Activity 4

2–3 CLASS SESSIONS

Identifying Solids

Activity Overview

Students perform their procedures to separate the solid and liquid parts of the simulated hazardous waste mixture. They then separate out the different solids. Rather than conduct tests to determine the hazardous nature of the solid substances, they conduct tests to help identify each solid. Identifying solids is another way to gather information about potential hazards.

CONCEPTS, PROCESSES, AND ISSUES

(with NSE 5–8 Content Standards Correlation)

1. Hazardous materials are substances that pose a danger to the health and safety of living organisms. *(PhysSci: 1)*
2. Careful observation can provide important information about a substance. *(Inquiry: 1)*
3. Hazardous substances may be present as solids, liquids, or gases. *(PhysSci: 1)*
4. Mixtures of pure substances can be separated using techniques based on the different chemical and physical properties of the substances. *(PhysSci: 1; Inquiry: 1)*
5. Pure substances are identified by performing qualitative tests to determine their chemical and physical properties. *(PhysSci: 1; Inquiry: 1)*
6. Scientists evaluate the results of investigations and use evidence to draw conclusions. *(History: 2)*

TEACHING SUMMARY

Step 1.
Explain the purpose of testing the solids.

Step 2.
Separate the solids and conduct four identification tests on each solid.

Step 3. ***(Assessment)***
Identify each solid and discuss whether the solids are hazardous.

MATERIALS

For the teacher

- 1 Transparency 1.4, "Feedback Form: Analyzing Data" (optional)
- 1 Transparency 1.5, "Scoring Guide: Analyzing Data" (optional)
- 1 Transparency 2.1, "Graphic Organizer: Hazards Testing" (optional)
- 1 Transparency 4.1, "Key to Identifying Solids"
- * 1 overhead projector
- * masking tape (optional)

For each group of four students

- 1 30-mL graduated cup
- 1 magnet
- 1 dropper bottle of Liquid B (50,000 ppm copper chloride)
- 1 30-mL dropper bottle of ethanol
- 1 dropper bottle of water
- 2 plastic vials with lids
- 1 plastic cup, with lid, containing simulated hazardous waste
- 2 droppers
- 1 funnel
- 1 metal screen
- 2 pairs of forceps
- 2 plastic spoons
- 2 narrow-mouthed plastic cups (to serve as the base for the funnel)
- * 2 SEPUP trays
- 1 cup of water

For each student

- * 1 pair of safety goggles
- * 1 written procedure from Investigation 3, "Making a Plan"

1 paper copy of Transparency 1.4, "Feedback Form: Analyzing Data" (optional)
1 paper copy of Transparency 1.5, "Scoring Guide: Analyzing Data" (optional)

**Not supplied in kit*

ADVANCE PREPARATION

If you are conducting this activity with multiple classes, you must prepare additional simulated hazardous waste so that each group of four students has its own 60-mL sample (see Advance Preparation in Activity 1). Each group of four students will be separating the substances in its own sample. If possible, make sure that each sample contains at least a small amount of each solid and liquid.

If you decide to set aside the liquids in individual cups (see Teaching Step 2), you can have students use masking tape to label their samples.

Teacher's Note

The simulated hazardous waste contains mineral oil. Any item that comes into direct contact with the simulated waste may retain an oily residue. Lab equipment, such as SEPUP trays and droppers, must be thoroughly cleaned with hot soapy water to remove this residue.

Safety Note

The chemicals used in this activity may cause skin irritation. Use caution when handling solutions. Always wear safety goggles and thoroughly rinse any area that comes into direct contact with laboratory chemicals.

Teaching Suggestions

GETTING STARTED

Step 1. Explain the purpose of testing the solids.

In this activity, students begin to conduct the lab that they designed in Investigation 3, "Making a Plan." Rather than testing the solids for different types of hazards, however, they conduct tests on each solid to identify it. Explain that, in some cases, it is more convenient to identify the substance itself and research the known hazards than to test for potential hazards. Remind students that this was one approach modeled by the HAZMAT team in the video: after quickly identifying some of the substances in the waste, they used Material Safety Data Sheets (MSDS) to determine the potential hazards.

Point out that many common chemicals, whether used in the laboratory or in the home, have known effects. This is one reason that labels are so important. It is not necessary for every bottle in a chemistry classroom to list all of the potential hazards associated with the chemical it contains; the name of the chemical is usually all you need to look up the relevant safety information. Ask, ***When you did your household survey, was every substance in your home labeled? Why might unlabeled containers be a cause for concern?*** The name of the substance is often one of the most essential pieces of information in an emergency situation.

Have students take out (or return to them) their procedures from Investigation 3, "Making a Plan."

INVESTIGATING

Step 2. Separate the solids and conduct four identification tests on each solid.

Distribute Investigation 4, "So Many Solids." Point out that students will use their own procedure only in Procedure Part One: Separating Solids, and that they will not be separating or testing the liquids during this investigation (they will investigate the liquids in the next activity). Stress the safety precautions the students should take, such as not handling waste directly with their bare hands. Remind students that this is a simulation and that the components in the mixture are not really hazardous wastes. However, some of the materials can irritate skin or eyes or stain clothing, so students should handle them with care.

You may also want to review the common signs of chemical reactions—color change, production of gases (usually detected as bubbling), formation of a precipitate, and release of energy—to prepare students for their observations of reactivity with copper chloride.

Distribute the materials that your students plan to use for the separation of the substances. After the students have separated the solids from the liquids, they are instructed to pour the liquids into a cup with a lid and return the liquids to the teacher. You can then either set aside the cups (labeled by group) or pour all of the liquids together and redistribute them during the next investigation.

Teacher's Note

After the students have separated the solids, they will have 2–4 different solids (depending on how they are separated). Each of the four identification tests must be conducted on each solid, resulting in a maximum of 16 tests. If you are concerned about time or the ability of your students to conduct so many tests, consider having each team of two students test only two of the four solids. Each group of four can then share test results.

When the students place the iron washers in either water or ethanol to conduct the density tests, some remaining residue may discolor the liquid. This will not affect the test results. However, some students may consider the test more reliable if the liquid appears uncontaminated. For this reason, you may want to encourage students to test the iron washers last or to conduct the density in water test first (since discolored water can easily be replaced). Sample results of testing the solids are shown in the table below.

SYNTHESIZING

Step 3. ***(Assessment)*** **Identify each solid and discuss whether the solids are hazardous.**

After students have completed their investigations, have them respond to Question 1, which provides an opportunity to discuss the process of science. Explain to students that scientists commonly revise their procedures to create experiments that achieve reliable and reproducible results.

When answering Question 2, students may need help in using the table to identify the solids. You may wish to have students create a key, similar to the one shown on Transparency 4.1, "Key to Identifying Solids," to help them organize the different properties they have tested. Remind them of the graphic organizers used in Activity 2, "Identifying Types of Hazards," which modeled the use of a graphic organizer to produce a key.

Encourage students to use the data they collected to justify their conclusions (that is, to support their answers with evidence) when answering Question 2c. After each group has had a chance to identify the solids, discuss responses as a class. Ask some student groups to share their conclusions. You may want to have different groups explain how they determined the identity of a particular solid and have them practice using evidence from the lab to support their conclusions. Be sure to discuss any conflicting conclusions or results. Point out that two of the solids that looked similar (the iron and aluminum washers were identical in shape) were chemically different, whereas two of the solids that looked different (the squares were different colors) were chemically the same. Use Question 2 to discuss how the characteristic properties of a substance can be used to separate and identify different substances.

After students have answered Question 4, they may want to know about the hazards posed by solid substances. Remind students that the solids used in this activity were part of a simulation and, to ensure student safety, they were not hazardous. However, hazardous solids do exist. You may want to ask students if they can provide any examples. They may suggest poisons (such as rat poison), powders (such as arsenic), and household substances (such as mothballs). Remind students

Sample Results of Testing Solids

Test	Cup A (dark circles)	Cup B (silver circles)	Cup C (light squares)	Cup D (black squares)
Density (compared to water)	sinks; more dense than water	sinks; more dense than water	floats; less dense than water	floats; less dense than water
Density (compared to ethanol)	sinks; more dense than ethanol	sinks; more dense than ethanol	sinks; more dense than ethanol	sinks; more dense than ethanol
Magnetism	magnetic	not magnetic	not magnetic	not magnetic
Reactivity with copper chloride	slow color change (copper chloride becomes green)	quick formation of bubbles	no reaction	no reaction

that hazardous materials are substances that pose a danger to the health and safety of living organisms. As a result, many solids can become hazardous when misused (for example, soap can be toxic if ingested). This is why it is important to use chemicals carefully and for their intended purpose only.

QUESTION 1

What changes (including any additions or deletions) did you have to make to your planned procedure during the lab?

Students may have had to add steps to their procedures, such as "Use a spoon to scoop any waste remaining in the cup into a funnel" or "Use forceps to lift the metal screen and use a spoon to scrape off remaining solids." Students may have encountered unexpected difficulties and had to change materials or procedures; for example, some students may have planned to use the forceps to lift the different solids but used the spoon instead. Students may have described unnecessary steps, such as moving the solids from one container to another several times.

QUESTION 2 ***(Assessment)***

Several local companies have just released a list of solid wastes they once produced. Not all of these solids are present in your hazardous waste mixture. The following table [on the student page] provides more information.

a. *Predict which of the substances listed in the table would float in water. The density of water is 1.00 g/cm^3. Hint: A substance must be less dense than water in order to float in it.*

Lithium and high-density polyethylene (HDPE) should float in water because both are less dense than water.

b. *Predict which of the substances in the table would float in ethanol. The density of ethanol is 0.79 g/cm3 . Hint: A substance must be less dense than alcohol in order to float in it.*

Lithium should float in ethanol because it is less dense than ethanol.

c. *Use your answers to 2a and 2b and the other information provided in the table to identify each solid you tested. Support each identification with at least two pieces of evidence.*

Although student responses will vary, guide students to support their answers with evidence from their observations. A complete and correct Level 3 response is shown here.

The silvery circles are aluminum because aluminum is a metal that reacts quickly with copper chloride, just like this metal did in the lab when it formed bubbles. The silvery circles can't be iron, which also reacts with copper chloride, because iron is magnetic and the silvery circles are not.

The dark circles are iron because iron is a magnetic metal that reacts slowly with copper chloride. The dark circles are magnetic and caused a slow color change in the copper chloride. This was the most difficult solid to identify because the only evidence that showed that it was iron and not nickel was the reaction with copper chloride. The table doesn't say what kind of reaction occurs, only that it happens slowly. It would help if we knew what kind of reaction occurs between iron and copper chloride.

Both the light- and dark-colored squares are high-density polyethylene (HDPE). HDPE is the only solid nonmetal that (1) floats in water and (2) sinks in ethanol, just like the squares did when tested.

QUESTION 3

Did the results of the four tests provide enough evidence for you to identify each solid with confidence? Why or why not?

Some students will say that they had enough evidence because they were able to identify each of the solids. They may point out that the results of their tests matched identically the properties of a particular solid described in the table, allowing accurate identification.

Students whose test results do not match the sample results may not feel that they have enough evidence to confidently identify the solids. For example, if students did not observe a color change after copper chloride was added to the iron washers, they may not be sure whether

the metal is iron or nickel. They may suggest repeating the tests or conducting other tests.

Other students may point out that the tests themselves, as well as the information in the table, highlighted particular information about the solids, making identification easier. Identifying a solid without such instructions and a table would be more difficult and require additional tests. For example, there are other silvery metals that are not listed in the table that are nonmagnetic and react with copper chloride. To conclusively identify the metal as aluminum, additional tests might be required. Determining which tests would help distinguish among the metals might require additional research.

Highlight the fact that substances have characteristic properties, such as density and magnetism, that can be used to identify them. Testing additional properties is one way to gather more information about a substance to identify it.

QUESTION 4

Would you label the solids found in your mixture as hazardous? Explain.

Most students would not label these solids as hazardous since they are common materials that are not highly corrosive, flammable, reactive, or toxic (nor are they biohazards or radioactive). Aluminum and high-density polyethylene are used to store many everyday products, including food and drink. Iron is also used in common objects, such as cars and bikes. The ever-present nature of these substances suggests that they are not hazardous; otherwise, their use would likely be restricted. Also, household hazardous substances are required to be appropriately labeled; these materials do not carry any warnings or cautions.

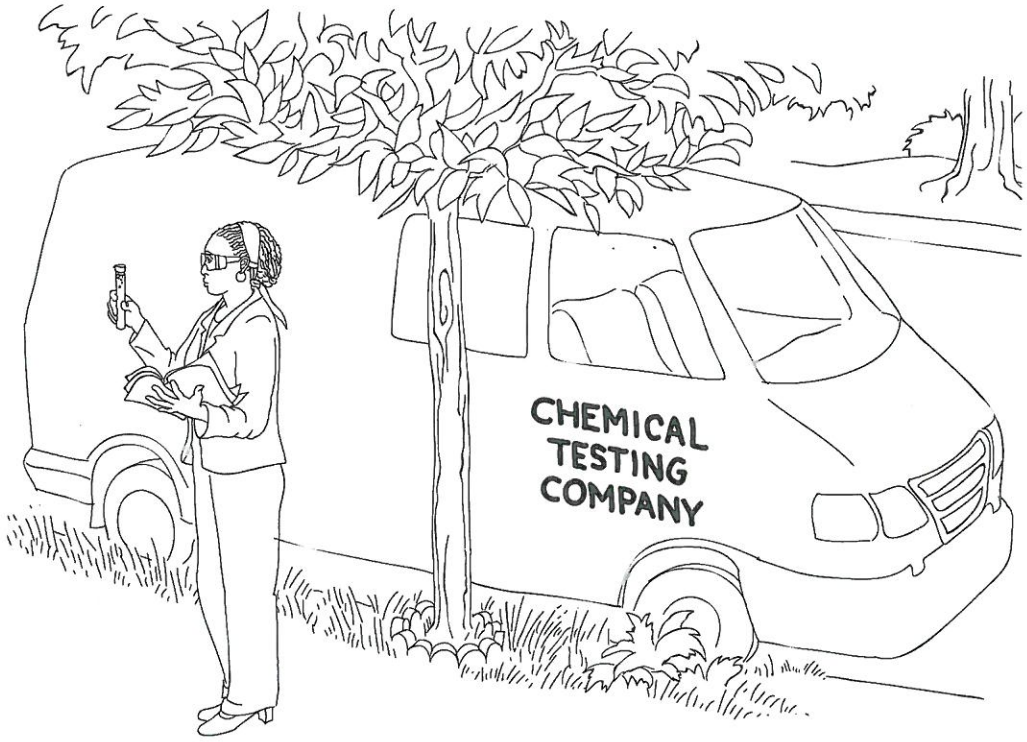
So Many Solids

• • • • ▸ CHALLENGE

How hazardous are the solids in the hazardous waste mixture?

HAZMAT teams follow several steps when dealing with unidentified waste. After addressing any immediate hazards, they often attempt to identify the substance or substances in the waste. You can more easily handle materials safely if you know exactly what they are.

In this activity, you will follow your own procedure for separating the different solids from the rest of the simulated hazardous waste. You will then conduct several tests on each solid. You can use the results of the tests to help you identify each solid.



MATERIALS

For each group of four students

- 1 **30-mL graduated cup**
- 1 **magnet**
- 1 **dropper bottle of Liquid B (copper chloride)**
- 1 **dropper bottle of ethanol**
- 1 **dropper bottle of water**
- 2 **plastic vials with lids**
- 1 **plastic cup, with lid, containing simulated hazardous waste**
- 2 **droppers**
- 1 **funnel**
- 1 **metal screen**
- 2 **pairs of forceps**
- 2 **plastic spoons**
- 2 **narrow-mouthed plastic cups**
- 2 **SEPUP trays**
- 1 **cup of water**

For each student

- 1 **pair of safety goggles**
- 1 **written procedure from Investigation 3, "Making a Plan"**

Safety Note: Do not touch simulated hazardous waste or bring it into contact with your eyes or mouth. Wear safety goggles while working with chemicals. Wash your hands after completing the activity.

• • • • ▶ PROCEDURE

Part One: Separating Solids

1. Review with your group your written procedure for separating the solids from the liquids in the simulated hazardous waste.
2. Follow your procedure to separate and rinse the solids. Be sure to record any changes that you make to your procedure.
3. Pour the liquid hazardous waste into the cup with a lid. Place the lid on the cup and return the liquid waste to your teacher.
4. Use a spoon to divide the solids equally between your team of two and the other half of your group.
5. Review with your partner your written procedure for separating the different solids.
6. Follow your procedure to separate the different solids. Be sure to record any changes that you make to your procedure.

Part Two: Testing Solids

7. The table below describes four tests that you can use to identify solids. Create a data table to record the results of conducting these four tests on each solid that you have separated from the mixture.

8. Work with your partner to test each solid. Record the results of each test in your data table.

Tests to Identify Solids

Test	Procedure	Evaluating Test Results
Density (compared to water)	Add 60 drops (3 mL) of water to a vial. Place a solid in the vial, cap the vial, and shake gently.*	If the solid floats, it is less dense than water. If the solid sinks, it is more dense than water.
Density (compared to ethanol)	Add 60 drops (3 mL) of ethanol to a vial. Place a solid in the vial, cap the vial, and shake gently.*	If the solid floats, it is less dense than ethanol. If the solid sinks, it is more dense than ethanol.
Magnetism	Use the forceps to hold a magnet over a solid.	If the solid is attracted to the magnet, it is magnetic. If the nothing happens, it is not magnetic.
Reactivity with copper chloride	Create a control by placing 7 drops of copper chloride (Liquid B) in a clean, empty cup of your SEPUP tray. Place a solid in another cup and add 7 drops of copper chloride to the solid.	Compare the two cups to determine whether any reaction occurs. If a reaction occurs, the solid reacts with copper chloride. If nothing happens, the solid does not react with copper chloride.

*To remove a solid from the vial, pour the contents of the vial back into the graduated cup. (If the solid sticks to the sides of the vial, you can rinse the solid loose with water.) Use the forceps to remove the solid and then carefully pour the liquid back into the vial.

• • • • ▶ ANALYSIS

Group

1. What changes (including any additions or deletions) did you have to make to your planned procedure during the lab?

Individual

2. Several local companies have just released a list of solid wastes they once produced. The table below provides more information. Not all of these solids are present in your hazardous waste mixture.
   a. Predict which of the substances listed in the table would float in water. The density of water is 1.00 g/cm^3.
   Hint: A substance must be less dense than water in order to float in it.
   b. Predict which of the substances in the table would float in ethanol. The density of ethanol is 0.79 g/cm^3.
   Hint: A substance must be less dense than ethanol in order to float in it.
   c. Use your answers to Questions 2a and 2b and the other information provided in the table to identify each solid you tested. Support each identification with at least two pieces of evidence.
3. Did the results of the four tests provide enough evidence for you to identify each solid with confidence? Why or why not?
4. Would you label the solids found in your mixture as hazardous? Explain.

Information on Local Solid Wastes

	Physical State	Density (g/cm^3)	Magnetism	Reactivity with copper chloride
Lithium	solid metal	0.53	nonmagnetic	reacts quickly
High-density polyethylene (HDPE)	solid nonmetal	0.95	nonmagnetic	no reaction
Polystyrene	solid nonmetal	1.05	nonmagnetic	no reaction
Polyvinylchloride (PVC)	solid nonmetal	1.34	nonmagnetic	no reaction
Aluminum	solid metal	2.70	nonmagnetic	reacts quickly
Iron	solid metal	7.87	magnetic	reacts slowly
Nickel	solid metal	8.90	magnetic	no reaction
Gold	solid metal	19.3	nonmagnetic	no reaction

Key to Identifying Solids