Topic 2.5

In what ways do scientists communicate about elements and compounds?

Key Concepts

- Chemical symbols are used to represent elements.
- Chemical formulas are used to represent the types and numbers of atoms in compounds.

Key Skills

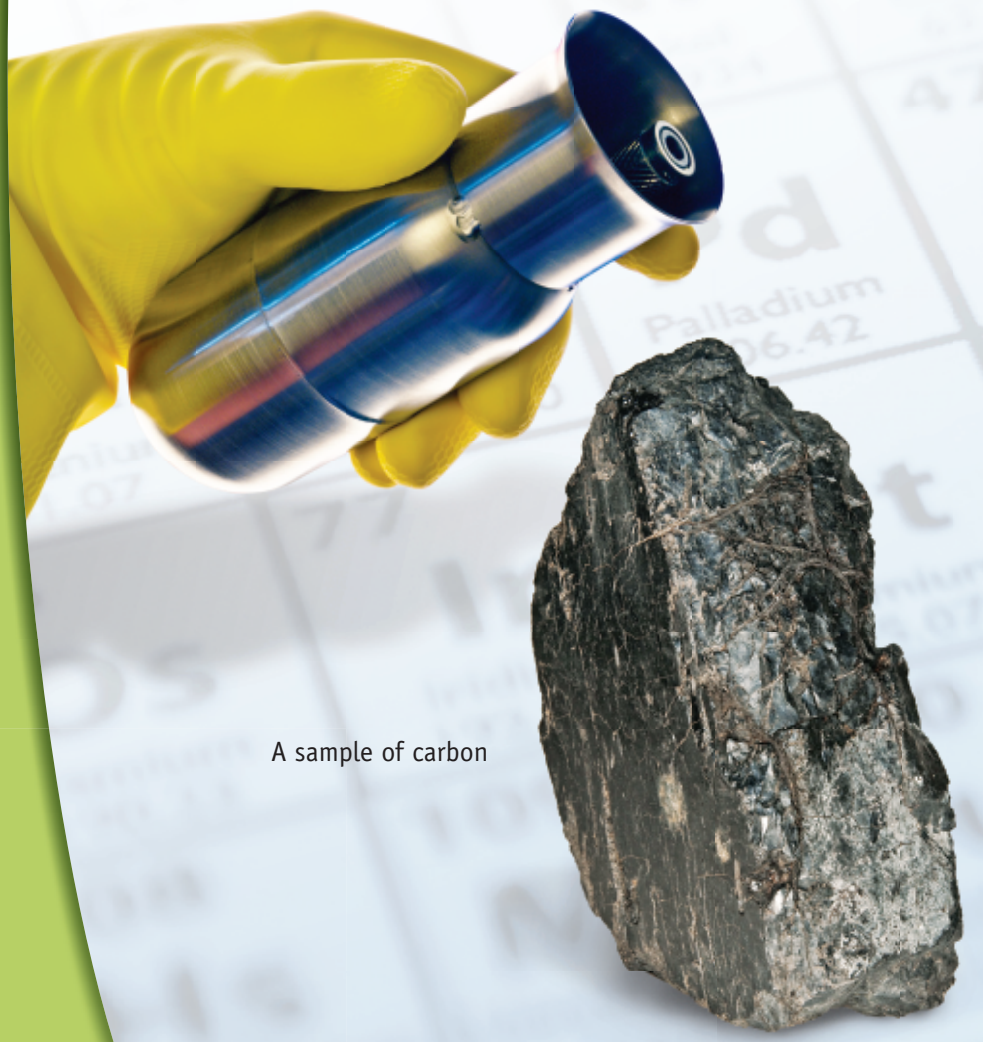
Inquiry
Research

Key Terms

chemical symbol
molecule
chemical formula

All of the compounds that exist on Earth are built from the elements on the periodic table. How many is "all"? Scientists estimate that there may be as many as 10^{200} different compounds. That number is a 1 with 200 zeros after it! The periodic table lists just under 120 elements, and only 80 of these commonly form compounds. Think of how many different structures you would be able to build if you had 80 different kinds of building blocks. The compounds that are made up of just carbon and hydrogen atoms number in the millions!

A canister containing hydrogen



A sample of carbon

Starting Point Activity

The photos in the circles show products that are entirely carbon, entirely hydrogen, or compounds that result when carbon and hydrogen combine chemically. Use the photos and your imagination to discuss possible answers to these questions.

1. How do the physical properties of hydrogen and carbon alone compare with the physical properties of the substances that are made from them?
2. List three chemical properties that many of the carbon and hydrogen compounds appear to have in common.

pencil "lead" (pure carbon)

diamond (pure carbon)

hydrogen-powered car (pure hydrogen)

gasoline (a compound of carbon and hydrogen)

natural gas (a compound of carbon and hydrogen)

candle wax (a compound of carbon and hydrogen)

plastic (a compound of carbon and hydrogen)

acetylene (a compound of carbon and hydrogen)

Chemical symbols are used to represent elements.

chemical symbol: letters used to represent the names of elements

Scientists use shorthand when they talk about elements, much the same way that you use shorthand if you send a text message. **Chemical symbols** are short forms used to represent the names of elements in compounds. You have already seen them used on the periodic table.

Chemical symbols are either one or two letters. Often the first letter of the element name is used—for instance, C for carbon and N for nitrogen. When scientists ran out of letters, they began using the first letter of the element name and a second letter from the name—for instance, Ca for calcium and Zn for zinc.

Some of the elements were discovered in ancient times and have Latin names. (For a long time, Latin—the language of ancient Rome—was the language used by most scientists to communicate their ideas.) As a result, some elements have chemical symbols that are based on their Latin name. For example, the symbol for the element gold is Au. What's the link? Au is the short form of the word *aurum*, which is the Latin word for gold. **Table 2.6** shows some other examples of chemical symbols that come from the Latin names for elements.

Table 2.6 Some Chemical Symbols That Come from the Latin Names for Elements

Element Name	Chemical Symbol	Latin Name	Meaning of Name
silver	Ag	argentum	Latin for "silver"
mercury	Hg	hydrargyrum	Latin for "liquid silver"
tin	Sn	stannum	Latin for "tin"
potassium	K	kalium	Latin for an Arabic word, *al-qalyah*, meaning "plant ashes"
iron	Fe	ferrum	Latin for "grey"
lead	Pb	plumbum	Latin for "lead"
sodium	Na	natrium	Latin for "sodium"
copper	Cu	cuprum	Latin for "Cyprian" (metal from the island, Cyprus)

Go to **scienceontario** to find out more

Elements: Atoms and Molecules

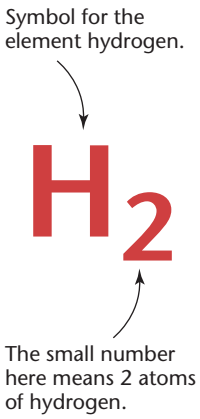
Almost all elements exist as atoms. A few elements, however, exist as molecules. **Table 2.7** lists these. A **molecule** is a type of particle that is made up of two or more atoms that are joined together by what's called a chemical bond. Chemists use a chemical formula as shorthand to describe a molecule. A **chemical formula** uses both chemical symbols and numbers. The chemical symbol is written first, and the number of atoms is shown with a subscript. A subscript is written smaller and slightly below the rest of the text. Figure 2.12 summarizes the parts of a chemical formula.

molecule: a type of particle made up of two or more atoms bonded together

chemical formula: a short form for writing the name of a compound using chemical symbols and numbers

Table 2.7 Elements That Exist As Molecules

Element	Chemical Symbol	Number of Atoms in the Molecule	Chemical Formula
hydrogen	H	2	H_2
nitrogen	N	2	N_2
oxygen	O	2	O_2
fluorine	F	2	F_2
chlorine	Cl	2	Cl_2
bromine	Br	2	Br_2
iodine	I	2	I_2
phosphorus	P	4	P_4
sulfur	S	8	S_8



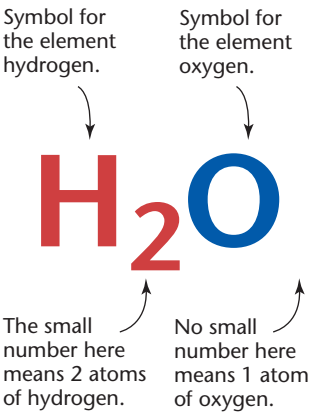
▲ **Figure 2.12** This shows the chemical formula for hydrogen.

LEARNING CHECK

1. Refer to Figure 2.11 on pages 126 and 127. What are the chemical symbols for the following elements: helium, aluminum, tungsten, cadmium, krypton, francium, iodine, cobalt, and barium?
2. Why does silver have the chemical symbol Ag and not a symbol like Si or Sl?
3. Draw and label a diagram to explain what the symbol P_4 means. Use Figure 2.12 as a guide.
4. Refer to **Table 2.6**. Explain how the chemical symbol for each of the elements listed is related to the Latin name for each element.
5. What chemical symbols would you use if the following new (and imaginary) elements were discovered: Asherium, Phoenixium, Wymium, Searlium, Edwardium, Weberum, Canadium, and Ontarium?

ACTIVITY LINK
Activity 2.11, on page 138

Chemical formulas are used to represent the types and numbers of atoms in compounds.



▲ **Figure 2.13** This shows the chemical formula for the compound water, H_2O.

When two or more atoms are joined together chemically, they form a molecule. If the atoms joined together are of the same type, then the substance is an element. If the atoms joined together are of different types, then the substance is a compound. Just as we can use chemical symbols and chemical formulas to represent elements, we also can use them to represent compounds. Refer to **Figure 2.13**.

While many of the substances that we use are complex mixtures, some are simple chemical compounds that are made up of just a few different elements. **Figure 2.14** shows a few examples.

▶ **Figure 2.14** These three compounds are commonly found in many homes.

A Hydrogen peroxide is a compound made up of the elements of hydrogen (H) and oxygen (O). Its chemical formula is H_2O_2. This means that there are 2 atoms of hydrogen and 2 atoms of oxygen in every molecule of hydrogen peroxide. It is often used as a disinfectant for wounds.

B Lye is the common name for a compound called sodium hydroxide. Sodium hydroxide is made up of 1 atom of sodium (Na), 1 atom of oxygen (O), and 1 atom of hydrogen (H). The chemical formula is NaOH. It is the main ingredient in many kinds of oven cleaner.

C Table salt is a compound that is made up of atoms of sodium (Na) and chlorine (Cl). The chemical formula for table salt is NaCl. Sodium chloride is the type of salt compound that you put on your food.

LEARNING CHECK

1. Two different atoms are joined together to make a molecule. Is this an element or a compound? Explain your answer.
2. Explain which elements and how many atoms of each element are present in hydrogen peroxide, H_2O_2.
3. Baking soda is a compound with 1 atom of sodium, 1 atom of hydrogen, 1 atom of carbon, and 3 atoms of oxygen. What is the chemical formula for baking soda?

Inquiry Focus

Activity 2.10

BUILDING MOLECULES

To understand how atoms combine to form compounds, we can build models. In this activity, you will draw and build some common molecules.

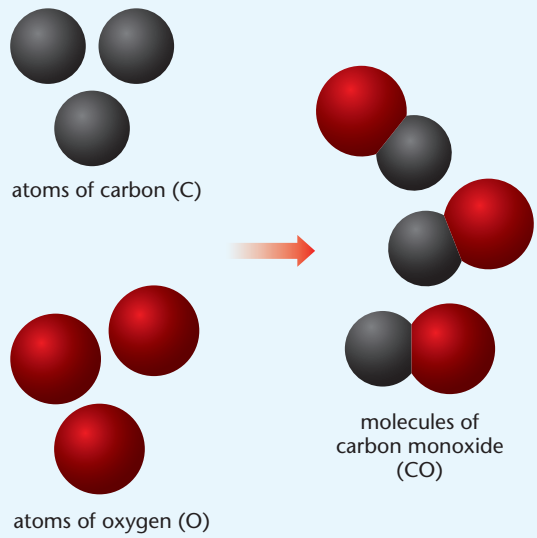
What To Do

1. Copy the table below. One entry in the second column has been filled in for you.

Chemical Formula	Number and Type of Atom Present	Drawing of Molecule
H_2O (this is water)	2 atoms hydrogen (H) 1 atom oxygen (O)	
H_2 (this is hydrogen)		
NH_3 (this is ammonia)		
CO_2 (this is carbon dioxide)		
CH_4 (this is methane)		

2. Complete the second column of the table. Use the information in this topic as a guide.
3. Using the materials provided by your teacher, build a model for each of the molecules in the table using the information from the first column.

   Hints:
   - Start with the atom written first in the chemical formula.
   - The element you start with is the centre atom. All other atoms attach to this atom.
4. Sketch your models in the third column of the table.



▲ An atom of the element carbon (C) combines with an atom of the element oxygen (O) to form a molecule of carbon monoxide (CO). The chemical symbols C and O are used to represent the two atoms. The chemical formula, CO, represents the molecule. Spheres of different colours can be used to model atoms and molecules.

WEATHER
30°C

The Bombay Chronicle

CRICKET
NEWS
INSIDE

THURSDAY, MARCH 13, 1930 - BOMBAY, INDIA

Gandhi Goes on Salt March to Dandi

Mohandas Karamchand Gandhi began a non-violent march to Dandi, Gujarat yesterday. The protester is perhaps better known by his other name, Mahatma Gandhi, or great soul. The march, a protest of the tax the British Empire has placed on salt in India, will be 400 km long. Gandhi also plans to break the British tax law at the end of the march in another show of protest.

In doing so, he hopes to inspire other Indians to join his ongoing peaceful opposition to British rule in India. However, Gandhi's simple act may do much more than that. News coverage of the march is poised to draw the world's gaze to the plight of the Indian independence movement. Can the steps of one man shake the British throne's hold on our nation? Only time will tell.

Large numbers of Indians joined Mohandas Gandhi to protest the British-imposed salt tax.

The Science behind the Story

We toss it on French fries, cucumber slices, and popcorn without a second thought. But common table salt, sodium chloride (NaCl), may be the most political compound found on our planet. Produced by the evaporation of salt-rich sea water or by mining it from the ground, salt was once so rare and expensive that people gave their very lives to gain control over it.

Pause and Reflect

1. What is the chemical name and formula for the salt we put on our food?

Why is salt so important?

NaCl, commonly known as table salt, occurs naturally as cubic crystals.

For a long time in human history, salt was one of the most expensive compounds around. Like water, salt is essential for life. For example, the chemical reactions in your body that send signals from your brain and spine to other parts of your body require sodium (Na). Salt (NaCl) is one of the main sources of it. Salt also plays a large role in preserving food and making food taste better. For this reason, the demand for salt has always been great. Until the invention of modern mining methods, the world supply of salt was very limited, keeping prices high. As a result, those who had control of salt also controlled a great deal of power.

Pause and Reflect

2. Why was salt so expensive in the past?
3. Describe two important uses for salt.

Inquire Further

4. The Sifto Salt Mine in Goderich, Ontario is one of the largest salt mines in the world. The mine was discovered in 1866 under Lake Huron. Create a historical graphic novel explaining how the mine was discovered and how its discovery caused the town to be struck by salt fever!
5. Find out more about Gandhi's salt march. Did Gandhi get arrested for his actions? What was the end result of his protest?
6. Salt played a major role in wars in the past. The Arabic word for peace actually means "to negotiate for salt." Find out what this word is.
7. Canadians get far too much salt in their diet.
   a) Find out what happens to your body when you eat too much salt.
   b) Think of three ways you could cut down on your salt consumption.

Because salt is affordable today, we often take it for granted.

What food do you put salt on?

Research Focus

Activity 2.11

LEARNING MORE ABOUT THE ELEMENTS AND THEIR COMPOUNDS

The chemical and physical properties of elements can change significantly when they are found in compounds. How are some of the most common elements used in the world around you? What are some of the social and environmental consequences that are linked with using them?

What To Do

1. In pairs, choose one of the following elements:

titanium	sulfur
iron	magnesium
copper	calcium
carbon	nitrogen
gold	phosphorus
oxygen	chlorine
nickel	cadmium
hydrogen	

2. Use the Internet or other sources of information to find out the following for your element:
   - chemical symbol
   - sources of the element (where and how is it found?)
   - common uses of the element (both as an element and as part of a compound)
   - some social and environmental consequences of its use
3. Compile your information in a format to share with the class. Your teacher will provide you with template choices that you can select from.

What Did You Find Out?

1. Do you think the benefits of using your element outweigh the risks? Give reasons to justify your answers.

lithium metal

Onboard the space shuttle

prescription lithium compound medication

▲ The element lithium has an atomic number of 3 and the chemical symbol Li. It is very reactive, so it is not found as an element in nature. Instead, it is commonly found as part of compounds. One of these compounds is lithium hydroxide. It is used to remove carbon dioxide from the air in the space shuttle. Another lithium compound is lithium carbonate. It is used as a drug in the treatment of certain mood disorders.

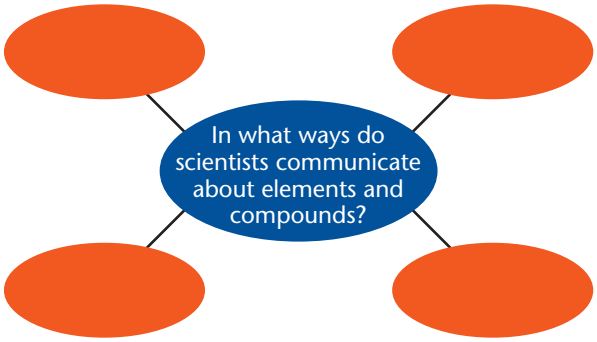
Topic 2.5 Review

Key Concept Summary

- Chemical symbols are used to represent elements.
- Chemical formulas are used to represent the types and numbers of atoms in compounds.

Review the Key Concepts

1. Answer the question that is the title of this topic. Copy and complete the graphic organizer below in your notebook. Fill in four examples from the topic using key terms as well as your own words.



2. T/I You have come into contact with the elements carbon, oxygen, nitrogen, and silicon already today. Find the symbols for these elements in the periodic table in **Figure 2.9** and write the symbols in your notebook.

3. K/U Why is the chemical symbol Fe used for iron?

4. K/U Use words and a picture to show the particle that is produced when two atoms of the same type are combined and when two atoms of different types combine.

5. K/U List the names and formulas of the nine elements that exist as molecules.

6. A Explain what every letter and number represents in the chemical formula for glucose, $C_6H_{12}O_6$.

7. C Draw a labelled diagram to model the structure of a) hydrogen sulfide, H_2S;
b) silicon hydride, SiH_4
c) chlorine, Cl_2.

8. A Propane is a molecule that contains 3 atoms of carbon and 8 atoms of hydrogen. Write the chemical formula for propane.

9. A The photograph shows equipment that passes an electrical current through the compound water. This causes a chemical reaction that decomposes water into the elements that make it up, oxygen and hydrogen. Write the chemical formulas for all the substances involved in this chemical reaction.