a. sodium bromide
  - b. magnesium bromide
  - c. magnesium sulfide
7.
  - a. potassium chloride
  - b. magnesium chloride
  - c. magnesium selenide
8.
  - a. sodium nitride
  - b. magnesium nitride
  - c. aluminum sulfide
9.
  - a. lithium nitride
  - b. magnesium phosphide
  - c. lithium phosphide
10.
  - a. iron(III) bromide or ferric bromide
  - b. iron(II) bromide or ferrous bromide
  - c. gold(III) sulfide or auric sulfide
  - d. gold(I) sulfide or aurous sulfide
11.
  - a. chromium(III) oxide or chromic oxide

- b. chromium(II) oxide or chromous oxide
- c. lead(II) chloride or plumbous chloride
- d. lead(IV) chloride or plumbic chloride

12.

- a. chromium(III) nitrate or chromic nitrate
- b. iron(II) phosphate or ferrous phosphate
- c. calcium chromate
- d. aluminum hydroxide

13.

- a. ammonium nitrate
- b. potassium dichromate
- c. copper(I) carbonate or cuprous carbonate
- d. sodium hydrogen carbonate or sodium bicarbonate

14.

- a. aluminum hydrogen sulfate or aluminum bisulfate
- b. magnesium hydrogen sulfate or magnesium bisulfate

15.

- a. cobalt hydrogen carbonate or cobalt bicarbonate
- b. lithium hydrogen carbonate or lithium bicarbonate

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