ACTIVITY 5

Atomic Structure

BROWARD COUNTY ELEMENTARY SCIENCE BENCHMARK PLAN

Grade 5—Quarter 1
Activity 5

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 define the word *element.* (An element is a pure substance that cannot be broken down into any other substance.) Ask them if they would be able to see a 100-gram chunk of the element copper. (Yes, most elements can be seen if given a large enough sample.) Tell the class that elements are made of atoms, and atoms are made of even smaller parts that can't be seen. Ask students what we call representations of things we cannot see, but want to study. (These representations are called models.) And, finally, ask them to list the parts of the atomic model they made and how the model was helpful. (After listing the parts of the atomic model, students might say that the model showed how the parts of an atom fit together.)

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 5

Atomic Structure

OBJECTIVES

Students are introduced to the structure of the atom and the nature of subatomic particles.

The students

- explore the properties of protons, neutrons, and electrons
- calculate the number of protons, neutrons, and electrons in an atom, given its atomic number
- interpret information on the periodic table
- construct model atoms
- define *isotope*

SCHEDULE

About 40 minutes

VOCABULARY

atom
electron
element
energy level
isotope
neutron
nucleus
periodic table
proton
subatomic particles

MATERIALS

For each student

1	Activity Sheet 5
1	periodic table chart

For each team of four

6	beads, blue
6	beads, orange
6	beads, yellow
	colored pencils* (optional)
1	pipe cleaner, 40-cm
1	pipe cleaner, 50-cm
1	trough, clear, plastic

For the class

1 roll	fishing line
	illustrations of atoms from textbooks (optional)*
1	poster, Periodic Table of Elements
1	ruler, metric*
1	scissors*
	DSR *Matter and Change*

*provided by the teacher

PREPARATION

1. Make a copy of Activity Sheet 5 for each student. Tear off one copy of the periodic table chart (from the pad of 40) for each student.

2. Cut the fishing line into lengths of 60 cm (about 2 ft) each, two lengths per team.

3. Each team of four will need two lengths of fishing line, two pipe cleaners (one of each length), and six each of the blue, orange, and yellow beads. Place the materials in a trough for easier handling. (In the chemistry laboratory, a "trough" is a pan that holds water into which other objects are placed. The troughs in the kit are used for that purpose as well as for holding activity materials, as here.) Each student will also need a periodic table chart for reference.

4 Look for textbook illustrations of atoms to show the students. Display the poster of the Periodic Table of Elements in the classroom for reference in this and all subsequent activities.

BACKGROUND INFORMATION

Atoms are composed of ***protons, neutrons,*** and ***electrons,*** each of which is uniquely essential to the structure and function of the atom. The core of the atom is the ***nucleus,*** which consists of protons and neutrons. Most of the mass of an atom (about 99.9 percent) is in the nucleus, even though the nucleus occupies only a tiny part of the atom. If the nucleus of an atom were the size of a golf ball, the electrons would be about 2.5 km (1.5 mi) away.

Each proton in the nucleus contains one positive charge. The neutron is roughly the same mass as the proton, but contains no charge. Electrons have a negative charge and are thousands of times less massive than either protons or neutrons. Electrons occupy cloud configurations at several distinct distances from the nucleus, called ***energy levels.*** Each consecutive distance away from the nucleus represents a higher energy level. Although there are many different energy levels, the students will model only the first and second levels in this activity. For your information, electron capacities for the first four levels are listed in Figure 5-1.

Energy Level	Electron Capacity
1	2
2	8
3	18
4	32

▲ *Figure 5-1. Electron capacities for the first four energy levels.*

▼ **Activity Sheet 5**

Atomic Structure

1. Choose an atom from the list on the board. Make a model of this atom. Use one length of fishing line to string together the beads representing the protons and the beads representing the neutrons in the nucleus. Use the pipe cleaners to hold the beads representing the electrons in rings around the nucleus. Connect the model pieces with the other length of fishing line.
2. Fill in the blanks for the atom you built: Answers will vary.

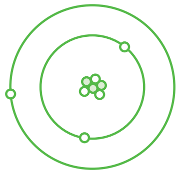
Name of Element ________ Symbol ________
Atomic Number ________ Mass Number ________
Number of Electrons ________ Number of Protons ________

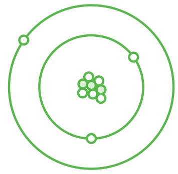
3. Classify the three main subatomic particles according to mass, charge, and location in the atom.

	Mass	Charge	Location
Proton	1	+1	Nucleus
Neutron	1	0	Nucleus
Electron	0	–1	Outside nucleus, in energy levels

4. What is an isotope?
An isotope is an atom of an element with the same atomic number and the same number of protons, but with a different number of neutrons. It has the same charge but a different mass number.

5. Using your model pieces, build an atom of lithium. Now modify your model to represent an isotope of lithium with a mass number of 8. Draw both models in the space below.


lithium –6

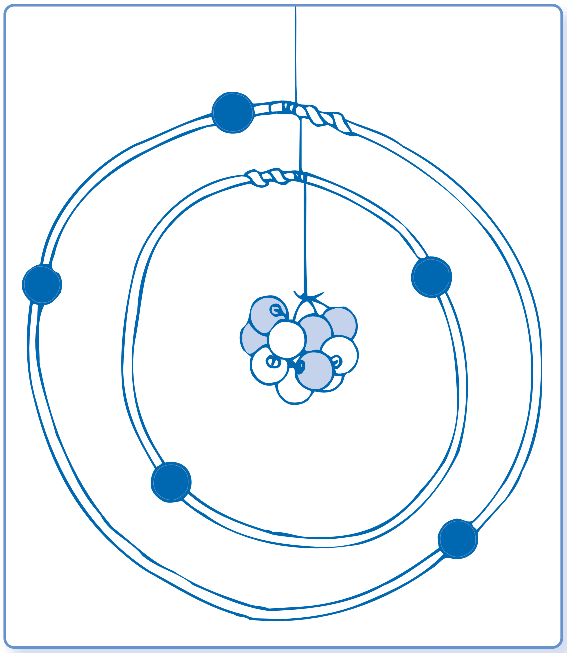

lithium –8

Guiding the Activity

Additional Information

1 A boron atom contains five protons, five neutrons, and five electrons. Demonstrate for the class the modeling of a boron atom, as shown in Figure 5-2. Let the blue beads represent electrons, the orange beads represent neutrons, and the yellow beads, protons.

Note: *You may wish to assemble the boron atom model ahead of time.*



▲ ***Figure 5-2.*** *A model boron atom.*

2 Write the words *element* and *atom* on the board. Tell the students that the model you have just assembled represents one atom of an element called boron. Ask, **What is an element? What is an atom?**

An ***element*** *is a pure substance that cannot be broken down into any other substances. An* ***atom*** *is the smallest particle of an element that has all the properties of the element.*

As appropriate, read or review pages 2–3 of the Delta Science Reader *Matter and Change*.

3 Explain to the students that an atom is composed of three main subatomic particles. Under the word *atom,* write the term *subatomic particles*. Below that, write *protons, neutrons,* and *electrons*. Ask, **What does it mean to say that protons, neutrons, and electrons are all subatomic particles?** If necessary, explain that **subatomic particles** are the smaller parts that make up an atom.

It means that protons, neutrons, and electrons are the building blocks of atoms.

Guiding the Activity

	Additional Information
Write the word *nucleus* on the board. Explain that the **nucleus,** or center, of an atom is composed of protons and neutrons. A **proton** has one positive charge and a mass equal to one mass unit. A **neutron** has no charge, but has a mass that is also equal to 1 mass unit. Ask, **What kind of charge does the nucleus as a whole have?**	*A positive charge.*
Tell the students that the **electrons** are located around the nucleus. Electrons are so tiny that they have almost no mass, and each electron carries one negative charge. Hold up the model atom that you assembled. Ask, **Which colors represent the protons, neutrons, and electrons?**	*Although they will not be able to distinguish the protons from the neutrons, students should be able to figure out that the neutrons and protons are the orange and yellow beads and the electrons are the blue beads. Write the color code of the beads on the board for reference.*
Again, hold up the model. Ask, **How does the number of protons compare with the number of electrons? What can you conclude from this about the total charge of the atom?**	*The number of protons and the number of electrons are equal. Thus, the positive and negative charges balance and the atom is neutral.*
4 Write *energy levels* on the board. Explain that the electrons swirl around an atom at certain average distances from the nucleus. The areas where the electrons travel are called **energy levels.** In this model, energy levels are represented by rings. As the students observe the model, ask, **Why do you think I put two electrons on the inner ring and three on the outer ring?**	*Accept whatever guesses the students may make.*
Explain that only a certain number of electrons can be held in an energy level. The first energy level can hold two electrons. The second energy level can hold up to eight electrons. Ask, **If we wanted to model the element carbon, which has six electrons, how many electrons (beads) would go on the inner ring? How many would go on the outer ring?**	*Students should respond that two electrons would go on the inner ring and four on the outer. Reinforce for the students that the electrons do not orbit around the nucleus like planets around the sun. Rather, they occupy a three-dimensional electron cloud a certain average distance from the nucleus.*

Guiding the Activity

Additional Information

If you have textbook illustrations of atoms, show them to the students now. Have the students note the various subatomic particles and how they are represented.

The pipe cleaners in the models are merely a way to hold the electrons (beads) in place; they do not describe the real positions or movement of the electrons.

5 Write the term *periodic table* on the board and distribute a periodic table chart to each student. Give students time to study it. Ask, **What information does the periodic table give us?**

*The **periodic table** is an orderly listing of all the elements, arranged from left to right and top to bottom in order of increasing atomic number. It shows the atomic number and the mass number of a single atom of each element. It also shows the element's name and symbol.*

Explain to the students that the atomic number of an atom tells the number of protons in the atom. And because, in a neutral atom, the number of protons and the number of electrons are equal, it also tells the number of electrons. The mass number (sometimes called the atomic mass) of the element tells the mass of one atom, which is approximately the sum of the number of protons and neutrons in the nucleus, since each proton and each neutron has a mass equal to one mass unit, and the electrons have virtually no mass.

6 Give each team a trough containing two pipe cleaners (one of each length), six of each color bead (orange, yellow, and blue), and two lengths of fishing line. Distribute a copy of **Activity Sheet 5** to each student.

Write the words *hydrogen, helium, lithium, beryllium, boron,* and *carbon,* on the board. Have each team choose an element from this list to model. Instruct the students to use the periodic table to find the information they need, such as the number of electrons. Have them complete steps 1–3 of the activity sheet.

Students may need to be reminded that the atomic number equals the number of protons (and the number of electrons). For these small atoms, the atomic number equals the number of neutrons as well.

Guiding the Activity

Additional Information

Invite teams to share their models with the class. Have them tell what information they found on the periodic table and describe how they illustrated it in their models.

7 Next, tell the students that two atoms of the same element are not always identical. Remove a neutron from your demonstration model and ask, **Is the charge of the atom affected by this change?**

No. The atom is still neutral because a neutron has no charge.

Tell the students that, although the number of neutrons has changed, the model is still an atom of boron. Explain that atoms with the same number of protons but a different number of neutrons in their nuclei are called **isotopes** of an element. Write the term *isotope* on the board. Ask, **Do two isotopes of the same atom have the same mass?**

No. Because the neutron has mass, the isotope that has more neutrons will have greater mass.

Tell the students to complete the activity sheet. Discuss their answers with them.

8 To wrap up, ask, **What have you learned about the structure of the atom and the nature of subatomic particles from making a model of an atom?**

Students should have learned the following:

1. *Protons and neutrons are in the nucleus, and electrons are outside the nucleus.*
2. *Protons have a mass of 1 and a charge of +1.*
3. *Neutrons have a mass of 1 and no charge.*
4. *Electrons have virtually no mass and a charge of –1.*

Ask, **In what ways are the models you built in this activity different from real atoms?**

Obviously the models are much bigger than real atoms. In the models, the electrons are the same size as the protons and neutrons. In real atoms, electrons are much smaller and much farther away from the nucleus (relatively speaking). Also, electrons do not travel in an orbit but may be a certain distance in any direction from the nucleus.

REINFORCEMENT

Have the students pick from the periodic table an element with an atomic number between 1 and 14 and sketch an atom of that element using colored pens or pencils. Have them show the sketch to another student, who should compare the information in the drawing to that in the periodic table to figure out the identity of the element.

Assessment Opportunity

This Reinforcement also may be used as an ongoing assessment of students' understanding of science concepts and skills.

SCIENCE NOTEBOOKS

Have students write their names on their periodic table charts and place them, along with their completed activity sheets, in their science notebooks.

CLEANUP

Leave the Periodic Table poster on display in the classroom. You may wish to decorate the classroom with the students' "atoms." When finished, put the beads and spool of fishing line back in the kit. The pipe cleaners should be straightened and returned to the kit as well.

SCIENCE AT HOME

Ask students to find three items in their homes that are composed of a pure element. For each item, they should use the periodic table to find out the symbol of the element the item is made of and the number of protons and neutrons in an atom of that element.

Connections

Science Extension

Have cooperative-learning groups research theoretical models of the atom through history, from John Dalton's solid-sphere model (1807), to J. J. Thompson's "plum pudding" model (1903), Ernest Rutherford's nucleus-centered model (1911), Niels Bohr's model (1913), and finally to contemporary refinements. Suggest that students build models to illustrate and compare early theories of atomic structure. Ask volunteers to create a bulletin board time line showing the development of atomic models.

Science and the Arts

Let students use a variety of materials of their own choice to create models of atoms. Encourage students to be imaginative and creative, and suggest that they try to show electrons in different energy levels in a three-dimensional "cloud" around the nucleus. Give students an opportunity to explain their models.

Science and Careers

Make sure students understand that radioactive elements are used to produce X-ray pictures of structures that cannot be observed directly. Invite a medical or industrial radiologist to visit the class and describe his or her work. Ask the visitor to bring X-ray photographs to show and explain to students.

Science and Health

Explain that radon is a colorless, odorless, radioactive gas that occurs naturally in soil and rock as a by-product of the decay of uranium. Suggest that students research the health hazards of radon exposure. (In high concentrations, radon can cause lung cancer.) Encourage students to find out about radon test kits that are available for home use.

Students might enjoy researching the names and percentages of the elements in the human body. Suggest that they also find out the functions of various elements in maintaining good health. Ask volunteers to use this information to create a large poster for classroom display.

Science and Language Arts

If students have difficulty remembering the type of charge associated with each subatomic particle, suggest that they use the following mnemonic device: a **P**roton has a **P**ositive charge; a **NEUTR**on is **NEUTR**al, or has no charge; and an electron has the remaining possibility, a negative charge.

Ask students to find out how the elements got their names and symbols. Many elements were first named in Latin or Greek—thus the symbols Pb for lead and Au for gold, for example. Other elements were named for their discoverers or place of discovery. Still others were named for specific properties such as color.

Science and Social Studies

Ask students to use a dictionary to determine the origin of the word *atom* (from the Greek *atomos,* meaning "indivisible"). Encourage students to research the first application of this term and its later acceptance and use by the scientific community. (The Greek philosopher Democratus reasoned that if bits of matter were broken down into smaller and smaller particles, eventually a point would be reached at which a particle could not be divided any further. Democratus called this indivisible particle an atom. However, it was not until the 1800s that scientists were able to support Democratus' viewpoint.)