Name _____ Class _____ Date _____

CHAPTER 5 Elements, Compounds, and Mixtures

SECTION 1

Elements

BEFORE YOU READ

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

- What is an element?
- How do elements differ from other materials?
- How are elements classified?

California Science Standards

8.7.c

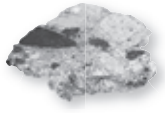
What Are Elements?

Many materials can be broken down into different components. For example, some rocks contain copper. When they are heated in a large furnace, the copper separates from the rest of the rock. Another example is the breakdown of water when electricity is passed through it. The electric current causes hydrogen and oxygen gases to form.

Some materials cannot be separated or broken down into other materials. An **element** is a pure substance that cannot be separated into simpler substances by chemical or physical methods. This is how elements are different from all other materials.

A **pure substance** is a material in which all of the basic particles are identical. All of the particles of a pure substance are alike, no matter where the substance is found. Pure substances that are not elements can be broken down into simpler substances. ☑

The basic particles of an element are called *atoms*. Copper is an example of an element. All of the atoms in a piece of pure copper are alike. As shown in the figure below, iron is also an element.



The atoms of iron in the meteorite from space are identical to the atoms of iron in a steel spoon. There are also atoms of iron in the cereal, in the boy's braces, and even in his blood.

STUDY TIP

Organize In your notebook, make a concept map, using the terms *element, substance, metal, nonmetal,* and *metalloid.*

READING CHECK

1. Compare How do elements differ from other pure substances?

_____

_____

_____

TAKE A LOOK

2. Identify Look at the illustration, and identify one source of iron that comes to Earth from somewhere else.

_____

How Can Elements Be Classified?

Elements can be classified based on their properties. There are two types of properties, chemical and physical. Characteristic physical properties include hardness, melting point, and density. Chemical properties include reactivity and flammability. ☑

READING CHECK

3. List What are three physical properties that are characteristics of an element?

_____

_____

Two elements may have a particular property in common, but you can use other properties to tell them apart. For example, the elements helium and krypton are both colorless, odorless, unreactive gases. However, these elements have different densities (mass per unit volume). Helium is less dense than air, so a helium balloon floats upward. A krypton-filled balloon, on the other hand, would sink to the floor. Krypton is denser than air.

Critical Thinking

4. Make Inferences Compare the properties of iron with those of cobalt and nickel. How do you think cobalt and nickel are used in manufactured products?

_____

_____

_____

_____

_____

_____

Unique Properties of Elements

Cobalt	Iron	Nickel
		
• Melting point: 1,495°C • Density: 8.9 g/cm^3 • Conducts electricity and heat. • Reactivity: Does not react with oxygen in the air.	• Melting point: 1,535°C • Density: 7.9 g/cm^3 • Conducts electricity and heat. • Reactivity: Reacts by combining with oxygen in the air to form rust.	• Melting point: 1,455°C • Density: 8.9 g/cm^3 • Conducts electricity and heat. • Reactivity: does not react with oxygen in the air.

The figure above shows some of the properties of three different elements. The physical properties shown are melting point, electrical and thermal conductivities, and density. Each element has other physical properties, as well, including color, hardness, and texture. The figure also includes a chemical property—the reactivity of the element with oxygen in the air.

If you had a piece of metal, could you determine which of the elements it was, based on these properties? Iron can be distinguished from both other elements by physical and chemical properties. The density of iron is much less than that of either cobalt or nickel, and it reacts with oxygen in the air.

READING CHECK

5. Explain Why can't you use the density or reactivity with air to determine whether a sample is cobalt or nickel?

_____

_____

_____

You can't use those properties to tell nickel and cobalt apart. However, their melting points differ by 40°C. So, you can use melting points to tell them apart. ☑

How Can Elements Be Sorted?

Think about all the different types of dogs that you have seen. Dogs can be classified based on different properties. These include size, ear shape, and length of coat. You can often determine a dog's breed just with a quick glance. The figure below shows three kinds of terriers. They are not exactly alike, but they share some properties.

Even though these dogs are different breeds, they have enough in common to be classified as terriers.

The elements can be sorted based on properties, just as the dogs in the illustration can. There are three major categories of elements: metals, nonmetals, and metalloids. The elements iron, cobalt, and nickel are all metals. They are not exactly alike, but they have similar properties. ☑

Metals tend to be shiny solids (except mercury, which is a shiny liquid). Metals conduct heat and electric current well. **Nonmetals** do not conduct heat or electric current very well. Many nonmetals are gases. The solid nonmetals have a dull appearance. **Metalloids** have some of the properties of metals and some of the properties of nonmetals. Metalloids are important in electronics because their electrical conductivity can vary with conditions.

Three Major Categories of Elements			
Property	**Metals**	**Nonmetals**	**Metalloids**
Appearance	shiny	dull	some shiny
Conductivity of heat and electricity	good	poor	some good
Malleability—ability to be hammered into sheets	malleable	not malleable	some somewhat malleable
Ductility—ability to be made into wires	ductile	not ductile	some somewhat ductile
Brittleness	not brittle	brittle	some brittle

TAKE A LOOK

6. Describe What are some of the physical properties that describe terriers?

_____

_____

READING CHECK

7. Identify What are the three main categories of elements?

_____

_____

Say It

Explore Applications The properties of metals make them very useful in everyday things. In groups of three or four, make a list of things that you use for cooking that are made of metal. Make another list of things used for cooking that are never made of metal. Discuss why the properties of metals determine which things are in which group.

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Section 1 Review

8.7.c 

SECTION VOCABULARY

element a substance that cannot be separated or broken down into simpler substances by chemical means

metal an element that is shiny and conducts heat and electricity well

metalloid an element that has properties of both metals and nonmetals

nonmetal an element that conducts heat and electricity poorly

pure substance a sample of matter, either a single element or a single compound, that has definite chemical and physical properties

1. Compare How does the ability to conduct heat differ between metals and nonmetals?

_____

2. Classify Fill in the blanks to complete the table.

Element	Property	Classification
Copper	shiny solid	
Oxygen	gas	
Silicon	Electrical conductivity varies, depending on conditions.	

3. Evaluate Assumptions Your friend tells you that all of the electric wires in your home are metals. From what you know about elements, tell whether or not this statement is true. Explain your answer.

_____

_____

4. Apply Concepts Several elements are used between the panes of glass in double windows designed to block heat flow. From what category are these elements chosen. How do you know?

_____

_____

5. Make Calculations Two elements, hydrogen and helium, make up most of the atoms in the universe: 92.7% of atoms are hydrogen, and 6.9% of atoms are helium. What percentage of atoms in the universe is neither hydrogen nor helium? Show your work.

Name _____ Class _____ Date _____

CHAPTER 5 Elements, Compounds, and Mixtures

SECTION 2

Compounds

BEFORE YOU READ

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

- What are compounds made of?
- What happens during a chemical reaction?
- Are the properties of compounds like the properties of the elements used to make them?

California Science Standards

8.3.b, 8.5.a, 8.7.c

What Are Compounds?

Most elements take part in chemical changes fairly easily, so they are rarely found in pure form in nature. Instead, they are found combined with other elements in compounds. A **compound** is a pure substance composed of two or more elements that are chemically combined. The figure below shows some compounds that you might find in your kitchen and what elements make up those compounds. ☑

STUDY TIP

Ask Questions Read this section silently. In your notebook, write down questions that you have about the section. Discuss them in a small group.

Familiar Compounds

Compound	Elements combined
Table salt	sodium and chlorine
Water	hydrogen and oxygen
Sugar	hydrogen, carbon, and oxygen
Carbon dioxide	carbon and oxygen
Baking soda	sodium, hydrogen, carbon, and oxygen

READING CHECK

1. Describe What is a compound?

_____

_____

_____

_____

A chemical change, or reaction, happens when one or more substances are changed into one or more other substances. During a chemical reaction, new substances form because atoms are rearranged. The properties of a compound can be very different from those of its elements. For example, water is made of hydrogen and oxygen. Both are gases at room temperature. Water is a liquid at room temperature. ☑

In some chemical reactions, two or more elements combine to form a compound. In other chemical reactions, a compound can be separated into elements or simpler compounds. Still other reactions involve changing compounds into other compounds. In all cases, though, different materials exist after the reaction occurs.

READING CHECK

2. Compare How do the properties of a compound compare with those of its elements?

_____

_____

_____

What Properties Do Compounds Have?

Just as each element has physical and chemical properties, each compound has characteristic properties. Physical properties of compounds include melting point, boiling point, density, and color. The table below shows some of the physical properties of three colorless liquids. These properties can be used to tell them apart, even though the three compounds look alike in a container.

Critical Thinking

3. Analyze Data How can you tell from the table that all of the compounds listed are liquids at room temperature?

_____

_____

_____

_____

_____

Physical Properties

	Melting point (°C)	Boiling point (°C)	Odor	Density (g/mL)
Chloroform	−64	61	strong	1.48
Ethanol	−114	75	mild	0.79
Water	0	100	none	1.00

Chemical properties can be used to identify compounds, too. Chemical properties include changes that occur when compounds are exposed to other chemicals or to heat or light. The figure below shows how the chemical properties of three common white solids differ.

TAKE A LOOK

4. Identify What element is part of both of the non-flammable compounds in the table?

_____

Chemical Properties

	Reacts with acid	Flammable
Sodium chloride (salt)	no	no
Sucrose (sugar)	no	yes
Sodium bicarbonate (baking soda)	yes	no

The properties of a compound differ, not only from those of other compounds, but also from those of its elements. Sodium chloride is made of two very reactive and toxic elements—sodium and chlorine. Sodium is a metal that reacts violently with water and can cause damage if it touches skin. Chlorine is a poisonous gas. The combination of the two elements results in sodium chloride. Sodium chloride, or table salt, is safe to eat.

CALIFORNIA STANDARDS CHECK

8.5.a Students know reactant atoms and molecules interact to form products with different chemical properties.

Word Help: interact
to act upon one another

5. Identify Give one property of sodium chloride that is not a property of sodium or chlorine.

_____

How Can I Tell Two Compounds Apart?

You can tell one compound from another because every compound has a unique set of properties. This means that a compound can be identified by measuring or observing some of its properties. These properties are different for different compounds. ☑

Suppose you are given two white powders and told that one is powdered sugar and the other is baking soda. You must identify which is sugar without tasting it. How can you do this? Knowing that baking soda will fizz in an acid like vinegar, but sugar will not, gives you a way to identify the sugar.

You can put each powder into a beaker. Then, add some vinegar to each beaker. The powder that fizzes is the baking soda. ☑

READING CHECK

6. Identify How can a compound be identified?

_____

_____

_____

READING CHECK

7. Describe What chemical property of baking soda can be used to identify it from sugar?

_____

_____

Do Elements Always Combine in the Same Way to Make Compounds?

You may have heard that carbon monoxide is a poisonous gas and that plants use carbon dioxide to make oxygen. How are these compounds different? Carbon monoxide has one carbon atom combined with one oxygen atom. Carbon dioxide has one carbon atom combined with two oxygen atoms.

The properties of a compound depend on which elements combine and how much of each element is in the compound. It is similar to making words from letters. The same letters can be combined to make the words "hose" and "shoe," but the words are different.

Say It

Discuss The paragraph to the left compares elements to letters of the alphabet. In small groups, discuss other comparisons that can help you better understand how compounds differ from one another.

Can Compounds Be Broken Down?

Some compounds can be broken down into their elements by applying heat or using electricity. In the figure below, mercury oxide forms mercury and oxygen.

When mercury oxide is heated, it undergoes a chemical change in which it separates into the elements mercury and oxygen.

TAKE A LOOK

8. Identify What is used to break down the mercury oxide into mercury and oxygen?

_____

Name _____ Class _____ Date _____

Section 2 Review

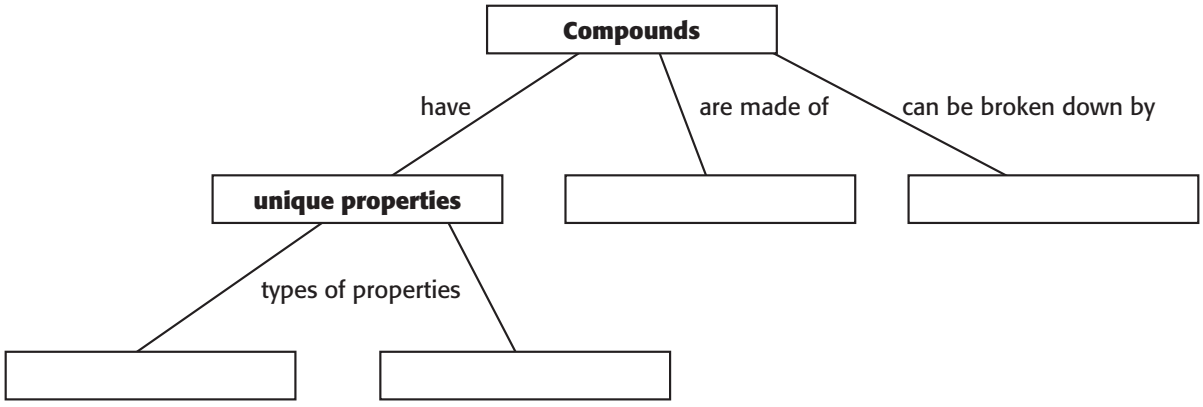
8.3.b, 8.5.a, 8.7.c

SECTION VOCABULARY

compound a substance made up of atoms of two or more different elements joined by chemical bonds.	

1. **Explain** How do the basic particles of a compound differ from the basic particles of an element?

2. **Organize** Fill in the Knowledge Web below with words from this section.



3. **Draw Conclusions** A plant label made of copper is bright and shiny when it is placed in the garden. After a few months, the label has a dull, greenish color. When you rub your finger over the surface, some soft material rubs off. What has happened to the copper?

4. **Analyze Ideas** If a piece of pure iron is placed in pure nitrogen, nothing happens. If the iron is exposed to air, it begins to rust. What conclusion can you make about air, based on this observation?

Name _____ Class _____ Date _____

CHAPTER 5 | Elements, Compounds, and Mixtures

SECTION 3

Mixtures

BEFORE YOU READ

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

- How do mixtures differ from elements and compounds?
- How can mixtures be separated?
- What are solutions, and how are they characterized?

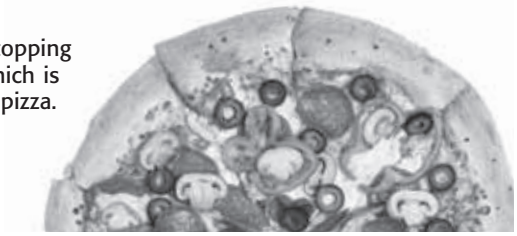
California Science Standards

8.7.c

What Are the Properties of Mixtures?

The illustration in the figure below shows a familiar mixture—a pizza. When you look at a piece of pizza, you can easily see different parts that have different properties. A **mixture** is a combination of two or more substances that are not chemically combined.

You can see each topping on this mixture, which is better known as a pizza.



STUDY TIP

Brainstorm The main focus of this section is mixtures of substances. Brainstorm words and phrases related to mixtures. Record your work in your notebook.

Chemicals can form mixtures. No chemical change happens when a mixture is made. That means that each chemical keeps its same identity. The pepperoni and olives on the pizza don't change when they are mixed. Making a mixture is therefore a physical change. ☑

READING CHECK

1. Identify What kind of change occurs when a mixture forms?

_____

Sometimes, you can see the components of the mixture. For example, if you mix sugar and sand together, you can see the different crystals in the mixture. In other mixtures, such as salt water, you cannot see the individual parts. Even so, there is no chemical reaction. You don't change the salt or the water by making the mixture.

Because the components of a mixture are not changed into new chemicals, they can often be separated easily. The olives and pepperoni can be picked off the pizza by hand. A magnet can pull iron particles out of a mixture of iron and sand. ☑

READING CHECK

2. Explain Why can mixtures often be separated easily?

_____

_____

_____

_____

Other mixtures are not separated so easily. Salt can't simply be picked out of seawater. Salt can be separated from the water in salt water, though, by letting the water evaporate. Heating the seawater speeds up the process.

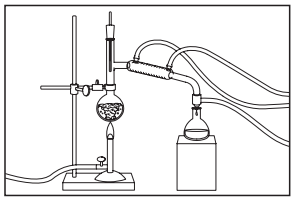
TAKE A LOOK

3. Identify Distillation always requires the addition of energy to convert a substance to a gas. How is energy added in the illustration?

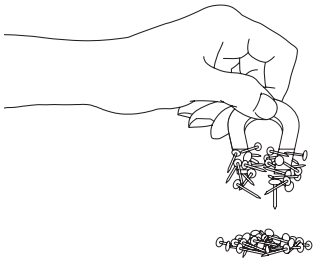
_____

How Can Mixtures Be Separated?

The figure below shows three methods of separating the parts of a mixture.



Distillation is the process that separates a mixture based on boiling points. Water in this mixture evaporates and then condenses as pure water.



A **magnet** can be used to separate a mixture of the elements iron and aluminum. Iron is attracted to the magnet, but the aluminum is not.

Critical Thinking

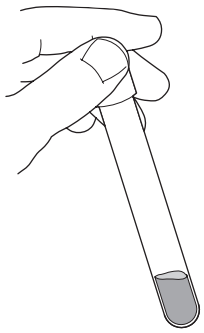
4. Infer How does the separation of blood into several layers in a centrifuge show that blood is a mixture instead of a pure substance?

_____

_____

_____

_____



Blood is separated into its parts by a machine called a **centrifuge**. In the test tube of blood at the left, a layer of plasma rests on top of a layer of red blood cells. A centrifuge separates mixtures by the densities of the components.

Another method of separating the parts of a mixture is to dissolve one of the substances in water, filter the mixture, and then evaporate the water. This is shown below as a diagram called a *flow chart*. The flow chart for the separation of table salt and sulfur is illustrated.

TAKE A LOOK

5. Identify What is not collected in the process shown by the flow chart?

_____

Dissolving In the first step, water is added, and the mixture is stirred. Salt dissolves in water. Sulfur does not. →	**Filtering** In the second step, the mixture is poured through a filter. The filter traps the solid sulfur. →	**Evaporating** In the third step, the water is evaporated. The salt is left in the evaporating dish on the hot plate.

Do Mixtures Have Fixed Ratios?

A compound is made of elements that are always present in a fixed ratio. For example, water is always two parts hydrogen and one part oxygen.

A mixture, however, does not have a fixed ratio of components. If you make a mixture of salt and water, you can put in a little salt or a lot of salt. Either way, you make a mixture. The figure below compares mixtures and compounds. ☑

Mixtures	Compounds
are made of elements, compounds, or both	are made of elements
keep the original properties of the components	do not have the original properties of the components
do not require heat or electricity for separation of components	require heat or electricity for separation of components
may have any ratio of components	must have a set ratio of components

READING CHECK

6. Compare How does the ratio of components in a mixture compare with the ratio of elements in a compound?

_____

_____

_____

_____

What Is a Solution?

Salt water is an example of a solution. A **solution** is a *homogeneous* mixture. This means that a solution appears to be a single substance. The particles of the substances in a solution are evenly spread out. The appearance and properties are the same throughout the solution.

The process in which particles of substances separate and spread evenly throughout a mixture is known as *dissolving*. In a solution, the component that is present in the largest amount is called the **solvent**. Substances present in smaller amounts are called **solutes**. ☑

Say It

Discuss Read "What Is a Solution?" Then, in small groups, discuss the solvent and solutes in soft drinks.

WATER AS A SOLVENT

Water is a very common solvent. In a salt water solution, water is the solvent, and salt is the solute. Water is the solvent of many of the solutions that you come across in daily life. In fact, your body contains many water solutions—blood plasma, saliva, and tears are all water solutions. Reactions inside cells take place in water solutions. So many different substances dissolve in water that it is often called the "universal solvent." ☑

READING CHECK

7. Identify In a solution, what component is present in the largest amount?

_____

READING CHECK

8. Identify What is called the universal solvent?

_____

TYPES OF SOLUTIONS

Water is not the only solvent, though. Many other liquids dissolve substances, some of which do not dissolve in water. *Hydrocarbon solvents*, such as turpentine, are used to dissolve grease and other substances that don't dissolve in water.

In fact, solvents do not have to be liquids. Gases or even solids are able to acts as solvents by dissolving other substances. The air around you is a solution of oxygen and other gases in nitrogen. Many familiar metals are *alloys*. Alloys, such as bronze, are solid solutions in which a metal is the solvent. Other metal or nonmetal elements are the solutes.

The table below shows some examples of solutions. The key point in forming a solution is that the particles of the components are evenly spread throughout the solution.

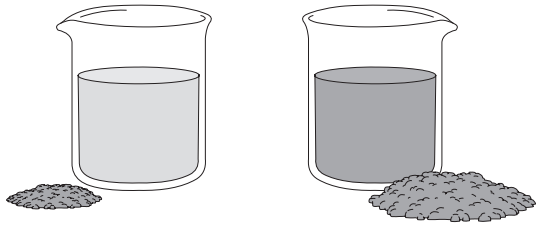
Examples of Solutions in Various States of Matter

State of matter	Example
Gas in a gas	dry air (oxygen in nitrogen)
Gas in a liquid	soft drinks (carbon dioxide in water)
Liquid in a liquid	antifreeze (an alcohol in water)
Solid in a liquid	salt water (salt in water)
Solid in a solid	brass (zinc in copper)

How Much Solute Can Be Added to a Solvent?

A measure of the amount of solute in a given amount of solvent is **concentration**. The concentration of a solution tells the mass of solute in a volume of solution. The units of concentration are grams of solute per milliliter of solvent (g/mL). As more solute is added, the concentration of the solution becomes greater. ☑

Solutions are often described as being concentrated or dilute. A *dilute solution* is one that has a small amount of solute dissolved in the solvent. A *concentrated solution* has more solute in solution. These terms do not tell you the actual concentration of the solution. Rather, they describe a relative concentration.



The dilute solution (left) contains less solute than the concentrated solution (right).

Critical Thinking

9. Apply Ideas If you look at the side of a quarter, you can see layers of different metals. Is the coin a solid solution? Explain.

_____

_____

_____

_____

TAKE A LOOK

10. Identify In each of the example solutions, circle the name of the solute.

READING CHECK

11. Define What two things do you need to know in order to calculate concentration?

_____

_____

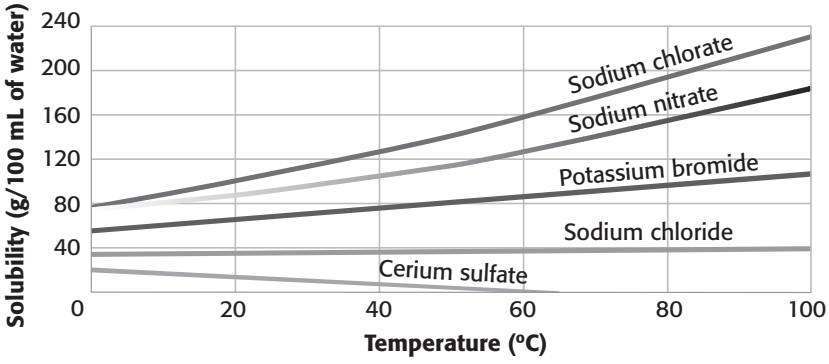
SOLUBILITY

Is there a limit to the amount of solute that can be added to a solution? The answer is yes. Think about how you add sugar to lemonade. As you add some sugar to the lemonade and stir it, the sugar dissolves. If you add more sugar, you make a solution that is more concentrated. Eventually, no matter how much you stir, some sugar remains as a solid at the bottom of the glass.

To find the maximum amount of sugar that you could add to the lemonade, you need to know the solubility of sugar in water. **Solubility** refers to the ability of a solute to dissolve in a solvent at a certain temperature.

For most solids, the solubility in water increases as temperature increases. This is shown on the graph below as a line that slopes upward to the right. However, there are some exceptions. Does the graph show an exception to this rule? Yes, the line for cerium sulfate slopes downward to the right. This means that as the temperature increases, cerium sulfate gets less soluble.

Experiments have determined the solubility of many substances in various solvents. The graph below shows the solubility of several compounds in water.



For most solids, solubility increases as temperature increases. Therefore, the amount of solute that can dissolve increases as the temperature increases. However, some solids, such as cerium sulfate, become less soluble as temperature increases.

Critical Thinking

12. Infer If you keep adding sugar to lemonade, why does the sugar eventually stop dissolving?

_____

_____

_____

Math Focus

13. Read a Graph What is the solubility of sodium chlorate at 60°C?

_____

Name _____ Class _____ Date _____

Section 3 Review

8.7.c

SECTION VOCABULARY

concentration the amount of a particular substance in a given quantity of a mixture, solution, or ore

mixture a combination of two or more substances that are not chemically combined

solubility the ability of one substance to dissolve in another at a given temperature and pressure

Wordwise The root *solute-* means "to free" or "to loosen."

solute in a solution, the substance that dissolves the solute

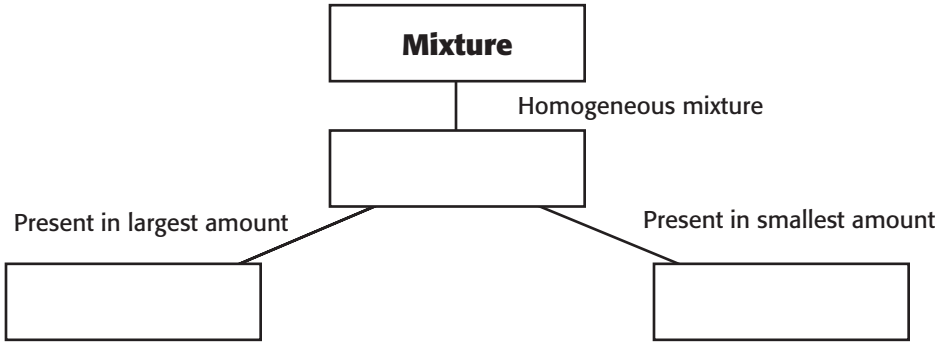
solution a homogeneous mixture throughout which two or more substances are dispersed

solvent in a solution, the substance in which the solute dissolves

1. Identify What are the solvent and solute in a solution containing 100 g of ethanol and 3 g of sucrose?

_____

2. Organize Complete the Concept Map for a mixture shown below.



3. Analyze Processes In a steel factory, iron is melted. Then, other elements, such as carbon and nickel, are added to the melted iron to make steel. What is the reason for melting the iron?

_____

_____

_____

4. Apply Concepts Suppose you added a cup of sugar to hot water, and all of the sugar dissolved. Then the water cooled, and some of the sugar was seen as a solid on the bottom of the beaker. Explain why this happened.

_____

_____

_____