

4

Elements, Compounds, and Mixtures

The Big Idea

Matter can be classified into elements, compounds, and mixtures.

SECTION

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About the **PHOTO**

Within these liquid-filled glass lamps, colored globs slowly rise and fall. But what are these liquids, and what keeps them from mixing together? The liquid inside these lamps is a mixture. This mixture is composed of four compounds, which include mineral oil, wax, water, and alcohol. The water and alcohol mix, but they remain separated from the globs of wax and oil.

PRE-READING **Activity**



FOLDNOTES **Key-Term Fold** Before you read the chapter, create the FoldNote entitled "Key-Term Fold" described in the **Study Skills** section of the Appendix. Write a key term from the chapter on each tab of the key-term fold. Under each tab, write the definition of the key term.



What You Will Learn

- Describe pure substances.
- Describe the characteristics of elements, and give examples.
- Explain how elements can be identified.
- Classify elements according to their properties.

Vocabulary

element	nonmetal
pure substance	metalloid
metal	

READING STRATEGY

Reading Organizer As you read this section, make a concept map by using the terms above.

Elements

Imagine that you work for the Break-It-Down Company. Your job is to break down materials into simpler substances.


You haven't had any trouble breaking down materials so far. But one rainy Monday morning, you get a material that seems very hard to break down. First, you try physical changes, such as crushing and melting. But these do not change the material into something simpler. Next, you try some chemical changes, such as passing an electric current through the material. These do not change it either. What's going on?

Elements, the Simplest Substances

You couldn't break down the material described above because it is an element. An **element** is a pure substance that cannot be separated into simpler substances by physical or chemical means. In this section, you'll learn about elements and the properties that help you classify them.

Only One Type of Particle

Elements are pure substances. A **pure substance** is a substance in which there is only one type of particle. So, each element contains only one type of particle. These particles, called *atoms*, are much too small for us to see. For example, every atom in a 5 g nugget of the element gold is like every other atom of gold. The particles of a pure substance are alike no matter where they are found, as shown in **Figure 1**.

 **Reading Check** Explain why an element is a pure substance. (See the Appendix for answers to Reading Checks.)

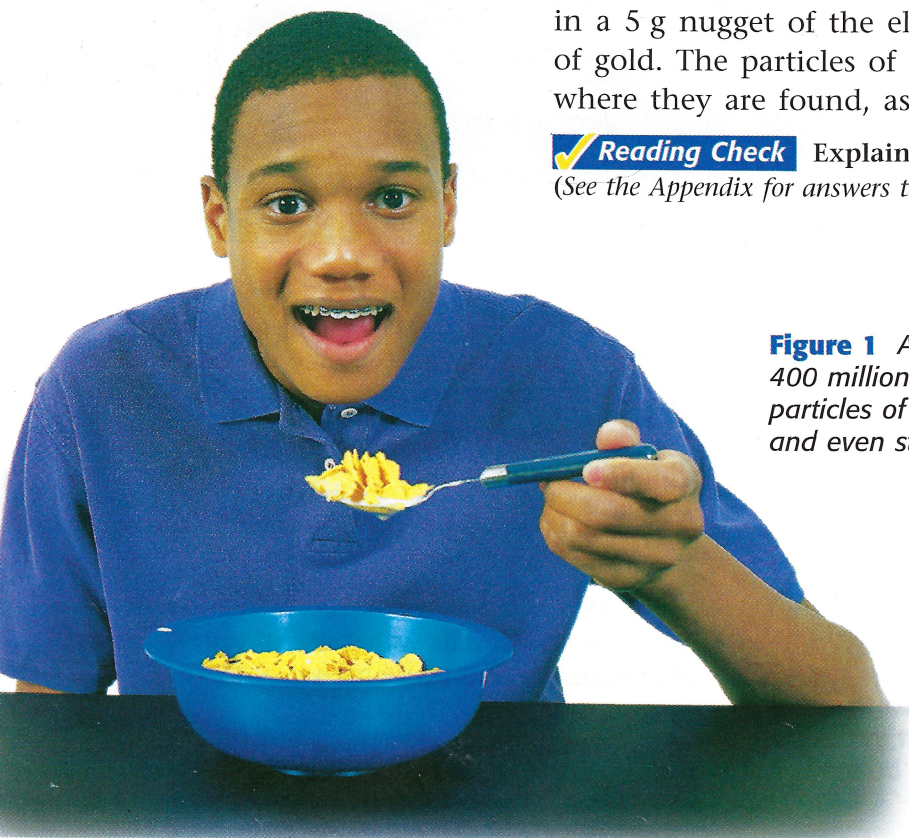
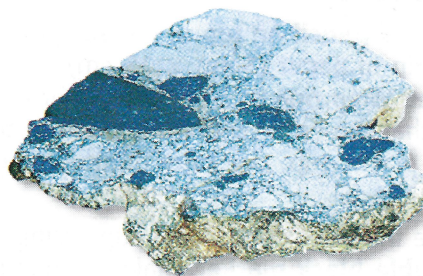


Figure 1 A meteorite might travel more than 400 million kilometers to reach Earth. But the particles of iron in a meteorite, a steel spoon, and even steel braces are alike.



Properties of Elements

Each element can be identified by its unique set of properties. For example, each element has its own *characteristic properties*. These properties do not depend on the amount of the element present. Characteristic properties include some physical properties, such as boiling point, melting point, and density. Chemical properties, such as reactivity with acid, are also characteristic properties.

An element may share a property with another element, but other properties can help you tell the elements apart. For example, the elements helium and krypton are both unreactive gases. However, the densities (mass per unit volume) of these elements are different. Helium is less dense than air. A helium-filled balloon will float up if it is released. Krypton is denser than air. A krypton-filled balloon will sink to the ground if it is released.

Identifying Elements by Their Properties

Look at the elements shown in **Figure 2**. These three elements have some similar properties. But each element can be identified by its unique set of properties.

Notice that the physical properties shown in **Figure 2** include melting point and density. Other physical properties, such as color, hardness, and texture, could be added to the list. Chemical properties might also be useful. For example, some elements, such as hydrogen and carbon, are flammable. Other elements, such as sodium, react with oxygen at room temperature. Still other elements, including zinc, are reactive with acid.

Quick Lab

Separating Elements

1. Examine a sample of nails provided by your teacher.
2. Your sample has **aluminum nails** and **iron nails**. Try to separate the two kinds of nails. Group similar nails into piles.
3. Pass a **bar magnet** over each pile of nails. Record your results.
4. Were you successful in completely separating the two types of nails? Explain.
5. Based on your observations, explain how the properties of aluminum and iron could be used to separate cans in a recycling plant.

element a substance that cannot be separated or broken down into simpler substances by chemical means

pure substance a sample of matter, either a single element or a single compound, that has definite chemical and physical properties

Figure 2 The Unique Properties of Elements

Cobalt



- Melting point: 1,495°C
- Density: 8.9 g/cm³
- Conducts electric current and heat energy
- Unreactive with oxygen in the air

Iron



- Melting point: 1,535°C
- Density: 7.9 g/cm³
- Conducts electric current and heat energy
- Combines slowly with oxygen in the air to form rust

Nickel



- Melting point: 1,455°C
- Density: 8.9 g/cm³
- Conducts electric current and heat energy
- Unreactive with oxygen in the air




Figure 3 Even though these dogs are different breeds, they have enough in common to be classified as terriers.

Classifying Elements by Their Properties

Think about how many different breeds of dogs there are. Now, think about how you tell one breed from another. Most often, you can tell just by their appearance, or the physical properties, of the dogs. **Figure 3** shows several breeds of terriers. Many terriers are fairly small in size and have short hair. Not all terriers are alike, but they share enough properties to be classified in the same group.

Categories of Elements

Elements are also grouped into categories by the properties they share. There are three major categories of elements: metals, nonmetals, and metalloids. The elements iron, nickel, and cobalt are all metals. Not all metals are exactly alike, but they do have some properties in common. **Metals** are shiny, and they conduct heat energy and electric current. **Nonmetals** make up the second category of elements. They do not conduct heat or electric current, and solid nonmetals are dull in appearance. **Metalloids**, which have properties of both metals and nonmetals, make up the last category.

 **Reading Check** What are three characteristics of metals?

Categories Are Similar

Imagine being in a music store. The CDs are categorized by type of music. If you like rock-and-roll, you would go to the rock-and-roll section. You might not know every CD, but you know that a CD has the characteristics of rock-and-roll for it to be in this section.

By knowing the category to which an unfamiliar element belongs, you can predict some of its properties. **Figure 4** shows examples of each category and describes the properties that identify elements in each category.

metal an element that is shiny and that conducts heat and electricity well

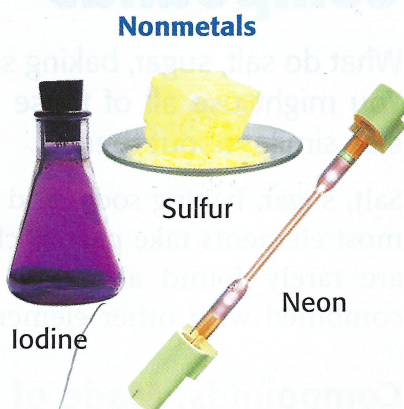
nonmetal an element that conducts heat and electricity poorly

metalloid an element that has properties of both metals and nonmetals

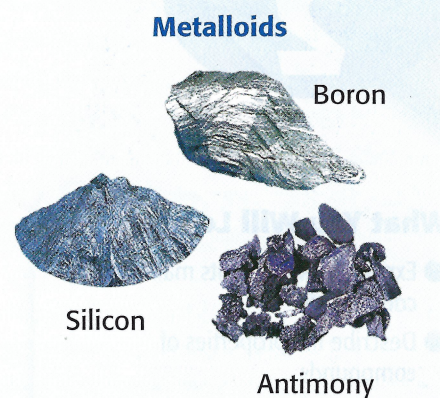
Figure 4 The Three Major Categories of Elements



Metals are elements that are shiny and are good conductors of heat and electric current. They are *malleable*. (They can be hammered into thin sheets.) They are also *ductile*. (They can be drawn into thin wires.)



Nonmetals are elements that are dull (not shiny) and that are poor conductors of heat and electric current. Solids tend to be brittle and unmeltable. Few familiar objects are made of only nonmetals.



Metalloids are also called semi-conductors. They have properties of both metals and nonmetals. Some metalloids are shiny. Some are dull. Metalloids are somewhat malleable and ductile. Some metalloids conduct heat and electric current as well.

SECTION Review

Summary

- A substance in which all of the particles are alike is a pure substance.
- An element is a pure substance that cannot be broken down into anything simpler by physical or chemical means.
- Each element has a unique set of physical and chemical properties.
- Elements are classified as metals, nonmetals, or metalloids, based on their properties.

Using Key Terms

1. Use the following terms in the same sentence: *element* and *pure substance*.

Understanding Key Ideas

2. A metalloid
 - a. may conduct electric current.
 - b. can be ductile.
 - c. is also called a semiconductor.
 - d. All of the above
3. What is a pure substance?

Math Skills

4. There are eight elements that make up 98.5% of the Earth's crust: 46.6% oxygen, 8.1% aluminum, 5.0% iron, 3.6% calcium, 2.8% sodium, 2.6% potassium, and 2.1% magnesium. The rest is silicon. What percentage of the Earth's crust is silicon?

Critical Thinking

5. **Applying Concepts** From which category of elements would you choose to make a container that wouldn't shatter if dropped? Explain your answer.
6. **Making Comparisons** Compare the properties of metals, nonmetals, and metalloids.
7. **Evaluating Assumptions** Your friend tells you that a shiny element has to be a metal. Do you agree? Explain.

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