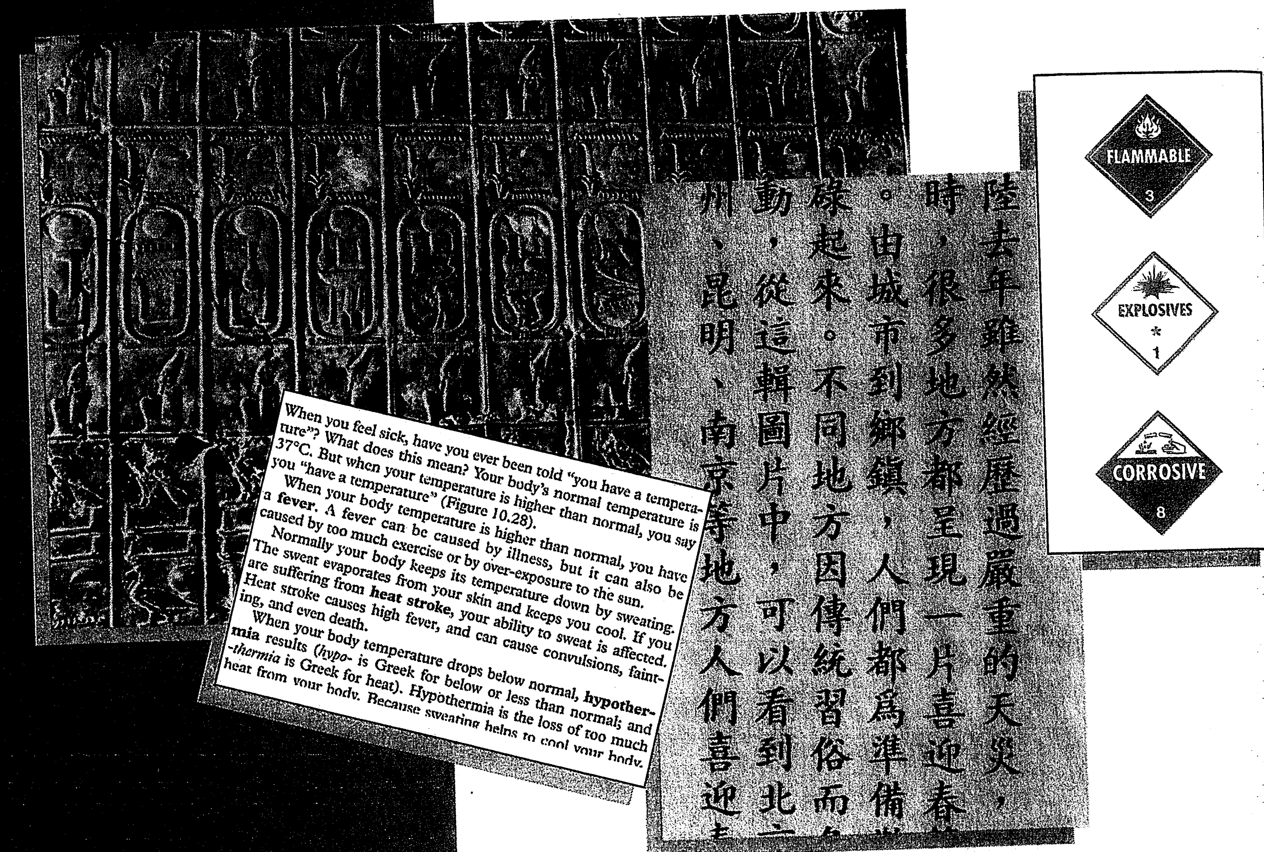
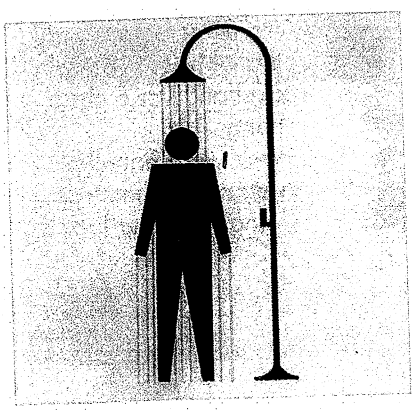
SOUTH - WESTERN

SCIENCE PROBE I

CHAPTER 3



SYMBOLS AND FORMULAS



The early chemists, working in several countries and speaking different languages, wanted to tell each other about their new discoveries. They wanted to find out what other scientists were thinking and what kinds of experiments they were doing. They needed a way of writing about elements, compounds, and chemical reactions that scientists throughout the world could understand.

Some of the symbols shown on this page and page 43 can be understood by anyone who reads English. Others can be understood by people who read other languages using the same alphabet. Still others can be understood by people who use other alphabets and other ways of writing. And some, such as the skull and crossbones, are understood almost everywhere in the world. Chemists wanted a truly international system of symbols, to be used the world over. In this chapter you will find out about that system.

ACTIVITY 3A / SYMBOLS

GROUP ACTIVITY

1. With your group, think of ways in which symbols could be used in chemistry. How could they be used to tell you about elements and compounds and how they react?
2. Examine the symbols in Table 3.1 and suggest how those symbols were chosen. Repeat for Tables 3.2 and 3.3. Your group could brainstorm possible explanations for the symbols in Table 3.3.
3. The three tables list symbols for 21 elements. There are over 100 elements in total. There are millions of different compounds made up of these elements; how do you think you could use these same symbols to represent compounds? ❖

Element	Symbol
Carbon	C
Hydrogen	H
Iodine	I
Nitrogen	N
Oxygen	O
Phosphorus	P
Uranium	U

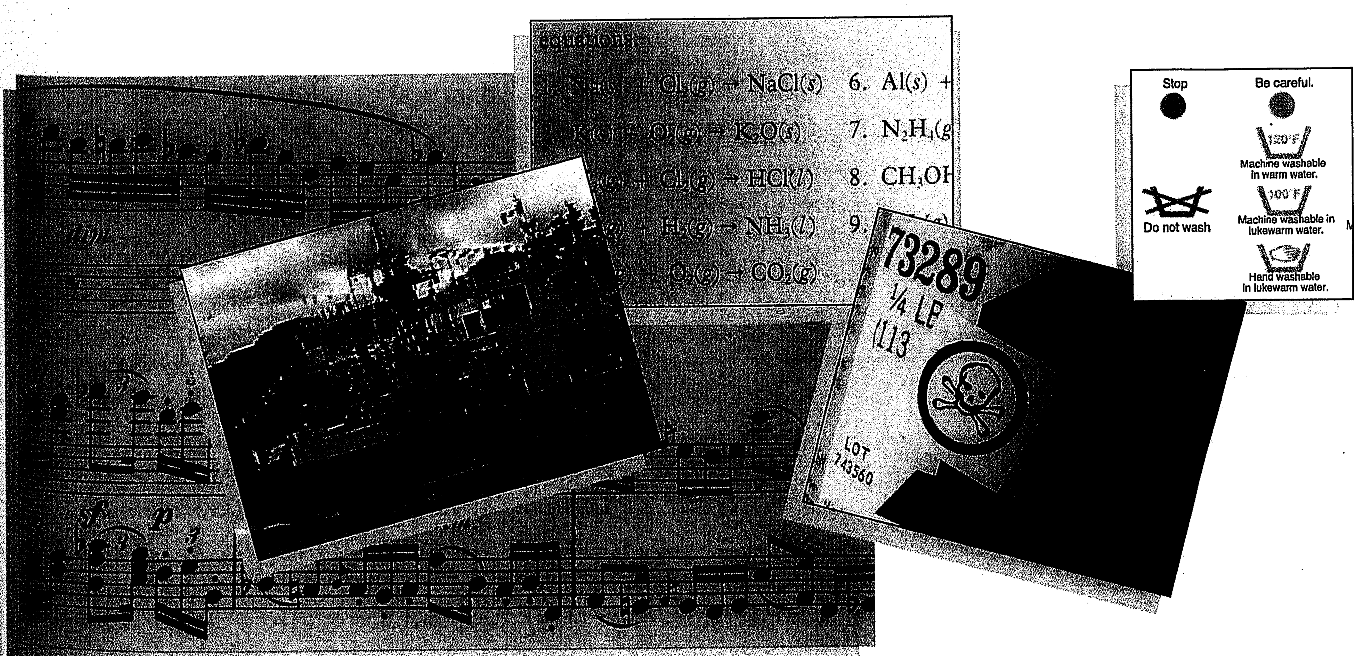
TABLE 3.1

Element	Symbol
Aluminum	Al
Arsenic	As
Calcium	Ca
Cobalt	Co
Magnesium	Mg
Manganese	Mn
Platinum	Pt
Zinc	Zn

TABLE 3.2

Element	Symbol
Copper	Cu
Gold	Au
Iron	Fe
Lead	Pb
Mercury	Hg
Silver	Ag

TABLE 3.3



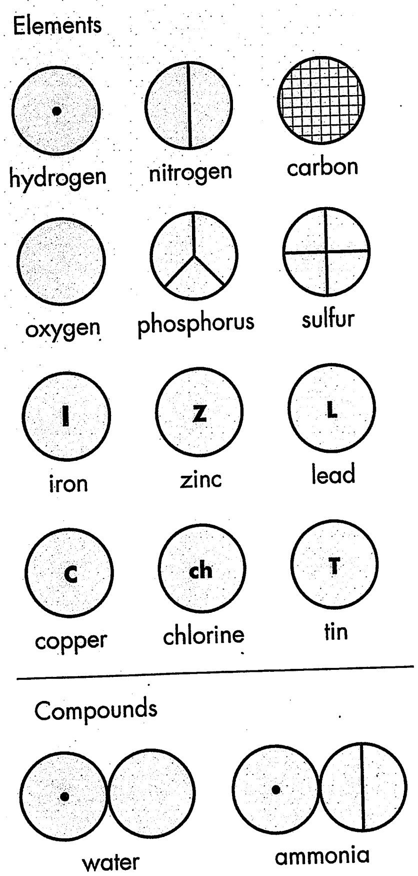


FIGURE 3.1
Some of Dalton's symbols for elements and compounds. Scientists found that Dalton's system was difficult to use.

3.1 ELEMENTS AND THEIR SYMBOLS

Around 400 B.C., a Greek scholar, Democritus, suggested that matter is made up of tiny particles. We call these particles **atoms.** More than 2000 years later, in 1808, John Dalton (1766–1844), an English scientist, suggested that each element has its own kind of atom. He also suggested that compounds are made up of combinations of different kinds of atoms. When explaining his model, Dalton represented elements by symbols and compounds by combinations of symbols (Figure 3.1).

Dalton's model has been useful in explaining many properties of matter. Over the years, the model has been modified as scientists have gained new knowledge, but much of it has remained the same. However, Dalton's system of symbols was never widely used.

Simpler symbols based on Dalton's model were suggested by Jons Jakob Berzelius (1779–1848). He suggested that all elements be represented by the first letter of their name in Latin, or by the first letter and another letter from the name. The first letter of the symbol would always be capitalized, and the second letter would be lower case. Berzelius's suggestion seemed so convenient to other scientists that his system became widely accepted and is still used today. These same symbols are now used in all languages, even those that use a different alphabet. In this way, the symbols are truly international.

THE ORIGIN OF SYMBOLS FOR THE ELEMENTS

You may wonder why the symbols for the elements are based on their Latin names. First, some of the elements were known to the Latin-speaking Romans as early as two thousand years ago and were therefore named by the Romans. These elements occur in nature in almost pure form. Thus, they are easy to separate and identify. An example of such an element is gold (*aurum* in Latin), whose symbol is Au.

Second, for more than a thousand years, Latin was used throughout Europe and was considered to be the language of learning. Long after the Roman Empire had collapsed, scholars in Europe continued to use Latin for their writings. As alchemists and scientists discovered new elements, it was natural for them to give the elements Latin names. To keep the system consistent, even elements discovered very recently are given Latinized names. Examples are uranium, einsteinium, and californium.

The English names of certain elements are the same as or very similar to their names in Latin, so it is easy to recognize these symbols. Examples are carbon (*carbo* in Latin), whose symbol is C, and aluminum (*alumen* in Latin), whose symbol is Al. Other elements, however, have English names that are very different from the Latin names.

DID YOU KNOW

■ Latin was the language of the Roman Empire. It was spoken for many centuries, from about 300 B.C. to A.D. 500. Modern languages such as Italian, Spanish, and Portuguese developed from Latin. Mexico and countries in South America and Central America are known as Latin American, because most of their citizens speak Spanish or Portuguese.

Thus, their symbols are less easy to recognize. An example is silver (*argentum* in Latin), whose symbol is Ag.

Table 3.4 lists both the English and the Latin names of some elements and their symbols.

English name	Symbol	Latin name
Antimony	Sb	Stibium
Arsenic	As	Arsenicum
Bismuth	Bi	Bismutum
Carbon	C	Carbo
Copper	Cu	Cuprum
Gold	Au	Aurum
Iron	Fe	Ferrum
Lead	Pb	Plumbum
Mercury	Hg	Hydrargyrum
Silver	Ag	Argentum
Sulfur	S	Sulfur
Tin	Sn	Stannum

TABLE 3.4 ***English and Latin Names of Some Elements***

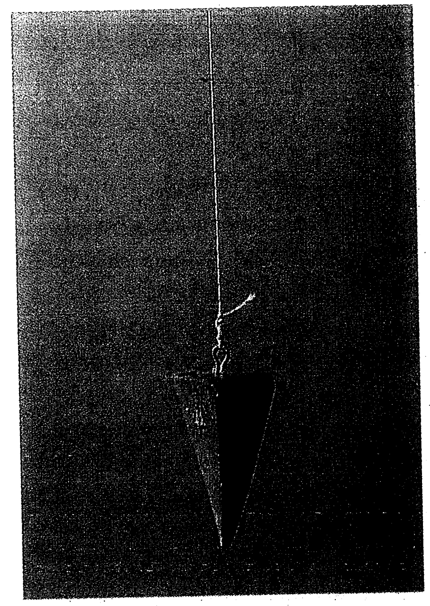


FIGURE 3.2
A heavy weight on a string is called a plumb bob. At one time, plumb bobs were often made of lead. Where do you think the name plumb bob came from?

Some English words are related to the Latin names for elements. For example, the Romans used lead pipes in their water systems. The Latin word for lead is *plumbum*, so people who work with pipes and water systems today are called plumbers. A plumb bob is a heavy weight hung from a string. It is used for finding vertical lines (Figure 3.2). Since lead has a high density, it makes a good weight, and so lead, or *plumbum*, gave plumb bobs their name.

GROUPS OF ELEMENTS

There are over 100 elements. Although each element is different from every other, there are groups of elements that have similar properties. When elements are grouped according to their properties, naming the compounds they form becomes easier.

ACTIVITY 3B / CLASSIFYING ELEMENTS

In this activity, you will classify some elements based on their physical properties.

MATERIALS

safety goggles apron

samples from the following list of elements:

aluminum	chromium	iron	nickel	tin
bismuth	cobalt	lead	nitrogen	tungsten
calcium	copper	magnesium	silicon	zinc
carbon	iodine	mercury	sulfur	➡

CAUTION!

■ Some elements are poisonous and dangerous. Follow your teacher's instructions very carefully for observing the elements.

PROCEDURE

1. Draw a data table in your notebook, using the following headings: Element, Symbol, Properties. (Note: The column labelled "Properties" in your table will actually contain only a few of the many properties of each element.)
2. Put on your safety goggles and apron.
3. Carefully observe each of the elements that your teacher has made available. Record the name of the element and its symbol (Figure 3.3). (You can find the symbols of all the elements in the alphabetical list of elements in Appendix C.) Then fill in the column labeled "Properties." Use the following questions as a guide in your investigation:
   (a) What color is the element? (If the element is not visible, say so.)
   (b) What is the state of matter (solid, liquid, or gas) of the element?
   (c) Is the element shiny or dull?
   (d) Is the element heavy or light for its size compared with the others? (That is, how would you rate its density?)
   (e) Has the element any other special property that you notice?
4. Wash your hands thoroughly after you have completed this activity.

FIGURE 3.3
Observe each element carefully and record the name and the symbol of the element in your notebook.

DISCUSSION

1. One way to classify elements is according to whether they appear to be metals or not. In a table in your notebook, list the metals in one column and the non-metals in another column. If there are any elements that do not seem to fit into either category, list them in a third column.
2. Think of two other ways that you could classify the elements you studied in this activity. Discuss your ways of classifying the elements with other members of your class.
3. How did you decide whether or not an element was a metal? ❖

METALS AND NON-METALS

Based on experiments on many elements over many years, elements with certain characteristics are considered to be **metals**. Metals, such as the gold shown in Figure 3.4, typically have the following properties:

- They are shiny.
- They are **ductile**; that is, they can be pulled (stretched) into wires.
- They are **malleable**; that is, they can be beaten into sheets.
- They are good **conductors**; that is, they are able to conduct (transfer) electricity and heat.

Non-metals are elements that do not have these properties. If you look at Appendix B, The Periodic Table of the Elements, you will see that all the metals are grouped together on the left-hand side of the table, and all the non-metals, except hydrogen, are grouped together to the right of the metals.

As usual in nature, however, things are not so simple. Some elements do not fit very well into either group. Other elements have properties of both groups. Hydrogen is a gas, but when it forms compounds, it behaves as a metal would. Aluminum has the properties of a typical metal, but it sometimes acts like a non-metallic element. Silicon and germanium have both metallic and non-metallic properties.

DID YOU KNOW

■ Silicon and germanium conduct electricity, but not nearly as well as metals like copper and iron. For this reason, these two elements are called "semiconductors." Semiconductors are used in electronic devices such as radios, television sets, CD players, computers, and calculators. Complex electronic circuits are set into the surface of tiny chips made of silicon. As the technology of these microcircuits and semiconductors has become more advanced, electronic devices have become smaller and more convenient for people to use.

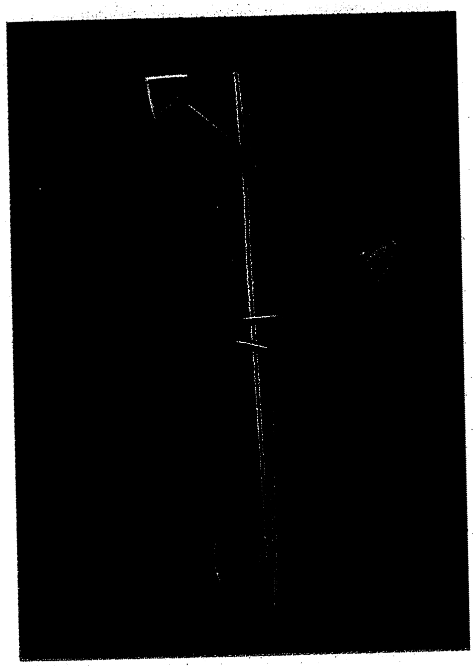


FIGURE 3.4 ◀
This brooch called Mood, was created out of sterling silver and gold by artist Andy Cooperman. What properties of gold make it easy for artist and jewellers to work with?

▶ REVIEW 3.1

1. Mercury is considered to be a metal, even though it is a liquid at room temperature. What properties do you think mercury has that make it a metal?
2. Summarize the rules for writing symbols for elements.
3. Imagine that you are a scientist who has just discovered a new element. You decide to name it either Montaium (after Montana) or after yourself. (For example, if your last name is Tang, the new element would be tangium.) Suggest two possible symbols for each name. To check that you do not use any existing symbols, refer to the alphabetical list of names and symbols in Appendix C.
4. Use Appendix C to explain why rechargeable batteries are sometimes called "NiCad" batteries.

3.2 CHEMICAL FORMULAS

Just as symbols represent elements, combinations of symbols represent compounds. A **chemical formula** is the combination of symbols representing a particular compound. For example, water has the chemical formula H_2O. This formula tells you that the compound contains hydrogen and oxygen. It also tells you the relative numbers of atoms of hydrogen and oxygen in the compound. The small number 2, called a subscript and written below the line, refers to the symbol to its left, H. The number 1 is not usually written in chemical formulas. Thus, the formula H_2O tells you that in water there are two atoms of hydrogen for every one of oxygen.

Another familiar compound is table salt, or sodium chloride. It has the chemical formula NaCl. This formula shows that table salt is made up of the elements sodium (Na) and chlorine (Cl). It also tells you that there is one atom of sodium for every atom of chlorine.

The formulas for other compounds are similar. Calcium chloride, for example, has one atom of calcium for every two atoms of chlorine. Thus, its chemical formula is $CaCl_2$. Aluminum chloride has one atom of aluminum for every three atoms of chlorine, so its chemical formula is $AlCl_3$.

This system of chemical formulas is used for all compounds, including those that have more than two elements. Magnesium sulfate, for example, which contains atoms of magnesium, sulfur, and oxygen, has the formula $MgSO_4$. Baking soda (sodium hydrogen carbonate) has the formula $NaHCO_3$. Acetylsalicylic acid, commonly known as "ASA" or "aspirin," has the formula $C_9H_8O_4$.

Table 3.5 lists the common names of some compounds, their chemical formulas, and explanations of what the formulas mean.

Name of compound	Chemical formula	Meaning of formula
Table salt (sodium chloride)	NaCl	For every one atom of sodium, there is one atom of chlorine.
Chalk (calcium carbonate)	$CaCO_3$	For every one atom of calcium, there are one atom of carbon and three atoms of oxygen.
Copper sulfate	$CuSO_4$	For every one atom of copper, there are one atom of sulfur and four atoms of oxygen.
Baking soda (sodium hydrogen carbonate)	$NaHCO_3$	For every one atom of sodium, there are one atom of hydrogen, one atom of carbon, and three atoms of oxygen.

TABLE 3.5 ***Explanation of Some Chemical Formulas***

EXTENSION

It sounds so simple — telling what kinds of atoms there are in a compound and how many of each there are. In fact, working out the chemical formula of a compound can require many investigations in many laboratories, and even then the formula may not be known for certain. Scientists are still discovering new compounds, many of them made by plants. Even in common foods, such as broccoli and carrots, there are compounds that are still unknown. In rain-forest plants, many of which are in danger of becoming extinct, scientists are finding many potentially valuable drugs.

Watch the news and read reports on the environment to find out about new and valuable materials that are being discovered. For one of these, make a poster showing where it is produced, how it is treated, and how it may be used.

MOLECULES

When atoms join together, they form a larger particle. This larger particle is called a **molecule**. A molecule of water, for example, is made up of two atoms of hydrogen and one atom of oxygen. Another compound, hydrogen peroxide, also consists of hydrogen and oxygen, but the relative numbers of the atoms are different. As a result, water and hydrogen peroxide have very different properties. Examine the molecules and formulas of these two compounds, shown in Figure 3.5. Figure 3.6 shows two other common compounds, both of which are made up of carbon and oxygen.

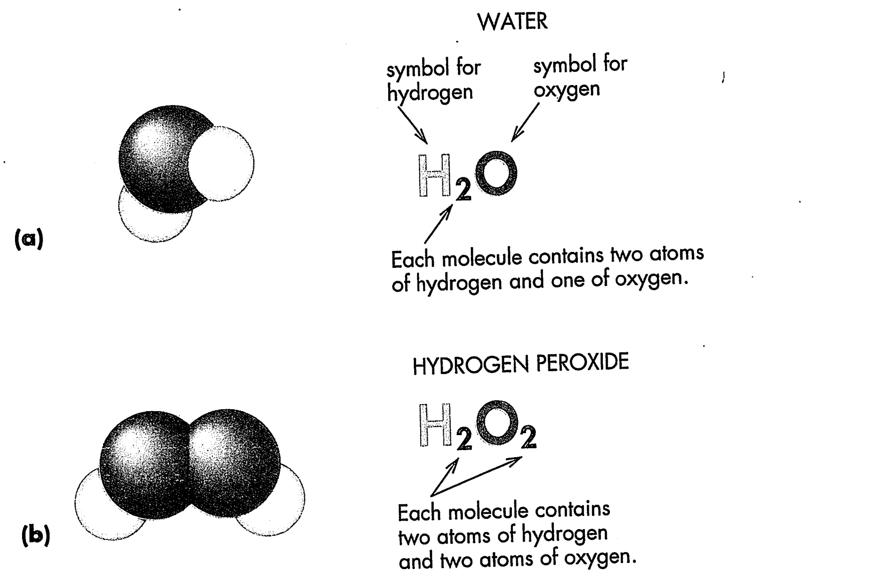


FIGURE 3.5 ▶
(a) In water molecules, there are two hydrogen atoms for every oxygen atom.
(b) In hydrogen peroxide, which is used to lighten hair color and as a disinfectant for minor cuts, the number of hydrogen and oxygen atoms is equal.

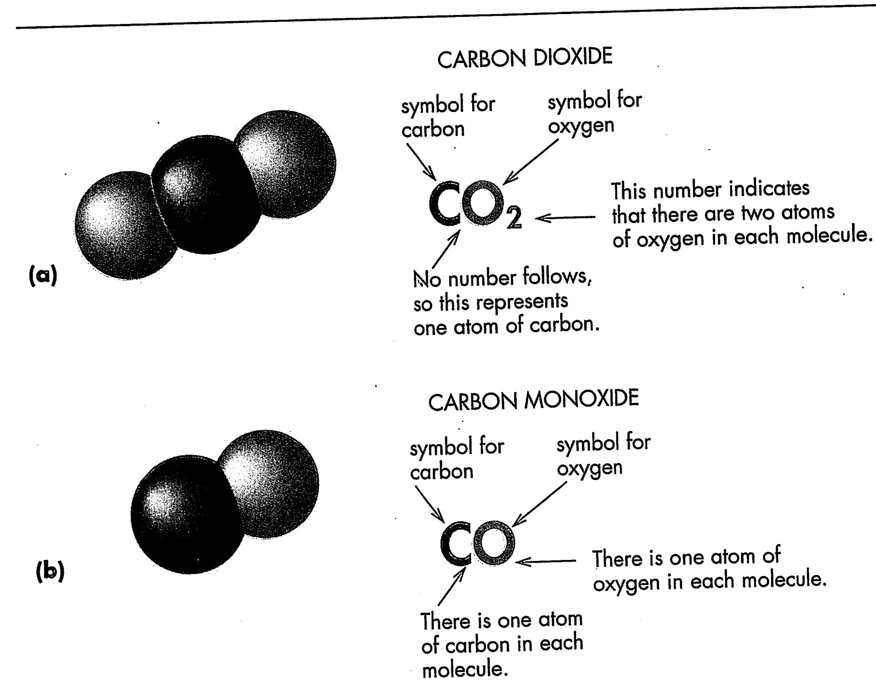


FIGURE 3.6 ▶
Both carbon dioxide and carbon monoxide contain only atoms of carbon and oxygen, but these compounds have very different properties. Carbon monoxide (one of the gases in automobile exhaust) is extremely poisonous. Carbon dioxide is used by plants to make food.

MOLECULES OF ELEMENTS

The atoms of some elements join together with atoms like themselves. That is, the atoms of an element may form a molecule of the element. The oxygen in the air consists of oxygen molecules. The formula for these molecules is O_2 (Figure 3.7). Nitrogen, another gas in air, also consists of molecules. The formula for these molecules is N_2. A few other elements also consist of molecules; for example, sulfur molecules have eight atoms and are shown by the formula S_8 (Figure 3.8).

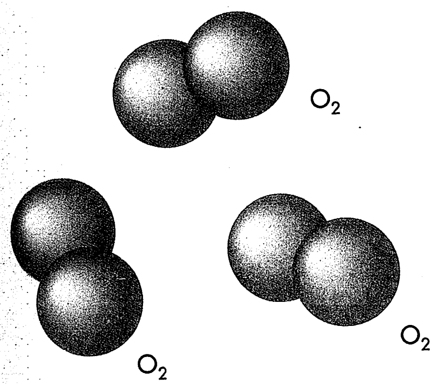


FIGURE 3.7
Each molecule of oxygen is made up of two atoms.

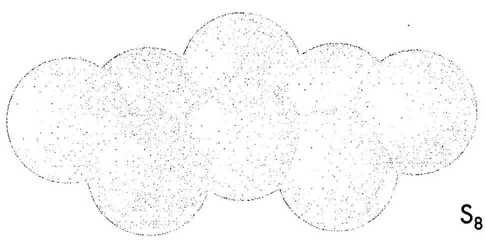


FIGURE 3.8
A molecule of sulfur is made up of eight atoms.

EXTENSION

Atoms of oxygen form molecules that have two atoms each. These molecules are represented by the formula O_2. This form of oxygen makes up about 20 percent of the air. Under certain conditions — for example, in intense ultraviolet light — oxygen atoms can form a larger molecule that has three atoms. This form of oxygen is called ozone and has the formula O_3. Find out about the importance of the ozone layer of our atmosphere and why people are concerned about it.

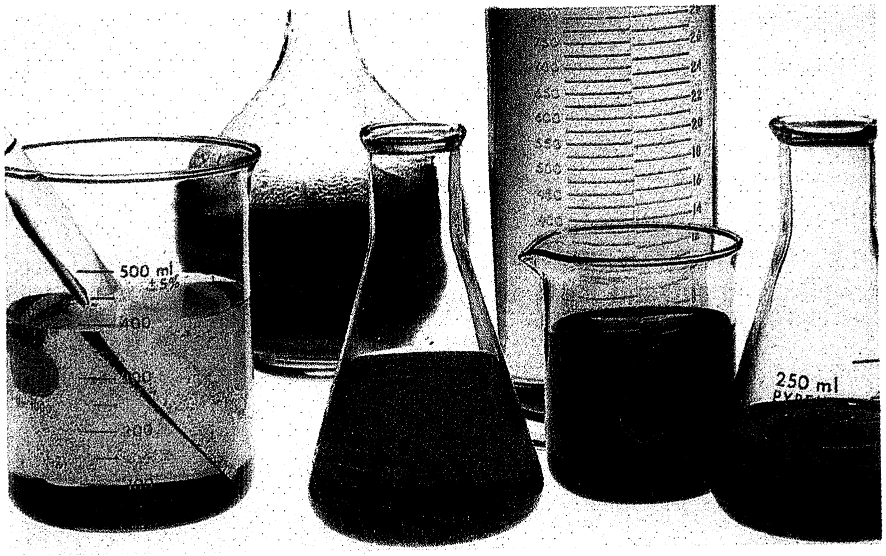
REVIEW 3.2

1. (a) What is a molecule?
   (b) How is a molecule of a compound different from a molecule of an element?
2. Explain the meaning of the following chemical formulas. (If necessary, refer to the table in Appendix C for the symbols of the elements.)
   (a) H_2O (water)
   (b) CO_2 (carbon dioxide)
   (c) $MgSO_4$ (magnesium sulfate)
   (d) Fe_2O_3 (iron oxide)
3. Write a chemical formula for each of the following.
   (a) A molecule of hydrogen that is made up of two atoms of hydrogen.
   (b) A molecule of propane that is made up of three atoms of carbon and eight atoms of hydrogen.

3.3 NAMING COMPOUNDS

There are thousands of chemical compounds, each with a different chemical name. The name of each compound tells you what elements are in it. Compounds may contain many elements or just a few elements (Figure 3.9). There are many common compounds that contain only two elements.

FIGURE 3.9 ▶
Many food colorings are compounds with complex molecules. For example, one red food coloring has the formula $Na_3C_{18}N_2S_3O_{11}$. A common blue coloring has the formula $Na_2C_{16}N_2S_2O_8$.



ACTIVITY 3C / LOOKING AT COMPOUNDS

In this activity, you will learn about compounds that are made up of only two elements. You will also discover how these compounds are named.

MATERIALS

sealed vials containing samples of five or more of the compounds listed in Table 3.6.

CAUTION!

■ **Do not open the vials.**

PROCEDURE

Examine the vials containing the compounds. In your notebook, list the names of the compounds. Write a description of each compound beside its name.

DISCUSSION

1. What properties do these compounds have in common?
2. What type of element is given first in the name of a compound?

TABLE 3.6 ▶
Some Common Compounds

Chemical name	Common name	Formula	Use
Boron oxide	—	B_2O_3	In heat-resistant glass; as a herbicide
Calcium chloride	—	$CaCl_2$	In bleaching powder; for melting ice on roads
Calcium oxide	Quicklime or lime	CaO	In mortar and plaster for construction
Copper chloride	—	$CuCl$	To make red-colored glass
Iron oxide	Rust	Fe_2O_3	Useless (unwanted product that forms on iron and steel)
Potassium iodide	—	KI	In table salt, to make "iodized" salt
Silver chloride	—	$AgCl$	In photography
Sodium chloride	Salt	$NaCl$	In food; for melting ice on roads

3. (a) What type of element has its name changed?
(b) How is the name changed?

4. Use your answer to questions 2 and 3 to complete the following word equations.
(a) iron + fluorine →
(b) magnesium + oxygen →
(c) nickel + iodine →

5. Suggest general rules for naming compounds, based on what you have learned in this activity. ❖

REVIEW 3.3

1. (a) What information is given by the chemical name of a compound?
(b) What additional information is given by the chemical formula?

2. Divide a page in your notebook into two columns. Label one column "Metals" and the other column "Non-metals." List the following elements in the appropriate column. (Recall that in the periodic table in Appendix B, metals appear to the left of the staircase line and non-metals appear to the right.)
sodium
nitrogen
carbon
calcium
lead
chlorine
helium
zinc

FIGURE 3.10
Sea salt is "harvested." Can you tell from this picture how the process works?

3. Complete the following word equations:
(a) calcium + oxygen →
(b) sodium + sulfur →
(c) aluminum + chlorine →

4. Sea salt (Figure 3.10) contains a number of compounds that are formed by the reaction of metallic elements with non-metallic elements. In a reference, find out what compounds are found in sea water, and how these compounds can be used.

3.4 WRITING CHEMICAL FORMULAS

The name of a compound gives some useful information, but it does not show the composition of the compound. For example, from the name "calcium chloride," it is not evident that the composition of this compound is two chlorine atoms for each calcium atom. The chemical formula $CaCl_2$ tells you this. How do scientists know that a compound like calcium chloride should have the formula $CaCl_2$, rather than $CaCl$, $CaCl_3$, or some other formula?

COMBINING CAPACITY

After performing many experiments, scientists have learned how elements combine with one another to form compounds. By analyzing many compounds, scientists have found out how many atoms of each of the different elements are in a molecule of each of these compounds. From all these experiments, scientists have inferred that different elements have different abilities to combine with other elements. **Combining capacity** is sometimes used to describe the ability of an element to combine with other elements.

Element	Symbol	Combining capacity
Aluminum	Al	3
Barium	Ba	2
Calcium	Ca	2
Magnesium	Mg	2
Potassium	K	1
Silver	Ag	1
Sodium	Na	1
Zinc	Zn	2

TABLE 3.7
Combining Capacities of Some Metals

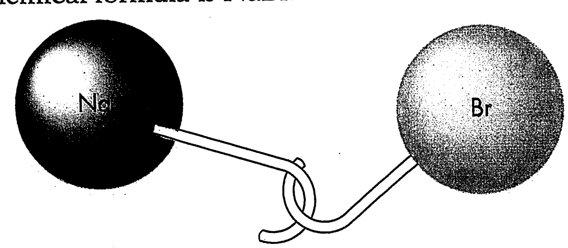
Scientists have given a numerical value to the combining capacity of each element. Sodium has been assigned a combining capacity of 1. In the compound sodium chloride (NaCl), there is one atom of chlorine for each atom of sodium. This means that chlorine also has a combining capacity of 1. In the compound calcium chloride ($CaCl_2$), there is one atom of calcium for every two chlorine atoms. Each of the two chlorine atoms has a combining capacity of 1, so calcium must have a combining capacity of 2. In aluminum chloride ($AlCl_3$), for each aluminum atom there are three chlorine atoms. Each chlorine atom has a combining capacity of 1, so the combining capacity of aluminum must be 3.

Tables 3.7 and 3.8 list the combining capacities of some metals and some non-metals. If you know the combining capacities of the elements, you can predict the chemical formulas of compounds that contain only two elements.

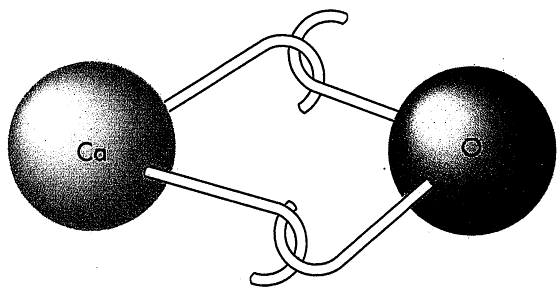
TABLE 3.8 ▶
Combining Capacities of Some Non-metals

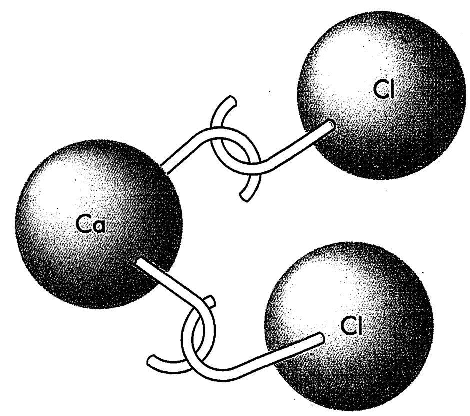
Element	Symbol	Combining capacity	Combined name
Bromine	Br	1	Bromide
Chlorine	Cl	1	Chloride
Fluorine	F	1	Fluoride
Iodine	I	1	Iodide
Oxygen	O	2	Oxide
Sulfur	S	2	Sulfide

It is simple to predict the chemical formulas of compounds in which the two elements have the same combining capacity. For example, the compound sodium bromide is made up of sodium and bromine. Each of these elements has a combining capacity of 1. This means that for each atom of sodium in the compound, there is one atom of bromine. Thus, the chemical formula is NaBr.



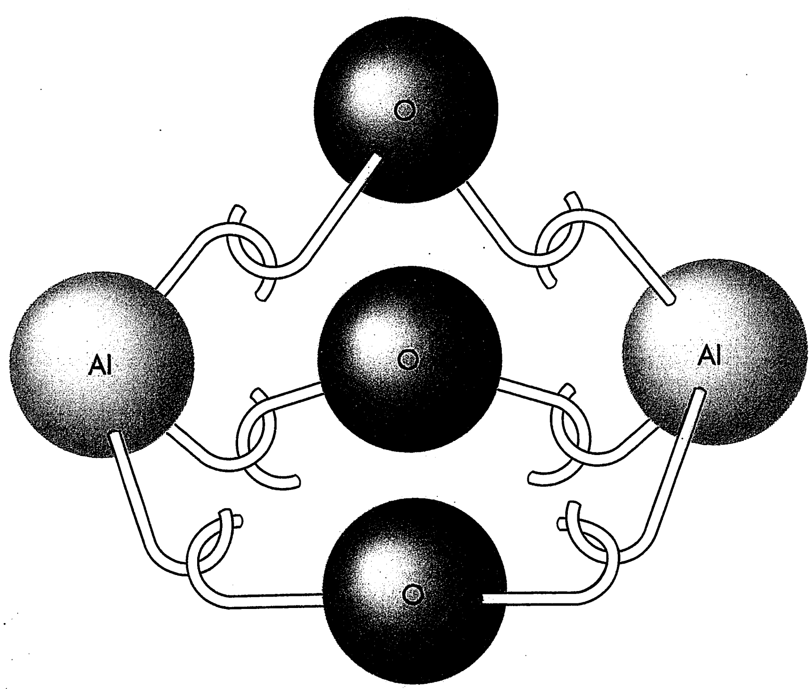
The compound calcium oxide is made up of calcium and oxygen. For both of these elements, the combining capacity is 2. Thus, one atom of calcium can combine with one atom of oxygen. The chemical formula of calcium oxide is CaO.





If the combining capacities of the two elements in a compound are different, then the numbers of atoms are also different. For example, calcium has a combining capacity of 2, and chlorine has a combining capacity of 1. Therefore, in the compound calcium choride, *one* atom of calcium combines with *two* atoms of chlorine. The chemical formula of calcium chloride is $CaCl_2$.

Aluminum has a combining capacity of 3. Oxygen has a combining capacity of 2. Therefore, in the compound aluminum oxide, *two* aluminum atoms must combine with *three* oxygen atoms. The chemical formula of aluminum oxide is Al_2O_3.



Element	Symbol	Combining capacity
Copper	Cu	1, 2
Iron	Fe	2, 3
Lead	Pb	2, 4
Nickel	Ni	2, 4

TABLE 3.9
Some Elements That Have More Than One Combining Capacity

Some metals have different combining capacities in different compounds. You can see from Table 3.9 that copper, iron, lead, and nickel all have more than one possible combining capacity. In naming compounds of these metals, their combining capacity is shown in Roman numerals following the name of the metal. For example, there is a compound named iron(II) oxide ("iron-two-oxide") and another compound named iron(III) oxide ("iron-three-oxide"). Similarly, there are two compounds of copper and oxygen, shown in Figure 3.11.

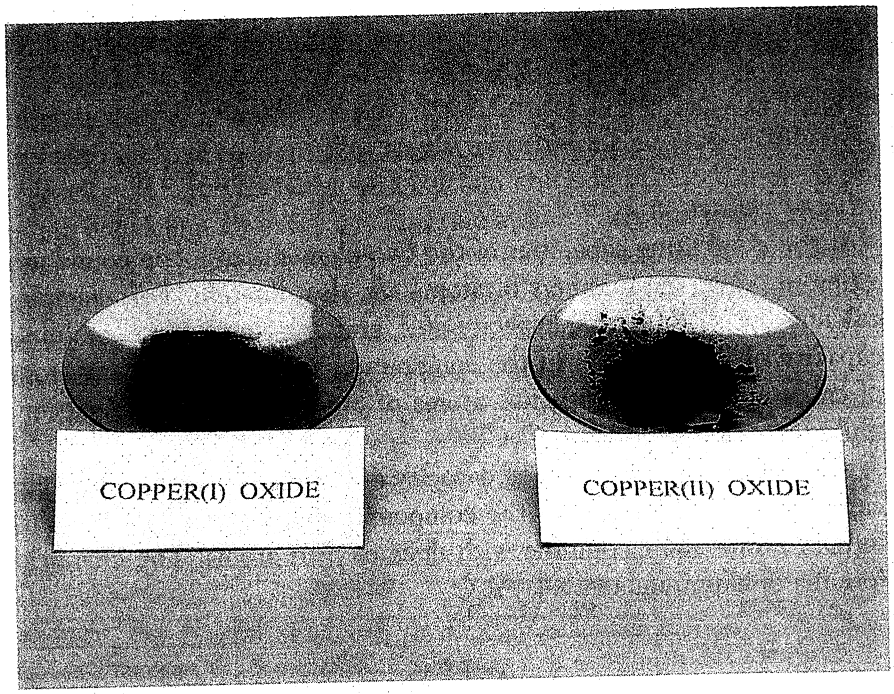


FIGURE 3.11 ▶
Copper(I) oxide is red and copper(II) oxide is black. The names are read as "copper-one-oxide" and "copper-two-oxide."

▶ INSTANT PRACTICE

1. Here are some examples of chemical compounds. Use Tables 3.7 and 3.8 and the above method to determine their chemical formulas.
   (a) sodium fluoride
   (b) magnesium fluoride
   (c) potassium iodide
   (d) potassium chloride
   (e) zinc oxide
   (f) silver oxide
   (g) aluminum fluoride
   (h) aluminum sulfide

2. Refer to Table 3.6 on page 52. The table gives the names and chemical formulas of compounds containing copper and iron. For each of these compounds, write the formula in your notebook. Beside the formula, write the chemical name, including the combining capacity.

GROUPS OF ATOMS

Scientists have found that there are groups of atoms that sometimes act together as if they were a single atom. Several of these, shown in Table 3.10, act like non-metallic elements. These groups can combine with metals, forming compounds. Some examples of compounds that you may have already used or read about are sodium hydrogen carbonate ($NaHCO_3$), calcium hydroxide ($Ca(OH)_2$), and potassium nitrate (KNO_3).

Name of group	Formula	Combining capacity
Carbonate	CO_3	2
Hydrogen carbonate	HCO_3	1
Hydroxide	OH	1
Nitrate	NO_3	1
Phosphate	PO_4	3
Sulfate	SO_4	2

TABLE 3.10 ***Some Common Groups of Atoms That Act Like Non-metals***

You are now able to understand the name of a familiar compound, copper sulfate, in which copper and the sulfate group are combined. In this compound, the combining capacity of copper is 2, so the complete name for the compound is copper(II) sulfate. The formula is $CuSO_4$.

DID YOU KNOW

■ John Polanyi, a chemist, won the Nobel prize in chemistry in 1986. When he tells of his studies of molecular motion, he describes a chemical reaction as a dance. "At the beginning of the dance—the chemical reaction—two atoms are holding hands. At the end, two others are holding hands. What happened?"

CHEMICAL FORMULAS AND THE LAW OF CONSERVATION OF MASS

In Chapter 2, you learned that in a chemical reaction, the total mass of the products is always equal to the total mass of the reactants. Now that you are familiar with atoms, molecules, chemical symbols, and chemical formulas, you can understand why this is so. In a chemical reaction, the atoms are rearranged, but the total number of atoms is the same before and after the reaction. Also, the number of atoms of each element on the products side of the equation is the same as the number of atoms on the reactants side. Atoms are not created or destroyed during the reaction. For example, Figure 3.12 shows what happens when hydrogen burns in air. Hydrogen molecules and oxygen molecules are broken apart, and water molecules are formed.

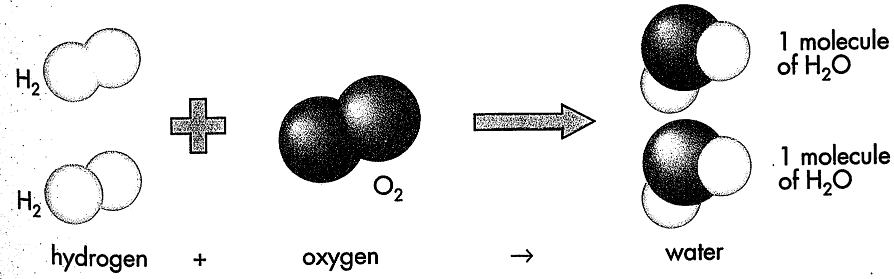


FIGURE 3.12 ◀
The combustion of hydrogen

▶ REVIEW 3.4

1. (a) What is a subscript?
   (b) In a chemical formula, what does a subscript tell you? Give two examples.

2. Name the elements present in the following compounds. Also tell the numbers of atoms of each element represented in the formula. (If necessary, refer to Appendix C to recall the symbols for the elements.)
   (a) ZnS (d) $FeCl_3$
   (b) $CuCl_2$ (e) Al_2O_3
   (c) $FeCl_2$ (f) Mg_3N_2

3. Name the following compounds. (If necessary, refer to Appendix C.)
   (a) $NaBr$ (c) ZnS
   (b) MgO (d) Al_2O_3

4. Write a chemical formula for each of the two compounds whose molecules are shown in Figure 3.13.

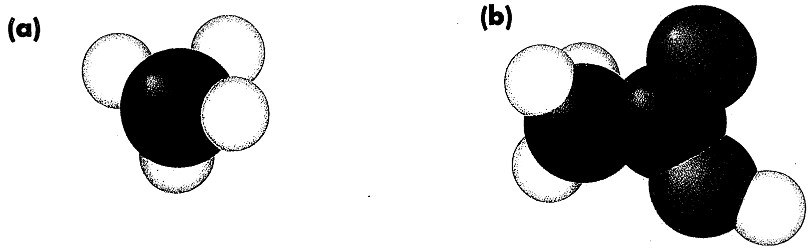


FIGURE 3.13
Methane, (a), is the main component of natural gas. It is used in home heating and for most Bunsen burners. Each molecule of methane contains one atom of carbon and four atoms of hydrogen.

Acetic acid, (b), which in diluted form is called vinegar, has molecules made up of two atoms of carbon, two atoms of oxygen, and four atoms of hydrogen.

5. Write a chemical formula for each of the following. For each, state whether it is an element or a compound.
   (a) one molecule of nitrogen that is made up of two atoms of nitrogen
   (b) sodium nitrate
   (c) one molecule of octane (a compound found in gasoline) that is made up of 8 atoms of carbon and 18 atoms of hydrogen

CHAPTER REVIEW

KEY IDEAS

- Every element can be represented by a symbol that consists of one or two letters. This system of symbols is understood throughout the world.
- Elements can be classified as metals or non-metals.
- The names of many compounds indicate what elements are in them.
- Chemical formulas tell what elements are present in a compound and the relative numbers of the different kinds of atoms.
- Molecules consist of two or more atoms joined together to make a larger particle.
- The combining capacity of an element can be used to predict how that element will join with the atoms of other elements to form compounds.
- In a chemical reaction, atoms are rearranged but are not created or destroyed.

VOCABULARY

atom
metal
ductile
malleable
conductor
non-metal
chemical formula
molecule
combining capacity

V1. In a mind map based on the word "symbol," show how all the terms in the list above can be linked.

V2. Using as many words as possible from the vocabulary lists in this chapter and in Chapter 2, write a story about the discovery of a new element.

CONNECTIONS

C1. Identify the elements in the following compounds, and tell the relative numbers of atoms of the elements.

(a) KCO_3 (c) Ag_2S
(b) $CuBr_2$

C2. Which of the following formulas are of elements and which are of compounds?

(a) P_4 (c) $PbSO_4$
(b) C_3H_8 (d) Br_2

C3. Write names for the following compounds:

(a) $CdCl_2$ (d) FeI_2
(b) CaI_2 (e) PbS
(c) CuF_2

C4. (a) What does "molecule" mean when it refers to an element?
(b) How is the meaning different when "molecule" refers to a compound?

C5. Write chemical formulas for the following compounds:

(a) magnesium chloride
(b) silver iodide
(c) zinc oxide
(d) aluminum sulfide

C6. (a) State the law of conservation of mass.
(b) State the law in another way, using "atoms" in your statement.

C7. Using what you know about the combining capacity of elements and the combining capacity of groups of atoms, explain the meaning of the following chemical formulas.

(a) $Cu(NO_3)_2$
(b) $Al(OH)_3$
(c) $Ca_3(PO_4)_2$

EXPLORATIONS

E1. Helium, a very unreactive element, belongs to a "family" of elements called the noble gases. Do some research on this family to find out the names of the other members and where they are found on the periodic table of the elements (Appendix C).

E2. Mercury is an element that is both useful and very poisonous. Do some research and write a report on the uses of mercury. Include information about mercury poisoning in your report.

E3. Find out how carbon dioxide is used in fire extinguishers. In your notebook, draw a diagram showing what is inside the extinguisher.

REFLECTIONS

R1. Examine Table 3.3 on page 43. Explain why the ancient Romans were familiar with the elements listed in this table but were not familiar with many others known to us today.

R2. Compared with a science student in China or the Middle East, what advantage do you have in learning the chemical symbols?

R3. What advantages can you think of for having a set of chemical symbols that are accepted everywhere in the world?