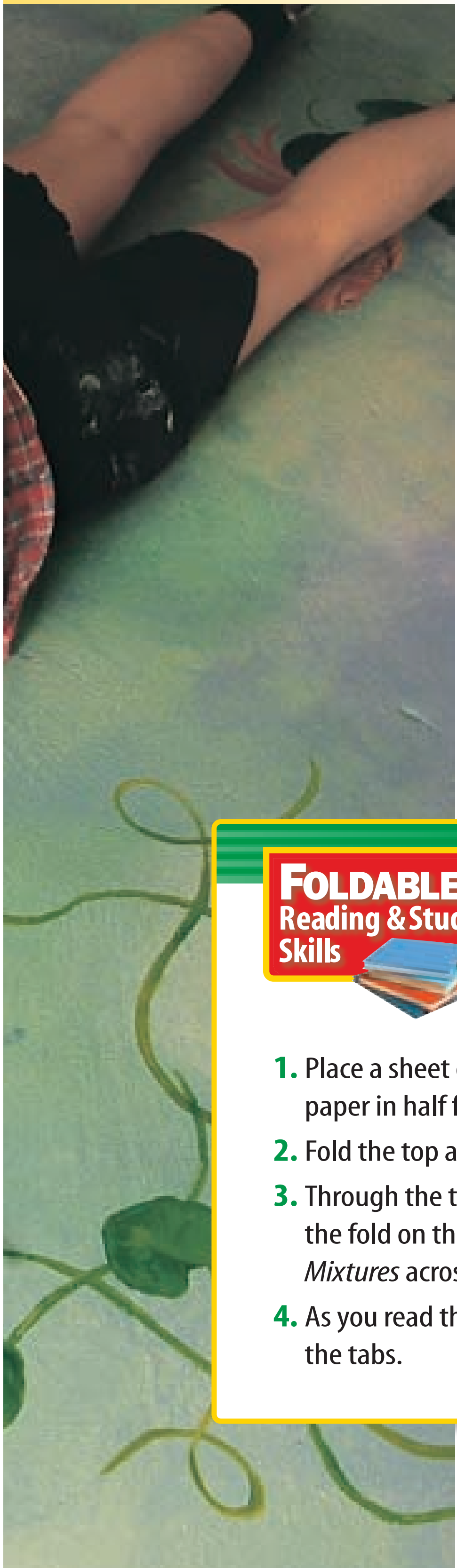
CHAPTER 17

Classification of Matter

Paintings like this one are mixtures that combine many different chemical pigments. They can be mixed skillfully to achieve a well blended color or the artist can intentionally show the individual pigments within one brush stroke. All the materials in a painting can undergo physical and chemical changes with time. In this chapter, you will learn about mixtures and how to separate them. You also will learn about the physical and chemical properties of matter and you'll learn to distinguish between physical and chemical change.

What do you think?

Science Journal Look at the picture below with a classmate. Discuss what you think this might be or what is happening. Here's a hint: *Let the layers settle it.* Write your answer or your best guess in your Science Journal.



EXPLORE ACTIVITY

Imagine yourself marooned on an island without fresh water. What could you do to get clean drinking water? Could you purify seawater? One way you could do this is distillation. Discover how to purify water in this activity.

Demonstrate the distillation of water

1. Place 75 mL of water in a 200-mL beaker and add 20 drops of red food coloring.
2. Place the beaker on a hot plate.
3. Add ice to an evaporating dish until the dish is half full. Place the evaporating dish on the beaker as shown in the photo.
4. Turn on the hot plate and slowly bring the water and food coloring solution to a boil.
5. After boiling the solution for five minutes, carefully remove the evaporating dish using tongs. Touch the drops of liquid on the bottom of the dish to a piece of white paper.
6. Observe the liquid on the paper.

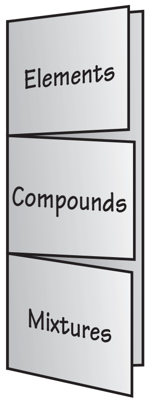
Observe

In your Science Journal, discuss where the liquid came from. What was in the beaker that is not in the liquid on the paper?

Before You Read

FOLDABLES Reading & Study Skills

Making a Vocabulary Study Fold **Make the following Foldable to ensure you have understood the content by defining the vocabulary terms from this chapter.**



1. Place a sheet of paper in front of you so the short side is at the top. Fold the paper in half from the left side to the right side.
2. Fold the top and bottom in. Unfold the paper so three sections show.
3. Through the top thickness of the paper, cut along each of the fold lines to the fold on the left, forming three tabs. Label *Elements, Compounds,* and *Mixtures* across the front of the tabs as shown.
4. As you read the chapter, define each term and list examples of each under the tabs.

SECTION 1

Composition of Matter

As You Read

What You'll Learn

- **Define** substances and mixtures.
- **Identify** elements and compounds.
- **Compare and contrast** solutions, colloids, and suspensions.

Vocabulary

substance
element
compound
heterogeneous mixture
homogeneous mixture
solution
colloid
Tyndall effect
suspension

Why It's Important

You can form a better picture of your world when you understand the concepts of elements and compounds.

Pure Substances

Have you ever seen a picture hanging on a wall that looked just like a real painting? Did you have to touch it to find out? If so, the rough or smooth surface told you which it was. Each material has its own properties. The properties of materials can be used to classify them into general categories.

Materials are made of a pure substance or a mixture of substances. A pure **substance,** or simply a substance, is either an element or a compound. Substances cannot be broken down into simpler components and still maintain the properties of the original substance. Some substances you might recognize are helium, aluminum, water, and salt.

Elements All substances are built from atoms. If all the atoms in a substance are alike, that substance is an **element.** The graphite in your pencil point and copper coating of most pennies are examples of elements. In graphite all the atoms are carbon atoms, and in a copper sample, all the atoms are copper atoms. The metal substance beneath the copper in the penny is another element—zinc. There are 90 elements found in nature. More than 20 others have been made in laboratories, but most are unstable and exist only for short periods of time. Some elements you might recognize are shown in **Figure 1.** Some less common elements and their properties are shown in **Figure 2.**

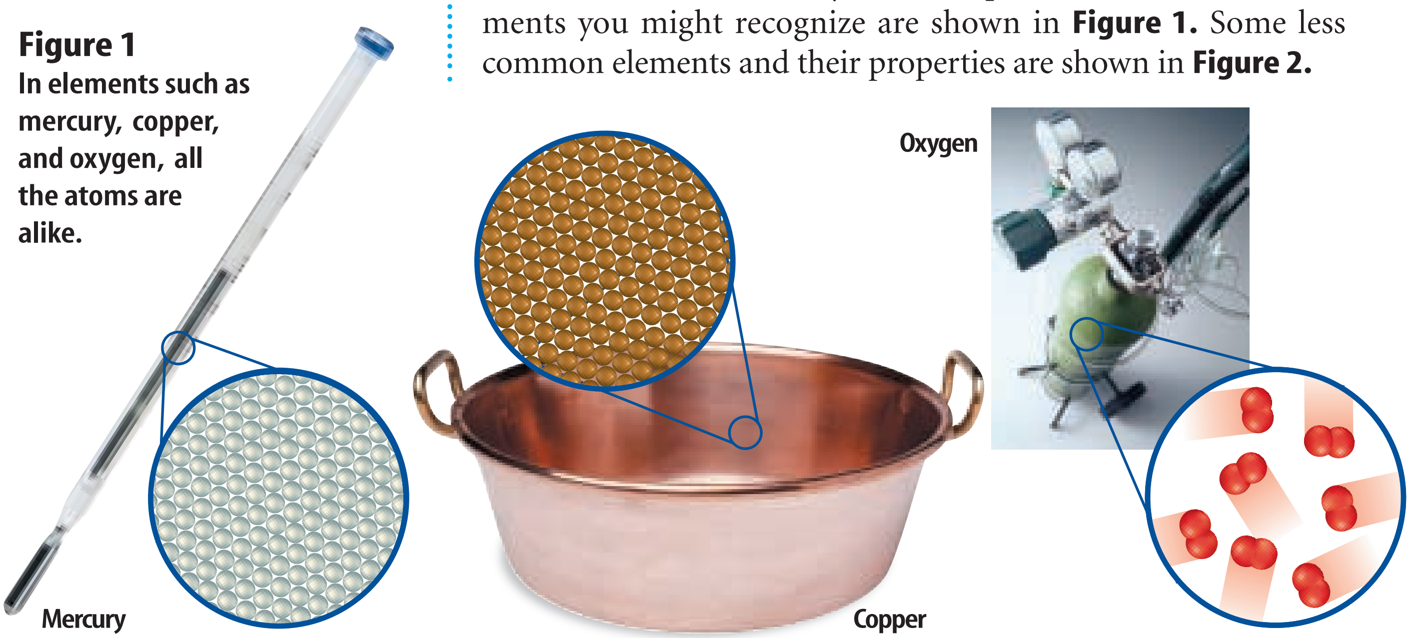


Figure 1
In elements such as mercury, copper, and oxygen, all the atoms are alike.

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NATIONAL GEOGRAPHIC

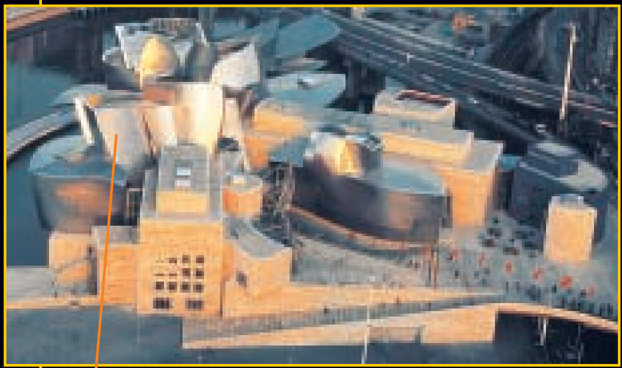
VISUALIZING ELEMENTS

Figure 2

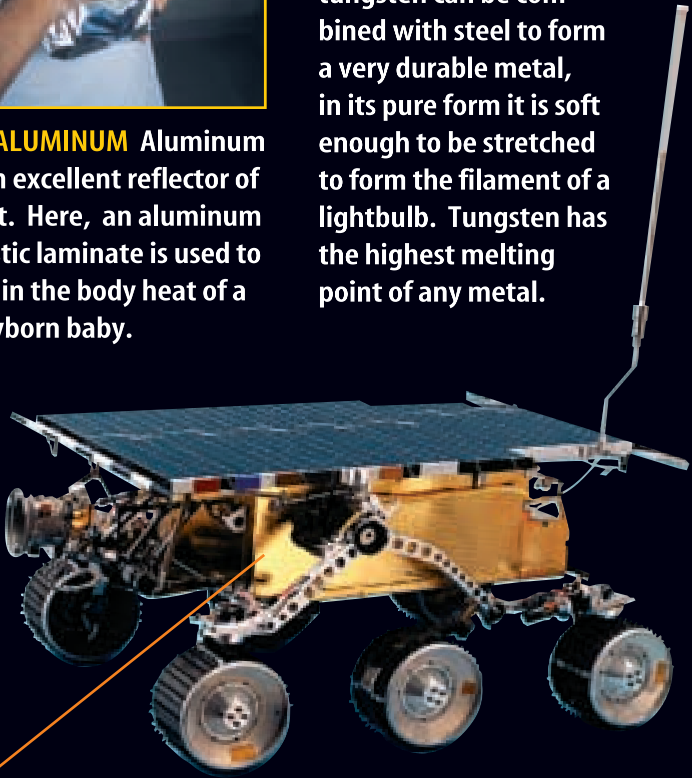
Most of us think of gold as a shiny yellow metal used to make jewelry. However, it is an element that is also used in more unexpected ways, such as in spacecraft parts. On the other hand, some less common elements, such as americium (am-uh-REE-see-um), are used in everyday objects. Some elements and their uses are shown here.

▲ **ALUMINUM** Aluminum is an excellent reflector of heat. Here, an aluminum plastic laminate is used to retain the body heat of a newborn baby.

▲ **TUNGSTEN** Although tungsten can be combined with steel to form a very durable metal, in its pure form it is soft enough to be stretched to form the filament of a lightbulb. Tungsten has the highest melting point of any metal.



▲ **TITANIUM** (Tie-TAY-nee-um) Parts of the exterior of the Guggenheim Museum in Bilbao, Spain, are made of titanium panels. Strong and lightweight, titanium is also used for body implants.



▲ **GOLD** Gold's resistance to corrosion and its ability to reflect infrared radiation make it an excellent coating for space vehicles. The electronic box on the six-wheel Sojourner Rover, above, part of NASA's Pathfinder 1997 mission to Mars, is coated with gold.

▲ **LEAD** Because lead has a high density, it is a good barrier to radiation. Dentists drape lead aprons on patients before taking x-rays of the patient's teeth to reduce radiation exposure.

◄ **AMERICIUM** Named after America, where it was first produced, americium is a component of this smoke detector. It is a radioactive metal that must be handled with care to avoid contact.

Compounds Two or more elements can combine to form substances called compounds. A **compound** is a substance in which the atoms of two or more elements are combined in a fixed proportion. For example, water is a compound in which two atoms of the element hydrogen combine with one atom of the element oxygen. Chalk contains calcium, carbon and oxygen in the proportion of one atom of calcium and carbon to three atoms of oxygen.

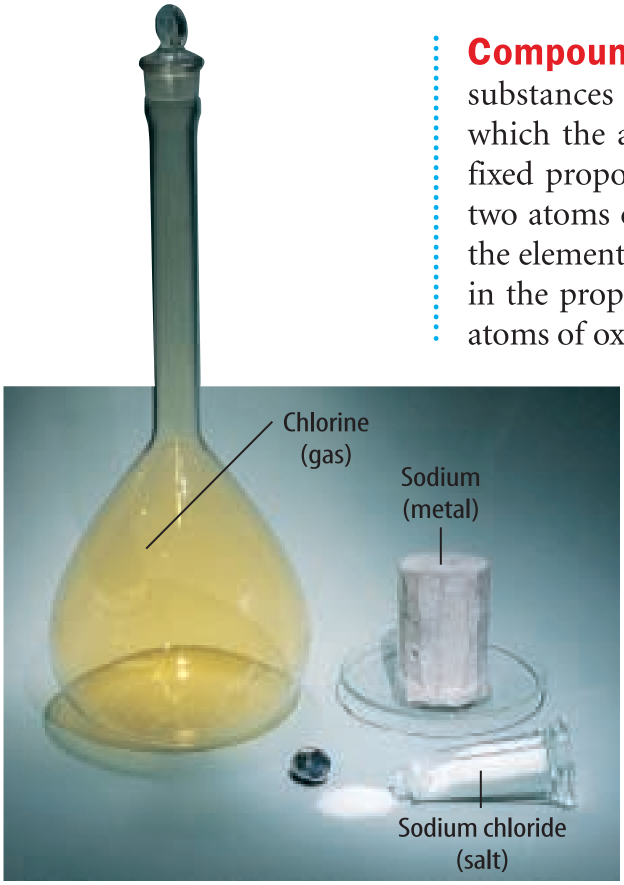


Figure 3
Chlorine gas and sodium metal combine dramatically in the ratio of one to one to form sodium chloride.

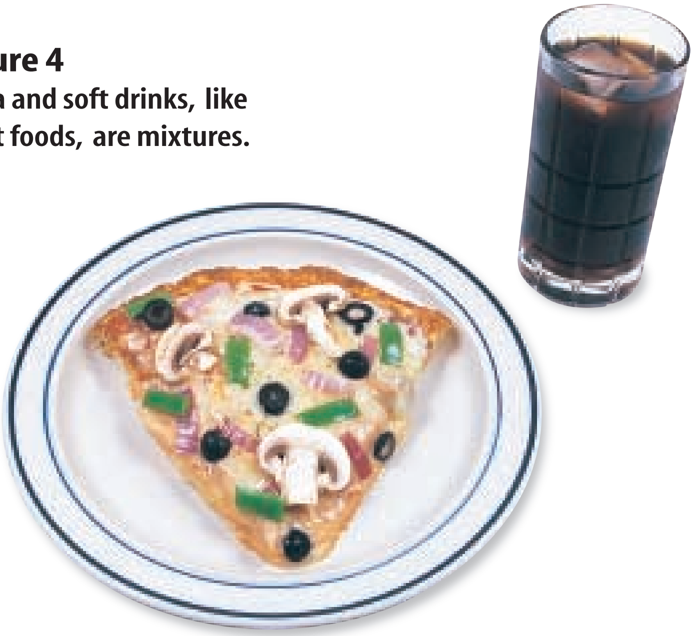
Reading Check *How are elements and compounds related?*

Can you imagine yourself putting something made from a silvery metal and a greenish-yellow, poisonous gas on your food? You might have shaken some on your food today—table salt is a chemical compound that fits this description. Even though it looks like white crystals and adds flavor to food, its components—sodium and chlorine—are neither white nor salty, as shown in **Figure 3.** Like salt, compounds usually look different from the elements in them.

Mixtures

Are pizza and a soft drink one of your favorite lunches? If so, you enjoy two foods that are classified as mixtures—but two different kinds of mixtures. A mixture, such as the pizza or soft drink shown in **Figure 4,** is a material made up of two or more substances that can be easily separated by physical means.

Figure 4
Pizza and soft drinks, like most foods, are mixtures.



Heterogeneous Mixtures Unlike compounds, mixtures do not always contain the same proportions of the substances that make them up—the pizza chef doesn't measure precisely how much of each topping is sprinkled on. You easily can see most of the toppings on a pizza. A mixture in which different materials can be distinguished easily is called a **heterogeneous** (het uh ruh JEE nee us) **mixture.** Granite, concrete, and dry soup mixes are other heterogeneous mixtures you can recognize.

You might be wearing another heterogeneous mixture—clothing made of permanent-press fabric like that seen in **Figure 5A.** Such fabric contains fibers of two materials—polyester and cotton. The amounts of polyester and cotton can vary from one article of clothing to another, as shown by the label. Though you might not be able to distinguish the two fibers just by looking at them with your naked eye, you probably could tell using a microscope, as shown in **Figure 5B.** Therefore, a permanent-press fabric is also a heterogeneous mixture.

Most of the substances you come in contact with every day are heterogeneous mixtures. Some components are easy to see, like the ingredients in pizza, but others are not. In fact, the component you see can be a mixture itself. For example, the cheese in pizza is also a mixture, but you cannot see the individual components. Cheese contains many compounds, such as milk proteins, butterfat, colorings, and other food additives.

TRY AT HOME **Mini LAB**

Separating Mixtures

Procedure

1. Put equal amounts of **soil, clay, sand, gravel,** and **pebbles** in a **clear-plastic container.** Add **water** until the container is almost full. Wash your hands well after handling the materials.
2. Stir or shake the mixture thoroughly. Predict the order in which the materials will settle.
3. Observe what happens and compare your observations to your predictions.

Analysis

1. In what order did the materials settle?
2. Explain why the materials settled in the order they did.

Figure 5
Heterogeneous mixtures can be hard to detect.

A You can't tell at a glance that this fabric is a mixture of cotton and polyester.

B With a microscope however, the difference between the two fibers is clear—the polyester fiber is perfectly smooth and the cotton is rough.

Magnification: 600×

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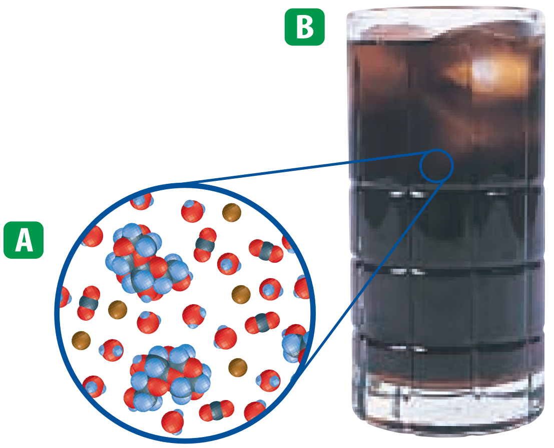


Figure 6
A soft drink can be either heterogeneous or homogeneous.
A As carbon dioxide fizzes out it is a heterogeneous mixture.
B The resulting flat soft drink is a homogeneous mixture of water, sugar, flavor, color and some remaining carbon dioxide.

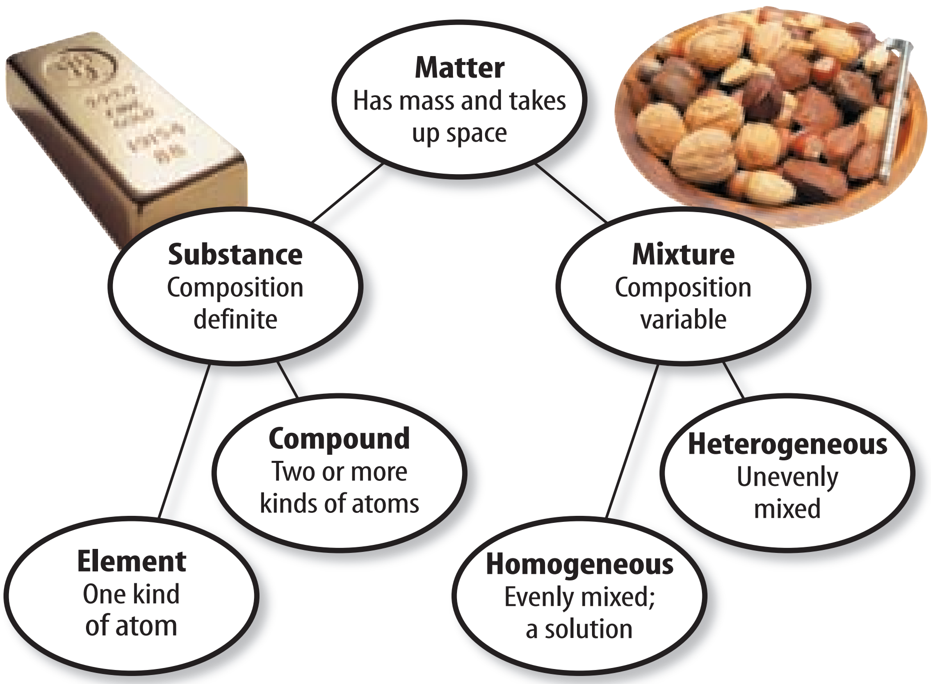
Homogeneous Mixtures Remember that soft drink you had with your pizza? Regular and diet soft drinks look alike but taste different and contain different amounts of calories.

Cold soft drinks in sealed bottles are examples of homogeneous mixtures. A **homogeneous** (hoh muh JEE nee us) **mixture** contains two or more gaseous, liquid, or solid substances blended evenly throughout. Soft drinks contain water, sugar, flavoring, coloring, and carbon dioxide gas. **Figure 6** will help you to visualize these particles in a liquid soft drink.

Vinegar is another homogeneous mixture. It appears clear even though it is made up of particles of acetic acid mixed with water. Another name for homogeneous mixtures like vinegar and a cold soft drink is solution. A **solution** is a homogeneous mixture of particles so small that they cannot be seen with a microscope and will never settle to the bottom of their container. Solutions remain constantly and uniformly mixed. The differences between substances and mixtures are summarized in **Figure 7.**

✔ Reading Check *What kind of mixture is a solution?*

Figure 7
All matter can be divided into substances and mixtures.

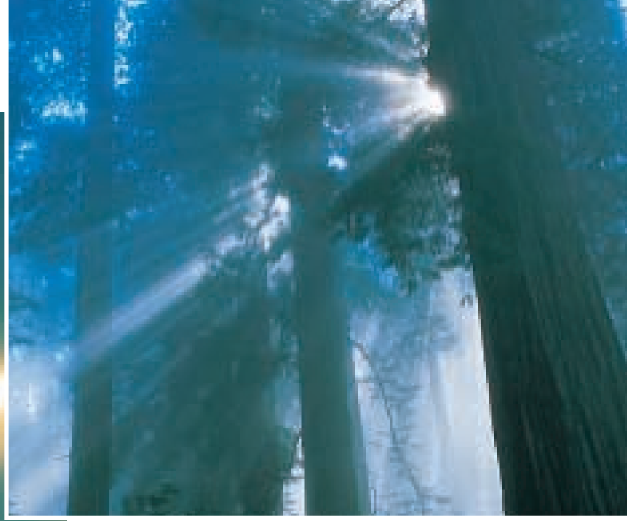


Colloids Milk is an example of a specific kind of mixture called a colloid. Like a heterogeneous mixture, it contains water, fats, and proteins in varying proportions. Like a solution, its components won't settle if left standing. A **colloid** (KAH loyd) is a type of mixture that never settles. Its particles are larger than those in solutions but not heavy enough to settle. The word *colloid* comes from a Greek word for glue. The first colloids studied were in gelatin, a source of some types of glue.

Paint is an example of a liquid with suspended colloid particles. Gases and solids can contain colloidal particles, too. For example, fog consists of particles of liquid water suspended in air, and smoke contains solids suspended in air.

Figure 8
Fog is a colloid composed of water droplets suspended in air.

A The light from the headlights is scattered by fog.



B The same colloid allows you to see the sunlight as it streams through the trees.

Detecting Colloids One way to distinguish a colloid from a solution is by its appearance. Fog appears white because its particles are large enough to scatter light as shown in **Figure 8.** Sometimes it is not so obvious that a liquid is a colloid. For example, some shampoos and gelatins are colloids called gels that appear almost clear. You can tell for certain if a liquid is a colloid by passing a beam of light through it, as shown in **Figure 9.** A light beam is invisible as it passes through a solution, but can be seen readily as it passes through a colloid. This occurs because the particles in the colloid are large enough to scatter light, but those in the solution are not. This scattering of light by colloidal particles is called the **Tyndall effect.**

Reading Check *How can you distinguish a colloid from a solution?*

Figure 9
Because of the Tyndall effect, a light beam is scattered by the colloid suspension on the right, but passes invisibly through the solution on the left.

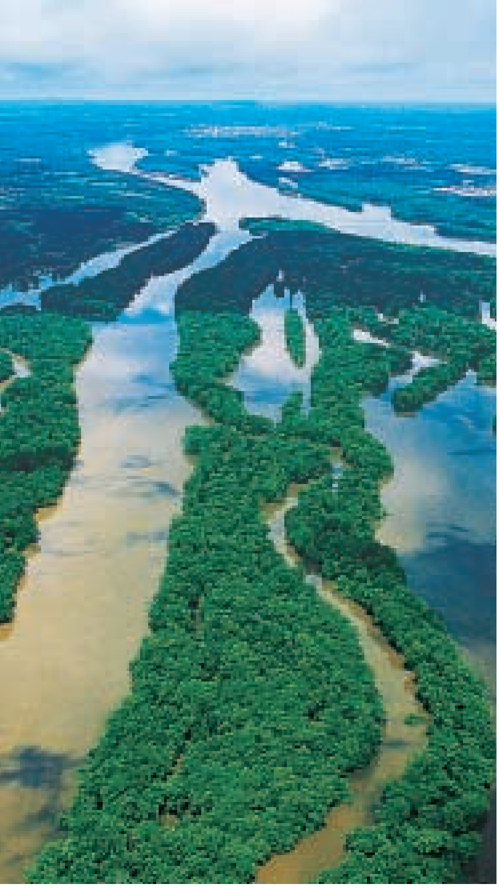


Figure 10
Layers of mud build up until they can be thousands of feet thick. The mud deposited by the Mississippi River is said to be more than 10,000 m thick.

Table 1 Comparing Solutions, Colloids, and Suspensions

Description	Solutions	Colloids	Suspensions
Settle upon standing?	no	no	yes
Separate using filter paper?	no	no	yes
Particle Size	0.1–1 nm	1–100 nm	$>$ 100 nm
Scatter Light	no	yes	yes

Suspensions Some mixtures are neither solutions nor colloids. One example is muddy pond water. If pond water stands long enough, some mud particles will fall to the bottom, and the water clears. Pond water is a **suspension,** which is a heterogeneous mixture containing a liquid in which visible particles settle. **Table 1** summarizes the properties of different types of mixtures.

Earth Science INTEGRATION

River deltas are a large scale example of how a suspension settles. Rivers flow swiftly through narrow channels, picking up soil and debris along the way. As the river widens, it flows more slowly. Suspended particles settle forming deltas at the mouth, as shown in **Figure 10.**

Section 1 Assessment

1. How is a compound similar to a homogeneous mixture? How is it different?
2. Distinguish between a substance and a mixture. Give examples.
3. Describe the differences between colloids and suspensions.
4. Why is vinegar considered a solution?
5. **Think Critically** Why do the words "Shake well before using" on a bottle of fruit juice indicate that the fruit juice is a suspension?

Skill Builder Activities

6. **Comparing and Contrasting** In terms of suspensions and colloids, compare and contrast a glass of milk and a glass of fresh-squeezed orange juice. **For more help, refer to the Science Skill Handbook.**
7. **Communicating** In your Science Journal, make a list of the liquid products you find in your home. Classify each as a solution, a colloid, or a suspension. **For more help, refer to the Science Skill Handbook.**

Activity

Elements, Compounds, and Mixtures

Elements, compounds, and mixtures all contain atoms. In elements, the atoms all have the same identity. In compounds, two or more elements have been combined in a fixed ratio. In a mixture, the ratio of substances can vary.

What You'll Investigate

What are some differences among elements, compounds, and mixtures?

Materials

plastic freezer bag containing the following labeled items:

copper wire
small package of salt
pencil
aluminum foil
chalk (calcium carbonate)
piece of granite
sugar water in a vial

Goals

- **Determine** whether several materials are elements, compounds, or mixtures.

Safety Precautions

Procedure

1. Copy the data table into your Science Journal and use it to record your observations.
2. Obtain a bag of objects. Identify each object and classify it as an element, compound, heterogeneous mixture, or homogeneous mixture. The elements appear in the periodic table. Compounds are named as examples in Section 1.

Conclude and Apply

1. If you know the name of a substance, how can you find out whether or not it is an element?

Classification of Objects

Object	Identity	Classification
1		
2		
3		
4		
5		
6		
7		

2. **Examine** the contents of your refrigerator at home. Classify what you find as elements, compounds, or mixtures.
3. Then, identify whether the mixtures are homogeneous or heterogeneous, and whether they are colloids or suspensions.

Communicating Your Data

Enter your data in the data table and compare your findings with those of your classmates. **For more help, refer to the Science Skill Handbook.**

SECTION

2 Properties of Matter

As You Read

What You'll Learn

- **Identify** substances using physical properties.
- **Compare and contrast** physical and chemical changes.
- **Compare and contrast** chemical and physical properties.
- **Determine** how the law of conservation of mass applies to chemical changes.

Vocabulary

physical property
physical change
distillation
chemical property
chemical change
law of conservation of mass

Why It's Important

Understanding chemical and physical properties can help you use materials properly.

Physical Properties

You can stretch a rubber band, but you can't stretch a piece of string very much, if at all. You can bend a piece of wire, but you can't easily bend a matchstick. In each case, the materials change shape, but the identity of the substances—rubber, string, wire, wood—does not change. The abilities to stretch and bend are physical properties. Any characteristic of a material that you can observe or attempt to observe without changing the identity of the substances that make up the material is a **physical property.** Examples of other physical properties are color, shape, size, melting point, and boiling point. What physical properties can you use to describe the items in **Figure 11?**

Appearances How would you describe a tennis ball? You could begin by describing its shape, color, and state of matter. For example, you might describe the tennis ball as a brightly colored hollow sphere. You can measure some physical properties, too. For instance, you could measure the diameter of the ball. What physical property of the ball is measured with a balance?

To describe a soft drink in a cup, you could start by calling it a liquid with a brown color and sweet taste. You could measure its volume and temperature. Each of these characteristics is a physical property of that soft drink.

Figure 11
Appearance is the most obvious physical property. *How would you describe the appearance of these items?*

Figure 12
The best way to separate substances depends on their physical properties.

A **Size is the property that helps separate poppy seeds from sunflower seeds.**

B **Magnetism readily separates iron from sand.**

Behavior Some physical properties describe the behavior of a material or a substance. As you might know, objects that contain iron, such as a safety pin, are attracted by a magnet. Attraction to a magnet is a physical property of the substance iron. Every substance has a specific combination of physical properties that make it useful for certain tasks. Some metals, such as copper, can be drawn out into wires. Others, such as gold, can be pounded into sheets as thin as 0.1 micrometers (μm), about 4 millionths of an inch. This property of gold makes it useful for decorating picture frames and other objects. Gold that has been beaten or flattened in this way is called gold leaf.

Think again about your soft drink. If you knock over the cup, the drink will spread out over the table or floor. If you knock over a jar of molasses however, it does not flow as easily. The ability to flow is a physical property of liquids.

Using Physical Properties to Separate Do you lick the icing from the middle of a sandwich cookie before eating the cookie? If you do, you are using physical properties to identify the icing and separate it from the rest of the cookie. **Figure 12A** shows a mixture of poppy seeds and sunflower seeds. You can identify the two kinds of seeds by differences in color, shape, and size. By sifting the mixture, you can separate the poppy seeds from the sunflower seeds quickly because their sizes differ.

Now look at the mixture of iron filings and sand shown in **Figure 12B.** You probably won't be able to sift out the iron filings because they are similar in size to the sand particles. What you can do is pass a magnet through the mixture. The magnet attracts only the iron filings and pulls them from the sand. This is an example of how a physical property, such as magnetic attraction, can be used to separate substances in a mixture. Something like this is done to separate iron for recycling.

Environmental Science
INTEGRATION

Recycling conserves natural resources. In some large recycling projects, it is difficult to separate aluminum metal from scrap iron. What physical properties of the two metals would help separate them?

Mini LAB

Identifying Changes

Procedure

WARNING: *Clean up any spills promptly. Potassium permanganate can stain clothing.*

1. Add **water** to a **250-mL beaker** until it is half-full.
2. Add a crystal of **potassium permanganate** to the water and observe what happens.
3. Add 1 g of **sodium hydrogen sulfite** to the solution and stir it until the solution becomes colorless.

Analysis

1. Is dissolving a chemical or a physical change?
2. What evidence of a chemical change did you see?

Physical Change

If you break a piece of chewing gum, you change some of its physical properties—its size and shape. However, you have not changed the identity of the materials that make up the gum. Each piece still tastes and chews the same.

The Identity Remains the Same The changes in state that you have studied are all examples of physical changes. When a substance freezes, boils, evaporates, or condenses, it undergoes physical changes. A change in size, shape, or state of matter is called a **physical change.** These changes might involve energy changes, but the kind of substance—the identity of the element or compound—does not change.

Reading Check *Does a change in state mean that a new substance has formed? Explain.*

Iron is a substance that can change states if it absorbs or releases enough energy—at high temperatures, it melts. However, in both the solid and liquid state, iron has physical properties that identify it as iron. Color changes can accompany a physical change, too. For example, when iron is heated it first glows red. Then, if it is heated to a higher temperature, it turns white, as shown in **Figure 13.**

Using Physical Change to Separate A cool drink of water is something most people take for granted, but in some parts of the world, drinkable water is scarce. Not enough drinkable water can be obtained from wells. Many such areas that lie close to the sea obtain drinking water by using physical properties of water to separate it from the salt. One of these methods, which uses the property of boiling point, is a type of distillation.

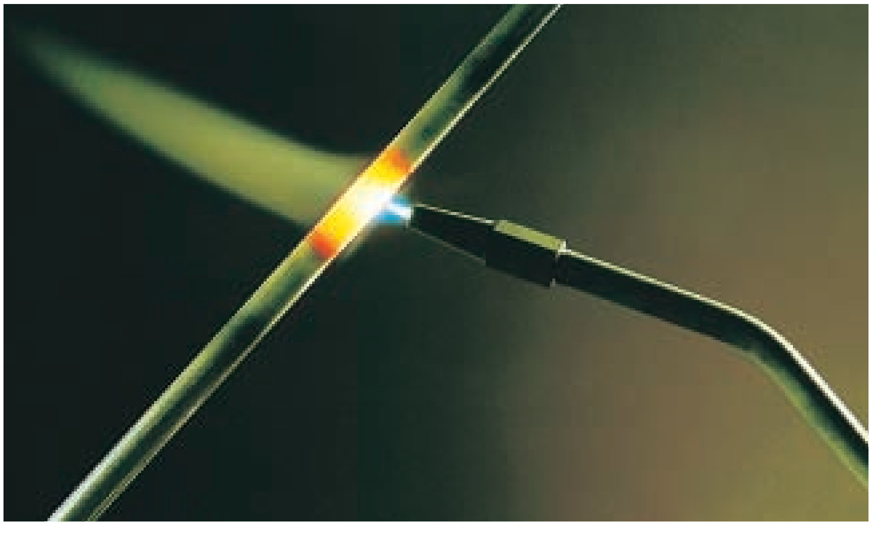


Figure 13
Heating iron raises its energy level and it changes color. These energy changes are physical changes because it is still iron.

Distillation **Distillation** is a process for separating substances in a mixture by evaporating a liquid and recondensing its vapor. It usually is done in the laboratory using an apparatus similar to that shown in **Figure 14.** As you can see, the liquid vaporizes and condenses, leaving the solid material behind.

Two liquids having different boiling points can be separated in a similar way. The mixture is heated slowly until it begins to boil. Vapors of the liquid with the lowest boiling point form first and are condensed and collected. Then, the temperature is increased until the second liquid boils, condenses and is collected. Distillation is used often in industry. For instance, natural oils such as mint are distilled.

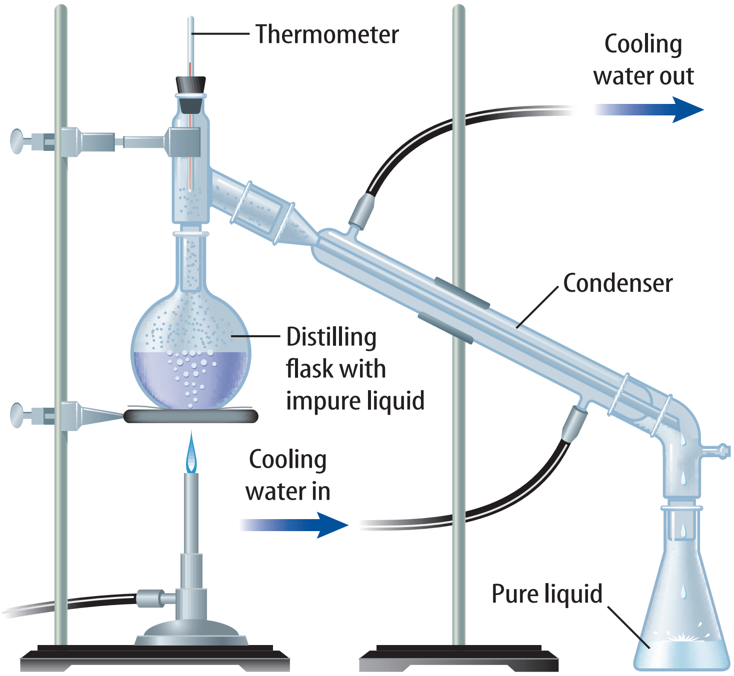


Figure 14
Distillation can easily separate liquids from solids dissolved in them. The liquid is heated until it vaporizes and moves up the column. Then, as it touches the water-cooled surface of the condenser, it becomes liquid again.

Chemical Properties and Changes

You probably have seen warnings on cans of paint thinners and lighter fluids for charcoal grills that say these liquids are flammable (FLA muh buhl). The tendency of a substance to burn, or its flammability, is an example of a chemical property because burning produces new substances during a chemical change. A **chemical property** is a characteristic of a substance that indicates whether it can undergo a certain chemical change. Many substances used around the home, such as lighter fluids, are flammable. Knowing which ones are flammable helps you to use them safely.

A less dramatic chemical change can affect some medicines. Look at **Figure 15.** You probably have seen bottles like this in a pharmacy. Many medicines are stored in dark bottles because they contain compounds that share chemical properties; that is, they can change chemically if they are exposed to light.

Figure 15
The brown color of these bottles tells you that these vitamins may react to light. Reaction to light is a chemical property.

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Detecting Chemical Change

If you leave a pan of chili cooking unattended on the stove for too long, your nose soon tells you that something is wrong. Instead of a spicy aroma, you detect an unpleasant smell that alerts you that something is burning. This burnt odor is a clue telling you that a new substance has formed.

Earth Science INTEGRATION

In a thunderstorm, light and sound tell you that changes have taken place. The pungent smell of ozone indicates that a chemical reaction also took place. Lightning converts oxygen gas, O_2, into ozone, O_3. Ozone is unstable and soon breaks up forming oxygen again.

The Identity Changes The smell of rotten eggs and the formation of rust on bikes or car fenders, are signs that a chemical change has taken place. A change of one substance to another is a **chemical change.** The foaming of an antacid tablet in a glass of water and the smell in the air after a thunderstorm are other signs of new substances being produced. In some chemical changes, a rapid release of energy—detected as heat, light, and sound—is a clue that changes are occurring.

Reading Check *What is a chemical change?*

Clues, such as heat, cooling, or the formation of bubbles or solids in a liquid, are helpful indicators that a reaction is taking place. However, the only sure proof is that a new substance is produced. Consider the following example. The heat, light, and sound produced when hydrogen gas combines with oxygen in a rocket engine are clear evidence that a chemical reaction has taken place. But no clues announce the reaction that takes place when iron combines with oxygen to form rust because the reaction takes place so slowly. The only clue that iron has changed into a new substance is the presence of rust. Burning and rusting are chemical changes because new substances form. You sometimes can follow the progress of a chemical reaction visually. For example, you can see silver tarnish being removed in **Figure 16.**

Figure 16
Some reactions are visible only after they take place.

A Tarnish mars the surface of this silver pitcher.

B You can remove the tarnish using another chemical reaction with aluminum foil and baking soda.

C The tarnish is gone and no silver is lost.

Using Chemical Change to Separate One case where you might separate substances using a chemical change is in cleaning tarnished silver. Tarnish is silver sulfide formed from sulfur compounds in the air. It can be changed back into silver using a chemical reaction. To do this you place the tarnished item in a pot of water containing baking soda and some crumpled aluminum foil. Then you heat the pot. The procedure and its results are shown in **Figure 16.**

You don't usually separate substances using chemical changes in the home. In industry and chemical laboratories, however, this kind of separation is common. For example, many metals are separated from their ores and then purified using chemical changes.

Math Skills Activity

Calculations with the Law of Conservation of Mass

When a chemical reaction takes place, the total mass of the reactants equals the total mass of the products. The total number of atoms of reactants also equals the total number of atoms of products.

Example Problem

In the following reaction, 18 g of hydrogen react completely with 633 g of chlorine. How many grams of HCl are formed? $H_2 + Cl_2 \rightarrow 2HCl$

Solution

1. *This is what you know.* mass H_2 = 18 g; mass Cl_2 = 633 g
2. *This is what you need to find:* mass of HCl
3. *This is the equation you need to use:* mass reactants = mass products
4. *Solve for the mass of HCl:* $(g\ H_2 + g\ Cl_2) = (g\ HCl)$

   Substitute the known values: $(18\ g + 633\ g) = 651\ g\ HCl$

   Check your answer by subtracting the mass of H_2 from the mass of HCl. Do you obtain the mass of the Cl_2?

Practice Problems

1. In the following reaction, 24 g of CH_4 react with 96 g of O_2 to form 66 g of CO_2. How many grams of H_2O are formed? $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
2. In the following equation, 54.0 g of Al react with 409.2 g of $ZnCl_2$ to form 196.2 g of Zn metal. How many grams of $AlCl_3$ are formed? $2Al + 3ZnCl_2 \rightarrow 3Zn + 2AlCl_3$

For more help, refer to the Math Skill Handbook.

A Flowing water shaped and smoothed these rocks in a physical process.

B Both chemical and physical changes shaped the famous White Cliffs of Dover lining the English Channel.

Figure 17
Weathering can involve physical or chemical change.

Weathering—Chemical or Physical Change?

The forces of nature continuously shape Earth's surface. Rocks split, deep canyons are carved out, sand dunes shift, and curious limestone formations decorate caves. Do you think these changes, often referred to as weathering, are physical or chemical? The answer is both. Geologists, who use the same criteria that you have learned in this chapter, say that some weathering changes are physical and some are chemical.

Physical Large rocks can split when water seeps into small cracks, freezes, and expands. However, the smaller pieces of newly exposed rock still have the same properties as the original sample. This is a physical change. Streams can cut through softer rock, forming canyons, and can smooth and sculpt harder rock, as shown in **Figure 17A.** In each case, the stream carries rock particles far downstream before depositing them. Because the particles are unchanged, the change is a physical one.

Chemical In other cases, the change is chemical. For example, solid calcium carbonate, a compound found in limestone, does not dissolve easily in water. However, when the water is even slightly acidic, as it is when it contains some dissolved carbon dioxide, calcium carbonate reacts. It changes into a new substance, calcium hydrogen carbonate, which does dissolve in water. This change in limestone is a chemical change because the identity of the calcium carbonate changes. The White Cliffs of Dover, shown in **Figure 17B,** are made of limestone and undergo such chemical changes, as well as physical changes. A similar chemical change produces caves and the icicle-shaped rock formations that often are found in them.

SCIENCE Online

Research Visit the Glencoe Science Web site at **science.glencoe.com** to find out more about cave formations. Communicate to your class what you learn.

CLICK HERE

The Conservation of Mass

Wood is combustible, or burnable. As you just learned this is a chemical property. Suppose you burn a large log in the fireplace, as shown in **Figure 18,** until nothing is left but a small pile of ashes. Smoke, heat, and light are given off and the changes in the appearance of the log confirm that a chemical change took place. At first, you might think that matter was lost during this change because the pile of ashes looks much smaller than the log did. In fact, the mass of the ashes is less than that of the log. However, suppose that you could collect all the oxygen in the air that was combined with the log during the burning and all the smoke and gases that escaped from the burning log and measure their masses, too. Then you would find that no mass was lost after all.

Not only is no mass lost during burning, mass is not gained or lost during any chemical change. In other words, matter is neither created nor destroyed during a chemical change. According to the **law of conservation of mass,** the mass of all substances that are present before a chemical change equals the mass of all the substances that remain after the change.

Figure 18
This reaction appears to be destroying these logs. When it is over, only ashes will remain. Yet you know that no mass is lost in a chemical reaction. *How can you explain this?*

Reading Check ***Explain what is meant by the law of conservation of mass.***

Section 2 Assessment

1. In terms of substances, explain why evaporation of water is a physical change and not a chemical change.
2. Name four physical properties you could use to describe a liquid.
3. Why is flammability a chemical property rather than a physical property?
4. How does the law of conservation of mass apply to chemical changes?
5. **Think Critically** The law of conservation of mass applies to physical changes as well as to chemical changes. How might you demonstrate this law for melting ice and distillation of water?

Skill Builder Activities

6. **Drawing Conclusions** What evidence tells you that chemical and physical changes take place in a candle as it burns? **For more help, refer to the Science Skill Handbook.**
7. **Solving One-Step Equations** Two chemicals with a combined mass of 25.48 g react in a flask that has a mass of 142.05 g. A gas is produced that totally escapes into a flask that has an empty mass of 141.65 g. After the reaction, the first flask and its contents have a mass of 167.16 g. Calculate the total mass of the second flask and gas. **For more help, refer to the Math Skill Handbook.**

Activity Design Your Own Experiment

Checking Out Chemical Changes

Mixing materials together does not always produce a chemical change. You must find evidence of a new substance with new properties being produced before you can conclude that a chemical change has taken place. Try this activity and use your observation skills to deduce what kind of change has occurred.

Recognize the Problem

What evidence indicates a chemical change?

Form a Hypothesis

Think about what happens when small pieces of limestone are mixed with sand. What happens when limestone is mixed with an acid? Based on these thoughts, form a hypothesis about how to determine when mixing substances together produces a chemical change.

Goals

- **Observe** the results of adding dilute hydrochloric acid to baking soda.
- **Infer** that the production of new substances indicates that a chemical change has occurred.
- **Design** an experiment that allows you to compare the activity of baking soda with that of a product formed when baking soda reacts.

Possible Materials

baking soda
small evaporating dish
hand lens
1*M* hydrochloric acid (HCl)
10-mL graduated cylinder
electric hot plate

Safety Precautions

Limestone

Sand

Test Your Hypothesis

Plan

1. As a group, agree upon a hypothesis and decide how to test it. Write the hypothesis statement.
2. To test your hypothesis, devise a plan to compare two different mixtures. The first mixture consists of 3 mL of hydrochloric acid and 0.5 g of baking soda. The second mixture is 3 mL of hydrochloric acid and the solid product of the first mixture. Describe exactly what you will do at each step.
3. Make a list of the materials needed to complete your experiment.
4. **Design** a table for data and observations in your Science Journal so that it is ready to use as your group observes what happens.

Do

1. Make sure your teacher approves your plan before you start.
2. Read over your entire experiment to make sure that all steps are in logical order.
3. **Identify** any constants and the variables of the experiment.
4. Should you run any test more than once? How will observations be summarized?
5. Assemble your materials and carry out the experiment according to your plan. Be sure to record your results as you work.

Analyze Your Data

1. What happened to the baking soda? Did anything happen to the product formed from the first mixture? Explain why this occurred.
2. What different properties of any new substances did you observe after adding hydrochloric acid to the baking soda?

Draw Conclusions

1. Did the results support your hypothesis? Explain.
2. If you had used vinegar, which contains acetic acid as the acid, do you think a new susbstance would have formed? How could you test this?

Communicating Your Data

Write a description of your observations in your Science Journal. **Compare** your results with those of other groups. **Discuss** your conclusions.

Intriguing Elements

Did you know...

...Silver-white cobalt, which usually is combined with other elements in nature, is used to create rich paint pigments. It can be used to form powerful magnets, treat cancer patients, build jet engines, and prevent disease in sheep.

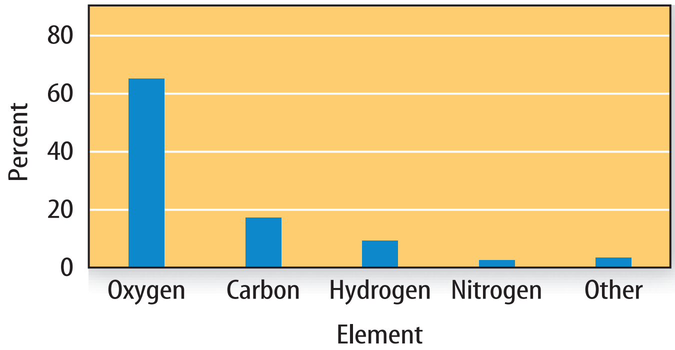
Few scientists have seen the rare and elusive element astatine. Earth's supply is lean—probably only about 28 g of astatine total. Chemically, it's similar to iodine.

...You have something in common with diamonds—carbon. Diamonds form from carbon under extremely high pressures and temperatures deep inside Earth. Carbon is an essential element in living organisms, making up about 18 percent of the human body.

...Gold is the most ductile (stretchable) of all the elements. Just 29 g of gold—about ten wedding bands—can be pulled into a wire

100 km long. That's long enough to stretch from Toledo, Ohio, to Detroit, Michigan, and beyond.

Percent of Chemical Elements in the Human Body



...Zinc makes chewing gum taste better. Up to 0.3 mg of zinc acetate can be added per 1,000 mg of chewing gum to provide a tart, zingy flavor.

Do the Math

1. For kids, the recommended daily allowance (RDA) of zinc is 10 mg. If chewing gum were your only source of zinc, how many milligrams of gum with the maximum amount of zinc would you have to chew to get your RDA of zinc?
2. If you made the thinnest possible gold wire with 100 g of gold, how long would your wire be?
3. If you had 50 atoms of hydrogen, how many atoms each of oxygen, carbon, and nitrogen would you need to have the elements in the same proportion as they are in your body?

Go Further

What is the element most recently discovered by scientists? Go to the Glencoe Science Web site at **science.glencoe.com** to find out. CLICK HERE

CONTENTS

Reviewing Main Ideas

Section 1 Composition of Matter

1. Elements and compounds are substances. A mixture is composed of two or more substances.
2. You can distinguish the different materials in a heterogeneous mixture either using your naked eye or using a microscope.
3. Colloids and suspensions are two types of heterogeneous mixtures. The particles in a suspension will settle eventually. Particles of a colloid will not. *What simple observation tells you that the substance shown here is a colloid?*

4. In a homogeneous mixture, the particles are distributed evenly and are not visible, even when using a microscope. Homogeneous mixtures can be composed of solids, liquids, or gases.
5. A solution is another name for a homogeneous mixture that remains constantly and uniformly mixed. *Is the substance in the container below a solution? How do you know?*

Section 2 Properties of Matter

1. Physical properties are characteristics of materials that you can observe without changing the identity of the substance.

2. Chemical properties indicate what chemical changes substances can undergo. *What type of chemical change might these bottles prevent?*
3. In physical changes, the identities of substances remain unchanged.
4. In chemical changes, the identities of substances change—new substances are formed. *Is the process of cleaning rust with bleach a physical or chemical change?*

5. The law of conservation of mass states that during any chemical change, matter is neither created nor destroyed.

After You Read

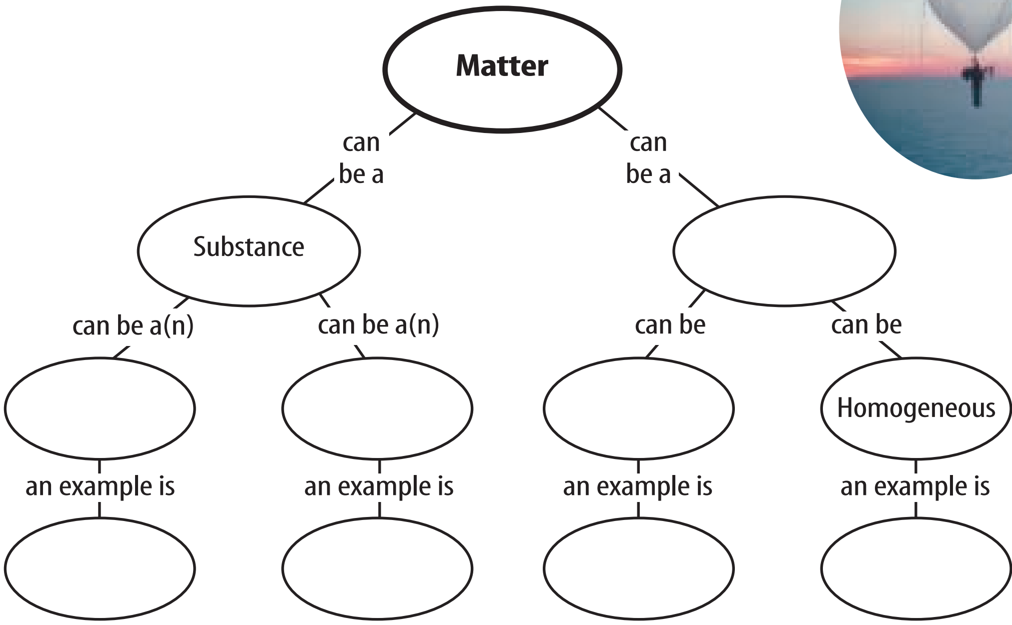
FOLDABLES Reading & Study Skills

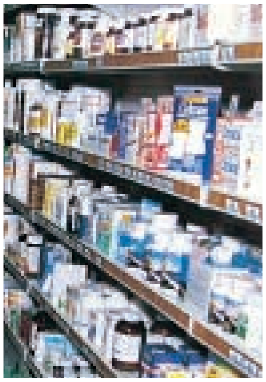
To help you review the classifications of matter, use the Vocabulary Study Fold you made at the beginning of the chapter.

Chapter 17 Study Guide

Visualizing Main Ideas

Complete the concept map below about matter.





Vocabulary Review

Vocabulary Words

a. chemical change
b. chemical property
c. colloid
d. compound
e. distillation
f. element
g. heterogeneous mixture
h. homogeneous mixture
i. law of conservation of mass
j. physical change
k. physical property
l. solution
m. substance
n. suspension
o. Tyndall effect

Study Tip

THE PRINCETON REVIEW

Make sure to read over your class notes after each lesson. Reading them will help you better understand what you've learned, as well as prepare you for the next day's lesson.

Using Vocabulary

Replace the underlined words with the correct vocabulary words.

1. Substances formed from atoms of two or more elements are called mixtures.

2. A colloid is a heterogeneous mixture in which visible particles settle.

3. Freezing, boiling, and evaporation are all examples of chemical change.

4. According to the Tyndall effect, matter is neither created nor destroyed during a chemical change.

5. A mixture in which different materials are easily identified is a homogeneous mixture.

6. Compounds are made from the atoms of two or more colloids.

7. Distillation is a process that can separate two liquids using chemical change.

Chapter 17 Assessment

Checking Concepts

Choose the word or phrase that best answers the question.

1. Bending a copper wire is an example of what type of property?
   A) chemical **C)** conservation
   B) physical **D)** element

2. Which of the following is NOT an element?
   A) water **C)** oxygen
   B) carbon **D)** hydrogen

3. Which of the following is an example of a chemical change?
   A) boiling **C)** evaporation
   B) burning **D)** melting

4. What type of substance is gelatin?
   A) colloid **C)** substance
   B) compound **D)** suspension

5. A visible sunbeam is an example of which of the following?
   A) an element **C)** a suspension
   B) a solution **D)** the Tyndall effect

6. You start to eat some potato chips from an open bag you found in your locker and notice that they taste unpleasant. What do you think might cause this unpleasant taste?
   A) combustion **C)** physical change
   B) chemical change **D)** melting

7. How would you classify the color of a rose?
   A) chemical change **C)** physical change
   B) chemical property **D)** physical property

8. How would you describe the process of evaporating water from seawater?
   A) chemical change **C)** physical change
   B) chemical property **D)** physical property

9. Which of these warnings refers to a chemical property of the material?
   A) Fragile **C)** Handle with Care
   B) Flammable **D)** Shake Well

10. Which of the following is a substance?
    A) colloid **C)** mixture
    B) element **D)** solution

Thinking Critically

11. Describe the contents of a carton of milk using at least four physical properties.

12. Black carbon and the colorless gases hydrogen and oxygen combine to form sugar. How do you know sugar is a compound?

13. The word *colloid* means "gluelike." Why was this term chosen to name certain mixtures?

14. Use a nail rusting in air to explain the law of conservation of mass.

15. Mai says that ocean water is a solution. Tom says that it's a suspension. Can they both be correct? Explain.

Developing Skills

16. **Making and Using Tables** Different colloids can involve different states. For example, gelatin is formed from solid particles in a liquid. Complete this table using these colloids: *smoke, marshmallow, fog,* and *paint.*

Common Colloids

Colloid	Example
Solid in a liquid	Gelatin
Solid in a gas	
Gas in a solid	
Solid in a liquid	
Liquid in a gas	

17. **Comparing and Contrasting** Give examples of solutions, suspensions, and colloids from your daily life and compare and contrast their properties.

18. Using Variables, Constants, and Controls Marcos took a 100-cm^3 sample of a suspension, shook it well, and poured equal amounts into four different test tubes. He placed one test tube in a rack, one in hot water, one in warm water, and the fourth in ice water. He then observed the time it took for each suspension to settle. What was the variable in the experiment? What was one constant?

19. Interpreting Data Hannah started with a 25-mL sample of pond water. Without shaking the sample, she poured 5 mL through a piece of filter paper. She repeated this with four more pieces of filter paper. She dried each piece of filter paper and measured the mass of the sediment. Why did the last sample have a higher mass than did the first sample?

20. Concept Mapping Make a network tree to show types of liquid mixtures. Include these terms: *homogeneous mixtures, heterogeneous mixtures, solutions, colloids,* and *suspensions.*

Performance Assessment

21. Design an Experiment Assume that some sugar was put into some rice by mistake. Design an experiment to separate the mixture. In your Science Journal, list your hypothesis and your experimental steps. Then carry out the experiment, and report the results.

Technology

Go to the Glencoe Science Web site at **science.glencoe.com** or use the **Glencoe Science CD-ROM** for additional chapter assessment.

CLICK HERE

THE PRINCETON REVIEW Test Practice

A student did some research about which elements are found in the human body. The information is shown below.

Elements in the Human Body

Element	Percent
Oxygen	65%
Calcium	2.0%
Carbon	18.0%
Hydrogen	10.0%
Phosphorus	1.0%
Other elements	4.0%

Study the table and answer the following questions.

1. Which element makes up 1.0 percent of the human body?

A) calcium
B) hydrogen
C) phosphorus
D) carbon

2. About how much greater is the percentage of carbon in the human body than hydrogen?

F) 3 percent
G) 8 percent
H) 10 percent
J) 15 percent

3. Which element, together with phosphorus, makes up 3 percent of the human body?

A) hydrogen
B) oxygen
C) calcium
D) nitrogen

4. Which two elements make up three fourths of the human body?

F) carbon and calcium
G) oxygen and hydrogen
H) oxygen and nitrogen
J) phosphorus and carbon

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