# Unit: Unit 2: Atomic Structure and Bonding

## Chapter: Chapter 3: Unlocking the Atom

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

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## Chapter Title: Unlocking the Atom   
# Lesson Title: Atomic Number and Mass  
  
### Essential Question:  
- What can the atomic number and atomic mass tell us about an element?  
  
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### 1. Big Idea:  
Atoms are composed of subatomic particles (protons, neutrons, electrons), and their arrangement determines an element's atomic number and mass.  
  
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### 2. Essential Question:  
- 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 spread on icy roads during the winter to prevent accidents. The ice seems to vanish when salt is added. But why does this happen? Where does the ice go? To answer this, we need to understand the structure of the materials involved—like salt and water—at the atomic level. Every substance, including salt and water, is made of atoms. But are all atoms the same? No. Atoms differ based on the number of subatomic particles they contain.  
  
#### Chapter Phenomenon:   
Is salting the road a magic trick? Not really! To understand what is happening, we need to break down the structure of atoms and recognize that different elements are made up of different numbers of protons, neutrons, and electrons. In this lesson, we'll explore what an element's atomic number and atomic mass can tell us about its structure and properties.  
  
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### 4. Vocabulary:  
  
- \*\*Atomic mass unit (amu):\*\* A unit of mass used to express atomic and molecular weights, approximately equal to the mass of one proton or neutron.  
- \*\*Atomic number:\*\* The number of protons in the nucleus of an atom, which determines the element's identity.  
- \*\*Element symbol:\*\* A one- or two-letter abbreviation representing an element (e.g., H for hydrogen, O for oxygen).  
- \*\*Mass number:\*\* The total number of protons and neutrons in the nucleus of an atom.  
  
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### 5. SMART Objectives:  
  
By the end of the lesson, students will be able to:  
  
1. Identify the subatomic particles (protons, neutrons, electrons) and their charges.  
2. Describe how the number of protons, neutrons, and electrons in an atom determines its atomic number and atomic mass.  
3. Calculate the atomic mass of an element using the number of protons, neutrons, and electrons.  
  
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### 6. Engage (Ignite):  
  
#### Phenomenon-Related Question:  
- Why does salt on icy roads make the ice seem to disappear? Could this be explained by understanding what salt and ice are made of?  
  
#### Hands-On Experiment: "Modeling Atoms with Subatomic Particles"  
  
\*\*Materials Needed:\*\*  
- Colored balls or beads to represent protons (red), neutrons (blue), and electrons (green).  
- Small paper or plastic plates to represent atomic nuclei.  
- Markers and sticky notes for labeling elements.  
  
\*\*Procedure:\*\*  
1. Use the colored balls to represent the subatomic particles (protons, neutrons, and electrons).  
2. Place the correct number of protons and neutrons in the center of the plate to represent the nucleus.  
3. Arrange the electrons in "orbitals" around the nucleus using sticky notes or markers.  
4. Create models for different elements, such as hydrogen (1 proton, 0 neutrons, 1 electron) and carbon (6 protons, 6 neutrons, 6 electrons).  
  
\*\*Follow-up Questions:\*\*  
1. What do you notice about the number of protons in each element’s nucleus?  
2. How do the number of neutrons and electrons compare to the number of protons?  
3. How does the arrangement of subatomic particles help us understand atomic number and mass?  
  
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### 7. Pre-Explore (Direct Instruction):  
  
Atoms are the basic building blocks of all matter. But atoms themselves are made up of even smaller particles called \*\*subatomic particles\*\*: protons, neutrons, and electrons.  
  
- \*\*Protons\*\* have a positive charge (+) and are found in the nucleus of the atom.  
- \*\*Neutrons\*\* have no charge (neutral) and are also found in the nucleus.  
- \*\*Electrons\*\* have a negative charge (−) and move around the outside of the nucleus in regions called "orbitals."  
  
The number of protons in an atom's nucleus determines its \*\*atomic number\*\*. This is a very important number because it tells us which element the atom is. For example:  
- An atom with 1 proton is always hydrogen (H).  
- An atom with 6 protons is always carbon (C).  
  
The \*\*mass number\*\* is the total number of protons and neutrons in an atom’s nucleus. For example, if an atom has 6 protons and 6 neutrons, its mass number is 12.  
  
The mass of an atom is measured in \*\*atomic mass units (amu)\*\*. One proton or one neutron has a mass of approximately 1 amu. Electrons are so much smaller that their mass is negligible when calculating atomic mass.  
  
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### 8. Evaluate (Progress Check) - Pre-Explore:  
  
1. How many protons, neutrons, and electrons are in an atom of carbon-12?  
2. What is the atomic number of carbon-12? How do you know?  
3. How would you calculate the atomic mass of an atom?  
  
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### 9. Explain (Lightbulb):  
  
#### 9.1 Subatomic Particles: Protons, Neutrons, and Electrons  
  
Atoms are made up of three types of subatomic particles: protons, neutrons, and electrons. Each of these particles has a different charge and location within the atom.  
  
- \*\*Protons\*\* are positively charged and are found in the nucleus of the atom. The number of protons in the nucleus determines the element. For example, an atom with one proton is hydrogen (H), while an atom with six protons is carbon (C).  
- \*\*Neutrons\*\* are neutral particles, meaning they have no charge. They are also found in the nucleus. Neutrons add mass to the atom but do not change the element.  
- \*\*Electrons\*\* are negatively charged particles that are found in the space around the nucleus. They are much smaller than protons and neutrons and move rapidly in regions called orbitals.  
  
#### Sample Problem 1:  
  
\*\*Question:\*\*   
How many protons, neutrons, and electrons are in a nitrogen atom with an atomic number of 7 and a mass number of 14?  
  
\*\*Solution:\*\*  
- \*\*Protons:\*\* The atomic number tells us there are 7 protons.  
- \*\*Neutrons:\*\* The mass number is 14, so the number of neutrons is 14 - 7 = 7.  
- \*\*Electrons:\*\* In a neutral atom, the number of electrons equals the number of protons, so there are 7 electrons.  
  
\*\*Progress Check:\*\*  
- How many protons, neutrons, and electrons are in an oxygen atom with an atomic number of 8 and a mass number of 16?  
  
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#### 9.2 Atomic Number and Element Identity  
  
The \*\*atomic number\*\* is key to identifying an element. It tells us the number of protons in the nucleus of an atom. Since each element has a unique number of protons, the atomic number is like an element’s fingerprint.  
  
For example:  
- Hydrogen has 1 proton, so its atomic number is 1.  
- Helium has 2 protons, so its atomic number is 2.  
- Carbon has 6 protons, so its atomic number is 6.  
  
Changing the number of protons changes the identity of the atom. For example, adding one proton to a carbon atom (6 protons) would turn it into nitrogen (7 protons).  
  
#### Sample Problem 2:  
  
\*\*Question:\*\*   
If an atom has 11 protons, what element is it?  
  
\*\*Solution:\*\*   
Look at the periodic table. An atom with 11 protons is sodium (Na).  
  
\*\*Progress Check:\*\*   
What element has 9 protons? How do you know?  
  
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#### 9.3 Atomic Mass and Isotopes  
  
The \*\*mass number\*\* of an atom is the total number of protons and neutrons in the nucleus. Since electrons are so small, they don’t contribute much to the atom’s mass.  
  
For example:  
- Carbon-12 has 6 protons and 6 neutrons, giving it a mass number of 12.  
- Carbon-14 has 6 protons and 8 neutrons, giving it a mass number of 14.  
  
These different forms of carbon are called \*\*isotopes\*\*. Isotopes are atoms of the same element (same number of protons) but with different numbers of neutrons. Isotopes of an element have different mass numbers but are still the same element.  
  
#### Sample Problem 3:  
  
\*\*Question:\*\*   
How many neutrons are in an isotope of oxygen with a mass number of 18?  
  
\*\*Solution:\*\*   
Oxygen has an atomic number of 8, which means it has 8 protons. The number of neutrons is 18 - 8 = 10 neutrons.  
  
\*\*Progress Check:\*\*   
How many neutrons are in an isotope of chlorine with a mass number of 35?  
  
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### 10. Evaluate (Progress Check):  
  
1. What is the atomic number of an atom with 9 protons?  
2. How would you find the number of neutrons in an atom if you know its mass number and atomic number?  
3. Why is the atomic number important for identifying an element?  
  
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### 11. Elaborate (Deep Dive):  
  
Atoms of the same element can have different numbers of neutrons, which results in different \*\*isotopes\*\* of that element. Even though isotopes have the same number of protons (and are therefore the same element), they have different atomic masses because of the difference in the number of neutrons.  
  
For example:  
- \*\*Carbon-12\*\* has 6 protons and 6 neutrons.  
- \*\*Carbon-14\*\* has 6 protons and 8 neutrons.  
  
Both are carbon, but they have different masses.  
  
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### 12. Extension Activity:  
  
Have students research a real-world application of isotopes, such as how isotopes are used in medicine (e.g., radioactive isotopes in cancer treatment) or in environmental science (e.g., using isotopes to track water movement).  
  
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### 13. Conclusion:  
  
In this lesson, you learned that the atomic number tells us how many protons an atom has, which defines the element. The mass number is the total number of protons and neutrons in the atom’s nucleus, which determines the atom’s mass. Together, these concepts help us understand the structure of atoms and how isotopes of the same element can differ.  
  
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### 14. Homework:  
  
1. Complete the worksheet on atomic structure, including questions on protons, neutrons, electrons, atomic number, and mass number.  
2. Research the role of isotopes in carbon dating. Write a short paragraph explaining how scientists use isotopes to determine the age of ancient objects.  
  
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### 10. Evaluate (Progress Check) - Explain  
  
#### Scaffolded Questions:  
1. \*\*DOK 1 (Recall):\*\* What is an atom?  
 - \*Answer:\* An atom is the smallest unit of an element that still retains the properties of that element.  
  
2. \*\*DOK 2 (Application):\*\* How do electrons, protons, and neutrons differ in their charges and locations within an atom?  
 - \*Answer:\* Protons have a positive charge and are found in the nucleus. Neutrons have no charge (neutral) and are also found in the nucleus. Electrons have a negative charge and are found orbiting the nucleus in electron shells.  
  
3. \*\*DOK 3 (Strategic Thinking):\*\* Explain how the atomic number and mass number of an element can be used to determine the number of protons, neutrons, and electrons in an atom.  
 - \*Answer:\* The atomic number equals the number of protons in an atom. For a neutral atom, it also equals the number of electrons. The mass number is the sum of protons and neutrons in the nucleus. To find the number of neutrons, subtract the atomic number from the mass number.  
  
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### 11. Elaborate (Power Up)  
  
#### Mini-Tasks:  
1. \*\*Task:\*\* Investigate how atoms of different elements combine to form compounds. Explain why some elements bond easily with others while some do not.  
 - \*Hint:\* Think about the role of electrons, especially in the outermost shell or "valence shell."  
  
2. \*\*Task:\*\* Draw a Bohr model of a carbon atom and a nitrogen atom. Compare their electron arrangements and predict how they might behave in a chemical reaction.  
  
3. \*\*Open-Ended Question:\*\* Imagine you are designing a new material using elements from the periodic table. What properties would you want the elements to have, and how would you combine them to get the desired results?  
 - \*Hint:\* Think about properties like reactivity, conductivity, and strength.  
  
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### 12. Final Evaluation  
  
#### Debate Question:  
\*\*Should the periodic table be reorganized to reflect new discoveries in atomic structure, or should it remain as it is to maintain consistency?\*\*  
- \*\*Arguments for:\*\*   
 - New discoveries in subatomic particles and isotopes could offer a more accurate way to categorize elements.  
 - The periodic table could reflect modern theories of quantum mechanics.  
- \*\*Arguments against:\*\*  
 - The current periodic table is a well-established tool that helps in understanding chemical behavior.  
 - Reorganization might confuse students and professionals who have been using the current system for decades.  
  
#### Assessment Questions:  
  
\*\*Multiple-Choice Questions:\*\*  
1. What is the charge of an electron?  
 - A) Positive  
 - B) Negative  
 - C) Neutral  
 - D) Both positive and negative   
 - \*Answer:\* B) Negative  
  
2. Which of the following is found in the nucleus of an atom?  
 - A) Electrons  
 - B) Protons and neutrons  
 - C) Neutrons and electrons  
 - D) Protons and electrons   
 - \*Answer:\* B) Protons and neutrons  
  
3. What determines the atomic number of an element?  
 - A) The number of neutrons in the nucleus  
 - B) The number of protons in the nucleus  
 - C) The number of electrons in the atom  
 - D) The total number of protons and neutrons   
 - \*Answer:\* B) The number of protons in the nucleus  
  
4. What is the total charge of a neutral atom?  
 - A) Positive  
 - B) Negative  
 - C) Zero  
 - D) Depends on the number of neutrons   
 - \*Answer:\* C) Zero  
  
\*\*Long-Answer Questions:\*\*  
1. Explain how the electron configuration of an atom determines its reactivity. Provide examples of elements that are highly reactive and explain why.  
 - \*Hint:\* Think about elements with nearly full or nearly empty outer electron shells.  
  
2. Describe the differences between an ionic bond and a covalent bond. Give an example of a compound formed by each type of bond and explain how the bond affects the properties of the compound.  
 - \*Hint:\* Consider how electrons are shared or transferred.  
  
3. Imagine you have two isotopes of the same element. Explain how they are similar and how they are different. What impact do their differences have on the element's atomic mass?  
 - \*Hint:\* Isotopes have the same number of protons but different numbers of neutrons.  
  
4. Predict what would happen if all the electrons in an atom were removed. How would this affect the atom's charge and stability?  
 - \*Hint:\* Think about the role of electrons in balancing the charge of protons.  
  
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### 13. Extend (Beyond the Lesson) [Optional]  
  
#### Additional Tasks:  
- \*\*Reading:\*\* Research how the discovery of the neutron changed the way scientists understand the atom. Why was this discovery so important for developing modern atomic theory?  
   
- \*\*Challenge:\*\* Investigate a real-world application of atomic structure, such as how silicon atoms are used in computer chips. Write a short report explaining why silicon’s atomic properties make it ideal for this purpose.  
  
#### Spaced Practice Activity:  
- \*\*Task:\*\* Over the next week, revisit the periodic table and pick one element per day. Research how that element is used in everyday life, then summarize what you’ve learned in your science journal. Keep track of trends you notice, such as similarities in usage among elements in the same group (column).  
   
- \*\*Question for Reflection:\*\* How might understanding the behavior of atoms and elements help in solving environmental problems like pollution or renewable energy development?