7.3 Bonding in Metals

**Essential Understanding** The characteristic properties of metals depend on the mobility of valence electrons among metal atoms.

**Reading Strategy**

**Cause and Effect** A cause and effect chart is a useful tool when you want to describe how, when, or why one event causes another. A cause is the reason something happens. The effect is what happens.

As you read Lesson 7.3, use the cause and effect chart below. Complete the chart to show how the mobility of electrons in a metal causes the properties of metals.

---

**Cause**

The sea of electrons in metals causes the characteristic properties of metals.

**Effects**

Property:

Because:

Property:

Because:

Property:

Because:

EXTENSION Draw a diagram that illustrates each effect in the chart.
Lesson Summary

Metallic Bonds and Metallic Properties The properties of metals are based on the attraction between stationary metal cations and the valence electrons that surround them.

- The valence electrons in metals surround metallic cations in what is called a sea of electrons.
- Properties of metals, such as conductivity, ductility, and malleability, are the result of these electrons being free to move from one part of the metal to another.
- Metal atoms are packed together tightly in crystalline structures.

Alloys Alloys are mixtures of elements, at least one of which is a metal.

- The composition of alloys can be varied to result in an alloy with desired properties.
- A widely used alloy is steel, which contains iron, carbon, and other metals.
- Alloys are either substitutional or interstitial, depending on how they form.

Metallic Bonds and Metallic Properties

1. Is the following sentence true or false? Metals are made up of cations and valence electrons, not neutral atoms. _________________

2. What are metallic bonds?

3. Name three properties of metals that can be explained by metallic bonding.
   a. _________________________________
   b. _________________________________
   c. _________________________________

4. What happens to an ionic crystal when a force is applied to it?

5. Metal atoms in crystals are arranged into very _________________ and orderly patterns.
6. Label each of the following arrangements of atoms with the correct name.

7. Circle the letter of each metal whose atoms form a face-centered cubic pattern.
   a. magnesium  
   b. copper  
   c. sodium  
   d. aluminum

Match the arrangement with the number of neighbors belonging to each atom in the arrangement.

8. body-centered cubic  
   a. 12

9. face-centered cubic  
   b. 8

10. hexagonal close-packed

Alloys
11. A mixture of two or more elements, at least one of which is a metal, is called a(n) 
   ____________________.

12. Is the following sentence true or false? Pure metals are usually harder and more durable 
    than alloys. ____________________

13. The most common use of nonferrous alloys is in ________________.

14. What four properties make steel an important alloy?
    a. ____________________
    b. ____________________
    c. ____________________
    d. ____________________
15. What are the component elements for the following alloys?
   a. sterling silver ________________________________
   b. brass ________________________________
   c. stainless steel ________________________________
   d. cast iron ________________________________

16. __________ alloys have smaller atoms that fit into the spaces between larger atoms. __________ alloys have component atoms that are roughly equal in size.

Guided Practice Problems

Use electron dot structures to determine formulas of the ionic compounds formed when
   a. potassium reacts with iodine.
   b. aluminum reacts with oxygen.

Potassium Reacts with Iodine

Analyze

Step 1. Is one of the elements a metal? If so, which one? __________

Step 2. Metal atoms __________ their valence electrons when forming ionic compounds. Nonmetal atoms __________ electrons when forming ionic compounds.

Solve

Step 3. Draw the electron dot structures for potassium and iodine.

potassium __________ 
iodine __________

Step 4. The metal atom, __________, must lose _______ electron(s) in order to achieve an octet in the next-lowest energy level. The nonmetal atom, __________, must gain _______ electron(s) in order to achieve a complete octet.

Step 5. Using electron dot structures, write an equation that shows the formation of the ionic compound from the two elements. Make sure that the electrons lost equals the electrons gained.

Step 6. The chemical formula for the ionic compound formed is _____.

Aluminum Reacts with Oxygen
Analyze

Step 1. Is one of the elements a metal? If so, which one? ________________

Step 2. Metal atoms ________________ valence electrons when forming ionic compounds. Nonmetal atoms ________________ electrons when forming ionic compounds.

Solve

Step 3. Draw the electron dot structures for aluminum and oxygen.

aluminum ________________  oxygen ________________

Step 4. The metal atom, ________________, must lose ____ electron(s) in order to achieve an octet in the next-lowest energy level. The nonmetal atom, ________________, must gain ____ electron(s) in order to achieve a complete octet.

Step 5. Using electron dot structures, write an equation that shows the formation of the ionic compound from the two elements. Make sure that the electrons lost equals the electrons gained.

Step 6. The chemical formula for the ionic compound formed is ________________.

Apply the Big idea

Sodium is a very reactive element. It can make compounds with elements from Groups 5, 6, and 7. Draw electron dot diagrams of compounds made with sodium as the cation and elements from Groups 5, 6, and 7 as the anions. How do they differ?
For Questions 1–9, complete each statement by writing the correct word or words. If you need help, you can go online.

7.1 Ions
1. The __________________________ of a representative element is also the number of valence electrons it has.

2. When an atom loses one or more valence electrons, it becomes a ________________ charged ion, also known as a(n) ________________.

3. When an atom gains one or more valence electrons, it becomes a ________________ charged ion, also known as a(n) ________________.

7.2 Ionic Bonds and Ionic Compounds
4. Ionic compounds are composed of positive and negative ions, but the compounds themselves are electrically ________________.

5. At room temperature, most ionic compounds are ____________________________.

6. In general, ionic compounds have __________________________ melting points.

7. Ionic compounds exhibit the property of electrical __________________________ when they are melted or in an aqueous solution.

7.3 Bonding in Metals
8. In a pure metal, the __________________________ can be modeled as a sea of electrons.

9. The properties of alloys are often __________________________ to the properties of the elements they contain.
Review Vocabulary

Write the meaning of each vocabulary term below. Then invent a method that will help you remember the meaning of the terms. One has been done for you.

<table>
<thead>
<tr>
<th>Vocabulary</th>
<th>Meaning</th>
<th>How I’m going to remember the meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>formula unit</td>
<td>shows what anions and cations are in an ionic compound and the simplest ratio of these ions</td>
<td>formula unit - “for” showing ions and ratio simply, e.g., NaCl</td>
</tr>
<tr>
<td>ionic bond</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ionic compound</td>
<td></td>
<td></td>
</tr>
<tr>
<td>metallic bond</td>
<td></td>
<td></td>
</tr>
<tr>
<td>valence electron</td>
<td></td>
<td></td>
</tr>
<tr>
<td>chemical formula</td>
<td></td>
<td></td>
</tr>
<tr>
<td>electron dot formula</td>
<td></td>
<td></td>
</tr>
<tr>
<td>halide ion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>coordination number</td>
<td></td>
<td></td>
</tr>
<tr>
<td>alloy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>octet rule</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>