



California Science Standards

8.7.c, 8.8.a, 8.8.b, 8.8.d

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What are the physical properties of matter?
- What is density?
- What is a physical change of matter?
- What makes objects float or sink?

STUDY TIP

Increase Vocabulary Read this section silently. Underline all the words that are new to you.

READING CHECK

1. **Describe** What are physical properties?

What Are the Physical Properties of Matter?

We use one or more of our senses to identify an object. The properties we are sensing are the physical properties of the object. A **physical property** of matter can be detected and measured without making a new substance. If a new substance is made, a chemical property has been measured. Here we will consider only physical properties. ✓

There are many physical properties that can help you identify an object. Examples of physical properties include color, odor, texture, and shape. How would you identify a fruit as an apple? You would probably first look at its color and shape. Its odor, and certainly its taste, would help confirm that the fruit was an apple.

The physical properties of an object may also include its strength, flexibility, ability to conduct electricity, and magnetism. Some other important physical properties of matter are listed in the table below.

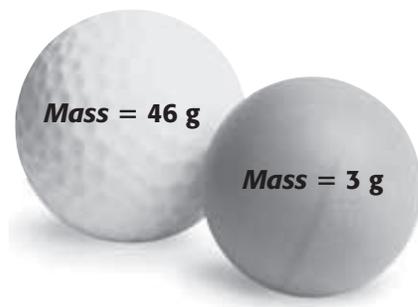
Physical property	Description
Thermal conductivity	how heat moves through a substance
Ductility	the ability of a substance to be pulled into a wire shape
State	the physical form of matter (solid, liquid, or gas)
Malleability	the ability of a substance to be rolled into a shape
Solubility	the ability of a substance to dissolve
Density	how compact a substance is
Compressibility	the ability of a substance to be squeezed or pressed together

Critical Thinking

2. **Apply Concepts** You are given two balls that are made from the same rubber. They are also the same size and color. One is hollow and one is solid. Give three physical properties that can be used to identify the ball that is solid.

SECTION 2 Physical Properties *continued***DENSITY**

Density is a physical property of matter that describes how its mass and volume are related. **Density** is a measure of the amount of matter in a given volume. For example, a golf ball and table-tennis ball have similar volumes, so they occupy about the same amount of space. However, since the golf ball has more mass, it has a greater density than the table-tennis ball does. ✓



A golf ball is denser than a table-tennis ball because the golf ball contains more matter in a similar volume.

To find an object's density (D), you measure its mass (m) and volume (V) and then use the following formula:

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

The units of density are the results of a mass unit (kg or g) being divided by a volume unit (L, mL, or cm^3). For example, one density unit for solids is grams per cubic centimeter (g/cm^3), and one density unit for liquids is grams per milliliter (g/mL).

A substance's density does not depend on how much of the substance there is. Generally, in the same room at the same time, a lot of something or a little of it will have the same density. For example, 1 kg of solid iron will have the same density as 1 g of solid iron.

How Is Density Determined?

You can solve a density problem by taking the following steps:

1. Write the density equation, $D = m \div V$.
2. Replace m and V with the measurements given in the problem, and then solve for D .

For example, what is the density of mercury if 270 g of mercury has a volume of 20 mL?

$$D = m \div V$$

$$D = 270 \text{ g} \div 20 \text{ mL} = 13.5 \text{ g/mL}$$

READING CHECK

3. Describe What is density a measure of?

Math Focus

4. Determine How much more matter is in a golf ball than in a table-tennis ball?

CALIFORNIA STANDARDS CHECK

8.8.b Students know how to calculate the density of substances (regular and irregular solids and liquids) from measurements of mass and volume.

5. Calculate A nugget of gold that has a mass of 28 g (1 oz) has a volume of 1.45 cm^3 . What is its density? Show your work.

SECTION 2 Physical Properties *continued*

USING DENSITY TO IDENTIFY SUBSTANCES

Density is a useful physical property. At the same temperature and pressure, the density of a substance is always the same. So, density can be used to help identify an unknown substance. ✓

The densities of some common substances are given in the table below.

Densities of Common Substances at 20°C and 1 atm			
Substance	Density (g/cm ³)	Substance	Density (g/cm ³)
Helium (gas)	0.000166	Zinc (solid)	7.13
Oxygen (gas)	0.00133	Silver (solid)	10.5
Water (liquid)	1.00	Lead (solid)	11.4
Pyrite (solid)	5.02	Mercury (liquid)	13.5

DENSITY OF SOLIDS

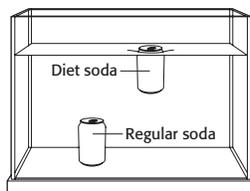
Would you rather carry around 1 kg of lead or 1 kg of feathers? They have the same mass, but they are very different. Lead is much denser than feathers. A 1 kg mass of lead has about the same volume as a stick of butter. A 1 kg mass of feathers would take up about the same space as a pillow. The difference in volume makes the lead easier to carry.

DENSITY, FLOATING, AND SINKING

If you know the density of a substance, you can tell if it will float or sink. For example, if the density of an object is less than the density of water, the object will float in water. Cork, many types of wood, and some plastics are less dense than water. That is why they float in it.

If the density of an object is greater than the density of water, it will sink in water. Rock and many types of metal are denser than water, so they sink. ✓

The figure below shows a can of diet soda and a can of regular soda in a tank of water. You can see that their densities are different.



In a tank of water, a can of diet soda floats, and a can of regular soda sinks.

READING CHECK

6. Describe Under what conditions is the density of a substance always the same?

TAKE A LOOK

7. Identify You are given an unknown solid with a density of about 7 g/cm³. Which solid is it?

READING CHECK

8. Describe When will an object sink in water?

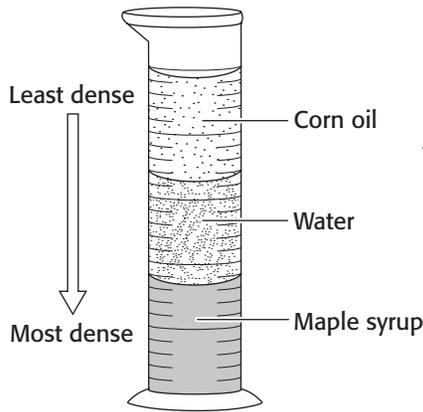
Critical Thinking

9. Apply Concepts Which can of soda in the drawing is less dense than water? How do you know?

SECTION 2 Physical Properties *continued*

Take a look at the following figure. It shows different kinds of liquids in a graduated cylinder. What do you think causes them to look that way? Each of the liquids (maple syrup, water, and corn oil) has a different density. When these three liquids are carefully poured into the cylinder, they form three different layers.

This happens because their densities are different. The liquid that is most dense is in the bottom layer, and the liquid that is least dense is on the top. ✓



This graduated cylinder contains three liquids that form three layers because of their densities. The layers are in order of increasing density from top to bottom.

READING CHECK

10. Identify Several liquids are poured into a container. They do not mix or dissolve in one another. What must be true of the liquid in the top layer?

What Is a Physical Change?

Any change that affects the physical properties of a substance is a **physical change**. Imagine that a piece of silver is pounded into a heart-shaped charm. This is a physical change because only the shape of the silver has changed. The piece of silver is still silver. Take a look at the figure below to see some other examples of physical changes. ✓

A change from a solid to a liquid is a physical change. All changes of state are physical changes.



This aluminum can has gone through the physical change of being crushed. The identity of the can has not changed.



READING CHECK

11. Describe What is a physical change?

TAKE A LOOK

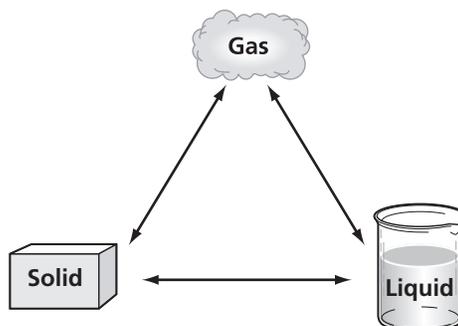
12. Identify Name the physical change that happened to the popsicle.

SECTION 2 Physical Properties *continued***EXAMPLES OF PHYSICAL CHANGES**

When a substance changes from a solid to a liquid, it is said to have changed state. Solid, liquid, and gas are the three states of matter. Any change in state is a physical change. ✓

✓ **READING CHECK**

13. Identify When a liquid changes into a gas, what kind of physical change occurs?



When you freeze water to make ice, you cause a physical change. Heating water in a teapot makes steam. This is also a physical change. Sugar seems to disappear or dissolve in water. However, if the water evaporates, the sugar reappears, so dissolving is a physical change.

REVERSIBILITY OF PHYSICAL CHANGES

In the figure above, the arrows each have two heads. This means that each change can be reversed. A solid can change into a liquid and then back into a solid. ✓

Physical changes are often easy to undo. Suppose a solid cube of gold is melted and then poured into a bear-shaped mold. When it cools, the gold becomes solid again, and a bear-shaped charm is formed. The gold goes from solid to liquid to solid again, but it never stops being gold. These are physical changes because only the state and shape of the substance changes.

MATTER AND PHYSICAL CHANGES

Physical changes do not change the identity of matter. Melting, changing from liquid to gas, changing from liquid to solid, and changing shape are all examples of physical change. Physical changes can often be reversed easily, and the identity of the substance itself never changes. ✓

✓ **READING CHECK**

14. Identify What change or changes of state can happen to a gas? Looking at the figure may help you with the answer.

✓ **READING CHECK**

15. Identify What happens to the identity of a substance when it makes a physical change?

Section 2 Review

8.7.c, 8.8.a, 8.8.b, 8.8.d



SECTION VOCABULARY

density the ratio of the mass of a substance to the volume of the substance

physical change a change of matter from one form to another without a change in chemical properties

physical property a characteristic of a substance that does not involve a chemical change, such as density, color, or hardness

1. Describe In words, explain how to calculate the density of a substance.

Use this table to answer questions 2 and 3.

Substance	Density (g/cm ³)
Wood (oak)	0.85
Water	1.00
Ice cube	0.93
Aluminum	2.7
Lead	11.3
Gold	19.3
Ethanol	0.94
Methanol	0.79

2. Identify Will any of the other substances in the table float in methanol? Why?

3. Identify Which substance would have a mass of 135 g when it has a volume of 50 cm³? Show your work.

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

4. Identify Two balls have the same mass, but one has a larger volume than the other. Which ball has the larger density?

5. Explain Most substances become more dense when they freeze. However, when water freezes, it becomes less dense. What must happen for this to be true? Hint: The mass stays the same.
