Activity 1 Elements and Compounds

GOALS

In this activity you will:

- Separate water by electrolysis into the two elements from which it is composed.
- Test the two elements to determine their identities.
- Learn one way to determine the chemical formula of a material.
- Compare characteristic properties of a material to those of its constituent elements.
- Represent materials with chemical formulas using numbers and the symbols of elements.
- Practice safe laboratory techniques with flames and explosions.

What Do You Think?

Matter is the name for all the "stuff" in the universe. Anything that has mass and occupies space is called matter.

- How many kinds of matter are there in the universe: 1, 10, 100, 1000, 10,000, or more than 10,000?
- What makes up matter?

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

Investigate

1. Look around your classroom at the kinds of matter that make up the things you can see.

   a) Make a list of 10 kinds of materials that make up the objects you see. For example, you might list the wood that makes up your pencil, or the glass that makes the windows.

   b) To understand the nature of matter, it helps to know if it is simple or complex. Is it made from only one kind of material or is it a mixture of various materials? Classify each of the 10 materials you listed as pure or mixtures.

c) For each material you thought was a mixture, write your best guess about what materials make it up.

2. Sometimes the materials that make up a substance are not obvious. Early scientists thought that water was an element. In other words, they thought that there was only one kind of material in water. They had not discovered a way of breaking it down further. Water, however, can be broken down further.

   a) Carefully observe the characteristic properties of water. Record your observations in your log.

3. Put on your safety goggles and apron. Assemble the apparatus for separating water as shown in the diagram. Fill two test tubes with water. Submerge them in the water in the beaker and invert them. Make sure you do not allow any air to enter the test tubes. Make sure that the ends of the wires are stripped. Polish them with steel wool. Insert the ends of the wires into the test tubes. Add about 1 to 2 mL of sodium sulfate solution to the water in the beaker.

4. Plug in the battery. Let the reaction run until a test tube is full of gas. (Your teacher may decide to have you stop the reaction sooner.)

   a) Note what happens when the power is turned on. Record your observations in your *Active Chemistry* log.

   b) How do the relative amounts of gas formed in the test tubes compare?

5. Disconnect the battery. Place stoppers on the test tubes and remove them from the water.

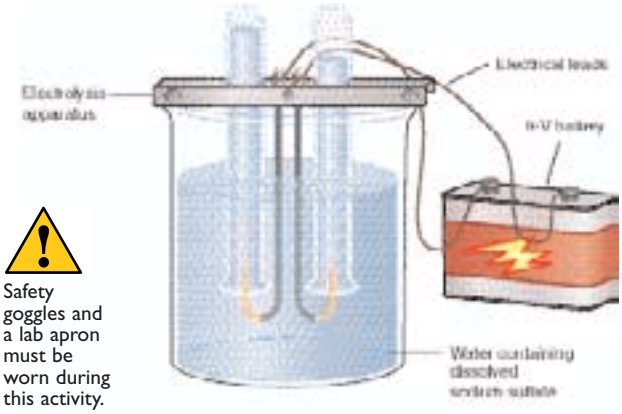
   a) What gas do you think is contained in each test tube? (Hint: You've probably heard that water is H-2-O, written, H_2O.) Record your prediction, and give reasons for your prediction.

   b) Observe the physical properties of each gas. Record these properties in your log.

6. You are going to use a lighted wooden splint to identify the gas in each test tube. First, examine the test tube with the smaller volume of gas. Light a wooden splint. Blow out the flame, but leave the splint glowing. Hold the test tube with its mouth up. Remove the stopper. Quickly bring the glowing splint to the mouth of the test tube.

   a) Observe what happens to the splint, and record your observations.

   b) What gas do you think was produced in this test tube?

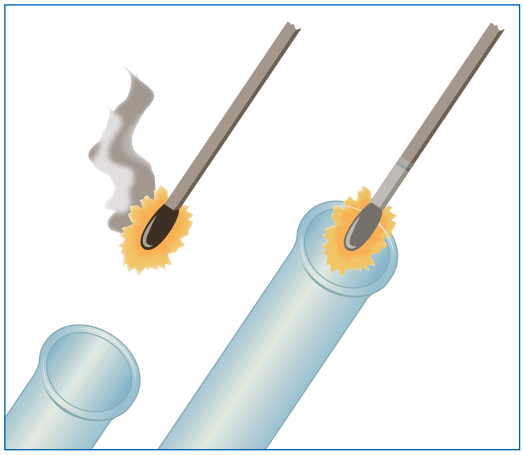


Safety goggles and a lab apron must be worn during this activity.

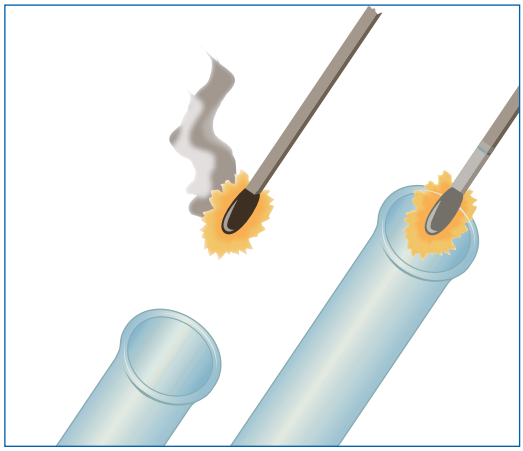
Be certain that the mouth of the test tube is pointed away from everyone.

Clean up spills immediately.

Safety goggles and a lab apron must be worn during this activity.



c) In your log record any additional properties of the gas that you discovered.



7. Next, examine the test tube that is full of gas (or contains the larger volume of gas). Light a wooden splint. Remove the stopper. Quickly bring the burning splint to the mouth of the test tube.

Both the teacher and the students must be shielded.

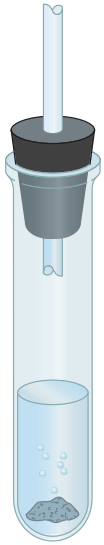
a) Record your observations.

b) What gas do you think was produced in this test tube?

c) In your log record any additional properties of the gas that you discovered.

8. Return the splints and equipment as directed by your teacher. Clean up your work station. Wash your hands.

9. Your teacher will demonstrate a way you can use what you investigated to produce a special effect. Your teacher will set up a gas generator, similar to the one shown in the diagram. The test tube contains 10 mL of 6M HCl (hydrochloric acid – a compound of hydrogen and chlorine) and 3 g of mossy zinc.



a) What gas do you think is being produced in the test tube? Give a reason for your answer.

10. An egg has been emptied out. There is a small hole in the top and another in the bottom of the egg. One of the holes is taped. The egg will be placed over the gas generator, and gas will be collected in the egg for several minutes.

11. The egg will then be mounted in an egg holder behind a shield. If you have a video camera available, be prepared to start recording. Your teacher will remove the tape, and light the top of the egg with a burning splint. Begin recording or observing the reaction until it is over.

a) Record your observations in your log.

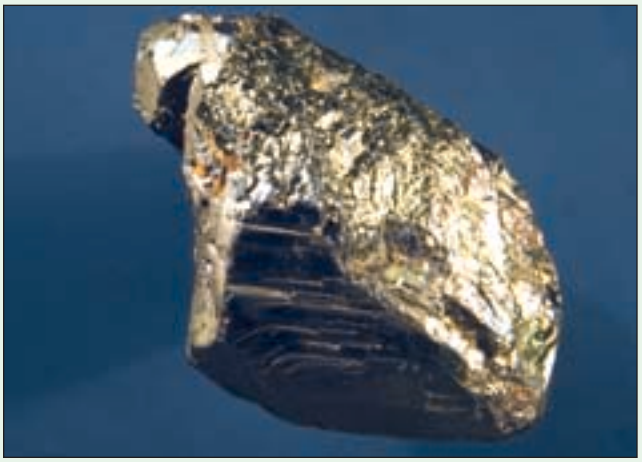
b) If the gas in the egg was hydrogen and air contains oxygen, what substance do you think may have been created in this process?

Chem Talk

THE STRUCTURE OF MATTER

In this investigation you used electricity to separate water into two gases. You knew that the gases were different because they reacted differently to the burning and glowing splints. Since water is referred to as H_2O, a first guess would be that hydrogen (H) and oxygen (O) were created in the experiment. The test for hydrogen is a small explosion when exposed to a burning splint. The test for oxygen is igniting a glowing splint. If you look back on the results of the experiment, you find that the hydrogen gas filled one test tube while the oxygen filled half of the other test tube. There was twice as much hydrogen as oxygen. That's where the "2" comes from in the chemical formula H_2O.

Hydrogen and oxygen are elements. An **element** is any material that cannot be broken down into simpler materials. You are probably familiar with many elements like hydrogen, oxygen, zinc, gold, or helium. Other elements like strontium and beryllium are more exotic and less likely to be familiar to you. Every kind of matter you observe in your everyday life is made up of the chemical elements. There are only about a hundred different kinds of chemical elements. This is an amazing discovery of chemistry – everything you observe in the world is made of different combinations of a hundred elements. Chemistry is the study of how these elements combine and the characteristics of these combinations.



Chem Words

element: any material that cannot be broken down into simpler materials (composed of only one kind of atom).

Elements are represented by symbols. The symbol is one or two letters that represent the name. It's easier to write O than to write oxygen. It's easier to write H than to write hydrogen. The symbols come from many different sources. However, the same symbols are used for each element in all countries of the world.

Symbols for Some Elements

Name of Element	Symbol
aluminum	Al
bromine	Br
calcium	Ca
carbon	C
chlorine	Cl
copper	Cu
gold	Au
helium	He
hydrogen	H
iodine	I
iron	Fe
lead	Pb
magnesium	Mg
mercury	Hg
neon	Ne
nickel	Ni
nitrogen	N
oxygen	O
phosphorus	P
potassium	K
silicon	Si
sodium	Na
sulfur	S
tin	Sn
zinc	Zn

When elements combine they form new substances called **compounds**. These compounds have entirely new characteristics. It is like combining the letters of the alphabet to make words. Twenty-six letters can be combined to make thousands of different words.

Water is an example of a compound. A water molecule, H_2O, is composed of two atoms of hydrogen and one atom of oxygen. (For now, think of an atom as the smallest particle of an element and a molecule as the smallest unit of a compound.) In this activity you used electricity to separate water into its elements, hydrogen and oxygen. This process is called **electrolysis**. You observed that oxygen gas made a glowing splint burst into flame, and that hydrogen gas was explosive. However, to extinguish a burning splint, you could use liquid water. The compound has very different characteristics than the elements from which it is made.

Compounds are represented by **chemical formulas**. A chemical formula shows the symbols of the elements that are combined to make the compound. If there is more than one atom of an element, a subscript is added after the symbol indicating how many atoms of that element there are. For example, as you discovered in this activity, the chemical formula for water is H_2O.

Examples of Some Chemical Formulas

Compound	Common Name	Chemical Formula
calcium carbonate	chalk	$CaCO_3$
carbon dioxide	dry ice	CO_2
hydrochloric acid	muriatic acid	HCl
hydrogen sulfide	rotten-egg gas	H_2S
sodium hydrogen carbonate (or sodium bicarbonate)	baking soda	$NaHCO_3$
sodium chloride	table salt	NaCl
sodium nitrate	fertilizer	$NaNO_3$
sulfuric acid	battery acid	H_2SO_4

Chem Words

compound: a material that can be separated chemically (composed of two or more different kinds of atoms).

electrolysis: the use of electricity to cause chemical decomposition of materials.

chemical formula: the combination of the symbols of the elements that make up the particular compound.

From the table of chemical formulas, you can see that carbon dioxide is a compound of carbon and oxygen. There are two atoms of oxygen for every atom of carbon. Sodium hydrogen carbonate (sodium bicarbonate) is a compound of sodium, hydrogen, carbon, and oxygen. There are three atoms of oxygen for every atom of the other elements. Also, there are a total of three atoms in the carbon dioxide formula and a total of six atoms in sodium hydrogen carbonate.

To generate the gas to fill the empty eggshell in this activity (the teacher demonstration), zinc was placed in hydrochloric acid. Zinc is an element. Hydrochloric acid (HCl) is a compound of hydrogen and chlorine. The reaction of the zinc and hydrochloric acid created a gas. Given the explosion you observed, you can guess that the gas produced was hydrogen. The hydrogen gas came from the hydrogen in the hydrochloric acid.

There's much more to the structure of matter than you can discover in just one activity. However, this activity may have raised some new questions in your mind. For example:

- Can all compounds be separated into their elements?
- What techniques can be used to separate compounds?
- What are elements made of?
- What are atoms?
- What are molecules?

These questions and many more will be explored in other *Active Chemistry* activities.

Checking Up

1. In your own words, explain the difference between an element and a compound.
2. Why are symbols useful in describing chemical elements?
3. What are the symbols for the following elements: carbon, copper, gold, and helium?
4. What information does a chemical formula of a compound provide?

Reflecting on the Activity and the Challenge

Part of the problem you are facing in creating a special effect is understanding what matter is made of and how it can change. In this activity you broke a chemical compound down into its component elements using electrolysis. In another part of the activity a compound was made from chemical elements through a fast and noisy reaction. There are only about one hundred elements, but there are many thousand compounds. You should begin thinking of ways in which some of the reactions you observe could be made to appear more dramatic on screen, without making them any larger in real life. You can now use the concepts of elements and compounds to provide the chemistry description of what is occurring.

Chemistry to Go

1. The table on the right contains several common compounds that are probably familiar to you.

   For each compound:

   a) List the names of the elements present.

   b) State the number of atoms of each element present.

   c) Give the total number of atoms present in each compound.

2. Write a chemical formula for nitrous oxide (laughing gas) that is made up of two atoms of nitrogen and one atom of oxygen.

3. Choose one compound from the table in **Question 1**.

   a) Describe the properties of each element in the compound.

Common Name	Formula
sugar	$C_{12}H_{22}O_{11}$
marble	$CaCO_3$
natural gas	CH_4
rubbing alcohol	C_3H_8O
glass	SiO_2

   b) Explain how the property of the compound is different from the property of each element.

Preparing for the Chapter Challenge

In a short paragraph, summarize the difference between an element and a compound and describe how the properties of a compound can be very different from the properties of the elements that make it up. Explain why knowing these differences is important when designing special effects for a movie set.

Inquiring Further

How is electrolysis used in industry?

Use the reference materials available to you to explore how electrolysis is used in industry to produce hydrogen gas and other elements from compounds.