# Unit: Unit 2: Atomic Structure and Bonding

## Chapter: Chapter 3: Unlocking the Atom

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

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### Essential Question:   
- \*\*How have discoveries over time influenced our current understanding of atomic structure?\*\*  
  
### 1. Big Idea:   
- \*Atoms are the building blocks of all matter, and our understanding of their structure has evolved over time through the contributions of many scientists.\*  
  
### 2. Essential Questions:   
- How have discoveries over time influenced our current understanding of atomic structure?   
- How did different atomic models contribute to the current view of the atom?   
  
### 3. Phenomenon-Based Learning   
\*\*Chapter 3 Phenomenon:\*\* \*Is Salting the Road a Magic Trick?\*   
In cold northern countries, ice and snow can cause dangerous conditions on roads. To make roads safer, salt is spread on icy streets, causing the ice to magically vanish. But what is really happening? The answer lies at the atomic level. Understanding the structure of atoms can help explain how different substances like salt and water interact. This lesson will take students through the history of atomic theory and help them understand how our current model of the atom can explain such phenomena.  
  
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### 4. Vocabulary:   
- \*\*Bohr\*\*: A scientist who developed a model of the atom with electrons in specific orbits around the nucleus.  
- \*\*Dalton\*\*: Proposed the first modern atomic theory, stating that matter is made of indivisible atoms.  
- \*\*Democritus\*\*: An ancient Greek philosopher who first suggested that matter is made up of tiny particles called atoms.  
- \*\*Electrons\*\*: Negatively charged particles that orbit the nucleus of an atom.  
- \*\*Nuclear Model\*\*: Rutherford’s model of the atom, which introduced the idea of a dense central nucleus.  
- \*\*Neutrons\*\*: Neutral particles found in the nucleus of an atom.  
- \*\*Plum-pudding model\*\*: Thomson’s model of the atom, which suggested that electrons were scattered throughout a positively charged substance.  
- \*\*Protons\*\*: Positively charged particles found in the nucleus of an atom.  
- \*\*Rutherford\*\*: A scientist who discovered the nucleus and proposed the nuclear model of the atom.  
- \*\*Schrodinger\*\*: Developed the quantum mechanical model of the atom, where electrons are described as being in probability zones rather than fixed orbits.  
- \*\*Thomson\*\*: Discovered the electron and proposed the plum-pudding model of the atom.  
- \*\*Quantum mechanical model\*\*: The modern atomic model, which describes electrons in terms of probability clouds rather than fixed orbits.  
  
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### 5. SMART Objectives:   
By the end of this lesson, students will be able to:   
1. Name key scientists (Democritus, Dalton, Thomson, Rutherford, Bohr, Schrodinger) who contributed to the development of atomic theory.   
2. Trace the evolution of atomic models from the plum-pudding model to the quantum mechanical model.   
3. Compare and contrast the contributions of different scientists to the understanding of atomic structure.   
4. Explain how changes in the atomic model have helped us better understand the nature of matter.   
  
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### 6. Engage (Ignite):   
\*\*Phenomenon-Related Question:\*\*   
- Have you ever wondered why salt makes ice disappear on roads during winter? What if we told you that the answer lies in the tiny particles called atoms?   
  
\*\*Hands-On Experiment:\*\*   
\*Objective\*: To visualize the idea of atoms and how something invisible can have a real effect on the world around us.   
  
\*\*Materials\*\*:   
- Two glasses of water   
- Table salt   
- A spoon   
- Ice cubes   
  
\*\*Procedure\*\*:   
1. Fill one glass with water and add a spoonful of salt. Stir to dissolve it.   
2. Add ice cubes to both glasses (one with saltwater and one with plain water).   
3. Observe what happens to the ice in both glasses over 10-15 minutes.   
  
\*\*Follow-Up Questions\*\*:   
1. What happened to the ice in the glass with saltwater?   
2. Why do you think the salt caused the ice to melt faster?   
3. How do you think the structure of salt and water at the atomic level caused this reaction?   
  
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### 7. Pre-Explore (Direct Instruction):   
\*\*Background Information:\*\*   
Before we can understand how salt causes ice to melt, we need to understand the basic building blocks of all matter: atoms. The way we think about atoms today has changed a lot over the centuries, thanks to the discoveries of many scientists. Let's take a journey through history to see how our understanding of the atom has evolved.   
  
- \*\*Democritus (460 – 370 BCE)\*\*: Democritus was one of the first people to suggest that matter is made of tiny particles called atoms. He believed that atoms were indivisible and indestructible. However, his ideas were mostly philosophical and lacked experimental evidence.   
  
- \*\*John Dalton (1803)\*\*: Dalton was the first to propose a scientific atomic theory. He suggested that:   
 1. All matter is made of atoms, which are indivisible and indestructible.   
 2. All atoms of a given element are identical in mass and properties.   
 3. Atoms of different elements can combine to form compounds.   
 4. Chemical reactions involve the rearrangement of atoms, but atoms themselves are not changed.   
  
- \*\*J.J. Thomson (1897)\*\*: Thomson discovered the electron, a negatively charged particle smaller than the atom itself. This led him to propose the "plum-pudding model" of the atom, where electrons were scattered throughout a positively charged substance, much like plums in a pudding.   
  
- \*\*Ernest Rutherford (1911)\*\*: Rutherford conducted the famous gold foil experiment, where he shot particles at a thin sheet of gold. Most particles passed through, but some were deflected. This led him to propose the "nuclear model" of the atom, where a small, dense nucleus is at the center, with electrons orbiting around it.   
  
- \*\*Niels Bohr (1913)\*\*: Bohr introduced the idea that electrons orbit the nucleus in specific energy levels or shells. This model explained why atoms only emit light at certain wavelengths.   
  
- \*\*Erwin Schrodinger (1926)\*\*: Schrodinger developed the quantum mechanical model of the atom. In this model, electrons are not in fixed orbits but are found in probability zones called "orbitals." This model is the one we use today to describe atoms.   
  
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### 8. Evaluate (Progress Check) - Pre-Explore:   
1. What was Democritus' main idea about matter?   
2. How did Dalton’s atomic theory differ from Democritus' ideas?   
3. Why was Rutherford’s gold foil experiment important in understanding the structure of the atom?   
  
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### 9. Explain (Lightbulb):   
#### The Evolution of Atomic Models   
Our understanding of the atom has changed many times over the years. Let’s break down each model in more detail and see how each scientist contributed to what we know today.  
  
1. \*\*Democritus and Dalton’s Model of the Atom\*\*   
 Democritus believed that if you kept cutting matter into smaller and smaller pieces, you would eventually reach something that could not be divided any further. He called these pieces “atomos,” which means "indivisible" in Greek. Hundreds of years later, John Dalton took this idea and developed the first scientific atomic theory. He proposed that atoms were tiny, solid spheres that could not be split. Dalton’s model was simple but provided a foundation for future scientists to build on.   
   
 \*\*Progress Check:\*\*   
 - How did Dalton’s theory support Democritus’ idea of indivisible atoms?   
  
2. \*\*Thomson’s Plum-Pudding Model\*\*   
 In 1897, J.J. Thomson discovered the electron, which proved that atoms were not indivisible after all. He proposed a new model of the atom called the "plum-pudding model." In this model, he thought that negatively charged electrons were scattered throughout a positively charged substance, like plums in a pudding. This was the first time scientists realized that atoms had smaller parts inside them.   
   
 \*\*Progress Check:\*\*   
 - What major discovery did Thomson make, and how did it change the way scientists viewed atoms?   
  
3. \*\*Rutherford’s Nuclear Model\*\*   
 Ernest Rutherford’s gold foil experiment in 1911 changed the atomic model again. When Rutherford shot particles at a thin sheet of gold foil, most passed through, but some bounced back. This was surprising because it suggested that atoms were mostly empty space, with a small, dense, positively charged nucleus at the center. Rutherford’s nuclear model showed that electrons orbit this nucleus, rather than being scattered randomly.   
   
 \*\*Progress Check:\*\*   
 - How did Rutherford’s model change from Thomson’s plum-pudding model?   
  
4. \*\*Bohr’s Planetary Model\*\*   
 Niels Bohr improved upon Rutherford’s model by suggesting that electrons move in specific orbits or energy levels around the nucleus. These orbits are like the paths of planets around the sun, which is why this is sometimes called the "planetary model." Bohr’s model helped explain why atoms emit light in specific colors or wavelengths.   
   
 \*\*Progress Check:\*\*   
 - How did Bohr’s model explain the behavior of electrons better than Rutherford’s model?   
  
5. \*\*Schrodinger’s Quantum Mechanical Model\*\*   
 Finally, Schrodinger developed the modern view of the atom, known as the "quantum mechanical model." In this model, electrons do not follow fixed paths but are found in areas of probability called orbitals. This model is based on complex mathematics, but it gives us the most accurate picture of the atom.   
  
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### 10. Extend (Deepen Understanding):   
- \*\*Sample Problem:\*\*   
 - If you were to compare Dalton’s model of the atom to Rutherford’s, what would be the main differences?   
  
- \*\*Student Problem:\*\*   
 - Create a timeline of atomic model discoveries and describe the changes in each model.   
  
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### 11. Evaluate (Progress Check):   
- How did the discovery of the electron change the way scientists viewed the atom?   
- Why was Rutherford’s discovery of the nucleus important for understanding atomic structure?   
- How does the quantum mechanical model differ from Bohr’s planetary model?   
  
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### 12. Closure:   
Understanding the structure of atoms has come a long way, from Democritus’ indivisible particles to the quantum mechanical model we use today. Each new discovery built upon the work of earlier scientists, leading to the detailed and complex model we use now. By understanding how atoms work, we can explain many phenomena, like why salt melts ice on the roads. It all starts with the tiny particles called atoms.   
  
### Summary of Key Concepts:   
1. Atoms are the building blocks of all matter.   
2. The atomic model has evolved over time, thanks to the work of many scientists.   
3. The quantum mechanical model is the most accurate model of the atom we have today.   
  
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This lesson plan provides a structured and engaging way to guide students through the history of atomic models and their importance in understanding the nature of matter. With hands-on activities, scaffolded questions, and clear explanations, students will gain a deeper understanding of how science builds upon itself to improve our understanding of the world.  
  
### 10. Evaluate (Progress Check) - Explain  
  
To ensure students understand the key concepts covered in this section, here are three scaffolded questions, progressing in difficulty:  
  
\*\*(DOK 1 - Recall)\*\*   
1. \*\*What is an atom?\*\*   
 \_(This checks basic recall of the definition of an atom.)\_  
  
\*\*(DOK 2 - Skill/Concept)\*\*   
2. \*\*How do protons, neutrons, and electrons differ in terms of charge and location in an atom?\*\*   
 \_(This requires students to distinguish between subatomic particles based on their properties.)\_  
  
\*\*(DOK 3 - Strategic Thinking)\*\*   
3. \*\*Explain why the number of protons determines the element, but not the number of neutrons or electrons.\*\*   
 \_(This question asks students to apply their understanding of atomic structure to explain a concept.)\_  
  
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### 11. Elaborate (Power Up)  
  
Encourage deeper thinking with the following tasks and open-ended questions:  
  
1. \*\*Mini-task:\*\*   
 Draw a model of an atom and label its parts. Then, explain how the arrangement of these parts affects the atom's behavior in chemical reactions.  
  
2. \*\*Open-ended question:\*\*   
 If you could change the number of electrons in an atom, what would happen to its chemical properties? How might this affect its interactions with other atoms?  
  
3. \*\*Extension question:\*\*   
 What do you think would happen if atoms didn’t have neutrons? How might this affect the stability of elements?  
  
These tasks encourage students to apply their knowledge in creative ways and think more deeply about atomic structure and its implications in chemistry.  
  
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### 12. Final Evaluation  
  
#### Debate Question:  
\*\*Should scientists be allowed to manipulate the number of protons in an atom to create new elements?\*\*   
- \*\*Pro\*\*: It could lead to new materials with unique properties, and help in advancing technology, medicine, or energy solutions.   
- \*\*Con\*\*: The manipulation of atomic structures might be dangerous, as it could create unstable elements or harmful byproducts.  
  
#### Assessment Questions:  
  
\*\*Multiple Choice Questions:\*\*  
  
1. \*\*What is the charge of an electron?\*\*   
 a) Positive   
 b) Negative   
 c) Neutral   
 d) It doesn't have a charge   
 \*\*Correct Answer:\*\* b) Negative  
  
2. \*\*Which particle determines the identity of an element?\*\*   
 a) Neutron   
 b) Electron   
 c) Proton   
 d) Molecule   
 \*\*Correct Answer:\*\* c) Proton  
  
3. \*\*Where are neutrons located in an atom?\*\*   
 a) Outside the nucleus   
 b) In the nucleus   
 c) Orbiting around the nucleus   
 d) Mixed with electrons   
 \*\*Correct Answer:\*\* b) In the nucleus  
  
4. \*\*What happens if an atom gains or loses electrons?\*\*   
 a) It becomes a new element   
 b) It becomes an ion   
 c) It becomes a proton   
 d) It forms a neutron   
 \*\*Correct Answer:\*\* b) It becomes an ion  
  
\*\*Long-Answer Questions:\*\*  
  
1. \*\*Explain the difference between isotopes of the same element. How does changing the number of neutrons affect the atom?\*\*   
 \_(This question requires students to explain isotopes and the role of neutrons in atomic structure.)\_  
  
2. \*\*Describe how the arrangement of electrons in an atom influences its chemical reactivity. Use examples to illustrate your answer.\*\*   
 \_(This question encourages students to apply their understanding of electron configuration to chemical reactions.)\_  
  
3. \*\*Discuss how the discovery of the electron has changed our understanding of the atom. How did earlier models differ from today's model?\*\*   
 \_(This question examines the historical development of atomic theory.)\_  
  
4. \*\*If you were a scientist who discovered a new element, what steps would you take to verify its properties and confirm its place on the periodic table?\*\*   
 \_(This encourages students to think critically about the scientific process and the role of experimentation.)\_  
  
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### 13. Extend (Beyond the Lesson)  
  
\*\*Suggested Activities & Readings:\*\*  
  
1. \*\*Activity\*\*:   
 Research a real-world application of isotopes, such as carbon dating or medical imaging. Prepare a short presentation explaining how isotopes are used and why they are important.  
  
2. \*\*Reading\*\*:   
 Find an article about the discovery of a new element (like element 118, Oganesson). Reflect on the challenges involved in creating and studying new elements.  
  
3. \*\*Spaced Practice Task\*\*:   
 Over the next week, revisit the periodic table and practice identifying elements by their atomic number. Try to identify trends in reactivity, size, and behavior across different groups and periods.  
  
\*\*Additional Questions for Critical Thinking:\*\*  
  
- How do scientists predict the existence of new elements before they are discovered?   
- Imagine a world where atoms could no longer bond. How would this affect life as we know it?   
- How are atoms and molecules related to the materials we use in everyday life, such as plastics or metals?  
  
These tasks challenge students to apply their knowledge to new situations and think about the broader implications of atomic theory in the real world. They also offer opportunities for spaced practice, helping reinforce learning over time.