

# 4-1 What are three types of matter?

## INVESTIGATE



### Sorting Matter HANDS-ON ACTIVITY

1. Prepare a chart divided into two columns. Label one column "Elements" and the other column "Not Elements."
2. Your teacher will give you samples of several different types of matter. Observe each type of matter.
3. Write the name of each type of matter in one of the two columns. Refer to the periodic table on pages 66 and 67 to help you identify which ones are elements.

**THINK ABOUT IT:** What do you think the objects that are not elements are made of?

SORTING MATTER	
Elements	Not Elements

▲ Figure 4-2

### Objective

Describe similarities and differences among elements, compounds, and mixtures.

### Key Terms

**element:** substance that cannot be chemically broken down into simpler substances

**compound:** substance made up of two or more elements that are chemically combined

**mixture:** two or more substances that have been physically combined

**substance:** any element or compound

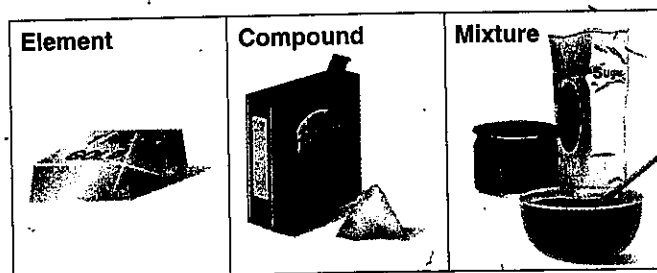
**Organizing Matter** You may have items that you like to collect, such as rocks, stamps, sea glass, or baseball cards. If you do, you may sort your collection based on different or similar characteristics, such as size, shape, date, or team. Kinds of matter can be sorted, too. Just like you might sort your collection based on one characteristic, matter can be organized, or classified, into three groups based on the makeup of the matter.

- 1 **LIST:** What are some of the ways to organize a collection?

**Elements, Compounds, and Mixtures** Matter can be classified into three main types—elements, compounds, and mixtures. You have learned that an **element** is made up of only one kind of atom. For example, pure gold is always made up of

atoms that contain 79 protons. A **compound** is made up of atoms of two or more elements that are chemically combined. The elements in a given compound are always combined in a fixed ratio. For example, every particle of the compound baking soda is made up of one atom of sodium, one atom of hydrogen, one atom of carbon, and three atoms of oxygen.

A **mixture** is made up of two or more kinds of matter that are physically combined or mixed together. The kinds of matter in a mixture can be present in any amounts. A mixture of sugar and cinnamon can contain any amount of sugar and any amount of cinnamon.



▲ Figure 4-3 Examples of the three main types of matter

- 2 **IDENTIFY:** What are the three main types of matter?

**Substances** Elements and compounds share a similar characteristic. Every sample of an element has the same exact properties as every other sample. Similarly, all samples of a given compound have the same exact properties as every other sample of that compound. For example, the

Copper used to make a teakettle will have the same properties as the copper used to make an electric wire. A sample of pure sugar, a compound used to sweeten coffee, will be identical to a sample of pure sugar used to make candy. Because they share this characteristic, elements and compounds are classified as substances. A **substance** is any element or compound.

**DEFINE:** What is a substance?

### CHECKING YOUR UNDERSTANDING

1. Matter is classified into three groups based on the \_\_\_\_\_ of the matter.
2. An \_\_\_\_\_ is made up of only one kind of atom.
3. A \_\_\_\_\_ is made up of atoms of different elements that are chemically combined.
4. The elements in a given compound are always combined in a \_\_\_\_\_ ratio.
5. A \_\_\_\_\_ is made up of two or more different kinds of matter that are physically combined.
6. The amounts of the different kinds of matter in a \_\_\_\_\_ can vary.
7. A \_\_\_\_\_ is any element or compound.

### CRITICAL THINKING

8. **ANALYZE:** A sample of matter is made up of three different atoms that are chemically combined. What type of matter is it? How do you know?
9. **HYPOTHESIZE:** A substance is made up of two atoms of oxygen. Is it an element or a compound? How do you know?

### Web InfoSearch

**Properties:** Substances can be recognized by their physical and chemical properties. These properties can be labeled as *extensive properties* and *intensive properties*. Extensive properties include weight and mass. Intensive properties include melting point and boiling point.

**SEARCH:** Use the Internet to find out more about these types of properties. List other intensive and extensive properties. Start your search at [www.conceptsandchallenges.com](http://www.conceptsandchallenges.com). Some key search words are **intensive properties** and **extensive properties**.



## People in Science

### ROBERT BOYLE (1627–1691)

The Irish-born scientist Robert Boyle was the first scientist to establish the scientific method of experimentation to test hypotheses. He questioned the early belief that materials were made up of four elements—earth, air, fire, and water. He believed that the basic elements of matter were “corpuscles.” These corpuscles, or particles, could be found in various types and sizes, and could arrange themselves into groups called mixtures and compounds. Robert Boyle also showed that the properties of a compound are different from those of the particles that it is made up of.

Robert Boyle contributed a vast amount of knowledge to the scientific world. His work with gases and pressure led to Boyle’s law. He is also credited with the invention of the match.

**Thinking Critically** Robert Boyle believed that the basic elements of matter were corpuscles. What would a modern scientist call these basic elements of matter?



▲ Figure 4-4 Robert Boyle

# 4-2 What is a compound?

## Objectives

Explain that a compound is made up of two or more elements. Describe how chemical bonds form new substances.

## Key Terms

**molecule:** smallest part of a substance that has all the properties of that substance

**chemical bond:** force of attraction that holds atoms together

**Combining Elements** An element can combine with other elements to form a new substance called a compound. A compound is a substance made up of two or more elements that are chemically combined. For example, hydrogen and oxygen are elements. They are both gases with very different properties at room temperature. When these two elements chemically combine, they can form two different compounds that are liquids at room temperature. You are familiar with one of these compounds. It is water. The other compound is hydrogen peroxide, a substance used to clean cuts.

1 **EXPLAIN:** What is a compound?

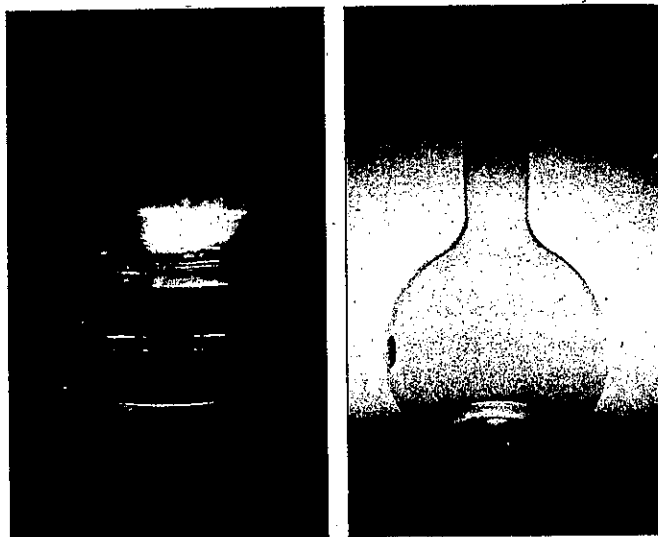
**Common Compounds** Sugar is a compound. It is made of carbon, hydrogen, and oxygen. Table salt is a compound, too. It is made of the elements sodium and chlorine. You may be familiar with some of the compounds listed in Figure 4-5.

Compound	Elements
Sand	Silicon, oxygen
Hydrogen peroxide	Hydrogen, oxygen
Chalk	Calcium, carbon, oxygen
Rust	Iron, oxygen

▲ Figure 4-5

2 **NAME:** What elements are in chalk?

**Properties of Compounds** The properties of a compound are very different from the properties of the elements that make it up. Some elements that make up a compound may be dangerous. But a compound formed from these elements may be relatively harmless. For example, sodium is a very active metal. Chlorine is a yellow, poisonous gas. When combined, these elements make up the compound sodium chloride, or table salt.



▲ Figure 4-6 The active metal sodium (left) chemically combines with the poisonous gas chlorine (right) to form table salt.

3 **CONTRAST:** What are the properties of sodium, chlorine, and sodium chloride?

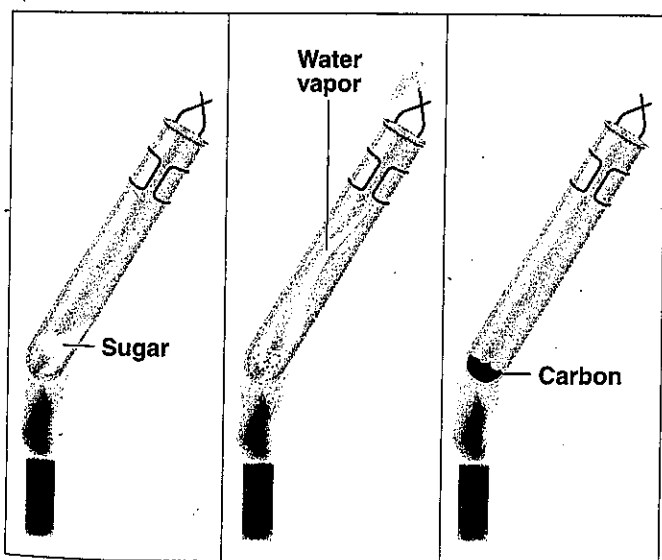
**Molecules** Most compounds are made of molecules. A **molecule** is the smallest part of a substance that has all the properties of that substance. A molecule can be a single atom or may be made up of a great many atoms. For example, a molecule of iron is a single iron atom. A molecule of sucrose, a type of sugar, is made up of 45 atoms.

Silicon dioxide is a compound found in sand. It is made of the elements silicon and oxygen. One molecule of silicon dioxide is made from one atom of silicon and two atoms of oxygen. A single molecule of silicon dioxide has all the properties of silicon dioxide. Just as all the atoms of an element are alike, all the molecules of a compound are alike.

4 **DEFINE:** What is a molecule?

**Breaking Down Compounds** A compound is formed as a result of a chemical change. The elements in a compound combine by forming chemical bonds between the atoms. A **chemical bond** is the force of attraction that holds atoms in a molecule together. Atoms bond together to form molecules. When bonding occurs, a new substance with its own properties is formed.

A chemical change can also cause the molecules that make up a compound to break down into simpler substances. In order to break the molecules down, the chemical bonds holding the atoms together have to be broken. Heating a compound is one way to break it down. When sugar is heated, it melts. If the melted sugar is heated long enough, hydrogen and oxygen enter the air in the form of water vapor. Finally, only a black solid remains. This solid is the element carbon. So, heating sugar can cause it to break down into water, containing hydrogen and oxygen, and carbon. These are the elements that make up sugar.



▲ Figure 4-7 Heating sugar can break it down into simpler substances.

Another way to break down a compound is by using electricity. Scientists working in laboratories can obtain hydrogen gas and oxygen gas by passing electricity through a sample of slightly acidic water.

5 **EXPLAIN:** How can a compound be broken down into the elements that make it up?

### ✓ CHECKING UNDERSTANDING

1. A compound is made up of two or more \_\_\_\_\_.
2. The compound \_\_\_\_\_ is made up of the elements hydrogen, oxygen, and carbon.
3. The properties of a compound are \_\_\_\_\_ from the properties of the elements that form it.
4. A \_\_\_\_\_ is the smallest part of a substance that has all the properties of that substance.
5. A compound is formed as a result of a \_\_\_\_\_.
6. A \_\_\_\_\_ is the force of attraction that holds atoms together.
7. Using heat and electricity can \_\_\_\_\_ a compound into the elements that make up the compound.

### 💡 THINKING CRITICALLY

8. **INFER:** A recipe calls for a cup of sugar to be heated slowly over a low flame. What could happen if the sugar is heated over a high flame?
9. **HYPOTHESIZE:** When an unknown solid is heated, two different gases and a liquid are formed. Is the solid a compound or an element? How do you know?
10. **ANALYZE:** How is a molecule different from an atom?

### HEALTH AND SAFETY

The compound carbon monoxide is a deadly gas. It is difficult to detect because it is odorless and colorless. Carbon monoxide can be produced by the incomplete burning of fuels in cars and in heating furnaces. If it is inhaled in small amounts, it can cause people to feel sleepy. If it is inhaled in large amounts, it can cause death. Why do you think having a carbon monoxide detector in your home is a good idea?

# 4-3 What is a mixture?

## INVESTIGATE



### Separating a Mixture HANDS-ON ACTIVITY

1. Place one-half cup of iron-fortified cereal into a plastic sandwich bag. Squeeze as much air out of the bag as you can. Seal the plastic bag.
2. Use your hands to crush the cereal into a fine powder. Then, pour the cereal into a bowl. Add enough water to the bowl to completely cover the cereal.
3. Cover one end of a magnet with plastic wrap and use it to stir the mixture for at least 10 minutes. Remove the magnet and let the liquid on the magnet drain back into the bowl.
4. Hold the magnet over a sheet of white paper. Use a hand lens to observe the particles on the end of the magnet.

**THINK ABOUT IT:** What did you observe on the end of the magnet? Where did the matter come from?



### Objective

Describe the physical properties of a mixture.

**Mixtures** Cut up some tomatoes, lettuce, onions, and green peppers. Put the pieces in a bowl and stir them together. What do you have? Some people would say that you have a salad. A scientist might say that you have a mixture. You have learned that a mixture is made up of two or more substances that are physically combined. Each part of a mixture keeps its own properties.

Not all mixtures are as easy to identify. If you put some salt in a glass of water and stir, you would have a mixture of salt and water. But this mixture is different from the salad mixture. You cannot see the individual parts of salt or water.

- 1 ► **CONTRAST:** What is the difference between a salad mixture and a salt-water mixture?

**Kinds of Mixtures** The kinds of matter in a mixture can be present in varying amounts. The discussion above describes the two basic types of mixtures—evenly mixed and unevenly mixed. The mixture of salt and water is evenly mixed. You cannot see the individual particles of salt or water. The salt is still salt, and the water is still water. However, they are so evenly mixed that every part of this mixture is exactly the same as every other part. A drop taken from the top of the mixture will be identical to a drop taken from the bottom.

The salad is unevenly mixed. One part of the salad may have more tomato while another part has more green pepper. Each part of the mixture keeps its own properties. A tomato is still red and tastes like a tomato.

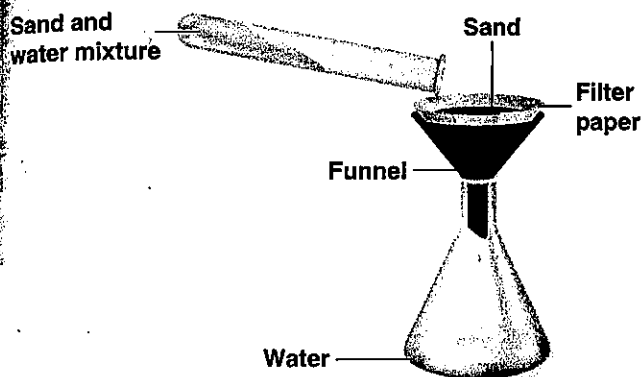


▲ **Figure 4-8** A salad is a mixture. Each part of the mixture keeps its own properties.

- 2 ► **INFER:** Why do the different kinds of matter in a mixture keep their own properties?

**Separating a Mixture** The properties of the different kinds of matter in a mixture can be used to separate the mixture. Because the parts of a mixture are not chemically combined, they can be separated by physical means. For example, each of the different vegetables could be picked out of the salad by hand.

A physical property of water is that it evaporates when it is heated. So, if you heat a mixture of salt and water, the water will evaporate and the salt will be left behind. The mixture will be separated. Some mixtures can be separated by filtering. If a mixture of sand and water is poured into a filter, the water will pass through. The sand will be trapped by the filter.



▲ Figure 4-9 Separating a mixture of sand and water

3 **EXPLAIN:** How can you separate a mixture of sand and water?

### ✓ CHECKING CONCEPTS

1. Salt water is an example of a \_\_\_\_\_.
2. The substances in a mixture are \_\_\_\_\_ combined.



## Real-Life Science

### MIXTURES THAT YOU CAN EAT

Have you ever gone camping or hiking and taken some trail mix with you? As the name of this snack tells you, trail mix is a mixture. You can see the individual bits of dried fruits and nuts. You could pick out the individual parts with your fingers if you wanted to.

Think about some of the other foods that you eat every day. Many of these foods are mixtures. Rice and beans, vegetable soup, ice cream—all are mixtures.

**Thinking Critically** If you were to make trail mix, do you have to follow the recipe exactly?

3. The substances in a mixture can be present in \_\_\_\_\_ amount.
4. The substances in a mixture always keep their own \_\_\_\_\_.
5. The substances in a mixture can be \_\_\_\_\_ by using the physical properties of the substances.
6. A mixture of \_\_\_\_\_ and water can be separated by filtering the mixture.



### THINKING CRITICALLY

7. **HYPOTHESIZE:** Will freezing a mixture of salt and water separate the two substances? Explain your answer.
8. **CLASSIFY:** A teaspoon of instant coffee is placed in a cup of boiling water. Is this a mixture or a compound? Explain your answer.

### DESIGNING AN EXPERIMENT

Design an experiment to solve the following problem. Include a hypothesis, variables, a procedure, and a type of data to study.

**PROBLEM:** You have a mixture of sand, water, and gravel. How can you separate this mixture into its different parts?



#### ENERGY TRAIL MIX

1 c. dried apricots
2 c. raisins
½ c. dry roasted peanuts
½ c. almonds
½ c. pineapple chunks
½ c. banana chips or coconut chips
Combine ingredients; mix well. Store in an airtight container. Makes 1¾ quarts.

▲ Figure 4-10 Recipe for trail mix

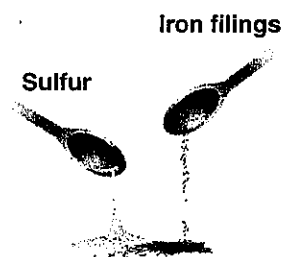
# 4-4 How are mixtures and compounds different?

## Objective

Contrast the properties of mixtures with the properties of compounds.

**Making a Mixture** The different kinds of matter in a mixture are physically combined. A fruit salad is a mixture of different kinds of fruit. You can make a mixture of iron filings and sulfur by mixing the two substances together.

Iron filings are magnetic slivers of gray metal. Sulfur is a nonmetallic yellow powder. Just like each piece of fruit in a salad keeps its properties, each substance in the iron-sulfur mixture will keep its own properties. You would be able to see the grains of yellow powder and slivers of gray metal in a mixture of these two substances.



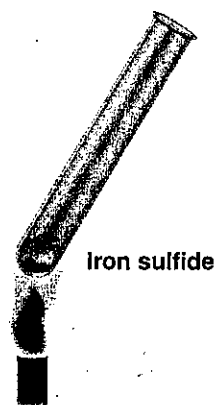
A mixture of sulfur and iron filings

◀ Figure 4-11  
Making a mixture of sulfur and iron

1 **INFER:** How can you make a mixture of iron filings and sulfur?

**Making a Compound** A compound is made up of two or more elements. It is formed as a result of a chemical change. The elements in a compound combine by forming chemical bonds between the atoms of the elements. For example, molecules of sugar are formed as a result of a chemical change. Atoms of hydrogen form chemical bonds with atoms of oxygen and atoms of carbon to produce molecules of sugar.

Not only can iron and sulfur be physically combined to make a mixture, they can also be chemically combined to form a compound. This compound is called iron sulfide. Iron sulfide forms when a mixture of iron filings and sulfur is heated. The atoms of the two elements will combine to form chemical bonds with each other. The compound iron sulfide will be produced. Like all compounds, the properties of iron sulfide are different from the properties of the elements that make it up.



◀ Figure 4-12  
Making the compound iron sulfide

2 **EXPLAIN:** What happens when a mixture of iron filings and sulfur is heated?

## Comparing Mixtures and Compounds

Mixtures and compounds are different in several ways. A mixture of iron and sulfur does not have a definite chemical composition. The mixture might contain equal parts of each element. Or, it might have twice as much of one element as the other. Each substance in a mixture of iron and sulfur keeps its own properties. A mixture of iron and sulfur can be separated by physical means. For example, a magnet can be used to attract the iron.

The compound iron sulfide always has a definite chemical composition. Every molecule of iron sulfide contains one atom of iron and one atom of sulfur.

When elements combine chemically, each element loses its properties. The iron and sulfur in iron sulfide cannot be separated by physical means. Figure 4-13 lists some differences between mixtures and compounds.

COMPARING MIXTURES AND COMPOUNDS	
Mixtures	Compounds
Made of two or more substances physically combined	Made of two or more substances chemically combined
Substances keep their own properties	Substances lose their own properties
Can be separated by physical means	Can be separated only by chemical means
Have no definite chemical composition	Have a definite chemical composition

Figure 4-13 Differences between mixtures and compounds

► **CONTRAST:** How are mixtures and compounds different?

### ✓ CHECKING CONCEPTS

1. The elements in a \_\_\_\_\_ are chemically combined.
2. Each kind of matter in a \_\_\_\_\_ keeps its own properties.
3. A \_\_\_\_\_ does not have a definite chemical composition.
4. A \_\_\_\_\_ cannot be separated by physical means.

### 💡 THINKING CRITICALLY

5. **INFER:** When a certain poisonous gas is combined with a chemically active metal, a fine white powdery substance results. The new substance is neither poisonous nor chemically active. Is the powder a mixture or a compound? How do you know?
6. **COMPARE:** Water is a compound. Salt water is a mixture. List the differences between water and salt water.

## Integrating Earth Science

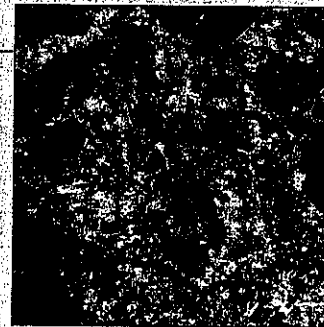
TOPICS: rocks, minerals

### CLASSIFYING ROCKS

Like other types of matter, rocks can be classified as elements, compounds, or mixtures. Some rocks are actually made of pure elements. For example, copper and gold are elements that can be found in nearly pure form. However, rocks that are mixtures of different compounds are more common than are rocks made of pure elements.

Some compounds that can be found in certain rocks include quartz, mica, and feldspar. Quartz is a hard, cloudy-looking rock that is actually a compound made up of silicon and oxygen. One form of mica is a black compound made up of the elements potassium, aluminum, silicon, oxygen, and hydrogen. Feldspar is a milky-white or pink compound that can be made up of aluminum, silicon, sodium, potassium or calcium and oxygen. A mixture of these three compounds can be found in a type of rock called granite. Granite is a hard rock with big grains of quartz, mica, and feldspar.

**Thinking Critically** How would you classify granite?



▲ Figure 4-14 Granite is a mixture.



▲ Figure 4-15 Mica can be found in granite.