

Naming Ionic Compounds

Are you familiar with any of the pure compounds that are commonly called baking soda, cream of tartar, vinegar, aspirin, and sugar (Figure 1)? Have you ever wondered why chemistry uses complicated names rather than the simple, common names like these? Table salt is perhaps the clearest example of a well-known compound. Its important role in nutrition and food preservation has given it a different common name in every culture. From the time of Berzelius, the language of chemistry was intended to be universally understood. So the scientific naming of ionic compounds is the same whether you are studying in a school in Russia, South Africa, or British Columbia.

Rules for Naming Ionic Compounds

The rules for writing chemical formulas are universal. If you know what ions are present in a compound, the rules predict both the formula and the compound name. The rules for writing the name, when you know the formula, are relatively simple.

Naming Monovalent Metals

Monovalent metals have only one possible ion charge. All the metals in the first 20 elements and all the metals in the first two columns of the Periodic Table (alkali and alkaline earth metals) are monovalent metals.

- The name of the metal ion is written first in a formula.
- The name is written in lower case and is spelled exactly the same as the element name: Na is *sodium* and Al is *aluminum*.

Naming Non-metal Ions

- The non-metal ion is written second in a formula.
- To distinguish non-metal ions from polyatomic ions, the names of non-metal ions are given the suffix *ide*: oxygen becomes *oxide*, and chlorine becomes *chloride*.

Naming Polyatomic Ions

- Positive polyatomic ions are written first, like metals.
- Negative polyatomic ions are written second and the name of the ion is not changed: SO_4^{2-} is named *sulfate*.

Naming Multivalent Metals

- If the metal is multivalent, such as iron (Fe^{2+} and Fe^{3+}) or copper (Cu^+ and Cu^{2+}), the ion charge of the metal must be in its name.
- The ion charge is written as a Roman numeral in brackets following the metal name, with no space between them: the Cu^{2+} ion is named *copper(II)* and read “copper two”; the Cu^+ ion is named *copper(I)* and read “copper one.”

LEARNING TIP

Since there are many elements and compounds, explain to a partner why it is important to have clear chemical names for elements and compounds.



Figure 1 Vinegar and baking soda also have chemical names that scientists use.

Did You KNOW?

Past Naming System

In the past, chemists had to remember the ion charges of multivalent metals—the charges were not part of the name (for example, copper(II) chloride). This older system of naming metals used the suffixes *ous* and *ic* to refer to the different ion charges. Copper(II) chloride was cuprous chloride and iron(II) oxide was ferrous oxide. To learn more about this naming system, go to

www.science.nelson.com



Determining the Ion Charge from a Formula

The ion charge of a multivalent metal is not shown directly in the formula of a compound. Recall that the total ion charges must balance, and you can work backward from the non-metal ion charge to determine the metal ion charge. For example, CuCl_2 has chloride as the non-metal ion, with an ion charge of 1^- . There are two chloride ions, so the one copper ion must be copper(II). CrP has phosphide as the negative ion, with an ion charge of 3^- . There is only one chromium ion, so it is chromium(III). Fe_2S_3 has three sulfur ions, each with a charge of 2^- , for a total negative charge of 6^- . The two iron ions must therefore have a total charge of 6^+ , so they are iron(III).

The rules for naming ionic compounds are summarized in Table 1.

LEARNING TIP

Check your understanding. Review tables 1 and 2. Then, with a partner, explain in your own words how the ionic compounds in Table 2 are named.

Table 1 Summary of Naming Rules

Positive (metal) ion (written first)	Negative (non-metal) ion (written second)
Monovalent: Use name of element.	Single element: Use element name ending in <i>ide</i> .
Multivalent: Use name of element followed by Roman numeral in brackets.	Polyatomic ions: Use name of the polyatomic ion with no changes.
Polyatomic: Use name of ion.	

The examples in Table 2 will help you name ionic compounds.

Table 2 Examples of Ionic Compounds

Ionic compounds containing single ions
<ol style="list-style-type: none">1. CaO: The positive ion (Ca^{2+}) can only have one ion charge (monovalent), so it keeps the element name, <i>calcium</i>. The negative ion (O^{2-}) is named <i>oxide</i>. The name of the compound is <i>calcium oxide</i>.2. FeS: Fe is iron, and it is a multivalent metal. S is sulfur and has an ion charge of 2^-. Since there is only one ion of iron, it must have an ion charge of 2^+. Therefore, the iron ion must be <i>iron(II)</i>. The negative ion (S^{2-}) is named <i>sulfide</i>. The name of the compound is <i>iron(II) sulfide</i>.3. LiCl: The positive ion (Li^+) is named <i>lithium</i> (monovalent). The negative ion (Cl^-) is named <i>chloride</i>. The name of the compound is <i>lithium chloride</i>.4. K_2S: The positive ion (K^+) is named <i>potassium</i>. The negative ion (S^{2-}) is named <i>sulfide</i>. The name of the compound is <i>potassium sulfide</i>.
Ionic compounds containing polyatomic ions
<ol style="list-style-type: none">5. Ca(OH)_2: The positive ion (Ca^{2+}) is named <i>calcium</i> (monovalent). The negative polyatomic ion (OH^-) is named <i>hydroxide</i>, and it does not change. The name of the compound is <i>calcium hydroxide</i>.6. BaCO_3: The positive ion (Ba^{2+}) is named <i>barium</i> (monovalent). The negative ion (CO_3^{2-}) is named <i>carbonate</i>. The name of the compound is <i>barium carbonate</i>.7. CrSO_4: Cr is chromium, and it is a multivalent metal. The polyatomic group SO_4 has an ion charge of 2^-. Since there is only one ion of chromium, it must have an ion charge of 2^+. Therefore, the chromium ion must be <i>chromium(II)</i>. The negative ion (SO_4^{2-}) is named <i>sulfate</i>. The name of the compound is <i>chromium(II) sulfate</i>.8. $(\text{NH}_4)_3\text{PO}_4$: The positive ion NH_4^+ is named <i>ammonium</i> (a polyatomic positive ion). The negative ion (PO_4^{3-}) is named <i>phosphate</i>. The name of the compound is <i>ammonium phosphate</i>.

1. What are monovalent metals?
2. Will two metals form an ionic compound? Explain.
3. Write the name and symbol for the ion of each element listed below.
 - (a) sodium
 - (b) chlorine
 - (c) copper with an ion charge of 2+
 - (d) aluminum
 - (e) phosphorous
4. Write the name for each ion.
 - (a) Ca^{2+}
 - (b) F^-
 - (c) Br^-
 - (d) Fe^{3+}
 - (e) Pb^{2+}
 - (f) Fe^{2+}
 - (g) Pb^{4+}
 - (h) P^{3-}
5. Write the name of the ion for each of the following non-metal elements.
 - (a) chlorine
 - (b) bromine
 - (c) iodine
 - (d) phosphorous
 - (e) oxygen
 - (f) sulfur
 - (g) nitrogen
6. Write the name of each polyatomic ion.
 - (a) SO_4^{2-}
 - (b) PO_4^{3-}
 - (c) NO_3^-
 - (d) OH^-
 - (e) HCO_3^-
 - (f) CO_3^{2-}
7. Write the names of the compounds formed by the following combinations of elements.
 - (a) sodium and iodine
 - (b) lithium and bromine
 - (c) silver and phosphorous
 - (d) barium and oxygen
8. Use the tables of metals, non-metals, and polyatomic ions on pages 239 to 242 and the Periodic Table at the back of this book to name the following ionic compounds.
 - (a) NaBr
 - (b) CaSO_4
 - (c) K_2S
 - (d) $\text{Ni}(\text{NO}_3)_2$
 - (e) Mg_3N_2
 - (f) $\text{Fe}_2(\text{CO}_3)_3$
 - (g) Cr_2O_3
 - (h) $\text{Al}_2(\text{SO}_4)_3$
 - (i) Cu_2SO_4
 - (j) $\text{Pb}(\text{NO}_3)_4$
9. Chromium is reacted with oxygen to form two chromium ions for every three oxide ions. What is the name of the compound?
10. There are two correct formulas for the reaction of nickel and oxygen: NiO and Ni_2O_3 . What are the names of these compounds? Explain why two different names are necessary.
11. Does a compound called calcium aluminide exist? Explain.
12. Which of the following chemical formulas are correct? Explain why the incorrect formulas are incorrect.
 - (a) Al_2O_3
 - (b) CrSO_4
 - (c) Fe_3O_2
 - (d) $\text{Fe}_2(\text{SO}_4)_2$
13. How does using a common naming system for chemical compounds benefit scientists?