Activity 2 Elements and Their Properties

What Do You See?

GOALS

In this activity you will:

- Apply ancient definitions of elements to materials you believe are elements.
- Test some properties of several common elements.
- Classify elements as metals, nonmetals, or metalloids.
- Learn to differentiate between chemical and physical properties of materials.
- Organize a table of the elements you tested based on their properties.
- Practice safe handling of corrosive chemicals in the laboratory.

What Do You Think?

Throughout history, philosophers and scientists have talked about "the elements." Reference to elements is most frequent today in the field of chemistry.

- **What is an element?**

The *What Do You Think?* question is meant to get you thinking about what you already know or think you know. Don't worry about being right or wrong. Discussing what you think you know is an important step in learning.

Record your ideas about this question in your *Active Chemistry* log. Be prepared to discuss your responses with your small group and the class.

Investigate

1. Work individually first and then in your group.
   a) Make a list of four or more substances you use or see every day that meet your definition of an element.
2. The ancient Greeks believed that the four elements were earth, air, fire, and water. The alchemists of the early Renaissance identified a limited number of elements including: mercury, sulfur, and salt.
   a) Does each of the above "elements" satisfy your definition of an element? Why or why not?

Element	Initial observation	Conducts electricity	Reacts with HCl	Magnetic or nonmagnetic	Metal or nonmetal
aluminum					
carbon					
copper					
iodine					
iron					
magnesium					
silicon					
sulfur					
zinc					

Safety goggles and a lab apron must be worn *at all times* in a chemistry lab.

Be sure the terminals are kept apart between trials.

3. Your teacher will provide jars containing several common elements: aluminum, carbon, copper, iodine, iron, magnesium, silicon, sulfur, and zinc.

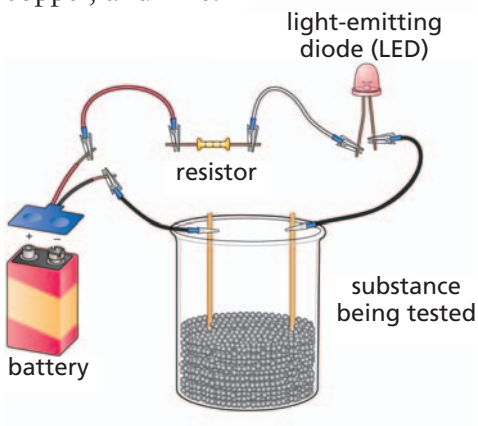
   You will investigate the properties of these elements. By observing common properties, you may gain an insight into how an organizational chart can be created for all of the known elements. Observe the sample of the chemical element in each jar (without removing any). You can describe this initial observation of each element in the first column of a table similar to the one shown.

   a) Record your observations in a table.

4. One of the properties of the elements on Mendeleev's cards was the ability of the element to conduct electric current. Some materials can conduct electricity while others cannot. Using a conductivity meter, you will be able to complete the second column of the chart.

   Insert the terminals of the electrical conductivity apparatus into the jar containing each element. If the light on the apparatus goes on, that means that a complete circuit is created, and an electric current is passing through both the light bulb (LED) and the sample of the element in the jar.

   It is important to make sure that the part of the apparatus immersed into the elements stays dry and is not contaminated by any of the other elements in which it has been immersed. Also, your teacher will provide you with steel wool to polish the metal strips before you test them. The steel wool removes the non-conducting oxides from the surface, especially on the aluminum, copper, and zinc.

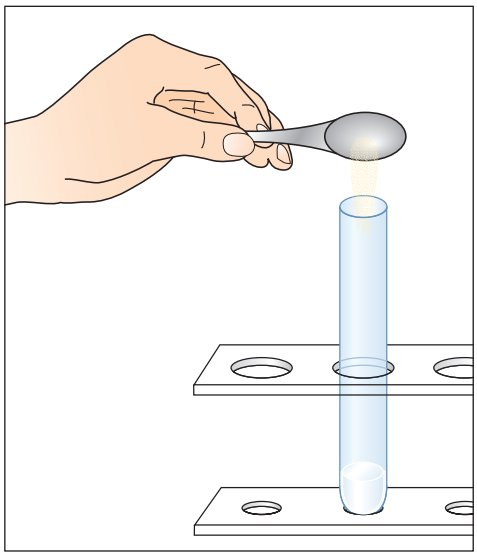


a) Test the samples of each element with the electrical conductivity apparatus. Record whether the element conducts electric current, (yes) or (no).

b) Based on your initial observation and the results of the conductivity test, can you suggest a way to group the elements? Describe an arrangement in your log.

5. Another property of each element known to Mendeleev was how it reacts with an acid.

Pour 5 mL of 1 *M* hydrochloric acid (HCl) into each of nine small test tubes. (1 *M* is an indication of the concentration of the acid.) Use a scoop or tongs to remove a small portion of each element from the jar and add it to the hydrochloric acid. It is important to add the hydrochloric acid to the test tube first so that you will not be surprised by a reaction that occurs when you pour acid over a reactive element. Place a piece of white paper in the background behind the test tube and observe the reaction between the element and hydrochloric acid by looking through the side of the test tube.



a) Test a small sample of each element for its reaction with hydrochloric acid (HCl). Record whether it reacts with the acid, (yes) or (no).

b) For those elements that do react, try to determine whether all show the same type of reaction. (Do they all do the same thing?) Compare the relative vigor of the reactions. If the reaction is vigorous, include a + sign next to your "yes." If the reaction is weak, place a − sign next to your "yes."

6. Dispose of the contents of the test tubes and clean the test tubes as directed by your teacher.

a) Now that three columns of observations are included in the table, describe a way to arrange the different elements.

7. Place a small amount of each sample on a watch glass. Use a magnet and test the element to see if it is attracted to the magnet.

a) Record your observations in your table.

8. A metal is generally a solid that is shiny, malleable, and a good conductor of heat and electricity. Nonmetals have a wide range of properties. Some are dull and brittle, but others, like diamond, are hard and brilliant, and still others are gases or liquids. Most are poor conductors of electricity. Classify each of the elements you observed as either a metal or nonmetal.

a) Record your observations in the table in your *Active Chemistry* log.

9. When elements combine with oxygen they form oxides. Another way to determine whether an element is a metal or nonmetal is to see how the oxide reacts with pH paper.

The term pH is a way of describing how acidic or basic a solution is. A pH of 7 is neutral, below 7 is acidic, and above 7 is basic. Most oxides of metals will produce a pH greater than 7 (base). Most oxides of nonmetals will produce a pH less than 7 (acid). The pH paper comes with a key of pH number and color.

You will now investigate the pH of the oxides to see if your initial determination of metal versus nonmetal was correct. The elements that you have been investigating form common oxides (compounds containing oxygen), as shown in the table below.

If the oxide is a solid, add a small amount of the oxide to a test tube. Then add about 10 mL of deionized water. Stir the mixture to get some of the oxide to dissolve. Some of the oxides may already be in solution. Transfer 10 mL of the solution to the test tube in which you will be determining the pH.

a) Make a table to record your observations in your *Active Chemistry* log. Complete the table.

Wash your hands and arms thoroughly after the activity.

Oxides of elements	pH test
aluminum oxide	
carbon dioxide	
copper oxide	
iron (III) oxide	
magnesium oxide	
silicon dioxide	
sulfur dioxide	
zinc oxide	

b) Were all of the oxides that had a pH more than 7 identified in your table as metals?

c) Were all of the oxides that had a pH less than 7 identified in your table as nonmetals?

The pH observation is the one you rely on to tell the difference between metals and nonmetals. (There are some exceptions to this.)

10. Create an index card for each element. Find a way to sort them based on their properties. You may try arranging them and/or color coding them. Your method of sorting will be successful if you can quickly find an element and know from its position whether it:
    - conducts electricity
    - reacts with hydrochloric acid (HCl)
    - is metallic or nonmetallic.

    a) Record your method of sorting the cards in your *Active Chemistry* log.

11. Dispose of the materials as directed by your teacher. Clean up your workstation.

12. Compare and contrast your arrangement with that of another group.

    a) In what two ways are the arrangements similar?

    b) In what two ways are the arrangements different?

    c) Which of these two arrangements do you think better allows you to find quickly if an element conducts electricity, reacts with HCl, or is metallic?

Chem Talk

PHYSICAL AND CHEMICAL PROPERTIES

Classifying Elements Using Properties

You began this activity by trying to define the meaning of an **element**. The ancient Greek philosopher Aristotle defined an element as "a body into which other bodies may be analyzed . . . and not itself divisible into bodies different in form." The first modern definition of element, which is not much different, is from Robert Boyle: "Bodies, which not being made of any other bodies, or of one another, are the ingredients of which all those . . . mixed bodies are . . . compounded." Scientists now state that an element is any material that cannot be broken down by chemical means into simpler materials.

Before the mid-19th century, scientists were busy discovering elements and observing and recording their properties. Then they tried to organize the elements they had discovered in a useful way. At first, they listed the elements alphabetically. However, every time a new element was discovered, the whole list had to be changed. They tried other methods. Could elements be organized by properties like state (solid, liquid, or gas), color, or taste? None of these methods appeared practical or safe! However, chemists worldwide were sure that elements existed in families that had similar physical and chemical properties.

To the Russian scientist, Dimitri Mendeleev (1843–1907), the development of a tool to organize the elements began the same way that so much of science inquiry begins. He began with a simple question. The question Mendeleev wanted answered was: "What is the relationship of the elements to one another and to the chemical families to which they belong?" At that time there were 63 known elements. To help him with his organization, he developed a card system, much the same as you did in this activity. He wrote the properties of each known element on a different card. Then he spent many hours arranging and rearranging the cards. He was looking for patterns or trends in the data in front of him. Mendeleev, however, had more information on his cards than you presently have. In the following activities, you will look at additional properties of elements that will help you organize your game.

Physical and Chemical Properties

In this activity, you observed several properties of the elements you were provided. You probably initially observed the color of the element and whether the element was a liquid or a solid. You then

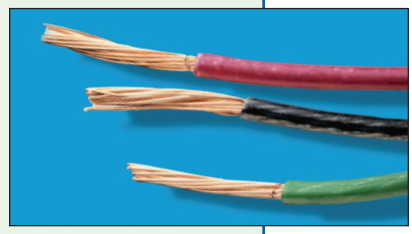
Chem Words

element: any material that cannot be broken down into simpler materials.

Chem Words

physical property: a property of matter that can be measured without causing chemical change or composition of the material. Density is a physical property of a substance.

chemical property: a property that is displayed when matter undergoes a change in composition (it undergoes a chemical reaction). The burning of wood is a chemical property.



investigated whether or not the element conducted electricity. You could have also observed the luster, measured the density (its mass/volume relationship) or the strength, or determined the malleability of each element. In each case, you would not have changed the element itself. In this *Investigation*, the element in the jar still looked the same after you removed the electrical conductivity apparatus as it did when you initially inserted it. It was unchanged. If measuring a property of a substance does not change the chemical identity of the substance, you are measuring a **physical property**.

On the other hand, when you observed whether the element reacted with hydrochloric acid, the element clearly changed. A **chemical property** is a property that is displayed when matter undergoes a change in composition (it undergoes a chemical reaction).

When elements combine with oxygen they form oxides. In the investigation, you saw that the oxides of metals are basic (have a pH greater than 7) and the oxides of nonmetals are acidic (have a pH less than 7) when tested with pH paper. You know that cars and coal-generating power plants emit sulfur dioxide and carbon dioxide into the atmosphere. When these nonmetal oxides combine with water they produce acid rain. Your tests on the nonmetal oxides should have confirmed this observation.

Checking Up

1. Define an element.
2. What question did Mendeleev use to guide his science inquiry?
3. In your own words, describe the difference between a physical and a chemical property.

What Do You Think Now?

At the beginning of the activity you were asked to think about the question:

- **What is an element?**

The question was used to find out what you already know or think you know about elements.

At this point in the activity, it is time to reflect on what you think now. Has your definition of an element been enriched? If you were given several more elements, would you be able to classify them as either metals or nonmetals?

Chem Essential Questions

What does it mean?

Chemistry explains a macroscopic phenomenon (what you observe) with a description of what happens at the nanoscopic level (atoms and molecules) using symbolic structures as a way to communicate. Complete the first column of the chart in your *Active Chemistry* log.

MACRO	NANO	SYMBOLIC
What observations did you make of elements in this activity?	*In chemistry, you try to explain what you see with your eyes about what is happening at the molecular level. You have not yet looked at elements at this level. However, this is the chemist's goal. A nanometer is one-billionth of a meter. It is used to describe the size of atoms and molecules. That is why we call this the nanoscopic level.*	*Symbols are used to represent elements. Aluminum is represented as Al, and zinc has the symbol Zn. These symbols can also be used to represent interactions the elements have with other substances. In this activity, you used pH to see if a material is an acid or a base. The pH is a symbol that chemists use to "talk about" acids and bases.*

How do you know?

A new element is given to you for testing. Describe the tests that you would perform to determine if an element conducted electricity or reacted with hydrochloric acid.

Why do you believe?

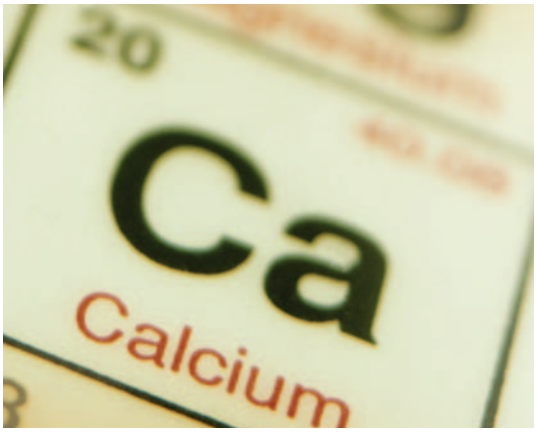
Because different elements possess different properties, they have many different uses. For example, since copper metal is a good electrical conductor, it is used in speaker wiring. Choose two of the elements you worked with in this activity and suggest a use for them based on a particular property they exhibit.

Why should you care?

Knowledge of how the elements are classified or grouped might be an important component of your game. How can arranging elements by conductivity and other properties be a part of a game?

Reflecting on the Activity and the Challenge

In this activity, you learned not only the definition of an element but also some of the properties of elements. Measuring these properties not only enabled Mendeleev to place the elements in his periodic table but also allowed other chemists to identify the elements. You have tried to sort the cards of elements in the same way that Mendeleev did. Perhaps your periodic-table game can have sorting cards as one part of the strategy.



Chem to Go

1. Make a list of three more physical properties of an element that you can observe.
2. Make a list of three more chemical properties of an element that you can measure.
3. Why did you want the metals to be clean or polished before you tested them for electrical conductivity?
4. What criteria did you use to differentiate metals from nonmetals in this investigation?

   a) Is this a valid statement of a trend you saw: as the color of the element becomes darker, the element is less metallic? Support your assessment of this statement with evidence that you observed in your investigation.

   b) Is this a valid statement of a trend you saw: the elements react with hydrochloric acid more as you move down a list of the elements in alphabetical order? Support your assessment of this statement with evidence that you observed in your investigation.
5. Which statement describes a chemical property?

   a) Its crystals are a metallic gray. c) It forms a violet-colored gas.

   b) It has a "chemical-like" smell. d) It reacts with hydrochloric acid to form a gas.
6. A student investigated the physical and chemical properties of a sample of unknown gas. Which statement represents a conclusion rather than an experimental observation?

   a) The gas is colorless.

   b) The gas is carbon dioxide.

   c) When the gas is bubbled in limewater, the liquid becomes cloudy.

   d) When placed in the gas, a flaming splint stops burning.
7. Which element is most likely to be a good conductor of electricity?

   a) copper c) sodium

   b) carbon d) neon
8. The pH test for tin oxide would show that it is:

   a) acidic (pH less than 7)

   b) basic (pH greater than 7)

   Explain your choice.
9. ***Preparing for the Chapter Challenge***

   Prepare a set of index cards for each of the elements with which you are familiar. Record as many properties of each element you know on the card. Use your observations in the following activities and any research you complete on your own to add information to each card.