Learning Experience 1

Teacher Guide

Mystery of the Hindenburg Disaster: Properties of Matter

Overview

This learning experience serves as an introduction to the chemistry module. The story of the Hindenburg is designed to engage student interest and to have them begin to think about the chemical principles and concepts that they will be exploring in the rest of the module. These include the physical and chemical properties of matter, physical and chemical change, the relationship between the structure of matter and its properties, and how an understanding of the structure and properties of materials is critical to the design of new products. Students begin to develop an understanding of the nature of scientific research with the idea that theories must be supported by valid and reproducible data and that the same data may give rise to different interpretations.

In this learning experience, students are challenged to solve a decades-old mystery: What caused the luxury airship Hindenburg to burn and crash in 1937? Using information about the airship, its structure, its components, and other information, students develop an explanation for the disaster. This first learning experience introduces students to many of the concepts in chemistry that they will be exploring in the semester. It also provides you with an opportunity to determine students' prior understanding about mixtures, compounds, and physical and chemical properties.

Goals for Student Understanding

- Students know that materials are selected for certain purposes based on their physical and chemical properties.
- Students understand that data and evidence give rise to theories and explanations and that theories and explanations are subject to testing and revision.

Student Assessment Outcomes

Students should be able to:

- Explain why a material with a given set of physical and chemical properties was selected for a specific purpose.
- Propose and revise hypotheses and explanations on the basis of data and evidence.

Assumptions of Prior Knowledge and Skills

Students should already know:

- Matter exists as solid, liquid, and gas.

- Compounds are made up of two or more elements joined together.
- Mixtures contain different substances within them.
- Different substances have different properties.
- Scientific explanations are based on evidence and scientific knowledge.
- Some materials can conduct electricity.
- How to use data to develop a hypothesis or scientific explanation.

Possible Misconceptions or Commonly Held Ideas

- Students may believe that once a discovery or scientific "fact" is determined, it is irrefutable.
- Students may confuse compound and mixture.
- Students may confuse elements and compounds.
- Students may believe that only elements or compounds can react, not mixtures.

Assessment Strategies

Students have a number of opportunities in this learning experience to express their initial and developing understanding of concepts related to the properties of substances. By taking note of the answers given by students completing group work or working individually, you can determine pacing, identify which concepts need more or less emphasis, and gauge students' understanding of the content at the end of the learning experience. These formative and summative assessment opportunities include:

Opportunities	Page	Information Gathered About
Brainstorming	SB 2	Students ideas about the kind of evidence that is needed to solve a house fire.
Flammability of Hydrogen	SB 2	Students' powers of observation and language used to discuss a chemical reaction.
What Caused the Hindenburg to Crash?	SB 2	Students' ability to use evidence to support conclusions gathered from data. Students' ability to present their finding clearly and with full explanations.
Thinking About What You Did	SB 9	Students' abilities to relate key ideas about the Hindenburg in a concept map.

SB = Student Book

Suggested Class Sessions

4 class sessions (45 minutes each)

Advance Preparation

1. Have a VCR and TV ready to view the video of the Hindenburg.
2. If possible, set up a computer that can play the voice recording of the Herb Morrison broadcast (at http://www.otr.com/hindenburg.html).
3. Read through the demonstration "The Flammability of Hydrogen." Assemble materials for use during session 1. Carry out a trial demonstration before class to be sure of the procedure and possible hazards.

Teaching Sequence Preview

Setting the Context

- Students read about determining the cause of a house fire.
- Students brainstorm about the kind of evidence they might need to determine the cause of a fire.

Experimenting and Investigating

- Students discuss what they know about the Hindenburg.
- Students examine photographs, video, and data about the structure and materials of the Hindenburg and about weather conditions.
- Students develop an explanation as to why the Hindenburg crashed and burned.

Processing for Meaning

- Students present their hypotheses about the cause of the Hindenburg disaster.
- Students explain their hypotheses in terms of their understanding about the chemical and physical properties of matter.

Science Background

For such a major destruction to occur, there needed to be an origin for a sparkand an initial fuel for combustion, and the flame needed to burn rapidly over the entire structure. The original investigation into the Hindenburg disaster implicated hydrogen gas as the initial cause of the fire. The investigation, carried out by scientists and engineers in the United States and Germany, concluded that a spark of static electricity ignited a hydrogen leak. However, a more recent inquiry initiated by Addison Bain, former manager of NASA's hydrogen program and an advocate of hydrogen as a fuel, suggests that hydrogen may not have been the culprit but, rather, that the fire started as a result of a highly exothermic reaction involving the coating painted on the airship's fabric skin. Bain came to his conclusion based on several observations and knowledge about the properties of the materials that made up the Hindenburg:

- Hydrogen burns with a pale blue flame. The craft, initially, was a ball of orange-red flames.
- Hydrogen, when mixed with oxygen, can explode. But the craft did not explode. Instead, it burned in several directions.
- Hydrogen, being lighter than air, burns with upward flames. The first fires burned downward.
- The craft remained aloft and upright for 37 seconds after the initial fire. If the hydrogen had exploded, the airship would have fallen immediately.
- No one smelled garlic; the hydrogen gas was laced with a garlic-smelling chemical that would indicate a hydrogen leak.

Through his study of photographs and footage of the disaster and his analyses of some remaining materials, Bain reached the conclusion that the fire was the result of a combination of the nature of the coating on the skin used to prevent overheating from the sun (the heat produce when the skin reacts is sufficient to melt iron) and the prevailing weather conditions. During a storm like the one through which the Hindenburg flew, a form of static electricity (called *precipitation charge*) is formed when moisture falls through the air and rubs against other particles in the air. Precipitation charge in the air results in the opposite charge being created on the ground; thus, sky-to-ground lightning occurs where the precipitation charge finds the path of least resistance to return to a neutral state.

When the Hindenburg passed through the storm, particles in the air rubbed against it, causing the craft to become statically charged. The metal in its skin held the charge. Ironically, the engineers who designed the craft anticipated this possibility but assumed that the charge would be carried to the ground through the mooring lines and harmlessly dispersed. However, in this case, apparently all of the charge did not dissipate through the rope; some of the panels of the skin remained charged. Eventually, the built-up charge in the panels took the form of spark, igniting the materials in the protective coating and starting a fire that quickly enveloped the craft.

Setting the Context

[Student Book pg. 1]

Purpose

In this Setting the Context, students begin by considering what kinds of evidence and thinking might go into solving a mystery, in this case, the origins of a house fire. The goal of this activity is to have students begin to think about the nature of evidence and about properties of materials. This activity also focuses students on the questions involved in any fire:

- the cause of ignition of the fire,
- the initial fuel for combustion, and
- the rate at which the fire spreads

Have students brainstorm and then bring them together to discuss their ideas about investigating a house fire.

Possible Responses to Brainstorming

Student ideas for procedures and evidence might include:

- Examining the materials in the house to see if they were highly flammable.
- Determining patterns of smoke and the path of the fire through the house.
- Looking for combustible residues, such as gasoline or kerosene.
- Talking to witnesses.
- Looking for signs of a break-in.
- Moving from the areas of least damage to most damage to find the origins of the fire.

Continue by informing students that they will be taking on the role of investigators to determine the cause of the Hindenburg disaster. They will use both evidence and knowledge about the physical and chemical properties of substances that made up the Hindenburg to reach their conclusion.

Experimenting and Investigating

[Student Book pg. 2]

Purpose

In the first part of this investigation, you will demonstrate one of the chemical properties of hydrogen: its flammability. In their analysis of the Hindenburg disaster, students recognize that the materials in the airship were primarily mixtures and that these mixtures were made up of substances that had characteristic physical and chemical properties, such as density and flammability. Further, the properties of a mixture may reflect the properties of its component substances. Students learn to use data to formulate and support their hypothesis about why the

Hindenburg crashed and present their argument orally. Students should begin to understand that the same data may be interpreted in different ways.

DEMONSTRATION: The Flammability of Hydrogen

This demonstration enables students to observe one of the chemical properties of hydrogen: its flammability. Students should observe closely what happens when a flame is introduced into hydrogen gas. This demonstration should provide firsthand data about the characteristics of burning hydrogen (blue flame and an explosion) that can then be compared with the visual and written data about the Hindenburg disaster. This demonstration also serves as a dramatic introduction to chemical reactions.

Teaching Strategies

The blue flame is very difficult to see because it occurs so quickly. Encourage the students to watch carefully. Turning out the lights first might help. This might be an opportune time to inform students that although exploding chemical reactions are dramatic, most chemical reactions take place without explosions, flames or loud noises.

Hydrogen is made from the reaction between zinc metal and sulfuric acid. A simple procedure for producing hydrogen gas is provided below. (If you have the equipment available, you might want to consider a water displacement procedure in order to capture the hydrogen.)

Materials (to fill one test tube with hydrogen)

- 1.0 g mossy zinc
- 4.0 ml 2.0 M sulfuric acid
- 2 test tubes (15-ml)
- 1 rubber stopper to fit test tube
- test tube rack or beaker
- test tube holder
- 2 goggles
- 2 lab aprons
- wood splint
- matches
- fire extinguisher

Procedure

(see Figure 1.1 for setup)

1. Put on a lab apron and a pair of goggles.

2. Measure 1.0 gram of mossy zinc and place it in a standard test tube. Place the test tube in a test tube rack or beaker.

3. Add 4 ml of sulfuric acid to the mossy zinc.

4. Loosely hold the second test tube upside down on top of the first test tube (containing the reactants) in order to capture the produced, rising hydrogen and to allow the air in the tube to escape.
   Note: It will take about 5 minutes to produce enough hydrogen from 1.0 gram mossy zinc and 4 ml of 2.0 M sulfuric acid to fill the top test tube. (A higher molarity of sulfuric acid or more mossy zinc will reduce the time. However, the reaction will be more violent, and acid might spill out of the test tube.)

5. After 5 minutes, close the top test tube containing the hydrogen gas with a stopper, keeping the open end down.

6. Hold the test tube so that the stoppered end is facing down. Have a student volunteer (wearing goggles and a lab apron) use a match to light a wood splint and hand it to you. Remove the stopper. Quickly put the flame on the end of the wood splint into the open end of the test tube (hold it at an angle so the opening is facing slightly upwards). An explosion takes place inside the test tube and the loud reverberation produces a barking sound.

Teaching Strategies
Several Web sites have video clips of this demonstration. You may want to have your students view this reaction again on one of these sites.

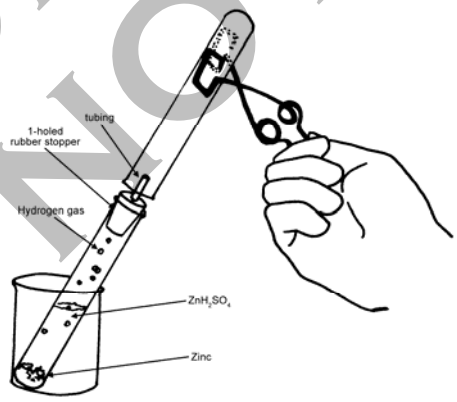

Figure 1.1: *Setup for hydrogen production demonstration.*

Discussion

After the demonstration, have students describe what they saw and heard. Insist that students be clear and precise in describing their observations.

CHALLENGE: What caused the Hindenburg disaster?

Have students work in groups of four to:

- Discuss what they know about the Hindenburg and dirigibles, in general.
- Analyze data, examine video footage and photographs, and read a description of the Hindenburg and its demise.
- Develop a theory about the cause of the crash based on the evidence.
- Prepare a presentation for the class explaining their theory and the evidence to support it.

Students should work together as a team (of three or four members) to develop an explanation that they can defend based on the data provided. Students should be able to prepare a clear, well-documented presentation of their ideas and thinking.

Facilitating the Challenge

Begin by asking whether any students have heard about the Hindenburg and discussing what they know of the disaster. Next, have students brainstorm the kinds of information they might need as committee members to investigate the cause of the disaster. Students might suggest an examination of the other materials that made up the Hindenburg, the weather conditions, the activities that occurred within the Hindenburg (such as the smoking room), the experience of the crew, and the possibility of sabotage. Tell the students that, as the investigating committee, they are being provided with specific information from different sources.

Processing for Meaning

[Student Book pg. 9]

Purpose

Student groups present their explanations and the evidence that supports it. Students listen to other ideas and explanations, consider other perspectives and explanations, and decide whether to incorporate them into their thinking. Students may then modify their own ideas based on the explanations of others or explain why they stand by their own conclusions. Students should be able to describe their explanation and supporting evidence clearly and concisely. Students should listen to others, carefully consider other points of view, and review their own reasoning.

After each group has presented its ideas, have the class decide whether it can reach a consensus about what factors led to the crash. If consensus cannot be reached, have students identify their differences and why the same data might lead to different conclusions. Continue the discussion by having the students begin to think about the chemical principles involved in the Hindenburg. This discussion provides the opportunity for students to revisit and clarify their understandings about mixtures and physical and chemical properties.

Responses to Questions for Discussion
The following kinds of questions may facilitate discussion:

1. Which parts of the Hindenburg do you think were made up of mixtures? *Mixtures include the duralumin frame, the coating of the fabric skin, the gelatin mixture around the gas cells, the diesel fuel, and the garlic-aroma additive.*

2. Which of the properties listed in Table 1.1 are physical properties? Which are chemical properties? *Students may not make a clear distinction at this point between physical and chemical properties, but they should recognize color, odor, density, rigidity, hardness, and flexibility, and the ability to conduct a charge as physical properties; and flammability and corrosion as chemical properties. Students may not use some of these terms, especially those that are not used in the text. For instance, students might say "lightness or heaviness" instead of density.*

3. How do you think the individual properties of the substances mixed in the coating affect its properties once they are mixed? Would the properties of these substances remain the same or change? Explain. *The mixture will reflect the properties of the substances that make them up because they are unchanged in the mixture and, therefore, retain their properties.*

4. Why might it have been important to understand the conductivity of some of the materials? *The scientists who designed the airship recognized that static electricity might accumulate on the surface, so the ropes to the ground needed to be made of material that could conduct the charge to the ground to neutralize it.*

5. Why might it have been important to understand the flammability of some of the materials used to construct a dirigible? *No material used should be flammable because it might cause the airship to burn and crash.*

6. Why do you think it is important to know the properties of substances that are used in mixtures? *The mixtures will reflect the properties of the substances, and some of the properties may be inappropriate or actually dangerous in the functions that the materials are used for. Other substances may actually make a product better.*

7. When you hear something advertised as "new and improved," what do you think that might mean? *It could mean that some component of the product was changed and, therefore, the product might carry out its intended function better.*

Response to Thinking About What You Did
Students begin to develop skills in concept mapping using their understandings about the Hindenburg disaster. You may want to take time to discuss the idea of concept mapping as a way of putting their new understandings together and making connections among the ideas they have been investigating. You may want to have students map something simple, such as a pizza or a sport. Reinforce the idea that there is no one "right" map (although there can be incorrect ones) and that by comparing their maps to those of others, they can see how other students are making connections. However, since students can make incorrect or inaccurate connections, concept maps can serve as a way of assessing their understandings. You may want to have students compare their maps and discuss the differences among them. Students will be developing concept maps in several learning experiences in the course.

The following rubric is used for scoring concept maps.

Score	Description
Level 4	Student uses all of the terms listed and presents them with logical connections. All of the relevant components of the Hindenburg, the weather conditions, and other relevant factors and characteristics related to the disaster are included. The linking verbs are present and accurate.
Level 3	Student uses most of the terms listed and presents them with logical connections. Linking words are present and accurate
Level 2	Student uses many of the terms listed, but there are minor flaws in some of the connections and in the linking words.
Level 1	Student uses some of the terms listed, but there are major flaws in the connections, and the linking words are irrelevant or absent.
Level 0	Student concept map is totally inaccurate or absent.

Unit 1

Organization of Matter

Unit 1: Organization of Matter

Overview

Unit 1 introduces students to the concepts related to the overall organization of matter. Students study the properties of substances, learn the difference between a compound and an element, and create their own periodic table of elements.

How you identify an unknown is the central question in Learning Experience 2. Students read about an anthrax scare and learn that they will role-play chemists who are testing a white powder to see if it could be anthrax or a hoax. Students examine the ingredients of common white powders in their home. They run tests of properties on these powders and on three unknowns in the lab. Students formally present their results and make recommendations that can range from "confirm the suspected identity of the unknown as flour" to "expedite testing for the presence of anthrax." Students see in the lab that each substance or mixture of substances they test has a unique set of properties. They learn that the uniqueness of each substance is due to its unique atomic composition and structure.

Learning Experience 3 explores the periodic table of elements. Students view a demonstration of the decomposition of water and learn that elements are special substances that contain only one type of atom. For this reason, they cannot break down into other substances. Students read about how Mendeleev used information on the elements known in his time to organize them into a table based on patterns of repeating properties. Students re-create this work by making their own table of elements and present their work at a mock scientific conference. Students learn that there are repeating properties among the elements.

Learning Experience
2

Teacher Guide

Anthrax Hoax at the Newspaper: Identifying an Unknown White Powder

Overview

One of the most common activities a chemist does is identify unknowns. This work is often done by measurement of some of the properties of the unknown material. In this learning experience, students are challenged to identify an unknown material. As they attempt to meet this challenge, they grapple with understanding the distinction between a substance and a mixture, and learn about the different properties of materials.

Students are introduced to these ideas in the context of a story about the delivery of a white powder that might be anthrax to a newspaper office. It is then found out that the white powder is a hoax. Authorities continue to test this powder in an effort to find the person responsible. Students are then asked to brainstorm ideas on if and how substances can be identified.

Students then take on the role of workers in a government laboratory who are evaluating three samples of white powder: the one delivered to the newspaper office and two others received at other places. They will first see if the material is a household product, and then check to see if it is similar to the material found in several other hoax letters, which would suggest that a single person is perpetrating the hoaxes. Working within this context, students are told that accuracy is required of them. Students complete the tests and then present their data and results to the class.

At the end of the learning experience, students are asked to propose ideas for why each substance has a unique set of properties. If students draw on their prior knowledge about the atomic nature of matter, they should be able to propose the idea that white powders that look alike can be made of different building blocks, i.e., of different atoms. The overall goals of the learning experience are for students to understand that earth is made up of a number of different substances that can be mixed with other substances or separated, that each substance can be identified by its unique set of properties, and that each substance has a unique atomic composition and structure.

Goals for Student Understanding

- Students understand that each substance has a uniform composition and unique physical and chemical properties.
- Students know that most products are mixtures of different substances and that mixtures can be homogenous or heterogeneous.
- Students know that each substance has a unique set of physical and chemical properties.

- Students know the differences between physical properties (e.g., density, melting point, boiling point, conductivity, and solubility) and chemical properties (e.g., flammability, reactivity with acid, reactivity with water, and reactivity with a pH indicator).
- Students know that each substance has a unique atomic composition and arrangement.
- Students understand that there are two common atomic arrangements: networks, which are solid substances that are one large group of atoms or ions connected by chemical bonds throughout; and molecules, which are small groups of atoms connected by chemical bonds.

Student Assessment Outcomes

Students should be able to:

- Define "substance."
- Classify products as substances, homogenous mixtures, or heterogeneous mixtures.
- Use physical and chemical properties to identify an unknown substance by comparing its properties to those of known substances.
- Identify properties as physical or chemical.
- Distinguish representations of different substances.
- Identify representations of different substances as network solids or molecules.

Assumptions of Prior Knowledge and Skills

Students should already know:

- All matter has mass.
- All matter is made up of atoms.
- Elements are the building blocks of matter; slightly more than 100 elements are known.
- How to carry out basic mathematical operations involving ratios.
- How to follow procedures, observe carefully, and record observations.

Possible Misconceptions or Commonly Held Ideas

Some students believe:

- Matter is continuous.
- Melting point and boiling point are chemical properties.
- Conductivity is a chemical property.
- Substances found in the natural world are different from substances made or possessed in the laboratory.
- Atoms are large enough to be seen by sight or by a light microscope.
- Each unit (atom or molecule) of a substance has all the properties that a measurable sample has.
- Atoms and molecules are the same.

Assessment Strategies

Students have a number of opportunities in this learning experience to express their initial and developing understanding of concepts related to the properties of substances. By taking note of the answers given by students completing group work or working individually, you can determine pacing, identify which concepts need more or less emphasis, and gauge students'

understanding of the content at the end of the learning experience. These formative and summative assessment opportunities include:

Opportunities	Page	Information Gathered About
Brainstorming	SB 13	Students' initial ideas about what a substance is and how substances differ from each other.
Thinking About What You Read	SB 14	Students' initial ideas about ways that different white powders can be identified.
Recognizing Substances and Mixtures	SB 15	Students' understanding of the definition of "substance" and their ability to recognize that most products are mixtures of substances.
Data Analysis	SB 23	Students' ability to measure selected physical and chemical properties, to use this information to identify an unknown substance, and to distinguish physical and chemical properties.
Can the Anthrax Hoaxes be Identified? and Questions for Discussion	SB 23–24	Students' ability to summarize, describe, and generalize the strategies (related to identification of physical and chemical properties) they used to identify the unknown substances.
Thinking About What You Read	SB 25	Students' ability to read and recall that substances are different because of their atomic composition and structure.
Checks for Understanding	TG Appendix B	Students' understanding of the range of concepts presented throughout the learning experience. These questions can be used in class, for homework, or as a quiz at the end of the learning experience.

SB = Student Book; TG = Teacher Guide

You should determine ahead of time which of these assessment opportunities you will evaluate formally (assign a grade) and which you will evaluate more informally.

Suggested Class Sessions

6–8 class sessions (45 minutes each)

Advance Preparation

1. If you are choosing to use the Think Sheets, copy Think Sheets 2.1, 2.2., and 2.3 for each student. These are found in Appendix A.
2. Choose substances to use as the three unknown samples. You can make all the samples the same or different. Make sure that at least two of the three samples are common household products (powdered sugar, talcum powder, flour, baking soda, baking powder, and cream of tartar).
3. If you do not have universal pH indicator, prepare red cabbage juice for this purpose. Cover a head of red cabbage with water, heat the water to a boil, continue boiling for five minutes, let cool, and pour off the juice. Store the juice in the refrigerator.

4. If you do not have an apparatus for measuring the conductivity of solutions, construct two conductivity testers. Each tester is a circuit that is constructed from a 9-volt battery, a light-emitting diode (LED) rated for use with a 9-volt battery—these are available at stores that carry electronics part, 2 clip leads, 2 pieces of insulated wire, cardboard, and tape, as shown in Figure T2.1.

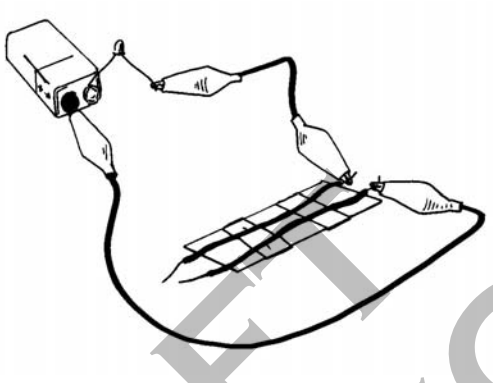

Figure T2.1: *A low-conductivity test circuit. The test solution should be placed between the two wires that are secured to a piece of cardboard.*

When making the low-conductivity test circuit, be sure that the short leg of the LED is closest to the negative terminal of the battery. Connect the long leg of the LED to the clip lead.

Use two disposable pieces of insulated wire that have had their ends stripped for the open part of the circuit. Stabilize the two wires by taping them to a small piece of cardboard, as shown in Figure T2.1. Keep the ends fairly close together so that they can fit into the wells on a wellplate. The cardboard and cork will help prevent the two wires from accidentally touching each other, which would create a short circuit and destroy the LED.

Have spare LEDs on hand in case one is destroyed. Do NOT use this tester for high-conductivity materials such as metals, because the LED will be destroyed. If the LED keeps getting destroyed when testing solutions, try using a 1.5-volt D-cell battery in place of the 9-volt battery.

Teaching Sequence Preview

Setting the Context

- The teacher encourages students to discuss what they already know about substances.
- Students read a story that explains the context for the learning experience, in which students will role-play chemists who are running tests on unknown samples that were used in an anthrax hoax.
- Students complete an activity examining common household products that could have been used as an anthrax hoax.

Experimenting and Investigating

- The teacher introduces the challenge in which students make an initial determination on a white powder to see if it is a common household product.
- Students discuss how to identify different materials.

- Students investigate and compare some of the properties of household products and unknown samples, and use their test results to provide a preliminary identification of the unknown samples.

Processing for Meaning

- Each student group gives a presentation explaining how they identified one of the unknown samples.
- Students compare the results from different groups and discuss further steps that could be taken to verify the initial identification of the unknown samples.
- Students read that different substances have different atomic composition and structure, which explains why each has unique properties.

Setting the Context

[Student Book pg. 13]

Purpose

Students are given a context in which it is important to consider how different materials could be identified, and are introduced to the concepts of substance and mixture. Students will:

- Learn that they will be role-playing the chemists testing white powders that were used in an anthrax hoax.
- Explain what they already know about substances and how substances differ from each other.
- Read the story about possible anthrax exposure by an editor's assistant.
- Brainstorm possible household products that could be used in an anthrax hoax.
- Read about the differences between substances and mixtures.
- Research the ingredients of common household products and categorize each product as a substance or mixture based on its ingredients list.
- Brainstorm possible tests that could be used to distinguish materials that are similar in appearance.

Materials and Preparation

Hand out Think Sheet 2.1 to students to use in the activity Recognizing Substances and Mixtures.

Begin by having students read the Prologue. Then, using the Brainstorming questions as a guide, encourage students to talk about what they know about substances and how substances differ from each other.

Responses to Brainstorming Questions

1. Have you heard of anthrax hoaxes? What do you know about them? *Answers will vary.*
2. What do you think the word "substance" means to chemists? *Answers will vary depending on prior instruction. Students may say the word "chemical."*

3. Using your definition of substance in question 2, what common household products are substances? *Some students may think that substances, or "chemicals" are only found in labs, or that they are not natural, or not edible.*
4. Are all substances different from each other? If so, in what ways are they different? *Answers will vary but students may mention ideas about elements.*

Listening for Understanding
The discussion around some of these questions may alert you to various misconceptions students may have. In particular, students may view substances in the lab as distinct from, and not connected to, substances found in everyday life. If students express this point of view, it may be worthwhile to explore their ideas and then link the discussion to the kinds of household products students will be testing.

STORY: Horror, then Hoax, at the Digest
Have students read the story as homework before class. The story describes a fictional account of a possible anthrax scare. After students read the story, divide the class into groups of two to four students. (These groups should remain the same through Experimenting and Investigating.) Have students answer Thinking About What You Read, discuss this section with their groups, and then write the answers to the questions in their notebooks.

Responses to Thinking About What You Read Questions
1. What are the characteristics of the material Dylan received in the mail? *A white powder. Dylan did not seem to notice any strong smell or other characteristic.*
2. Why was it likely that the scare was a hoax? *The dispatcher says that anthrax is very hard to get hold of, so, most likely, the powder is a hoax.*
3. Since the anthrax letter turned out to be a hoax, what common household products might have been used? List all that you can think of. *Flour, talcum powder, baking soda, baking powder, and cream of tartar are some possible candidates that students may mention.*

Suggested Homework
Have students complete the following activity at home.

ACTIVITY: Recognizing Substances and Mixtures
In this activity, students read about substances and mixtures and then look at the ingredients of household products that could be used in an anthrax hoax. They use the ingredients list to see if these products are substances or mixtures. Some possible answers that students may get as they complete this task are:

1. In the previous section, you identified possible household products that could be used in an anthrax scare. At home, try to find as many of the products the class listed as you can. Look for an ingredients list on the container and record the ingredients for each product.

   Flour: unbleached white flour, malted barley flour, niacin, iron, thiamin mononitrate, riboflavin, folic acid

Powdered sugar: sugar, cornstarch

Baking powder: cornstarch, sodium bicarbonate, sodium aluminum sulfate, monocalcium phosphate

Baking soda: sodium bicarbonate

Talcum powder: talc, fragrance

Cream of tartar: potassium bitatrate

2. Identify which products you examined in question 1 that you think are mixtures and which products you think are substances. (You need to use the ingredients list to help you do this because homogenous mixtures appear uniform throughout and can be mistaken for substances.) *Flour, powdered sugar, baking powder, and talc are mixtures (if the talc does not contain fragrance is could be classified as a substance). Baking soda and cream of tartar are substances.*

3. Examine the list of ingredients on labels for other household products such as cleaning products, grooming products, or foods. (You do not need to record the list of ingredients.) Make a list of the products you examined and identify which products appear to be substances, which homogenous mixtures, and which heterogeneous mixtures. *Answers will vary.*

4. Based on your survey of products, are most household products substances or mixtures? *By examining ingredients lists, students will see that most products contain more than one ingredient and, therefore, are mixtures.*

5. You looked at several kinds of white powders in your home, any of which could have been used for an anthrax hoax. What kinds of tests might you do to see if two substances that look alike are the same or not? List all the tests you can think of. *Answers will vary depending in students' prior knowledge.*

Teaching Strategies
When students describe the ingredients lists, point out that ingredients are usually listed in decreasing order of concentration. You can then discuss what concentration is and why it is important in determining the properties of mixtures.

Experimenting and Investigating

[Student Book pg. 16]

Purpose

Students learn about the different kinds of properties that can be used to identify materials and carry out some tests themselves as they role-play lab chemists examining three unknown samples that could be anthrax. Students are also introduced to lab safety and some common lab procedures. Students will:

- Discuss the challenge in which they will try to determine if the white powders are a hoax.

- Compile a list of possible tests that could be used to distinguish materials that are similar in appearance.
- Review and discuss physical and chemical properties, and how to distinguish between these types of properties.
- Test selected properties (reactions with water, vinegar, and pH indicator; solubility; and the conductivity of the powder mixed with water) of common household products and unknown samples.
- Use the results of their tests to make any possible initial identification of the unknown samples.

Materials and Preparation

- See Advance Preparation.
- Hand out Think Sheet 2.2 to students to use in the Data Analysis.

CHALLENGE: What is the unknown white powder?

Students are asked to role-play chemists performing quick comparison tests to help assess the probability of whether several powders are anthrax or a common household product. Their goal is to make initial findings that can guide further testing in a more specialized lab. One of the samples is the one opened by Dylan at the *New York Digest*. Student will compare the properties of common household products and unknown samples to see if they match. Students are told that they will need to present their results later on.

Students will need three to four 45–minute class sessions to complete the challenge.

Facilitating the Challenge

- Have students work in groups of two to four. The number in the group may depend on the space and materials you have available.
- Review the safety rules in the lab.
- Model using lab equipment and doing procedures for students, such as transferring solids and preventing contamination.
- Introduce and discuss the challenge with students before proceeding to the pre-lab discussion.
- As students proceed through the lab, have them identify when they are testing a physical property and when they are testing a chemical property, and to explain their reasoning.

Suggested Homework

Have students review their data and copy it into a table, if needed.

At the end of the lab, have students analyze their results by answering the Data Analysis questions. This work should be completed by the entire group, but each student must keep his/her own record of all answers.

Responses to Data Analysis Questions

1. You examined the appearance of each material in this lab. Is appearance a physical or chemical property? Explain your reasoning. *A physical property; the substance does not change.*
2. Summarize the data on the properties of the household products in a table.
   Some sample results are appended. Results will vary depending on the actual products tested, the equipment used, the specific procedure followed, and so on.

Material	Reaction with Vinegar	Reaction with Water	Solubility in Water	Conductivity	pH
Baking Powder	Yes	Yes			
Baking Soda	Yes	No	Fully dissolves	No	6.1–9.2
Cream of Tartar	No	No	Partially dissolves	No	4.5
Flour	No	No	Partially dissolves	No	4.5
Sugar (powdered)	No	No	Fully dissolves	No	4.5
Talc	No	No	No	No	4.5

3. Summarize the data on the properties of the unknown samples in a table. *Answers will vary depending on the products selected for the unknown samples.*
4. Examine both tables. Do any of the unknown samples appear to be a common household product that is white and powdery? Explain your reasoning. *Answers will vary depending on the products selected for the unknown samples.*
5. Do any of the unknown samples appear to be something other than the household products that were tested? Explain your reasoning. *Answers will vary depending on the products selected for the unknown samples.*

Processing for Meaning

[Student Book pg. 23]

Purpose

Students discuss each group's identification of the unknown substances and analyze what they learned about the measurement of properties. Students will:

- Present the evidence they used to identify one of the unknown samples they tested.
- Determine recommendations for further testing based on the evidence presented about the possible identity of the unknown samples.
- Discuss further tests that could be carried out to confirm identification.
- Discuss how testing mixtures may affect the results of the tests.
- Read about how differences in properties reflect differences at the atomic level and that each substance is made up of atoms and or molecules as its building blocks.

Materials and Preparation

Hand out Think Sheet 2.3 to students to use in the Questions for Discussion.

PRESENTATION: Is the Anthrax Threat Real or a Hoax?

Have student prepare a presentation about the identification of one of their three unknown samples. Assign one third of the groups to present their results for unknown sample 1, one third of the groups to present their results for unknown sample 2, and one third of the groups to present their results for unknown sample 3.

Teaching Strategies
Give students particular tasks to complete as they listen to each presentation, such as keeping track of the identifications of all the unknown samples.

When the presentations are complete, have a class discussion about students' results. To aid the discussion, you may use the Questions for Discussion on page 24 in the student book as starting points for different conversations.

Responses to Questions for Discussion

1. What evidence did each group use to make its conclusions about the identities of the samples? *Answers will vary, but typically students will see a match on all the tests they performed in order to make a positive identification.*
2. Did all the groups obtain the same results? If not, what might have caused differences in identification? *Answers will vary depending on the care students took in measuring and recording their data.*

Listening for Understanding
As students discuss differences in results, students should be able to think about and, perhaps, distinguish between results that vary a little due to differences in measuring techniques and differences that are big enough to call into question the identification of the substance.

3. What other tests can be done to confirm of the identity of the samples? *Students should mention density, melting point, and other properties that they didn't yet test.*

Teaching Strategies
If there are some unknowns that have ambiguous results, or some household products that cannot be distinguished by the tests run in the lab, have students return to the lab and run some density tests. Density of a powder can be measured by determining the mass of a certain amount of powder and then determining the volume of that same amount of powder in a liquid in which the powder is insoluble. A less accurate method is to measure the volume of the powder directly (this measurement will include the volume of the air between the particles). Using a powder funnel when adding the powder to a graduated cylinder is recommended.

4. What effect did the use of mixtures (in the common household products) have on measuring properties? *Students should refer to the fact that substances retain their properties in mixtures.*

5. Each substance has a unique set of properties that allows it to be identified. Using what you know about the nature of matter, offer an explanation for why each substance is unique. *Answers will vary. Students should begin to think at the atomic or molecular level as one way of explaining differences.*

Suggested Homework

Have students read "What Differentiates Hoax from Horror?" and answer the Thinking About What You Read questions that follow. Discuss the answers in class, if possible.

Responses to Thinking About What You Read Questions

1. Explain why each substance has different properties. *Each substance has different kinds of atoms and a different arrangement of atoms.*

2. What is a network? What is a molecule? *A network is a group of atoms that are chemically bonded throughout a substance. A molecule is a small group of atoms bonded together.*

3. Two different substances with different properties are made up of the same kinds of atoms. Explain what else must be different about these two substances. *The atoms must occur in a different ratio or be arranged in a different structure.*

Suggested Homework

Have students read "From a Crime Scene to Chemistry" on page 25.

Checking for Understanding

It is suggested that you end this learning experience by having students answer the Checks for Understanding questions on their own and then discuss their answers as a whole class. By doing so, both you and your students will be able to assess and clarify understanding of the learning experience content. A soft copy of the Checks for Understanding questions—without answers—are on the Chemistry Field-Test Resources Web page (in PDF and in Word). The Checks for Understanding Questions and Answers for this learning experience are located in Appendix B.

Appendix B also contains an Assessment Item Bank of short-answer and multiple-choice items, with answers. You may decide which items to use, when to use them (e.g., at the end of this learning experience or after a group of learning experiences), and how to use them (e.g., as homework, quizzes, or tests). A soft copy of the Item Bank items—without answers—are on the Chemistry Field-Test Resources Web page (in PDF and in Word) so that you can customize your use of items.