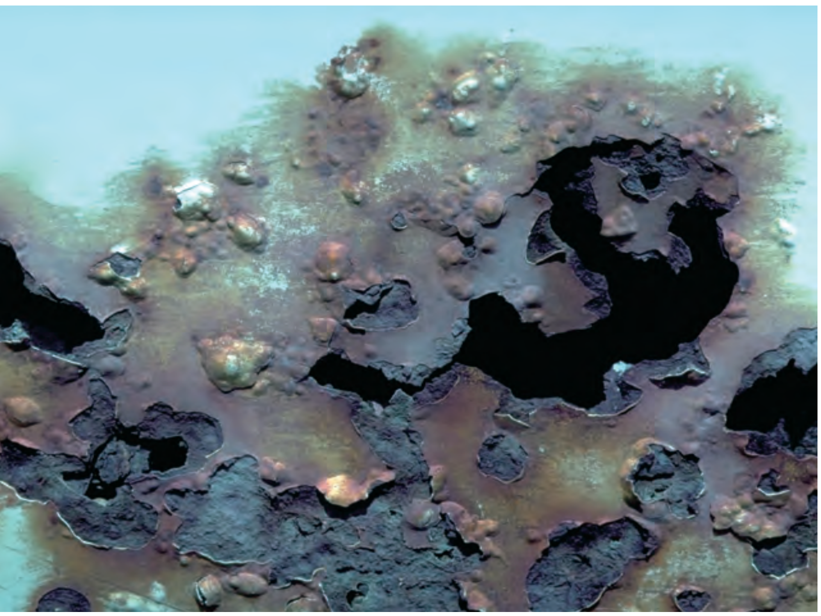
LESSON 22

Combining Elements



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What is going on here? Is a chemical reaction taking place? What are the reactants and products of this reaction?

INTRODUCTION

In the previous lesson, you discovered that elements can be classified into groups on the basis of their characteristic properties. In Inquiry 22.1, you will return to this theme and attempt to classify elements into two major groups. Your classification will then be used as a springboard to investigate the chemical properties of one of these groups in more detail. In Inquiry 22.2, you will investigate how two elements from the two groups you have identified react to make a compound. You will compare some of the properties of the reactants and products of the reaction and use a simple word equation to describe the reaction that has taken place.

OBJECTIVES FOR THIS LESSON

Examine the properties of four elements.

Place the four elements into two major groups.

Identify these groups on the periodic table.

Make a compound from elements in these two groups.

Construct a simple chemical equation for the reaction that has taken place.

Discuss the differences between reactants and products.

Getting Started

1. In Lesson 21, you grouped elements according to their properties. Your teacher will review some of these groups. Be prepared to contribute the name of a group you identified.

2. Imagine you have to split the elements you investigated into two groupings. Discuss the following questions with the other members of your group:

   A. How would you select the groupings?

   B. What properties (criteria) would you use to decide which elements go into which groupings? (The best groupings may use more than one property as criteria.)

   C. What names would you give each grouping?

   D. What are some elements you would put into each grouping?

3. Write your ideas in your science notebook.

SAFETY TIP

Wear your safety goggles at all times.

MATERIALS FOR LESSON 22

For you

- 1 copy of Student Sheet 22.1: Splitting the Periodic Table
- 1 copy of Student Sheet 22.2: Reacting Two Elements
- 1 pair of safety goggles

For you and your lab partner

- 2 test tubes
- 1 250-mL beaker
- 1 pair of scissors
- 1 index card
- 1 piece of steel wool
- 1 metric ruler
- Masking tape

For your group

- 1 bolt
- 1 cylinder
- 1 lump of yellow solid
- 1 lump of black solid

Inquiry 22.1
Splitting the Periodic Table

PROCEDURE

1. One student from your group should collect a plastic box containing the materials.

2. Check the contents of the plastic box against the materials list. (The plastic box does not contain the steel wool. You will collect that later.)

3. Take out the bolt, the cylinder, and the yellow and black samples. These are all elements. Examine them closely. Your teacher will ask you to identify them.

4. Sort these elements into the two groupings you identified in "Getting Started." If they do not fit easily into the two groupings, try changing the criteria you used to select the groupings. If necessary, decide on a new name for each grouping. Construct a table in your notebook that compares the properties of the elements in the two groupings. Compare as many different properties as you can. Use the information you collected about these elements in Student Sheet 21.1a (Table 1) to help you.

5. Your teacher will discuss the groupings you selected and choose two of the groupings to conduct a class brainstorming session. Your teacher will record the properties of each group on a Venn diagram. At the end of the brainstorming session, copy the completed Venn diagram into your notebook.

6. Label the Venn diagram on Student Sheet 22.1 with the names of the two groups. Try to place the elements you have encountered (both in the lessons and in your own experience) into one of the groups. If any elements seem to have intermediate properties (properties between both groups), place them in the area where the circles overlap.

7. Your teacher will ask you to give the names of elements and where you placed them on the Venn diagram.

8. Look at the periodic table in Student Sheet 21.1b. Is it possible to draw a line through the table that separates the nonmetals from the metals? Discuss this with your group and then use a pencil to draw the line.

Inquiry 22.2
Reacting Two Elements

PROCEDURE

1. If the index card does not already have holes in it, cut two round holes, each with a diameter that is slightly larger than the diameter of the test tubes (see Figure 22.1).

2. Put 150 mL of water into the beaker.

3. Use masking tape to affix the index card to the top of the beaker (see Figure 22.2).

4. Invert an empty test tube. Place the test tube through one of the holes in the card, making sure the open end of the test tube is resting on the bottom of the beaker (see Figure 22.3). You may need to tape the tube into place.

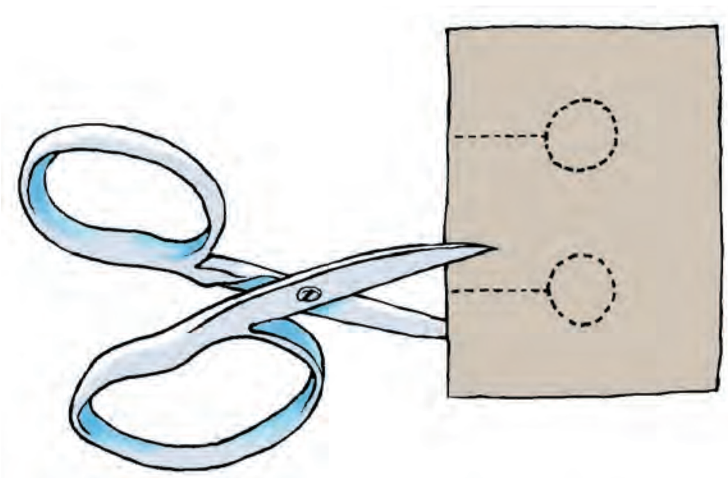

Figure 22.1 *Cut two holes in the index card. Each hole should have a diameter that is slightly larger than the diameter of the test tubes.*

Figure 22.2 *Use tape to affix the index card to the top of the beaker.*

Figure 22.3 *Place an empty test tube through the index card, with the open end of the test tube resting on the bottom of the beaker.*

5. In Table 1 on Student Sheet 22.2, fill in the diagram of the empty test tube to show the water level in the test tube.

6. Collect a piece of damp steel wool from your teacher. The steel wool has been dipped in vinegar to clean off any grease or dirt. Steel wool is mainly iron with a little carbon added. For the purposes of this inquiry, it can be treated as if it is pure iron.

7. Quickly put the steel wool into the second test tube. Push it down to the bottom of the tube with a pencil.

8. Place the test tube through the other hole in the card, making sure the open end of the test tube is resting on the bottom of the beaker (see Figure 22.4).

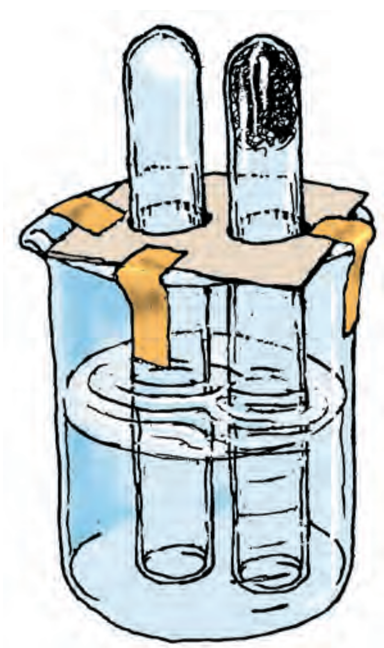

Figure 22.4 *The completed apparatus for Inquiry 22.2.*

9. Immediately show the water level by filling in the diagram in Table 1. Write a description of the damp steel wool in the third column of the table.

10. Watch the apparatus carefully. Do you notice anything happening in the tubes?

11. After about 15 minutes, look at the level of the water in each tube. Record your observations in the appropriate places in Table 1.

12. Describe the appearance of the steel wool.

13. Answer the following question on the student sheet: Has the water level changed in either tube? If so, can you explain the changes?

14. Air is about 20 percent oxygen. Keeping the tubes in position, remove the card and use the ruler to help you determine the approximate fraction of the length of the test tube that the water has moved. Answer these questions on Student Sheet 22.2: Has the water level changed in either tube? If so, can you explain the change? What can you conclude from your observations?

15. Clean the test tubes and the beaker. Make sure you remove the steel wool from the test tube and place it in the trash. Return the cleaned apparatus and the index card to the plastic box.

REFLECTING ON WHAT YOU'VE DONE

1. Discuss your results and compare them with those of other pairs.

2. Answer the following questions in Steps 4 through 8 on the student sheet: Why were two test tubes used in this experiment? What two elements have probably combined in the test tube containing the steel wool? Suggest a name for the new substance that has been formed. Name the reactants and the product(s) of the chemical reaction that has taken place. All chemical reactions have reactants and products and can be written as simple word equations. For example, you know that hydrogen combines with oxygen to form water. A simple word equation to describe this reaction is as follows:

   hydrogen + oxygen → water

   Write a word equation for the chemical reaction that took place in the test tube.

Synthesizing New Materials

Imagine what it would be like to invent a new substance. Many of the materials that we take for granted were invented. These materials are synthetic, which means they don't exist in nature. They have been made—or synthesized—from natural substances. Can you think of any examples of synthesized substances?

Probably the most well known group of synthetic substances is the plastics. Some of the early plastics were made from natural substances, such as cellulose and latex, which are found in plants. The first really synthetic plastic was called Bakelite™, after its inventor, Leo Baekeland. In 1907, he found a way to control a chemical reaction between two existing substances to produce a brittle, dark brown plastic that was, because of its insulating properties, used for making electrical fittings and household items.

HAGLEY MUSEUM AND LIBRARY

In 1931, Wallace Carothers, working at Dupont, invented a silklike synthetic plastic that was eventually called nylon. He made it by mixing together an acid and a solution of another substance, diamine. Nylon, when used as a fiber, has many of the properties of silk but is stronger. In this picture, Carothers demonstrates another synthetic compound—a type of rubber.

CORBIS/DIGITAL STOCK

This vintage radio was made from Bakelite™, an early plastic.

Synthetic Materials Help Win a War

Many new synthetic plastics were first produced in bulk in the 1930s, just in time to play an important role in World War II. Here are some examples, which contributed to the victory of the Allies.

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Silk, used to make parachutes, is produced by silkworms. It was in short supply during World War II, but nylon came to the rescue!

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Nylon was used in the manufacture of parachutes for aircrew and paratroopers.

FDR LIBRARY

When the Japanese army took over the rubber plantations in the Far East, rubber was in short supply. The tires on this army truck were made from a new plastic, sometimes called synthetic rubber.

FDR LIBRARY

Polyacrylics (for example, Plexiglass™) were transparent and light and didn't shatter like glass—ideal properties when it came to aircraft manufacture.

FDR LIBRARY

Nylon and silk stockings were recycled to ensure adequate supplies.

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Polyvinyl chloride (PVC) was used to insulate electrical wires inside aircraft.

Hundreds of synthetic plastics are in use today, all with different properties. They are used in products as varied as soda bottles, lenses, and artificial body parts. ☐

Alchemy Into Chemistry

Since the dawn of civilization, chemical reactions have seemed magical. Certain rocks weep molten metal if put in a fire. Two substances mixed together burst into flames. Juice from a certain plant cures illness. It is no surprise, then, that early thinkers mixed magic with observation and experiment as they tried to understand the world.

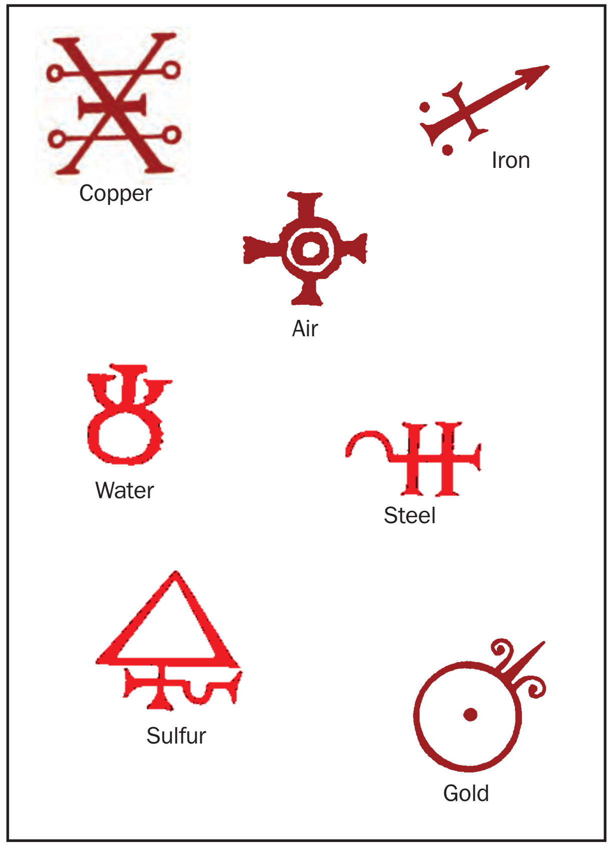
The study of matter in ancient times began as alchemy, a mishmash of primitive chemistry, superstition, and showmanship. Alchemy had two main magical aims: to change common metals into gold and to find a medicine that would cure all ills, including old age. By the 1600s, alchemists were slowly learning that observation and experiment provided more useful information than magic and sorcery. They learned to make hypotheses, gather evidence, and form conclusions. The modern science of chemistry was born. ☐

Many books about alchemy were written. This medieval handwritten and hand-illuminated book was a forerunner to the modern chemistry text.

This woodcut shows an alchemist's lab in 16th-century Europe. The big pot in the middle of the furnace was used for purifying liquids by a process called distillation.

CORBIS/ARCHIVO ICONOGRAFICO, S.A.

The Alchemist, *by the Italian artist Giovanni Stradano, depicts a wide variety of activities that may have taken place in an alchemist's laboratory. Versions of many of the apparatus being used can be found in a modern laboratory. Can you identify any of them?*



Alchemists used their own symbols that represented pure substances and mixtures. Can you identify which of these symbols represent elements, compounds, or mixtures?

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Scientist or alchemist? Isaac Newton was one of the greatest scientists the world has ever known. A physicist and mathematician, he lived and worked in the 1600s, just when real science was taking hold. Newton invented a form of calculus and discovered the laws that govern the motion of the planets. He was also fascinated by and learned a lot from alchemy.