Unit: Unit 2: Atomic Structure and Bonding

Chapter: Chapter 3: Unlocking the Atom

Lesson: Lesson 1: The Evolution of Atomic Models and Structure

# Atomic Structure and Bonding

## Unlocking the Atom

### The Evolution of Atomic Models and Structure

#### Essential Questions:

**1. How did scientists' understanding of the atom change over time?**

**2. What evidence led to the development of different atomic models?**

**3. Why are atomic models important for understanding the nature of matter?**

#### 1. Big Idea:

The journey of atomic discovery shows how scientific models evolve as new evidence is gathered.

#### 2. Essential Questions:

**- What are the key discoveries that shaped our current understanding of the atom?**

**- How do atomic models help explain the behavior of matter at the smallest scale?**

#### 3. Phenomenon-Based Learning:

This lesson will explore the evolution of atomic models by guiding students through key historical discoveries in atomic theory. We will focus on how these discoveries changed our understanding of matter and its composition.

**Phenomenon:**

Imagine a time when scientists believed that atoms were indivisible. Then, new experiments showed that atoms could be broken down into smaller parts. This discovery changed the way scientists thought about the world.

#### 4. Vocabulary:

**- Atom: The smallest unit of an element that retains its chemical properties.**

**- Electron: A negatively charged particle found outside the nucleus of an atom.**

**- Nucleus: The central part of an atom, containing protons and neutrons.**

**- Proton: A positively charged particle in the nucleus of an atom.**

**- Neutron: A neutral particle in the nucleus of an atom.**

**- Atomic Model: A representation or theory of the structure of an atom based on scientific evidence.**

**- Quantum Mechanics: A branch of physics that explains the behavior of particles at the atomic and subatomic levels.**

#### 5. SMART Objectives:

**1. Identify key scientists and their contributions to the development of atomic models within 30 minutes of the lesson.**

**2. Explain how experimental evidence led to changes in atomic models over time, by the end of the lesson.**

**3. Compare and contrast different atomic models (Dalton, Thomson, Rutherford, Bohr, Quantum Model) through group discussions within 45 minutes.**

**4. Predict the behavior of atoms based on the current atomic model within a 30-minute quiz at the end of the lesson.**

#### 6. Engage (Ignite):

**Phenomenon-Related Question:**

What if an atom is not the smallest particle of matter? Can it be divided further?

**Hands-On Experiment:**

**Activity: "Seeing the Invisible"**

Materials: A balloon, a magnet, iron filings, and a plastic sheet.

**Procedure:**

1. 1. Blow up the balloon and rub it on your hair to give it a static charge.
2. 2. Place the plastic sheet on a table and scatter the iron filings over it.
3. 3. Slowly bring the charged balloon close to the iron filings and observe what happens.

**Follow-Up Questions:**

**1. What causes the iron filings to move?**

**2. How might this experiment relate to the presence of invisible particles, like electrons?**

**3. How could this phenomenon help scientists discover new things about atoms?**

#### 7. Pre-Explore (Direct Instruction):

**Background Information:**

The concept of the atom dates back to ancient Greece. The philosopher Democritus proposed that matter was made of indivisible particles called "atoms." However, it wasn't until thousands of years later that scientists began to gather evidence for the existence of atoms and their internal structure.

In this lesson, we will explore the evolution of atomic models—from Dalton's solid sphere model to the modern quantum mechanical model.

**Interactive Elements:**

**- Group Discussion: Discuss what you think an atom looks like based on your current knowledge.**

**- Scaffolded Question: How do you think scientists discover things that are too small to see?**

#### 8. Evaluate (Progress Check) - Pre-Explore:

**1. What was Democritus's early idea of the atom? (DOK 1)**

**2. How did Dalton's atomic theory build on this idea? (DOK 2)**

**3. Why do you think scientists needed to change their models of the atom? (DOK 3)**

#### 9. Explore (Pathfinder):

**Hands-On Activity: "Building Atomic Models"**

**Objective: To create models of different atomic theories to show how they have changed over time.**

**Materials: Clay, marbles, toothpicks, small magnets, and string.**

**Procedure:**

**1. Dalton's Model: Use clay to make solid spheres representing atoms.**

**2. Thomson's Model: Stick small marbles (representing electrons) into a larger clay sphere (representing the atom) to mimic the "plum pudding" model.**

**3. Rutherford's Model: Create a central nucleus using a large marble and place smaller marbles (electrons) at a distance around it.**

**4. Bohr's Model: Use string to represent electron orbits around a nucleus made of clay.**

**5. Quantum Model: Use small magnets to represent the unpredictable locations of electrons around a nucleus.**

**Group Discussion:**

* - Compare the different models your group created.
* - How did each model improve upon the one before it?
* - What did each model fail to explain?

**Retrieval Practice:**

* - Use a quiz with true/false and multiple-choice questions to reinforce the key ideas of each atomic model.

#### 10. Explain (Lightbulb):

(Approximately 4500 words)

**The Journey of Atomic Discovery**

In this section, we will explore how the atomic model has changed over time, starting with Dalton and moving through to the modern quantum mechanical model. Each model was shaped by new discoveries and experiments, showing how science builds upon previous knowledge.

#### \*\*1. Dalton’s Atomic Theory (1803)\*\*

Dalton proposed that all matter is made of small, indivisible particles called atoms. He believed that atoms of the same element are identical, and that chemical reactions involve the rearrangement of these atoms. However, Dalton's model couldn't explain why some substances conducted electricity or why atoms emitted radiation.

**Sample Problem:**

If Dalton’s theory is correct, what would happen if we mixed 10 grams of hydrogen with 10 grams of oxygen? Would they react in any way to form a new substance?

**Student Progress Check:**

Based on Dalton’s theory, explain why atoms of different elements combine in specific ratios.

#### \*\*2. Thomson’s “Plum Pudding” Model (1897)\*\*

In 1897, J.J. Thomson discovered the electron. He proposed that atoms were like “plum pudding,” where negatively charged electrons were scattered within a positively charged "soup." Thomson’s model explained the presence of electrons but didn't account for the atom's overall structure.

**Sample Problem:**

According to Thomson’s model, what would happen if you applied an electric field to an atom? How would the electrons behave?

**Student Progress Check:**

What evidence did Thomson use to propose his atomic model?

#### \*\*3. Rutherford’s Nuclear Model (1911)\*\*

Ernest Rutherford’s famous gold foil experiment revealed that atoms have a small, dense nucleus at their center, surrounded by empty space. This experiment showed that most of the atom's mass is concentrated in a tiny nucleus, contradicting Thomson’s model.

**Sample Problem:**

How did Rutherford’s gold foil experiment lead to the discovery of the nucleus? Why was this a groundbreaking discovery?

**Student Progress Check:**

Explain how Rutherford’s experiment challenged Thomson’s model of the atom.

#### \*\*4. Bohr’s Model (1913)\*\*

Niels Bohr expanded on Rutherford’s model by proposing that electrons move in fixed orbits around the nucleus. This model explained the emission of light from atoms and why electrons don’t spiral into the nucleus.

**Sample Problem:**

How does Bohr’s model explain the behavior of electrons in different energy levels?

**Student Progress Check:**

Why did Bohr believe that electrons move in specific orbits?

#### \*\*5. The Quantum Mechanical Model (1926-Present)\*\*

The modern atomic model is based on quantum mechanics. Electrons no longer orbit the nucleus in fixed paths but exist in regions called electron clouds. This model explains the behavior of electrons at the atomic level more accurately than Bohr’s model.

**Sample Problem:**

How does the quantum mechanical model explain the uncertainty in an electron’s position?

**Student Progress Check:**

How does the quantum mechanical model differ from Bohr’s model of the atom?

#### 11. Evaluate (Progress Check) - Explain:

**1. What did Rutherford’s experiment reveal about the structure of the atom? (DOK 1)**

**2. How did Bohr’s model improve upon Rutherford’s model? (DOK 2)**

**3. What is the main difference between Bohr’s model and the quantum mechanical model? (DOK 3)**

#### 12. Elaborate (Power Up):

**Mini-Tasks:**

1. 1. Create a timeline of the evolution of atomic models, highlighting the key discoveries and experiments that led to changes in the model.
2. 2. Write a paragraph explaining how the discovery of the electron changed scientists' understanding of the atom.

**Open-Ended Question:**

Why do you think it took so long for scientists to develop the quantum mechanical model of the atom, even after the discovery of electrons and the nucleus?

#### 13. Final Evaluation:

**Debate Question:**

Do you think our current atomic model is the final and complete understanding of the atom? Why or why not?

**Assessment Questions:**

**Multiple-Choice Questions:**

1. 1. Who discovered the electron?

* - a) Dalton
* - b) Thomson
* - c) Rutherford
* - d) Bohr

**- Correct Answer: b**

1. 2. What did Rutherford’s gold foil experiment demonstrate?

* - a) Atoms are indivisible.
* - b) Electrons surround the nucleus.
* - c) Atoms have a dense nucleus.
* - d) Electrons move in circular orbits.

**- Correct Answer: c**

1. 3. According to Bohr’s model, how do electrons move?

* - a) In random paths
* - b) In fixed orbits
* - c) In electron clouds
* - d) In straight lines

**- Correct Answer: b**

1. 4. Which model of the atom is based on probabilities rather than fixed orbits?

* - a) Dalton’s model
* - b) Thomson’s model
* - c) Bohr’s model
* - d) Quantum mechanical model

**- Correct Answer: d**

**Long-Answer Questions:**

1. 1. Explain how Thomson’s discovery of the electron changed the atomic model.
2. 2. Describe Rutherford’s gold foil experiment and how it led to the discovery of the nucleus.
3. 3. Compare and contrast Bohr’s atomic model with the quantum mechanical model.
4. 4. How did the discovery of the neutron change the understanding of atomic structure?

#### 14. Extend (Beyond the Lesson) [Optional]:

**Additional Task:**

Research how modern technology, such as electron microscopes, allows scientists to visualize atoms and their behavior. How do these technologies build upon the atomic models discussed in class?

**Spaced Practice:**

In upcoming lessons, we will explore how the atomic model helps explain chemical bonding and the behavior of elements in the periodic table. Review your notes on atomic structure, as this will be important for understanding future lessons on chemical reactions and bonding.

This lesson allows us to see how scientific knowledge grows and evolves over time as new evidence is discovered.