9.3 Naming and Writing Formulas for Molecular Compounds

1 FOCUS

Objectives

9.3.1 **Interpret** the prefixes in the names of molecular compounds in terms of their chemical formulas.

9.3.2 **Apply the rules** for naming and writing formulas for binary molecular compounds.

Guide for Reading

Build Vocabulary L2

Word Parts The word *prefix* comes from the Latin word *praefigere* meaning "to fasten before." Tell students they will learn to fasten a prefix such as *di-, tri-, tetra-* to the names of elements to indicate how many atoms of each element are in a formula of a molecular compound.

Reading Strategy L2

Visualize Encourage students to visualize the meaning of the prefixes used in binary molecular compounds. Write some names on the chalkboard, for example, carbon tetrachloride. Then draw one circle representing carbon and four circles representing chlorine. All the circles combined constitute the five atoms in CCl_4. Ask, **How many circles should I draw for fluorine in sulfur hexafluoride)?** *(six)* How many should I draw for sulfur? *(one)*

2 INSTRUCT

Connecting to Your World

The prefix *milli-* means one-thousandth of something and the prefix *kilo-* means 1000 of something. Ask, **How many milligrams of gold are in one gram of gold?** *(1000)* **How many milligrams are in one kilogram of gold?** *(1,000,000)* **Based on $12,500 for a kilogram, is one cent the actual value for one milligram?** *(The price is actually one and one-quarter cent.)*

Guide for Reading

Key Concepts

- What does a prefix in the name of a binary molecular compound tell you about the compound's composition?
- How do you write the formula for a binary molecular compound?

Reading Strategy

Monitoring Your Understanding
Before you read, preview the Key Concepts, the headings, the boldfaced sentences, and the visuals. List two things you expect to learn. After reading, state what you learned about each item you listed.

Connecting to Your World

Gold was one of the first metals to attract human attention. When gold was discovered in California in the late 1840s, people from all over the world came to find it and make their fortune. Today, gold is still greatly prized and valued. Whereas one milligram of gold is worth only about one cent, one kilogram of gold is worth approximately $12,500. In this case, using the correct prefix (*milli-* or *kilo-*) makes quite a difference! Prefixes are important in chemistry, too. In this section, you will learn how prefixes in the name of a binary molecular compound tell you its composition.

Naming Binary Molecular Compounds

Recall that binary ionic compounds are composed of the ions of two elements, a metal and a nonmetal. Binary molecular compounds are also composed of two elements, but both elements are nonmetals and they are not ions. These differences affect the naming of these compounds and their formulas. Binary molecular compounds are composed of molecules, not ions, so ionic charges cannot be used to write formulas or to name them. In addition, when two nonmetallic elements combine, they often do so in more than one way. For example, the elements carbon and oxygen combine to form two invisible gaseous compounds, CO and CO_2. CO is illustrated in Figure 9.12. How would you name a binary compound formed by the combination of carbon and oxygen atoms? It might seem satisfactory to call it carbon oxide. However, the two carbon oxides, CO and CO_2, are very different compounds. Sitting in a room with small amounts of the carbon oxide CO_2 in the air would not present any problems. You exhale CO_2 as a product of your body chemistry. Thus it is normally present in the air you breathe. On the other hand, if the same amount of the other carbon oxide, CO, were in the room, you could die of asphyxiation. The binary compound CO is a poisonous gas that interferes with your blood's ability to carry oxygen to body cells. Obviously, a naming system that distinguishes between these two compounds is needed.

Section Resources

Print
- **Guided Reading and Study Workbook,** Section 9.3
- **Core Teaching Resources,** Section 9.3
- **Transparencies,** T98

Technology
- **Interactive Textbook with ChemASAP,** Assessment 9.3
- **Go Online,** Section 9.3

Table 9.4

Prefixes Used in Naming Binary Molecular Compounds

Prefix	Mono-	Di-	Tri-	Tetra-	Penta-	Hexa-	Hepta-	Octa-	Nona-	Deca-
Number	1	2	3	4	5	6	7	8	9	10

Prefixes in the masses of gold samples distinguish between large and small samples. Prefixes in the names of binary molecular compounds help distinguish compounds containing different numbers of atoms. **A prefix in the name of a binary molecular compound tells how many atoms of an element are present in each molecule of the compound.** Table 9.4 lists the prefixes used to name binary molecular compounds. According to the table, the prefix *mono-* indicates the presence of one oxygen atom in CO. The prefix *di-* indicates the presence of the two oxygen atoms in CO_2. The two compounds of carbon and oxygen, CO and CO_2, are thus named carbon monoxide and carbon dioxide, respectively. *Laughing gas* is the common name for the gaseous compound dinitrogen monoxide (N_2O), which is used as an anesthetic. When inhaled, N_2O tends to make people laugh. Notice that the second element in the name ends with *-ide*. The names of all binary molecular compounds end in *-ide*. Also note that the vowel at the end of a prefix often is dropped when the name of the element begins with a vowel. For CO, you would write carbon *mon*oxide, not carbon *mono*oxide. If just one atom of the first element is in the formula, omit the prefix *mono-* for that element.

Here are some guidelines for naming binary molecular compounds. First, confirm that the compound is a binary molecular compound—that is, a compound composed of two nonmetals. The name must identify the elements in the molecule and indicate the number of each atom of each element. Name the elements in the order listed in the formula. Use prefixes to indicate the number of each kind of atom. Omit the prefix *mono-* when the formula contains only one atom of the first element in the name. The suffix of the name of the second element is *-ide*. Now, apply these guidelines to naming N_2O. The formula shows that the compound consists of two nonmetals, so it is a binary molecular compound. Two atoms of nitrogen are combined with one atom of oxygen. Thus the prefix of nitrogen is *di-* and the prefix of oxygen is *mono-*. The name of the compound is dinitrogen monoxide. Using the same guidelines, the name of SF_6 is sulfur hexafluoride. Notice that it is not necessary to use the prefix *mono-* before sulfur. What about the compound Cl_2O_8? This binary molecular compound consists of two chlorine atoms (prefix *di-*) and eight oxygen atoms (prefix *octa-*). The name is dichlorine octoxide.

Checkpoint ***What suffix ends the names of all binary molecular compounds?***

Go Online NSTA SCILINKS

For: Links on Carbon Monoxide
Visit: www.SciLinks.org
Web Code: cdn-1093

Figure 9.12 Carbon monoxide is an invisible, gaseous compound of carbon and oxygen. It is a toxic product of incomplete burning, such as occurs in automobile engines and faulty furnaces.

Differentiated Instruction

Gifted and Talented L3

Increasingly large quantities of the binary molecular compound CO_2 are released into the atmosphere annually by the burning of fossil fuels. Once in the atmosphere, carbon dioxide traps solar energy near Earth's surface. As a result, some scientists predict that over time global temperatures will rise. Ask students to learn more about global warming and prepare an oral or written report or a poster that explains it.

Naming Binary Molecular Compounds

CLASS Activity

Naming Binary Molecular Compounds L2

Purpose Students convert the subscripts in a formula to prefixes in the name.

Materials paper and pencil

Procedure Have students make a chart with three columns: *element name, number of atoms,* and *prefix*. Have them fill in the columns for N_2O and then name the compound. For example:

Nitrogen	2	di-
Oxygen	1	mono-

The name is dinitrogen monoxide. Write the molecular formulas for other compounds on the board and have students add them to their charts. Some possibilities are CCl_4, PBr_5, and P_4S_3.

Discuss L2

Students may be interested in knowing how the order of the elements in the names of most molecular compounds is established. Ordinarily, the less electronegative element appears first in the name. For example, a compound containing carbon and sulfur is carbon disulfide (CS_2). Carbon is less electronegative than sulfur so it appears first. Electronegativity increases from left to right on the periodic table and decreases from top to bottom. Thus the first element in the name and formula is the element further to the left, for example, disulfur dichloride (S_2Cl_2). For elements in the same column, the element nearer the bottom of the table goes first, for example, iodine heptafluoride (IF_7).

Go Online NSTA SCILINKS

Download a worksheet on **Carbon Monoxide** for students to complete, and find additional teacher support from NSTA SciLinks.

Answers to...

Checkpoint *-ide*

Writing Formulas for Binary Molecular Compounds

Relate L1

Students may be interested in knowing that the hardness of substances such as silicon carbide have been quantified using the Mohs scale, which ranges from zero to 10. Tell students the graphite in their pencils has a rating of 0.5 Mohs. Diamond is the hardest mineral at 10 Mohs and silicon carbide is 9.3.

3 ASSESS

Evaluate Understanding L2

Challenge students to name the following pairs of compounds and to identify what each pair has in common: PBr_3 and $CrBr_3$, N_2O and Na_2O, ClI_4 and PbI_4, P_2O_3 and Fe_2O_3 *(Each pair consists of a binary molecular compound and a binary ionic compound with one element in common.)*

Reteach L1

Have students write the names of these binary molecular compounds: NO, SiO_2, N_2O_4, ClF_3. *(nitrogen monoxide, silicon dioxide, dinitrogen tetroxide, chlorine trifluoride)* Have students write the formulas for these compounds: arsenic pentachloride, iodine tribromide, tetraphosphorus hexoxide. *($AsCl_5$, IBr_3, P_4O_6)*

Connecting Concepts

Yes, chlorine can form only one bond; silicon can form four. An electron dot structure shows silicon sharing one electron with each chlorine for a total of eight electrons around silicon. Each chlorine also is surrounded by eight electrons.

Interactive Textbook

If your class subscribes to the Interactive Textbook, use it to review key concepts in Section 9.3.

with ChemASAP

Figure 9.13 A grinding wheel made of silicon carbide (SiC) can shape even the toughest materials. **Inferring** ***What causes the sparks?***

Writing Formulas for Binary Molecular Compounds

Suppose you know the name of a molecular compound and want to write the formula. **Use the prefixes in the name to tell you the subscript of each element in the formula. Then write the correct symbols for the two elements with the appropriate subscripts.** A simple example is silicon carbide. Silicon carbide is a hard material like diamond. It is used as an abrasive and for cutting and grinding, as shown in Figure 9.13. The name *silicon carbide* has no prefixes, so the subscripts of silicon and carbon must be one. Thus the formula for silicon carbide is SiC. The name of another binary molecular compound is dinitrogen tetroxide. The prefix *di-* before nitrogen tells you that the compound contains two nitrogen atoms; the prefix *tetra-* tells you that the molecule also contains four oxygen atoms. Thus the formula for dinitrogen tetroxide is N_2O_4.

9.3 Section Assessment

20. Key Concept What information do prefixes in the name of a binary molecular compound tell you about the composition of the compound?

21. Key Concept Describe how to write the formula of a binary molecular compound.

22. Write the names for these molecular compounds.
a. NCl_3 **b.** BCl_3 **c.** NI_3
d. SO_3 **e.** N_2H_4 **f.** N_2O_3

23. Write the formulas or names for these molecular compounds.
a. CS_2 **b.** carbon tetrabromide
c. Cl_2O_7 **d.** diphosphorus trioxide

24. Write the formulas for these binary molecular compounds.
a. phosphorus pentachloride
b. iodine heptafluoride
c. chlorine trifluoride
d. iodine dioxide

25. The name a student gives for the molecular compound $SiCl_4$ is monosilicon trichloride. Is this name correct? Explain.

Connecting Concepts

Covalent Bonds In Section 8.1, you learned about covalent bonds. Are the bonds between silicon and chlorine in silicon tetrachloride ($SiCl_4$) single bonds? Justify your answer by drawing an electron dot structure of silicon tetrachloride.

Interactive Textbook

Assessment 9.3 Test yourself on the concepts in Section 9.3.

with ChemASAP

Section 9.3 Assessment

20. Prefixes indicate the number of atoms of each element in a molecule of the compound.

21. Write the symbols for each element with a subscript corresponding to the prefix before each element in the name.

22. **a.** nitrogen trichloride **b.** boron trichloride **c.** nitrogen triiodide **d.** sulfur trioxide **e.** dinitrogen tetrahydride **f.** dinitrogen trioxide

23. **a.** carbon disulfide **b.** CBr_4 **c.** dichlorine heptoxide **d.** P_2O_3

24. **a.** PCl_5 **b.** IF_7 **c.** ClF_3 **d.** IO_2

25. No; the correct name is silicon tetrachloride.