

## Section 2

# Compounds

**Key Concept** A compound is formed by chemically combining two or more elements.

### What You Will Learn

- A compound is made up of two or more elements that are chemically combined to form a new substance with different properties.
- During a chemical reaction, the reactant atoms of two or more elements interact and join to form molecules of one or more compounds.
- Each compound has a unique set of physical and chemical properties that differ from the properties of the elements that make up the compound.

### Why It Matters

Understanding how compounds are formed can help you understand the different properties that result when you combine certain substances.

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What do salt, sugar, baking soda, and water have in common? You might use all of these to bake bread. Is there anything else similar about them? Salt, sugar, baking soda, and water are all compounds. Because most elements take part in chemical changes fairly easily, they are rarely found alone in nature. Instead, they are found combined with other elements as compounds.

### Compounds: Made of Elements

A **compound** is a pure substance composed of two or more elements that are chemically combined. Elements combine by reacting, or undergoing a chemical change, with one another. A chemical change, or reaction, happens when one or more substances are changed into one or more new substances that have new and different properties.

**Figure 1** shows magnesium reacting with oxygen. A compound called *magnesium oxide* is forming. The compound is a new pure substance. It is different from the elements that make it up. Most of the substances that you see every day are compounds. **Table 1**

lists some familiar examples.



**Figure 1** As magnesium (a solid) burns, it reacts with oxygen (a gas) and forms the compound magnesium oxide (a solid).

| Table 1 Familiar Compounds |                                      |
|----------------------------|--------------------------------------|
| Compound                   | Elements combined                    |
| Table salt                 | sodium and chlorine                  |
| Water                      | hydrogen and oxygen                  |
| Citric acid                | hydrogen, carbon, and oxygen         |
| Carbon dioxide             | carbon and oxygen                    |
| Baking soda                | sodium, hydrogen, carbon, and oxygen |

### Chemical Reactions Form Compounds

A chemical reaction is the process by which substances change into new substances. This process involves rearranging the atoms of a substance into new combinations with atoms of other substances. The atoms join in various patterns to form new substances that have different chemical properties. When two or more elements combine, a new compound is formed. The properties of the new compound are different from the properties of the elements that formed the compound.

**Standards Check** Explain how a compound is formed.



## Properties of Compounds

Like an element, each compound has its own physical properties. Physical properties include melting point, density, and color. Compounds can also be identified by their chemical properties. Some compounds, such as calcium carbonate (found in chalk), react with acid. Other compounds, such as hydrogen peroxide, react when exposed to light.

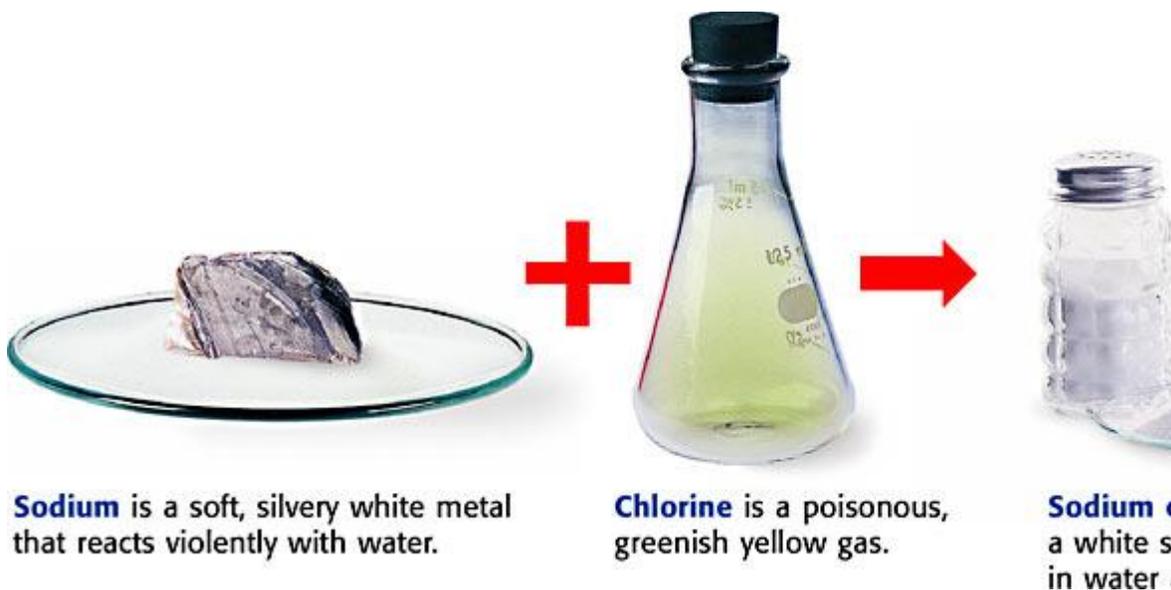
**Standards Check** What are three physical properties used to identify compounds?



### Properties: Compounds Versus Elements

A compound has properties that differ from the properties of the elements that make up the compound. **Figure 2** shows that table salt, or sodium chloride, is made of two very dangerous elements—sodium and chlorine. Sodium reacts violently with water. Chlorine is a poisonous gas. But when combined, these elements form a harmless compound that has unique properties. Sodium chloride is safe to eat. It also dissolves (without exploding!) in water.

#### Figure 2 Forming Sodium Chloride



### The Ratio of Elements in a Compound

Elements do not randomly join to form compounds. Instead, elements join in a specific ratio according to their masses. For example, for water, the ratio of the mass of hydrogen to the mass of oxygen is 1 to 8. This mass ratio can be written as 1:8. For water, this ratio is always 1:8. That is, every sample of water has a 1:8 mass ratio of hydrogen to oxygen. If a sample of a compound has a mass ratio of hydrogen to oxygen that is not 1:8, the compound cannot be water.

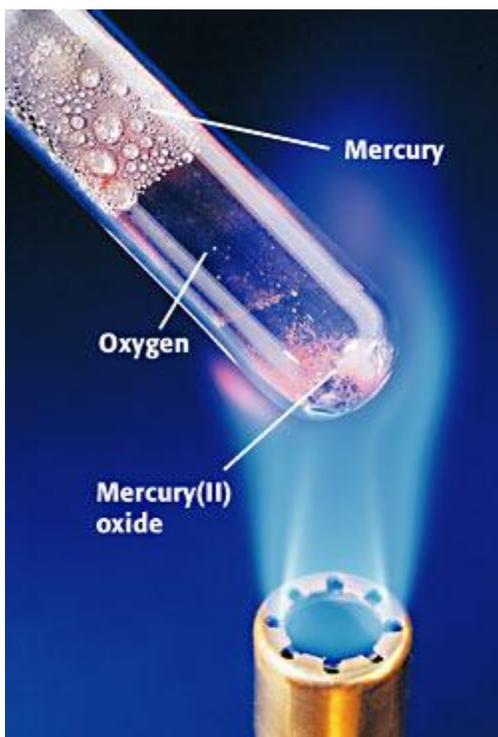
### Breaking Down Compounds

Some compounds can be broken down into their elements by chemical changes. Other compounds break down to form simpler compounds instead of elements. These simpler compounds can then be broken down into elements through more chemical changes. For example, carbonic acid is a compound that helps give carbonated beverages their "fizz." When you open a can of soda, carbonic acid breaks down into carbon dioxide and water and makes the soda fizz. This carbon dioxide and water could then

be broken down into the elements carbon, oxygen, and hydrogen through chemical changes.

### Methods of Breaking Down Compounds

The only way to break down a compound is through a chemical change. Sometimes, energy is needed for a chemical change to happen. Two ways to add energy to break down a compound are to apply heat and to apply an electric current. For example, heating the compound mercury(II) oxide breaks it down into the elements mercury and oxygen, as shown in **Figure 3**.



**Figure 3** When mercury(II) oxide is heated, it undergoes a chemical change in which it separates into the elements mercury and oxygen.

**Standards Check** What elements combine to form mercury(II) oxide?

### Compounds in Your World

Compounds are all around you. They make up the food you eat, the school supplies you use, and the clothes you wear—even you are made of compounds!

### Compounds in Industry

The compounds found in nature are not usually the raw materials needed by industry. Often, these compounds must be broken down to provide elements or other compounds that can be used as raw material. For example, aluminum is used in cans and airplanes. But in nature, aluminum is found in the form of the compound aluminum oxide. Pure aluminum is produced by breaking down aluminum oxide.

### Compounds in Nature

Proteins are compounds found in all living things. Nitrogen is one of the elements needed to make proteins. **Figure 4** shows how some plants get their nitrogen from the air. Other plants get nitrogen from nitrogen compounds in the soil. Animals get their nitrogen by eating plants or by eating animals that have eaten plants. The proteins in the food are broken down as an animal digests the food. The simpler compounds that form are used by the animal's cells to make new proteins.



**Figure 4** The bumps on the roots of this pea plant

are home to bacteria that form compounds from nitrogen in the air. The pea plant makes proteins from these compounds.

Another compound that plays an important role in life is carbon dioxide. You exhale carbon dioxide that was made in your body. Plants take in carbon dioxide, which is used in photosynthesis. Plants use photosynthesis to make compounds called *carbohydrates*. Plants and plant-eating animals get energy by breaking down these carbohydrates through chemical changes.

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## Section Summary

- A compound is a pure substance composed of two or more elements.
  - During a chemical reaction, the atoms of two or more elements react with each other to form molecules of compounds.
  - Each compound has unique physical and chemical properties that differ from those of the elements that make up the compound.
  - Compounds can be broken down into simpler substances only by chemical changes.
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