TOPIC
2.5

How do we name and write formulas for compounds?

Key Concepts

- The chemical name of an ionic compound communicates its composition.
- You can determine the formula of an ionic compound from its name.
- Multivalent metals form more than one ion.
- Polyatomic ions are made up of more than one atom.
- Names and formulas of covalent compounds reflect their molecular structure.

Curricular Competencies

- Transfer and apply learning to new situations
- Generate and introduce new or refined ideas when problem solving
- Contribute to finding solutions to problems at a local and/or global level through inquiry

What comes to mind when you hear the word *lime*? You may have pictured a small green citrus fruit. But lime is also the common name for a hugely important chemical with a broad variety of applications in farming, the food industry, and pulp and paper manufacturing, to name just a few. Chemists working with the compound lime know that it is an ionic compound composed of calcium and oxygen, but the name *lime*, its common name, does not communicate that. In fact, the fruit lime and the compound lime are not related. The chemical name calcium oxide and the chemical formula CaO, however, clearly describe the composition of the compound.

Starting Points

Choose one, some, or all of the following to start your exploration of this Topic.

1. **Identifying Preconceptions** Considering what you know about compounds, what information about a compound would you expect a chemical name to communicate? What information would you expect a chemical formula to communicate? What does the chemical formula CaO tell you about calcium oxide?
2. **Questioning and Predicting** Limestone is a type of rock composed mainly of the compound with the chemical name calcium carbonate and the chemical formula $CaCO_3$. Do research to find out some things about limestone. What is the origin of the word *limestone*? What kind of compound is calcium carbonate? What elements does it contain? What information do the name and chemical formula give you?
3. **Applying First Peoples Perspectives** Some B.C. First Peoples have specific connections with lime and limestone. Do research or consider contacting local Elders or knowledge-keepers to find out about these connections.

Key Terms

There are four key terms that are highlighted in bold type in this Topic:

- binary ionic compound
- polyatomic ion
- multivalent metal
- binary covalent compound

Flip through the pages of this Topic to find these terms. Add them to your class Word Wall along with their meaning. Add other terms that you think are important and want to remember.

CONCEPT 1

The chemical name of an ionic compound communicates its composition.

Activity

Names in Everyday Life

Names are important in every part of our lives. Write a few sentences to explain the importance of names in each of the following aspects of your life. Why are clear, unique names important in each case?

- Getting around: streets, cities, towns, landmarks
- Communicating: conversation, social media, messaging
- Consuming: product and brand names; names of medications; names of books, songs, and movies

binary ionic compound
a compound made up of ions of one metal element and ions of one non-metal element

The large bulging mass around the person's neck in **Figure 2.36** is called a goitre. These growths are caused by iodine deficiency. Goitres are uncommon today in developed countries because compounds containing the iodide ion, such as potassium iodide, KI, are added to our table salt. Before iodized table salt, goitres were common in Europe, but they were never common among coastal Aboriginal peoples of British Columbia. Why not? Traditional foods of coastal peoples include seaweed, a rich source of iodine. Potassium iodide is an example of a binary ionic compound. In chemistry, *binary* means "composed of two elements." **Binary ionic compounds** are composed of ions of one metal element and ions of one non-metal element joined by ionic bonds.

Figure 2.36 When a person does not take in enough iodine, their thyroid gland swells in an attempt to absorb as much iodine as possible, resulting in a goitre. To prevent iodine deficiency, iodine is added to table salt in the form of compounds containing the iodide ion, such as potassium iodide. Seaweed contains other compounds that include the iodide ion.

Names of Binary Ionic Compounds

The name of a binary ionic compound comes from the names of its elements, as described below.

- The first part of *potassium iodide* names the positive ion, potassium, K^+. The positive ion is always a metal in a binary ionic compound. The positively charged metal ion is always named first. Its name is the same as the name of its element.
- The second part of *potassium iodide* names the negative ion, iodide, I^-. The negative ion in a binary ionic compound is always a non-metal. The name of the negative ion in a binary ionic compound always ends with the suffix *-ide*. The negative ion of iodine is iodide.

Common negative ions of non-metals are shown in **Table 2.5**. The periodic table also lists ion charges.

Table 2.5 Ions of Non-Metals

Element	Ion	Symbol	Group
fluorine	fluoride	F^-	17
chlorine	chloride	Cl^-	17
bromine	bromide	Br^-	17
iodine	iodide	I^-	17
oxygen	oxide	O^{2-}	16
sulfur	sulfide	S^{2-}	16
selenium	selenide	Se^{2-}	16
nitrogen	nitride	N^{3-}	15
phosphorus	phosphide	P^{3-}	15

Extending the Connections

Where do the naming rules come from?

The international system for naming chemicals is maintained by the International Union of Pure and Applied Chemistry (IUPAC). Research to find out more about IUPAC, its history, its systems, and its members.

Before you leave this page . . .

1. Each of the following pairs of elements react to form a binary ionic compound. What is the name of the compound in each case?
   - **a)** lithium and oxygen
   - **b)** calcium and fluorine
   - **c)** magnesium and sulfur
   - **d)** rubidium and bromine
2. What is the difference between the name of a non-metal element and the name of the negative ion it forms?

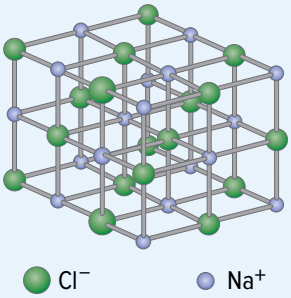
CONCEPT 2

You can determine the formula of an ionic compound from its name.

Activity

Ion Ratios

This diagram represents a crystal of sodium chloride. How does the structure of sodium chloride relate to its chemical formula? Follow these steps to find out:



1. Count the total number of ions of each element.
2. Compare the total number of positive ions with the total number of negative ions.
3. What is the ratio of positive ions to negative ions for each compound?
4. The chemical formula of sodium chloride is NaCl. The chemical formula of calcium chloride, another ionic compound, is $CaCl_2$. What ratio of ions would you expect to see in calcium chloride?

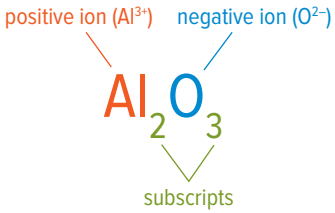


Figure 2.37 Formulas for ionic compounds are always written with the positive ion first and the negative ion second. In binary ionic compounds, the positive ion is a metal ion and the negative ion is a non-metal ion.

The chemical formula of a binary ionic compound contains element symbols to identify each ion. The positively charged metal ion comes first and the negatively charged non-metal ion comes second, as shown in **Figure 2.37**. Some formulas have small numbers, called subscripts, written to the right of one or both symbols. The subscripts indicate the ratio of each type of ion in the compound. If no subscript is shown, you assume the number to be 1. For example, the formula Ag_2O means Ag_2O_1. The chemical formula for an ionic compound represents the smallest repeating part of the crystal lattice. This unit is called the *formula unit* for that compound. Examine **Figure 2.38** to see some examples of chemical formulas of binary ionic compounds, and their meanings.

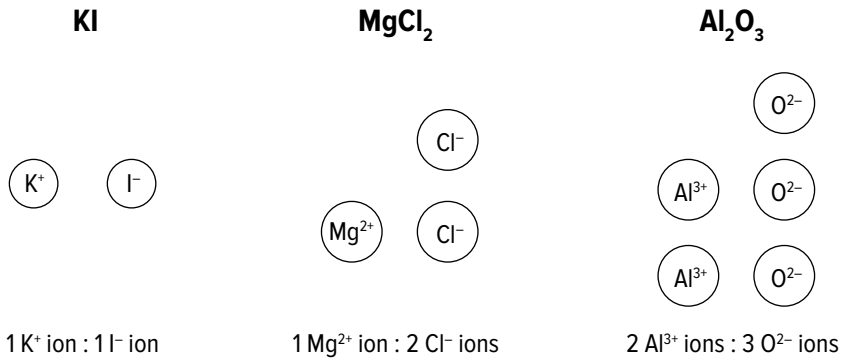


Figure 2.38 The subscripts in chemical formulas of ionic compounds tell you the ratio of the ions in the compound.

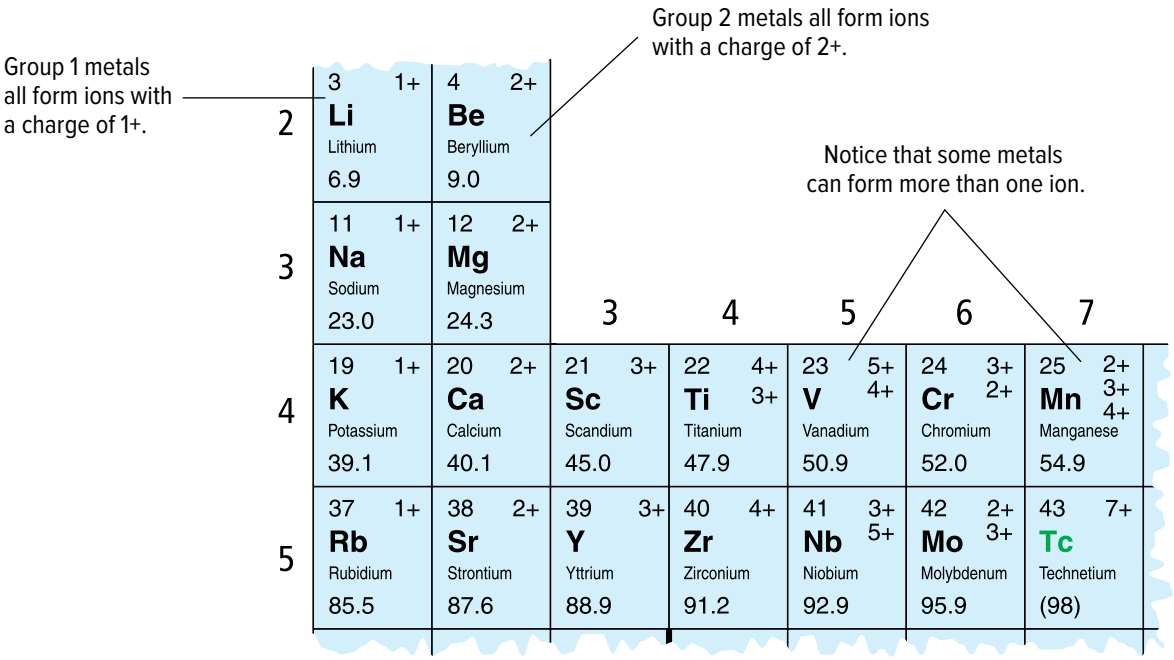
Writing Formulas of Ionic Compounds

Although an ionic compound is made up of ions, overall the compound is electrically neutral—it has no charge. So the positive charges on the metal ions must balance the negative charges on the non-metal ions. For example, in aluminum oxide, there are two aluminum ions, Al^{3+}, and three oxide ions, O^{2-}. What is the total charge?

Charge from Al^{3+} ions	Charge from Cl^{-} ions
There are 2 aluminum ions in the formula, each with a charge of 3+. $2 \times (3+) = 6+$	There are 3 oxide ions in the formula, each with a charge of 2−. $3 \times (2-) = 6-$
Total charge: $(6+) + (6-) = 0$	

When writing the formula of a binary ionic compound, you first need to determine the charges on the ions. **Table 2.5** lists the ions of non-metals. For metals that form only one type of ion, all you need to do to figure out the ion charge is to look at the periodic table, as shown in **Figure 2.39**. (You can find the charges for non-metal ions on the periodic table, too.) Once you know the charges, you can figure out the formula.

Figure 2.39 The periodic table lists the charges of ions commonly formed by the various elements.



Sample Problem

Writing the Formulas of Ionic Compounds

What are the chemical formulas of each of these compounds?

a) calcium chloride

b) aluminum sulfide

Solutions

a) calcium chloride

1. Identify each ion and its charge.

Calcium is a Group 2 metal, so its ion charge is 2+: Ca^{2+}

Chlorine is a Group 17 non-metal, so its ion charge is 1–: Cl^{-}

2. Determine the number of ions needed to balance positive charges with negative charges. In this case, two chloride ions are needed to balance the positive charge on a calcium ion.

Charge from Ca^{2+}	Charge from Cl^{-}
A calcium ion has a charge of 2+. $1 \times (2+) = 2+$	A chloride ion has a charge of 1−. Therefore, two chloride ions are needed to balance the charge of one calcium ion. $2 \times (1-) = 2-$

3. Use subscripts to write the formula. Remember to write the metal ion first. Do not include a subscript if the subscript would be "1."

The formula for calcium chloride is $CaCl_2$.

b) aluminum sulfide

1. Identify each ion and its charge.

From the periodic table, the aluminum ion is Al^{3+}.

Sulfur is a Group 16 non-metal, so its ion charge is 2–: S^{2-}

2. Determine the number of ions needed to balance positive charges with negative charges. In this case, two aluminum ions are needed to balance the charges on three sulfide ions.

Charge from Al^{3+}	Charge from S^{2-}
An aluminum ion has a charge of 3+. The lowest common multiple of 3 and 2 is 6. To get 6+, multiply 3+ by 2. $2 \times (3+) = 6+$	A sulfide ion has a charge of 2−. To get 6−, multiply 2− by 3. $3 \times (2-) = 6-$

3. Use subscripts to write the formula. Remember to write the metal ion first.

The formula of aluminum sulfide is Al_2S_3.

Practice Problems

1. Write the formulas of the ionic compounds containing the following ions.
   - **a)** Na^+ and Br^-
   - **b)** K^+ and S^{2-}
   - **c)** Zn^{2+} and I^-
   - **d)** Mg^{2+} and N^{3-}
2. Write the formulas of the following ionic compounds.
   - **a)** sodium iodide
   - **b)** zinc oxide
   - **c)** magnesium chloride
   - **d)** potassium selenide
   - **e)** silver sulfide
   - **f)** aluminum iodide
   - **g)** aluminum phosphide
   - **h)** barium phosphide
   - **i)** calcium sulfide
   - **j)** rubidium bromide
3. Silver iodide has a crystal structure similar to ice and can cause water to freeze. It has been used in rainmaking experiments, in which it is released into clouds to try to induce precipitation. A silver iodide generator is shown in **Figure 2.40**. What is the chemical formula of silver iodide?

Figure 2.40 Silver iodide generators are designed for cloud seeding.

Extending the Connections

A Grain of Salt

Sodium chloride, ordinary table salt, is probably the most familiar of ionic compounds. Although salt is inexpensive and plentiful today, this was not always the case. Why was salt so expensive in the past? Where did people get salt in the past? How do we get salt today? What is the role of sodium chloride in the human body? What happens when you get too much? Choose one or more of these questions to investigate.

Connect to Investigation 2-G on page 174

Before you leave this page . . .

1. What is a formula unit and how does it relate to the formula for an ionic compound?
2. Even though ionic compounds are made up of charged particles, they are electrically neutral. Why is this?

CONCEPT 3

Multivalent metals form more than one ion.

multivalent metal a metal element that can form two or more types of ions with different charges

As you can see when you examine the periodic table, some metals form more than one type of ion. Such metals are called **multivalent metals**. For example, copper can form ions with a 1+ or 2+ charge, as shown in Figure 2.41. To distinguish between the ions, a Roman numeral is written after the name of the metal. For example, Cu^{+} is written as copper(I), pronounced "copper one." Cu^{2+} is written as copper(II), pronounced "copper two." On the periodic table, the ion charges for a given element are listed with the most common charge at the top and the least common charge at the bottom.

Figure 2.41 Although both of these compounds contain copper and oxygen, copper(II) oxide, CuO, is black and copper(I) oxide, Cu_2O, is red.

Naming and Writing Formulas for Ionic Compounds Containing Multivalent Metals

To write the chemical formula of a multivalent metal, follow the same process as for the binary ionic compounds you have been naming so far. The only difference is that you cannot tell the charge on the metal ion by looking at the periodic table because there is more than one choice. Instead, look at the Roman numeral in the name, which will tell you the charge.

The Roman numerals for charges 1+ through 7+ are given in Table 2.6. For example, the name chromium(III) chloride tells you that the chromium ion in the compound is Cr^{3+}. The chloride ion is Cl^{-}. For a neutral compound, there must be three chlorine ions for every one chromium ion, so the formula is $CrCl_3$. When naming a compound that contains a multivalent ion, you must include a Roman numeral to show which charge the ion has. Sample Problem on the next page shows how.

Table 2.6 Roman Numerals

Metal Ion Charge	Roman Numeral
1+	I
2+	II
3+	III
4+	IV
5+	V
6+	VI
7+	VII

Sample Problem

Naming an Ionic Compound with a Multivalent Metal

The compound Fe_2O_3 is the main source of iron in the making of steel, which in turn is used for a huge number of applications, from cutlery to freighters like the one shown in **Figure 2.42**. Pure Fe_2O_3 is reddish in colour and is used as a pigment in paints. What is the name of Fe_2O_3?

Solution

1. Identify the ions.

- The ion of iron may be either Fe^{2+} or Fe^{3+}.
- The ion of oxygen is O^{2-}.

2. Determine the ratio of ions in the compound.

- According to the formula, the compound has 2 iron ions for every 3 oxide ions.

3. The negative charges and the positive charges must be equal in magnitude for the compound to be electrically neutral. Determine which of the two possible iron ions achieves this balance.

- Since there are 3 oxide ions, there is an overall negative charge of 6−.
- Since there are 2 iron ions, they must each have a charge of 3+ to give an overall positive charge of 6+.

4. Write the name of the compound using a Roman numeral to indicate the charge of the metal ion.

- The name of Fe_2O_3 is iron(III) oxide.

Figure 2.42 The iron compound Fe_2O_3, also called hematite, is the source of most iron used to make steel today. The rust that forms on iron and steel is a form of Fe_2O_3 combined with water.

Practice Problems

1. Write the names of the compounds with the following ions.

a) Co^{3+} and O^{2-}

b) Cu^{+} and Br^{-}

c) Cu^{2+} and Cl^{-}

d) Mn^{4+} and S^{2-}

2. Write the names of the following compounds. Each contains an ion of a multivalent metal.

a) FeO

b) Cu_3N

c) SnS_2

d) Sn_3N_2

e) Ni_2S_3

f) $MoCl_3$

g) PbF_4

h) TiS_2

Before you leave this page . . .

1. Explain why copper is able to form two different compounds with oxygen.

2. Why are Roman numerals included in the names of multivalent metal ions?

CONCEPT 4

Polyatomic ions are made up of more than one atom.

Activity

Research a Polyatomic Ion

Work in groups. Your teacher will assign you one of the polyatomic ions in Table 2.7. For your ion, conduct research to answer the following questions:

1. What is the shape of your ion? Use a kit or craft supplies to make a model.
2. What are two compounds in which your ion is found?
3. Choose one compound from question 2 and find out more about it. What are its properties? Is it found in nature? Does it have any applications?

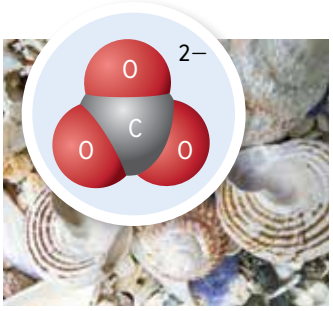


Figure 2.43 Shellfish use calcium carbonate to make their shells. The carbonate ion is shown here.

polyatomic ion an ion made up of two or more covalently bonded atoms

Limestone is an important industrial mineral that is obtained from quarries in several locations around British Columbia. Limestone is made of an ionic compound called calcium carbonate, $CaCO_3$, which is also the compound that shells such as those shown in Figure 2.43 are made of. The carbonate ion, CO_3^{2-}, is composed of carbon and oxygen atoms. An ion that, like carbonate, is composed of two or more atoms is a **polyatomic ion**—essentially, a charged molecule. Compounds containing polyatomic ions are not binary compounds because they always contain at least three elements. But like binary compounds, compounds containing polyatomic ions are named by writing the name of the positive ion followed by the name of the negative ion.

There are a limited number of polyatomic ions that regularly occur in compounds. You can look up their names, formulas, and charges in a table such as Table 2.7. Notice that the only positively charged polyatomic ion listed is the ammonium ion, NH_4^+.

Table 2.7 Names, formulas, and charges of some common polyatomic ions

1+ Charge	1− Charge	2− Charge	3− Charge
ammonium, NH_4^+	acetate, CH_3COO^- chlorate, ClO_3^- chlorite, ClO_2^- hydrogen carbonate, HCO_3^- hydroxide, OH^- nitrate, NO_3^- nitrite, NO_2^- permanganate, MnO_4^-	carbonate, CO_3^{2-} chromate, CrO_4^{2-} dichromate, $Cr_2O_7^{2-}$ peroxide, O_2^{2-} sulfate, SO_4^{2-} sulfite, SO_3^{2-}	phosphate, PO_4^{3-} phosphite, PO_3^{3-}

Sample Problem

Writing Chemical Formulas of a Compound with a Polyatomic Ion

Calcium nitrate is a key component of nitrogen-containing fertilizers. Nitrogen-containing fertilizers are important in increasing the yield of farms, but can also cause problems when an excess of nitrogen enters waterways. What is the formula of calcium nitrate?

Solution

1. Identify each ion and its charge. Use **Table 2.7** (or another table of polyatomic ions) to find the formula of the polyatomic ion.

calcium: Ca^{2+} nitrate: NO_3^-

2. Determine the number of ions needed to balance positive charges with negative charges. In this case, two nitrate ions are needed to balance the charge on calcium.

Charge from Ca^{2+}	Charge from NO_3^-
A calcium ion has a charge of 2+. $1 \times (2+) = 2+$	A nitrate ion has a charge of 1−. Therefore, 2 nitrate ions are needed to balance the charge of one calcium ion. $2 \times (1-) = 2-$

3. Use subscripts to write the formula. *If the polyatomic ion is going to take a subscript, use parentheses to enclose the polyatomic ion before adding the subscript, as shown.* This shows that the nitrate ion is a unit, and that there are two of them for each calcium ion. The formula of calcium nitrate is $Ca(NO_3)_2$.

Practice Problems

1. Write the formula of each of the following compounds.

- **a)** barium nitrate
- **b)** potassium carbonate
- **c)** nickel(II) sulfate
- **d)** magnesium phosphate
- **e)** sodium dichromate
- **f)** iron(II) chromate
- **g)** lead(IV) acetate
- **h)** ammonium sulfate

2. There is an error in each of the formulas of the following ionic compounds. Explain the error and correct each formula.

- **a)** sodium phosphate, Na_3P
- **b)** magnesium nitrate, $MgNO_3^{2-}$
- **c)** potassium sulfite, KSO_3^-
- **d)** sodium hydroxide, Na(OH)
- **e)** ammonium chloride, NH_3Cl
- **f)** sodium acetate, $Na(CH_3COO)_2$
- **g)** potassium dichromate, $(K)_2Cr_2O_7$

Before you leave this page . . .

1. What is a polyatomic ion?

2. How are parentheses used in writing formulas containing polyatomic ions?

3. Give the names and chemical formulas of two different polyatomic ions that contain nitrogen and oxygen.

AT ISSUE

What happened at B.C.'s molybdenum ghost town?

What's the Issue?

About 180 km northwest of Terrace sits Kitsault, a modern-day ghost town that has been abandoned for over 30 years. In 1979, Kitsault was built as an instant town to provide a home for workers at the nearby molybdenum mine. The town was meant to be a community that workers and their families would call home year round. It offered apartments and family housing, shops, recreation centres, a theatre, a library, and even a hospital. Yet just three years later, the 1200 people living in Kitsault abandoned the town nearly overnight. Since then, caretakers have looked after the buildings and properties, many of which look eerily as if residents had just stepped out for a breath of fresh air.

Dig Deeper

Collaborate with your classmates to explore one or more of these questions—or generate your own questions to explore.

1. Find out more about what happened to Kitsault in the past, and what is happening there now.
   a) Why was Kitsault abandoned? What did molybdenum have to do with it?
   b) What is the status of the mine and town today?
2. Molybdenum is a multivalent transition metal. In nature it is found in the form of various compounds (minerals) in rocks. All of Canada's molybdenum is mined in British Columbia. In what forms is molybdenum found in nature? What are some uses of molybdenum? Where is it currently mined in British Columbia and how? What effects does the mining have on local people and the environment?
3. The town of Kitsault lies within the traditional territory of the Nisga'a Nation. What sort of concerns do you think that First Peoples living near the molybdenum mine might have and why? Find out how any concerns have been addressed by the Nisga'a Nation.

Chemistry Connections

hazardous waste technician

chemistry teacher

occupational safety officer

What kinds of jobs are there for people interested in elements and compounds?

toxicologist

pharmacologist

Materials Engineer

Put your natural scientific curiosity and innovative mind to the test as a materials engineer. These experts spend their days researching and manipulating the properties of metals and other materials.

Chemistry Teacher

Organized, energetic, and passionate about chemistry: if this describes you, then you might have what it takes to be an inspiring chemistry teacher.

Forensic Scientist

It may not be the thrill-a-minute job you see on television, but if you are patient and detail-oriented, you may enjoy forensic science, a field that uses chemistry to help settle legal cases.

Questions

1. What other jobs and careers do you know or can you think of that involve working with chemicals or studying chemical reactions?
2. Research a job or career related to Unit 2 that interests you. Explain what attracted you to it. What kinds of things do you have to know, do, and understand for this job or career?

CONCEPT 5

Names and formulas of covalent compounds reflect their molecular structure.

Activity

Chemical Formulas of Covalent Compounds

Your teacher will provide models of each of the following compounds:

water, H_2O

hydrogen peroxide, H_2O_2

carbon dioxide, CO_2

carbon monoxide, CO

propane, C_3H_8

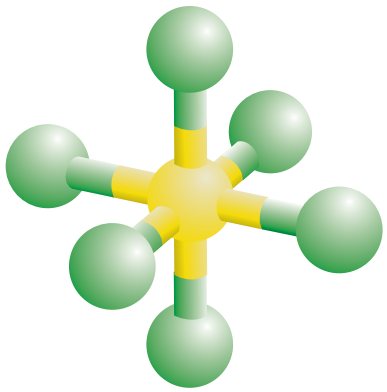
glucose, $C_6H_{12}O_6$

Sketch the models in your notebook. For each compound, compare the molecular model with the formula. What do chemical formulas of covalent compounds represent? How do they differ from ionic compounds? Why is the chemical formula of hydrogen peroxide not simplified to HO?

binary covalent compound a compound made up of the atoms of two elements joined by covalent bonds

Like binary ionic compounds, **binary covalent compounds** are made up of two elements only. Chemical formulas of binary covalent compounds indicate how many atoms of each element are present in a single molecule of the compound, as shown for sulfur hexafluoride, SF_6, in **Figure 2.44**. Like names for ionic compounds, names for binary covalent compounds have two parts—one part for each element in the compound. The following three rules will help you write names and formulas of binary covalent compounds.

Figure 2.44 The gas sulfur hexafluoride, SF_6, does not conduct thermal energy well and does not react easily with other substances. For these reasons it is sometimes used to insulate double-glazed windows.



Writing Names and Formulas of Binary Covalent Compounds

Follow these steps to write the name of a binary covalent compound.

1. The first element in the name and formula of a binary covalent compound is usually the one that is farther to the left on the periodic table.

   Example: In carbon monoxide, CO, carbon comes first because carbon is to the left of oxygen on the periodic table.

2. When naming, the suffix *-ide* is attached to the name of the second element.

   Example: Oxygen is changed to oxide in the name carbon monoxide.

3. When naming, prefixes are used to indicate how many atoms of each type are present in one molecule of the compound. **Table 2.8** lists the first 10 prefixes. The prefix *mono-* is used only for the second element in the name. When there is no prefix, *mono-* is implied, as in carbon monoxide. Also, when *mono-* comes before *-oxide*, an "o" is dropped. Thus, you write *monoxide*, not *monooxide*.

   Example: Using prefixes correctly, the name of CO is carbon monoxide.

   Note that when the addition of a prefix results in two vowels appearing together, the vowel at the end of the prefix is usually dropped. The "i" at the end of the prefixes *di-* and *tri-* are never dropped, however.

   Example: the correct name for PI_3 is phosphorus triiodide.

To write the formula for a binary covalent compound, write the element symbols in the order they appear in the name. Add subscripts based on the prefixes used in the name. Examples are provided in the Sample Problem on the next page.

Table 2.8 Prefixes Used to Name Binary Covalent compounds

Prefix	Number	Prefix	Number
mono-	1	hexa-	6
di-	2	hepta-	7
tri-	3	octa-	8
tetra-	4	nona-	9
penta-	5	deca-	10

Sample Problem

Names and Formulas of Binary Covalent Compounds

Nitrogen and oxygen form a wide variety of different covalent compounds with different properties. Two examples are described below. A third is shown in **Figure 2.45**.

a) Dinitrogen tetroxide is used in rocket fuels. What is its formula?

b) The toxic brown gas NO_2 is found in smog in urban areas. What is its name?

Figure 2.45 The compound NO acts to widen blood vessels, which can lessen chest pain in heart patients. The patient takes nitroglycerin pills, which react in the body to form NO. **What is the name of the compound NO?**

Solution

a) Nitrogen comes first in the formula, as in the name, because it is to the left of oxygen in the periodic table. The prefix *di* tells you that there are 2 nitrogen atoms and the prefix *tetr-* tells you that there are 4 oxygen atoms. (The *a* in *tetra* was dropped.)

The formula of dinitrogen tetroxide is N_2O_4.

b) Follow these steps to name a binary covalent compound.

1. Name the leftmost element in the formula first.	The first element is N (nitrogen).
2. Name the second element, making sure the name ends with the suffix *-ide*.	The second element is O (oxygen), which becomes *oxide*.
3. Add a prefix to each element's name to indicate the number of atoms of each element in a molecule of the compound. If the first element would get the prefix *mono*, do not include that prefix.	The compound's name is nitrogen dioxide.

The name of NO_2 is nitrogen dioxide.

Practice Problems

1. Write formulas for each of the following covalent compounds.

a) sulfur tetrafluoride

b) disulfur difluoride

c) dinitrogen trioxide

d) oxygen difluoride

e) nitrogen tribromide

f) diiodine hexachloride

2. Write the names of the following covalent compounds.

a) PI_3

b) SO_2

c) SO_3

d) S_2F_{10}

e) CCl_4

f) N_2O_5

g) N_2O

h) NI_3

i) P_2O_5

j) PBr_5

k) As_2S_3

l) ICl_3

Exceptions to the Rules

One important group of compounds breaks the naming rules given in this section. These are the compounds that contain hydrogen. You might think that HCl, for example, would be ionic. It contains hydrogen, found in the same group as the alkali metals, and a halogen. In fact, hydrogen is a non-metal, and HCl is known to be molecular. In its pure form, it is a gas at room temperature.

Although it is a covalent compound, HCl is not named in the same way as other covalent compounds you have encountered so far. Like other binary hydrogen-containing compounds, it is named as though it is an ionic compound. The correct name for HCl is thus hydrogen chloride, not hydrogen monochloride. Similarly, the name of H_2S is hydrogen sulfide, not dihydrogen monosulfide. When these types of compounds are added to water they form acidic solutions. You are probably already familiar with the name "hydrochloric acid," which is what HCl is called when it is dissolved in water.

Compounds containing hydrogen and carbon, such as ethane, C_2H_6, or ethanol, C_2H_5OH, are called *organic compounds*, and these have yet another set of naming rules, which you will encounter if you continue your studies in chemistry.

Figure 2.46 The characteristic smells of strawberries, pineapples, and bananas are due to organic compounds: methyl hexanoate, ethyl butanoate, and isoamyl acetate respectively. These compounds are named according to detailed rules based on their composition and structure.

Extending the Connections

Organic Compounds

Why are organic compounds so called? Are all organic compounds found in living things, like the ones in **Figure 2.46**? Find out the origin of the term *organic* in this context, and give some examples to demonstrate the diversity of organic compounds.

Before you leave this page . . .

1. What does the formula for a covalent compound tell you about the compound?
2. Identify two problems with the name mononitrogen monooxide for the compound NO and correct them.
3. Sketch a model of a molecule of carbon dioxide, CO_2, and carbon monoxide, CO. How do the names and formulas communicate the difference between these compounds?

TAKE a Stand

Make a Difference

What can we do about overconsumption of salt and sugar?

Salt and sugar: these two compounds, one ionic and one covalent, each have profound implications for human health. The media bombards us with different messages about consuming too much of these compounds, but how much is too much? On average, Canadians consume about 1.2 kg of salt and 40 kg of sugar annually. In other words, we consume the mass of a human brain in salt and the mass of four car tires in sugar each year. Are we consuming too much as a society? It would be hard to find an expert who did not think so. Many major health concerns in North America have been linked to overconsumption of these two compounds.

Too much sugar can lead to...

- obesity
- diabetes
- high blood pressure
- ageing of the body and brain
- heart disease
- tooth decay
- cancer

Too much salt can lead to...

- high blood pressure
- asthma
- osteoporosis
- obesity
- cancer

Changing how much of these compounds we eat and drink isn't always easy. Some foods that seem healthy are hidden sources of salt and sugar. For instance, ketchup actually contains more sugar than the same mass of ice cream. A piece of store-bought bread has a surprisingly large amount of salt in it. Reading nutrition labels can help, but are they clear enough and do they provide enough information?

Evaluate

1. Choose three packaged foods from your home and determine the sugar and salt content. Was this easy to do? How could the information have been clearer? What names were used for salt and sugar?

Analyze and Communicate

2. Choose one health problem related to consuming too much sugar that interests you, and one related to consuming too much salt. Find out more about each one. Do the results of your research leave you concerned about your own personal intake of salt or sugar, or that of family members? Explain your answer.
3. Decide which is more of a hazard, overconsumption of salt or overconsumption of sugar. Explain your position. Then design a plan to increase awareness about the hazards of overconsumption of salt or sugar at your school or at your home. Include strategies for reducing consumption.

Check Your Understanding of Topic 2.5

QP Questioning and Predicting PC Planning and Conducting PA Processing and Analyzing E Evaluating
AI Applying and Innovating C Communicating

Understanding Key Ideas

1. What ending do all binary compounds share, whether they are ionic or covalent compounds? PA C

2. Examine the following list of compounds. Which of these are binary compounds?
$AlCl_3$, H_2O, CNO, $C_6H_{12}O_6$, MgS, PbF_2, $NaHCO_3$, NaOH PA E

3. Write the names of the ionic compounds that form when the following elements react. PA C

a) silver and chlorine
b) oxygen and zinc
c) beryllium and iodine
d) fluorine and magnesium

4. Write formulas for each of the following compounds. PA C

a) iron(II) nitride
b) lead(II) oxide
c) copper(I) sulfide
d) tin(IV) fluoride

5. Write formulas for each of the following compounds. PA C

a) nitrogen dioxide
b) sulfur trioxide
c) dinitrogen tetroxide
d) phosphorus pentachloride

6. Name each of the following compounds. PA C

a) $AlPO_4$
b) Na_2CO_3
c) $KHCO_3$
d) $Mg(OH)_2$
e) NH_4Cl
f) $Na_2Cr_2O_7$

7. Identify the charge on the metallic ion in the following ionic compounds. Then name the compound. PA C

a) PbO_2
b) CuS
c) CrF_3
d) FeN

Connecting Ideas

8. Chromium is a transition metal used in chrome plating. PA E C

a) What ions does chromium form?
b) List the formulas and names of the possible binary ionic compounds chromium could form with oxygen and with fluorine.

Making New Connections

9. Seawater contains large quantities of dissolved ions, including sodium, calcium, magnesium, chloride, and bromide ions.

a) List all of the binary ionic compounds that could form from these ions. Give the chemical name and formula for each.
b) Which ions would you predict to be present in the greatest quantity in a sample of seawater? Explain your prediction and do research to check.
c) Come up with an additional question about the ions in seawater and research to answer your question. QP PA C

INVESTIGATION
2-G

GUIDED INQUIRY

How can you make a game out of names and formulas of ionic compounds?

Apply your creativity and knowledge to design a game to let you and your classmates practise naming and writing formulas for ionic compounds.

Skills and Strategies

- Planning and Conducting
- Processing and Analyzing
- Evaluating
- Communicating

What You Need

(suggested)

- craft materials
- computer access

Question

How can you design a game based on names and formulas of ionic compounds?

Procedure

1. Work in groups to come up with a game that involves the names and formulas for ionic compounds. Ask the following questions as you design your game:
   - What type of game will it be? a card game? a board game? a puzzle game? a computer game? a dice game?
   - What ions will you include in your game?
   - How will you include opportunities for naming and making formulas?
   - What will the rules for your game be?
   - What pieces will you need to make, if any?
2. Make a plan and produce your game.

Process and Analyze

3. Test your game several times within your group. Make adjustments to the game rules and pieces as necessary.
4. Set up a games café within the class. Teach other groups how to play your game and try out the games of other groups. Offer feedback on game play, accuracy of science content, and quality of game components.

Conclude and Communicate

5. Which was your favourite game, and why?
6. What worked well about the game you designed? If you were to try to market your game to science classrooms, what changes would you make, and why?

INVESTIGATION
2-H

STRUCTURED INQUIRY

Colours of Ionic Compounds

Skills and Strategies

- Planning and Conducting
- Processing and Analyzing
- Evaluating
- Communicating

Safety

- Some of these compounds are toxic. Do not remove them from their vials.

What You Need

- 8 vials of ionic compounds labelled with formulas
- 8 vials of ionic compounds labelled with names

Although the majority of common ionic compounds are white (as powders) or clear and colourless (as crystals), some compounds are coloured. The colour in these compounds is due to either the negative or positive ion (or very rarely, to both). By analyzing observations of a variety of compounds with different combinations of ions, we can infer which ion is coloured in a compound. For example, copper(II) nitrate is blue whereas sodium nitrate is white. We can conclude that the nitrate ion is not coloured and that therefore the copper(II) ion is coloured.

Question

How can we use our observations of different ionic compounds to identify coloured ions?

Procedure

1. Make a chart with columns for Formula, Name, and Appearance and eight blank rows. Examine the eight vials of ionic compounds that have the formulas marked on them. Record the formulas. Write the name for each compound after the formula. Also, describe the appearance of each compound, including its colour.
2. Make a chart with columns for Name, Formula, and Appearance and eight blank rows. Examine the eight vials of ionic compounds that have the names marked on them. Write the formula for each compound after the given name. Also, describe the appearance of each compound, including its colour.

Process and Analyze

1. Write the formulas of all the coloured compounds.
2. Inspect the formulas of the coloured compounds. What ions do the colourless or white compounds have in common?

Conclude and Communicate

3. Which positive and negative ions were coloured? Explain your conclusion. What further data could help you feel more confident about your conclusion?