Introduction to Solutions

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CHAPTER 1 Introduction to Solutions

Lesson Objectives

- Explain how solutions form.
- Identify properties of solutions.

Lesson Vocabulary

- insoluble
- soluble
- solute
- solvent

Introduction

When rocks or other substances dissolve in water, they form a solution. A solution is a homogeneous mixture of two or more substances. The particles of a solution are mixed evenly throughout it. The particles are too small to be seen or to settle out. An example of a solution is salt water.

Solutes and Solvents

A solution forms when one substance dissolves in another. The substance that dissolves is called the **solute**. The substance it dissolves in is called the **solvent**. For example, ocean water is a solution in which the solute is salt and the solvent is water. In this example, a solid (salt) is dissolved in a liquid (water). However, matter in any state can be the solute or solvent in a solution. Solutions may be gases, liquids, or solids. In **Table** 1.1 and the video at the URL below, you can learn about solutions involving other states of matter.

http://www.youtube.com/watch?v=NsdBUWnG2cQ

TABLE 1.1: Solutions and States of Matter

Solution	Solute	Solvent
Gas dissolved in gas *Example*: Earth's atmosphere	oxygen (and other gases)	nitrogen
Gas dissolved in liquid *Example*: carbonated water	carbon dioxide	water
Liquid dissolved in gas *Example*: moist air	water	air
Liquid dissolved in liquid *Example*: vinegar	acetic acid	water
Solid dissolved in liquid *Example*: sweet tea	sugar	tea
Solid dissolved in solid *Example*: bronze	copper	tin

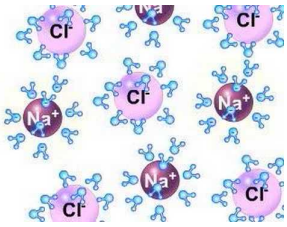
When a solute dissolves in a solvent, it changes to the same state as the solvent. For example, when solid salt

dissolves in liquid water, it becomes part of the liquid solution, salt water. If the solute and solvent are already in the same state, the substance present in greater quantity is considered to be the solvent. For example, nitrogen is the solvent in Earth's atmosphere because it makes up 78 percent of air.

How a Solute Dissolves

When a solute dissolves, it separates into individual particles that spread evenly throughout the solvent. Exactly how this happens depends on the type of bonds the solute contains. Solutes with ionic bonds, such as table salt (NaCl), separate into individual ions (Na^+ and Cl^-). Solutes with covalent bonds, such as glucose ($H_6C_{12}O_6$), separate into individual molecules. In either case, the individual ions or molecules spread apart and are surrounded by molecules of the solvent. This is illustrated in **Figure** 1.1 and in the videos at the URLs below.

http://www.youtube.com/watch?v=gN9euz9jzwc (0:47)



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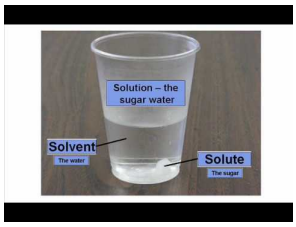
URL: https://www.ck12.org/flx/render/embeddedobject/5003

http://www.youtube.com/watch?v=hydUVGUbyvU (1:38)



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Rate of Dissolving

When you add sugar to a cold drink, you may stir it to help the sugar dissolve. If you don't stir, the sugar may eventually dissolve, but it will take much longer. Stirring is one of several factors that affect how fast a solute dissolves in a solvent. Temperature is another factor. A solid solute dissolves faster at a higher temperature. For example, sugar dissolves faster in hot tea than in ice tea. A third factor that affects the rate of dissolving is the surface area of the solute. For example, if you put granulated sugar in a glass of ice tea, it will dissolve more quickly than the same amount of sugar in a cube. That's because granulated sugar has much more surface area than a cube of sugar. You can see videos of all three factors at these URLs:

http://www.youtube.com/watch?v=cF55VAk1Nlk (1:04)

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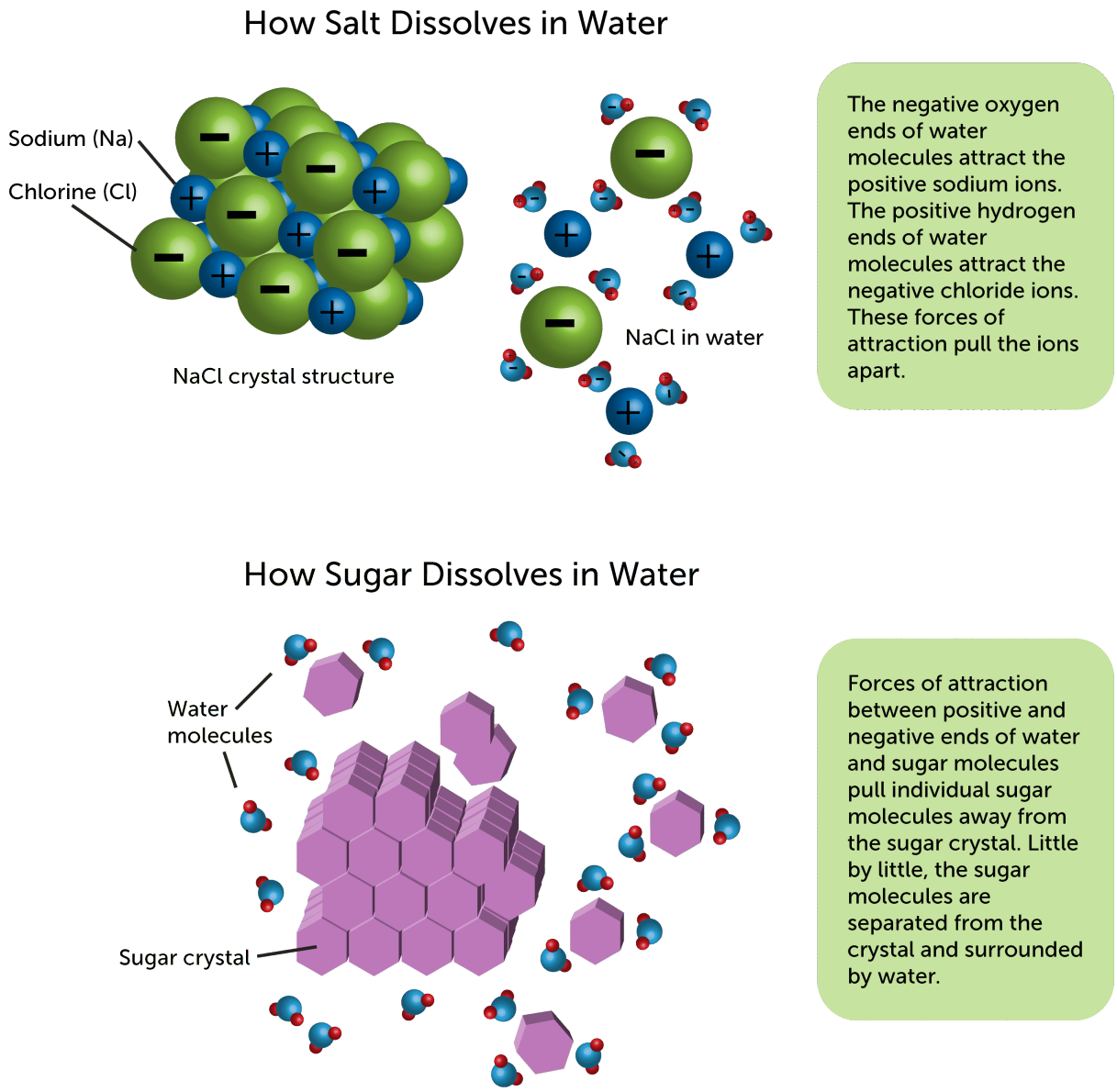
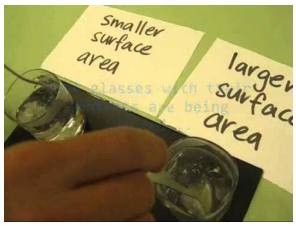


FIGURE 1.1

These two diagrams show how an ionic compound (salt) and a covalent compound (sugar) dissolve in a solvent (water).

http://www.youtube.com/watch?v=Yb-TdSqmIvc (1:04)



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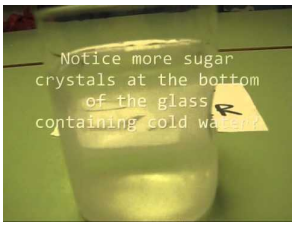
http://www.youtube.com/watch?v=TO42FOay7rg (1:38)



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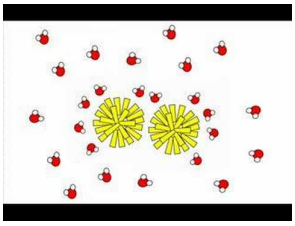
The Almost-Universal Solvent

Water is a polar compound. This means it has positively and negatively charged ends. This is why it is so good at dissolving ionic compounds such as salt and polar covalent compounds such as sugar. Solutes that can dissolve in a given solvent, such as water, are said to be **soluble** in that solvent. So many solutes are soluble in water that water is called the universal solvent.

However, there are substances that don't dissolve in water. Did you ever try to clean a paintbrush after painting with an oil-based paint? It doesn't work. Oil-based paint is nonpolar, so it doesn't dissolve in water. In other words, it is **insoluble** in water. Instead, a nonpolar solvent such as paint thinner must be used to dissolve nonpolar paint. You can see a video about soluble and insoluble solutes at this URL: http://www.youtube.com/watch?v=ek6CVVJk4OQ (1:51).



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Properties of Solutions

When a solute dissolves in a solvent, it changes the physical properties of the solvent. Two properties that change when a solute is added are the freezing and boiling points. Generally, solutes lower the freezing point and raise the boiling point of solvents. You can see some examples of this in **Figure** below. To see why solutes change the freezing and boiling points of solvents, watch this video: http://www.youtube.com/watch?v=z9LxdqYntlU (14:00).

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URL: https://www.ck12.org/flx/render/embeddedobject/651

In each of these examples, a solute changes the freezing and/or boiling points of a solvent.

Lesson Summary

- A solution forms when a solute dissolves in a solvent. The rate of dissolving is faster with stirring, a higher temperature, or greater surface area. Many solutes are soluble in water because water is polar.
- Solutes change the physical properties of solvents. They lower the freezing point and raise the boiling point of solvents.

Lesson Review Questions

Recall

1. What is a solute? What is a solvent?
2. Describe how an ionic compound such as salt dissolves in water.
3. List three factors that affect the rate at which a solute dissolves.
4. How do solutes affect the properties of solvents?

Apply Concepts

5. Create a lesson that explains to younger students how solutions form. With your teacher's approval, request permission to present your lesson to students in a lower grade.

Think Critically

6. Do you think paint thinner is soluble in water? Why or why not?

Points to Consider

Assume that you will stir salt into a cup of hot water to make a saltwater solution.

- How much salt do you think you could dissolve in the cup of hot water?
- Do you think you could dissolve more of some solutes than others?

References

1. Christopher Auyeung. CK-12 Foundation . CC BY-NC 3.0
2. Salt truck: Michael Pereckas; Salt to pot: Joy Sheng; Antifreeze: Courtesy of the EPA. Salt truck: http://commons.wikimedia.org/wiki/File:Salt_truck_Milwaukee.jpg; Salt to pot: CK-12 Foundation; Antifreeze: http://www.epa.gov/wastes/conserve/materials/antifree.htm . Salt truck: CC BY 2.0; Salt to pot: CC BY-NC 3.0; Antifreeze: public domain