# Unit: Unit 2: Atomic Structure and Bonding

## Chapter: Chapter 6: Ionic and Metallic Bonding

### Lesson: Lesson 1: Formation and Properties of Ions

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### Essential Questions:   
- \*\*How are ions formed, and what role do they play in chemical bonding?\*\*   
  
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### 1. Big Idea:   
The formation of ions is essential for understanding ionic bonding, which plays a critical role in determining the properties of compounds.   
  
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### 2. Essential Questions:   
These questions will drive the lesson and encourage critical thinking:   
- \*\*How are ions formed, and what role do they play in chemical bonding?\*\*   
  
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### 3. Phenomenon-Based Learning:   
  
- \*\*Unit Phenomenon: Danger! Icy Roads\*\*   
 In cold climates, salt is spread on icy roads to help melt the ice and snow. The salt dissolves in the water, but metal street signs and lampposts remain unaffected by the water. Why does salt dissolve while metal does not?   
  
- \*\*Chapter Phenomenon: Salt vs. Metal—Why Does Water Treat Them Differently?\*\*   
 Salt dissolves in water when spread on icy roads, whereas metals like street signs do not. This lesson will explore why salt, made of ions, interacts with water differently from metals, which do not form ions in the same way.   
  
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### 4. Vocabulary:   
Key terms to support the lesson:   
- \*\*Octet Rule\*\*: Atoms are more stable when they have eight electrons in their outer shell.   
- \*\*Anion\*\*: A negatively charged ion.   
- \*\*Cation\*\*: A positively charged ion.   
- \*\*Electrolyte\*\*: A substance that forms ions in a solution and can conduct electricity.   
- \*\*Electron Affinity\*\*: The energy change when an atom gains an electron.   
- \*\*Ionic Radius\*\*: The size of an ion, which can change depending on whether the ion is positive or negative.   
- \*\*Ionization\*\*: The process of gaining or losing electrons to form an ion.   
  
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### 5. SMART Objectives:   
By the end of this lesson, students will be able to:   
1. \*\*Describe how ions are formed\*\* by gaining or losing electrons.   
2. \*\*Write the symbols and charges of ions\*\* for common elements.   
3. \*\*Predict the charge of an ion\*\* based on its position on the periodic table.   
  
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### 6. Engage (Ignite):   
  
\*\*Phenomenon-Related Question\*\*:   
- \*\*Why does salt dissolve in water, but metal street signs do not?\*\*   
  
\*\*Hands-on Experiment: Salt Dissolution vs. Metal Reaction\*\*   
  
\*\*Objective\*\*: Demonstrate how salt (sodium chloride) dissolves in water, forming ions, while a piece of metal does not dissolve.   
  
\*\*Materials\*\*:   
- Table salt (NaCl)   
- Piece of metal (iron nail or aluminum foil)   
- Two beakers of water   
- Stirring rod   
  
\*\*Procedure\*\*:   
1. Add one teaspoon of salt (NaCl) to one beaker of water. Stir the solution and observe.   
2. Place a metal object (nail or aluminum foil) into the second beaker of water. Stir and observe.   
  
\*\*Follow-Up Questions\*\*:   
1. What happened when salt was added to the water?   
2. Did the metal dissolve in the water? Why or why not?   
3. Based on your observations, how do you think ions are involved in dissolving salt?   
  
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### 7. Pre-Explore (Direct Instruction):   
  
\*\*Background Information\*\*:   
- \*\*Ions\*\* are atoms or molecules that have gained or lost electrons, giving them a positive or negative charge.   
- \*\*Cations\*\* are positively charged ions, formed when atoms lose electrons (e.g., sodium ion Na⁺).   
- \*\*Anions\*\* are negatively charged ions, formed when atoms gain electrons (e.g., chloride ion Cl⁻).   
- The \*\*Octet Rule\*\* helps explain why atoms form ions. Atoms "want" to have a full outer shell of electrons, usually eight. To achieve this, they either lose or gain electrons.   
  
\*\*Interactive Elements\*\*:   
- Discuss the \*\*periodic table\*\* and how the position of an element can predict whether it will form a cation or anion.   
- Ask students: "Why do you think sodium (Na) forms a cation, while chlorine (Cl) forms an anion?"   
  
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### 8. Evaluate (Progress Check) - Pre-Explore:   
  
\*\*Scaffolded Questions\*\*:   
1. What is a cation, and how is it formed? (DOK 1)   
2. Why does chlorine form an anion instead of a cation? (DOK 2)   
3. How does the periodic table help predict the charge of an ion? (DOK 3)   
  
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### 9. Explore (Pathfinder):   
  
\*\*Activity\*\*: "Predicting Ion Charges with the Periodic Table"   
  
\*\*Objective\*\*: Use the periodic table to predict the charges of ions for different elements.   
  
\*\*Materials\*\*:   
- Periodic tables   
- Worksheet with a list of elements   
  
\*\*Procedure\*\*:   
1. Look at the periodic table and identify the group number for each element on the worksheet.   
2. Use the group number to predict whether the element will form a cation or anion, and determine its charge.   
  
\*\*Discussion\*\*:   
- Why do elements in Group 1 always form +1 cations? Why do elements in Group 17 form -1 anions?   
- Compare your predictions with your peers.   
  
\*\*Retrieval Practice\*\*:   
- Quiz: "Match the element with its ion charge."   
  
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### 10. Explain (Lightbulb)   
  
\*\*Comprehensive Explanation of Key Concepts\*\*:   
  
1. \*\*How Ions Are Formed\*\*   
Ions are formed when atoms gain or lose electrons. This process is called \*\*ionization\*\*. If an atom loses electrons, it becomes a \*\*cation\*\*. If it gains electrons, it becomes an \*\*anion\*\*. The driving force behind ion formation is the \*\*Octet Rule\*\*—atoms are more stable when they have eight electrons in their outer shell. For example, sodium (Na) has one electron in its outer shell. By losing that one electron, sodium achieves a full outer shell, becoming a Na⁺ ion.   
  
2. \*\*Symbols and Charges of Ions\*\*   
The symbol for an ion includes the element’s symbol with a superscript showing the charge. For example:   
- Sodium ion: Na⁺   
- Chloride ion: Cl⁻   
  
The charge indicates how many electrons were lost or gained. If an atom loses one electron, it becomes a +1 ion. If it gains two electrons, it becomes a -2 ion.   
  
3. \*\*Predicting Ion Charges Using the Periodic Table\*\*   
The periodic table is a powerful tool for predicting the charges of ions. Elements in the same group (vertical column) tend to form ions with the same charge.   
- \*\*Group 1 elements\*\* (like sodium) always form +1 cations.   
- \*\*Group 2 elements\*\* (like magnesium) form +2 cations.   
- \*\*Group 17 elements\*\* (like chlorine) form -1 anions.   
  
4. \*\*Real-World Example: Road Salt and Ions\*\*   
When road salt (NaCl) is spread on icy roads, it dissolves in water. The sodium ions (Na⁺) and chloride ions (Cl⁻) separate in the water, allowing the ice to melt more easily. This is because the ions disrupt the structure of ice, lowering its melting point. In contrast, metals like iron do not form ions easily in water, which is why street signs and lampposts do not dissolve in the same way.   
  
\*\*Solved Example\*\*:   
\*\*Problem\*\*: Predict the charge of an ion formed by magnesium (Mg).   
\*\*Solution\*\*: Magnesium is in Group 2 of the periodic table. Elements in Group 2 always lose two electrons and form +2 cations. Therefore, the charge of a magnesium ion is Mg²⁺.   
  
\*\*Practice Question\*\*:   
Predict the charge of the ion formed by aluminum (Al).   
  
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### 11. Evaluate (Progress Check) - Explain   
  
\*\*Scaffolded Questions\*\*:   
1. What is the charge of a potassium ion (K)? (DOK 1)   
2. How does the Octet Rule explain why chlorine forms a -1 ion? (DOK 2)   
3. Why do elements in Group 1 form +1 ions, while elements in Group 17 form -1 ions? (DOK 3)   
  
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### 12. Elaborate (Power Up):   
  
\*\*Mini-Task\*\*:   
- Research why certain ions (like calcium ions, Ca²⁺) are important for the human body. Explain what role these ions play in biological systems.   
  
\*\*Open-Ended Question\*\*:   
- How would road salt work differently if it were made of a metal that did not form ions in water?   
  
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### 13. Final Evaluation   
  
\*\*Debate Question\*\*:   
- Should cities continue to use road salt despite its potential environmental impact on plant life and water quality? What alternatives could be used?   
  
\*\*Assessment Questions\*\*:  
  
- \*\*Multiple-Choice Questions\*\*:   
1. What is the charge of a sodium ion?   
 a) +1   
 b) -1   
 c) +2   
 d) -2   
 \*\*Correct answer: a) +1\*\*   
  
2. Which of the following forms an anion?   
 a) Sodium   
 b) Magnesium   
 c) Chlorine   
 d) Calcium   
 \*\*Correct answer: c) Chlorine\*\*   
  
3. What is the term for the process of losing electrons?   
 a) Ionization   
 b) Electron affinity   
 c) Electrolyte formation   
 d) Cationization   
 \*\*Correct answer: a) Ionization\*\*   
  
4. Which group on the periodic table forms -1 anions?   
 a) Group 1   
 b) Group 2   
 c) Group 17   
 d) Group 18   
 \*\*Correct answer: c) Group 17\*\*   
  
- \*\*Long-Answer Questions\*\*:   
1. Explain how the Octet Rule helps predict the charge of ions formed by elements in Group 1 and Group 17.   
2. Describe why road salt dissolves in water but a metal nail does not.   
3. Predict the charge of an ion formed by sulfur (S) and explain your reasoning.   
4. How do ions help conduct electricity in a solution?   
  
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### 14. Extend (Beyond the Lesson) [Optional]:   
- Research alternatives to road salt that could reduce the environmental impact on plants and animals.   
- Create a poster explaining the importance of electrolytes in the human body and how ions play a role in maintaining health.