Activity 2

1 CLASS SESSION

Identifying Types of Hazards

Activity Overview

Different substances can pose different types of hazards. After being introduced to different hazard categories, students use chemical tests to determine the types of hazards posed by three unidentified liquids. They observe flammability tests of each liquid and conduct tests to determine whether each liquid is corrosive, reactive, or toxic.

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. Hazardous materials must be identified before being treated, moved, or disposed of. *(Perspectives: 4)*
3. Hazardous materials are commonly found in homes. *(Perspectives: 4)*
4. Substances can be hazardous because they are biohazards, corrosive, flammable, radioactive, reactive, or toxic. *(PhysSci: 1)*
5. Chemical tests are used to identify unknown substances. *(Inquiry: 1; PhysSci: 1)*

TEACHING SUMMARY

Step 1.
Introduce the idea that different substances can pose different types of hazards.

Step 2.
Test three unidentified liquids to determine the type(s) of hazard posed by each.

Step 3.
Discuss how testing can be used to evaluate hazardous substances.

MATERIALS

For the teacher

* 1 overhead projector
1 Transparency 2.1, "Graphic Organizer: Hazards Testing"
1 copper wire (coiled at one end)
* matches
* 1 beaker of water

For each group of four students

1 dropper bottle of each of the following:
Liquid A (3% hydrogen peroxide)
Liquid B (50,000 ppm copper chloride)
Liquid C (0.1 M hydrochloric acid)
5% ammonia
1 pH color chart

For each team of two students

* 1 SEPUP tray
1 strip of pH paper (orange)
1 strip of potassium iodide paper (white)
1 dropper
1 pair of forceps
* 1–2 paper towels

For each student

1 Student Sheet 2.1, "Testing for Hazards"
* 1 pair of safety goggles

**not supplied in kit*

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. Introduce the idea that different substances can pose different types of hazards.

Introduce this activity by telling students that they are now in training for their local HAZMAT team. At this point, they need to learn how to identify different types of hazards. Point out that the observations conducted in the previous activity cannot determine whether or not a substance is hazardous. Ask, ***Why are certain substances hazardous? In other words, in what ways can a substance pose a danger?*** Students are likely to point out that substances can be explosive, cause fires, irritate human skin, or be poisonous. All of these types of hazards can fit into a standardized system used by HAZMAT professionals. Explain that chemicals that can irritate human skin or be poisonous are considered toxic, and chemicals that ignite and cause fires are identified as flammable.

Hand out and use Investigation 2, "HAZMAT Training," to introduce some general hazard categories. Guide students in relating familiar hazards to one of these six categories. For example, chemicals that are explosive are part of a larger category of hazards known as reactive chemicals. You may wish to refer back to the data students collected on household hazardous substances. Ask, ***Which category do you think most household hazardous substances fall into?*** In some cases, students may have found household materials identified as flammable or corrosive. In many other cases, the chemicals may have been described as poisonous or as having the potential to cause skin or eye irritation; such substances are considered toxic.

Explain that it is important to identify the type of hazard before handling or transporting hazardous substances. For example, a corrosive substance might require a special container, and a reactive liquid might require gentle movement. The process of evaluating an unidentified, potentially hazardous substance can be thought of as consisting of two parts:

1. A test to determine whether a substance is hazardous in some general way. For example, a pH test, such as the one demonstrated in the video shown in Activity 1, can indicate whether a substance is a strong acid or base and thus likely to be corrosive. Such tests allow for safer handling of unidentified substances in the field.
2. A test to determine the identity of a substance or the exact chemical composition of a mixture. For example, a flame test, such as the one demonstrated in the video, can be used to identify certain substances, such as sodium. Such tests may take place either in the field or in a laboratory setting.

Tell students that in this investigation, they will practice the first level of testing. In the lab, they will perform chemical tests to determine whether three unidentified liquids are corrosive, reactive, or toxic. They will also have a chance to determine whether or not the liquids are flammable by observing a flammability test conducted in front of the class. (They will not be investigating biohazards and radioactive substances.)

Use Transparency 2.1, "Graphic Organizer: Hazards Testing," to explain how the tests will be conducted and how the results of a test can be used to determine whether the substance poses a hazard. Highlight the fact that the test for toxicity is a simulation and that a real toxicity test would require a different procedure.

Note that Transparency 2.1 provides a map, or organizer, to help students understand the relationship between the types of hazards and the laboratory tests. Explain to students that such maps can be used to organize ideas based on their relationships to each other. During the course of this module, students will create their own organizers to help clarify ideas.

INVESTIGATING

Step 2. Test three unidentified liquids to determine the type(s) of hazard posed by each.

> **Safety Note**
>
> *Be sure to wear safety goggles and take other appropriate safety precautions.*

Hand out Student Sheet 2.1, "Testing for Hazards." Begin the tests by conducting the flammability test of each liquid in front of the class. Then dip the coiled end of a copper wire in one of the liquids. 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 two

liquids. Remind students to record the results of each test on Student Sheet 2.1.

Explain that students will conduct the remaining tests in teams of two, but will share some materials as groups of four. The tests are similar to those that a real HAZMAT team might perform in the field. After distributing materials to students, circulate around the room to provide any additional guidance required. Allow the students time to complete their tests and record results. Then provide cleanup instructions.

SYNTHESIZING

Step 3. Discuss how testing can be used to evaluate hazardous substances.

As a class, discuss the results of the testing. As you discuss Question 1, point out that any given liquid (and by extension, any given solid or gas) may belong to more than one hazard category. Hazard categories simply provide a system for identifying hazards and how to best handle them safely.

Discuss students' responses to the remaining questions. Eventually, you may want to tell students that Liquid A is a hydrogen peroxide solution, Liquid B is a copper chloride solution, and Liquid C is a hydrochloric acid solution.

QUESTION 1

a. *Based on your testing, what hazard(s) does Liquid A pose? Liquid B? Liquid C?*

Liquid A is reactive. Liquid B is corrosive, reactive, and toxic. Liquid C is corrosive.

b. *What precautions can be taken to prevent accidents when using or storing hazardous substances such as these liquids?*

While all hazardous substances should be handled carefully, there are certain kinds of precautions that bear more consideration with each category of hazard. For example, since a corrosive liquid may affect human tissue, a person should wear gloves and goggles when using such a liquid and should avoid breathing in corrosive fumes as they can irritate the lungs (this is one reason why certain substances are suggested for use only in well-ventilated areas). A corrosive liquid can also dissolve other substances, so it is important to store corrosive substances in appropriate containers.

Reactive substances should not be mixed with other chemicals since they may react, causing unexpected fumes, flames, or explosions. A reactive liquid should be stored away from other chemicals, especially those substances it can react with. In some cases, reactive substances must be protected from air, so they don't react with oxygen in the air.

Toxic substances should also be handled carefully. This can be done by wearing gloves, rinsing any affected areas with water, and avoiding toxic fumes. Toxic substances should not be swallowed and should be kept out of reach of children.

Sample Results for Student Sheet 2.1, "Testing for Hazards"

Liquid	Flammable	Corrosive		Reactive		Toxic	
	Flammable? (yes or no)	Final color of pH paper	Corrosive? (yes or no)	Final color of potassium iodide paper	Reactive? (yes or no)	Final color of solution	Toxic? (yes or no)
A	no	orange	no	black	yes	clear	no
B	no	red	yes	black	yes	blue	yes
C	no	red	yes	white	no	clear	no

QUESTION 2

a. *If Liquids A, B, and C were mixed together, what hazard categories do you think would apply to this mixture? Explain your reasoning.*

Assuming that the mixture had all of the properties of the individual liquids, it could be corrosive, reactive, and toxic. Alternatively, the liquids could react with each other, producing a mixture with different properties than the original liquids. (Remind students that it is extremely dangerous to mix unidentified substances together because of the possibility of unknown reactions.) For example, the resulting mixture might be toxic, but not corrosive. However, mixing these liquids is not likely to produce a mixture with hazards completely different from the original liquids; for example, the mixture will not be a biohazard or radioactive.

b. *Explain exactly how you could determine how hazardous this mixture might be.*

The mixture could be tested for hazards. A flame test could determine whether the mixture is flammable. The mixture could then be tested with pH paper to see whether it is a strong acid or base, indicating the level of corrosiveness. Potassium iodide could be used to determine whether the mixture is reactive.

Highlight the fact that the test for toxicity was a simulation, and that determining whether the mixture is toxic would require a different test than simply adding ammonia. Encourage students to visualize chemical testing as a method for determining both the category of hazard and the identity of the substance. In some cases, it may be easier to identify the substance and research the known hazards (using Material Safety Data Sheets (MSDS), for example) than to conduct tests for every possible hazard.

QUESTION 3

What is the most common category of hazardous substances found in your home? Support your answer with evidence from Thinking More About Investigation 1, "What's Hazardous at Home?"

While students' answers will vary, the most common categories are likely to be toxic and corrosive. Encourage students to support their answers with evidence. For example, here is a possible student response:

Most of the hazardous substances in our house are toxic. Four of the five substances in my table caused eye and skin irritation. This means that these substances fall into the toxic category.

HAZMAT Training

• • • • ▶ CHALLENGE

What types of hazards can substances pose?

Substances can be hazardous in many different ways. The following table lists major categories of hazardous substances. Some substances belong to more than one category.

Imagine that you are training to become part of your local HAZMAT team and are learning how to recognize hazardous materials. In this activity, you will perform chemical tests to determine whether a liquid is corrosive, flammable, reactive, or toxic.

Categories of Hazardous Substances

Category	Hazard	Examples
Biohazard	can cause infection or disease in living organisms	medical wastes such as used syringes, tissue samples, and human blood
Corrosive	can dissolve or wear away other substances such as metals or human tissue	strong acids or bases such as sulfuric acid or bleach (sodium hypochlorite)
Flammable	can serve as fuel for a fire	gasoline, benzene, paint thinner
Radioactive	can release a type of energy that causes damage to the tissues of living organisms	spent nuclear fuel, uranium ore, radon
Reactive	can explode when exposed to other substances (such as air or water); can emit toxic fumes when mixed with other substances	hydrogen peroxide, alkali metals such as sodium or potassium
Toxic	can cause injury or death to living organisms; poisonous	antifreeze (ethylene glycol), mothballs (naphthalene), heavy metals such as mercury and arsenic

MATERIALS

For each group of four students

- 1 dropper bottle of each of the following:
  - Liquid A
  - Liquid B
  - Liquid C
  - 5% ammonia
- 1 pH color chart

For each team of two students

- 1 SEPUP tray
- 1 strip of pH paper (orange)
- 1 strip of potassium iodide paper (white)
- 1 dropper
- 1 pair of forceps
- 1–2 paper towels

For each student

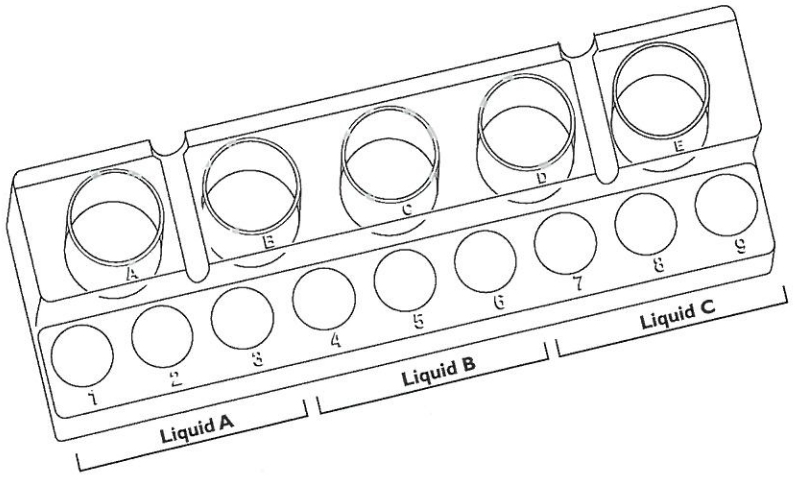
- 1 Student Sheet 2.1, "Testing for Hazards"
- 1 pair of safety goggles

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

• • • • ▶ PROCEDURE

1. Your teacher will demonstrate the flammability of the three liquids, and you and your partner will test whether each liquid is corrosive, reactive, or toxic. Observe the flammability tests and then record whether each liquid is flammable on Student Sheet 2.1, "Testing for Hazards."

2. Place 6 drops of Liquid A into Cups 1, 2, and 3 of your SEPUP tray.



3. Place 6 drops of Liquid B into Cups 4, 5, and 6.

4. Place 6 drops of Liquid C into Cups 7, 8, and 9.

5. Test each liquid to determine whether it is corrosive by completing the following steps:

   a. Tear the orange pH paper into 3 pieces.

   b. Use the forceps to place a piece of pH paper in Cup 1, Cup 4, and Cup 7.

   c. Record the final color of each piece of pH paper on Student Sheet 2.1.

   d. Compare the color of each piece of 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. Use this information to determine whether each liquid is corrosive. Record your conclusions on Student Sheet 2.1.

6. Test each liquid to determine whether it is reactive by completing the following steps:

   a. Tear the white potassium iodide paper into 3 pieces.

   b. Use the forceps to place a piece in Cup 2, Cup 5, and Cup 8.

   c. Record the final color of each piece of potassium iodide paper on Student Sheet 2.1.

   d. If the liquid is reactive, the paper will become either blue or black. Use this information to determine whether each liquid is reactive. Record your conclusions on Student Sheet 2.1.

7. Test each liquid to determine whether it is toxic by completing the following steps:

   a. Add 1 drop of ammonia solution to Cup 3, Cup 6, and Cup 9.

   b. Record the final color of each solution on Student Sheet 2.1.

   c. If the liquid is toxic, the solution will turn blue. This indicates the presence of simulated toxic materials such as heavy metals. Use this information to determine whether each liquid is toxic. Record your conclusions on Student Sheet 2.1.

8. Use the forceps to remove the pH and potassium iodide papers from each cup and place them on a paper towel. Follow directions from your teacher to dispose of the remaining wastes.

• • • • ▶ ANALYSIS

Group

1. a. Based on your testing, what hazard(s) does Liquid A pose? Liquid B? Liquid C?

   b. What precautions can be taken to prevent accidents when using or storing hazardous substances such as these liquids?

2. a. If Liquids A, B, and C were mixed together, what categories of hazard do you think would apply to this mixture? Explain your reasoning.

   b. Explain exactly how you could determine how hazardous this mixture might be.

Individual

3. What is the most common category of hazardous substances found in your home? Support your answer with evidence from Thinking More About Investigation 1, "What's Hazardous at Home?"

Testing for Hazards

Liquid	Flammable	Corrosive		Reactive		Toxic	
	Flammable? (yes or no)	Final color of pH paper	Corrosive? (yes or no)	Final color of potassium iodide paper	Reactive? (yes or no)	Final color of solution	Toxic? (yes or no)
A							
B							
C							

Graphic Organizer: Hazards Testing