Section 1

Understanding Solutions

Reading Preview

Key Concepts

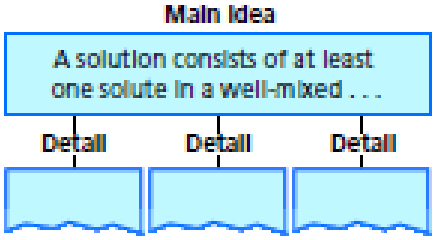
- What are the characteristics of solutions, colloids, and suspensions?
- What happens to the particles of a solute when a solution forms?
- How do solutes affect the freezing point and boiling point of a solvent?

Key Terms

- solution
- solvent
- solute
- colloid
- suspension

Target Reading Skill

Identifying Main Ideas As you read the *What Is a Solution?* section, write the main idea in a graphic organizer like the one below. Then write supporting details that further explain the main idea.



Lab zone Discover Activity

What Makes a Mixture a Solution?

1. Put about 50 or 60 milliliters of water into a plastic cup. Add a spoonful of pepper and stir well.
2. To a similar amount of water in a second cup, add a spoonful of table salt. Stir well.
3. Compare the appearance of the two mixtures.

Think It Over

Observing What is the difference between the two mixtures? What other mixtures have you seen that are similar to pepper and water? That are similar to table salt and water?

Imagine a hot summer day. You've been outdoors and now you're really thirsty. A tall, cool glass of plain tap water would taste great. But exactly what is tap water?

Tap water is more than just water. It's a mixture of pure water (H_2O) and a variety of other substances, such as chloride, fluoride, and metallic ions. Gases, such as oxygen and carbon dioxide, are also dissolved in tap water. The dissolved substances give tap water its taste.

What Is a Solution?

Tap water is one example of a mixture called a solution. A **solution** is a well-mixed mixture that contains a solvent and at least one solute. The **solvent** is the part of a solution present in the largest amount. It dissolves the other substances. The **solute** is the substance that is present in a solution in a smaller amount and is dissolved by the solvent. **A solution has the same properties throughout. It contains solute particles (molecules or ions) that are too small to see.**

Solutions With Water In many common solutions, the solvent is water. Sugar in water, for example, is the starting solution for flavored soft drinks. Adding food coloring gives the drink color. Dissolving carbon dioxide gas in the mixture produces a fizzy soda. Water dissolves so many substances that it is often called the "universal solvent."

Life depends on water solutions. Nutrients used by plants are dissolved in water in the soil. Sap is a solution that carries sugar dissolved in water to tree cells. Water is the solvent in blood, saliva, and tears. Reactions in cells take place in solution. To keep cells working, you must replace the water you lose in sweat and urine—two other water solutions.

Solutions Without Water Many solutions are made with solvents other than water, as you can see in Figure 1. For example, gasoline is a solution of several different liquid fuels. You don't even need a liquid solvent to make solutions. A solution may be made of any combination of gases, liquids, or solids.

Reading Checkpoint **What solvent is essential to living things?**

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Acids, Bases, and Solutions

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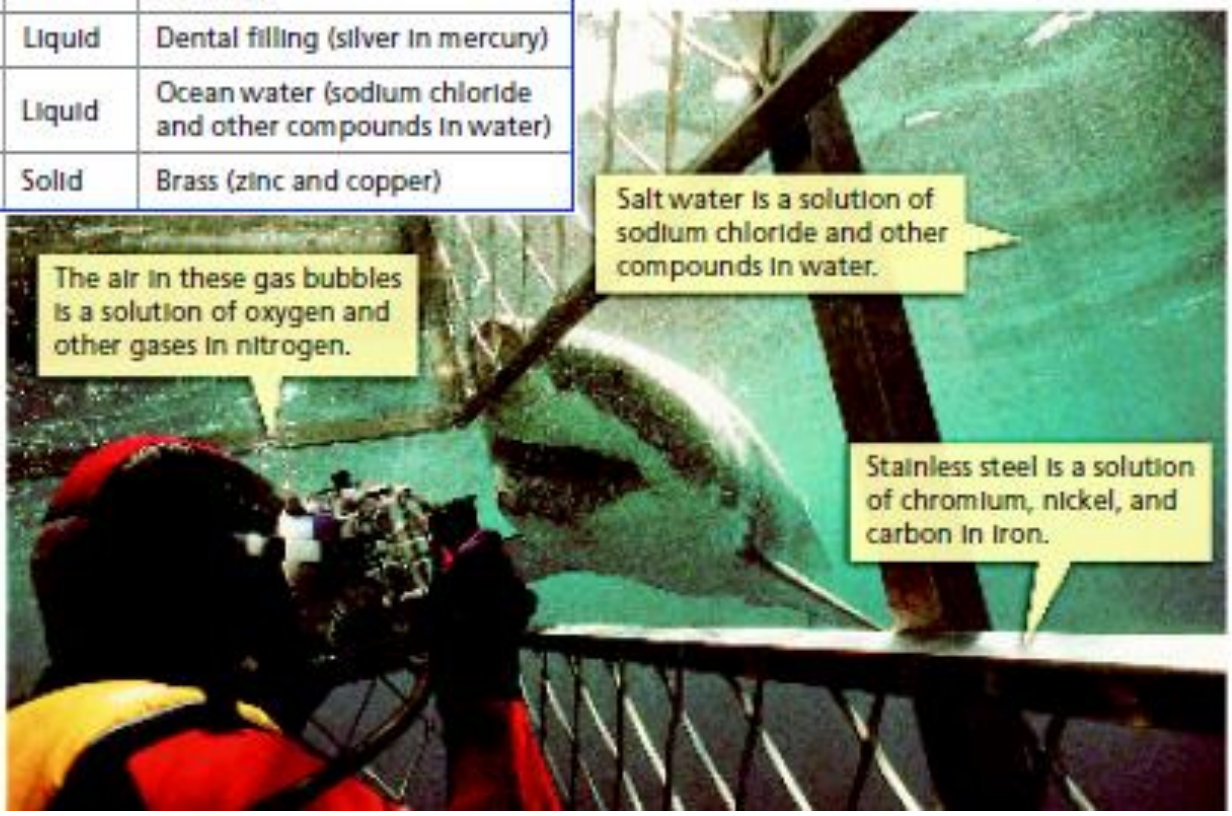
Examples of Common Solutions

Solute	Solvent	Solution
Gas	Gas	Air (oxygen and other gases in nitrogen)
Gas	Liquid	Soda water (carbon dioxide in water)
Liquid	Liquid	Antifreeze (ethylene glycol in water)
Solid	Liquid	Dental filling (silver in mercury)
Solid	Liquid	Ocean water (sodium chloride and other compounds in water)
Solid	Solid	Brass (zinc and copper)

FIGURE 1
Solutions can be made from any combination of solids, liquids, and gases. **Interpreting Photos** *What are the solutes and solvent for stainless steel?*



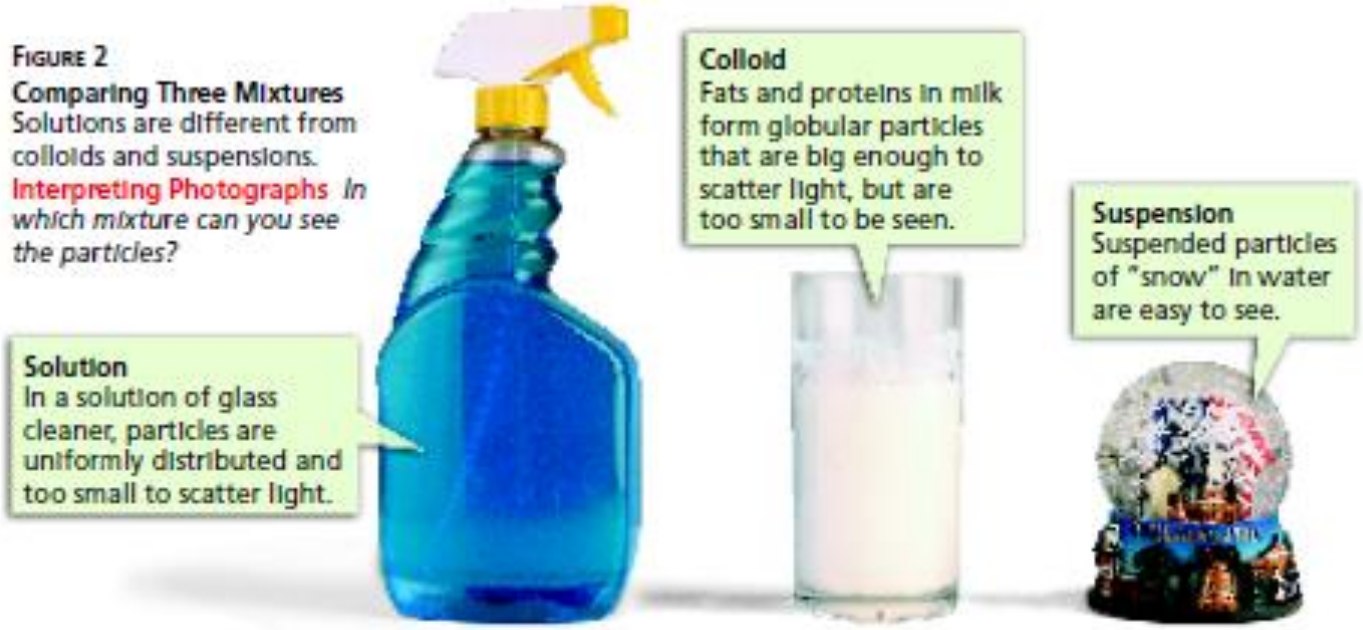


FIGURE 2
Comparing Three Mixtures
Solutions are different from colloids and suspensions.
Interpreting Photographs *In which mixture can you see the particles?*

Colloids and Suspensions

Not all mixtures are solutions. Colloids and suspensions are mixtures that have different properties than solutions.

Colloids Have you ever made a gelatin dessert? To do so, you stir powdered gelatin in hot water until the two substances are uniformly mixed. The liquid looks like a solution, but it's not. Gelatin is a colloid. A **colloid** (KAHL oyd) is a mixture containing small, undissolved particles that do not settle out.

Solutions and colloids differ in the size of their particles and how they affect the path of light. **A colloid contains larger particles than a solution. The particles are still too small to be seen easily, but are large enough to scatter a light beam.** For example, fog—a colloid that consists of water droplets in air—scatters the headlight beams of cars. In addition to gelatin and fog, milk, mayonnaise, shaving cream, and whipped cream are examples of colloids.

Suspensions If you did the Discover Activity, you noticed that no matter how much you stir pepper and water, the two never really seem to "mix" completely. When you stop stirring, you can still see pepper flakes floating on the water's surface and collecting at the bottom of the cup. Pepper and water make a suspension. A **suspension** (suh SPEN shun) is a mixture in which particles can be seen and easily separated by settling or filtration. **Unlike a solution, a suspension does not have the same properties throughout. It contains visible particles that are larger than the particles in solutions or colloids.**

Reading Checkpoint **Which kind of mixture has the largest particles?**

Lab zone **Try This Activity**

Scattered Light

1. Pour 50 mL of a gelatin-and-water mixture into a small, clean glass beaker.
2. Pour 50 mL of a saltwater solution into another clean beaker that is about the same size.
3. Compare the appearance of the two liquids.
4. In a darkened room, shine a small flashlight through the side of the beaker that contains gelatin. Repeat this procedure with the saltwater solution.
5. Compare the appearance of the light inside the two beakers.

Inferring What evidence tells you that gelatin is a colloid?

Particles in a Solution

Why do solutes seem to disappear when you mix them with a solvent? If you had a microscope powerful enough to look at the mixture's particles, what would you see? **When a solution forms, particles of the solute leave each other and become surrounded by particles of the solvent.**

Ionic and Molecular Solutes Figure 3 shows what happens when an ionic solid mixes with water. The positive and negative ions are attracted to the polar water molecules. Water molecules surround each ion as it leaves the surface of the crystal. As each layer of the solid is exposed, more ions can dissolve.

However, not every substance breaks into ions when it dissolves in water. A molecular solid, such as sugar, breaks up into individual neutral molecules. The polar water molecules attract the slightly polar sugar molecules. This causes the sugar molecules to move away from each other. But covalent bonds within the molecules are not broken.

Solutes and Conductivity You have a water solution, but you don't know if the solute is salt or sugar. How could you find out? Think about what you learned about the electrical conductivity of compounds. A solution of ionic compounds in water conducts electricity, but a water solution of molecular compounds may not. You could test the conductivity of the solution. If no ions are present (as in a sugar solution), electricity will not flow.

Reading Checkpoint **Which kind of solution conducts electricity?**

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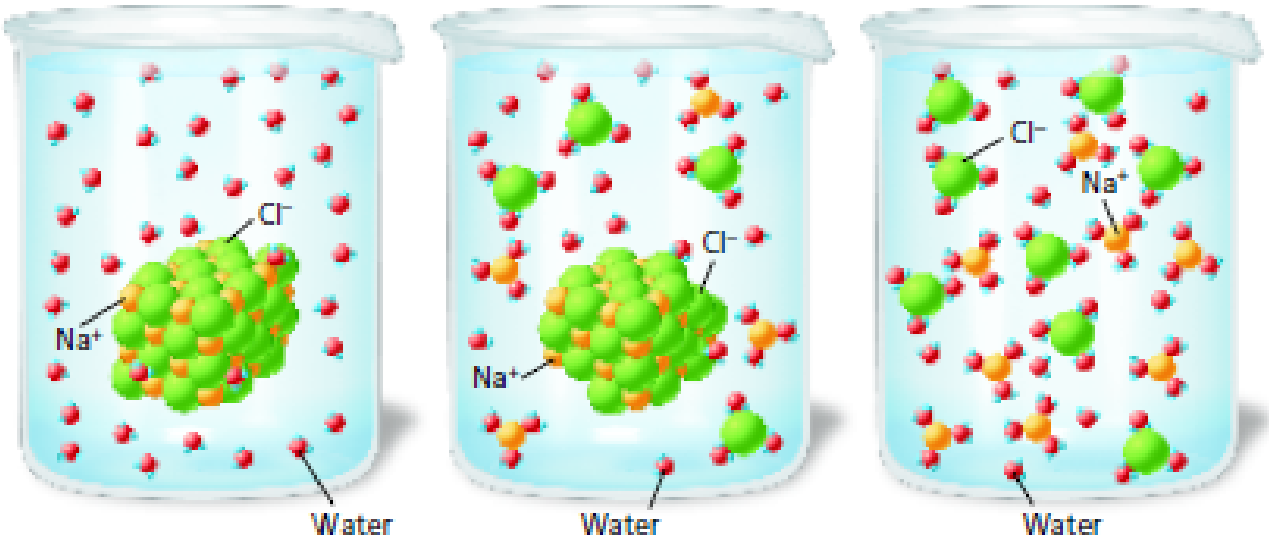
FIGURE 3
Salt Dissolving in Water
When an ionic solid—like table salt—dissolves, water molecules surround and separate the positive and negative ions. Notice that the sodium ions attract the oxygen ends of the water molecules.



Lab zone Skills Activity

Designing Experiments

How does the mass of a solute affect the boiling temperature of a given volume of water? Design an experiment using a solute, water, a balance, a hot plate, and a thermometer.

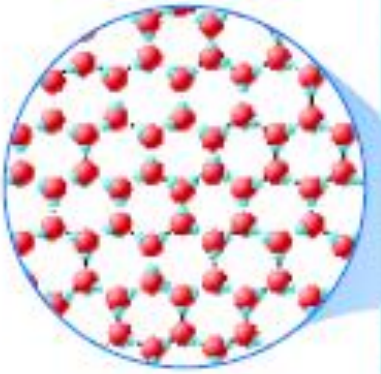
What variables should remain constant in your experiment? What is the manipulated variable? What will be the responding variable?

With approval from your teacher, do the experiment.

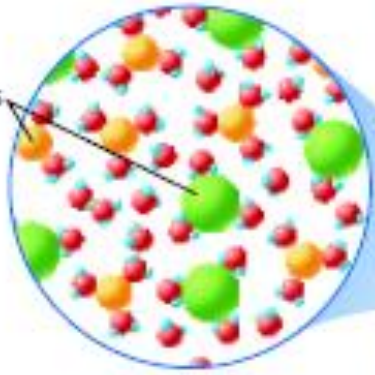
Effects of Solutes on Solvents

The freezing point of water is 0°C, and the boiling point is 100°C. These statements are true enough for pure water under everyday conditions, but the addition of solutes to water can change these properties. **Solutes lower the freezing point and raise the boiling point of a solvent.**

Lower Freezing Points Solutes lower the freezing point of a solvent. When liquid water freezes, water molecules join together to form crystals of solid ice. Pure water is made only of water molecules that freeze at 0°C. In a salt solution, solute particles are present in the water when it freezes. The solute particles make it harder for the water molecules to form crystals. The temperature must drop lower than 0°C for the solution to freeze. Figure 4 shows how solutes can affect the freezing point of water.



Freshwater lake ▶



Saltwater bay ▶

Figure 4
Salt's Effect on Freezing Point
Fresh water on the surface of a lake is frozen. At the same temperature, salt water is not frozen.

Higher Boiling Points Solutes raise the boiling point of a solvent. To see why, think about the difference between the molecules of a liquid and those of a gas of the same substance. In a liquid, molecules are moving close to each other. In a gas, they are far apart and moving more rapidly. As the temperature of a liquid rises, the molecules gain energy and escape into the air. In pure water, all the molecules are water. But in a solution, some of the particles are water molecules and others are particles of solute. The presence of the solute makes it harder for the water molecules to escape, so more energy is needed. The temperature must go higher than 100°C for the water to boil.

Car manufacturers make use of the effects of solutes to protect engines from heat and cold. The coolant in a car radiator is a solution of water and another liquid called antifreeze. (Often the antifreeze is ethylene glycol.) The mixture of the two liquids has a higher boiling point and lower freezing point than water alone. Because this solution can absorb more of the heat given off by the running engine, risk of damage to the car from overheating is greatly reduced. The risk of damage from freezing in very cold weather is also reduced.

Reading Checkpoint **Does salt water have a lower or higher freezing point than pure water?**

FIGURE 5
Calling Solutes to the Rescue? This couple might have prevented their car from overheating by using the proper coolant in the radiator. Relating Cause and Effect *Explain how coolant works.*

Section 1 Assessment

Target Reading Skill Identifying Main Ideas Use your graphic organizer to help you answer Question 1 below.

Reviewing Key Concepts

1. a. Defining What is a solution?
   b. Comparing and Contrasting How are solutions different from colloids and suspensions?
   c. Inferring Suppose you mix food coloring in water to make it blue. Have you made a solution or a suspension? Explain.
2. a. Reviewing What happens to the solute particles when a solution forms?
   b. Sequencing Describe as a series of steps what happens to sugar molecules when they dissolve in water.
3. a. Summarizing What effects do solutes have on a solvent's freezing and boiling points?
   b. Relating Cause and Effect Why is the temperature needed to freeze ocean water lower than the temperature needed to freeze the surface of a freshwater lake?
   c. Applying Concepts Why does salt sprinkled on icy roads cause the ice to melt?

Lab zone **At-Home Activity**

Passing Through With a family member, mix together a spoonful each of sugar and pepper in about 100 mL of warm water in a plastic container. Pour the mixture through a coffee filter into a second container. Ask your family member what happened to the sugar. Let the water evaporate overnight. Describe the difference between a solution and a suspension.