LESSON **15**

Separating a Soluble and an Insoluble Substance

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Sewage is a mixture. Why is knowledge of separation techniques important to ensure the health of our rivers?

INTRODUCTION

Sewage is very smelly stuff. It is also an interesting mixture. It usually looks like a cloudy brown liquid with lumps floating in it. It is difficult to believe that after it is processed in a sewage facility, it can be released as a clear liquid into a river that is the source of drinking water. Cleaning sewage is a complex process. Workers in treatment facilities apply scientific knowledge of the different properties of the substances found in sewage to remove them from the water. Many types of separation techniques and treatments are involved. Some of the large pieces are removed by a screen. Some of the smaller particles are removed by allowing them to settle out. Other particles are filtered out. Chemicals are added to speed up the cleaning process, and microorganisms are cultivated to eat some of the sewage. Separation techniques play a big part in keeping our rivers clean and a big part in our lives in general. In this lesson, you will apply your knowledge of solutions, separation techniques, and the phases of matter to a separation problem—happily, not the separation of sewage!

OBJECTIVES FOR THIS LESSON

Discuss evaporation as a separation technique.

Filter mixtures containing water.

Design and conduct an inquiry to clean rock salt.

Getting Started

1. One member of your group should collect the plastic box containing the materials. Another student should collect your group's plastic cup from Lesson 12.

2. Use a magnifying loupe to examine the contents of the plastic cup.

3. Discuss the following questions with the other members of your group:

   A. What do you think this blue substance is?

   B. How did it get there?

   C. Where did the water go?

4. Your teacher will ask you about your ideas and observations and will discuss the processes involved in forming the crystals.

5. Predict what will happen to the crystals if you add 25 mL of water to the cup.

6. Test your prediction by adding 25 mL of water to the cup. Use the plastic spoon to stir the contents.

SAFETY TIP

Wear your safety goggles at all times.

MATERIALS FOR LESSON 15

For you

- 1 copy of Student Sheet 15.1: Filtering a Solution
- 1 copy of Student Sheet 15.2: Cleaning Rock Salt
- 1 pair of safety goggles

For your group

- Plastic cup from Lesson 12 (labeled with the names of your group)
- 1 plastic cup
- 1 jar containing rock salt
- 1 jar containing zinc oxide
- 2 funnels
- 6 filter papers
- 2 100-mL graduated cylinders
- 2 lab scoops
- 2 loupes (double-eye magnifiers)
- 4 test tubes
- 2 test tube racks
- 2 250-mL beakers
- 2 plastic spoons

7. Think about the answers to the following questions:

A. What happens after you add 25 mL of water to the blue crystals?

B. What are the properties of the mixture?

C. What do you think you have made?

Be prepared to participate in a class discussion.

8. Divide your solution into approximately two equal parts. For the remainder of the lesson, you will work with your lab partner. Divide the apparatus in the plastic box between the two pairs in your group.

Inquiry 15.1
Filtering a Solution

PROCEDURE

1. Your teacher will show you how to fold a piece of filter paper and insert it into a filter funnel. As shown in this demonstration and in Figure 15.1, fold the paper and fit it inside the filter funnel. Wet the paper with a few drops of water so that it sticks to the funnel walls. Observe whether the water passes through the filter paper.

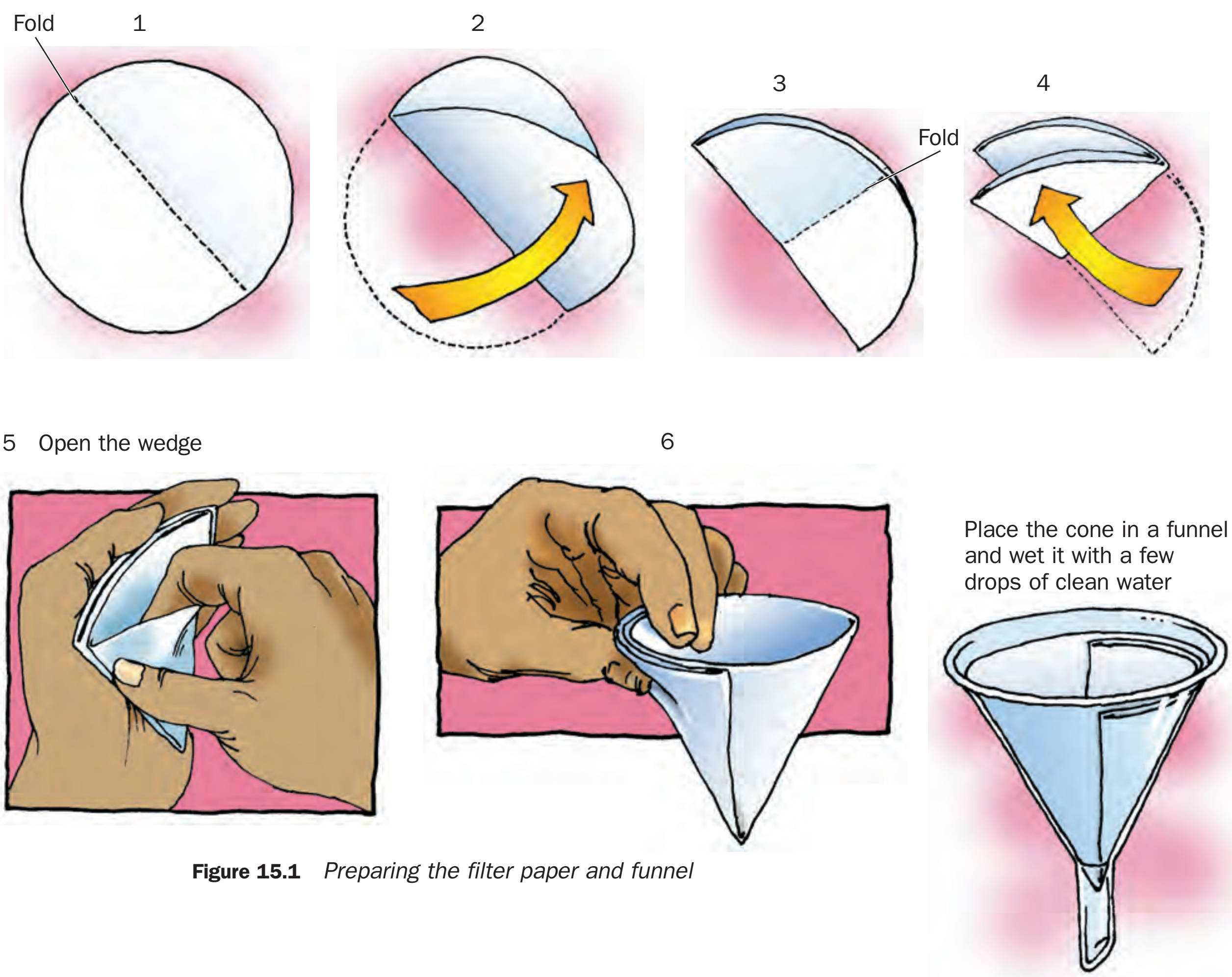


Figure 15.1 *Preparing the filter paper and funnel*

2. What do you think will happen to the copper(II) sulfate solution if you pour it into the funnel? Record your prediction in Table 1 on Student Sheet 15.1.

3. Place a test tube in the test tube rack. Place the funnel with the filter paper into the test tube (see Figure 15.2).

4. Test your prediction by pouring the solution into the funnel. Make sure the solution does not go over the edge of the paper. Record your result in Table 1.

5. Dispose of the filter paper. Fold a new one and place it in the filter funnel.

6. Add one lab scoop of zinc oxide to approximately 10 mL of water in a 250-mL beaker. Stir the mixture with a teaspoon. What will happen when you filter this mixture? Record your prediction in Table 1.

7. Use a clean test tube to repeat the filtration procedure. Record your result in Table 1.

8. Discuss your observations with your partner. What effect did filtration have on the two mixtures? Can you think of another property (other than clearness and uniformity of color) of solutions? Be prepared to participate in a class discussion of your results and to explain your ideas.

9. Use the plastic containers provided to dispose of the copper (II) sulfate solution and the zinc oxide solution. Place your used filter papers in the trash can. Rinse the apparatus and return it to the plastic box.

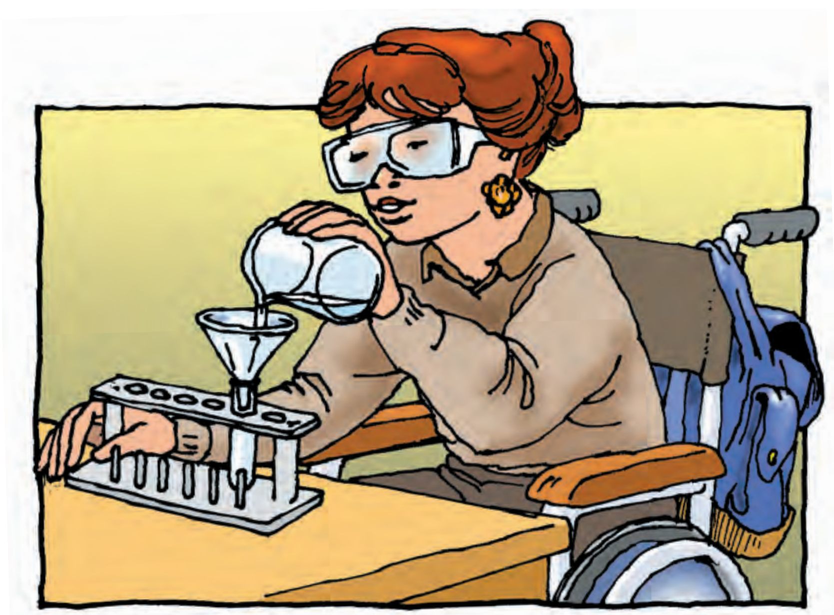


Figure 15.2 *After setting up your apparatus, pour the copper (II) sulfate solution into the funnel containing the filter paper.*

Inquiry 15.2
Cleaning Rock Salt

PROCEDURE

1. Put four lab scoops of rock salt into the plastic cup. Examine it with the magnifying loupe. Write a description of the rock salt on Student Sheet 15.2.

2. Most of the salt used in food is made from rock salt. Discuss these questions with your partner:

   A. Would you want to eat this sample?

   B. Do you think it is pure?

   C. What do you think the contaminants could be?

3. How could you use the remaining apparatus you have been given to obtain only the soluble component of the rock salt? Record your answers to the following questions on Student Sheet 15.2: What are you trying to do? What materials will you use?

4. On the student sheet, record the procedure devised by you and your partner.

5. Check your ideas with your teacher.

6. Follow your procedure to purify the salt. If you have any problems, consult with your teacher.

You eat this rock. What is it and how is it purified?

REFLECTING ON WHAT YOU'VE DONE

1. Your class will discuss the procedures used by the different pairs.

2. Read "Separating Solids From Liquids."

3. Your cleaned salt sample will not be obtained until a later lesson. When you get a sample of clean solid salt, look at it closely. Are any crystals present? Are they all the same shape? How clean is your salt? Is there any evidence that it is still not pure? If not, can you suggest why?

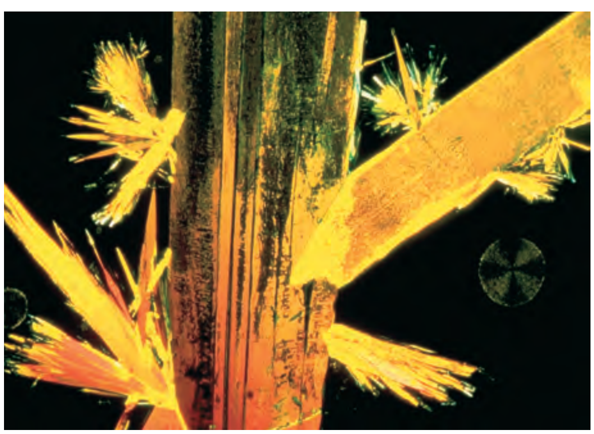
SEPARATING SOLIDS FROM LIQUIDS

When separating substances, it is important to choose the correct separation technique, which is a method used to separate the components of a mixture from each other. For example, insoluble solids can be separated from liquids in several different ways. The technique used depends on how well substances are mixed together.

To separate insoluble impurities from salt, you used a process called filtration. The filter paper allowed the soluble solute (salt) and the solvent (water) to pass through, but it trapped the larger pieces of insoluble impurities as a residue. The substances that pass through the filter paper are called the filtrate.

Large pieces of insoluble substances will often settle out of a mixture of a solid and a liquid. This process is called sedimentation, because the solid forms a sediment on the bottom of the container. If the solid is very fine, this process can be speeded up with a machine called a centrifuge. Centrifuges spin a test tube very fast, and the solid moves quickly to the bottom of the test tube.

To separate a solid solute from a solvent (like salt from water), you used evaporation. At room temperature, water evaporates from a solution very slowly. But the rate of evaporation can be accelerated by heating the solution. As the water evaporated from your salt and water solution, the solution became more concentrated. Eventually, a saturated solution of salt formed. As more water evaporated, the salt crystallized into white crystals. When crystallization happens slowly, big crystals form. Small crystals form when crystallization happens quickly. Crystalline solids have unique crystal shapes. Therefore, crystal shape is a characteristic property of a substance.



These potassium ferricyanide crystals were produced when the water in a saturated solution of potassium ferricyanide was slowly evaporated.

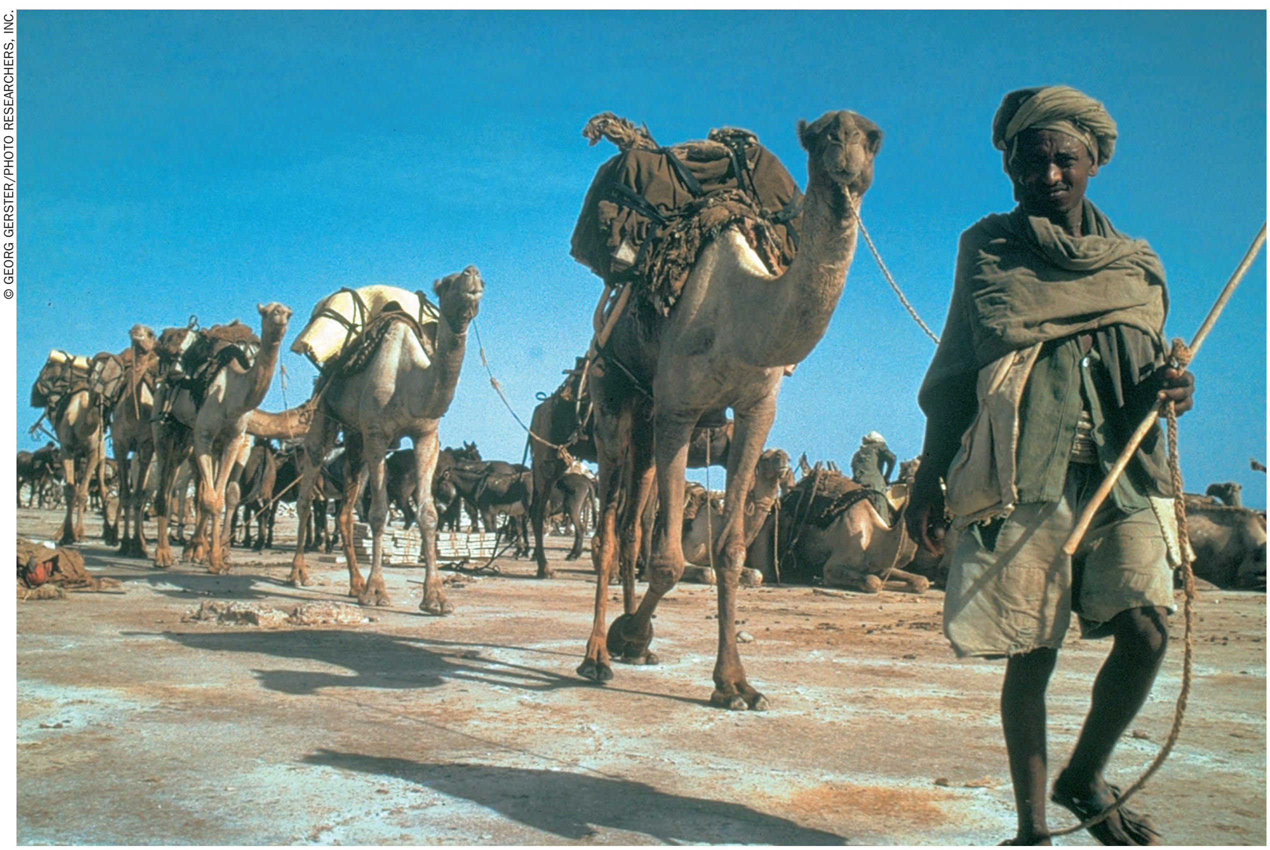
SEPARATING SOLUTIONS AND THE SALTY SEA

Why is the sea salty? Where does all that salt come from? How does it get there? Much of the salt comes from the land. When it rains, rainwater dissolves soluble substances, including common salt (sodium chloride), from soil and rocks. Some of these substances eventually find their way into creeks and rivers, and from there, they are carried to the sea.

Why is the sea saltier than rivers? Once in the sea, soluble substances are concentrated. Heat from the sun evaporates the water from the sea but leaves the salts behind. Over millions of years, seas become saltier and saltier. For the same reason, lakes that have no outlet to the sea quickly become salty. Lakes can even be saltier than seas are.

Salt is a valuable commodity that has been traded for thousands of years. It is used in food, providing flavor and acting as a food preservative. It is also used to make a wide variety of chemicals. These chemicals are used in many industrial processes, including making glass, soap, and chlorine.

Today, most salt comes from mines, although a lot is also extracted from the sea or salty lake water. Salt has been extracted from salty bodies of water throughout history. One common method of extraction is to let the heat



This caravan of camels is carrying salt across the Sahara Desert to be traded in another part of Africa.

COURTESY OF THE LIBRARY OF CONGRESS

Salt making by evaporation, Salt Lake, Utah (early 20th century).

from the sun completely evaporate seawater that is trapped in pools or small lagoons.

In some desert areas, water is very scarce. But many of these deserts are near seas (or salt lakes), and salt can be removed from seawater to get fresh water. This process is called desalination. Seawater that is desalinated is fresh enough to drink and to grow crops. In some desalination plants, the saltwater is heated. The water evaporates away from the salt, as steam. The steam then condenses to form fresh water. This process requires a lot of energy, so it is very expensive. Other desalination plants remove salt from water by a process called reverse osmosis. ☐

QUESTIONS

Use library or Internet resources to find information on the locations of the Salton and Aral Seas. Answer the following questions: What do the Salton and Aral Seas have in common? What environmental problems do they have?

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The Yuma Desalting Plant in Arizona is the world's largest desalination plant, capable of producing 72 million gallons of desalted water per day.