# 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 are essential in forming ionic bonds, leading to the creation of compounds with unique properties.  
  
  
  
 Essential Questions:  
- How are ions formed, and what role do they play in chemical bonding?  
- Why do some atoms lose electrons while others gain them?  
- How can the properties of ions explain why salt dissolves in water but metal street signs do not?  
  
  
  
 Phenomenon-Based Learning:  
 Phenomenon:   
Danger! Icy Roads  
  
In northern countries, road salt is used to melt ice and snow on streets during winter. As the salt dissolves, the ice disappears, making roads safer. However, metal street signs and lampposts exposed to the same environment do not dissolve in water or melt snow.  
  
 Chapter Phenomenon:   
Salt vs. Metal, Why Does Water Treat Them Differently?  
  
While salt dissolves in water, metals do not. What makes these materials behave differently in water? How do the formation and properties of ions help explain this phenomenon?  
  
  
  
 Vocabulary:  
  
- Octet Rule: Atoms tend to gain, lose, or share electrons to have eight electrons in their outer shell (valence shell), achieving a stable configuration like noble gases.  
- Anion: A negatively charged ion formed when an atom gains one or more electrons.  
- Cation: A positively charged ion formed when an atom loses one or more electrons.  
- Electrolyte: A substance that dissolves in water to produce a solution that conducts electricity due to the presence of ions.  
- Electron Affinity: The tendency of an atom to attract and gain electrons.  
- Ionic Radius: The size of an ion, which can differ from the size of the neutral atom due to the gain or loss of electrons.  
- Ionization: The process by which an atom or molecule acquires a charge by gaining or losing electrons.  
  
  
  
 SMART Lesson Objectives:  
- Describe how ions are formed when atoms gain or lose electrons.  
- Write the symbols and charges of common ions.  
- Predict the charge of an ion based on its position in the periodic table.  
   
  
  
 Ignite (Engage):  
  
**Question:**   
Why does salt melt ice, but metal street signs do not? What makes salt dissolve in water, creating a solution, while metals just sit in the water and do nothing?  
  
**Hands-On Experiment**:  
  
**Objective**: Observe how different substances behave when mixed with water.  
  
**Materials:**  
- Table salt (NaCl)  
- Metal paperclip  
- Two beakers  
- Water  
- Stirring rod  
- Thermometer  
  
**Procedure:**  
1. Fill two beakers with the same amount of water.  
2. Add a tablespoon of salt to one beaker and stir.  
3. Place the metal paperclip in the second beaker.  
4. Observe what happens in both beakers.  
5. Measure the temperature after adding the salt and note any changes.  
  
**Follow-up Questions**:  
1. What happened to the salt in the water?  
2. Did the metal paperclip change in any way when placed in water?  
3. How does this experiment relate to the phenomenon of salt melting ice but metal street signs remaining unaffected?  
  
  
  
 Direct Instruction (Pre-Explore Section):  
  
Atoms form ions by gaining or losing electrons to complete their outer electron shell, following the Octet Rule. When atoms lose electrons, they form cations, and when they gain electrons, they form anions. For example, sodium (Na) loses one electron to form a sodium ion (Na⁺), while chlorine (Cl) gains one electron to form a chloride ion (Cl⁻).   
  
The formation of ions explains why certain substances, like salt, dissolve in water. The ions separate in the water, allowing them to interact with the water molecules, which leads to the salt "disappearing."  
  
**Question**:   
Why don’t metals like iron dissolve in water?   
  
Metals do not form ions as easily in water, which is why they don’t dissolve like salt.   
  
  
  
 Progress Check (Evaluate):  
1. DOK Level 1: What is the charge on a sodium ion (Na⁺)?  
2. DOK Level 2: How does the Octet Rule help predict whether an atom will form a cation or anion?  
3. DOK Level 3: Explain why metals do not dissolve in water, using your understanding of ions.

Pathfinder (Explore) [Hands-On Section]:  
  
**Lab Activity**: Investigating Ionic Formation and Behavior  
  
**Objective:**   
You will explore how different atoms form ions and how these ions behave in water.  
  
**Materials:**  
- Sodium chloride (NaCl)  
- Magnesium ribbon (Mg)  
- Water  
- Two beakers  
- Conductivity tester  
  
**Procedure:**  
1. Dissolve one teaspoon of sodium chloride in water in the first beaker.  
2. Place a strip of magnesium in the second beaker with water.  
3. Use a conductivity tester to test the water in both beakers.  
4. Record your observations.  
  
**Discussion Questions**:  
1. How did the conductivity change when salt was added to the water?  
2. Why does salt water conduct electricity but pure water does not?  
3. What does this tell you about ions in solution?  
  
**Retrieval Practice**:  
- What happens when sodium chloride dissolves in water?  
- How do the properties of ions help explain the conductivity of saltwater?  
  
  
  
 Lightbulb (Explain):  
  
Ions are crucial in how substances interact with water and other elements. When atoms gain or lose electrons, they form ions, which are charged particles. The type of ion formed depends on the atom's electron configuration and its position on the periodic table.  
  
 **Formation of Ions:**  
- Cations form when an atom loses electrons. For example, sodium (Na) loses one electron to form Na⁺.  
- Anions form when an atom gains electrons. For example, chlorine (Cl) gains one electron to form Cl⁻.  
  
Ions are attracted to each other due to their opposite charges, resulting in an ionic bond. In the case of NaCl (table salt), sodium ions (Na⁺) and chloride ions (Cl⁻) form a crystal lattice, which dissolves easily in water.  
  
**Real-World Example**:  
When road salt (NaCl) is spread on icy roads, it dissolves in the water from the melting ice. The sodium and chloride ions interact with the water molecules, preventing the water from refreezing at higher temperatures.  
  
 **Solved Example**:  
Question: Predict the charge of a magnesium ion.  
  
Solution: Magnesium (Mg) has two electrons in its outer shell. It will lose these two electrons to follow the octet rule, forming a cation with a charge of 2⁺ (Mg²⁺).  
  
  
  
 Progress Check (Evaluate):  
1. DOK Level 1: What is the charge of a chloride ion?  
2. DOK Level 2: How does the Octet Rule help explain why sodium forms a positive ion and chlorine forms a negative ion?  
3. DOK Level 3: Explain why ionic solutions conduct electricity while pure water does not.  
  
  
  
 Power Up (Elaborate):  
  
Now that you understand how ions form and why they behave the way they do, consider this: How would the world be different if metals dissolved in water like salt does? What would that mean for buildings, cars, and even your electronics?   
  
  
  
 Progress Check (Final Evaluation):  
  
Debate Question:  
Should we continue using road salt to melt ice, considering its effects on the environment and infrastructure?  
  
Discussion Points:  
- How does road salt affect water sources and soil?  
- What are the alternatives to using road salt?  
- How does the ionic nature of salt lead to its effectiveness in melting ice?  
  
**Assessment Questions**:  
  
**Multiple Choice Questions**:  
1. What is the charge on a sodium ion?  
 a) -1   
 b) +1   
 c) -2   
 d) +2   
 Answer: b) +1  
  
2. Which of the following forms an anion?  
 a) Sodium   
 b) Magnesium   
 c) Chlorine   
 d) Helium   
 Answer: c) Chlorine  
  
3. What is the process of losing an electron called?  
 a) Ionization   
 b) Electron affinity   
 c) Electronegativity   
 d) Ionic radius   
 Answer: a) Ionization  
  
4. What type of bond is formed between Na⁺ and Cl⁻?  
 a) Covalent   
 b) Metallic   
 c) Ionic   
 d) Hydrogen   
 Answer: c) Ionic  
  
**Long-Answer Questions**:  
1. Explain the process of ion formation for magnesium.  
2. How does the Octet Rule help predict the formation of ions?  
3. Compare the behavior of salt and metal in water, based on their ionic properties.  
4. How does the formation of ions relate to the effectiveness of road salt in melting ice?  
  
  
  
 **Beyond the Lesson (Extend):**  
  
To further explore the impact of ions in everyday life, research how electrolytes in sports drinks help with hydration. How do the ions in these drinks assist your body during exercise? Additionally, look into how ionic compounds are used in medicine, such as in the formation of salts that help maintain bodily functions.