Key Objectives

2.2.1 EXPLAIN how mixtures are classified.

2.2.2 EXPLAIN how mixtures can be separated.

Additional Resources

Reading and Study Workbook, Lesson 2.2
Available Online or on Digital Media:
- Teacher Resources, Lesson 2.2 Review

Engage

CHEMISTRY & YOU: Have students study the photograph and read the opening text. Explain that the coffee in the cup is also a mixture. Ask: Can you use a filter to separate the water from the other components of the coffee? Explain. (No, because the particles are too small) Point out that not all mixtures can be separated with the same method. Tell students to keep this in mind as they read the lesson.

Activate Prior Knowledge

Review the concepts from Lesson 2.1, directing students’ attention back to Table 2.1. Emphasize that the substances in that table are pure substances because they do not contain impurities. Note that in this lesson, students will focus on substances that are not pure.

Foundations for Reading

BUILD VOCABULARY: Have students look up the term homogenize and explain how this process could be used to turn a heterogeneous mixture into one that is more homogeneous.

National Science Education Standards

A-1

Classifying Mixtures

How can mixtures be classified?

A salad bar, like the one in Figure 2.5, provides a range of items, such as lettuce, tomatoes, cheese, and green peppers. Customers choose which items to use in their salads and how much of each item to use. So each salad mixture has different types and amounts of components. A mixture is a physical blend of two or more components.

Most samples of matter are mixtures. Some mixtures are easier to recognize than others. You can easily recognize chicken noodle soup as a mixture of chicken, noodles, and broth. Recognizing air as a mixture of gases is more difficult. But the fact that air can be drier or more humid shows that the amount of one component of air—water vapor—can vary. Chicken noodle soup and air represent two different types of mixtures.

Based on the distribution of their components, mixtures can be classified as heterogeneous mixtures or as homogeneous mixtures.

Focus on ELL

1 CONTENT AND LANGUAGE: Write the word mixture on the board. Have students brainstorm examples of mixtures. Create a list of their ideas. Have students use a dictionary to look up the various uses of the word mixture. Once the scientific definition is determined, revisit the list of examples; point to each example and ask the class if it should stay on the list.

2 FRONTLOAD THE LESSON: Generate a discussion on the seasonings used in students’ favorite foods. Identify seasonings that are blends rather than single herbs or spices. Explain that the blends are examples of mixtures, because they are made by combining two or more spices and/or herbs. Have students predict how this fact explains why different brands of the same spice blend often taste quite different.

3 COMPREHENSIBLE INPUT: Perform as many teacher demos and class activities as possible to exposes students to a variety of approaches to separating mixtures. Use crumpled and torn paper to demonstrate the difference between reversible and irreversible physical changes.
QuickLab

**Purpose** To separate a mixture using paper chromatography

**Materials**
- green marking pen
- filter paper strip
- metric ruler
- clear plastic tape
- pencil
- rubbing alcohol
- clear plastic drinking cup
- clear plastic wrap

**Procedure**

1. Use the marking pen to draw a line across a strip of filter paper, as shown in the drawing. The line should be 2 cm from one end of the strip.
2. Tape the unmarked end of the filter paper to the center of a pencil so that the strip hangs down when the pencil is held horizontally, as shown in the diagram below.
3. Working in a well-ventilated room, pour rubbing alcohol into a plastic cup to a depth of 1 cm.
4. Rest the pencil on the rim of the cup so that the ink end of the strip touches the rubbing alcohol but does not extend below its surface. Use plastic wrap to cover the top of the cup.
5. Observe the setup for 15 minutes.

**Analyze and Conclude**

1. **Identify** How did the appearance of the filter paper change during the procedure?
2. **Analyze Data** What evidence is there that green ink is a mixture?
3. **Apply Concepts** How could you use this procedure to identify an unknown type of green ink?

**Heterogeneous Mixtures** In chicken noodle soup, the ingredients in the soup are not evenly distributed throughout the mixture. There is likely to be different amounts of chicken and noodles in each spoonful. A mixture in which the composition is not uniform throughout is a heterogeneous mixture.

**Homogeneous Mixtures** The substances in the olive oil in Figure 2.6 are evenly distributed throughout the mixture. So, olive oil doesn’t look like a mixture. The same is true for vinegar. Vinegar is a mixture of water and acetic acid, which dissolves in the water. Olive oil and vinegar are homogeneous mixtures.

A homogeneous mixture is a mixture in which the composition is uniform throughout. Another name for a homogeneous mixture is a solution.

Many solutions are liquids. But some are gases, like air, and some are solids, like stainless steel, which is a mixture of iron, chromium, and nickel.

The term phase is used to describe any part of a sample with uniform composition and properties. By definition, a homogeneous mixture consists of a single phase. A heterogeneous mixture consists of two or more phases. When oil and vinegar are mixed, they form a heterogeneous mixture with two layers, or phases. As shown in Figure 2.6, the oil phase floats on the water, or vinegar, phase.

**Figure 2.6 Homogeneous Mixtures**

Olive oil and vinegar are homogeneous mixtures. The substances in these mixtures are evenly distributed. When olive oil and vinegar are mixed, they form a heterogeneous mixture with two distinct phases.

**Focus on ELL**

**4 LANGUAGE PRODUCTION** Have students work in groups of four to complete the lab. Make sure each group has ELLs of varied language proficiencies so that more proficient students can help less proficient ones. Have students work according to their proficiency level.

**BEGINNING: LOW/HIGH** Have students draw a picture of their observations.

**INTERMEDIATE: LOW/HIGH** Allow students to orally explain their observations.

**ADVANCED: LOW/HIGH** Have students assist students with lower English proficiencies with the calculations and answering the questions.

**Explode**

**Classifying Mixtures**

**MAKE A CONNECTION** Bring orange juice or liquid salad dressing to class and compare the properties of these mixtures to those of pure water or pure NaCl. Explain that mixtures are variable in composition.

**Explore**

**OBJECTIVE** After completing this activity, students will be able to separate the components of a mixture by using paper chromatography.

**SKILLS FOCUS** Observing, inferring, drawing conclusions

**PREP TIME** 15 minutes

**CLASS TIME** 25 minutes

**ADVANCE PREPARATION** Cut the paper strips in advance to save time. Strips of paper toweling can be used in place of filter paper.

**SAFETY** Rubbing alcohol is poisonous and flammable. It is also an irritant when inhaled. Keep containers covered and away from heat. If the room is not well ventilated, use a fume hood.

**EXPECTED OUTCOME** Bands of color will separate on the filter paper.

**EXTENSION** Students could repeat the lab by using different brands of markers, different colors, or water in place of rubbing alcohol.

**ANALYZE AND CONCLUDE**

1. Bands of colors appeared as the alcohol moved up the paper.
2. The bands of colors indicate that green ink is a mixture.
3. The color pattern of the unknown ink could be compared with color patterns from known types of green ink.

**FOR ENRICHMENT** Students can research R<sub>f</sub> values of different dyes and how they are calculated (ratio of distance traveled by dye to distance traveled by solvent). They can then quantify this lab by calculating the R<sub>f</sub> values of the dyes in the ink.
Separating Mixtures

**Use Visuals** Direct students’ attention to Figure 2.8. Review the distillation process, and describe the components of the apparatus. **Ask** What might be an advantage to having a long condenser in a distillation apparatus? *(There would be more surface area on which the vapor can condense.)*

**Chemistry & You** Filtration; the brewed coffee passes through the filter paper, but the ground coffee beans do not.

**Explore**

**Teacher Demo**

**Purpose** Students will observe the separation of iron filings from iron-fortified breakfast cereal.

**Materials** iron-fortified breakfast cereal, 400-mL beaker, distilled water, magnetic stirrer with stirring bar

**Safety** Remind students not to eat the cereal.

**Procedure** Place a stirring bar in a 400-mL beaker. Add about 30 g of cereal to the beaker and add distilled water until the beaker is about half full. Using a magnetic stirrer, mix gently for about 20 minutes. Retrieve the stirring bar and observe the black iron filings attached to it.

**Expected Outcome** Iron filings will cover the stirring bar. They are added to cereal as an iron supplement. Explain that stomach acid changes the iron into a form the body can use.

**Separating Mixtures**

**How can mixtures be separated?**

If you have a salad containing an ingredient you don’t like, you can use a fork to remove the pieces of the unwanted ingredient. Many mixtures are not as easy to separate. To separate a mixture of olive oil and vinegar, for example, you could decant, or pour off, the oil layer. Or you might cool the mixture until the oil turned solid. The first method takes advantage of the fact that oil floats on water. The second method takes advantage of a difference in the temperatures at which the olive oil and vinegar freeze. Differences in physical properties can be used to separate mixtures.

**Filtration** The coffee filter in Figure 2.7 can separate ground coffee beans from brewed coffee. The liquid brewed coffee passes through the paper filter, but the solid coffee grounds cannot pass through the filter. Filter paper used in a laboratory is similar to coffee filters. Filter paper is often placed in a funnel. Then the mixture is poured into the funnel. Solid particles that cannot pass through the filter remain in the funnel. The rest of the particles in solution pass through the filter paper. The process that separates a solid from the liquid in a heterogeneous mixture is called filtration.

**Distillation** Tap water is a homogeneous mixture of water and substances that are dissolved in the water. One way to separate water from the other components in tap water is through a process called distillation. During a distillation, a liquid is boiled to produce a vapor that is then condensed into a liquid. Figure 2.8 shows an apparatus that can be used to perform a small-scale distillation.

As water in the distillation flask is heated, water vapor forms, rises in the flask, and passes into a glass tube in the condenser. The tube is surrounded by cold water, which cools the vapor to a temperature at which it turns back into a liquid. The liquid water is collected in a second flask. The solid substances that were dissolved in the water remain in the distillation flask because their boiling points are much higher than the boiling point of water.

**Distillation**

A working distillation apparatus was described in the writings of Maria of Alexandria, an alchemist who lived and worked nearly two thousand years ago. The city of Alexandria, located on the Nile River in North Africa, was a world center of science and culture at that time. Maria of Alexandria is also credited with inventing other chemical apparatus, such as the water bath to which this day the water bath is often referred to as the bain marie in her honor.
Sample Problem 2.1

**Separating a Heterogeneous Mixture**

How could a mixture of aluminum nails and iron nails be separated?

1. **Analyze** Identify the relevant concepts. In order to identify how to separate aluminum and iron nails, the properties of both aluminum and iron must be known.

2. **Solve** Apply concepts to this situation.

<table>
<thead>
<tr>
<th>Aluminum</th>
<th>Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>metal</em></td>
<td><em>metal</em></td>
</tr>
<tr>
<td><em>gray color</em></td>
<td><em>gray color</em></td>
</tr>
<tr>
<td><em>doesn’t dissolve in water</em></td>
<td><em>doesn’t dissolve in water</em></td>
</tr>
<tr>
<td><em>not attracted to magnet</em></td>
<td><em>attracted to magnet</em></td>
</tr>
</tbody>
</table>

The ability to be attracted by a magnet is a property that iron and aluminum do not share. You could use a magnet to remove the iron nails from a mixture of iron and aluminum.

10. **What physical properties could be used to separate iron filings from table salt?**

11. **Air is mainly a mixture of nitrogen and oxygen, with small amounts of other gases such as argon and carbon dioxide. What property could you use to separate the gases in air?**

**Sample Practice Problem**

Describe how you could separate metal paper clips and plastic paper clips in a bucket of paper clips. (A magnet could be used to remove the metal paper clips.)

**Evaluate**

**Informal Assessment**

Have students identify five items that fit each of the following categories:

1. **substance**
2. **homogeneous mixture**
3. **heterogeneous mixture**
4. **solution**

Have students select three items, one each from categories 2, 3, and 4. For each item selected, students should outline a method for separating the components. Then have students complete the 2.2 Lesson Check.

**Reteach**

Explain that distillation can be used to separate a mixture of gases. Show students the drawing of the fractional distillation of liquid air, on page R24 of the Elements Handbook. Ask: What physical property is used to separate the gases? (boiling point)

**Lesson Check Answers**

12. **as heterogeneous or homogeneous**
13. **differences in physical properties**
14. **A phase is any part of a sample with uniform composition. A homogeneous mixture has one phase; a heterogeneous mixture has two or more phases.**
15. **a. homogeneous b. heterogeneous c. homogeneous d. heterogeneous**
16. **Both have a uniform composition throughout. A substance has a definite composition; a solution has a variable composition.**
17. **Filtration separates solids from a liquid in a heterogeneous mixture. Distillation can separate a liquid from substances dissolved in the liquid.**
18. **Add water to dissolve the salt. Filter the mixture to remove the sand. Evaporate the water from the liquid to isolate the solid salt.**
19. **BIG IDEA Answers will vary; examples of mixtures at home include: sorting laundry, draining cooked pasta, putting away bags of groceries.**

**Answers**

10. **Iron is magnetic; table salt is not. Table salt will dissolve in water; iron will not.**
11. **By lowering the temperature to below the boiling point of each gas, you could condense each substance and separate the gases.**