# Unit: Unit 2: Atomic Structure and Bonding

## Chapter: Chapter 3: Unlocking the Atom

### Lesson: Lesson 2: Atomic Number and Mass

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### Essential Question:   
- What can the atomic number and atomic mass tell us about an element?   
  
### 1. Big Idea:   
Atoms are made up of subatomic particles, and the number of these particles determines the properties of different elements.   
  
### 2. Essential Questions:   
- What can the atomic number and atomic mass tell us about an element?  
  
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### 3. Phenomenon-Based Learning:   
\*\*Phenomenon\*\*:   
In northern countries, road salt is used to help melt ice and snow during the winter. Salt seems to make the ice vanish, but metal street signs and lampposts do not disappear when exposed to the same cold conditions. Why does this happen? How can understanding the structure of salt and water help us explain this phenomenon?   
  
In this chapter, we are on a journey to understand the nature of atoms, the basic building blocks of all substances. We’ll explore how atoms of different elements are different and how they come together to form substances like salt and water. By understanding the structure of atoms, we can uncover why salt can melt ice while other materials don’t seem to react with cold in the same way.   
  
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### 4. Vocabulary:   
- \*\*Atomic mass unit (amu)\*\*: A unit used to measure the mass of atoms and subatomic particles.  
- \*\*Atomic number\*\*: The number of protons in the nucleus of an atom, which determines the element.  
- \*\*Element symbol\*\*: A one- or two-letter abbreviation for an element.  
- \*\*Mass number\*\*: The total number of protons and neutrons in an atom's nucleus.  
  
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### 5. SMART Objectives:   
By the end of this lesson, students will be able to:   
1. Identify the three primary subatomic particles: protons, neutrons, and electrons, and their charges.   
2. Describe the relationship between the number of protons, neutrons, and electrons in an atom.   
3. Calculate the atomic mass of an element based on the number of subatomic particles.   
4. Use the atomic number and mass number to determine the identity and characteristics of an element.   
  
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### 6. Engage (Ignite):   
\*\*Phenomenon-related question\*\*:   
Imagine you’re in a place where the roads are covered in ice. You see workers spreading salt on the roads, and soon after, the ice starts to disappear. How does this happen? Why does ice melt when salt is added, but metal street signs don't disappear in the cold?   
  
\*\*Hands-on Experiment\*\*:   
\*\*Materials\*\*:   
- Table salt   
- Ice cubes   
- Two small plates   
- Timer   
  
\*\*Procedure\*\*:   
1. Place one ice cube on each plate.   
2. Sprinkle a small amount of salt on one of the ice cubes.   
3. Leave the other ice cube as it is.   
4. Start your timer and observe what happens over 10 minutes.   
5. Record your observations about the melting ice cube and the one with salt.   
  
\*\*Follow-up questions\*\*:   
1. What did you notice about the ice cube with salt compared to the one without salt?   
2. How do you think the salt affected the ice?   
3. Which properties of salt and ice could explain the difference in how they behave?  
  
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### 7. Pre-Explore (Direct Instruction):   
Atoms are the building blocks of all matter. If we look closely at an atom's structure, we find three main subatomic particles:   
1. \*\*Protons\*\*: These are positively charged particles found in the nucleus (center) of the atom.   
2. \*\*Neutrons\*\*: These have no charge (they are neutral) and are also found in the nucleus.   
3. \*\*Electrons\*\*: These are negatively charged particles that orbit around the nucleus in regions called electron clouds.   
  
The number of protons in an atom is called the \*\*atomic number\*\*, and it defines what element the atom is. For example, hydrogen atoms always have 1 proton, and oxygen atoms always have 8 protons.   
  
The \*\*mass number\*\* of an atom is the total number of protons and neutrons in its nucleus. Electrons don’t weigh much, so they don’t contribute significantly to the mass. To calculate the atomic mass of an atom, you can just add the number of protons and neutrons.   
  
\*\*Interactive Element\*\*:   
Ask students to imagine that they are building their own atom. Start with one proton. What element do they have now? (Answer: Hydrogen) Now, what happens if they add a neutron? Does it change the element? (No, it only changes the mass.)   
  
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### 8. Evaluate (Progress Check) - Pre-Explore:   
1. What are the charges of protons, neutrons, and electrons?   
2. What does the atomic number of an atom tell you?   
3. If an atom has 8 protons and 8 neutrons, what is its mass number?  
  
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### 9. Explain (Lightbulb):  
  
#### \*\*Subatomic Particles and Atomic Structure\*\*   
  
Atoms are made up of three types of subatomic particles: \*\*protons\*\*, \*\*neutrons\*\*, and \*\*electrons\*\*. These tiny particles are responsible for the identity and behavior of atoms. Let’s break down their roles:  
  
- \*\*Protons\*\* have a positive charge (+) and are found in the atom’s nucleus (the center of the atom). The number of protons an atom has determines what element it is. For example, an atom with 1 proton is hydrogen, while an atom with 6 protons is carbon.  
- \*\*Neutrons\*\* are neutral, meaning they have no charge. They are also found in the nucleus along with protons. The number of neutrons can change even within the same element – atoms with the same number of protons but different numbers of neutrons are called \*\*isotopes\*\*.  
- \*\*Electrons\*\* have a negative charge (−) and move around the nucleus in regions called electron clouds. Electrons are much smaller than protons and neutrons, and they don’t contribute much to the atom’s mass.  
  
#### \*\*Atomic Number and Mass Number\*\*   
The \*\*atomic number\*\* of an atom is the number of protons in its nucleus. This is a key characteristic because it defines the element. For example, every atom of carbon has 6 protons, so carbon’s atomic number is 6. The atomic number is often written above the element symbol on the periodic table.  
  
The \*\*mass number\*\* is the total number of protons and neutrons in the nucleus. Protons and neutrons each have a mass of about 1 atomic mass unit (\*\*amu\*\*). Electrons have almost no mass, so they are not included in the mass number.   
  
\*\*Example\*\*:   
Let’s look at oxygen. Oxygen has an atomic number of 8, which means it has 8 protons. If an oxygen atom also has 8 neutrons, its mass number is:   
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\text{Mass number} = 8 \, \text{protons} + 8 \, \text{neutrons} = 16 \, \text{amu}.  
\]   
This oxygen atom has a mass of 16 amu.   
  
\*\*Progress Check\*\*:   
An atom has an atomic number of 12 and a mass number of 24.   
- How many protons does it have?   
- How many neutrons does it have?   
  
\*\*Answer\*\*:   
- Atomic number = 12, so it has 12 protons.   
- Mass number = 24, so it has 24 − 12 = 12 neutrons.   
  
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### \*\*The Role of Electrons\*\*   
  
Electrons are negatively charged particles that orbit the nucleus of an atom. In a neutral atom, the number of electrons is equal to the number of protons. This balance of positive and negative charges means the atom overall has no charge. However, if an atom gains or loses electrons, it becomes an \*\*ion\*\*, which has either a positive or negative charge.  
  
Example:   
A neutral sodium atom has 11 protons and 11 electrons. If it loses one electron, it becomes a positive ion (Na⁺) because it has more protons than electrons.  
  
\*\*Progress Check\*\*:   
If a chlorine atom gains an electron, what type of ion does it become?  
  
\*\*Answer\*\*:   
Chlorine will become a negative ion (Cl⁻) because it now has more electrons than protons.   
  
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### \*\*Calculating Atomic Mass\*\*   
  
The atomic mass of an element is the average mass of all the isotopes of that element, weighted by how common each isotope is. For most elements, the atomic mass is close to the mass number of the most common isotope, but it is not always a whole number. On the periodic table, you’ll see the atomic mass listed below the element symbol.  
  
\*\*Example\*\*:   
Chlorine has two common isotopes: Cl-35 and Cl-37. The atomic mass of chlorine is 35.45 amu, because there are more Cl-35 atoms than Cl-37 atoms in nature, making Cl-35 more common.  
  
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### \*\*Final Thoughts\*\*   
  
Atoms are the building blocks of everything around us. By understanding atomic numbers, mass numbers, and the structure of subatomic particles, we can explain how different elements behave, why isotopes exist, and how reactions like melting ice with salt happen. Now that you know the basics of atomic structure, you are ready to dive deeper into how atoms bond together to form the compounds we see in everyday life, like the salt used to melt icy roads.  
  
### 10. Evaluate (Progress Check) - Explain   
Let's check if you understood the key concepts! Answer these questions to test your knowledge.  
  
\*\*DOK 1 (Recall):\*\*   
1. What is the chemical formula for water?  
  
\*\*DOK 2 (Understand):\*\*   
2. Why do atoms form chemical bonds? Explain in your own words.  
  
\*\*DOK 3 (Apply):\*\*   
3. Sodium (Na) bonds with chlorine (Cl) to form table salt (NaCl). Describe how this bond forms and predict what kind of bond it is.  
  
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### 11. Elaborate (Power Up)   
Now, let's dive deeper! These tasks will help you think more critically about what you've learned.  
  
\*\*Mini-tasks:\*\*  
1. \*\*Explore:\*\* Research the role of chemical bonds in living organisms. For example, what types of bonds are found in DNA, and why are they important?  
2. \*\*Compare:\*\* Compare ionic and covalent bonds. Which is stronger, and why? Give real-life examples of each.  
3. \*\*Design:\*\* Imagine you are a scientist creating a new material using chemical bonds. What properties would you want your material to have, and which type of bond would you use? Explain your reasoning.  
  
\*\*Additional Questions:\*\*   
- How might the properties of a substance change if it forms different types of bonds?   
- Could a substance with only covalent bonds conduct electricity? Why or why not?  
  
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### 12. Final Evaluation   
It's time for your final check! Use what you've learned to answer these questions.  
  
#### Debate Question:   
\*\*Should governments regulate the use of certain chemical compounds that are potentially dangerous, such as pesticides or plastics?\*\*   
- \*\*For Regulation:\*\*   
 - Dangerous chemicals can harm the environment and human health.  
 - Some chemicals are linked to pollution and long-term ecosystem damage.  
- \*\*Against Regulation:\*\*   
 - Many industries rely on these chemicals for important functions, such as farming and manufacturing.  
 - Innovations in safety can reduce the risks without banning useful substances.  
  
#### Multiple-Choice Questions (MCQs):   
  
1. \*\*Which of the following is an example of an ionic bond?\*\*   
 A. H2O   
 B. NaCl   
 C. CO2   
 D. O2   
 \*\*Correct Answer:\*\* B. NaCl   
  
2. \*\*What happens to electrons in a covalent bond?\*\*   
 A. They are transferred from one atom to another.   
 B. They are shared between atoms.   
 C. They are destroyed.   
 D. They stay with the atom that created them.   
 \*\*Correct Answer:\*\* B. They are shared between atoms.   
  
3. \*\*Which of the following substances is most likely to conduct electricity?\*\*   
 A. Sugar (C6H12O6)   
 B. Oxygen gas (O2)   
 C. Saltwater (NaCl dissolved in water)   
 D. Water (H2O)   
 \*\*Correct Answer:\*\* C. Saltwater (NaCl dissolved in water)   
  
4. \*\*Which bond type is typically found in organic compounds?\*\*   
 A. Ionic   
 B. Metallic   
 C. Covalent   
 D. Hydrogen   
 \*\*Correct Answer:\*\* C. Covalent   
  
#### Long-Answer Questions:   
  
1. \*\*Explain how an ionic bond is different from a covalent bond. Provide examples of each.\*\*   
 - Your answer should include how the electrons behave in each type of bond and at least one example of both an ionic and covalent compound.  
  
2. \*\*Describe how the structure of a molecule affects its properties. Use water (H2O) and carbon dioxide (CO2) as examples.\*\*   
 - Think about how the shape of the molecule and the type of bonds it has affect things like boiling point, freezing point, and solubility.  
  
3. \*\*Imagine you have a mystery substance. You know it conducts electricity when dissolved in water. What type of bond does this substance most likely have? Explain your reasoning.\*\*   
 - Be sure to talk about the role of electrons and how they contribute to conductivity.  
  
4. \*\*Why is the shape of a molecule important in determining its function in living organisms? Use the example of enzymes or DNA to support your answer.\*\*   
 - Think about how the shape of a molecule allows it to fit into specific places or interact in specific ways.  
  
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### 13. Extend (Beyond the Lesson) [Optional]   
Want to go further? Here are some extra tasks and readings to help you apply what you've learned:  
  
\*\*Additional Tasks:\*\*  
- \*\*Research:\*\* Investigate how chemical bonding is used in everyday products like plastic, glass, or metals. What makes these materials useful in different situations?  
- \*\*Real-World Challenge:\*\* Look into the environmental effects of chemical compounds like fertilizers or industrial chemicals. How do these substances affect ecosystems?  
  
\*\*Spaced Practice:\*\*  
- \*\*Week 1:\*\* Review the types of chemical bonds and their characteristics. Write a short paragraph describing an example of each type.  
- \*\*Week 2:\*\* Look at the properties of a new substance in your home (e.g., soap, plastic). Predict what types of bonds it has based on its properties.  
- \*\*Week 3:\*\* Revisit the debate question. Write a short opinion piece on whether you think chemical regulations should be stricter, based on what you’ve learned.  
  
This extension will help you see how chemistry is all around us and give you more practice with the concepts from this unit!