chapter 5

Matter—Properties and Changes

The BIG Idea

Properties and changes of matter can be classified as either chemical or physical.

SECTION 1
Physical Properties
Main Idea Physical properties of a substance can be observed without changing the identity of the substance.

SECTION 2
Chemical Properties
Main Idea A chemical property is a substance's ability to change into another substance.

SECTION 3
Physical and Chemical Changes
Main Idea Unlike a physical change, a chemical change involves changing one substance into a different substance.

Why do icebergs float?

This iceberg once was part of an Antarctic ice shelf. Density is a physical property. Ice floats in water because it is less dense than water. It underwent a physical change when it became an iceberg. In this chapter you'll learn about other physical and chemical properties and the changes associated with them.

Science Journal What happens to a swimming pool when the correct chemicals are not added to the water?

Start-Up Activities

Launch LAB

Classifying Different Types of Matter

Using your senses to observe characteristics of matter will help you classify, or categorize, it. This will help you understand what the types of matter are and can help you identify unknown types of matter. In this lab, you will observe and compare the characteristics of two items that you might be familiar with.

1. Obtain a table-tennis ball and a golf ball from your teacher.
2. How are the two balls similar?
3. Which ball is heavier?
4. Compare the surfaces of the table-tennis ball and the golf ball. How are their surfaces different?
5. Place each ball in water and observe.
6. **Think Critically** Create a classification system to classify different kinds of balls. Which characteristics might you use? Describe your classification system in your Science Journal.

Science Online | Preview this chapter's content and activities at ips.msscience.com

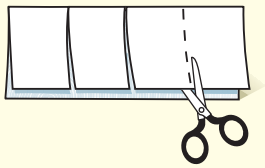
FOLDABLES™ Study Organizer

Properties and Changes of Matter Make the following Foldable to help you organize types of properties and changes into groups based on their common features.

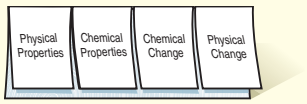
STEP 1 **Fold** a sheet of paper in half lengthwise. Make the back edge about 1.25 cm longer than the front edge.

STEP 2 **Fold** in half, then fold in half again to make three folds.

STEP 3 **Unfold and cut** only the top layer along the three folds to make four tabs.



STEP 4 **Label** the tabs as shown.



Find Main Ideas As you read the chapter, list examples of each type of property and each type of change under the appropriate tabs.

Daryl Benson/Masterfile

Get Ready to Read

Visualize

1 Learn It! Visualize by forming mental images of the text as you read. Imagine how the text descriptions look, sound, feel, smell, or taste. Look for any pictures or diagrams on the page that may help you add to your understanding.

2 Practice It! Read the following paragraph. As you read, use the underlined details to form a picture in your mind.

> Unprotected cars driven on salted roads and steel structures like the one shown in **Figure 14** can begin to rust after only a few winters. A shiny copper penny becomes dull and dark. An apple left out too long begins to turn brown. What do all these changes have in common? Each of these changes is a chemical change.
>
> — *from page 145*

Based on the description above, try to visualize chemical changes.
Now look at the photo on page 145.

- How closely does it match your mental picture?
- Reread the passage and look at the picture again. Did your ideas change?
- Compare your image with what others in your class visualized.

3 Apply It! Read the chapter and list three subjects you were able to visualize. Make a rough sketch showing what you visualized.

Reading Tip

Forming your own mental images will help you remember what you read.

Target Your Reading

Use this to focus on the main ideas as you read the chapter.

1 **Before you read** the chapter, respond to the statements below on your worksheet or on a numbered sheet of paper.

- Write an **A** if you **agree** with the statement.
- Write a **D** if you **disagree** with the statement.

2 **After you read** the chapter, look back to this page to see if you've changed your mind about any of the statements.

- If any of your answers changed, explain why.
- Change any false statements into true statements.
- Use your revised statements as a study guide.

Before You Read A or D		Statement	After You Read A or D
	1	A large ice cube is denser than a small ice cube.	
	2	All acids are too dangerous to touch.	
	3	Liquid water has different chemical properties than solid water.	
	4	Soap is an example of a base.	
	5	A chemical property of a substance describes its ability to change to a different substance.	
	6	Salts are the result of the reaction between an acid and a base.	
	7	A chemical change occurs when water boils.	
	8	Chemical changes occur in your body.	
	9	A bubbling liquid is a sure sign of a chemical change.	

Science Online

Print out a worksheet of this page at ips.msscience.com

section 1

Physical Properties

as you read

What You'll Learn

- **Describe** the common physical properties of matter.
- **Explain** how to find the density of a substance.
- **Compare and contrast** the properties of acids and bases.

Why It's Important

When you learn about physical properties, you can better describe the world around you.

Review Vocabulary

matter: anything that has mass and takes up space

New Vocabulary

- physical property
- density
- state of matter
- size-dependent property
- size-independent property

Physical Properties

Have you ever been asked by a teacher to describe something that you saw on a field trip? How would you describe the elephant in the exhibit shown in **Figure 1?** What features can you use in your description—color, shape, size, and texture? These features are all properties, or characteristics, of the elephant. Scientists use the term *physical property* to describe a characteristic of matter that you can detect with your senses. A **physical property** is any characteristic of matter that can be observed without changing the identity of the material. All matter, such as the elephant, has physical properties.

Common Physical Properties You probably are familiar with some physical properties, such as color, shape, smell, and taste. You might not be as familiar with others, such as mass, volume, and density. Mass (m) is the amount of matter in an object. A golf ball has more mass than a table-tennis ball. Volume (V) is the amount of space that matter takes up. A swimming pool holds a larger volume of water than a paper cup does. **Density** (D) is the amount of mass in a given volume. A golf ball is more dense than a table-tennis ball. Density is determined by finding the mass of a sample of matter and dividing this mass by the volume of the sample.

Formula for Density

$$\text{Density} = \text{mass/volume} \quad \text{or} \quad D = \frac{m}{V}$$

Figure 1 This large gray African elephant is displayed on the main floor of the National Museum of Natural History in Washington, D.C.

Density A table-tennis ball and a golf ball are about the same volume. When you decided which had a higher density, you compared their masses. Because they are about the same volume, the one with more mass had the higher density. Suppose you were asked if all the bowling balls in **Figure 2** were identical. They appear to be the same size, shape, and color, but do they all have the same mass? If you could pick up these bowling balls, you would discover that their masses differ. You also might notice that the heavier balls strike the pins harder. Although the volumes of the balls are nearly identical, the densities of the bowling balls are different because their masses are different.

Identifying Unknown Substances In some cases, density also can be used to identify unknown compounds and elements. The element silver, for example, has a density of 10.5 g/cm^3 at 20°C. Suppose you want to know whether or not a ring is pure silver. You can find the ring's density by dividing the mass of the ring by its volume. If the density of the ring is determined to be 11.3 g/cm^3, then the ring is not pure silver.

Figure 2 These bowling balls look the same but have different densities. **Identify** *the types of matter you think you would see, hear, taste, touch, and smell at a bowling alley.*

Applying Math — Solve a One-Step Equation

DETERMINING DENSITY An antique dealer decided to use density to help determine the material used to make a statue. The volume of the statue is 1,000 cm^3 and the mass is 8,470 g. What is its density?

Solution

1. *This is what you know:*
   - density = mass/volume = m/V
   - m = 8,470 g, V = 1,000 cm^3
2. *This is what you need to find out:*
   Find the density (D)
3. *This is the procedure you need to use:*
   - $D = m/V$
   - $D = m/V$ = 8,470 g/1,000 cm^3 = 8.470 g/cm^3
4. *Check your answer:*
   Substitute the density and one of the knowns back into the main equation. Did you calculate the other known?

Practice Problems

1. If a candlestick has a mass of 8.5 g and a volume of 0.96 cm^3, what is its density?
2. If the density of a plastic ball is 5.4 g/cm^3 and the volume is 7.5 cm^3, what is the mass of the plastic ball?

For more practice, visit ips.msscience.com/math_practice

Ryan McVay/PhotoDisc

Figure 3 All three states of water are present here—solid, liquid, and gas—but you can only see the solid and liquid states. The water vapor in the air is not visible.

State of Matter

State of matter is another physical property. The **state of matter** tells you whether a sample of matter is a solid, a liquid, or a gas. This property depends on the temperature and pressure of the matter. The ice in **Figure 3** is water in the solid state. Water in the liquid state can be seen in the ocean and in the clouds. Gaseous water cannot be seen but exists as vapor in the air. In each case, each molecule of water is the same—two hydrogen atoms and one oxygen atom. But water appears to be different because it exists in different states, as shown in **Figure 3.**

Size-Dependent and Size-Independent Properties

Some physical properties change when the size of an object changes. These properties are called **size-dependent properties.** For example, a wooden block might have a volume of 30 cm^3 and a mass of 20 g. A larger block might have a volume of 60 cm^3 and a mass of 40 g. The volume and mass of the block change when the size of the block changes. However, the density of both blocks is 0.67 g/cm^3. Some physical properties do not change when an object changes size. Density is an example of a **size-independent property.** Other examples of size-dependent and size-independent properties are shown in **Table 1.**

Table 1 Physical Properties

Type of Property	Property
Size-dependent properties	length, width, height, volume, mass
Size-independent properties	density, color, state

Mini LAB

Classifying Properties

Procedure

1. Obtain three different-sized **blocks** of the same type of wood.
2. Write all your observations of each block in your **Science Journal** as you make your measurements.
3. Measure the length, width, height, and mass of each block. Calculate the volume and density of each block.

Analysis

1. Which properties were size-dependent?
2. Which properties were size-independent?

Try at Home

Physical Properties of Acids and Bases

One way to describe matter is to classify it as either an acid or a base. The concentration of an acid or base can be determined by finding the pH of the sample. The pH scale has a range of 0 to 14. Acids have a pH below 7. Bases have a pH above 7. A sample with a pH of exactly 7 is neutral—neither acidic nor basic. Pure water is a substance with a pH of exactly 7.

Properties of Acids What do you think of when you hear the word *acid?* Do you picture a dangerous chemical that can burn your skin, make holes in your clothes, and even destroy metal? Some acids, such as concentrated hydrochloric acid, are like that. But some acids are edible. One example is shown in **Figure 4.** Carbonated soft drinks contain acids. Every time you eat a citrus fruit such as an orange or a grapefruit, you eat citric and ascorbic (uh SOR bihk) acids. What properties do these and other acids have in common?

Imagine the sharp smell of a freshly sliced lemon. That scent comes from the citric acid in the fruit. Take a big bite out of the fruit shown in **Figure 5** and you would immediately notice a sour taste. If you then rubbed your molars back and forth, your teeth would squeak. All of these physical properties are common in acids.

Reading Check ***What are two uses of an acid?***

Figure 4 When you sip a carbonated soft drink, you drink carbonic and phosphoric (faws FOR ihk) acids. **Identify** *an area of your body where acids are found.*

INTEGRATE Health

Aging Vitamin C and alpha-hydroxy acids are found in fruits and are the active ingredient in some anti-aging skin creams. It is believed that these ingredients slow down the aging process. Researchers examine safety issues regarding these products as well as their components.

Figure 5 All citrus fruits contain citric and ascorbic acids, which is why these fruits taste sour.

Figure 6 Soaps are bases, which is why they are slippery.

Science Online

Topic: Acids and Bases

Visit ips.msscience.com for Web links to information about acid and base reactions.

Activity List some common and industrial uses for acids and bases.

Physical Properties of Bases

Bases have physical properties that are different from acids. A familiar example of a base is ammonia (uh MOH nyuh), often used for household cleaning. If you got a household cleaner that contained ammonia on your fingers and then rubbed your fingers together, they would feel slippery. Another familiar base is soap, shown in **Figure 6,** which also has a slippery feel. You shouldn't taste soap, but if you accidentally did, you'd notice a bitter taste. A bitter taste and a slippery feel are physical properties of bases.

Reading Check ***What are two examples of products that contain bases?***

It is important to note that you should never taste, touch, or smell anything in a lab unless your teacher tells you to do so.

section 1 review

Summary

Physical Properties

- Characteristics that can be observed without changing the identity of the object.
- Color, shape, smell, taste, mass, volume, and density are all physical properties.
- Mass and volume are size-dependent properties of an object.

Density

- density = mass/volume

Properties of Acids and Bases

- Acids smell sharp, taste sour, and have a pH below 7.
- Bases are slippery, taste bitter, and have a pH above 7.

Self Check

1. **Describe** the physical properties of a baseball.
2. **Explain** why density is a size-independent property. How does it differ from a size-dependent property?
3. **Describe** Give an example of an acid and a base. How do they differ from a neutral substance?
4. **Think Critically** How could you identify a pure metal if you have a balance, a graduated cylinder, and a table of densities for metals? (1 mL = 1 cm^3)

Applying Math

5. **Solve One-Step Equations** What is the density of a substance with a mass of 65.7 g and a volume of 3.40 cm^3?

Science Online ips.msscience.com/self_check_quiz

section 2

Chemical Properties

A Complete Description

You've observed that the density of a table-tennis ball is less than the density of a golf ball. You also have noticed the state of water in an ice cube and in a lake. You've noticed the taste of acid in a lemon and the slippery feel of a base such as soap. However, a description of something using only physical properties is not complete. What type of property describes how matter behaves?

Common Chemical Properties If you strike a match on a hard, rough surface, the match probably will start to burn. Phosphorus (FAWS for us) compounds on the match head and the wood in the match combine with oxygen to form new materials. Why does that happen? The phosphorus compounds and the wood have the ability to burn. The ability to burn is a chemical property. A **chemical property** is a characteristic of matter that allows it to change to a different type of matter.

Reading Check *What is a chemical property?*

You see an example of a chemical property when you leave a half-eaten apple on your desk, and the exposed part turns brown. The property you observe is the ability to react with oxygen. Two other chemical properties are shown in **Figure 7.**

as you read

What You'll Learn

- **Describe** chemical properties of matter.
- **Explain** the chemical properties of acids and bases.
- **Explain** how a salt is formed.

Why It's Important

Chemical properties can help you predict how matter will change.

Review Vocabulary

solubility: the amount of a substance that will dissolve in a given amount of another substance

New Vocabulary

- chemical property
- reactivity
- salts

Figure 7 The chemical properties of a material often require a warning about its careful use. Gas pumps warn customers not to get near them with anything that might start the gasoline burning. Workers who use toxic chemicals have to wear protective clothing.

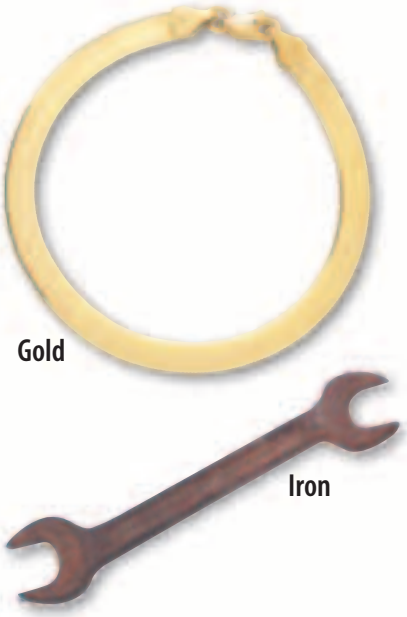


Figure 8 Gold and iron have different chemical properties that make them suitable for uses in a wide variety of jewelry and tools.

Choosing Materials Look at **Figure 8.** Would you rather wear a bracelet made of gold or one made of iron? Why? Iron is less attractive and less valuable than gold. It also has an important chemical property that makes it unsuitable for jewelry. Think about what happens to iron when it is left out in moist air. Iron rusts easily because of its high reactivity (ree ak TIH vuh tee) with oxygen and moisture in the air. **Reactivity** is how easily one thing reacts with something else. The low reactivity of silver and gold, in addition to their desirable physical properties, makes those metals good choices for jewelry.

(tl b)Morrison Photography, (br)Bob Daemmrich/Stock Boston

Reading Check *Why is a fiberglass boat hull better than one made of a metal?*

INTEGRATE Life Science

Chemical Properties and Pools

The "chlorine" added to swimming pools is actually a compound called hypochlorous acid, which forms when chlorine reacts with water. This acid kills bacteria, insects, algae, and plants. The person in **Figure 9** is testing the pool water to see whether it has the correct amount of chlorine.

Any time you have standing water, mosquitoes and other insects can lay eggs in it. Various plants and algae can turn a sparkling blue pool into a slimy green mess. Bacteria are another problem. When you go swimming, you bring along millions of uninvited guests—the normal bacteria that live on your skin. The chlorine compounds kill the bacteria—as well as insects, algae, and plants that might be in the pool.

Hypochlorous acid can cause problems as well. It combines with nitrogen in the pool to form chloramines. Have your eyes ever burned after swimming in a pool? Chloramines can irritate the skin and eyes of swimmers.

Figure 9 Pool water must be tested to keep the water safe for swimmers.
Determine *How do physical and chemical properties differ?*

Chemical Properties of Acids and Bases You have learned that acids and bases have physical properties that make acids taste sour and bases taste bitter and feel slippery. The chemical properties of acids and bases are what make them both useful but sometimes harmful. Several acids and bases are shown in **Table 2.**

Acids Many acids react with, or corrode, certain metals. Have you ever used aluminum foil to cover leftover spaghetti or tomato sauce? **Figure 10** shows what you might see the next day. You might see small holes in the foil where it has come into contact with the tomatoes in the sauce. The acids in tomato sauce, oranges, carbonated soft drinks, and other foods are edible. However, many acids can damage plant and animal tissue. Small amounts of nitric (NI trihk) acid and sulfuric (sul FYOOR ihk) acid are found in rain. This rain, called acid rain, harms plant and animal life in areas where acid rain falls. Sulfuric acid that has no water mixed with it is useful in many industries because it removes water from certain materials. However, that same property causes burns on skin that touches sulfuric acid.

Figure 10 Aluminum reacts easily with acids, which is why acidic food, such as tomatoes, should not be cooked or stored in aluminum.

Table 2 Common Acids and Bases

Name of Acid	Formula	Where It's Found
Acetic acid	CH_3COOH	Vinegar
Acetylsalicylic acid	$C_9H_8O_4$	Aspirin
Ascorbic acid (vitamin C)	$C_6H_8O_6$	Citrus fruits, tomatoes
Carbonic acid	H_2CO_3	Carbonated drinks
Hyrdrochloric acid	HCl	Gastric juice in stomach
Name of Base		
Aluminum hydroxide	$Al(OH)_3$	Deodorant, antacid
Calcium hydroxide	$Ca(OH)_2$	Leather tanning, manufacture of mortar and plaster
Magnesium hydroxide	$Mg(OH)_2$	Laxative, antacid
Sodium hydroxide	NaOH	Drain cleaner, soap making
Ammonia	NH_3	Household cleaners, fertilizer, production of rayon and nylon

Figure 11 These everyday items contain salts.

Bases A concentrated base is as dangerous as a concentrated acid. A base, such as sodium hydroxide (hi DRAHK side) can damage living tissue. It is not uncommon for someone who smells strong ammonia to get a bloody nose or to get a burn if a strong base is touched. Ammonia feels slippery to the touch because the base reacts with the proteins in the tissues on your fingertips, which results in damaged tissue.

Salts What happens in reactions between acids and bases? Acids and bases often are studied together because they react with each other to form water and other useful compounds called salts. **Salts** are compounds made of a metal and nonmetal that are formed when acids and bases react. Look at **Figure 11.** That white solid in your salt shaker—table salt—is the most common salt. Table salt, sodium chloride, can be formed by the reaction between the base sodium hydroxide and hydrochloric acid. Other useful salts are calcium carbonate, which is chalk, and ammonium chloride, which is used in some types of batteries.

section 2 review

Summary

Chemical Properties

- These properties have characteristics that cannot be observed without altering the identity of the substance.

Chemical Properties of Acids and Bases

- Strong acids and bases can be equally dangerous.
- Strong acids react with and corrode metals.
- Ammonia and sodium hydroxide are examples of bases.

Salts

- A salt is composed of a metal and a nonmetal.
- An acid and a base combine to form a salt and water.

Self Check

1. **Compare and Contrast** How do chemical and physical properties differ?
2. **Describe** three chemical properties of an acid.
3. **Identify** two different salts and their uses.
4. **Think Critically** Think about safety precautions you take around your home. Which ones are based on physical properties and which ones are based on chemical properties? Explain.

Applying Skills

5. **Classify** each of the following properties as being physical or chemical: iron rusting, gasoline burning, solid sulfur shattering, and lye feeling slippery.

section 3

Physical and Chemical Changes

Physical Change

The crowd gathers at a safe distance and the cameras from the news media are rolling. A sense of excitement, fear, and anticipation fills the air. The demolition experts are making their final inspections. Then, in just a few seconds, the old stadium becomes a pile of rubble. The appearance of the stadium changed.

What is physical change? Most matter can undergo physical change. A **physical change** is any change in size, shape, form, or state where the identity of the matter stays the same. Only the physical properties change. The stadium in **Figure 12** underwent a physical change from its original form to a pile of steel and concrete. The materials are the same; they just look different.

Reading Check *What is a physical change?*

Figure 12 This stadium underwent a physical change—its form changed.

AFP/CORBIS

as you read

What You'll Learn

- **Identify** physical and chemical changes.
- **Exemplify** how physical and chemical changes affect the world you live in.

Why It's Important

Chemical changes are all around us, from the leaves changing color in the fall to the baking of bread.

Review Vocabulary

weathering: the action of the elements in altering the color, texture, composition or form of exposed objects

New Vocabulary

- physical change
- chemical change

Examples of Physical Changes How can you recognize a physical change? Just look to see whether or not the matter has changed size, shape, form, or state. If you cut a watermelon into chunks, the watermelon has changed size and shape. That's a physical change. If you pop one of those chunks into your mouth and bite it, you have changed the watermelon's size and shape again.

Change of State Matter can undergo a physical change in another way, too. It can change from one state to another. Suppose it's a hot day. You and your friends decide to make snow cones. A snow cone is a mixture of water, sugar, food coloring, and flavoring. The water in the snow cone is solid, but in the hot sunshine, it begins to warm. When the temperature of the water reaches its melting point, the solid water begins to melt. The chemical composition of the water—two hydrogens and one oxygen—does not change. However, its form changes. This is an example of a physical change. The solid water becomes a liquid and drips onto the sidewalk. As the drops of liquid sit in the sunshine, the water changes state again, evaporating to become a gas. Water also can change from a solid to liquid by melting. Other examples of change of state are shown in **Figure 13.**

Figure 13 The four most common changes of state are shown here.
Explain *if physical changes can be reversed.*

A solid will melt, becoming a liquid.

As it cools, this liquid metal will become solid steel.

Water vapor in the air changes to liquid water when dew forms.

Liquid water in perspiration changes to a gas when it evaporates from your skin.

Figure 14 Chemical changes occur all around you.

This unprotected car fender was exposed to salt and water which caused it to rust.

Apples and pennies darken due to chemical changes.

This bridge support will have to be repaired or replaced because of the rust damage.

Chemical Changes

Unprotected cars driven on salted roads and steel structures like the one shown in **Figure 14** can begin to rust after only a few winters. A shiny copper penny becomes dull and dark. An apple left out too long begins to turn brown. What do all these changes have in common? Each of these changes is a chemical change. A **chemical change** occurs when one type of matter changes into a different type of matter with different properties.

Reading Check *What happens during a chemical change?*

Examples of Chemical Change Chemical changes are going on around you—and inside you—every day. Plants use photosynthesis to produce food—the product of chemical changes. When you eat fruits and vegetables produced by photosynthesis, these products must be chemically changed again so that the cells in your body can use them as food. There are many chemical changes occurring outside of your body, too. Silver tarnishing, copper forming a green coating, iron rusting, and petroleum products combusting are all examples of chemical changes that are occurring around you. Although these reactions may be occurring at different rates and producing different products, they are still examples of chemical changes.

Mini LAB

Comparing Chemical Changes

Procedure

1. Separate a piece of **fine steel wool** into two halves.
2. Dip one half in **tap water** and the other half in the same amount of **salt water.**
3. Place both pieces of steel wool on a **paper plate** and label them. Observe every day for five days.

Analysis

1. What happened to the steel wool that was dipped in the salt water?
2. What might be a common problem with machinery that is operated near an ocean?

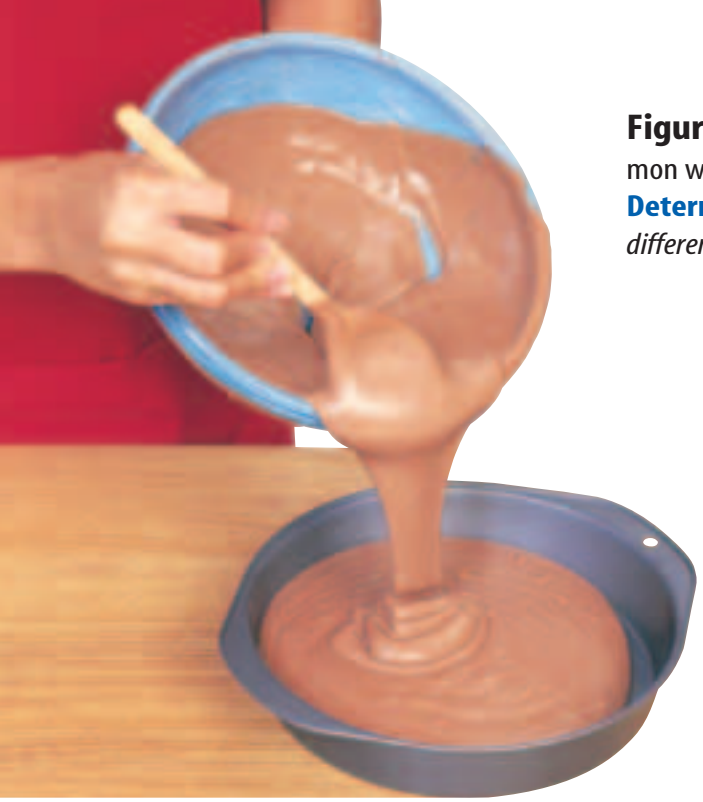


Figure 15 Chemical changes are common when food, such as cake, is cooked. **Determine** *How is a chemical change different from a physical change?*

New Materials Are Formed Ice melts, paper is cut, metal is hammered into sheets, and clay is molded into a vase. Seeing signs of these physical changes is easy—something changes shape, size, form, or state.

The only sure way to know whether a chemical change has occurred is if a new type of matter is formed that is chemically different from the starting matter. A chemical change cannot be reversed easily. For example, when wood burns, you see it change to ash and gases that have properties that are different from the wood and oxygen that burned. You can't put the ash and gases back together to make wood. When the cake shown in **Figure 15** is baked, changes occur that make the cake batter become solid. The chemical change that occurs when baking powder mixes with water results in bubbles that make the cake rise. Raw egg in the batter undergoes changes that make the egg solid. These changes cannot be reversed.

Reading Check ***How can you be sure that a chemical change has occurred?***

Signs of Chemical Change In these examples, you know that a chemical change occurred because you can see that a new substance forms. It's not always easy to tell when new substances are formed. What are other signs of chemical change?

One sign of a chemical change is the release or absorption of energy in the form of light, heat, or sound. Release of energy is obvious when something burns—light and heat are given off. Sometimes an energy change is so small or slow that it is difficult to notice, like when something rusts. Another sign that indicates a chemical change is the formation of a gas or a solid that is not the result of a change of state.

Science Online

Topic: Chemical Changes

Visit ips.msscience.com for Web links to information about physical and chemical changes.

Activity Describe the physical and chemical changes that are involved in making and baking a yeast bread.

Morrison Photography

Chemical and Physical Changes in Nature

Often, a color is evidence of a chemical change, an example of which is shown in **Figure 16.** Year round, leaves contain yellow, red, and orange pigments that are masked, or hidden, by large amounts of green chlorophyll. In autumn, changes in temperature and rainfall amounts cause trees to stop producing chlorophyll. When chlorophyll production stops, the masked pigments become visible.

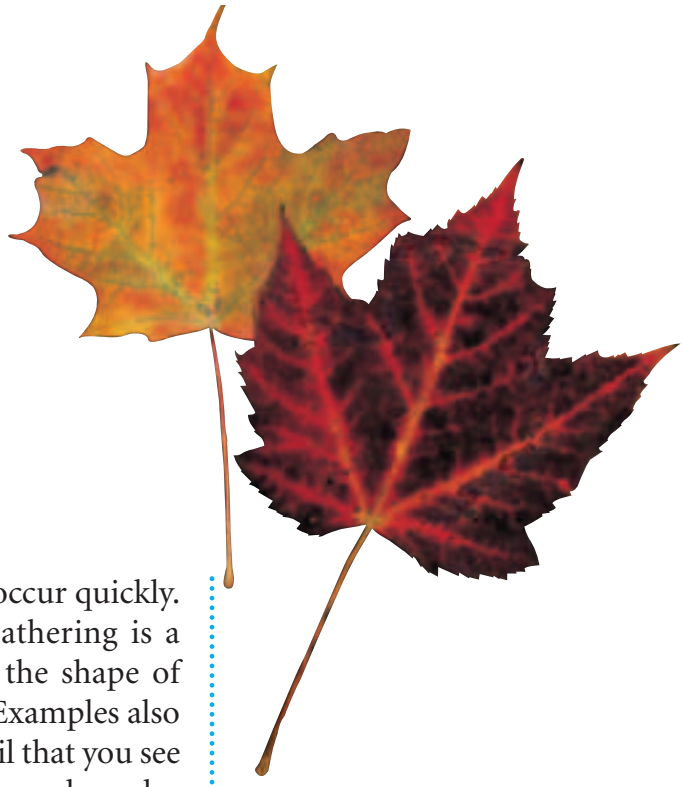


Figure 16 Chemical changes that occur in the fall bring about the color changes in these leaves.

Physical Weathering Some physical changes occur quickly. Others take place over a long time. Physical weathering is a physical change that is responsible for much of the shape of Earth's surface. Examples are shown in **Figure 17.** Examples also can be found in your own school yard. All of the soil that you see comes from physical weathering. Wind and water erode rocks, breaking them into small bits. Water fills cracks in rocks. When it freezes and thaws several times, the rock splits into smaller pieces. No matter how small the pieces of rock are, they are made up of the same things that made up the bigger pieces of rock. The rock simply has undergone a physical change. Gravity, plants, animals, and the movement of land during earthquakes also help cause physical changes on Earth.

Figure 17 You can see dramatic examples of physical weathering caused by water and wind on rocky coastlines.

Figure 18 Over many years, acidic rainwater slowly reacts with layers of limestone rock. It forms caves and collects minerals that it later deposits as cave formations.

Geologists Carlsbad Caverns in New Mexico contain cave formations similar to the ones shown here. Geologists study the history of the Earth as recorded in rocks and often investigate deep within Earth's caves. Stalagmites are cave formations that form on the floor of the cave and grow upward. Inside Carlsbad Caverns you will find a stalagmite called the Giant Dome that is 19 m tall. Research and find out more information about geologists and this huge cave.

Chemical Weathering Cave formations like the one in **Figure 18** form by chemical weathering. As drops of water drip through the rocks above this cavern room, minerals become dissolved in the water. These icicle shapes, or stalactites, are formed when the water evaporates leaving the mineral deposits. There are instances of unnatural chemical weathering. The acid in acid rain can chemically weather marble buildings and statues, and other outdoor objects.

section 3 review

Summary

Physical Changes

- Physical changes are changes in the size, shape, form, or state of an object where its identity remains the same.

Chemical Changes

- A chemical change occurs when one type of matter changes into another type of matter with different properties.
- Energy, in the form of light, heat, or sound can be released or absorbed.
- A gas or a solid, not resulting from a change of state, can be formed.
- Physical and chemical weathering also occur in nature.

Self Check

1. **List** five physical changes that you can observe in your home.
2. **Describe** how physical changes can alter Earth's surface.
3. **Explain** what happens when carbon burns. List the signs that a chemical change has occurred.
4. **Think Critically** Which of the following involves a chemical change: combining an acid and a base, dew forming, or souring milk.

Applying Skills

5. **Draw Conclusions** A log is reduced to a small pile of ash when it burns. Explain the difference in mass between the log and the ash.

Science Online ips.msscience.com/self_check_quiz

LAB

Sunset in a Bag

Real-World Question

How do you know when a chemical change occurs? You'll see some signs of chemical change in this lab.

Goals

- **Observe** a chemical change.
- **Identify** some signs of chemical change.

Materials

baking soda
calcium chloride
phenol red solution
warm water
teaspoons (2)
resealable plastic bag
graduated cylinder

Safety Precautions

Procedure

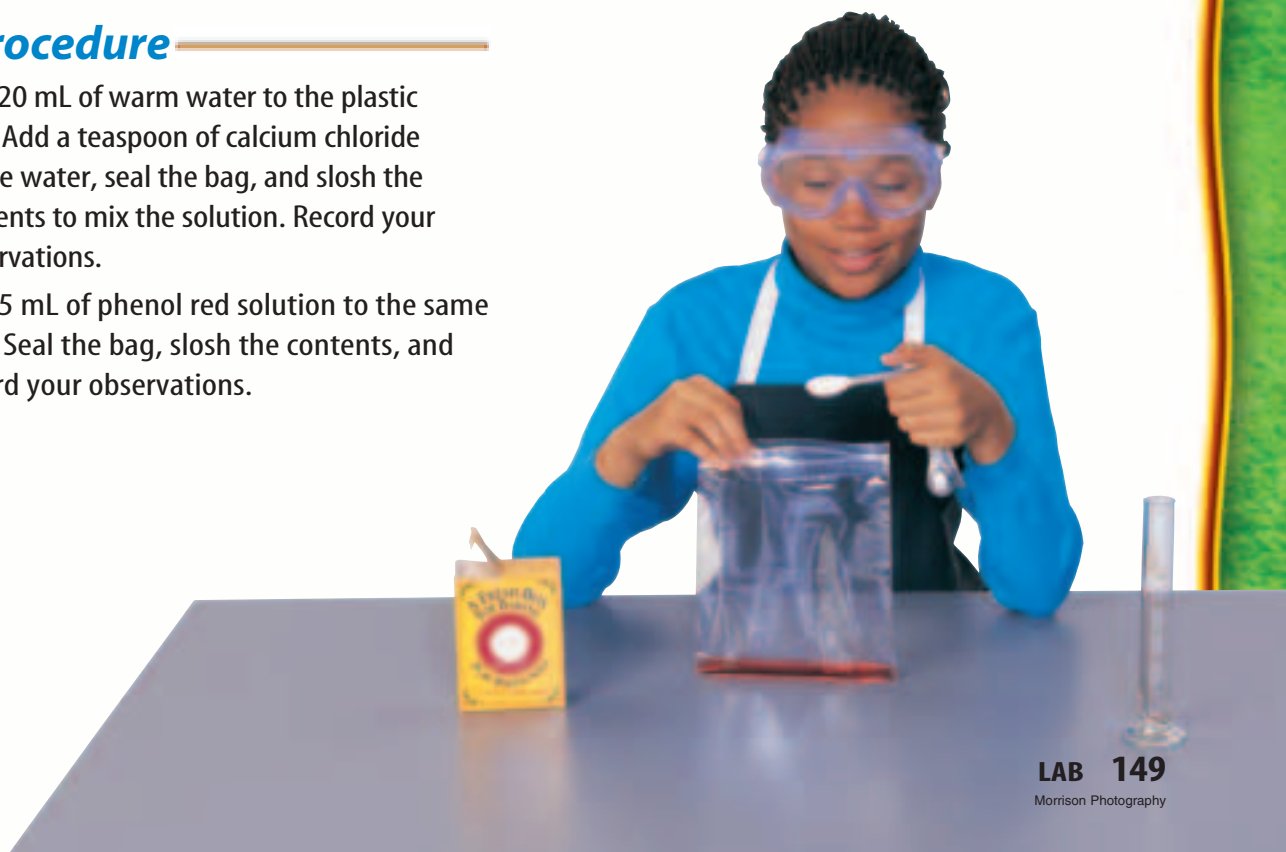
1. Add 20 mL of warm water to the plastic bag. Add a teaspoon of calcium chloride to the water, seal the bag, and slosh the contents to mix the solution. Record your observations.
2. Add 5 mL of phenol red solution to the same bag. Seal the bag, slosh the contents, and record your observations.
3. Open the bag and quickly add a teaspoon of baking soda. Seal the bag and slosh the contents to mix the ingredients together. Observe what happens.

Conclude and Apply

1. **Identify** in which step a physical change occurred. In which step did a chemical change occur? How do you know?
2. **Predict** if a change in energy always indicates a chemical change. Why or why not?

Communicating Your Data

Compare your conclusions with those of other students in your class. **For more help, refer to the Science Skill Handbook.**



Morrison Photography

LAB

Design Your Own

Homemade pH Scale

Goals

- **Design** an experiment that allows you to test solutions to find the pH of each.
- **Classify** a solution as an acid or a base according to its pH.

Possible Materials

vial of pH paper
1–14 pH color chart
distilled water
fruit juices
vinegar
salt
sugar
soft drinks
household cleaners
soaps and detergents
antacids

Safety Precautions

WARNING: *Never eat, taste, smell, or touch any chemical during a lab.*

Real-World Question

The more concentrated an acid or base is, the more likely it is to be harmful to living organisms. A pH scale is used to measure the concentration of acids and bases. A solution with a pH below 7 is acidic, a pH of 7 is neutral, and a pH above 7 is basic. In this lab, you will measure the pH of some things using treated paper. When it is dipped into a solution, this paper changes color. Check the color against the chart below to find the pH of the solution. How acidic or basic are some common household items?

Form a Hypothesis

Form a hypothesis to explain which kinds of solutions you are testing are acids and which kinds are bases. Copy and complete the table below.

pH of Solutions

Solution To Be Tested	pH	Acid, Base, or Neutral

pH	Color	pH	Color
1		8	
2		9	
3		10	
4		11	
5		12	
6		13	
7		14	

Morrison Photography

Test Your Hypothesis

Make a Plan

1. As a group, decide which materials you will test. If a material is not a liquid, dissolve it in water so you can test the solution.
2. List the steps and materials that you need to test your hypothesis. Be specific. What parts of the experiment will you repeat, if any?
3. Before you begin, copy a data table like the one shown into your Science Journal. Be sure to leave room to record results for each solution tested. If there is to be more than one trial for each solution, include room for the additional trials.
4. Reread the entire experiment to make sure that all the steps are in logical order.

Follow Your Plan

1. Make sure your teacher approves your plan and data table. Be sure that you have included any suggested changes.
2. Carry out the experiment as planned and approved. Wash your hands when you are done.
3. **Record** the pH value of each solution in the data table as you complete each test. Determine whether each solution is acidic, basic, or neutral.

Analyze Your Data

1. **Infer** Were any materials neither acids nor bases? How do you know?
2. **Interpret Data** Using your data table, conclude which types of materials are usually acidic and which are usually basic.
3. **Draw Conclusions** At what pH do you think acids become too dangerous to touch? Bases? Explain your answers.
4. **Analyze Results** What is the pH range of the foods that you tested?

Conclude and Apply

Determine Perhaps you have been told that you can use vinegar to dissolve hard-water deposits because vinegar is an acid. If you run out of vinegar, which of the items you tested could you most likely use instead of vinegar for this purpose?

Communicating Your Data

Compare your findings with those of other student groups. Discuss why any differences in the data might have occurred.

TIME **SCIENCE** AND HISTORY

SCIENCE CAN CHANGE THE COURSE OF HISTORY!

CRUMBLING MONUMENTS

Acid rain is eroding some of the world's most famous monuments

The Taj Mahal in India, the Acropolis in Greece, and the Colosseum in Italy, have stood for centuries. They've survived wars, souvenir-hunters, and natural weathering from wind and rain. But now, something far worse threatens their existence—acid rain. Over the last few decades, this form of pollution has eaten away at some of history's greatest monuments.

Acid rain leads to health and environmental risks. It also harms human-made structures. Most of these structures are made of sandstone, limestone, and marble. Acid rain causes the calcium in these stones to form calcium sulfate, or gypsum. Gypsum's powdery little blotches are sometimes called "marble cancer." When it rains, the gypsum washes away, along with some of the surface of the monument. In many cases, acidic soot falls into the cracks of monuments. When rainwater seeps into the cracks, acidic water is formed, which further damages the structure.

In London, acid rain has forced workers to repair and replace so much of Westminster Abbey that the structure is becoming a mere copy of the original. Because of pollution, many corroding statues displayed outdoors have been brought inside museums.

Throughout the world, acid rain has weathered many structures more in the last 20 years than in the prior 2,000 years. This is one reason some steps have been taken in Europe and the United States to reduce emissions from the burning of fossil fuels.

Identify **Which monuments and buildings represent the United States? Brainstorm a list with your class. Then choose a monument, and using your school's media center, learn more about it. Is acid rain affecting it in any way?**

Science Online

For more information, visit ips.msscience.com/time

Reviewing Main Ideas

Section 1 Physical Properties

1. A physical property can be observed without changing the makeup of the material.
2. Acids and bases have physical properties. Acids have a sharp smell and a sour taste. Bases have a bitter taste and feel slippery.
3. Mass, volume, state of matter, and density are examples of physical properties.

Section 2 Chemical Properties

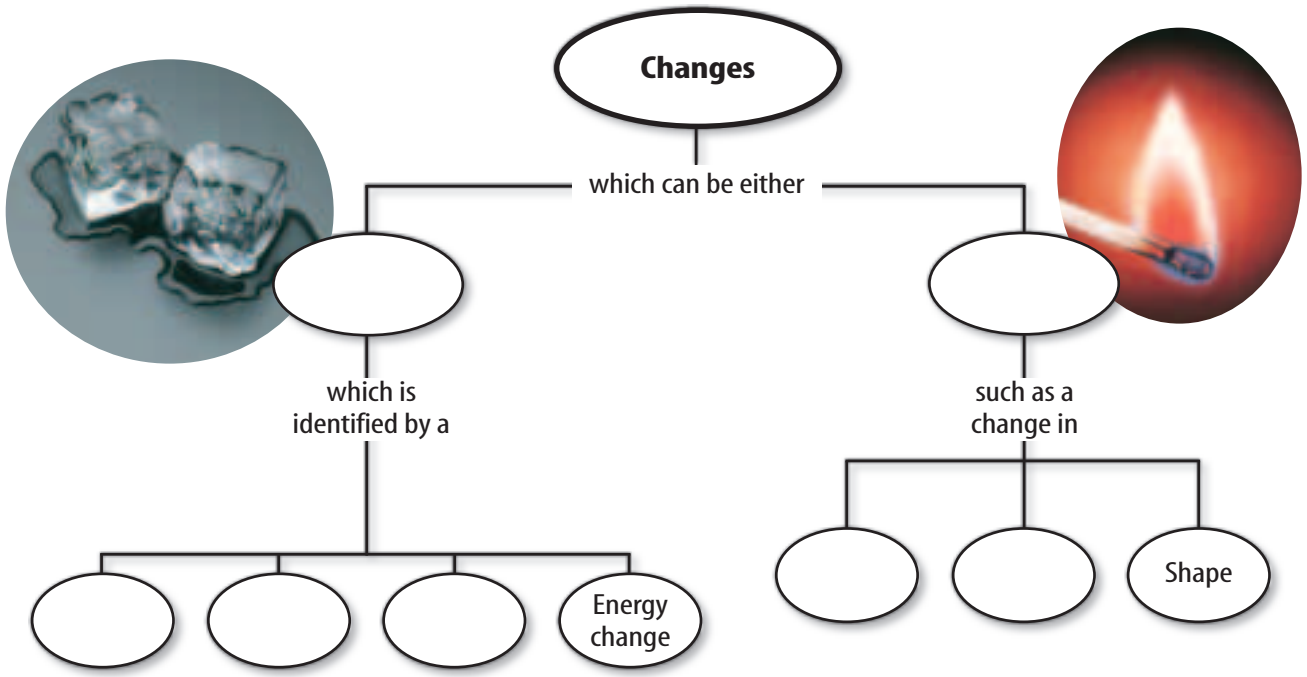
1. A chemical property is a characteristic of matter that allows it to change to a different type of matter.
2. Acids and bases are in many household products.
3. Acids and bases react with each other to produce water and a salt.

Section 3 Physical and Chemical Changes

1. A physical change is a change in the size, shape, form, or state of matter. The chemical makeup of the matter stays the same.
2. Water undergoes a change of state when it changes from a solid to a liquid or a liquid to a gas.
3. In chemical changes, new matter is changed to a different type of matter.
4. Evidence that a chemical change might have occurred includes a color or energy change or the formation of a gas or solid.

Visualizing Main Ideas

Copy and complete the following concept map about matter.



(l)file photo, (r)courtesy Diamond International

chapter 5 Review

Using Vocabulary

chemical change p. 145
chemical property p. 139
density p. 134
physical change p. 143
physical property p. 134
reactivity p. 140
salt p. 142
size-dependent property p. 136
size-independent property p. 136
state of matter p. 136

Answer the following questions using complete sentences.

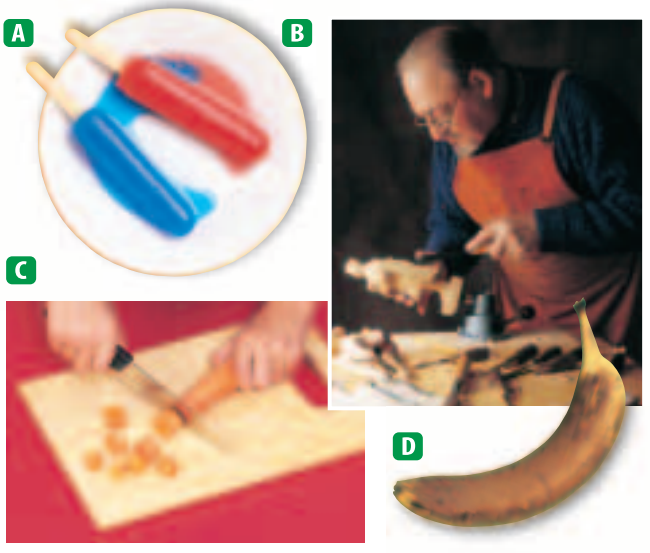
1. Mass divided by volume is the formula for which physical property?
2. Which type of properties include color, shape, size, and state?
3. Snow melting in sunshine is an example of which type of change?
4. Acid rain damaging marble statues is an example of which type of change?
5. Iron rusts in moist air. Which chemical property is this?

Checking Concepts

Choose the word or phrase that best answers the question.

6. Which of the following is a chemical property of a substance?
   A) density **C)** mass
   B) white powder **D)** reacts with HCl
7. Which item below is a sign of a chemical change?
   A) change of water vapor to liquid
   B) release of energy
   C) change from a liquid to a solid
   D) change in shape
8. Which type of change listed below results in new compounds being formed?
   A) chemical **C)** seasonal
   B) physical **D)** state
9. Salts are formed when which of the following react?
   A) solids and gases
   B) acids and bases
   C) bases and gases
   D) acids and solids
10. Which of the following physical properties does a base have?
    A) cold to touch
    B) gives off gas
    C) slippery and bitter taste
    D) sharp smell and sour taste
11. Which of the following changes when water evaporates?
    A) the physical properties of the water
    B) the chemical properties of the water
    C) the color of the water
    D) the mass of the water

Use the illustrations below to answer question 12.



12. Which figure above clearly identifies a chemical change?
    A) A
    B) B
    C) C
    D) D

Thinking Critically

13. **Explain** Think about what you know about density. Could a bag of feathers have more mass than the same size bag of rocks? Explain.

14. **Classify** each of the following as either a physical property or a chemical property.
    - **a.** Sulfur shatters when hit.
    - **b.** Copper statues turn green.
    - **c.** Baking soda is a white powder.
    - **d.** Newspaper turns brown when it is exposed to air and light.

Use the photo below to answer questions 15 and 16.

15. **Identify** The antacid dissolves in water. Is this a physical or a chemical property of the antacid? Explain.

16. **Draw Conclusions** Think about what you know about density. Is the antacid tablet more or less dense than water. Explain.

17. **Determine** A jeweler bends gold into a beautiful ring. What type of change is this? Explain.

18. **Compare and Contrast** Relate such human characteristics as hair and eye color, height, and weight to physical properties of matter. Relate human behavior to chemical properties. Think about how you observe these properties.

19. **Identify** Sugar dissolves in water. Is this a physical property or a chemical property of sugar?

20. **Evaluate** When butane burns, it combines with oxygen in the air to form carbon dioxide and water. Which two elements must be present in butane?

21. **Identify** each of the following as a physical change or a chemical change.
    - **a.** Metal is drawn out into a wire.
    - **b.** Sulfur in eggs tarnishes silver.
    - **c.** Baking powder bubbles when water is added to it.

Performance Activities

22. **Display** Create a display that demonstrates the characteristics of a chemical change. Be sure your display shows release of energy, change of color, and the formation of a solid.

Applying Math

Use the table below to answer questions 23–25.

Using the Density Formula

Sample	Mass (g)	Volume (cm^3)	Density (g/cm^3)
A	5.4	3.8	
B	6.8		0.65
C		8.6	2.18

23. **Determine Density** Knowing the mass and volume of Sample A, calculate its density.

24. **Determine** the mass of Sample C from its density and volume.

25. **Determine the volume** of Sample B from its mass and density.

Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

1. Which of the following properties is a size-independent property?

A. state **C.** mass
B. length **D.** volume

Use the table below to answer questions 2, 3 and 4.

Density of Some Pure Metals	
Metal	**Density (g/cm^3)**
Copper	8.96
Iron	7.87
Lead	11.3
Magnesium	1.74
Silver	10.5
Zinc	7.14

2. According to the table above, what is the mass of a 6.37-cm^3 sample of iron?

A. 0.809 g **C.** 7.87 g
B. 1.24 g **D.** 50.1 g

3. According to the table above, what is the volume of a 25.1 g piece of silver?

A. 8.25 cm^3 **C.** 5.73 cm^3
B. 2.39 cm^3 **D.** 3.46 cm^3

4. During an experiment, you measure the mass of an unknown substance as 28.4 g and its volume as 2.5 cm^3. Use the table above to determine the most likely identity of the unknown substance.

A. zinc **C.** lead
B. magnesium **D.** iron

5. Which of the following terms describes a substance with a pH of 7?

A. acidic **C.** basic
B. neutral **D.** bitter

Use the photograph below to answer questions 6 and 7.

6. Which of the following statements best explains why the nails in the photograph above rusted?

A. The nails drew rust from the air.
B. Iron in the nails changed into other elements.
C. The rust formed when iron mixed with oxygen and moisture in the air.
D. A temperature change drew rust out of the nails.

7. Which of the following best describes rust?

A. reversible physical change
B. irreversible physical change
C. reversible chemical change
D. irreversible chemical change

8. Which of the following describes a chemical change?

A. water freezing into ice
B. a match burning
C. dew forming on a leaf
D. magnetization of an iron nail

9. The density of a 30-g sample of gold is 19.3 g/cm^3. What is the density of a 90-g sample?

A. 6.43 g **C.** 57.9 g
B. 19.3 g **D.** 79.3 g

Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

10. Tell whether each of the following words describes an acid or a base: bitter, slippery, sour.

11. What is the density of a 25.3-g sample of quartz that has a volume of 9.55 cm^3?

12. Are all acids and bases dangerous? Explain why or why not, and give examples to support your answer.

13. Describe a chemical and a physical change that occurs in food as you chew it.

14. The density of stainless steel is 8.02 g/cm^3. What is the volume of a 9.25 g piece of stainless steel?

Use the photograph below to answer questions 15 and 16.

15. The photograph above shows a campfire with water heating in a cooking pot. Does the water experience a chemical or physical change as its temperature rises? Explain.

16. Are the logs on the campfire experiencing a chemical or physical change? How can you tell?

Part 3 Open Ended

Record your answers on a sheet of paper.

Use the photograph below to answer questions 17 and 18.

17. What would happen if you left the glass of cold water shown in the photograph above in sunlight for several hours? Describe how some physical properties of the water would change.

18. What properties of the water would not change? Explain why the density of the water would or would not change.

19. Suppose you have three different-sized balls, each having a different mass. Can you tell which has the greatest density simply by feeling which is heavier? Explain why or why not.

20. Describe the pH scale. What is its use?

21. What are some things you might observe during an experiment that would indicate a chemical change may be occurring? Explain which of these may, instead, be the result of a physical change.

Test-Taking Tip

Answer Every Part Make sure each part of the question is answered when listing discussion points. For example, if the question asks you to compare and contrast, make sure you list both similarities and differences.