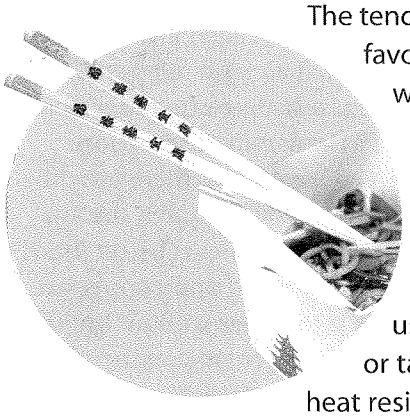
2.1 Properties of Matter

Connecting to Your World

The more than 1200 species of bamboo belong to a family of grasses that includes wheat and corn. In tropical regions, bamboo plants grow rapidly to great heights.



The tender shoots of some bamboo plants are a favorite food of pandas. People use the woody stems of mature plants to make furniture, fishing rods, and flooring. Because bamboo is inexpensive and abundant, disposable chopsticks are usually made from bamboo. Bamboo has properties that make it a good choice for use in chopsticks. It has no noticeable odor or taste. It is hard, yet easy to split, and it is heat resistant. In this section, you will learn how properties can be used to classify and identify matter.

Guide for Reading

Key Concepts

- How can properties used to describe matter be classified?
- Why do all samples of a substance have the same intensive properties?
- What are three states of matter?
- How can physical changes be classified?

Vocabulary

mass
volume
extensive property
intensive property
substance
physical property
solid
liquid
gas
vapor
physical change

Reading Strategy

Using Prior Knowledge Before you read, write a definition for the term *liquid*. After you read this section, compare and contrast the definition of *liquid* in the text with your original definition.

Describing Matter

Understanding matter begins with observation and what you observe when you look at a particular sample of matter is its properties. Is a solid shiny or dull? Does a liquid flow quickly or slowly? Is a gas odorless or does it have a smell? **Properties used to describe matter can be classified as extensive or intensive.**

Extensive Properties Recall that matter is anything that has mass and takes up space. The **mass** of an object is a measure of the amount of matter the object contains. The mass of a bowling ball with finger holes is five or six times greater than the mass of the bowling ball shown in Figure 2.1, which is used to play a game called candlepins. There is also a difference in the volume of the balls. The **volume** of an object is a measure of the space occupied by the object. Mass and volume are examples of extensive properties. An **extensive property** is a property that depends on the amount of matter in a sample.

Intensive Properties There are properties to consider when selecting a bowling ball other than mass. Beginning bowlers want a bowling ball that is likely to maintain a straight path. They use bowling balls with a hard surface made from polyester. Experienced bowlers want a bowling ball they can curve, or hook, toward the pins. Often, they use a polyurethane ball, which has a softer surface. Hardness is an example of an intensive property. An **intensive property** is a property that depends on the type of matter in a sample, not the amount of matter.

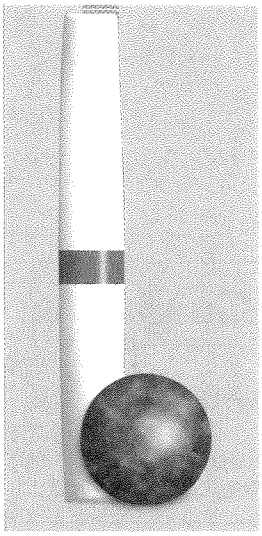
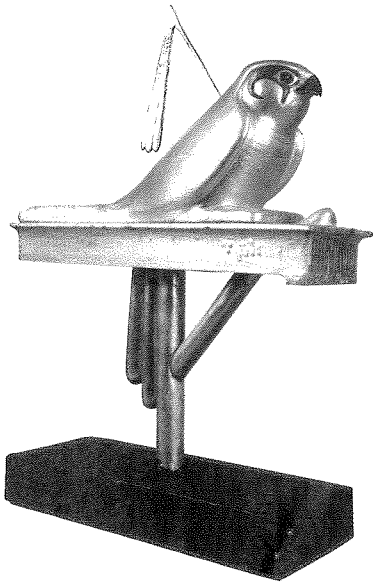


Figure 2.1 This bowling ball and candlepin are used in a game played mainly in New England.



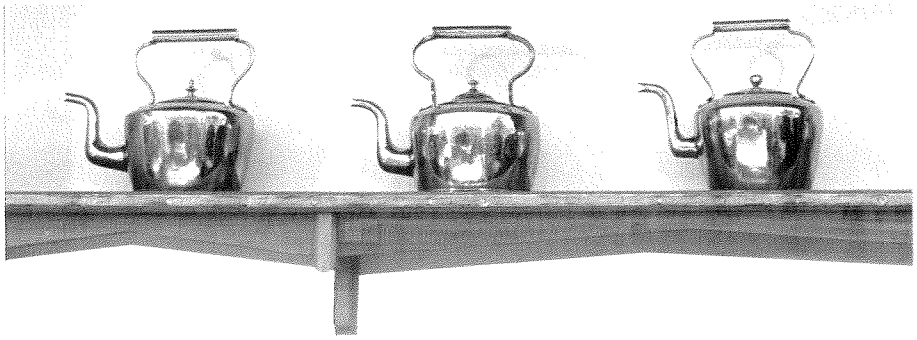


Figure 2.2 This gold falcon standard from Egypt is about 3000 years old. The copper kettles are about 150 years old. **Analyzing Data** ***Which of the properties listed in Table 2.1 could not be used to distinguish copper from gold?***

Identifying Substances

Each object in Figure 2.2 has a different chemical makeup, or composition. The sculpture of a falcon is mainly gold. The kettles are mainly copper. Matter that has a uniform and definite composition is called a **substance.** Gold and copper are examples of substances, which are also referred to as pure substances. **Every sample of a given substance has identical intensive properties because every sample has the same composition.**

Gold and copper have some properties in common, but there are differences besides their distinctive colors. Pure copper can scratch the surface of pure gold because copper is harder than gold. Copper is better than gold as a conductor of heat or electric current. Both gold and copper are malleable, which means they can be hammered into sheets without breaking. But gold is more malleable than copper. Hardness, color, conductivity, and malleability are examples of physical properties. A **physical property** is a quality or condition of a substance that can be observed or measured without changing the substance's composition.

Table 2.1 lists physical properties for some substances. The states of the substances are given at room temperature. (Although scientists use room temperature to refer to a range of temperatures, in this book it will be used to refer to a specific temperature, 20°C.) Physical properties can help chemists identify substances. For example, a colorless substance that was found to boil at 100°C and melt at 0°C would likely be water. A colorless substance that boiled at 78°C and melted at −117°C would most certainly not be water. Based on Table 2.1, it would likely be ethanol.

Checkpoint ***Which is a better conductor of electric current—gold or copper?***

Table 2.1

Physical Properties of Some Substances

Substance	State	Color	Melting point (°C)	Boiling point (°C)
Neon	gas	colorless	−249	−246
Oxygen	gas	colorless	−218	−183
Chlorine	gas	greenish-yellow	−101	−34
Ethanol	liquid	colorless	−117	78
Mercury	liquid	silvery-white	−39	357
Bromine	liquid	reddish-brown	−7	59
Water	liquid	colorless	0	100
Sulfur	solid	yellow	115	445
Sodium chloride	solid	white	801	1413
Gold	solid	yellow	1064	2856
Copper	solid	reddish-yellow	1084	2562

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For: Links on Physical Properties of Matter
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States of Matter

Depending on the circumstances, you use three different words to refer to water—water, ice, and steam. Water, which is a common substance, exists in three different physical states. So can most other substances. **Three states of matter are solid, liquid, and gas.** Certain characteristics that can distinguish these three states of matter are summarized in Figure 2.3.

Interactive Textbook

Animation 1 Relate the states of matter to the arrangements of their particles.

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Solids A **solid** is a form of matter that has a definite shape and volume. The shape of a solid doesn't depend on the shape of its container. The particles in a solid are packed tightly together, often in an orderly arrangement, as shown in Figure 2.3a. As a result, solids are almost incompressible; that is, it is difficult to squeeze a solid into a smaller volume. In addition, solids expand only slightly when heated.

Liquids Look at Figure 2.3b. The particles in a liquid are in close contact with one another, but the arrangement of particles in a liquid is not rigid or orderly. Because the particles in a liquid are free to flow from one location to another, a liquid takes the shape of the container in which it is placed. However, the volume of the liquid doesn't change as its shape changes. The volume of a liquid is fixed or constant. Thus, a **liquid** is a form of matter that has an indefinite shape, flows, yet has a fixed volume. Liquids are almost incompressible, but they tend to expand slightly when heated.

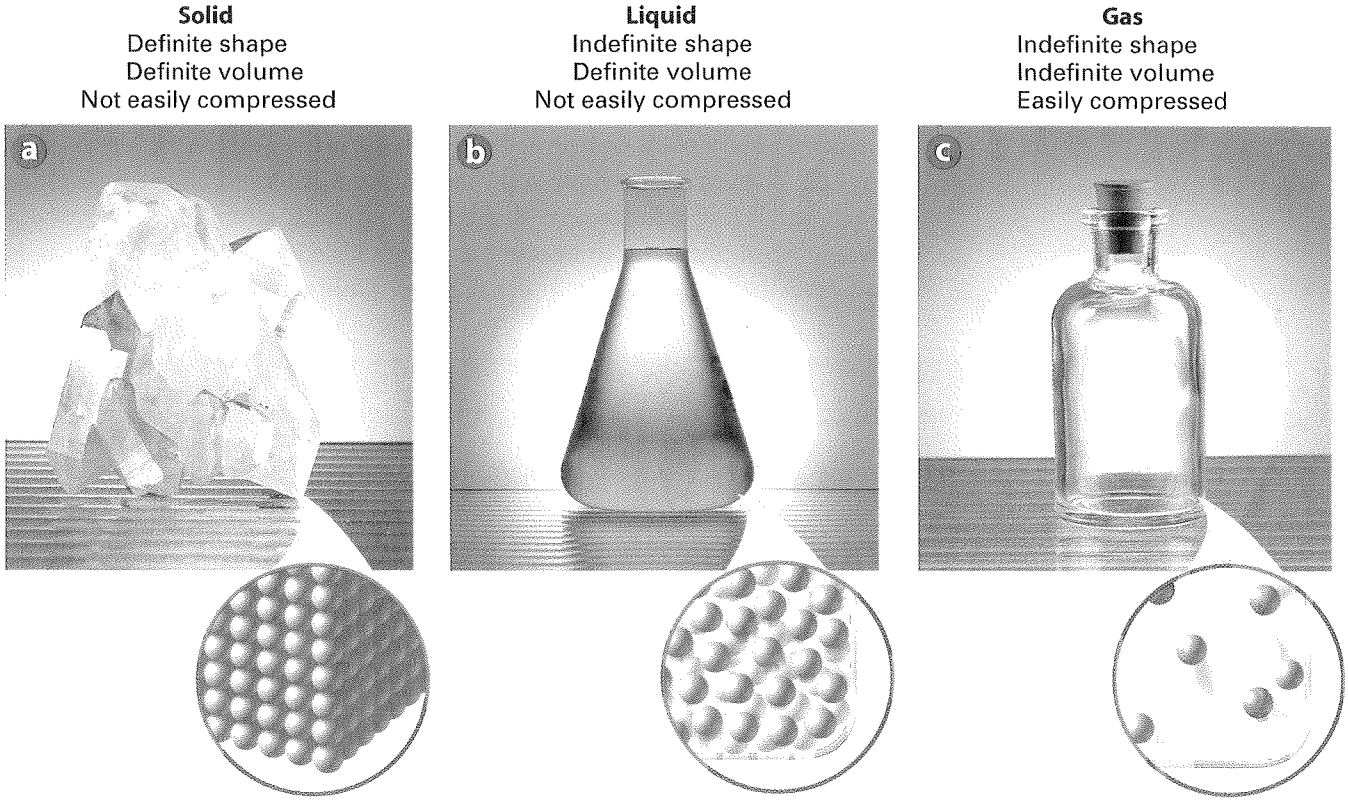

Figure 2.3 The arrangement of particles is different in solids, liquids, and gases. (a) In a solid, the particles are packed closely together in a rigid arrangement. (b) In a liquid, the particles are close together, but they are free to flow past one another. (c) In a gas, the particles are relatively far apart and can move freely.
Relating Cause and Effect ***Use the arrangements of their particles to explain the general shape and volume of solids and gases.***

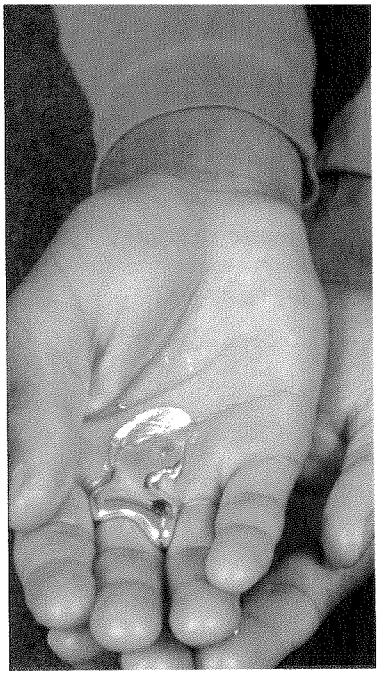

Figure 2.4 The silvery substance in the photograph is gallium, which has a melting point of 30°C. **Inferring** ***What can you infer about the temperature of the hand holding the gallium?***

Gases Like a liquid, a gas takes the shape of its container. But unlike a liquid, a gas can expand to fill any volume. A **gas** is a form of matter that takes both the shape and volume of its container. Look back at Figure 2.3c. As shown in the model, the particles in a gas are usually much farther apart than the particles in a liquid. Because of the space between particles, gases are easily compressed into a smaller volume.

The words *vapor* and *gas* are sometimes used interchangeably. But there is a difference. The term *gas* is used for substances, like oxygen, that exist in the gaseous state at room temperature. (*Gaseous* is the adjective form of *gas*.) **Vapor** describes the gaseous state of a substance that is generally a liquid or solid at room temperature, as in water vapor.

Checkpoint ***When should the term vapor be used instead of gas?***

Physical Changes

The melting point of gallium metal is 30°C. Figure 2.4 shows how heat from a person's hand can melt a sample of gallium. The shape of the sample changes during melting as the liquid begins to flow, but the composition of the sample does not change. Melting is an example of a physical change. During a **physical change,** some properties of a material change, but the composition of the material does not change.

Words such as *boil, freeze, melt,* and *condense* are used to describe physical changes. So are words such as *break, split, grind, cut,* and *crush.* However, there is a difference between these two sets of words. Each set describes a different type of physical change. Key Concept **Physical changes can be classified as reversible or irreversible.** Melting is an example of a reversible physical change. If a sample of liquid gallium is cooled below its melting point, the liquid will become a solid. All physical changes that involve a change from one state to another are reversible. Cutting hair, filing nails, and cracking an egg are examples of irreversible physical changes.

2.1 Section Assessment

1. Key Concept Name two categories used to classify properties of matter.
2. Key Concept Explain why all samples of a given substance have the same intensive properties.
3. Key Concept Name three states of matter.
4. Key Concept Describe the two categories used to classify physical changes.
5. Which property in Table 2.1 can most easily distinguish sodium chloride from the other solids?
6. In what way are liquids and gases alike? In what way are liquids and solids different?
7. Is the freezing of mercury a reversible or irreversible physical change? Explain your answer.
8. Explain why samples of gold and copper can have the same extensive properties, but not the same intensive properties.

Elements Handbook

Read about the metal indium on page R16. What is the melting point of indium? Which other metal has a similar melting point—gallium or gold? Provide data to support your answer.

Interactive Textbook

Assessment 2.1 Test yourself on the concepts in Section 2.1.

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