# Unit 2: Atomic Structure and Bonding

## Chapter 6: Ionic and Metallic Bonding

# Lesson 1: Formation and Properties of Ions

# - Big Idea:

Ions form when atoms gain or lose electrons, and these charged particles play a crucial role in chemical bonding, leading to the formation of ionic compounds.  
  
 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\*   
Chapter Phenomenon: \*Salt vs. Metal: Why Does Water Treat Them Differently?\*  
  
When road salt is spread on icy streets, the ice melts and the salt dissolves in water. However, metal objects like street signs do not dissolve. This difference in behavior is due to the formation of ions when salt dissolves but not when metals are exposed to water. This leads us to explore the concept of ions and how they behave in different substances.  
  
  
  
 4. Vocabulary  
  
- **Octet Rule**: Atoms gain or lose electrons to achieve a full outer shell, usually composed of 8 electrons.  
- **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 conducts electricity when dissolved in water, due to the presence of free ions.  
- **Electron Affinity**: The energy change when an atom gains an electron.  
- **Ionic Radius**: The size of an ion compared to its neutral atom.  
- **Ionization**: The process of gaining or losing electrons to form ions.  
- **Octet Rule**: The principle that atoms tend to form ions or bonds in a way that gives them a full outer shell of 8 electrons.  
  
  
  
 5. SMART Objectives  
  
By the end of this lesson, students will be able to:   
  
- Describe how ions are formed from neutral atoms.  
- Write the symbols and charges of common anions and cations.  
- Predict the charge of an ion based on its position on the periodic table.  
- Explain the role of ions in chemical bonding and how they contribute to the formation of ionic compounds.  
  
  
  
 Engage (Ignite)  
  
**Phenomenon-Related Question**: Why does salt melt ice, but metal doesn’t?   
  
Hands-on Experiment: Salt and Water Conductivity Test  
We'll test the conductivity of a salt solution to see how ions behave in water.  
  
**Materials**:   
- Table salt (NaCl)  
- Distilled water  
- Conductivity tester (or small LED bulb and wires)  
- Metal wire (for comparison)  
  
**Procedure**:  
1. Dissolve one teaspoon of salt into a cup of distilled water.  
2. Set up a conductivity tester with an LED bulb or a simple circuit.  
3. Dip the ends of the tester into the salt solution and observe if the LED light turns on.  
4. Repeat the test with just distilled water (no salt) and with a piece of metal wire in the water.  
  
**Follow-up Questions**:  
1. What happened when you tested the salt solution? Did the light turn on?  
2. Why do you think the salt solution conducted electricity, but distilled water did not?  
3. What role do ions play in the conductivity of the solution?  
  
  
  
Pre-Explore (Direct Instruction)  
  
**Background Information**:   
When road salt is spread on icy streets, the salt dissolves in water, breaking apart into sodium (Na⁺) and chloride (Cl⁻) ions. These ions are responsible for melting the ice and making the roads safer. This is because ions lower the freezing point of water. Metals, like the ones used in street signs and lampposts, do not dissolve or break into ions as salt does. Instead, metals form metallic bonds, which behave differently in water.  
  
  
  
 8. Progress Check - Pre-Explore  
  
**Scaffolded Questions**:   
1. What happens to road salt when it dissolves in water?  
2. What is the difference between a cation and an anion?  
3. How do ions in salt solutions help conduct electricity?  
  
  
  
 9. Explore (Pathfinder)  
  
**Activity**: \***Modeling Ion Formation**\*   
Students will model how ions form by simulating the transfer of electrons between atoms.  
  
**Materials**:   
- Paper cutouts of atoms (representing different elements)  
- Stickers or small beads (representing electrons)  
- Periodic tables for reference  
  
**Instructions**:  
1. Pair students up, giving each pair two different atom cutouts (e.g., one sodium atom and one chlorine atom).  
2. Have students move stickers (electrons) from one atom to another to show how sodium loses an electron and chlorine gains one.  
3. Label the resulting ions as Na⁺ (cation) and Cl⁻ (anion).  
  
**Group Discussion**:  
- Have students discuss why sodium gave away electrons and why chlorine gained them, focusing on achieving stable electron configurations.  
  
  
  
 10. Explain (Lightbulb) ( add property of the ions)  
**Main Ideas**:  
  
**Ions and the Octet Rule**:   
Atoms form ions to achieve a full outer electron shell, which is often 8 electrons (the octet rule). For example, sodium (Na) has 1 electron in its outer shell and tends to lose this electron, forming a Na⁺ ion with a full inner shell. Chlorine (Cl), on the other hand, has 7 electrons in its outer shell and tends to gain 1 electron, forming a Cl⁻ ion.  
  
**How Ions Form**:   
- **Cations**: Metals like sodium (Na) lose electrons to form positive ions (cations). For example, Na becomes Na⁺ after losing one electron.  
- **Anions**: Non-metals like chlorine (Cl) gain electrons to form negative ions (anions). For example, Cl becomes Cl⁻ after gaining one electron.  
  
**Role of Ions in Chemical Bonding**:   
Ions are important in forming ionic bonds, where positively charged cations and negatively charged anions attract each other. This attraction holds the ions together in a compound, like NaCl (table salt). In this case, Na⁺ and Cl⁻ combine to form a stable, neutral ionic compound.  
  
**Real-World Example**:   
In icy conditions, when salt (NaCl) is spread on roads, it dissolves in water and breaks into Na⁺ and Cl⁻ ions. These ions interfere with the water’s freezing process, lowering the freezing point and melting the ice faster.  
  
**Solved Example Problem**:   
Problem: Predict the charge of an ion formed by magnesium (Mg).   
Solution: Magnesium is in Group 2 of the periodic table and has 2 electrons in its outer shell. To achieve a full outer shell, magnesium will lose 2 electrons, forming a Mg²⁺ cation.  
  
**Practice Question**:   
Predict the charge of an ion formed by sulfur (S).   
  
  
  
 11. Progress Check - Explain  
  
**Scaffolded Questions**:   
1. What happens to the electrons when sodium forms a Na⁺ ion?   
2. Why does chlorine form a Cl⁻ ion?   
3. How do ionic bonds form between cations and anions?  
  
  
  
 12. Elaborate (Power Up)  
  
**Mini-Task**:   
Research and explain how electrolytes in sports drinks work to help maintain balance in the body. What role do ions play in this process?  
  
  
  
 13. Final Evaluation  
  
**Debate Question**:   
Should road salt be used to melt ice on streets, given its environmental impact on water sources and plant life? Discuss the pros and cons.  
  
**Assessment Questions**:  
  
**Multiple-Choice Questions**:   
1. What charge does a sodium ion (Na⁺) have?   
 a) +1   
 b) -1   
 c) +2   
 d) -2   
 Correct Answer: a) +1  
  
2. Which of the following is an anion?   
 a) Na⁺   
 b) Cl⁻   
 c) Mg²⁺   
 d) K⁺   
 Correct Answer: b) Cl⁻  
  
3. The octet rule states that atoms will gain or lose electrons to achieve:   
 a) 6 electrons in the outer shell   
 b) 8 electrons in the outer shell   
 c) 10 electrons in the outer shell   
 d) A stable proton count   
 Correct Answer: b) 8 electrons in the outer shell  
  
4. What is the ionic charge of an ion formed from oxygen (O)?   
 a) -2   
 b) +1   
 c) +2   
 d) -1   
 Correct Answer: a) -2  
  
**Long-Answer Questions**:   
1. Explain how sodium and chlorine form an ionic bond.  
2. Why do metals like sodium form cations, while non-metals like chlorine form anions?  
3. Describe the relationship between the position of an element on the periodic table and the type of ion it forms.  
4. How does the presence of ions in a solution allow it to conduct electricity?  
  
  
  
 14. Extend (Beyond the Lesson) (Mostly application real life appliactions )  
  
Additional Task:   
Research how road salt affects the environment and suggest alternative methods for melting ice that could minimize harm.  
  
Spaced Practice:   
Create a weekly review quiz to revisit the formation of ions and their role in chemical bonding.