Chemistry Chapter 7
Questions on Pages 225-226
2 points

Name: ______________________

Date: ______________ Hour: ______

Read the passage on the back of this worksheet taken from pages 225-226 of Glencoe *Chemistry: Matter and Change* (2008) and answer the following questions:

1. What is the minimum number of valence electrons that all metals have? ____________
2. What is meant by the term *electron sea model*? ______________________________

   ______________________________________________________________

   ______________________________________________________________
3. What is a delocalized electron? ______________________________________

   ______________________________________________________________
4. Looking at Figure 7.11, how are metal atoms held together? ____________________

   ______________________________________________________________
5. Which metal is a liquid at room temperature? ____________________________
6. Which element in Table 7.12 has the lowest melting point? ____________________
7. Which element in Table 7.12 has the highest boiling point? ____________________
8. Why are boiling points for metals much higher than the melting points? ____________

   ______________________________________________________________

   ______________________________________________________________
9. Metals are malleable. What does that mean? ______________________________

   ______________________________________________________________
10. Metals are ductile. What does that mean? ______________________________

    ______________________________________________________________
11. Why are metals good conductors? ______________________________________

    ______________________________________________________________
12. Why do metals have the property of luster? ______________________________

    ______________________________________________________________
13. Why are transition metals harder than other metals? ______________________

    ______________________________________________________________
14. According to Figure 7.12, why are metals malleable and ductile? ________________

    ______________________________________________________________

# Metallic Bonds and the Properties of Metals

**MAIN Idea** **Metals form crystal lattices and can be modeled as cations surrounded by a "sea" of freely moving valence electrons.**

**Real-World Reading Link** Imagine a buoy in the ocean, bobbing by itself surrounded by a vast expanse of open water. Though the buoy stays in the same area, the ocean water freely flows past. In some ways, this description also applies to metallic atoms and their electrons.

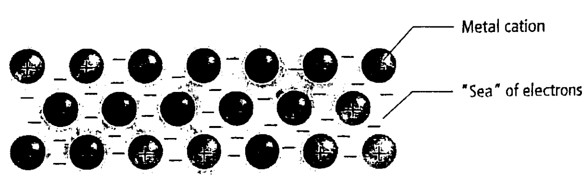
## Metallic Bonds

Although metals are not ionic, they share several properties with ionic compounds. The bonding in both metals and ionic compounds is based on the attraction of particles with unlike charges. Metals often form lattices in the solid state. These lattices are similar to the ionic crystal lattices discussed earlier. In such a lattice, 8 to 12 other metal atoms closely surround each metal atom.

**A sea of electrons** Although metal atoms always have at least one valence electron, they do not share these valence electrons with neighboring atoms, nor do they lose their valence electrons. Instead, within the crowded lattice, the outer energy levels of the metal atoms overlap. This unique arrangement is described by the electron sea model. The **electron sea model** proposes that all the metal atoms in a metallic solid contribute their valence electrons to form a "sea" of electrons. This sea of electron surrounds the metal cations in the lattice.

The electrons present in the outer energy levels of the bonding metallic atoms are not held by any specific atom and can move easily from one atom to the next. Because they are free to move, they are often referred to as **delocalized electrons.** When the atom's outer electrons move freely throughout the solid, a metallic cation is formed. Each such ion is bonded to all neighboring metal cations by the sea of valence electrons, as shown in **Figure 7.11.** A **metallic bond** is the attraction of a metallic cation for delocalized electrons.

■ **Figure 7.11** The valence electrons in metals (shown as a blue cloud of minus signs) are evenly distributed among the metallic cations (shown in red). Attractions between positive cations and the negative "sea" hold the metal atoms together in a lattice.
**Explain** *Why are electrons in metals known as delocalized electrons?*




| Table 7.12 Melting and Boiling Points | | |
|---|---|---|
| Element | Melting Point (°C) | Boiling Point (°C) |
| Lithium | 180 | 1347 |
| Tin | 232 | 2623 |
| Aluminum | 660 | 2467 |
| Barium | 727 | 1850 |
| Silver | 961 | 2155 |
| Copper | 1083 | 2570 |

**Properties of metals** The physical properties of metals can be explained by metallic bonding. These properties provide evidence of the strength of metallic bonds.

**Melting and boiling points** The melting points of metals vary greatly. Mercury is a liquid at room temperature, which makes it useful in scientific instruments such as thermometers and barometers. On the other hand, tungsten has a melting point of 3422°C. Lightbulb filaments are usually made from tungsten, as are certain spacecraft parts.

In general, metals have moderately high melting points and high boiling points, as shown in **Table 7.12.** The melting points are not as extreme as the boiling points because the cations and electrons are mobile in a metal. It does not take an extreme amount of energy for them to be able to move past each other. However, during boiling, atoms must be separated from the group of cations and electrons, which requires much more energy.

**Malleability, ductility, and durability** Metals are malleable, which means they can be hammered into sheets, and they are ductile, which means they can be drawn into wire. **Figure 7.12** shows how the mobile particles involved in metallic bonding can be pushed or pulled past each other. Metals are generally durable. Although metallic cations are mobile in a metal, they are strongly attracted to the electrons surrounding them and are not easily removed from the metal.

**Thermal conductivity and electrical conductivity** The movement of mobile electrons around positive metallic cations makes metals good conductors. The delocalized electrons move heat from one place to another much more quickly than the electrons in a material that does not contain mobile electrons. Mobile electrons easily move as part of an electric current when an electric potential is applied to a metal. These same delocalized electrons interact with light, absorbing and releasing photons, thereby creating the property of luster in metals.

**Hardness and strength** The mobile electrons in transition metals consist not only of the two outer s electrons but also of the inner d electrons. As the number of delocalized electrons increases, so do the properties of hardness and strength. For example, strong metallic bonds are found in transition metals such as chromium, iron, and nickel, whereas alkali metals are considered soft because they have only one delocalized electron, $ns^1$.

**Reading Check** **Contrast** the behavior of metals and ionic compounds when each is struck by a hammer.

■ **Figure 7.12** An applied force causes metal ions to move through delocalized electrons, making metals malleable and ductile.