

Foundations of Chemistry

Physical Properties

..... Before You Read

Before	Statement	After
	3. The weight of a material never changes, regardless of where it is.	
	4. Boiling is one method used to separate parts of a mixture.	

..... Read to Learn

Physical Properties

As you read in Lesson 1, the arrangement of atoms determines whether matter is a substance or a mixture. The arrangement of atoms also determines the properties of different types of matter. Each element and compound has a unique set of properties. When substances mix together and form mixtures, the properties of the substances that make up the mixture are still present.

You can observe some properties of matter. For example, you can see that gold is shiny. You can measure other properties of matter. For example, you can measure the mass of a sample of iron. Think about how you might describe the substances and mixtures in and around a flowing mountain stream. Could you describe some of the matter as a solid or a liquid? If you picked up a handful of pebbles from the bottom of the stream, why would the water leave your hand but not the pebbles? Could you describe the mass of the various rocks in the stream?

Each of these questions asks about the physical properties of matter. A **physical property** is a characteristic of matter that you can observe or measure without changing the identity of the matter. There are many types of physical properties. You will read about some types of physical properties in this lesson.

Key Concepts

- What are some physical properties of matter?
- How are physical properties used to separate mixtures?

Mark the Text

Identify the Main Ideas

Write a phrase beside each paragraph that summarizes the main point of the paragraph. Use the phrases to review the lesson.

REVIEW VOCABULARY

property

a characteristic used to describe something

Think it Over

1. Observe Record two physical properties of the matter around you.

Make a three-tab book to record what you learn about different states of matter.



Think it Over

2. Consider How does water vapor in the air change state below the freezing point?



Reading Check

3. Contrast How do solids, liquids, and gases differ?

States of Matter

How do aluminum, water, and air differ? Recall that aluminum is an element, water is a compound, and air is a mixture. How else do these three types of matter differ?

At room temperature, aluminum is a solid, water is a liquid, and air is a gas. Solids, liquids, and gases are called states of matter.

The state of matter is a physical property of matter. Substances and mixtures can be solids, liquids, or gases. For example, water in the ocean is a liquid, but water in an iceberg is a solid. In addition, water vapor in the air above the ocean is a gas.

The particles (atoms or groups of atoms) that make up all matter move constantly and attract each other. Your pencil is made up of trillions of moving particles.

Every solid, liquid, and gas is made up of moving particles that attract one another. The state of matter depends on how close together the particles are and how fast they move.

The particles in a solid are very close together. They can move only by vibrating back and forth. This is why solids cannot easily change shape.

The particles in a liquid are slightly farther apart than in a solid. Therefore, the particles can move past one another. This is why you can pour a liquid. The particles in a gas are farther apart. They move quickly and spread out to fill their container. ✓

Size-Dependent Properties

State is only one of many physical properties of matter. Some physical properties, such as mass and volume, depend on the size or the amount of matter. Measurements of these properties vary depending on how much matter is in a sample.

Mass Imagine holding a small dumbbell in one hand and a larger one in your other hand. What do you notice? The larger dumbbell seems heavier. The larger dumbbell has more mass than the smaller one.

Mass is the amount of matter in an object. Mass is a size-dependent property of a given substance because its value depends on the size of a sample.

Mass and Weight An object's mass and weight are not the same. Mass is an amount of matter in something. Weight is the pull of gravity on that matter. Weight changes with location, but mass does not. Suppose a dumbbell is on the Moon. The dumbbell would have the same mass on the Moon that it has on Earth. However, the Moon's gravity is much less than Earth's gravity. As a result, the dumbbell would weigh less on the Moon than on Earth.

Volume Another physical property that depends on the size or amount of a substance is volume. A unit often used to measure volume is the milliliter (mL). Volume is the amount of space something takes up. Suppose a full bottle of water contains 400 mL of water. If you pour exactly half of the water out, the bottle contains half of the original volume, or 200 mL, of water.

Size-Independent Properties

Some physical properties of a substance do not depend on the amount of matter present. These properties are the same for small samples and large samples. They are called size-independent properties. The table below and on the next page describes several physical properties of matter. The table provides examples of how physical properties can be used to separate mixtures. Notice that conductivity, boiling and melting points, state, density, solubility, and magnetism are size-independent properties.

Melting Point and Boiling Point The temperature at which a substance changes from a solid to a liquid is its melting point. The temperature at which a substance changes from a liquid to a gas is its boiling point. Different substances have different boiling points and melting points. For example, the boiling point for water is 100°C at sea level. The boiling point does not change for different volumes of water.



Think it Over

4. Analyze Does an astronaut have more mass on Earth than in space? Why or why not?

Math Skills

When you compare two numbers by division, you are using a ratio. Density can be written as a ratio of mass and volume. What is the density of a substance if a 5-mL sample has a mass of 25 g?

a. Set up a ratio.

$$\frac{\text{Mass}}{\text{Volume}} = \frac{25 \text{ g}}{5 \text{ mL}}$$

b. Divide the numerator by the denominator to get the mass (in g) of 1 mL.

$$\frac{25 \text{ g}}{5 \text{ mL}} = \frac{5 \text{ g}}{1 \text{ mL}}$$

c. The density is 5 g/mL.

5. Use Ratios A sample of wood has a mass of 12 g and a volume of 16 mL. What is the density of the wood?

Physical Properties of Matter

Property	Mass	Conductivity	Volume
Size-dependent or size-independent	size-dependent	size-independent	size-dependent
Description of property	the amount of matter in an object	the ability of matter to conduct, or carry along, electricity or heat	the amount of space something occupies
How the property is used to separate a mixture (example)	Mass typically is not used to separate a mixture.	Conductivity typically is not used to separate a mixture.	Volume could be used to separate mixtures whose parts can be separated by filtration.

Key Concept Check

6. Name What are five different physical properties of matter?

Interpreting Tables

7. Consider How might you separate a mixture of iron filings and salt?


Density Imagine holding a bowling ball in one hand and a foam ball of the same size in the other. The bowling ball seems heavier because the density of the material that makes up the bowling ball is greater than the density of foam.

Density is the mass per unit volume of a substance. Like melting point and boiling point, density is a size-independent property.

Conductivity Another property that is independent of the sample size is conductivity. Electrical conductivity is the ability of matter to conduct, or carry along, an electric current. Copper often is used for electrical wiring because it has high electrical conductivity.

Thermal conductivity is the ability of a material to conduct thermal energy. Metals tend to have high electrical and thermal conductivity. Stainless steel, for example, often is used to make cooking pots because of its high thermal conductivity. However, the handles on the pan probably are made out of wood, plastic, or some other substance that has low thermal conductivity.


Solubility Have you ever made lemonade by stirring a powdered drink mix into water? As you stir, the powder mixes evenly in the water. In other words, the powder dissolves in the water.

What would happen if you tried to dissolve sand in water? No matter how much you stir, the sand does not dissolve. **Solubility** is the ability of one substance to dissolve in another. The drink powder is soluble in water, but sand is not. The table below explains how physical properties such as conductivity and solubility can be used to identify objects and separate mixtures. 

Physical Properties of Matter				
Boiling/Melting Points	State of Matter	Density	Solubility	Magnetism
size-independent	size-dependent	size-independent	size-dependent	size-independent
the temperature at which a material changes state	whether something is a solid, a liquid, or a gas	the amount of mass per unit of volume	the ability of one substance to dissolve in another	attractive force for some metals, especially iron
Each part of a mixture will boil or melt at a different temperature.	A liquid can be poured off a solid.	Objects with greater density sink in objects with less density.	Dissolve a soluble material to separate it from a material with less solubility.	Use a magnet to attract iron shavings from a mixture of metals.

Separating Mixtures

In Lesson 1, you read about different types of mixtures. Recall that the substances that make up mixtures are not held together by chemical bonds. When substances form a mixture, the properties of the individual substances do not change.

You can separate the individual substances out of most mixtures by using differences in their physical properties. For example, when salt and water form a solution, the salt and the water do not lose any of their individual properties. Therefore, you can separate the salt from the water by using differences in their physical properties. Water has a lower boiling point than salt. When you boil salt water, the water evaporates, and the salt remains. 

You cannot use physical properties to separate a compound into the elements it contains. The atoms that make up a compound are bonded together and cannot be separated by physical means. For example, you cannot separate the hydrogen atoms from the oxygen atoms in water by boiling water.

Key Concept Check

8. Explain How are physical properties used to separate mixtures?

After You Read

Mini Glossary

density: the mass per unit volume of a substance

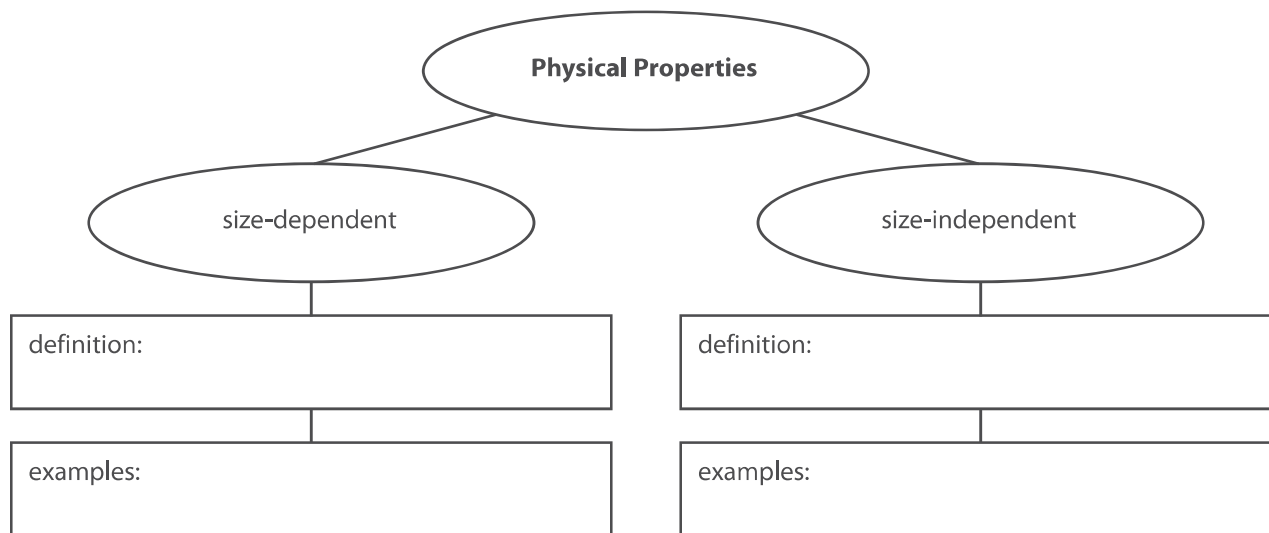
mass: the amount of matter in an object

physical property: a characteristic of matter that you can observe or measure without changing the identity of the matter

solubility: the ability of one substance to dissolve in another

- Review the terms and their definitions in the Mini Glossary. Write a sentence that explains how mass and weight are different.

- Physical properties of matter can be classified as size-dependent or size-independent. Define each classification, and give at least two examples of each.



- If you mix sand and water in a container, the sand will sink to the bottom. Explain why.

What do you think **NOW?**

Reread the statements at the beginning of the lesson. Fill in the After column with an A if you agree with the statement or a D if you disagree. Did you change your mind?



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