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.

   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

2. Identify What determines the properties of an object?

   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
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. ✔

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. ✔

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.
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.

CALCULATING DENSITY

The density of a liquid or solid is usually expressed in grams per cubic centimeter (g/cm³). 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 cm³ of ice has a mass of 9.17 g, what is the density of ice?

Critical Thinking

5. Apply Concepts A 1 kg mass of water has a density of 1 g/cm³. What is the density of a 10 kg mass of water?

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.

Math Skills

7. Calculate A piece of metal has a density of 11.3 g/cm³ and a volume of 6.7 cm³. What is the mass of the piece of metal?
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.
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 a 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.

READING CHECK

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

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

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.

LOOKING CLOSER

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

<table>
<thead>
<tr>
<th>Substance</th>
<th>Wood</th>
<th>Iron</th>
<th>Fabric dye</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical property</td>
<td>has a grainy texture</td>
<td>bends without breaking</td>
<td>has a dark color</td>
</tr>
<tr>
<td>Chemical property</td>
<td>is flammable</td>
<td>reacts with oxygen to form rust</td>
<td>reacts with bleach; loses color</td>
</tr>
</tbody>
</table>

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

LOOKING CLOSER

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

| boiling point  | the temperature at which a liquid becomes a gas |
| density        | the ratio of the mass of a substance to the volume of the substance; commonly expressed as grams per cubic centimeter for solids and liquids and grams per liter for gases |
| melting point  | the temperature and pressure at which a solid becomes a liquid |
| reactivity     | the capacity of a substance to combine chemically with another substance |

1. List  List five physical properties.

2. Calculate  What is the density of a rock that has a mass of 454 g and a volume of 100.0 cm³?

3. Infer  Brand X aluminum foil is thicker than Brand Y. Is thickness a physical property or chemical property? Explain your answer.

4. Apply Concepts  How could you use the physical properties of melting point and boiling point to identify a substance?

5. Explain  Iron is much denser than a feather. Yet, a particular sample of feathers weighs more than a sample of iron. Explain how this is possible.

6. Identify  Give two examples of chemical properties.