Activity 5

2–3 CLASS SESSIONS

Identifying Liquids

Activity Overview

Students perform their procedures to separate the different liquids from the simulated hazardous waste. They test each liquid for corrosiveness, reactivity, and toxicity, and observe flammability tests. They then conduct four additional tests on properties of the liquids to help identify them.

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. Substances can be hazardous because they are biohazards, corrosive, flammable, radioactive, reactive, or toxic. *(PhysSci: 1)*
5. Mixtures of pure substances can be separated using techniques based on the different chemical and physical properties of the substances. *(PhysSci: 1; Inquiry: 1)*
6. Pure substances are identified by performing qualitative tests to determine their chemical and physical properties. *(PhysSci: 1; Inquiry: 1)*

TEACHING SUMMARY

Step 1.
Discuss the three parts of the Procedure.

Step 2.
Separate liquids and test each liquid for possible hazards.

Step 3.
Conduct four identification tests on each liquid.

Step 4. ***(Assessment)***
Identify each liquid and discuss whether the mixture is hazardous.

Step 5.
Review the methods used for separating the mixtures and testing the solids and liquids.

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"
- 1 Transparency 3.1, "Graphic Organizer: Substances"
- 1 Transparency 4.1, "Key to Identifying Solids"
- 1 Transparency 5.1, "Key to Identifying Liquids"
- * 1 overhead projector
- 1 copper wire (coiled at one end)
- * matches
- * 1 beaker of water

For each group of four students

- 1 cup containing liquids from simulated hazardous waste
- 1 pH color chart
- 1 dropper bottle of potassium thiocyanate solution
- 1 60-mL dropper bottle of methanol
- 2 plastic vials with lids
- 1/2 effervescent tablet
- 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 team of two students

1 strip of pH paper (orange)
1 strip of potassium iodide paper (white)
1 stir stick

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

Be prepared to provide students with the liquid samples that they separated from the simulated hazardous waste mixture in Investigation 4, "So Many Solids."

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.

Use methanol in a well-ventilated area and keep vials containing methanol capped when not in use.

Teaching Suggestions

GETTING STARTED

Step 1. Discuss the three parts of the Procedure.

Distribute Investigation 5, "Looking at Liquids," and have students read the Challenge and skim the three parts of the Procedure.

In Part One: Separating Liquids, students will conduct the last part of the procedure that they wrote in Investigation 3, "Making a Plan," in which they separate the different liquids.

In Part Two: Evaluating Hazards, students will conduct the tests that they first used in Investigation 2, "HAZMAT Training," to determine what hazards (corrosiveness, flammability, reactivity, toxicity) the liquids may pose. Use Transparency 2.1, "Graphic Organizer: Hazards Testing," to review each of the tests and their test results. Remind students that the toxicity test is a simulation. In this activity, the toxicity test is not conducted in the same way as in Investigation 2. The ammonia is replaced with potassium thiocyanate, and the color red, not blue, indicates toxicity.

In Part Three: Identifying Liquids, students will conduct four more tests on the liquids to help identify them. One of the tests (miscibility) is similar to the density tests conducted on the solids in Investigation 4, "So Many Solids." When two liquids are added together, they tend to mix or not mix. This is known as **miscibility** and is a property characteristic of liquids. (It is similar to solubility; solubility usually refers to the ability of a solid to dissolve in a liquid. In Investigation 4, all of the solids were insoluble in both water and ethanol, which allowed students to focus on their relative densities.) You may want to point out to students that the word miscibility sounds like "mixability," which is what the word essentially means.

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 stain clothing, so students should handle them with care.

INVESTIGATING

Step 2. Separate liquids and test each liquid for possible hazards.

Have students take out (or return to them) their procedures from Investigation 3, "Making a Plan." Distribute the materials your students plan to use for the separation and testing. Students can then separate the two liquids.

Begin the testing of the liquids by conducting the flammability test of each liquid in front of the class. Be sure to wear safety goggles and take other appro-

priate safety precautions, including conducting the demonstration in a well-ventilated area. Then soak the coiled end of a copper wire in one of the liquids for several minutes. As you wait, instruct students to construct data tables to record test results, as stated in Step 4 of the Student Procedure. Remove the copper wire from the liquid and attempt to light the coiled end with a match. Rinse the copper wire with water and repeat the process with the other liquid.

When the copper wire that was dipped in the mineral oil is lighted, it should ignite (if the wire is well coated in mineral oil, a flame should burn for several seconds; if there is not much mineral oil on the wire, you may see just a spark). The iron (III) nitrate solution, being an aqueous solution, is not flammable. Compare the results. Remind students to record the results of each test. The table below contains sample results.

Sample Results of Identifying Hazards

Test	Cup A (clear liquid)	Cup B (orange-brown liquid)
Corrosiveness	not corrosive	corrosive
Flammability	flammable	not flammable
Reactivity	not reactive	reactive
Toxicity	not toxic	toxic

Explain to students that there are degrees of flammability. Extremely flammable substances often produce vapors (that is, gas) that can ignite; this means that extremely flammable substances can catch fire even before the liquid or solid makes direct contact with a flame. Moderately flammable substances ignite when in direct contact with a flame. Nonflammable substances do not burn under normal conditions.

If the orange-brown liquid does not produce the results described in the table above, the simulated waste may have been sitting too long. To ensure that you get the results described here, make sure that the orange-brown liquid is tested within 3–4 days of when you make the simulated hazardous waste.

Step 3. Conduct four identification tests on each liquid.

After students have determined the hazards posed by each liquid, they then can test different properties of each liquid. The following table contains sample results.

Sample Results of Identifying Liquids

Test	Cup A (clear liquid)	Cup B (orange-brown liquid)
Odor	odorless or mild oily odor	odorless
Miscibility in water	not miscible	miscible
Miscibility in methanol	not miscible	miscible
Presence of water	no water present	water present

During cleanup, equipment that contained liquid waste should be washed with soap and water to remove mineral oil residues.

SYNTHESIZING

Step 4. *(Assessment)* Identify each liquid and discuss whether the mixture is hazardous.

After students have completed their investigations, have them respond to Question 2 individually. In Question 2a, they are asked to create a graphic organizer similar to the one produced in Investigation 4, "So Many Solids"; display Transparency 4.1, "Key to Identifying Solids," to remind students of how to construct a graphic organizer to help distinguish among the various substances in the table.

Encourage students to use the data they collected to justify their conclusions, and discuss responses as a class. Ask different groups to explain how they determined the identity of a particular liquid and how they used evidence from the lab to support their conclusions. Be sure to discuss any conflicting conclusions or results. Then use Question 3 to highlight how the characteristic properties of a substance can be used to separate and identify different substances.

Discuss student responses to Question 4 as a class. Students are likely to agree that the waste should be identified as hazardous. Ask, ***Exactly how should the waste be labeled? As "hazardous"? Or would another label be more helpful?*** Students may suggest labeling the mixture with the four known hazards (corrosive, flammable, reactive, and toxic). Discuss why these more specific labels would be more helpful than simply a hazard sign. Inform students that they will find out more about how hazardous materials professionals handle labeling in the next activity.

QUESTION 1

Would you label the liquids found in your mixture as hazardous? Why or why not?

Most students would label the liquids as hazardous. The tests showed that iron nitrate is corrosive, reactive, and toxic. The mineral oil is flammable. All of these hazards pose a danger to living organisms.

QUESTION 2 ***(Assessment)***

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

a. *Create a graphic organizer, similar to the one created in Investigation 4, "So Many Solids," to help you identify each liquid.*

See Transparency 5.1, "Key to Identifying Liquids," for a sample response.

b. *Identify each liquid that 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.

One of the liquids is a clear, colorless liquid that is not miscible in water or methanol. Based on these properties, this liquid has to be either iso-octane or mineral oil. But iso-octane is toxic, and the liquid in the simulated hazardous waste is not. This means that this liquid has to be mineral oil. Also, the liquid does not smell like gasoline, which iso-octane does.

The other liquid is iron nitrate. It is soluble in water and methanol, like iodine solution, iron nitrate, and nitric acid. But it can't be iodine because iodine is not toxic, and the brown liquid is. Nitric acid has a strong odor, but the iron nitrate does not.

It would help if we had a real test for toxicity instead of a simulation since it is an important test for identifying the liquids.

QUESTION 3

You conducted a total of eight tests on each liquid. Which tests were most useful in identifying the liquids? Explain your reasoning.

Student responses will vary but may include flammability, miscibility, or toxicity. The response will depend on which tests students used first to compare the liquids in the table. Guide students to explain their reasoning. For example, here is a possible student response:

The miscibility tests were most useful in identifying the liquids because they narrowed down the choices for each liquid. The brown liquid was miscible in both water and methanol. Only three of the liquids listed in the table were miscible in both water and methanol. This narrowed down the possible choices to these three liquids. The odor test was also useful because it eliminated two of these three liquids, leaving only the iron nitrate.

QUESTION 4

Would you label the simulated hazardous waste mixture (containing both solids and liquids) as hazardous? Why or why not?

Most students would label the simulated hazardous waste mixture as hazardous since it contains substances that have been shown to be corrosive, flammable, reactive, and toxic. Although the mixture is not uniform and a person might not be exposed to the hazardous components, the possibility of danger exists.

Step 5. Review the methods used for separating the mixtures and testing the solids and liquids.

Ask students to review the methods they used to separate the solids and liquids present in the original mixture. These methods most likely included filtering, using a magnet, and using tweezers and droppers. Display Transparency 3.1, "Graphic Organizer: Substances," and refer to the properties of a mixture: it can be separated by physical means. Then ask students to review the methods they used to test the solids and liquids. These included physical tests, such as tests of density and magnetism, and chemical tests, such as a test to determine their reaction with pH paper. Emphasize that while there are many more tests that can be used to identify substances, all depend upon the unique properties of each substance.

Looking at Liquids

• • • • ▸ CHALLENGE

What are the liquids in the hazardous waste mixture? How hazardous are these liquids?

In training for your local HAZMAT team, you learned how to test for different types of hazards. To proceed with the safe handling and disposal of the simulated hazardous waste, you must now test and identify the liquid substances that are a part of the mixture.

MATERIALS

For each group of four students

- 1 cup containing liquids from simulated hazardous waste
- 1 pH color chart
- 1 dropper bottle of potassium thiocyanate solution
- 1 dropper bottle of methanol
- 2 plastic vials with lids
- 1/2 effervescent tablet
- 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 team of two students

- 1 strip of pH paper (orange)
- 1 strip of potassium iodide paper (white)
- 1 stir stick

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.

Methanol is toxic and can irritate your eyes or skin. Keep vials containing methanol capped when not in use.

• • • • ▶ PROCEDURE

Part One: Separating Liquids

1. Your teacher will return to you the cup that contains the liquid substances you found in the hazardous waste mixture. Pour half of the mixture into another cup and give it to the other half of your group.
2. Review with your partner your written procedure for separating the different liquids.
3. Follow your procedure to separate the different liquids. Be sure to record any changes that you make to your procedure.

Part Two: Evaluating Hazards

4. The following table describes four tests that you can use to identify hazardous substances. Create a data table to record the results of conducting these four tests on each liquid that you have separated from the mixture.

Tests to Identify Hazards

Test	Procedure	Evaluating Test Results
Flammability	Your teacher will conduct this test.	If you observe a flame or a spark, the liquid is flammable.
Corrosiveness	Tear the pH paper in half and use one-half for each liquid. Use a dropper to place 1 drop of liquid onto a piece of the pH paper.	Compare the color of the pH paper to the pH color chart. If the pH paper is dark red or bluish-purple, the liquid is a strong acid or base. Strong acids and bases are usually corrosive.
Reactivity	Tear the potassium iodide paper in half and use one-half for each liquid. Use a dropper to place 1 drop of liquid onto a piece of the potassium iodide paper.	If the paper turns blue or black, the liquid is reactive.
Toxicity	Place 6 drops of liquid into a small cup of a SEPUP tray. Add 1 drop of potassium thiocyanate solution.	If the solution turns red, the liquid is toxic.

5. Observe while your teacher conducts a flammability test on each liquid. Record the results in your data table.

6. Test each liquid for corrosiveness, reactivity, and toxicity. Record the results in your data table.

Part Three: Identifying Liquids

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

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

Tests to Identify Liquids

Test	Procedure	Evaluating Test Results
Odor	Bring your nose no closer than 10 centimeters (3 inches) near a liquid and use your hand to gently wave the air above the liquid toward your nose. Be careful not to come into direct contact with a liquid.	Describe any odors that you smell.
Miscibility in water	Add 50 drops of water to a vial. Then add 10 drops of a liquid. (To reuse the vial, pour the contents of the vial into a big cup of a SEPUP tray and rinse the vial with water.)	If the liquid forms a separate layer on the top or bottom of the water, it is not miscible in water. If the liquid mixes with the water, it is miscible in water.
Miscibility in methanol	Add 50 drops of methanol to a vial. Then add 10 drops of a liquid. (To reuse the vial, pour the contents of the vial into a big cup of a SEPUP tray and rinse the vial with water.)	If the liquid forms a separate layer on the top or bottom of the methanol, it is not miscible in methanol. If the liquid mixes with the methanol, it is miscible in methanol.
Presence of water	Break your effervescent tablet piece in half. Place 6 drops of liquid in a small cup of the SEPUP tray. Add a piece of the tablet to the liquid.	If bubbles appear in the solution, water is present in the liquid.

• • • • ▶ ANALYSIS

Group

1. Would you label the liquids found in your mixture as hazardous? Why or why not?

Individual

2. Several local companies have just released a list of liquid wastes they once produced. Not all of these liquids are present in your hazardous waste mixture. The table below provides more information.
   a. Create a graphic organizer, similar to the one created in Investigation 4, "So Many Solids," to help you identify each liquid.
   b. Identify each liquid that you tested. Support each identification with at least two pieces of evidence.
3. You conducted a total eight tests on each liquid. Which tests were most useful in identifying the liquids? Explain your reasoning.
4. Would you label the simulated hazardous waste mixture (containing both solids and liquids) as hazardous? Why or why not?

Information on Local Liquid Wastes

	Iodine Solution	Iron Nitrate Solution	Iso-octane	Mineral Oil	Nitric Acid	Lauric Acid Solution
Physical State	yellow to brown liquid	clear, orange liquid	clear, colorless liquid	clear, colorless to pale yellow liquid	clear, colorless or pale yellow liquid	clear, colorless liquid
Flammable?	no	no	yes, very	yes, slightly	no	yes
Reactive?	no	yes	no	no	yes	no
Toxic?	yes	yes	yes	no	yes	no
Miscible in Water?	yes	yes	no	no	yes	no
Miscible in Methanol?	yes	yes	no	no	yes	yes
Odor	mild irritating odor	odorless	gasoline-like odor	mild oily odor	strong, suffocating odor	mild odor, oily

Key to Identifying Liquids