SECTION 3

Mixtures

Imagine that you roll out some dough, add tomato sauce, and sprinkle some cheese on top. Then, you add green peppers, mushrooms, olives, and pepperoni! What have you just made?

A pizza, of course! But that's not all. You have also created a mixture—and a delicious one at that! In this section, you will learn about mixtures and their properties.

READING WARM-UP

Objectives

- Describe three properties of mixtures.
- Describe four methods of separating the parts of a mixture.
- Analyze a solution in terms of its solute and solvent.
- Explain how concentration affects a solution.
- Describe the particles in a suspension.
- Explain how a colloid differs from a solution and a suspension.

Terms to Learn

mixture	concentration
solution	solubility
solute	suspension
solvent	colloid

READING STRATEGY

Reading Organizer As you read this section, create an outline of the section. Use the headings from the section in your outline.

Properties of Mixtures

All mixtures—even pizza—share certain properties. A **mixture** is a combination of two or more substances that are not chemically combined. When two or more materials are put together, they form a mixture if they do not react to form a compound. For example, cheese and tomato sauce do not react when they are used to make a pizza. So, a pizza is a mixture.

No Chemical Changes in a Mixture

No chemical change happens when a mixture is made. So, each substance in a mixture has the same chemical makeup it had before the mixture formed. That is, each substance in a mixture keeps its identity. In some mixtures, such as the pizza in **Figure 1,** you can see each of the components. In other mixtures, such as salt water, you cannot see all the components.

Reading Check **Why do substances in a mixture keep their identities?** *(See the Appendix for answers to Reading Checks.)*

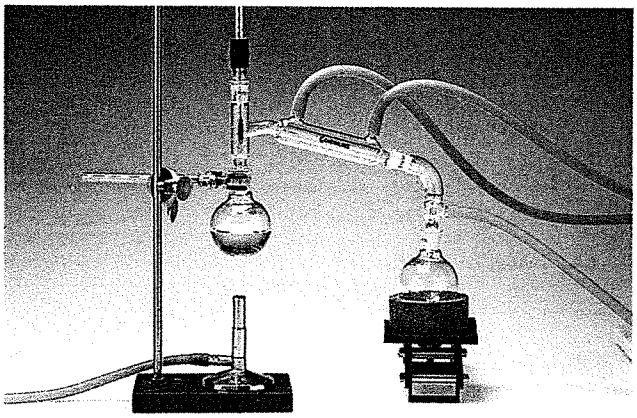
Separating Mixtures Through Physical Methods

You don't like mushrooms on your pizza? Just pick them off. This change is a physical change of the mixture. The identities of the substances do not change. But not all mixtures are as easy to separate as a pizza. You cannot just pick salt out of a saltwater mixture. One way to separate the salt from the water is to heat the mixture until the water evaporates. The salt is left behind. Other ways to separate mixtures are shown in **Figure 2.**

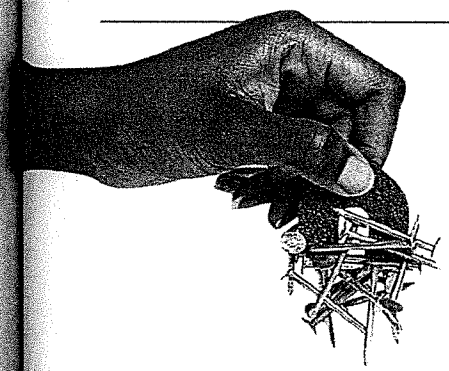
mixture a combination of two or more substances that are not chemically combined

Figure 1 *You can see each topping on this mixture, which is better known as a pizza.*

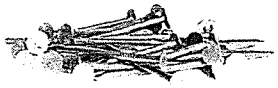
Figure 2 Common Ways to Separate Mixtures



Distillation (DIS tuh LAY shuhn) is a process that separates a mixture based on the boiling points of the components. Here, pure water (at right) is being distilled from a salt-water mixture (at left). Distillation is also used to separate crude oil into components, such as gasoline and kerosene.

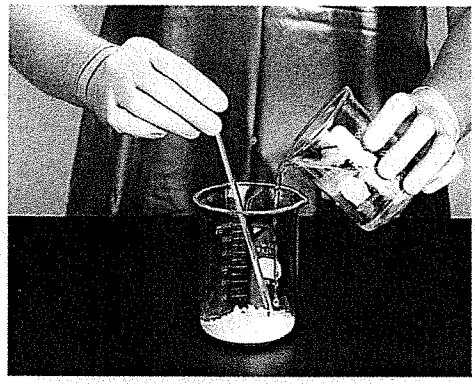


A **magnet** can be used to separate a mixture of the elements iron and aluminum. Iron is attracted to the magnet, but aluminum is not.



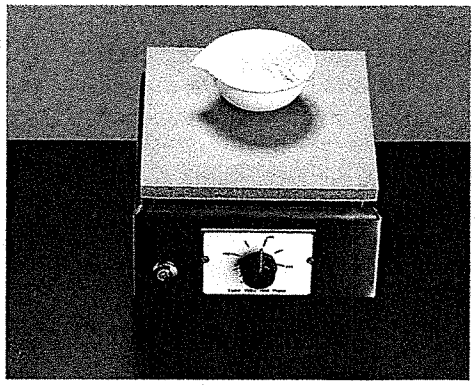
The different parts of blood are separated using a machine called a **centrifuge** (SEN truh FYOOJ). In the test tube at left, a layer of plasma rests above a layer of red blood cells. A centrifuge separates mixtures by the densities of the components.

Separating a mixture of sodium chloride (table salt) and sulfur takes more than one step.



❶ In the first step, water is added, and the mixture is stirred. Salt dissolves in water. Sulfur does not.

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



❸ In the third step, the water is evaporated. The sodium chloride is left behind.

Table 1 Mixtures and Compounds

Mixtures	Compounds
Made of elements, compounds, or both	Made of elements
No change in original properties of components	Change in original properties of components
Separated by physical means	Separated by chemical means
Formed using any ratio of components	Formed using a set ratio of components

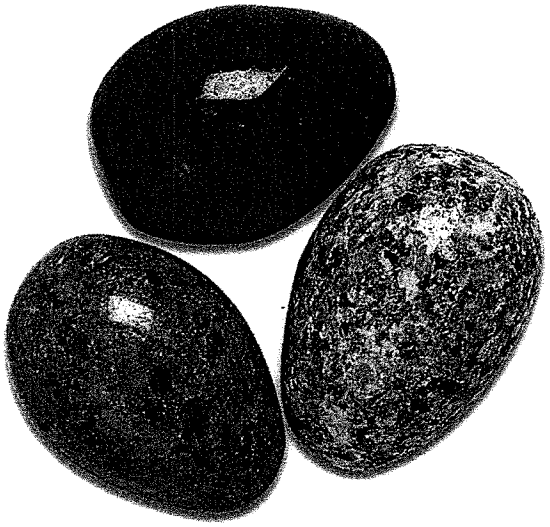


Figure 3 *These paperweights are made of granite. They are different colors because the granite used in each has different ratios of minerals.*

The Ratio of Components in a Mixture

A compound is made of elements in a specific mass ratio. However, the components of a mixture do not need to be mixed in a definite ratio. For example, granite is a mixture made of three minerals: feldspar, mica, and quartz. Feldspar is pink in color. Mica is black. Quartz is colorless. Look at the egg-shaped paperweights in **Figure 3.** The pink one is made from granite that has more feldspar than mica or quartz. That is why it is pink. The black one is made from granite that has more mica than the other minerals. The gray one is made from granite that has more quartz than the other minerals. Even though the proportions of the minerals change, this combination of minerals is always a mixture called *granite.* **Table 1** above summarizes the differences between mixtures and compounds.

Solutions

solution a homogeneous mixture of two or more substances uniformly dispersed throughout a single phase

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

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

A **solution** is a mixture that appears to be a single substance. A solution is composed of particles of two or more substances that are distributed evenly among each other. Solutions have the same appearance and properties throughout the mixture.

The process in which particles of substances separate and spread evenly throughout a mixture is known as *dissolving.* In solutions, the **solute** is the substance that is dissolved. The **solvent** is the substance in which the solute is dissolved. A solute must be *soluble,* or able to dissolve, in the solvent. A substance that is *insoluble,* or unable to dissolve, forms a mixture that is not a solution.

Salt water is a solution. Salt is soluble in water, meaning that salt dissolves in water. Therefore, salt is the solute, and water is the solvent. When two liquids or two gases form a solution, the substance with the greater amount is the solvent.

Table 2 Examples of Different States in Solutions	
States	**Examples**
Gas in gas	dry air (oxygen in nitrogen)
Gas in liquid	soft drinks (carbon dioxide in water)
Liquid in liquid	antifreeze (alcohol in water)
Solid in liquid	salt water (salt in water)
Solid in solid	brass (zinc in copper)

Examples of Solutions

You may think that all solutions are liquids. And in fact, tap water, soft drinks, gasoline, and many cleaning supplies are liquid solutions. However, solutions may also be gases, such as air. Solutions may even be solids, such as steel. *Alloys* are solid solutions of metals or nonmetals dissolved in metals. Brass is an alloy of the metal zinc dissolved in copper. Steel is an alloy made of the nonmetal carbon and other elements dissolved in iron. **Table 2** lists more examples of solutions.

Reading Check What is an alloy?

Particles in Solutions

The particles in solutions are so small that they never settle out. They also cannot be removed by filtering. In fact, the particles are so small that they don't even scatter light. Both of the jars in **Figure 4** contain mixtures. The mixture in the jar on the left is a solution of table salt in water. The jar on the right holds a mixture—but not a solution—of gelatin in water.

CONNECTION TO Language Arts

WRITING SKILL **Alloys** Research an alloy. Find out what the alloy is made of and the amount of each substance in the alloy. Also, identify different ways that the alloy is used. Then, write a song or poem about the alloy to recite in class.

Figure 4 *Both of these jars contain mixtures. The mixture in the jar on the left, however, is a solution. The particles in solutions are so small that they don't scatter light. Therefore, you can't see the path of light through the solution.*

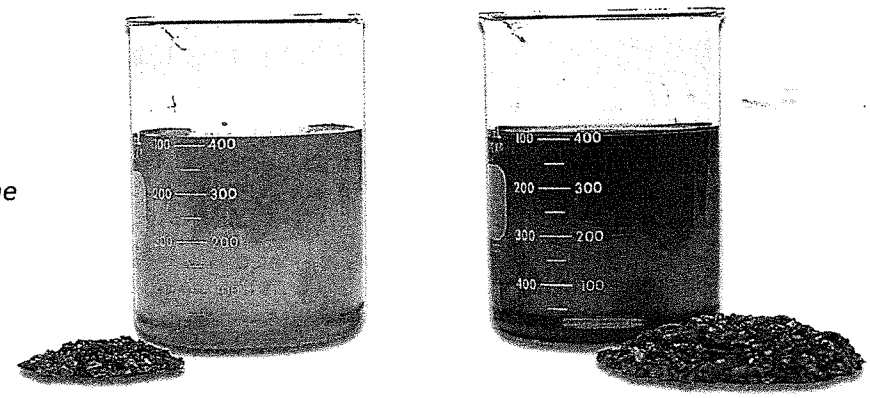


Figure 5 *The dilute solution* (left) *contains less solute than the concentrated solution* (right).

Concentration of Solutions

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

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

A measure of the amount of solute dissolved in a solvent is **concentration.** Concentration can be expressed in grams of solute per milliliter of solvent (g/mL).

Concentrated or Dilute?

Solutions can be described as being concentrated or dilute. In **Figure 5,** both solutions have the same amount of solvent. However, the solution on the left contains less solute than the solution on the right. The solution on the left is dilute. The solution on the right is concentrated. Keep in mind that the terms *dilute* and *concentrated* do not tell you the amount of solute that is dissolved.

Solubility

If you add too much sugar to a glass of lemonade, not all of the sugar can dissolve. Some of it sinks to the bottom. To find the maximum amount of sugar that can dissolve, you would need to know the solubility of sugar. The **solubility** of a solute is the ability of the solute to dissolve in a solvent at a certain temperature. **Figure 6** shows how the solubility of several different solid substances changes with temperature.

MATH FOCUS

Calculating Concentration What is the concentration of a solution that has 35 g of salt dissolved in 175 mL of water?

Step 1: One equation for finding concentration is the following:

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

Step 2: Replace grams of solute and milliliters of solvent with the values given, and solve.

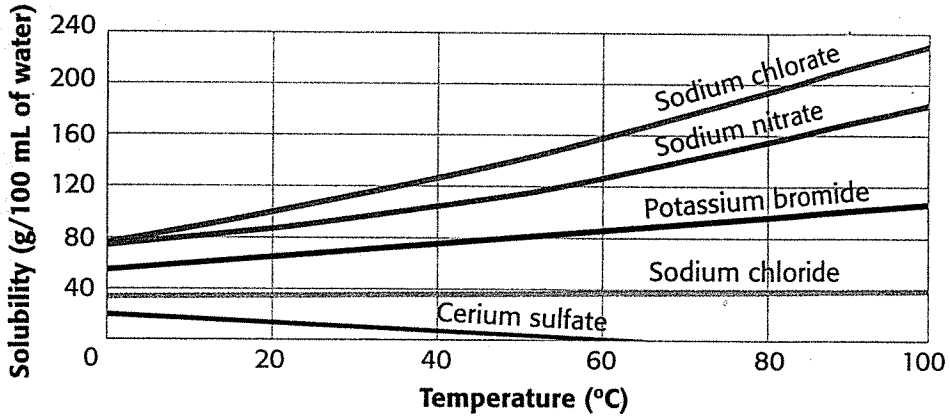
$$\frac{35 \text{ g salt}}{175 \text{ mL water}} = 0.2 \text{ g/mL}$$

Now It's Your Turn

1. What is the concentration of solution A if it has 55 g of sugar dissolved in 500 mL of water?
2. What is the concentration of solution B if it has 36 g of sugar dissolved in 144 mL of water?
3. Which solution is more concentrated?

Figure 6 **Solubility of Different Solids In Water**

The solubility of most solids increases as the temperature gets higher. So, more solute can dissolve at higher temperatures. However, some solids, such as cerium sulfate, are less soluble at higher temperatures.



Dissolving Gases in Liquids

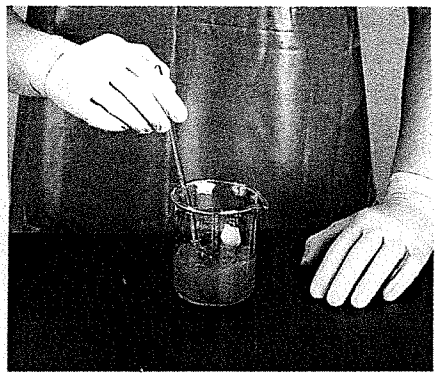
Most solids are more soluble in liquids at higher temperatures. But gases become less soluble in liquids as the temperature is raised. A soft drink goes flat faster when warm. The gas that is dissolved in the soft drink cannot stay dissolved when the temperature increases. So, the gas escapes, and the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

Reading Check How does the solubility of gases change with temperature?

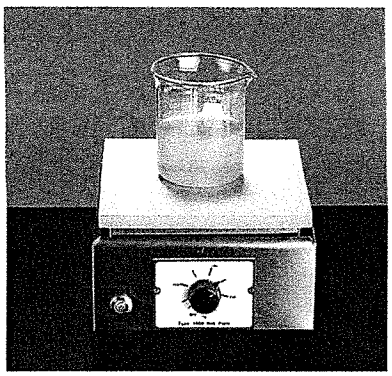
Dissolving Solids Faster in Liquids

Several things affect how fast a solid will dissolve. Look at **Figure 7** to see three ways to make a solute dissolve faster. You can see why you will enjoy a glass of lemonade sooner if you stir granulated sugar into the lemonade before adding ice!

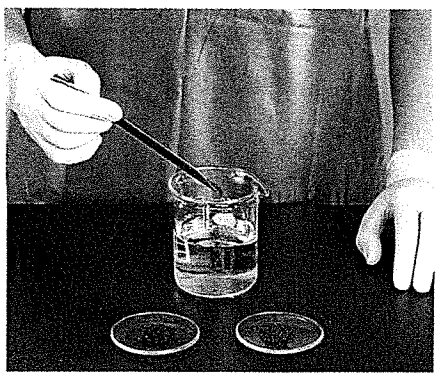
Figure 7 **How to Dissolve Solids Faster**



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.

Suspensions

Have you ever shaken a snow globe? If so, you have seen the solid snow particles mix with the water, as shown in **Figure 8.** 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 particles of a material are dispersed throughout a liquid or gas but are large enough that they settle out.

The particles in a suspension are large enough to scatter or block light. The particles are also too large to stay mixed without being stirred or shaken. If a suspension is allowed to sit, the particles will settle out, as they do in a snow globe.

A suspension can be separated by passing it through a filter. So, the liquid or gas passes through the filter, but the solid particles are large enough to be trapped by the filter.

Reading Check **How can the particles of a suspension be separated?**

SCHOOL to HOME

Suspensions

Many household items, such as paints, salad dressings, and medicines, are suspensions. With a parent, find several items that have directions that tell you to shake the bottle before use. Discuss what problems could arise if you do not shake the container before use.

ACTIVITY

Colloids

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

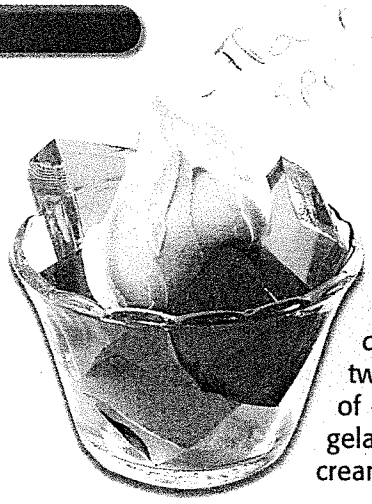
colloid a mixture consisting of tiny particles that are intermediate in size between those in solutions and those in suspensions and that are suspended in a liquid, solid, or gas

Some mixtures have properties between those of solutions and suspensions. These mixtures are known as colloids (KAHL OYDZ). A **colloid** is a mixture in which the particles are dispersed throughout but are not heavy enough to settle out. The particles in a colloid are relatively small and are fairly well mixed. You might be surprised at the number of colloids you see each day. Milk, mayonnaise, and stick deodorant—even the gelatin and whipped cream in **Figure 8**—are colloids.

The particles in a colloid are much smaller than the particles in a suspension. However, the particles are large enough to scatter light. A colloid cannot be separated by filtration. The particles are small enough to pass through a filter.

Figure 8 **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.

SECTION Review

Summary

- A mixture is a combination of two or more substances, each of which keeps its own characteristics.
- Mixtures can be separated by physical means, such as filtration and evaporation.
- A solution is a mixture that appears to be a single substance but is composed of a solute dissolved in a solvent.
- Concentration is a measure of the amount of solute dissolved in a solvent.
- The solubility of a solute is the ability of the solute to dissolve in a solvent at a certain temperature.
- Suspensions are mixtures that contain particles large enough to settle out or be filtered and to block or scatter light.
- Colloids are mixtures that contain particles that are too small to settle out or be filtered but are large enough to scatter light.

Using Key Terms

The statements below are false. For each statement, replace the underlined term to make a true statement.

1. The solvent is the substance that is dissolved.
2. A suspension is composed of substances that are spread evenly among each other.
3. A measure of the amount of solute dissolved in a solvent is solubility.
4. A colloid contains particles that will settle out of the mixture if left sitting.

Understanding Key Ideas

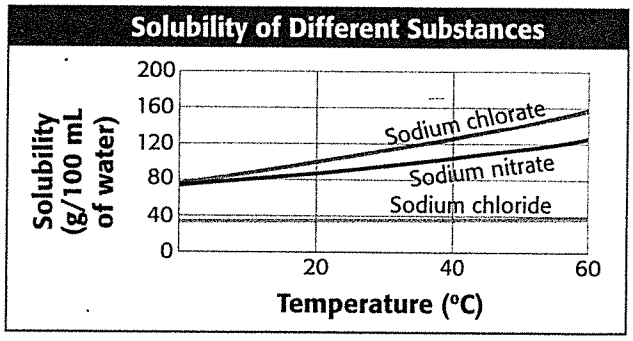
5. A mixture
   - **a.** has substances in it that are chemically combined.
   - **b.** can always be separated using filtration.
   - **c.** contains substances that are not mixed in a definite ratio.
   - **d.** All of the above
6. List three ways to dissolve a solid faster.

Critical Thinking

7. **Making Comparisons** How do solutions, suspensions, and colloids differ?
8. **Applying Concepts** Suggest a procedure to separate iron filings from sawdust. Explain why this procedure works.
9. **Analyzing Ideas** Identify the solute and solvent in a solution made of 15 mL of oxygen and 5 mL of helium.

Interpreting Graphics

Use the graph below to answer the questions that follow.



10. At what temperature is 120 g of sodium nitrate soluble in 100 mL of water?
11. At 60°C, how much more sodium chlorate than sodium chloride will dissolve in 100 mL of water?

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