1 EXPLORING MATERIALS

TALKING IT OVER

Consider the world around you. The book in your hands, the floor underneath your feet—each is made from a type of material. The word *material* can have several meanings. To a scientist or engineer, a **material** is a type of solid matter used to make things. For example, clothing, homes, and computers are all made from different materials. Materials scientists and materials engineers study existing materials and design new ones. When they design these materials, some of the things they think about are:

- How will they be used?
- What resources are needed to make them?
- What will happen to them when they are no longer useful?

For example, think about the materials used to make drink containers. Until 1947, almost all drink containers in the United States were made of glass. Consumers would return glass milk and soft drink bottles and get their deposits paid back, and the drink bottling companies would clean and refill the bottles to sell again. Today, most drink containers are made mainly of aluminum, plastic, or glass. Each material has particular characteristics, or **properties**, that make it useful for holding drinks. Each material is made from specific resources and has a set of effects on the environment when it is discarded or recycled.[1][2][3]

< Art 1.01 - IAPS Unit B Act 12 page B4 illustration of two students looking at different types of drink containers>

In this unit, you will learn about some of the properties materials engineers investigate when deciding what material to use for a specific purpose. For this activity, you will be looking at materials used in making disposable drink containers.

You are a materials scientist working for a bottling company. The president of the company has asked you which type of material to use to make containers for a new drink brand. You decide to look for a material that will both work well and have the fewest bad effects on the environment. Should it be aluminum, glass, or plastic? How will you decide? What evidence will you use?

GUIDING QUESTION

What information would help you decide which material is best for making a single-use drink container?[4]

PROCEDURE

[1] NGPS1A2
[2] NGCCCO2
[3] NGCCCO1
[4] NGCCCO2

PART A: COMPARING PROPERTIES OF MATERIALS

1. Prepare a data table for recording the advantages and disadvantages of each of the three materials—aluminum, glass, and plastic. Your table should fill an entire page in your science notebook. Give the table a title.
2. With your group,
   a. discuss and list the properties you already know of for each of the three materials—aluminum, glass, and plastic.
   b. decide whether each property is an advantage or disadvantage if you are using the material to make a drink container.
   c. record in your data table your decision from Step 2b.
3. With your group, discuss what other questions you would like answered before deciding which of the three materials—aluminum, glass, or plastic—is the best choice for making a single-use drink container. Record your group's questions in your science notebook.[5][6]

PART B: CHOOSING A MATERIAL

4. Review the information provided in the following graphs and descriptions. Complete the following with your group for each graph and description:
   a. Discuss what you think the data in the graph means about each of the three materials—aluminum, glass, and plastic. Is it an advantage or disadvantage if you are using that material to make a single-use drink container?
   b. Record in your data table your decision from Step 4a.[7]

< Art 1.02 – 1.05 - IAPS Unit B Act 12 Transparency 12.1 pg B-11 in TE, the following four graphs: Percent recycled; Containers per ton of material; Cost to produce container; Pollutants and waste created in producing one ton; include 1-2 descriptive sentences with each graph>

Art caption: [with Percent Recycled graph] This graph compares what percentage of the material is recycled with the percentage being disposed of in landfills or other ways. [with Containers per ton of material] This graph compares how many containers can be made out of 1 ton of each material. [with Cost to produce container] This graph compares the cost (in U.S. dollars) of making one container out of each material. [with Pollutants and waste created in producing one ton] This graph compares how many pounds of pollutants and waste are created during the process of manufacturing 1 ton of each material.

5. With your group, discuss which material you think is the best choice for making a single-use drink container based on the evidence you have. Record your group's choice and your reasoning for that choice in your science notebook.[8]

ANALYSIS

[5] NGSPAQ1
[6] NGSPAQ3
[7] NGSPAD1
[8] NGSPOE2

1. Did the graphs of the data help you make a decision about the advantages and disadvantages of each material? Explain.
2. Imagine you are an environmentalist who is concerned with pollution, litter, and problems with a bottle's impact on the environment. Based on the information from this activity, which material would you claim is the best for making a single-use drink container?[9][10][11]

   Write a letter from an environmentalist's viewpoint to the president of the drink company describing your recommendation at this time. Support your reasoning with evidence and identify the trade-offs of your decision.[12]

   Hint: To write a complete answer, first state your opinion. Provide two or more pieces of evidence that support your opinion. **Evidence** is factual information or data that support or refute a claim. Then consider all sides of the issue and identify the trade-offs of your decision. A **trade-off** is an exchange of one outcome for another—giving up something that is a benefit or advantage in exchange for something that may be more desirable.

[9] NGCCSF2
[10] NGCCCO2
[11] SEASET1
[12] ELWH681

2 INVESTIGATING ELEMENTS

LABORATORY

Chemicals are the substances that make up all living and nonliving things (together known as **matter**). **Elements** are the simplest pure substances. They cannot be broken down into simpler substances. Elements are the building blocks for all other types of matter. Elements are made of a single type of atom. **Atoms** are the basic building blocks of matter. A sample of aluminum is made up of many aluminum atoms held together by chemical bonds.[13]

Scientists have assigned a chemical symbol to each element. Sometimes the symbol is one uppercase letter. For example, the symbol for carbon is C. Sometimes the symbol is one uppercase letter and one lowercase letter. For example, cobalt is Co. Sometimes the symbol is based on an element's Latin name. Copper's symbol is Cu—from *cuprum*, the Latin name for copper. The symbol CU would never be used for an element, because an element symbol can contain only one uppercase letter.

In this activity, you will investigate the physical properties of several elements: aluminum (Al), carbon (C), copper (Cu), germanium (Ge), iron (Fe), mercury (Hg), nitrogen (N), and sulfur (S). A **physical property** is one that you can identify without knowing if the material reacts with another substance.[14]

< Art 2.01—Texas Grade 6 Unit 1 Act 3 page 10 photos of carbon, cobalt, and copper>

Art caption: Carbon (C) Cobalt (Co) Copper (Cu)

GUIDING QUESTION

How can scientists use physical properties to identify elements?[15]

MATERIALS

For each group of four students

1 set of 4 elements

1 plastic cup (9-ounce)

1 stir stick

water

paper towels

For each student

1 Student Sheet 2.1, "Physical Properties of Elements"

1 pair of chemical splash goggles

[13] NGPS1A1
[14] NGPS1A2
[15] NGPS1A2

SAFETY

Follow all safety rules. Pay close attention as your teacher demonstrates where to find and how to use classroom safety equipment. Wear safety eyewear. If a material does not bend easily, do not use more force because you could break or tear it. Watch out for sharp edges. Wash your hands after you complete the activity.

PROCEDURE[16][17]

1. With your group, carefully observe the four element samples provided. Do not damage the element samples; other classes will use them, too.
2. Use the information in the "Testing Physical Properties" table that follows to guide you as you investigate the physical properties of each of the element samples. Record your observations of the elements in the data table on Student Sheet 2.1, "Physical Properties of Elements."

Testing Physical Properties

PHYSICAL PROPERTIES	PROCEDURE	INTERPRETING TEST RESULTS
State at room temperature—whether the element is solid, liquid, or gas.	1. Observe the sample of the element. 2. Record its state.	Describe your observations in detail.
Color	1. Observe the sample of the element. 2. Record its color.	Describe your observations in detail.
Malleability—whether the element is flexible and can be hammered or bent without breaking	1. Try to bend the element gently. 2. Record how easily it bends.	If it does not bend it is *not malleable*. If it bends slightly, it is *somewhat malleable*. If it bends easily, it is *very malleable*.
Solubility in water—whether the element **dissolves** (mixes evenly to form a clear mixture) in water	1. Fill the plastic cup half full of water and place the material in the cup. 2. Leave the material in the water for at least one minute. Check to see if the material mixes with the water. 3. Once you have recorded your results,	If none of the material dissolves, it is *not soluble*. If some of the material dissolves, it is *somewhat soluble*. If all of the material dissolves, it is *very soluble*.

[16] NGSPPI3
[17] ELRS683

	remove and dry the material.	
Density—how compact the matter is in the element	1. Fill the plastic cup half full of water, and place the material in the cup. 2. Check to see if the material sinks or floats. With your stir stick, push underwater any material that floats, and see if it returns to the surface. 3. As soon as you have recorded results, remove and dry the material.	If it floats, it is *less dense* than water. If it sinks, it is *more dense* than water.

3. Examine the photos and information about four more elements in the "Properties of Four Elements" table that follows.

Properties of Four Elements

SULFUR (S)	MERCURY (Hg)	GERMANIUM (Ge)	NITROGEN (N)
< Art 2.02—photo of sample of solid sulfur>	< Art 2.03—Texas Grade 6 Unit 1 Act 3 page 11 photo of mercury>	< Art 2.04—Texas Grade 6 Unit 1 Act 3 page 11 photo of germanium>	< Art 2.05—photo of nitrogen gas sample (in some kind of see-through glass container, vial, etc)>
Sulfur is a brittle solid. It floats in water and does not dissolve. Many compounds with sulfur have a unique smell.	Mercury is a liquid. It sinks in water and does not dissolve.	Germanium is a brittle solid. It sinks in water and does not dissolve.	Nitrogen is a gas. If mixed with water, it forms bubbles that rise to the surface. It does not dissolve.

4. Add what you have learned about these four elements to the data table on Student Sheet 2.1.

ANALYSIS

1. Why do you think it is important for scientists to observe multiple physical properties in order to identify an element? Use examples from the data you collected in this activity to support your ideas.[18]
2. Copy the lists of words below.

element	gas	metal
iron	solid	property
carbon	liquid	malleable
water	metal	soluble
nitrogen	state	dense

   a. Look for a relationship between the words in each list. Cross out the word that does not belong.
   b. Circle the word or phrase that includes all the other words.
   c. Explain how the word or phrase you circled is related to the other words in the list.
3. Based on the sample of eight elements you have observed so far, and assuming the rest of the elements fit the same pattern, would you expect most elements to be solid, liquid, or gas at room temperature? Explain.[19]
4. When added to water at room temperature, most gases form bubbles that float to the top of the water and release into the air. What does this tell you about the density of gases?[20]
5. Describe what you have learned about the physical properties of aluminum in this activity. What information, if any, from this activity would be helpful in deciding if aluminum would be a good choice for making a drink container?[21][22][23][24]
6. In this activity, you recorded the color of each element you observed. Think of and explain two examples from this activity in which color does not help identify an element.[25]

EXTENSION

To explore more elements using several interactive Periodic Tables, see the *SEPUP Third Edition Chemistry of Materials* page of the SEPUP website at *www.sepuplhs.org/middle/third-edition* and go to the Investigating Elements links.

[18] NGPS1A2
[19] NGSPAD1
[20] NGPS1A2
[21] NGCCCO2
[22] NGCCSF2
[23] NGSPOE2
[24] NGCCCO1
[25] NGPS1A2