ACTIVITY 6

Making Molecules

BROWARD COUNTY ELEMENTARY SCIENCE BENCHMARK PLAN

Grade 5—Quarter 1
Activity 6

SC.A.2.2.1
The student knows that materials may be made of parts too small to be seen without magnification.

SC.H.1.2.3
The student knows that to work collaboratively, all team members should be free to reach, explain, and justify their own individual conclusions.

SC.H.1.2.4
The student knows that to compare and contrast observations and results is an essential skill in science.

SC.H.1.2.5
The student knows that a model of something is different from the real thing, but can be used to learn something about the real thing.

ACTIVITY ASSESSMENT OPPORTUNITIES

The following suggestions are intended to help identify major concepts covered in the activity that may need extra reinforcement. The goal is to provide opportunities to assess student progress without creating the need for a separate, formal assessment session (or activity) for each of the 39 hands-on activities at your grade.

1. Ask students to identify any other models they have used recently in class. (The periodic table is a model of how different atoms are related to each other. Three-dimensional models show how molecules and atoms are put together. Pictures show how molecules are made up of atoms bonded together.) Ask them to describe how these models were helpful to them. (Answers will vary, but students should describe being able to visualize things that they cannot actually see.)

2. Use the Activity Sheet(s) to assess student understanding of the major concepts in the activity.

In addition to the above assessment suggestions, the questions in bold and tasks that students perform throughout the activity provide opportunities to identify areas that may require additional review before proceeding further with the activity.

ACTIVITY 6

Making Molecules

OBJECTIVES

Students are introduced to the formation and structure of molecules.

The students

- discover that molecules form through the covalent bonding of atoms
- learn that the covalent bonding of two or more different types of atoms forms a covalent compound
- observe the symmetrical structure of molecules
- build models to demonstrate the three-dimensional structure of molecules

SCHEDULE

About 50 minutes

VOCABULARY

chemical formula
covalent bond
covalent compound
molecule

MATERIALS

For each student

1	Activity Sheet 6, Parts A and B
1 pr	safety goggles*

For each team of four

1	ball, foam, green
2	balls, foam, black
4	balls, foam, blue
6	balls, foam, red
7	balls, foam, white
20	pipe cleaners, 5-cm
1	trough, clear, plastic

For the class

DSR *Matter and Change*

PREPARATION

1. Make a copy of Activity Sheet 6, Parts A and B, for each student.
2. Each team of four will need 1 green ball, 2 black balls, 4 blue balls, 6 red balls, 7 white balls, and 20 pipe cleaners. Place all the materials for each team in a trough for easier handling.
3. Each color ball represents a different element. Write the color code for the balls on the board (Figure 6-1).

Ball Color	Element	Symbol
black	carbon	C
blue	nitrogen	N
green	copper	Cu
red	oxygen	O
white	hydrogen	H

▲ ***Figure 6-1.*** *Color code for the foam balls.*

BACKGROUND INFORMATION

In nature, atoms frequently join together. Several kinds of bonds can form between atoms. One is a ***covalent bond,*** in which atoms share electrons. By sharing electrons, each atom gets its outer energy level filled, because the covalent (or shared) electrons are in the outer energy levels of both atoms at the

same time. The combination of two or more atoms sharing electrons covalently is called a ***molecule.*** The resulting molecule is more stable—and less reactive—than either of the individual atoms alone. This stability is the driving force behind the formation of molecules.

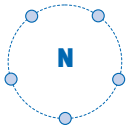
Molecules can form between atoms of the same element or between atoms of different elements. Hydrogen gas (H_2) is formed when two atoms of hydrogen bond together covalently. When atoms of two or more different elements bond together covalently, a covalent compound is formed. A water molecule (H_2O) is an example of a ***covalent compound.*** It is made up of two atoms of hydrogen and one atom of oxygen bonded together covalently. The chemical formula of a molecule tells the exact number and types of atoms that are being held together by covalent bonds. For example, one hydrochloric acid molecule (HCl) consists of one hydrogen atom (H) and one chlorine atom (Cl).

Another type of bond is an ***ionic bond,*** in which electrons are completely transferred from the outer energy level of one atom to the outer energy level of another. Compounds whose atoms are held together by ionic bonds are called ***ionic compounds.*** Common table salt, or sodium chloride (NaCl), is an example of an ionic compound.

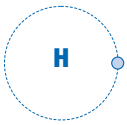
▼ **Activity Sheet 6, Part A**

Making Molecules

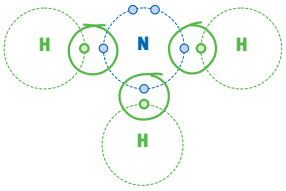
1. This nitrogen atom has five electrons in its outer energy level. How many more does it need to complete the level? 3



2. This hydrogen atom has one electron in its energy level. How many more does it need to complete the level? 1



3. In the space below, add hydrogen atoms around the nitrogen atom until all of the atoms have complete outer energy levels. (Recall the diagram of CO_2 your teacher drew on the board earlier.) Draw circles around the pairs of electrons that are being shared by the atoms.

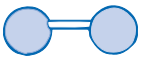


▼ **Activity Sheet 6, Part B**

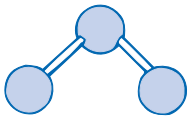
Making Molecules

4. Make the molecules listed below from the materials in your trough, according to the following rules:

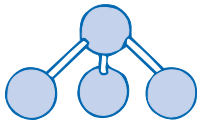
- Molecules with two atoms are always linear.



- Molecules with two atoms on either side of a central atom have a bent shape.



- Molecules with three atoms around a central atom are shaped like a pyramid.



a. CO_2	b. H_2O	c. NH_3	d. N_2	e. NO_2	f. CuO

5. List any molecules you made that are pure elements. N_2
6. List any molecules you made that are linear. CuO and N_2
7. List any molecules you made that are bent. CO_2, H_2O, NO_2
8. List any molecules you made that are pyramid-shaped. NH_3
9. List any molecules you made that are covalent compounds. all but N_2
10. Using the colored balls and pipe cleaners, create a molecule that you have not seen before. On the back of this sheet, give the formula for your molecule, give the molecule a name, and provide any other information you can about it.

Guiding the Activity

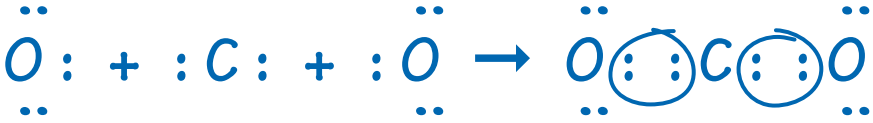
Additional Information

1 Begin with a discussion of molecules. Write *molecule* on the board. Ask, **What do you think a molecule is? Elicit several answers before moving on.**

Some correct answers may be: a compound; atoms that stay together (by bonding); something that is chemically stable; something that has a specific number of atoms; something that is made of specific types of atoms.

2 Draw Figure 6-2 on the board. Point to the left-hand side of the equation. Ask, **How many electrons does the carbon atom have in its outer energy level? How many electrons does an oxygen atom have?**

Carbon has four electrons in its outer energy level. Oxygen has six electrons in its outer energy level.



oxygen + carbon + oxygen → carbon dioxide (CO_2)

▲ ***Figure 6-2.*** *Carbon and oxygen share a total of eight electrons in carbon dioxide.*

Explain that when the three atoms join together to form a molecule of carbon dioxide (CO_2), by sharing electrons they all are able to fill their outer energy levels. Thus, carbon has its outer energy level filled with a total of eight electrons, and each of the two oxygen atoms has its outer energy level filled with eight electrons as well. Like three people under one umbrella, all three atoms benefit because each now has a full outer energy level.

Students may need to be reminded that the first energy level of an atom can hold two electrons and the second level can hold eight. Copy the chart in Figure 5-1 on the board, if necessary.

Write the term *covalent bonds* on the board. Explain that **covalent bonds** are bonds between two atoms in which the atoms share a pair of electrons. The bonds between the carbon and oxygen atoms in a molecule of carbon dioxide are covalent bonds. Tell the students that a **molecule** is formed as a result of a covalent bond between two or more atoms.

As appropriate, read or review pages 6–7 of the Delta Science Reader *Matter and Change*.

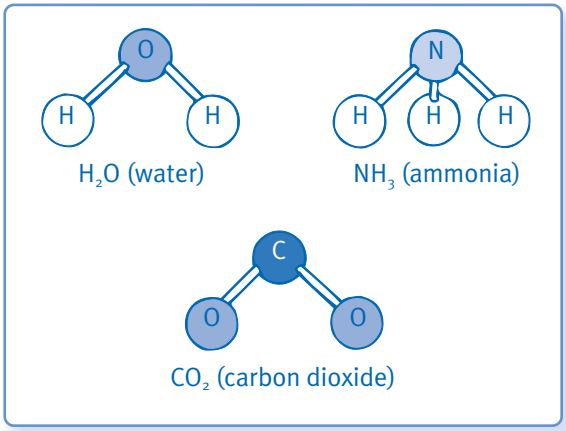
Guiding the Activity

	Additional Information
3 Write the term *covalent compound* on the board. Ask, **What do you think a compound is?**	*Students may say that a compound is a combination of atoms, a complex substance, and so forth.*
Explain that when covalent bonds form between atoms of different elements, molecules of a **covalent compound** are formed. The compound has properties different from those of any of the elements that make it up.	*Point out to students that covalent bonds can form not only between atoms of different elements, but also between atoms of the same element (except for metals) as well. For example, the molecule O_2 is made up of two oxygen atoms covalently bonded together. However, because it is formed from only one element—oxygen—it is not considered a covalent compound.*
4 Explain that molecules are made of specific types of atoms in very specific numbers. Write the formulas for water (H_2O) and hydrogen peroxide (H_2O_2) on the board. Explain that a **chemical formula** tells the exact numbers and kinds of atoms in a molecule. Explain that although both these molecules contain hydrogen and oxygen, they are very different and have very different properties. Ask, **How many atoms of hydrogen and oxygen are in each type of molecule?**	*Water has two atoms of hydrogen and one atom of oxygen; hydrogen peroxide has two atoms of each.*
Distribute a copy of **Activity Sheet 6, Parts A and B,** to each student, and have them complete Part A. Before continuing, review their answers.	*Make sure students understand that the molecule they draw in step 3—an ammonia molecule (NH_3)—has three hydrogen atoms, and that the outer energy levels of electrons of both the nitrogen atom and all the hydrogen atoms are complete.*
5 Next, instruct the students to look at the boxed list of molecules (a–f) in Part B of the activity sheet. Ask, **How many atoms make up each of these molecules?**	*N_2 and CuO have two each; CO_2, H_2O, and NO_2 have three each; NH_3 has four.*
Ask, **How many atoms of oxygen (O) are in the molecules labeled a, b, e, and f?**	*CO_2 and NO_2 each have two; H_2O and CuO each have one.*

Guiding the Activity

Explain the symmetry of molecules; that is, that most molecules made up of only a few atoms have a central atom of one kind with multiple copies of another kind of atom around it. For example, carbon or nitrogen forms the central atom in most of the molecules in this exercise. Because the electrons of each atom's outer energy level repel each other, the atoms in a molecule remain distant from one another. Depending on how many atoms make up a molecule, the molecule may be linear or bent at one or more angles (see Figure 6-3).

Additional Information



▲ ***Figure 6-3.*** *The bent shapes of molecules.*

6 Distribute to each team of four a trough containing 1 green ball, 2 black balls, 4 blue balls, 6 red balls, 7 white balls, and 20 pipe cleaners. Direct the students' attention to the color code on the board. Tell them to use this information and these materials to complete steps 4–9 in Part B of the activity sheet.

Tell each team to compare their models with those of other teams to make sure they have made them correctly. Review the students' answers to the questions in a class discussion.

This activity lends itself to cooperative learning. Encourage interaction among the students. Make sure that everyone is actively involved in making some of the molecules.

7 Have the students complete step 10 in Part B of the activity sheet.

Invite the students to share the molecules they made with the class. Have them explain the formation and structure of each model molecule.

To complete step 10, students may want to know energy level capacities for atoms with more than ten electrons. Again, refer to Figure 5-1 for these values.

Teams should be able to name the type of bond that connects the atoms in these molecules, explain how many electrons are shared between the atoms, and discuss why the angles at which they placed the atoms are correct.

Reinforcement

Have students use what they know about electron energy levels and covalent bonding to build additional model molecules, such as HNO_3, CH_4, H_2O_2, and H_2CO_3.

Science Notebooks

Have students place their completed activity sheets in their science notebooks.

Cleanup

Have the students dismantle their molecules and return the materials to the kit.

Science at Home

Have students use materials at home, such as toothpicks, straws, marshmallows, grapes, raisins, and so forth, to practice building models of various molecules.

Connections

Science Challenge

Give students the following instructions for separating liquid water into its two component gases, hydrogen and oxygen: Attach a length of copper wire to each terminal of a 9-volt battery. Wrap the other end of each wire around a metal paper clip, then attach each clip to one end of a pencil lead. Attach the paper clips to opposite sides of the top of a clear glass jar so the pencil leads hang down into the jar. Then fill the jar with water. Students will see bubbles forming on the leads—oxygen on one, hydrogen on the other. Tell students that they can tell which gas is which by looking at the battery terminals: oxygen collects on the lead connected to the positive terminal. Ask students which lead has more bubbles (the one producing hydrogen) and to explain why. (Each water molecule has two atoms of hydrogen to each atom of oxygen, so twice as much hydrogen is produced.)

Science Extension

- Students can use a chemical reaction to remove one oxygen atom from each molecule of hydrogen peroxide to produce water. Have each team put several rusty nails in a metal can, add hydrogen peroxide to cover the nails, and observe the reaction. Students will see bubbles of oxygen rising to the surface of the hydrogen peroxide, leaving water behind. (Caution: Warn students not to drink the remaining liquid, as it will not be pure water.)

- Do the following activity as a demonstration: Fill a small glass jar halfway with raw ground beef and the rest of the way with hydrogen peroxide. Ask students who are closest to the demonstration area to look closely at the jar and describe what they see (rapid bubbling of the peroxide). Explain that fresh meat contains a catalyst, a substance that speeds up a chemical reaction—in this case, the breakdown of hydrogen peroxide into water and oxygen. Next, light a long candle and let the wick burn for a few seconds, then blow it out and immediately put the glowing wick into the bubbles on the surface of the jar. The wick will burst into flame. Ask students to explain why this happened. (The bubbles contain pure oxygen, which fuels the fire.)

Science and Health

Suggest that students research and report on the digestion of proteins. Protein molecules are long polymer chains that are too large to pass through the wall of the intestines. Digestive enzymes break these molecules into pieces that are small enough to penetrate the intestinal wall and enter the bloodstream.

Science and Language Arts

Encourage students to write skits, poems, or songs about any aspects of atoms, elements, and molecules that they have studied in this activity or the previous one. For example, some students might choose to write and perform a skit about alchemists (see Science and Social Studies below) or a rap song incorporating names of elements.

Science and Social Studies

Students will probably enjoy reading about alchemists in the Middle Ages, particularly their attempts to transform less valuable metals such as lead and iron into gold. Ask students to explain why such a transformation is impossible. Make sure students understand that, although this aspect of alchemy has long been discredited, alchemists' investigations led to new discoveries about matter.