# Unit: Unit 2: Atomic Structure and Bonding

## Chapter: Chapter 6: Ionic and Metallic Bonding

### Lesson: Lesson 4: Metallic Bonding and Metal Characteristics

# Lesson Plan: \*\*Lesson 4: Metallic Bonding and Metal Characteristics\*\*  
  
\*Unit 2: Atomic Structure and Bonding\*   
\*Chapter 6: Ionic and Metallic Bonding\*  
  
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## Lesson Overview  
  
This lesson focuses on \*\*Metallic Bonding\*\* and the unique \*\*characteristics of metals\*\*. Students will explore how metallic bonding explains the properties of metals, such as \*\*malleability\*\*, \*\*ductility\*\*, \*\*conductivity\*\*, and \*\*luster\*\*. They will also analyze how the \*\*metallic lattice\*\* and the \*\*sea of electrons\*\* contribute to these properties.  
  
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## \*\*Lesson Objectives\*\*:   
By the end of the lesson, students will be able to:  
1. \*\*List the properties of metals\*\* (malleability, conductivity, etc.).  
2. \*\*Describe the formation of metallic bonds\*\* using the sea of electrons model.  
3. \*\*Analyze the relationship between the structure of metals\*\* (metallic lattice and sea of electrons) and their properties.  
  
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## \*\*Vocabulary\*\*:  
1. \*\*Boiling Point\*\*: The temperature at which a substance changes from a liquid to a gas.  
2. \*\*Conductivity\*\*: The ability of a material to allow heat or electricity to flow through it.  
3. \*\*Ductility\*\*: The ability of a material to be stretched into a wire.  
4. \*\*Luster\*\*: The way a metal reflects light, making it appear shiny.  
5. \*\*Malleability\*\*: The ability of a material to be hammered or rolled into thin sheets.  
6. \*\*Melting Point\*\*: The temperature at which a solid becomes a liquid.  
7. \*\*Metallic Lattice\*\*: The regular arrangement of positive metal ions surrounded by a sea of electrons.  
8. \*\*Sea of Electrons\*\*: A model where free electrons move throughout a metallic structure, allowing conductivity and other properties.  
9. \*\*Valence Electrons\*\*: Electrons in the outermost shell of an atom that are involved in bonding.  
  
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## \*\*Essential Question\*\*:  
- \*\*How does metallic bonding explain the unique properties of metals?\*\*  
  
### Answer:  
Metallic bonding involves a \*\*lattice of metal cations\*\* surrounded by a \*\*sea of free-moving electrons\*\*. This structure explains the unique properties of metals, such as their ability to conduct electricity (because the electrons can move freely), their malleability (because the metal atoms can slide over each other without breaking the bond), and their shiny luster (due to the interaction of light with the free electrons on the surface).  
  
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## \*\*Big Idea\*\*:  
\*\*Main Concept:\*\*   
Metals have unique properties due to the way their atoms bond with each other through metallic bonding.   
\*\*Subordinate Concept:\*\*   
The free movement of electrons in metals explains why they are malleable, ductile, conductive, and shiny.  
  
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## \*\*Phenomenon-Based Learning\*\*:  
  
### Unit Phenomenon:  
In cold northern countries, road salt is used to melt ice and snow on streets. While salt dissolves in water, metal street signs and lampposts remain intact, even though both are exposed to the same environment. Why do salt and metal behave so differently with water?  
  
### Chapter Phenomenon:  
Salt dissolves in water, but metals do not. Why does water treat these substances differently?  
  
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## \*\*SMART Objectives\*\*:  
1. \*\*Specific\*\*: Students will be able to list at least five properties of metals by the end of the lesson.  
2. \*\*Measurable\*\*: Students will describe the formation of metallic bonds in a written or oral explanation.  
3. \*\*Achievable\*\*: Through hands-on experiments and guided instruction, students will connect the structure of metals with their properties.  
4. \*\*Relevant\*\*: Understanding metallic bonding is key to explaining why metals are used in electrical wiring, construction, and everyday objects.  
5. \*\*Time-Based\*\*: Students will achieve the objectives within the 60-minute class period.  
  
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## \*\*Engage (Ignite)\*\*:  
  
### \*\*Phenomenon-Related Question\*\*:  
- \*\*Why don’t metal lampposts melt the snow like salt does?\*\*  
  
### \*\*Hands-On Experiment\*\*:   
\*\*Exploring Metal Conductivity and Malleability\*\*  
  
\*\*Materials\*\*:  
- Metal wire (copper or aluminum)  
- A small hammer  
- A piece of paper  
- A battery, lightbulb, and wires (to test conductivity)  
  
\*\*Procedure\*\*:  
1. \*\*Test Malleability\*\*: Place the metal wire on a solid surface and gently tap it with a hammer. Observe how the metal flattens but does not break.  
2. \*\*Test Conductivity\*\*: Connect the metal wire between the battery and the lightbulb using wires. Observe if the lightbulb lights up.  
3. \*\*Test Conductivity with Paper\*\*: Replace the metal wire with a strip of paper. Does the lightbulb light up?  
  
\*\*Follow-Up Questions\*\*:  
1. What happens to the metal wire when you hammer it? Does it break easily?  
2. Why does the lightbulb light up when the metal wire is used but not when you use the paper strip?  
3. How might this experiment connect to the properties of metals in everyday life?  
  
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## \*\*Pre-Explore (Direct Instruction)\*\*:  
  
### \*\*Background Information\*\*:  
\*\*Linking the Phenomenon to Metallic Bonds\*\*   
Metals, like the lampposts in the phenomenon, do not mix with water the same way salt does because they are held together by metallic bonds. These bonds form between \*\*metal atoms\*\* that release their \*\*valence electrons\*\*, creating a \*\*sea of electrons\*\*. This model explains why metals are shiny, can be bent without breaking, and conduct electricity.  
  
### \*\*Interactive Elements\*\*:   
- \*\*Discussion\*\*: How can the sea of electrons explain why metals conduct electricity?  
- \*\*Question\*\*: Why do you think metals are used in making wires and not other materials like paper?  
  
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## \*\*Evaluate (Progress Check) - Pre-Explore\*\*:  
  
### Scaffolded Questions:  
1. \*\*DOK 1\*\*: What are the valence electrons, and how do they relate to metallic bonding?  
2. \*\*DOK 2\*\*: Why do metals conduct electricity, while non-metals like paper do not?  
3. \*\*DOK 3\*\*: How does the structure of metals allow them to be both malleable and ductile?  
  
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## \*\*Explain (Lightbulb)\*\*:  
  
### \*\*Core Concepts: Metallic Bonding and Metal Properties\*\*  
  
#### \*\*1. The Structure of Metals: The Metallic Lattice\*\*  
Metals consist of \*\*positively charged ions\*\* arranged in a regular pattern, called a \*\*metallic lattice\*\*. Surrounding these ions is a “\*\*sea of electrons\*\*”—a group of electrons that are not tied to any one atom but move freely throughout the metal.  
  
- \*\*What is a metallic lattice?\*\*: The regular, repeating arrangement of metal ions in a solid form.  
- \*\*What is the sea of electrons?\*\*: A group of free-moving electrons that are shared among all the metal atoms.  
  
This structure allows metals to have many of the properties we observe:  
  
#### \*\*2. Properties of Metals Explained by Metallic Bonding\*\*  
  
- \*\*Luster\*\*: Metals are shiny because the free-moving electrons reflect light.  
   
 \*\*Sample Problem\*\*:   
 Why do metals have a shiny appearance?   
 \*\*Answer\*\*: The free electrons on the surface of metals interact with light, reflecting it, which gives metals their shiny or lustrous appearance.  
  
- \*\*Conductivity\*\*: Metals are good conductors of electricity because the electrons in the “sea” can move freely, carrying electrical charge.  
  
 \*\*Sample Problem\*\*:   
 Why do metals conduct electricity, while materials like paper do not?   
 \*\*Answer\*\*: In metals, the free electrons in the sea of electrons can move and carry electrical energy. In materials like paper, there are no free-moving electrons to carry the charge.  
  
- \*\*Malleability and Ductility\*\*: When a metal is hammered or stretched, the layers of atoms can slide over each other without breaking the bonds, thanks to the sea of electrons cushioning the movement.  
  
 \*\*Sample Problem\*\*:   
 Why can metals be hammered into sheets or drawn into wires without breaking?   
 \*\*Answer\*\*: In metals, the atoms can slide past each other while remaining bonded by the sea of electrons, making the metal malleable and ductile.  
  
#### \*\*3. Melting and Boiling Points of Metals\*\*  
Metals generally have high \*\*melting points\*\* and \*\*boiling points\*\* because a lot of energy is required to break the strong bonds between the positive metal ions and the sea of electrons.  
  
- \*\*What is a melting point?\*\*: The temperature at which a solid turns into a liquid.  
- \*\*What is a boiling point?\*\*: The temperature at which a liquid turns into a gas.  
  
\*\*Progress Check\*\*:   
Why do metals have high melting points?   
\*\*Answer\*\*: Metals have strong bonds between the metal ions and the sea of electrons, which requires a lot of energy to break apart, resulting in high melting points.  
  
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## \*\*Expand (Inquiry-Based Learning)\*\*:  
  
### \*\*Student Prompts\*\*:  
- Based on the experiment and what we have learned, why do you think metals are used in electrical wiring?  
- How does the "sea of electrons" model explain why metal street signs don't dissolve in water like salt does?  
  
### \*\*Expansion of Concepts\*\*:  
In the hands-on activity, students saw how metals conducted electricity, while paper did not. This is because of the \*\*free-moving electrons\*\* in metals, which can carry an electric charge. This same \*\*sea of electrons\*\* explains why metals are malleable and shiny.  
  
### \*\*Sample Problem\*\*:  
A student asks, “If metals are so strong, why don’t they break when we hammer them?”   
\*\*Answer\*\*: The metal atoms can slide past each other when hammered, but the sea of electrons keeps them bonded, making the metal malleable instead of brittle.  
  
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## \*\*Evaluate (Progress Check)\*\*:  
1. \*\*Why do metals conduct electricity?\*\*  
2. \*\*How does the metallic lattice structure explain the malleability of metals?\*\*  
3. \*\*What is the connection between the sea of electrons and the shiny appearance of metals?\*\*  
  
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## \*\*Conclusion\*\*:  
  
In this lesson, students learned that metals are unique because of the \*\*metallic bonds\*\* that hold them together. The \*\*sea of electrons\*\* explains why metals are \*\*conductive, malleable, ductile\*\*, and have \*\*luster\*\*. The structure of metals allows them to have high melting points and boiling points, making them useful in many everyday applications.  
  
### \*\*Exit Ticket\*\*:  
Write a short paragraph explaining how metallic bonding explains two properties of metals.  
  
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## \*\*Homework Assignment\*\*:  
1. Research one metal and describe how its properties make it useful in real-life applications. For example, why is copper used in electrical wires?  
  
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This lesson plan integrates interactive activities, discussions, and scaffolded learning to help students understand the \*\*formation of metallic bonds\*\* and how this explains the \*\*unique properties of metals\*\*. The hands-on experiment and real-world connections ensure a deep understanding of the content.  
  
### 10. Evaluate (Progress Check) - Explain  
  
\*\*Scaffolded Questions:\*\*  
  
1. \*\*Question (DOK 1 - Recall):\*\*   
 What is the atomic number of an element?  
 - \*\*Answer:\*\* The atomic number is the number of protons in the nucleus of an atom. It's unique to each element.  
  
2. \*\*Question (DOK 2 - Skill/Concept):\*\*   
 How does the atomic mass of an element differ from its atomic number?  
 - \*\*Answer:\*\* The atomic mass is the total number of protons and neutrons in an atom’s nucleus, while the atomic number only counts the protons.  
  
3. \*\*Question (DOK 3 - Strategic Thinking):\*\*   
 If two elements have the same atomic number but different atomic masses, what are these elements called, and how are they similar and different?  
 - \*\*Answer:\*\* These elements are called isotopes. They have the same number of protons (same atomic number) but different numbers of neutrons, leading to different atomic masses. Chemically, they behave similarly, but their physical properties, like stability and radioactivity, might differ.  
  
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### 11. Elaborate (Power Up)  
  
\*\*Mini-Tasks or Open-Ended Questions:\*\*  
  
1. \*\*Mini Task (DOK 2 - Skill/Concept):\*\*  
 Explore how the periodic table is organized. How do elements in the same group or family compare in terms of their properties?  
 - \*\*Answer:\*\* Elements in the same group (vertical column) have the same number of valence electrons, which gives them similar chemical behaviors. For example, Group 1 elements (alkali metals) are highly reactive and tend to lose one electron.  
  
2. \*\*Open-Ended Question (DOK 3 - Strategic Thinking):\*\*   
 Imagine you discovered a new element. Based on its atomic number and position in the periodic table, predict its chemical properties. How would you go about testing your predictions?  
 - \*\*Answer:\*\* The element’s chemical properties can be predicted based on its position in the periodic table. For example, if it’s in Group 2, it could be an alkaline earth metal, likely reactive and forming +2 ions. Testing could involve reacting it with water or acids to observe its reactivity, similar to other Group 2 elements like magnesium or calcium.  
  
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### 12. Final Evaluation  
  
\*\*Debate Question (DOK 4 - Extended Thinking):\*\*  
  
- \*\*Question:\*\* Should scientists use nuclear energy despite the potential risks of radiation and accidents?  
 - \*\*Arguments For:\*\* Nuclear energy is a highly efficient form of energy that produces very little environmental pollution compared to fossil fuels. It can provide large amounts of energy with fewer greenhouse gas emissions.  
 - \*\*Arguments Against:\*\* Nuclear energy poses significant risks, such as radioactive waste, potential for accidents (like Chernobyl or Fukushima), and high costs for safety measures and waste storage.  
  
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\*\*Assessment Questions:\*\*  
  
\*\*Multiple-Choice Questions (DOK 1-2):\*\*  
  
1. \*\*Question:\*\* What subatomic particles are found in the nucleus of an atom?   
 a) Electrons and neutrons   
 b) Protons and neutrons   
 c) Electrons and protons   
 d) Electrons only   
 - \*\*Answer:\*\* b) Protons and neutrons   
 - \*\*Explanation:\*\* The nucleus contains protons and neutrons, while electrons orbit around the nucleus.  
  
2. \*\*Question:\*\* Which element has 6 protons in its nucleus?   
 a) Oxygen   
 b) Nitrogen   
 c) Carbon   
 d) Hydrogen   
 - \*\*Answer:\*\* c) Carbon   
 - \*\*Explanation:\*\* The atomic number of carbon is 6, which means it has 6 protons.  
  
3. \*\*Question:\*\* What determines the chemical reactivity of an element?   
 a) The number of protons in the nucleus   
 b) The number of neutrons in the nucleus   
 c) The number of valence electrons   
 d) The number of isotopes   
 - \*\*Answer:\*\* c) The number of valence electrons   
 - \*\*Explanation:\*\* The number of valence electrons, which are the outermost electrons, determines how an atom interacts chemically with other atoms.  
  
4. \*\*Question:\*\* Which group in the periodic table contains highly reactive metals that easily lose one electron?   
 a) Group 1   
 b) Group 2   
 c) Group 17   
 d) Group 18   
 - \*\*Answer:\*\* a) Group 1   
 - \*\*Explanation:\*\* Group 1 elements are alkali metals, which are highly reactive and lose one electron to form positive ions.  
  
\*\*Long-Answer Questions (DOK 3-4):\*\*  
  
1. \*\*Question:\*\* Explain how the periodic table is arranged and the significance of its structure in understanding elements' properties.  
 - \*\*Answer:\*\* The periodic table is arranged by increasing atomic number. Elements are organized into groups (vertical columns) and periods (horizontal rows). Elements in the same group have similar properties because they have the same number of valence electrons. The periodic table helps predict the reactivity, atomic size, and other properties of elements based on their position.  
  
2. \*\*Question:\*\* Describe what isotopes are and give an example of how isotopes of an element are used in real life.  
 - \*\*Answer:\*\* Isotopes are atoms of the same element that have different numbers of neutrons but the same number of protons. An example is Carbon-14, an isotope of carbon used in carbon dating to determine the age of ancient objects.  
  
3. \*\*Question:\*\* How do valence electrons influence the way elements form chemical bonds?  
 - \*\*Answer:\*\* Valence electrons are the outermost electrons of an atom and are involved in forming chemical bonds. Atoms tend to gain, lose, or share valence electrons to achieve a stable electron configuration, often resembling the nearest noble gas configuration. For example, sodium (Na) loses one electron to form a bond with chlorine (Cl), which gains that electron, forming NaCl (table salt).  
  
4. \*\*Question:\*\* Compare and contrast ionic and covalent bonding, including examples of each.  
 - \*\*Answer:\*\* Ionic bonding occurs when one atom transfers electrons to another, resulting in the formation of charged ions. For example, sodium (Na) gives an electron to chlorine (Cl), forming Na+ and Cl-. Covalent bonding occurs when atoms share electrons, like in a water molecule (H2O), where hydrogen and oxygen share electrons to form bonds. Ionic bonds are typically stronger and occur between metals and non-metals, while covalent bonds occur between non-metals.  
  
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### 13. Extend (Beyond the Lesson)  
  
\*\*Additional Tasks and Readings:\*\*  
  
- \*\*Task 1:\*\* Research how elements like silicon (used in electronics) and rare earth elements (used in smartphones) are obtained and why they are important for modern technology.  
 - \*\*Purpose:\*\* To understand how chemistry is crucial in developing modern technology and the environmental impacts of mining these elements.  
  
- \*\*Task 2:\*\* Investigate a real-world application of isotopes in medicine, such as how iodine-131 is used in treating thyroid diseases.  
 - \*\*Purpose:\*\* To connect the concept of isotopes to real-world medical treatments and their importance in diagnostics and therapy.  
  
\*\*Opportunities for Spaced Practice:\*\*  
  
- \*\*Activity 1:\*\* Create flashcards for different groups on the periodic table, including key properties and examples of elements from each group.  
 - \*\*Purpose:\*\* Reinforce understanding of element groups and their properties over time.  
  
- \*\*Activity 2:\*\* Revisit periodic trends (like atomic radius or electronegativity) after a week and analyze how they correspond to the elements' positions on the periodic table.  
 - \*\*Purpose:\*\* Help students solidify their understanding of trends and how they apply to new elements they encounter.  
  
Each of these activities encourages students to explore the real-world applications of the concepts learned in the unit, ensuring deeper understanding and retention.