

Section 1

Elements

Key Concept An element is made up of only one type of atom and can be classified by a unique set of properties.

What You Will Learn

- An element is a pure substance in which there is only one kind of atom.
- An element cannot be broken down into a simpler substance by physical or chemical means.
- Each element can be classified by a unique set of physical and chemical properties.
- Based on their properties, elements are classified as metals, nonmetals, or metalloids.

Why It Matters

All of the matter that you see or use in your daily life is composed of elements.

Imagine that you work for the Break-It-Down Company. Your job is to break down materials into simpler substances. So far, breaking down materials has been easy. But one morning, you get a material that is very hard to break down. First, you try to break it down by using physical changes, such as crushing and melting. But these do not change the material into something simpler. Next, you try using chemical changes, such as those caused by passing an electric current through a material. These changes do not break down the material, either. Why not?

Elements, the Simplest Substances

You were unable to break down the material described above because the material 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 Kind of Atom

Elements are pure substances. A **pure substance** is a substance in which all of the "building-block" particles are identical. For elements, the building-block particles are called *atoms* and are much too small for us to see. For example, every atom in a 5 g piece of the element gold is

like every other atom of gold. The particles of a pure substance are alike no matter where the substance is found, as shown in **Figure 1**.



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

Classifying Elements

Each element can be classified 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 physical properties and chemical properties. Examples of physical properties are hardness, melting point, and density. Examples of chemical properties are reactivity and flammability.

Two elements may have a property in common. But properties other than the common property 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 differ from each other. Helium is less dense than air. If a helium-filled balloon is set free, it will float up into the air. Krypton is denser than air. If a krypton-filled balloon is set free, it will sink to the ground.

Identifying Elements by Their Properties

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

Figure 2 The Unique Properties of Elements

Cobalt	Iron	Nickel
		
<ul style="list-style-type: none">• Melting point: 1,495°C• Density: 8.9 g/cm³• Conductivity: conducts electric current and heat• Reactivity: unreactive with oxygen in the air	<ul style="list-style-type: none">• Melting point: 1,535°C• Density: 7.9 g/cm³• Conductivity: conducts electric current and heat• Reactivity: reacts by combining with oxygen in the air to form rust	<ul style="list-style-type: none">• Melting point: 1,455°C• Density: 8.9 g/cm³• Conductivity: conducts electric current and heat• Reactivity: unreactive with oxygen in the air

In **Figure 2**, notice that melting point, electrical conductivity, and density are physical properties. Other physical properties, such as color, hardness, thermal conductivity, 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.

Standards Check How are elements classified?

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Grouping Elements

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 the appearance, or by some physical properties, of the dogs. **Figure 3** shows three kinds 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.



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

Categories of Elements

Like terriers, elements are grouped into categories according to shared properties. 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 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. Some metalloids, but not all, conduct heat or electric current.

Standards Check What are three properties of metals?



Categories Are Similar

Imagine being in a music store. The CDs are grouped by type of music.

If you like rock-and-roll music, you would go to the rock-and-roll section. You might not know every CD, but you know that the music on a CD in the rock-and-roll section has many of the characteristics of rock-and-roll music.

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

Figure 4 The Three Major Categories of Elements

Metals	Nonmetals	Metalloids
 <p>Lead</p> <p>Copper</p> <p>Tin</p>	 <p>Iodine</p> <p>Sulfur</p> <p>Neon</p>	 <p>Silicon</p>
<p>Metals are elements that are shiny and are good conductors of heat and electric current. They are <i>malleable</i>. (They can be pounded or rolled into shape.) They are also <i>ductile</i>. (They can be drawn into thin wires.)</p>	<p>Nonmetals are elements that are dull (not shiny) and that are poor conductors of heat and electric current. Solids tend to be brittle and unmalleable. Few familiar objects are made of only nonmetals.</p>	<p>Metalloids are elements that are between <i>metals</i> and <i>nonmetals</i>. They have properties of both metals and nonmetals. Some metalloids are shiny and malleable. Some metalloids are dull and brittle. Some metalloids are good conductors of heat and electric current. Some metalloids are poor conductors of heat and electric current.</p>

Section 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.

