

CHAPTER 2 The Properties of Matter

SECTION

2

Physical Properties

BEFORE YOU READ

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

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

**National Science
Education Standards**
PS 1a, 1b

What Are 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 was measured. Chemical properties will be covered in the next section. ✓

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

Other physical properties of an object include its strength, flexibility, ability to conduct electricity, and magnetism. Some important examples of the physical properties of matter can be seen in the table below.

Physical Property	Description
Thermal conductivity	How heat moves through a substance
Ductility	The ability of substance to be pulled into wire
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 to be squeezed or pressed together

STUDY TIP

Ask Questions Read this section silently. In your science notebook, write questions that you have about this section. Underline all words you do not understand.

READING CHECK

1. Describe What are physical properties?

Critical Thinking

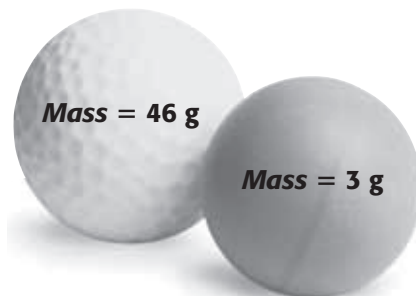
2. Applying Concepts You are given two balls that are made from the same rubber. They are also the same size and color. One is hollow and one is solid. Give three physical properties that could be used to identify the ball that is solid.

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

Density is a physical property of matter that describes how its mass and volume are related. **Density** is the amount of matter in a given volume. A golf ball and ping pong ball have similar volumes, so they occupy about the same amount of space. But since the golf ball has more mass, it has a greater density than the ping pong ball does. Take a look at the figure below. ✓

READING CHECK

3. Describe What is density a measure of?



A golf ball is denser than a ping pong ball because the golf ball contains more matter in a similar volume.

Math Focus

4. Determine How much more matter is in a golf ball than a ping pong ball?

A formula is used to find the density of an object. To find an object's density (D), you first measure its mass (m) and volume (V). Then use the formula below.

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

The units of density are a mass unit (kg or g) divided by a volume unit (L, mL, or cm^3). For example, a density unit could be grams per cubic centimeter (g/cm^3) for solids, and grams per milliliter (g/mL) for liquids. The density of a substance does not depend on how much of the substance you may have. One kilogram of iron has the same density as one gram of iron.

How Is the Density Determined?

When you are given a density problem, follow the following procedure:

Step 1: Write the density equation $D = \frac{m}{V}$

Step 2: Replace m and V with the measurements given in the problem.

Math Focus

5. Calculate What is the density of gold if 28 g (1 oz) of gold has a volume of 1.45 cm^3 ? Show your work.

Let's try a problem. What is the density of mercury if 270 g of mercury has a volume of 20 mL?

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

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

SECTION 2 Physical Properties *continued***USING DENSITY TO IDENTIFY SUBSTANCES**

Density is a useful physical property. It can be used to help identify a substance. When measured at the same temperature and pressure, the density of a substance is always the same. The density of some common substances can be seen 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

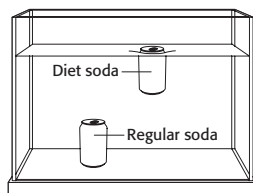
Would you rather carry around 1 kg of lead or 1 kg of feathers? They both have the same mass. But you know that they are very different. Lead is denser than feathers. It has about the same volume as a stick of butter. The feathers would be about the size of a pillow. This difference in volume makes the 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. If the density of an object is lower than the density of water, the object will float. Cork, many types of wood, and some plastics are less dense than water. This is why they will float.

If the density of an object is greater than the density of water, it will sink when submerged. 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?

STANDARDS CHECK

PS 1a A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample. A mixture of substances often can be separated into the original substances using one or more of the characteristic properties.

7. Identify You are given a solid found in the table above. The density is about 7 g/cm³. Which solid is it?

 **READING CHECK**

8. Describe When will an object sink in water?

Critical Thinking

9. Applying Concepts
Which can of soda is less dense than water? Explain

SECTION 2 Physical Properties *continued*

LIQUID LAYERS

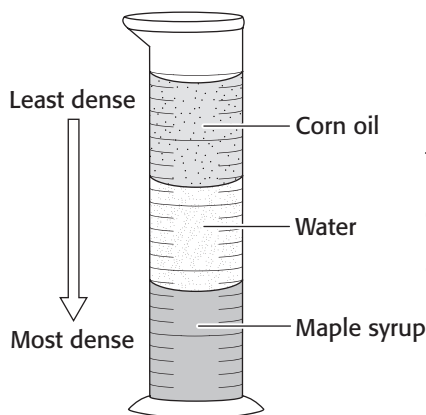
Take a look at the following figure. It shows different kinds of liquids in a graduated cylinder. Each of the liquids (maple syrup, water, and corn oil) has a different density. When these three items are carefully poured into the cylinder, they will form three different layers. What do you think causes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

This happens because their densities are different. The layer with the highest density is on the bottom, and the layer with the lowest density is on the top. ✓

READING CHECK

10. Identify Several liquids are poured into a container. They do not mix or dissolve into each other.

Which liquid will be the top layer?



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

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. ✓

READING CHECK

11. Describe What is a physical change?

Examples of Physical Change

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.



TAKE A LOOK

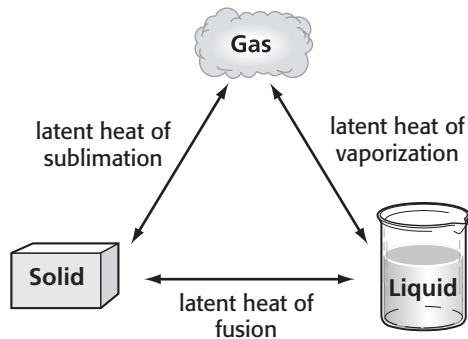
12. Identify Name the physical change that happened to the popsicle.

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

When a substance changes from a solid to a liquid, it changes state. The three states of matter are solid, liquid, and gas. Any change to a different state of matter is a physical change. See the figure below. ✓

Freezing water to make ice is 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. Therefore, dissolving is a physical change.

Changes of State**REVERSIBILITY OF PHYSICAL CHANGES**

The figure above shows arrows with two heads. This means that each change can be reversed. For example, a solid can change into a liquid, then back into a solid. ✓

Physical changes are often easy to undo. Suppose that some solid gold is melted and then poured into a bear-shaped mold. When it cools, the gold solidifies, and a bear-shaped charm is formed. These are physical changes because only the state and shape of the gold has changed. The gold charm is still gold.

MATTER AND PHYSICAL CHANGES

Physical changes do not change the identity of matter. All of the examples that you have read about are examples of a physical change. Physical changes can often be easily reversed, and the identity of the substance itself never changes. ✓

READING CHECK

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

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 after it has made a physical change?

Section 2 Review

NSES PS 1a, 1b

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 Write, in words, how to calculate the density of a substance.

Interpreting Tables Use the table below 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 substance 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.

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 When water freezes, its density gets lower. The change in density is different than that of most substances. Most substances get denser when they become solid. When a certain mass of water freezes, what property of water changes, causing its density to get lower? How does this property change?

SECTION 2 PHYSICAL PROPERTIES

- properties that can be observed and measured without making a new substance
- its mass or weight, its density, its compressibility
- the amount of matter in a given volume
- 23 times as much, or 44 g more
- $D = \frac{m}{V}$
 $D = \frac{28 \text{ g}}{1.45 \text{ cm}^3} = 19.3 \text{ g/cm}^3$
- when measured at the same temperature and pressure
- zinc
- If it is denser than water, it will sink.
- The diet soda—objects less dense than water float in the water.
- the liquid with the lowest density
- a change that affects the physical properties of a substance
- melting
- a change of state
- A gas can change into a liquid or into a solid.
- nothing

Review

- Divide the mass of the substance by its volume.
- No, because all the substances are more dense than methanol.
- $D = \frac{m}{V}$
 $D = \frac{135 \text{ g}}{50 \text{ cm}^3} = 2.7 \text{ g/cm}^3$
aluminum
- The ball with the smaller volume has the larger density.
- Its volume must get larger.

SECTION 3 CHEMICAL PROPERTIES

- change into new matter
- iron
- The identity of the substance does not change when the physical property is observed; when the chemical property is observed, the substance changes identity.
- Gasoline—its properties match the properties in the table.
- a change that produces a new substance
- its bad smell

- The cake has different properties than its ingredients do.
- color change, change in texture, odor given off, heat absorbed or released
- A new substance is not made.
- chemical changes

Review

- A chemical property of a substance describes the chemical change that can happen to the substance.
- When a substance reacts, it changes into a new substance. For the property to be a physical property, the substance must be the same after it has undergone the change.
- heat

Type of change	Description of change
Chemical	rusting
Physical	boiling
Physical	freezing
Chemical	burning

- a color change, a change in texture, an odor given off, heat absorbed or liberated
- Chemical change—a color change indicates that a chemical change has taken place.
- Heat felt above the flame: chemical change
Smoke: chemical change
Melted wax: physical change

Chapter 3 States of Matter

SECTION 1 THREE STATES OF MATTER

- the physical forms of a substance
- They move about the most in the gas state and the least in the solid state.
- They vibrate.
- They move past each other.
- a force that acts on the particles at the surface of a liquid
- water, cream, syrup
- There is more space between particles.

Review

- Solid: brick, penny, ice cube
Liquid: water, milk, soda, oil
Gas: air, oxygen, water vapor
- They are always moving.