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?

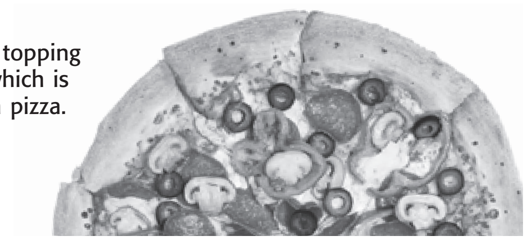
What Are the Properties of Mixtures?

The figure below shows a familiar mixture—a pizza. When you pick up a piece of pizza, you can see different parts of it that have different properties. A **mixture** is a combination of two or more substances that are not chemically combined.

STUDY TIP

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

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



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

READING CHECK

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

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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 saltwater, you cannot see the individual parts. Even so, the salt and the water are not changed by making the mixture.

Because the components of a mixture are not changed, they can often be separated easily. The olives and the pepperoni can easily be picked off the pizza. Iron particles can be pulled out of a mixture with sand using a magnet. ☑

READING CHECK

2. Explain Why can some mixtures be separated easily?

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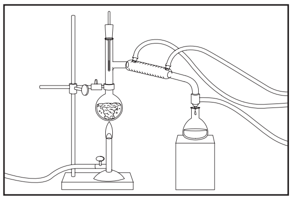
Other mixtures are not separated so easily. Salt can't simply be picked out of saltwater. Salt can be separated from the water by letting the water evaporate. Heating the saltwater in a container speeds up the process.

How Can Mixtures Be Separated?

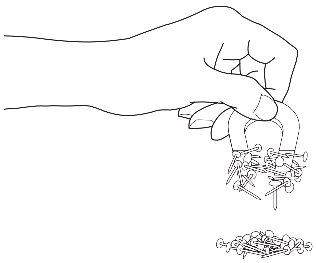
The figure below shows three methods of separating the parts of a mixture.

TAKE A LOOK

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



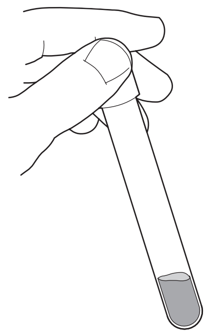
Distillation is the process that separates a mixture based on boiling points. Water in this mixture evaporates and then condenses as pure water.



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 separating 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 above, a layer of plasma rests atop 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. Then you filter the mixture and evaporate the water. This is shown in a diagram called a *flow chart*.

TAKE A LOOK

5. Identify What substance 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.

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Filtering In the second step, the mixture is poured through a filter. The filter traps the solid sulfur.

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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 in a fixed, or specified, ratio. For example, water is always two parts hydrogen and one part oxygen.

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

Mixtures and Compounds

Mixtures	Compounds
Made of elements, compounds, or both	Made of elements
No change in original properties of the components	Change in original properties of the components
Heat or electricity not required for separating components	Heat or electricity required for separating components
Made using any ratio of components	Made using a fixed ratio of components

READING CHECK

6. Compare How is the ratio of components in a mixture different from the ratio of elements in a compound?

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What Is a Solution?

Saltwater 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.

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

Say It

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

READING CHECK

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

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WATER AS A SOLVENT

Water is a very common solvent. In a saltwater 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 solutions in water; blood plasma, saliva, and tears are all solutions. Reactions in cells take place in water solutions. So many different substances dissolve in water that it is sometimes called the "universal solvent." ☑

READING CHECK

8. Identify What is called the universal solvent?

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Critical Thinking

9. Applying 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 What is the solute in each of the example solutions? Circle the name of each solute.

READING CHECK

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

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 become 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, copper, is the solvent. Other metal or nonmetal elements are solutes.

The table below shows some examples of solutions. In a solution, 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	carbonated water (carbon dioxide in water)
Liquid in a liquid	antifreeze (an alcohol in water)
Solid in a liquid	saltwater (salt in water)
Solid in a solid	brass (zinc in copper)

How Much Solute Can Be Added to a Solvent?

The amount of solute in a given amount of solvent is called the **concentration**. The concentration of a solution gives 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 increases. ☑

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, but rather a relative concentration.

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

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 more concentrated solution. Eventually, no matter how much you stir, some sugar remains as a solid at the bottom of the glass.

Suppose you want find the maximum amount of sugar that you could add to the lemonade. You need to know the solubility of sugar in water. **Solubility** is how much solute dissolves in a certain amount of solvent at a certain temperature.

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

Critical Thinking

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

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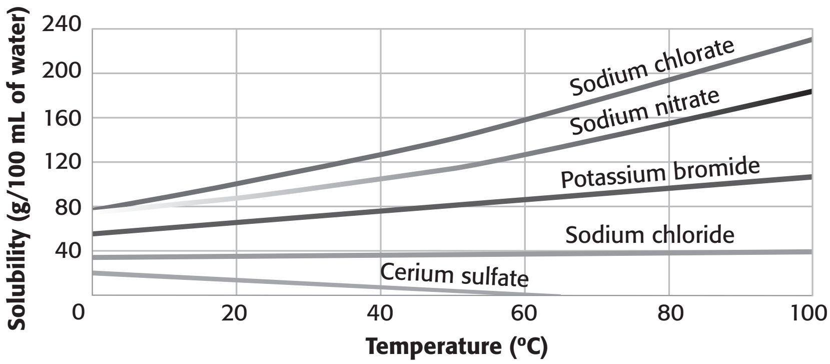
Solubility of Different Solids in Water



Math Focus

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

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CALCULATING CONCENTRATION

The equation for calculating concentration is $concentration = \frac{grams\ of\ solute}{milliliters\ of\ solvent}$. Let's try a problem. What is the concentration of a solution that has 35 g of salt dissolved in 175 mL of water?

Step 1: write the equation

$$concentration = \frac{grams\ of\ solute}{milliliters\ of\ solvent}$$

Step 2: substitute values

$$concentration = \frac{35\ \text{g}}{175\ \text{mL}} = 0.2\ \text{g/mL}$$

Math Focus

14. Calculate What is the concentration of a solution if it has 55 g of sugar dissolved in 500 mL of water? Show your work.

DISSOLVING GASES IN LIQUIDS

Most solids are more soluble in liquids at higher temperatures. However, gas becomes less soluble in liquids as the temperature is raised. A soft drink goes flat faster when warm than when cool. The gas that is dissolved in the soft drink cannot stay dissolved when the temperature increases. Therefore, the gas escapes, and the soft drink becomes "flat". ☑

READING CHECK

15. Identify Are gases more soluble at high or low temperatures?

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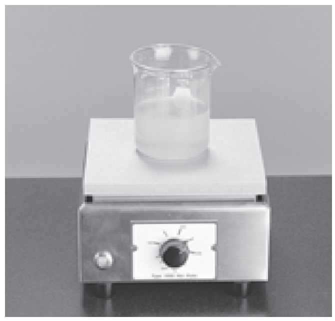
DISSOLVING SOLIDS FASTER IN LIQUIDS

Several things affect how fast a solid will dissolve. Look at the figure below to see three ways to make a solid dissolve faster. You will enjoy a glass of lemonade sooner if you stir sugar into the lemonade before adding ice.

How to Dissolve Solids Faster

Mixing by stirring or shaking causes the solute particles to separate from one another and spread out more quickly among the solvent particles.



Heating causes particles to move more quickly. The solvent particles can separate the solute particles and spread them out more quickly.

Crushing the solute increases the amount of contact it has with the solvent. The particles of the crushed solute mix with the solvent more quickly.

TAKE A LOOK

16. Identify What are three ways to make a solid dissolve faster?

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What Are Suspensions?

Have you ever shaken a snow globe? If so, you have seen the solid snow particles mix with the water, as shown in the figure below. When you stop shaking the globe, the snow settles to the bottom. This mixture is called a suspension. A **suspension** is a mixture in which the particles of a material are large enough to settle out. ☑

The particles in a suspension are large enough to scatter or block light. The particles are too large to stay mixed without being shaken or stirred.

A suspension can be separated by passing it through a filter. The solid particles get trapped by the filter. The liquid or gas part of the suspension passes through the filter. ☑

READING CHECK

17. Describe What is a suspension?

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READING CHECK

18. Describe How can a suspension be separated?

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What Are Colloids?

Some mixtures have properties between those of solutions and suspensions. A **colloid** is a mixture in which the particles are spread throughout but are not large enough to settle out. The particles of a colloid are not as small as those of a solution. However, they are smaller than those of a suspension. You might be surprised at the number of colloids you see each day. Milk, mayonnaise, gelatin, and whipped cream are all colloids. ☑

The particles of a colloid are large enough to scatter light. An example of this is the headlights of a car that is traveling through fog. However, a colloid cannot be separated by a filter. The particles of the colloid are small enough to pass through the filter.

READING CHECK

19. Describe What is a colloid?

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Properties of Suspensions and Colloids

Suspension This snow globe contains solid particles that will mix with the clear liquid when you shake it up. But the particles will soon fall to the bottom when the globe is at rest.

Colloid This dessert includes two tasty examples of colloids—fruity gelatin and whipped cream.

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Section 3 Review

SECTION VOCABULARY

colloid a mixture consisting of tiny particles that are intermediate in size between those in solutions and those in suspensions and that are suspended in a liquid, solid, or gas

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

solute in a solution, the substance that dissolves the solute

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

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

suspension a mixture in which particles of a material are more or less evenly dispersed throughout a liquid or gas

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

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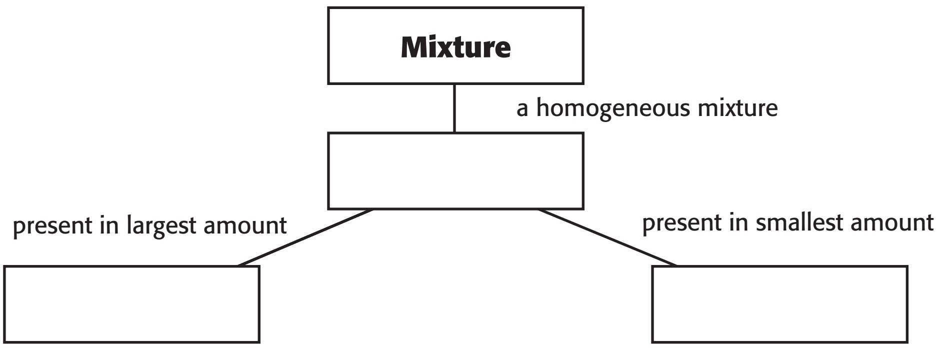
2. **Organize** Complete the Concept Map for a mixture shown below.



3. **Calculate** What is the concentration of a solution if it has 25 g of salt dissolved in 400 mL of water? Show your work.

4. **Apply Concepts** Suppose you add a cup of sugar to hot water and all of the sugar dissolves. Then the water cools and some of the sugar is seen as a solid on the bottom of the beaker. Explain why this happened.

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SECTION 2 COMPOUNDS

1. a pure substance composed of two or more elements that are joined by chemical bonds
2. 1:4
3. Room temperature is about 25°C. This value falls between the melting point and the boiling point of each of the three compounds.
4. sodium
5. They are different.
6. heat
7. proteins and carbohydrates

Review

1. The particles of a compound contain atoms of more than one element. The particles of an element are the atoms of that element.
2. physical, chemical, elements, heat or electricity
3. There was a chemical reaction with something in the air. It formed a new compound that had properties different from those of copper.
4. heat and electricity
5. 1:2

SECTION 3 MIXTURES

1. a physical change
2. The components in the mixtures are not changed.
3. the flame or the burner
4. A pure substance has the same particles throughout, so it cannot separate into layers.
5. the water
6. The ratio of components in a mixture is not fixed, but a compound always has the same elements in the same ratio.
7. the solvent
8. water
9. It is not a solution, because the metals are not spread evenly throughout the coin.
10. Oxygen, carbon dioxide, alcohol, salt, and zinc should be circled.
11. amount of solute and amount of solution
12. You add more than the solubility of sugar in water.
13. 160 g/100 mL of water
14. $concentration = \frac{grams\ of\ solute}{milliliters\ of\ solvent}$

    $concentration = \frac{55\text{ g}}{500}\text{ mL} = 0.11\text{ g/mL}$
15. low temperatures
16. mixing by stirring, heating the solution, crushing the solid
17. a mixture in which the particles of a material are large enough to settle out
18. by passing it through a filter
19. a mixture in which the particles are spread throughout but are not large enough to settle out

Review

1. The solvent is ethanol; the solute is sucrose.
2. Middle box: solution

   Bottom boxes, from left to right: solvent, solute
3. $concentration = \frac{grams\ of\ solute}{milliliters\ of\ solvent}$

   $concentration = \frac{25\text{ g}}{400}\text{ mL} = 0.0625\text{ g/mL}$
4. The solubility of sugar is lower in cold water than in hot water, so some of the sugar came out of solution.

Chapter 4 Introduction to Atoms

SECTION 1 DEVELOPMENT OF THE ATOMIC THEORY

1. An atom is the smallest particle of an element that keeps its properties.
2. in a regular or repeating pattern
3. when new information is found that does not fit the original theory
4. positive
5. negative
6. a beam of small, positively charged particles
7. Most particles followed a straight path.
8. In the center of the atom is the nucleus. Electrons move in mostly empty space outside the nucleus.
9. about 19 mi
10. Electrons move around the nucleus in definite areas called energy levels.
11. The nucleus is the center circle. The nine smaller circles are electrons.
12. Electron clouds are regions where electrons are likely to be found.