Unit 2: Atomic Structure and Bonding

## Chapter 6: Ionic and Metallic Bonding

# Lesson 1: Formation and Properties of Ions

Essential Questions:   
- How are ions formed, and what role do they play in chemical bonding?  
  
  
 1. Big Idea:   
- Ions are formed when atoms gain or lose electrons, which results in charged particles that play a crucial role in the formation of ionic bonds.  
  
  
  
 2. Essential Questions   
- How are ions formed, and what role do they play in chemical bonding?  
  
  
  
 3. Phenomenon-Based Learning   
  
Unit Phenomenon: Danger! Icy Roads   
In northern countries, where winter brings cold weather, roads can be covered in ice and snow. To make roads safer, salt is spread on the ice to melt it. While salt dissolves in water, metal objects like lampposts remain unchanged in the snow. Why do salt and metal behave differently?  
  
**Chapter Phenomenon: Salt vs. Metal – Why Does Water Treat Them Differently?**   
Salt dissolves in water and helps melt ice, but metals, like street signs, do not dissolve in water. Instead, they remain solid and intact. Why is there such a difference in how water interacts with salt versus metal?  
  
  
  
 4. Vocabulary   
- Octet Rule: Atoms tend to gain, lose, or share electrons to have eight electrons in their outermost shell, achieving a stable electron configuration.  
- Anion: A negatively charged ion formed when an atom gains electrons.  
- Cation: A positively charged ion formed when an atom loses electrons.  
- Electrolyte: A substance that produces ions when dissolved in water, allowing the solution to conduct electricity.  
- Electron Affinity: The energy change that occurs when an atom gains an electron.  
- Ionic Radius: The size of an ion, which can change depending on whether the atom has gained or lost electrons.  
- Ionization: The process of gaining or losing electrons to form ions.  
  
  
  
 5. SMART Objectives   
By the end of this lesson, students will be able to:   
- Describe how ions are formed through the gain or loss of electrons.   
- Write the symbols and charges of common ions and explain the octet rule, including its exceptions.   
- Predict the charge of an ion based on its position on the periodic table.   
  
  
  
 6. Engage (Ignite)   
  
**Phenomenon-Related Task**:   
Ask students: “Why do we add salt to icy roads in winter, and why doesn’t metal like street signs dissolve in the snow?”   
  
**Hands-On Activity: Investigating Salt and Water**   
- **Materials Needed**: Table salt (NaCl), small beakers, water, stirring sticks, and a metal object (like a small steel nail).   
- **Procedure**:   
 1. Fill two beakers with water.   
 2. In one beaker, dissolve a tablespoon of salt in water by stirring.   
 3. In the other beaker, place the metal nail and observe.   
 4. Record your observations for both beakers.   
   
**Discussion Questions**:   
1. What happened to the salt when it was mixed with water?   
2. Did the metal nail dissolve or change in the water?   
3. How does this relate to what happens when salt is spread on icy roads?  
  
  
  
 7. Pre-Explore (Direct Instruction)   
  
 **Phenomenon to Key Concepts:**   
- When salt dissolves in water, it breaks down into ions (Na⁺ and Cl⁻). These ions interact with water molecules, which is why salt melts ice. On the other hand, metals like iron (Fe) do not dissolve in water because of the type of bonding and the way metal atoms are structured.   
  
**Interactive Discussion**:   
- Ask students, "What do you think happens to the atoms in salt when it dissolves in water?"   
- Explain how gaining or losing electrons forms ions, and how this relates to the octet rule, where atoms strive to have eight electrons in their outer shell.  
  
  
  
 8. Evaluate (Progress Check) - Pre-Explore   
  
1. What happens to the atoms in salt when it dissolves in water?   
2. Why does the metal nail not dissolve like the salt?   
3. What is the difference between an ion and a neutral atom?  
  
  
  
 9. Explore (Pathfinder)   
  
**Hands-On Activity: Predicting Ion Charges on the Periodic Table**   
- **Materials Needed**: Periodic tables, whiteboards, and markers.   
- **Instructions**:   
 1. Using your periodic table, find an element in Group 1 (like sodium). Write its symbol and predict whether it will form a cation or an anion.   
 2. Now, find an element in Group 17 (like chlorine). Will it form an anion or a cation?   
 3. Write the ion’s charge based on its group number.   
  
**Data Collection & Group Discussion**:   
- Discuss how the position of an element on the periodic table helps to predict the charge of the ions formed.   
- Engage in group discussions about how this relates to the octet rule.  
  
  
  
 10. Explain (Lightbulb)   
  
This section will provide a detailed explanation of the main concepts of the lesson, using the unit and chapter phenomenon to illustrate how ions are formed and their significance in chemical bonding.  
  
**Formation of Ions**   
Atoms are neutral when they have the same number of protons and electrons. However, when an atom gains or loses electrons, it no longer has the same number of these particles. This imbalance creates a charge, and the atom becomes an ion. There are two types of ions:   
1. **Cations**: These are positively charged ions formed when an atom loses electrons. For example, sodium (Na) loses one electron to form Na⁺.   
2. **Anions**: These are negatively charged ions formed when an atom gains electrons. For example, chlorine (Cl) gains one electron to form Cl⁻.  
  
**The Octet Rule**   
Atoms tend to gain, lose, or share electrons until they have eight electrons in their outer shell. This is known as the octet rule. For example:   
- Sodium (Na) has one electron in its outer shell. It will lose this electron to achieve a full outer shell, becoming Na⁺.   
- Chlorine (Cl) has seven electrons in its outer shell. It will gain one more electron to complete its octet, becoming Cl⁻.   
  
**Exceptions to the Octet Rule**   
- Not all atoms follow the octet rule. Elements like hydrogen (H) and helium (He) only need two electrons to fill their outer shell. Transition metals, like iron (Fe), also don’t always follow the octet rule.  
  
**Ionic Bonds and the Role of Ions in Bonding**   
When ions form, they can attract each other due to their opposite charges. For example, Na⁺ and Cl⁻ come together to form NaCl, or table salt. This attraction between oppositely charged ions is called an ionic bond. Ionic bonds are strong and form between metals and non-metals.   
  
**Predicting Ion Charges on the Periodic Table**   
- **Group 1 elements**: These elements (like sodium) always form +1 cations by losing one electron.   
- **Group 17 elements**: These elements (like chlorine) form -1 anions by gaining one electron.   
- **Group 2 elements**: These elements (like magnesium) form +2 cations by losing two electrons.   
- **Group 16 elements**: These elements (like oxygen) form -2 anions by gaining two electrons.  
  
  
  
 11. Evaluate (Progress Check) - Explain   
  
1. What is the charge and symbol for a chlorine ion?   
2. How does sodium achieve a stable electron configuration?   
3. Why do metals tend to form cations?  
  
  
  
 12. Elaborate (Power Up)   
  
**Mini-Tasks or Open-Ended Questions**:   
1. Can you think of other examples where ions play a role in real-life applications, such as in health or technology (e.g., electrolytes in sports drinks)?   
2. How would the properties of materials change if ions were not involved in bonding?  
  
  
  
 13. Final Evaluation   
  
**Debate Question**:   
- Debate the importance of ions in everyday life. What would happen if ions didn’t exist, and all atoms stayed neutral?  
  
**Assessment Questions**:   
- **Multiple-Choice Questions**:   
 1. What type of ion is formed when an atom gains electrons?   
 A) Cation   
 B) Anion   
 C) Neutral atom   
 D) Proton   
 Answer: B) Anion   
  
 2. Which group on the periodic table forms ions with a -1 charge?   
 A) Group 1   
 B) Group 2   
 C) Group 17   
 D) Group 18   
 Answer: C) Group 17   
  
 3. What happens to sodium when it forms an ion?   
 A) It gains one electron.   
 B) It loses one electron.   
 C) It gains two electrons.   
 D) It loses two electrons.   
 Answer: B) It loses one electron.   
  
 4. Which of the following is an exception to the octet rule?   
 A) Chlorine   
 B) Hydrogen   
 C) Sodium   
 D) Oxygen   
 Answer: B) Hydrogen   
  
- **Long-Answer Questions**:   
 1. Explain how the octet rule helps predict the formation of ions. Give two examples of ions that follow the octet rule.   
 2. Predict the ion that would form from an element in Group 2 of the periodic table. Explain how you arrived at your answer.   
 3. Describe the difference between a cation and an anion. Provide one example of each.   
 4. Describe why metals tend to form cations and non-metals tend to form anions.  
  
  
  
 14. Extend (Beyond the Lesson)   
  
**Additional Tasks or Readings:**   
- Research how electrolytes (ions in water) help the body function, especially in sports and exercise.   
- Investigate how ion formation is critical in industries like battery production and water purification.   
  
**Future Lessons Preview**:   
- Preview how ions interact in different types of chemical reactions, setting up the next chapter on chemical compounds and reactions.