

SECTION 2 **Properties of Matter**

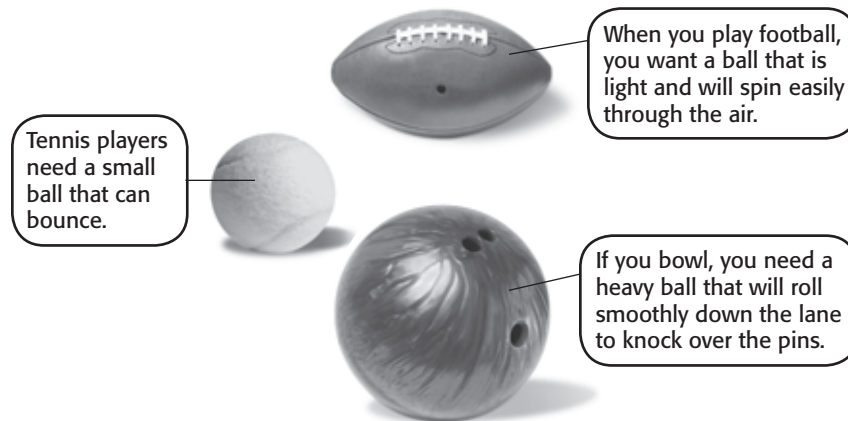
**KEY IDEAS**

As you read this section, keep these questions in mind:

- Why are color, volume, and density physical properties?
- Why are flammability and reactivity chemical properties?

**What Are Physical Properties?**

Each of the balls in the figure below is used in a different sport because it has certain properties.



A *physical property* is a characteristic that can be observed without changing the identity of the substance. Some of the properties of an object are easy to observe. For example, you can observe an object’s color, texture, shape, odor, or weight. In general, the properties of an object are determined by the properties of the materials the object is made of. ✓

Many of the physical properties of materials that make up objects can be measured. These properties include strength, hardness, magnetism, and the ability to conduct heat and electricity.

Some physical properties depend on how much of a material you have. In other words, a large amount of a material may have different properties than a smaller amount of the material. Other physical properties do not depend on how much of the material is present. This means that no matter how large or small a sample of material is, the particular property is always the same.

**READING TOOLBOX**

**Underline** As you read, use a red pen or colored pencil to underline physical properties of matter. Use a blue pen or colored pencil to underline chemical properties of matter.

**LOOKING CLOSER**

**1. Identify** List three properties of objects that you can observe in this picture.

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**READING CHECK**

**2. Identify** What determines the properties of an object?

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**SECTION 2** Properties of Matter *continued*

### Which Physical Properties Depend on Amount?

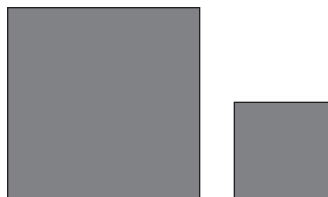
Some physical properties of a material depend on how much of the material you have. For example, two objects made of the same material may have different masses and volumes. ✓

**READING CHECK**

**3. Identify** Give two physical properties of an object that depend on the amount of material you have.

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These two objects are made of the same material. However, the objects have different volumes.

### Which Physical Properties Do Not Depend on Amount?

Many physical properties of a substance do not depend on how much of the substance you have. In other words, some physical properties stay the same no matter how small or large a sample is. These properties depend on what the substance is made of. They include:

- state
- melting point
- boiling point
- density

#### MELTING POINT AND BOILING POINT

*State* is the physical form of a substance. Solid, liquid, and gas are three common states of matter. For example, water can be in the form of solid ice, liquid water, or water vapor. ✓

**READING CHECK**

**4. Define** What is state?

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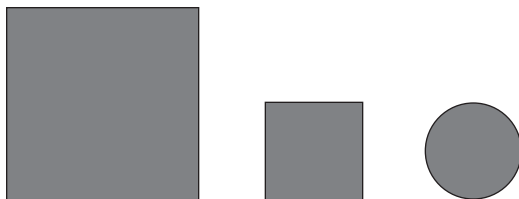
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When ice melts, water is changing from one state to another. The temperature at which a substance changes from a solid to a liquid is called the **melting point**. When water boils, it is also changing from one state to another. The temperature at which a substance changes from a liquid to a gas is called the **boiling point**.

Melting point and boiling point do not depend on how much of a substance is present. For example, a small sample of water has the same boiling point as a much larger sample of water.

**SECTION 2** Properties of Matter *continued***DENSITY**

**Density** is a measure of how much matter is in a certain volume of a substance. This physical property of a substance does not depend on how much of the substance you have.



All of these objects are made of the same material. The mass and volume of the objects differ. However, the density of the material making up the objects is the same. Density is a physical property of a substance that does not depend on the size of the sample.

**CALCULATING DENSITY**

The density of a liquid or solid is usually expressed in grams per cubic centimeter ( $\text{g}/\text{cm}^3$ ). A cubic centimeter has the same volume as a millimeter (mL).

**Density equation:**

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

$$D = \frac{m}{V}$$

If  $10.0 \text{ cm}^3$  of ice has a mass of  $9.17 \text{ g}$ , what is the density of ice?

<b>Step 1:</b> List the given and unknown values.	<b>Given:</b> mass, $m = 9.17 \text{ g}$  volume, $V = 10.0 \text{ cm}^3$	<b>Unknown:</b> density, $D$
<b>Step 2:</b> Write the equation.	$D = \frac{m}{V}$	
<b>Step 3:</b> Insert the known values and solve for the unknown value.	$D = \frac{9.17 \text{ g}}{10.0 \text{ cm}^3}$ $D = 0.917 \text{ g}/\text{cm}^3$	

**Critical Thinking**

**5. Apply Concepts** A  $1 \text{ kg}$  mass of water has a density of  $1 \text{ g}/\text{cm}^3$ . What is the density of a  $10 \text{ kg}$  mass of water?

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**Math Skills**

**6. Write an Equation** Rearrange the density equation to show how to find the mass of a substance if you know the volume and density.

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**Math Skills**

**7. Calculate** A piece of metal has a density of  $11.3 \text{ g}/\text{cm}^3$  and a volume of  $6.7 \text{ cm}^3$ . What is the mass of the piece of metal?

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**SECTION 2** Properties of Matter *continued*

**DENSITY VERSUS WEIGHT**



More mass

Denser



Less mass

Less dense

Both of these objects have the same volume, but the brick has a larger mass. Therefore, the density of the brick is greater than the density of the sponge.

**Critical Thinking**

**8. Apply Concepts** If the brick and sponge had the same mass, which one would have a greater volume?

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Because many dense materials feel heavy, people sometimes confuse density and weight. However, density and weight are not the same thing.

**How Can Physical Properties Affect the Use of Substances?**

**DETERMINING USES**

People often choose a material for a particular use because of its physical properties. For example, helium gas is often used to fill balloons. The density of helium is lower than the density of air. As a result, a balloon filled with helium can float in the sky.

People choose to use some substances because of their ability to conduct electricity. For example, metals are good conductors of electricity. Thus, metals such as copper are used in power lines and electric motors.

Sometimes people need a substance that does not conduct electricity or heat. For example, plastic foam does not conduct heat well. Thus, plastic foam can be used to make cups for hot liquids.

**Talk About It**

**Describe** Choose an object in your classroom. Identify and describe to the class some of the physical properties of the whole object. Also, identify and describe the substances it is made of. Explain why you think the particular substances are useful for the object.

**LOOKING CLOSER**

**9. Predict** Would aluminum be as useful as a food wrapping if it had a much lower melting point? Explain your answer.

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Some metals can be rolled into thin, flexible sheets. This physical property makes aluminum a good choice for food wrappings.

**SECTION 2** Properties of Matter *continued***IDENTIFYING SUBSTANCES**

Because many physical properties stay constant, you can use them to identify a material. For example, all samples of pure water are colorless liquids at room temperature and atmospheric pressure. Pure water is never a powdery green solid.

You can often identify a substance by comparing the properties you observe with known properties of a substance. For example, if you know the density of substance, you can do research to find what substance has that density. Many reference books list properties of different substances.

**What Are Chemical Properties?**

A *chemical property* describes how a substance changes into a new substance. A substance may change into a new substance by combining with another substance or by breaking apart. In general, chemical properties are not as easy to observe as physical properties. ✓

**FLAMMABILITY**

One example of a chemical property is *flammability*, or the ability to burn. Wood is an example of a flammable substance. When wood burns, it produces different substances. A substance that does not burn has the chemical property of *nonflammability*.

A substance always has both its physical and chemical properties, even when you cannot observe them. For example, wood has the chemical property of flammability even if the wood is not burning.

Because of its chemical property of flammability, wood makes a good fuel.


 **READING CHECK**

**10. Identify** Give two ways that a substance can change into a new substance.

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**Critical Thinking**

**11. Infer** How does wood that is not burning differ from a nonflammable material?

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**SECTION 2** Properties of Matter *continued***REACTIVITY**

The ability of a substance to react with another substance is called **reactivity**. Reactivity is another example of a chemical property.

Some elements react very easily with other elements. For example, if you drop a piece of aluminum foil into vinegar, tiny gas bubbles form. However, if you drop a piece of copper wire into vinegar, no gas bubbles will form. Bubbles are one clue that a chemical reaction is taking place. In nature, reactive elements are usually found as compounds. Less-reactive elements are more likely to be uncombined. ✓

**READING CHECK**

**12. Identify** In nature, what kind of elements are likely to be found as compounds?

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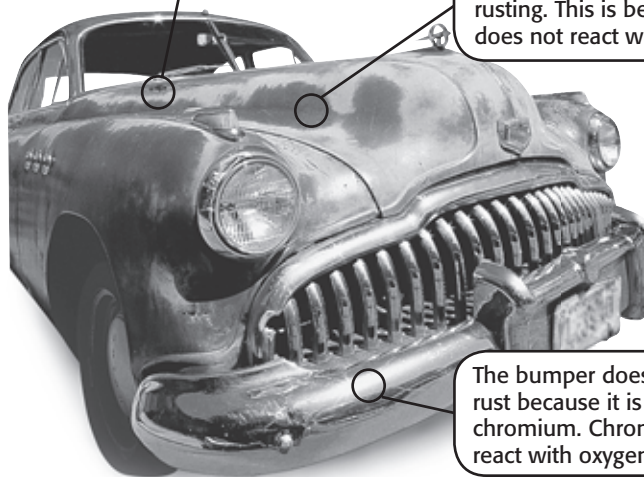
**How Can Chemical Properties Determine Uses?**

In some cases, a chemical property can cause problems. Iron is an element that has many useful physical and chemical properties. However, iron reacts readily with oxygen. This chemical property can be undesirable in some situations.

Iron reacts with oxygen in the air to form *rust*. Cars are made mostly of steel, which is a mixture of iron and other metals. The paint on a car can prevent the iron from reacting with oxygen. However, over time, the iron may become exposed to the air and the reaction between iron and oxygen can occur.

This hole started as a chip in the paint. The chip exposed the iron in the car to oxygen. The iron rusted and crumbled away.

Steel contains iron. Paint on the steel keeps the iron from rusting. This is because paint does not react with oxygen.



The bumper does not have any rust because it is covered with chromium. Chromium does not react with oxygen.

**LOOKING CLOSER**



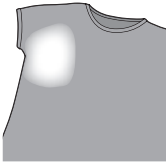
**13. Identify** Which of the following reacts most easily with oxygen—iron, paint, or chromium?

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**SECTION 2** Properties of Matter *continued*

**PHYSICAL VERSUS CHEMICAL PROPERTIES**

It is important to remember the differences between physical and chemical properties. You can observe physical properties without changing the identity of the substance. You can observe chemical properties only when the identity of the substance changes. The table below describes some physical and chemical properties of a few common substances.

<b>Comparison of Physical and Chemical Properties</b>			
<b>Substance</b>	<b>Wood</b>	<b>Iron</b>	<b>Fabric dye</b>
			
Physical property	has a grainy texture	bends without breaking	has a dark color
Chemical property	is flammable	reacts with oxygen to form rust	reacts with bleach; loses color

**LOOKING CLOSER**

**14. Infer** When bleach reacts with fabric dye, there is a chemical change. What kind of change happens to the fabric? Explain your answer.

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<b>Material or object</b>	<b>Observation</b>	<b>Physical or chemical property?</b>
Chalk	forms bubbles when put into vinegar	
Ice cream	melts in the sun	
Tin	bends easily	
Paper	burns quickly	
Liquid water	evaporates	
Car door	starts to rust	
Helium balloon	floats in air	

**LOOKING CLOSER**

**15. Identify** Complete the table to identify each example as a physical property or a chemical property.