

## CHAPTER 8 Chemical Bonding

SECTION  
3

## Covalent and Metallic Bonds

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- How are covalent bonds formed?
- What are molecules?
- What are metallic bonds?
- How does bonding affect a metal's properties?



California Science Standards

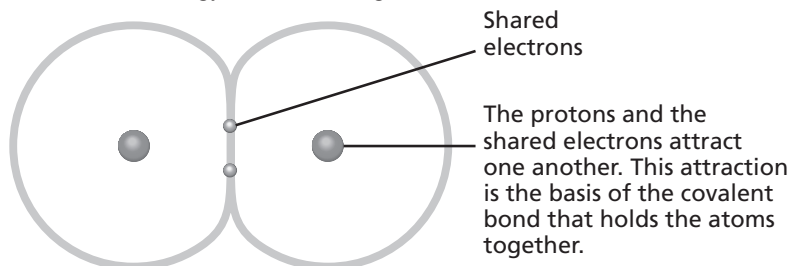
8.3.a, 8.3.b

**What Are Covalent Bonds?**

Another type of bond is a covalent bond. A **covalent bond** forms when atoms share electrons. Covalent bonds most often form between atoms of nonmetals. Remember that most nonmetals can fill the outermost energy level by gaining an electron. When a covalent bond forms, both atoms are able to fill their outermost energy level. They do this by sharing electrons between the two atoms. ✓

Hydrogen is one example of an atom that bonds covalently. A hydrogen atom has one electron in its outermost level. Two hydrogen atoms can come together and share their electrons. This fills the first energy level of both atoms. The electrons move around both hydrogen nuclei. The protons and the shared electrons attract one another. This attraction holds the atoms together.

By sharing electrons in a covalent bond, each hydrogen atom (the smallest atom) has a full outermost energy level containing two electrons.

**What Are Molecules?**

Atoms that join with each other by covalent bonds form particles called **molecules**. Most molecules are made of atoms of two or more elements. The atoms share electrons. In the figure above, two hydrogen atoms have formed a covalent bond. The result is a hydrogen molecule. ✓

**STUDY TIP**

**Compare** As you read, make a chart comparing covalent bonds and metallic bonds.

**READING CHECK**

**1. Explain** How do electrons behave in covalent bonds?

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**READING CHECK**

**2. Identify** What type of bond joins the atoms in molecules?

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**SECTION 3** Covalent and Metallic Bonds *continued***PROPERTIES OF MOLECULES**

Remember that an atom is the smallest piece of an element that still has the properties of that element. In the same way, a molecule is the smallest piece of a covalently bonded compound that has the properties of that compound. This means that if a molecule is broken down, it will no longer have the properties of that compound.

Most covalently bonded substances have low melting and boiling points. (Water is an exception to this.) Many are gases at room temperature. When a substance with covalent bonds forms a solid, the solid tends to be soft.

**How Can You Model a Covalent Bond?**

An *electron-dot diagram* is a model that shows only the valence electrons of an atom. The figure below shows the electron-dot diagrams for the elements in the second row of the periodic table.

Electron-Dot Diagrams	Li·	Be·	B·	·C·	·N·	·O·	·F·	·Ne·
	Li·	Be·	B·	·C·	·N·	·O·	·F·	·Ne·

**TAKE A LOOK****3. Apply Concepts**

Hydrogen has one valence electron. Draw an electron-dot diagram of a hydrogen atom.

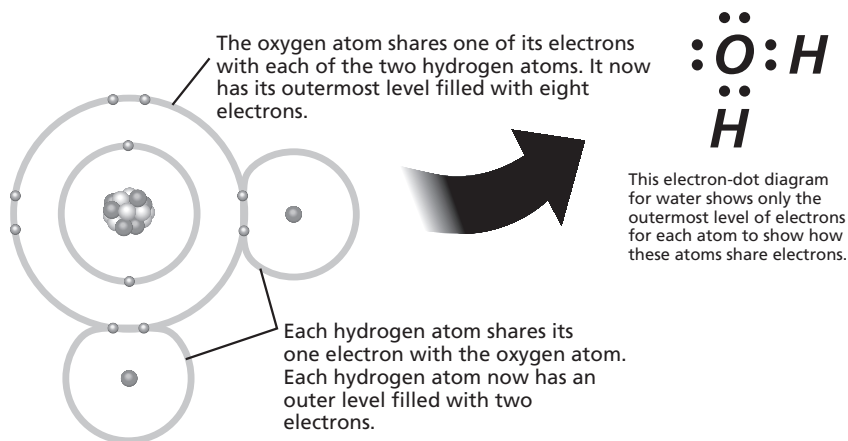
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Electron-dot diagrams are used to show how atoms bond in molecules. In the diagram below, you can see the pairs of electrons that form the covalent bonds in a water molecule.

**Critical Thinking**

**4. Apply Concepts** Draw the electron-dot diagram that shows how two hydrogen atoms bond with a covalent bond.

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**SECTION 3** Covalent and Metallic Bonds *continued***What Kinds of Molecules Can Form?**

Molecules contain at least two atoms bonded by covalent bonds. The simplest molecules are made up of only two bonded atoms. They are called *diatomic molecules*. If the two atoms are of the same element, the substance is known as a *diatomic element*. The oxygen and nitrogen in the air that we breathe are both diatomic elements. ✓

In a molecule of any diatomic element, each of the shared electrons is counted as a valence electron for both atoms. So, both atoms of the molecule have filled outermost energy levels.

**Electron-Dot Diagrams for Chlorine, Oxygen, and Nitrogen Gas****COUNTING COVALENT BONDS**

We have seen how atoms can share one or more pairs of electrons. The oxygen atom in water shares two pairs of electrons, one pair with each hydrogen atom. We say that the oxygen atom in a water molecule forms two covalent bonds.

The number of shared pairs of electrons tells you the number of covalent bonds in a molecule. In the figure above, you counted the number of electron pairs shared in molecules of chlorine, oxygen, and nitrogen. In a chlorine molecule, there is one covalent bond. There are two covalent bonds in an oxygen molecule and three in a nitrogen molecule.

Many molecules are more complex than the molecules in the figure. As you may suspect, these molecules have many covalent bonds.

**READING CHECK**

**5. Identify** What type of molecule is made of two of the same atom?

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**TAKE A LOOK**

**6. Count** How many electrons are around each chlorine atom, each oxygen atom, and each nitrogen atom? (Remember, the electrons that are shared count for each atom.)

**Chlorine:** \_\_\_\_\_

**Oxygen:** \_\_\_\_\_

**Nitrogen:** \_\_\_\_\_

**7. Count** How many pairs of electrons are shared in each molecule?

**Chlorine:** \_\_\_\_\_

**Oxygen:** \_\_\_\_\_

**Nitrogen:** \_\_\_\_\_

**Critical Thinking**

**8. Apply Concepts** How many covalent bonds does phosphorus (P) form in the molecule shown below:



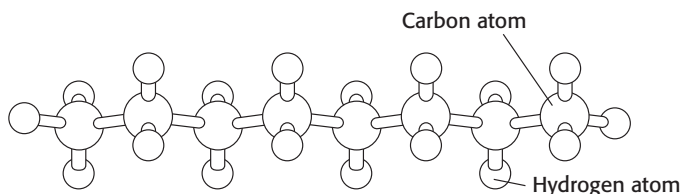
**SECTION 3** Covalent and Metallic Bonds *continued*

**MORE COMPLEX MOLECULES**

Many molecules are much larger and more complex than diatomic molecules or water. Complex molecules have many atoms joined by covalent bonds. Complex molecules make up many important and familiar substances, such as gasoline, soap, plastics, proteins, and sugars. In fact, most of the substances that make up your body are complex molecules!

Carbon (C) atoms are the basis of many complex molecules. Carbon has four valence electrons. To fill its outer energy level, a carbon atom needs to gain four electrons. Therefore, carbon atoms can form four covalent bonds. Carbon atoms can form bonds with other carbon atoms. They also can bond to atoms of other elements, such as oxygen, hydrogen, and nitrogen. Most of the molecules that carbon forms are very complex.

**Model of an Octane Molecule Found in Gasoline**



**TAKE A LOOK**

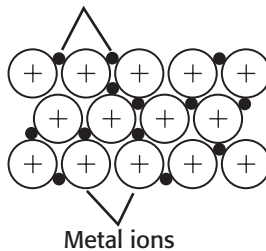
**9. Count** How many covalent bonds does an atom of carbon form in this molecule?

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**What Are Metallic Bonds?**

The bonding in metals is different from the bonding we have discussed. Metals are substances like copper, iron, silver, and nickel. A **metallic bond** is a bond formed by the attraction between positively charged metal ions and the electrons around the ions. ✓

Valence electrons from outer shells of metal atoms



The bonding in metals is a result of the closeness of many metal atoms. Their outermost energy levels overlap. Because of the overlapping, metallic bonds form and extend throughout the metal in all directions. The valence electrons can move throughout the metal. The electrons keep the ions together and cancel the positive charge of the ions. ✓

**READING CHECK**

**10. Describe** How is a metallic bond formed?

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**READING CHECK**

**11. Explain** How do valence electrons behave in a metallic bond?

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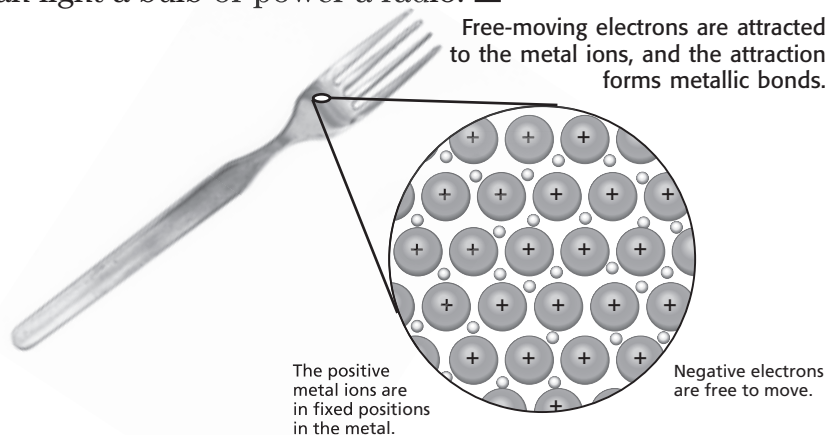
**SECTION 3** Covalent and Metallic Bonds *continued*

## What Are the Properties of Metals?

You probably know whether something is metal as soon as you look at it. Most metals are very shiny like gold, silver, copper, nickel, and platinum. Metals have other characteristic properties, too.

### CONDUCTING ELECTRIC CURRENT

Metallic bonding allows metals to conduct electricity. Metals are used to make wires. When one end of the wire is attached to an electrical source, the valence electrons are free to move throughout the wire and do work. They can light a bulb or power a radio. ✓



✓ **READING CHECK**

**12. Explain** Why can a wire conduct an electric current when it is connected to an electrical source?

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### RESHAPING METALS

The atoms in metals can be rearranged easily because the electrons move around freely. The valence electrons of metals are constantly moving around the metal ions. This movement maintains the metallic bonds. So, no matter how the shape of the metal is altered, it won't break. This is why metals can so easily change their shape. Two properties describe a metal's ability to be reshaped:

- *Ductility* is the ability to be shaped into long, thin wires.
- *Malleability* is the ability to be hammered into thin sheets. ✓

Ductility and malleability are the properties that make many metals useful for people. Copper can be stretched to make electrical wires. Aluminum can be pounded to form sheets of foil. Silver and gold can be mixed with other metals and bent to form jewelry and fill cavities in teeth.

✓ **READING CHECK**

**13. Define** What does ductility mean? What does malleability mean?

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# Section 3 Review

8.3.a, 8.3.b 

## SECTION VOCABULARY

<p><b>covalent bond</b> a bond formed when atoms share one or more pairs of electrons</p> <p><b>metallic bond</b> a bond formed by the attraction between positively charged metal ions and the electrons around them</p>	<p><b>molecule</b> a group of atoms that are held together by chemical forces; a molecule is the smallest unit of matter that can exist by itself and retain all of a substance's chemical properties</p>
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**1. Apply Ideas** The following is a list of elements: gold, carbon, oxygen, aluminum, copper, and fluorine. In the table below, list each under the correct heading.

Forms covalent bonds	Forms metallic bonds

**2. Apply Concepts** Nitrogen has five valence electrons, and hydrogen has one. An ammonia molecule has one nitrogen atom and three hydrogen atoms. Draw an electron-dot diagram for a molecule of ammonia.

**3. Apply Concepts** In addition to conducting electricity, metals conduct heat quickly. Substances with covalent bonds are not good conductors of heat or electricity. Which type of substance would you use as insulating material for a hot mitt?

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Which type of substance would you use as a heating coil in an electric toaster?

**4. Make Inferences** What happens to the properties of oxygen when oxygen bonds with hydrogen to form water?

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**5. Identify** List three properties of metals that are caused by metallic bonding.

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