Introduction to Atoms

Objectives
After this lesson, students will be able to
K.3.1.1 Describe the structure of an atom.
K.3.1.2 Describe elements in terms of their atoms.
K.3.1.3 Explain how models are useful for understanding atoms.

Target Reading Skill
Previewing Visuals Explain that looking at the visuals before they read helps students activate prior knowledge and predict what they are about to read.

Answers
Sample questions and answers:
What particles are in the center of an atom? (Protons and neutrons)
What particles move around the outside of the nucleus? (Electrons)

Teaching Resources
• Transparency K20

Preteach
Build Background Knowledge
Parts Make Up the Whole Distribute hand lenses and sections from the Sunday newspaper comics. Have students examine the comics with the hand lenses and describe what they see. Ask: How do the Sunday comics compare to the painting in Figure 1? (Both are made up of tiny dots of color.) Explain that like these images, matter is made of tiny parts called atoms.

Reading Preview
Key Concepts
• What is the structure of an atom?
• How are elements described in terms of their atoms?
• Why are models useful for understanding atoms?

Key Terms
• nucleus • proton
• neutron • electron
• atomic number • isotope
• mass number • model

Target Reading Skill
Previewing Visuals Before you read, preview Figure 2. Then write two questions you have about the diagram in a graphic organizer like the one below. As you read, answer your questions.

Structure of an Atom

Q. What particles are in the center of an atom?
A.

Think It Over
Infering Make a sketch showing what you think the object looks like. Tell how you inferred the properties of the object from indirect observations.

Discover Activity
What’s in the Box?
1. Your teacher will give you a sealed box that contains an object. Without opening the box, move the box around to find out as much as you can about the object.
2. Make a list of your observations about the object. For example, does the object slide or roll? Is it heavy or light? Is it soft or hard? Is the object round or flat?
3. Think about familiar objects that could give you clues about what’s inside the box.

Think It Over
Inferring Make a sketch showing what you think the object looks like. Tell how you inferred the properties of the object from indirect observations.

Skills Focus
Inferring
Materials
tape, shoe box, an object such as a pencil, empty soda can, sock, marble, or sponge
Time 10 minutes
Tips Have students bring shoe boxes from home. Place a different object in each shoebox and securely tape it closed. Emphasize that students are making indirect observations and may not draw precise conclusions.

Think It Over
Students’ sketches should be consistent with their observations, but may not be correct. Students should explain how their indirect observations led them to identify certain properties of the object. For example, a round object will roll and a soft object will make less sound when hitting the sides of the box.

Glance at the painting below and you see people enjoying an afternoon in the park. Now look closely at the circled detail of the painting. There you'll discover that the artist used thousands of small spots of color to create these images of people and the park.

Are you surprised that such a rich painting can be created from lots of small spots? Matter is like that, too. The properties of matter that you can observe result from the properties of tiny objects that you cannot see. As you learned in Chapter 1, the tiny objects that make up all matter are atoms.

FIGURE 1
Sunday Afternoon on the Island of La Grande Jatte
This painting by artist Georges Seurat, which is made from tiny dots of paint, gives you a simple model for thinking about how matter is made of atoms.
Structure of an Atom

If you could look into a single atom, what might you see? Figuring out what atoms are made of hasn’t been easy. Theories about their shape and structure have changed many times and continue to be improved even now. Until about 100 years ago, scientists thought atoms were the smallest particles of matter. Now, scientists know more. Atoms are made of even smaller particles called protons, neutrons, and electrons.

Understanding the structure of atoms will help you understand the properties of matter.

Particles in Atoms An atom consists of a nucleus surrounded by one or more electrons. The nucleus (núk sheez) (plural nuclei) is the very small center core of an atom. The nucleus is a group of smaller particles called protons and neutrons. Protons have a positive electric charge (indicated by a plus symbol, +). Neutrons have no charge. They are neutral. The third type of particle in an atom moves in the space outside the nucleus. Electrons move rapidly around the nucleus and have a negative electric charge. An electron is shown by the symbol e–.

Look at the model of a carbon atom in Figure 2. If you count the number of protons and electrons, you’ll see there are six of each. In an atom, the number of protons equals the number of electrons. As a result, the positive charge from the protons equals the negative charge from the electrons. The charges balance, making the atom neutral.

What kind of charge does a proton have?

Parts of an Atom

Focus Explain that all matter is made up of small particles called atoms.

Teach Diagram an atom on the board. Label the nucleus and electron cloud. Ask: What particles of an atom are found in the nucleus? (Protons and neutrons) Where are electrons found? (In a cloud around the nucleus) Add the symbols for the particles.

Apply Point out that protons have a positive electric charge, electrons are negative, and neutrons are neutral. Ask: Why is the carbon atom in Figure 2 neutral? (The equal number of protons and electrons causes the positive and negative charges to cancel each other out.) Learning modality: visual

Teach Key Concepts

Parts of an Atom

Teach Key Concepts

1. **Protons** Have a positive electric charge. Positively charged

2. **Neutrons** Have no charge.

3. **Electrons** Have a negative electric charge.

Monitor Progress

Independent Practice

Differentiated Instruction

English Learners/Beginning Vocabulary: Link to Visual: Point to each label in Figure 2 and pronounce each word, including atom. Invite students to repeat each word. Give students cards with one word from the diagram on each. Cover the words in the diagram and have students match the word cards to the diagram. Correct pronunciations as needed.

Learning modality: visual

English Learners/Intermediate Vocabulary: Link to Visual: Have students do the activity described at left without word cards. Also, add the words positive charge, negative charge, and no charge and have students match the particle to its charge.

Learning modality: visual

Monitor Progress

Independent Practice

Teaching Resources

Transparency K21

Help Students Read

Vocabulary: Word Origin Explain that atom comes from the Greek word atomos, meaning "indivisible." Ask: How is being indivisible related to the smallest unit of matter? (The atom is the smallest particle that matter can be broken into.)

Go Online


Students can review atoms in an online activity.

Go Online


Students can save their diagrams in their portfolios.

Answers

Figure 2 None; neutrons have no charge.

A proton has a positive charge.
Modeling Atomic Structure

Materials apron, beads in two colors, glue, disposable gloves, newspapers, large sheet of plain paper, tape, old toothbrush, watercolor paint

Time 15 minutes

Focus Ask: Can you see an atom? (No, atoms are too small.) Why is it useful to model an atom? (Sample answer: To learn about its structure and properties)

Teach Students can choose different-colored beads for the protons and neutrons. Have students glue these in the center of the paper for the nucleus. Students may choose as many protons and neutrons as they wish. Students can model the electron cloud by dipping the toothbrush in paint and flicking the bristles over the top of the paper in a large circle around the nucleus. (Tape newspapers to the work surface.)

Apply Ask: If your atom is neutral, how many electrons does it have? (The same number as the number of protons) Why are the electrons shown as a cloud? (The electrons move all the time and may be anywhere within the space shown by the cloud.) Learning modality: kinesthetic

Making Analogies About Atomic Parts

Time 15 minutes

Focus Tell students that an analogy makes an abstract idea easier to understand.

Teach Ask: Which is easier to understand—the mass of an elephant compared to the mass of a cat or saying that a proton has 2,000 times more mass than an electron? (The elephant and the cat) Explain that, like the proton, the elephant (about 8,000 kg) has 2,000 times more mass than the cat (about 4 kg). Challenge student groups to develop their own analogies.

Apply Ask: Does your analogy also reflect the larger volume held by the electrons? (In most student analogies, the larger mass will also have the larger volume.) Challenge students to develop an analogy to compare the volumes of the nucleus and electron cloud. Learning modality: logical/mathematical

Models of Atoms

For over two centuries, scientists have created models of atoms in an effort to understand why matter behaves as it does. As scientists have learned more, the model of the atom has changed.

1808 Dalton Model
British chemist John Dalton concluded that each element is made of atoms that are all alike. He also thought that different elements have atoms of different mass. Dalton imagined atoms as tiny, solid balls.

1897 Thomson Model
British scientist J.J. Thomson discovered the electron. He later proposed a new model, suggesting that an atom is a positively charged sphere with electrons embedded in it. His model could be described as looking like a muffin with berries or raisins scattered through it.

1904 Nagaoka Model
Japanese physicist Hantaro Nagaoka proposed a model of the atom that had a large sphere in the center with a positive charge. His model showed the electrons revolving around this sphere like the planets around the sun.

A Cloud of Electrons
Electrons move within a sphere-shaped region surrounding the nucleus. Scientists depict this region as a cloud of negative charge because electrons may be anywhere within it. Electrons with lower energy usually move in the space near the atom’s nucleus. Electrons with higher energy move within the space farther from the nucleus.

Most of an atom’s volume is the space in which electrons move. That space is huge compared to the space taken up by the nucleus. To picture the difference, imagine holding a pencil while standing at the pitcher’s mound in a baseball stadium. If the nucleus were the size of the pencil’s eraser, the electrons could be as far away as the top row of seats!

Background
Facts and Figures Chemistry books often show electrons as they are in Bohr’s atomic model, because the grouping of electrons in orbital shells helps explain the reactivity of atoms. It is the electrons in the outer shell of the atom that are gained, lost, or shared when an atom of one element reacts with the atom of another element. Using the Bohr model helps chemists describe the formation of chemical bonds.

The current atomic model is very similar to the one proposed in the 1920s. The refinements of the model have affected the structure of the nucleus. Subatomic particles, called quarks, make up protons and neutrons. The force that holds these subatomic particles together comes from other particles called gluons.
Focus Tell students that the first atomic model was proposed almost 200 years ago. A few years before this, in 1806, Lewis and Clark returned from exploring the Louisiana Territory. Also point out that the existence of neutrons was not discovered until the era of the Great Depression, a few years before World War II.

Teach Invite students to compare and contrast the atomic models diagrammed in the timeline. Ask: What was one of the first theories about atomic structure that has stood the test of time? (Sample answer: The positive charge is located in the center of the atom.)

Writing in Science Research and Write Find out more about one of the scientists who worked on models of the atom. Write an imaginary interview with this person in which you discuss his work with him.

Writing in Science Writing Mode Research Scoring Rubric

4 Exceeds criteria; includes a lively and imaginative interview with insightful questions and accurate and complete answers that reflect the life of the scientist

3 Meets criteria

2 Includes only brief but accurate information

1 Includes some incorrect and/or incomplete information

Science and History

1925 1950 1975 2000

Comparing Particle Masses Although electrons occupy most of an atom’s volume, they don’t account for much of its mass. It takes almost 2,000 electrons to equal the mass of just one proton. On the other hand, a proton and a neutron are about equal in mass. Together, the protons and neutrons make up nearly all the mass of an atom.

Atoms are too small to be measured in everyday units of mass, such as grams or kilograms. Instead, scientists use units known as atomic mass units (amu). A proton or a neutron has a mass equal to about one amu. The mass of an electron is about 1/2,000 amu.

Differentiated Instruction Special Needs Classifying Atomic Particles Give students two types of balls that differ in mass but are similar in size, such as marbles and foam balls. Invite students to choose a ball to represent a proton. Repeat for a neutron and an electron. (The heavier balls would be protons and neutrons; lighter ones, electrons.) learning modality: kinesthetic

Gifted and Talented Researching Quarks Tell students that protons and neutrons are made up of even smaller particles called quarks. Encourage students to use Internet sources to find out about these subatomic particles. Students can prepare a poster to share what they learned with the class. learning modality: logical/mathematical

Monitor Progress Skills Check Have students develop a table in which they compare and contrast the mass and volume of protons, neutrons, and electrons.
Atoms and Elements

Teach Key Concepts

Atoms Are Specific to Elements

Focus Remind students that an element is a pure substance.

Teach Explain that each element is made of atoms that are different from the atoms of other elements. Ask: How do atoms of one element differ from those of another element? (In their number of protons)

Diagram the atomic nuclei of three different elements. Have students count the number of protons in each. Explain that the number of protons is the element’s atomic number.

Apply Ask: What does mass number equal? (The sum of protons and neutrons)

Address Misconceptions

Many Different Particles

Focus Students may confuse the particles that make up elements and the particles that make up atoms.

Teach Remind students that elements are a kind of matter. Ask: What are the particles that make up elements and compounds? (Atoms) Point out that an atom is the smallest particle of an element. Ask: What particles make up an atom? (Protons, neutrons, and electrons)

Apply Ask: What would happen if protons were added to an atom? (The atom becomes a different element.)

Learning modality: verbal

Modeling Atoms

Teach Key Concepts

Usefulness of Scientific Models

Focus Ask: How can you guess what is inside a sealed box? (Sample answer: By making observations that don’t depend on seeing what’s inside the box)

Teach Ask: Why is it difficult for scientists to study atoms? (Atoms are too small to be seen, even by powerful microscopes.) Why is it helpful for scientists to use models to study atoms? (Scientists make predictions and test the models to see if the atoms behave as predicted.)

Apply Ask: Once scientists develop a model, can they change it? (Yes, as they get more observations from testing)

Learning modality: verbal

Atoms and Elements

Each element consists of atoms that differ from the atoms of all other elements. An element can be identified by the number of protons in the nucleus of its atoms.

Atomic Number Every atom of an element has the same number of protons. For example, the nucleus of every carbon atom contains 6 protons. Every oxygen atom has 8 protons, and every iron atom has 26 protons. Each element has a unique atomic number—the number of protons in its nucleus. Carbon’s atomic number is 6, oxygen’s is 8, and iron’s is 26.

Isotopes Although all atoms of an element have the same number of protons, their number of neutrons can vary. Atoms with the same number of protons and a different number of neutrons are called isotopes (eye suh talp). Three isotopes of carbon are illustrated in Figure 3. Each carbon atom has 6 protons, but you can see that the number of neutrons is 6, 7, or 8. An isotope is identified by its mass number, which is the sum of the protons and neutrons in the nucleus of an atom. The most common isotope of carbon has a mass number of 12 (6 protons + 6 neutrons) and may be written as “carbon-12.” Two other isotopes are carbon-13 and carbon-14. As shown in Figure 3, a symbol with the mass number above and the atomic number below may also be used to represent an isotope. Although these carbon atoms have different mass numbers, all carbon atoms react the same way chemically.
Modeling Atoms

Atoms are too small to be seen. Each element has a unique atomic number because all of the atoms of that element have the same number of protons. Each atom of nitrogen-15 contains 7 protons, 8 neutrons, and 7 electrons. 3. a. Atoms are too small to be seen. b. To describe the structure of atoms and explain how matter behaves

Monitor Progress

Answers

Figure 3 Carbon-14

Reading Checkpoint

Sample answer: When objects or events are too small, too large, too slow, too fast, too dangerous, or too far away to see.

Assess

Reviewing Key Concepts

1. a. Protons, neutrons, and electrons b. Proton—positive charge; neutron—no charge; electron—negative charge. c. Each atom has equal numbers of positively charged protons and negatively charged electrons.

2. a. The number of protons in each atom of that element. b. Each element has a unique atomic number because all atoms of that element have the same number of protons. c. Each atom of nitrogen-15 contains 7 protons, 8 neutrons, and 7 electrons.

3. a. Atoms are too small to be seen. b. To describe the structure of atoms and explain how matter behaves

Reteach

Help students draw a concept map that shows elements as types of matter and the atom as the smallest particle of an element. Also show that atoms are composed of protons and neutrons in a nucleus with electrons in an electron cloud.

Performance Assessment

Writing Have students write a description of the model used to describe atoms. Also have them describe why scientists use this model.

Teaching Resources

- Section Summary: Introduction to Atoms
- Review and Reinforce: Introduction to Atoms
- Enrich: Introduction to Atoms