Pause and Check

Readers can do many things when they realize their understanding of a concept is breaking down. On this page, you are reading about the two components of solutions: the solute and the solvent. Can you distinguish between these two things? Focus on the solute and create a two-column chart to record "What It Is" and "What It Is Not." Add information from the text to your chart. What do you notice about the column entitled "What it is not"? What is it describing?

Solutions

As you learned in the previous chapter, a solution is a homogeneous mixture because it has the same appearance throughout. Solutions can occur as solids, liquids, or gases. Solid solutions are called alloys (Figure 8.4). Liquid and gaseous solutions are simply called solutions.

Solutions consist of solutes and solvents. A solute is the substance that dissolves. A solvent is the substance into which the solute dissolves. The solvent is usually the substance present in the greatest amount. For example, in the air you breathe, nitrogen is found in the greatest amount. It is the solvent into which solutes such as oxygen, argon, and carbon dioxide dissolve. In seawater, salt and other substances (solutes) dissolve in water (solvent). Examples of common solutions are shown in Table 8.2.

Water — The Universal Solvent

Water is often referred to as the universal solvent because many different solids, liquids, and gases dissolve in it to form solutions. For example, seawater is a solution of water with many dissolved solids, such as salt and magnesium, and gases, such as oxygen and carbon dioxide.

Not all substances are soluble in water. For example, many oils and fats do not dissolve in water. However, you can remove fats and oils from clothes and dishes by using a solution of soap or detergent in water. These cleansers break up the fats and oils so they can be washed away.

Table 8.2 Examples of Common Solutions

<table>
<thead>
<tr>
<th>Solute</th>
<th>Solvent</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>zinc (solid)</td>
<td>copper (solid)</td>
<td>brass</td>
</tr>
<tr>
<td>salt, minerals (solid)</td>
<td>water (liquid)</td>
<td>seawater</td>
</tr>
<tr>
<td>benzene (liquid)</td>
<td>rubber (solid)</td>
<td>rubber cement</td>
</tr>
<tr>
<td>ethylene glycol (liquid)</td>
<td>water (liquid)</td>
<td>antifreeze</td>
</tr>
<tr>
<td>carbon dioxide (gas)</td>
<td>water (liquid)</td>
<td>soft drink</td>
</tr>
<tr>
<td>oxygen, argon (gas)</td>
<td>nitrogen (gas)</td>
<td>air</td>
</tr>
</tbody>
</table>
C17 Learning Checkpoint

Components of Solutions

1. Name three types of solutions — one solid, one liquid, and one gas.
2. Identify three common solutions used in the kitchen. List the solutes and solvents found in each solution.
3. Name a substance that dissolves in water. How can you prove that it is water soluble?
4. Make a list of three substances that cannot dissolve in water. For each substance, identify a solvent in which it will dissolve.

Suggested Activity • C18 Quick Lab on page 218

Take It Further

Most clothing is washed in water using laundry detergent. Most detergents work best in hot water. Some fabrics (e.g., wool) can be damaged by the heat from hot water (and hot air in dryers). Dry cleaners use different solvents to clean clothing. Find out more about these solvents. Begin your search at ScienceSource.

Solubility

Solubility is the relative ability of a solute to form a solution when added to a certain solvent. It is also defined as the maximum amount of solute you can dissolve in a fixed amount of solvent at a given temperature. To form a solution, the solute particles must be attracted to the solvent particles, which allows the particles to spread evenly throughout the solution. For example, salt dissolves in water because the salt particles are attracted to the water particles (Figure 8.5, left). This forms a saltwater solution.

However, salt does not dissolve in olive oil because the salt particles are not attracted to the oil particles (Figure 8.5, right). When a substance does not dissolve in a solvent, that substance is insoluble in that solvent. A solution is not formed by the combination of the two substances when one of the substances is insoluble in the other other.

Figure 8.5 (Left) Salt (brown) dissolves in water (blue) because the particles are attracted to one another. (Right) Salt particles (brown) form clumps and do not dissolve in olive oil (green) because the particles are not attracted to one another.
**Concentration — Qualitative**

The amount of solute in a solvent can be expressed in qualitative terms. A **concentrated solution** is a solution that contains a large amount of dissolved solute and very little solvent. For example, frozen juice concentrate is a concentrated solution of orange juice solids (solute) and a small amount of water (solvent). A **dilute solution** has very little solute dissolved in the solvent. By adding water (solvent) to the frozen juice concentrate (solute), you would be diluting the frozen orange juice. This would create a diluted solution of orange juice (Figure 8.6).

**Concentration — Quantitative**

The **concentration** of a solution is the amount of solute dissolved in a specific amount of solvent. For example, if 5 g of salt are dissolved in 500 mL of water, the concentration of the solution is 5 g/500 mL (or 1 g/100 mL). This can be read as “five grams per five hundred millilitres” or “one gram per one hundred millilitres.” We could also call this a 1 percent solution. For example, a concentration of 1 g/100 mL means that 100 mL of the solvent has 1 g of solute dissolved in it.

**Saturation**

In all solutions, there is a maximum amount of solute that can be dissolved in a given amount of solvent at a given temperature. This is called **saturation**. A **saturated solution** is one that has been formed from the maximum amount of solute for a given amount of solvent at a certain temperature. Every solution has a **saturation point** at a given temperature, which means that no more solute can be dissolved in a fixed volume of solvent at that temperature.

If more solute can be dissolved in a solvent at a given temperature, then the solution is unsaturated. You can dissolve more solute in an **unsaturated solution**. Under certain circumstances, a saturated solution can be cooled below a critical temperature to form a **supersaturated solution**, which contains more solute than would normally be dissolved in the solution.

**WORDS MATTER**

The prefix "un" means "not." The prefix "super" means "above, beyond or over."
Factors Affecting Solubility

Here is a summary of what you will learn in this section:
• The particle theory of matter explains how solutes dissolve in solvents.
• Solubility is affected by temperature, type of solute or solvent, particle size, and stirring.

Salt has many different uses, and it also comes in different forms. Rock salt is used in water softeners to help remove unwanted particles of dissolved minerals from water (Figure 8.7, top). Table salt is used to add flavour to foods (Figure 8.7, bottom). They both dissolve in water, since salt particles are attracted to water particles, but table salt dissolves more quickly than rock salt.

Solubility is an interesting property of solute particles and their interaction with solvent particles. For example, when you paint with water-based paints, it is easy to clean up and remove the paint from your brush with water. However, oil-based paints do not dissolve in water. Cleaning up is made more difficult because only certain solvents, such as turpentine, will dissolve oil-based paints.

Figure 8.7 Rock salt (top) takes longer to dissolve than table salt (bottom).

C20 Starting Point

One Lump or Two Teaspoons

If you have ever eaten at a restaurant or shopped in a grocery store, you may have seen that sugar comes in different forms. You can buy granular (loose) sugar by the bag or packet, and you can also buy sugar cubes. In this activity, you will determine which dissolves more quickly in water: one sugar cube or two teaspoons of granular sugar.

Work with a partner. Measure 50 mL of water into each of two colourless, transparent containers. Then add one sugar cube to one container while your partner adds two teaspoons of sugar to the other container. Do not shake either container or touch them in any way. Determine which sample finishes dissolving first: one sugar cube or two teaspoons of granular sugar.
Solubility and the Particle Theory

In Chapter 7, you learned that all matter is made up of particles. According to the particle theory of matter, those particles are in constant motion. Particles are constantly rotating, vibrating, and moving about from one place to another. In a solution, this means that solute particles are always bumping against other solute particles as well as solvent particles.

Figure 8.8 shows that dissolving a salt crystal begins with water particles bumping into salt particles at the edge of the crystal. The water particles are attracted to the individual salt particles. With constant motion, they are able to free individual salt particles from the larger crystal. Individual salt particles are then carried away by bumping into water particles. This leaves room for other water particles to bump into and carry off other salt particles at the edge of the crystal. The process continues until all the salt particles are surrounded by water particles and are evenly distributed throughout the water.

Rate of Dissolving

How quickly a substance dissolves in a solvent is variable. A teaspoon of table sugar will dissolve rapidly in a hot drink (Figure 8.9). The same amount of sugar will take much more time to dissolve in a glass of ice water. Similarly, table salt dissolves rapidly in water at room temperature. Large pieces of salt, like those used in home water softeners, dissolve much more slowly, which makes this type of salt ideal for use over long periods. The rate of dissolving is affected by stirring, temperature, and particle size.
Stirring

Stirring a solution increases the rate at which a solute dissolves in a solvent. For example, you may have tried to make a soft drink by dissolving flavour crystals in a pitcher of water (Figure 8.10). The flavour crystals are the solute and water is the solvent. If the package of flavour crystals is poured into the water, dissolving begins, but clumps of powder may remain. To speed up the process, you probably used a spoon to stir the water with the flavour crystals. This results in a more uniform arrangement of flavour crystals and water particles and makes dissolving occur more quickly. You can actually see the flavour crystals being stirred until they dissolve in the water. The end result is a solution, as all parts of the soft drink mixture look the same.

Figure 8.11 is a particle diagram of water particles surrounding salt particles. It illustrates how salt particles dissolve more quickly in water that is stirred compared to salt particles in water that is not stirred. As shown in the left part of the diagram, the water particles at the edge of a salt crystal tend to remain near the edge of the crystal. This limits the number of water particles that can interact with individual salt particles and it limits the amount of dissolving that can occur. As shown in the right part of the diagram, stirring the water pushes some of the salt particles surrounded by water particles away from the edge of the crystal and increases the number of water particles that are able to interact with salt particles. Thus, more salt particles are exposed to and come in contact with more water particles. This speeds up the dissolving process.
Using a Particle Diagram to Explain Rate of Dissolving

John Dalton (1766–1844) was a chemist, meteorologist, and physicist. He is best known for developing ideas about particles. His early records contain particle diagrams, which he used to represent the chemicals he was studying.

In your notebook, make a particle diagram to show why stirring the water and sugar cubes in this glass tends to increase the rate of dissolving of the sugar cubes (Figure 8.12).

**Temperature**

As you learned in the previous chapter, temperature affects the speed at which particles move. Particles move more rapidly at higher temperatures, as heat is transferred by the movement of the particles. Since the rate of dissolving depends on solute particles bumping into solvent particles, when the particles move more rapidly, more solvent and solute particles will bump into one another. In addition, the solvent particles at the edge of a piece of solute will more rapidly carry away the solute particles that they meet. This will quickly spread the solute particles throughout the solvent. With increasing temperature, most solutes dissolve more rapidly in most solvents. This explains, for example, why a teaspoon of sugar dissolves more quickly in a cup of hot tea than in a glass of iced tea.

**Particle Size**

Particle size also affects the rate of dissolving. Large particles take longer to dissolve than smaller particles of the same substance. For example, sugar cubes dissolve more slowly than granular sugar. Similarly, rock salt, which is lumpy, dissolves more slowly than table salt, which is made of tiny crystals. You learned that solvent particles must bump into solute particles for dissolving to occur. Particles of a solvent will contact solute particles at the surface of a clump or crystal of solute particles. Therefore, large pieces of a solute must be broken apart to enable solvent particles to come in contact with solute particles.