

## section 2 Types of Bonds

### What You'll Learn

- what ionic bonds and covalent bonds are
- what particles are produced by ionic and covalent bonding
- about polar and nonpolar covalent bonds

### Mark the Text

### Locate Information

Underline every heading in the section that asks a question. Then, highlight the answers to those questions as you find them.

### Reading Check

1. **Explain** What is a compound?

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### Before You Read

Some atoms share electrons and become more stable. Describe a situation in which people share something and everyone benefits.

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### Read to Learn

#### Gain or Loss of Electrons

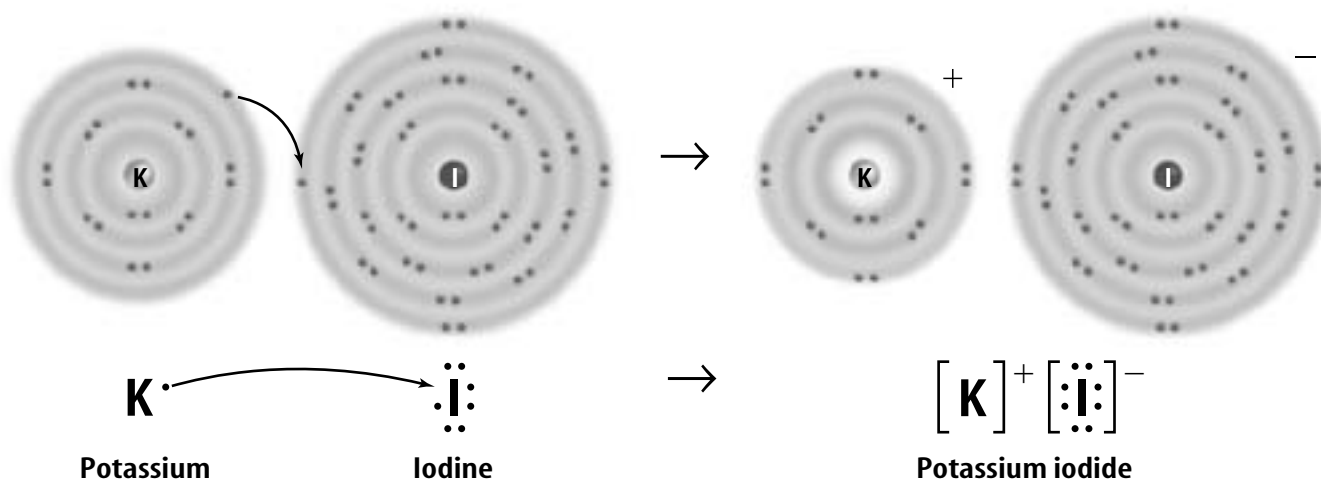
Imagine that you and a friend decide to go to the movies. You find out that you do not have enough money to buy a ticket. But your friend has enough money for both of you and loans you the money. Now you both have enough money to get tickets to go to the movies.

Just as a friend can loan you money, atoms can loan electrons to other atoms. Atoms loan electrons so both can reach a stable energy level. When atoms gain, lose, or share electrons, an attraction forms between the atoms. The atoms are pulled together to form a compound. The attraction creates a bond that joins the atoms.

A compound is completely different from the atoms that make it up. A compound has different physical and chemical properties from the atoms that are in it. A compound is two or more atoms bonded together.

#### What are some common compounds?

**Ions** form when atoms gain or lose electrons and become changed particles with more or less electrons than protons. Many common compounds are formed by the loss or gain of just one electron. These compounds are made from a Group 1 element, such as sodium, and a Group 17 element, such as chlorine. Examples are sodium chloride, also known as table salt, and potassium iodide, an ingredient in iodized salt.



### How is potassium iodide formed?

What happens when potassium and iodine bond to form potassium iodide? The figure above shows the electron dot diagrams and electron distribution for this process.

An atom of potassium has one electron in its outer level. This is not a stable outer energy level. When a potassium atom combines with an iodine atom, the potassium atom loses the one electron in its outer level. The third energy level now becomes a complete outer level. The potassium atom now has one less electron than it has protons. The positive and negative charges are no longer equal. Recall that an ion is a charged particle that is formed when an atom gains or loses electrons. The potassium atom is now a positive ion. It has more protons with positive charges than electrons with negative charges.

The potassium ion has a 1+ charge. The symbol for a positive potassium ion is  $K^+$ . The plus sign shows its positive charge. In the symbol  $K^+$ , the plus sign is a superscript. *Superscript* means “written above.”

### How does the iodine atom change?

The iodine atom also changes when it combines to form potassium iodide. An iodine atom has seven electrons in its outer energy level. A stable outer energy level has eight electrons. When the iodine atom reacts with the potassium atom, the iodine atom gains one electron from potassium. There are now eight electrons in iodine’s outer energy level.

The iodine atom now has a stable outer energy level, but it has one more electron than it has protons. It has more negative particles than positive particles. The iodine atom has become a negative ion with a charge of 1-. Now it is called an iodide ion and its symbol is written as  $I^-$ .

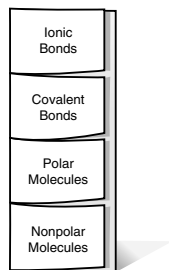
### Picture This

- Describe** How many electrons are there in potassium’s outer energy level *after* the bond has formed?

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**B Build Vocabulary**

Make a Foldable like the one below. As you read this section, add the definitions of ionic bonds, covalent bonds, polar molecules, and nonpolar molecules to your Foldable.



**Picture This**

**3. Think Critically** Explain why magnesium chloride cannot be made from one atom of magnesium and one atom of chlorine.

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**Ionic Compounds**

An ionic compound forms when two or more ions combine. Notice that the ionic compound potassium iodide does not have a charge. The 1+ charge and the 1- charge cancel each other out. This means the compound is neutral or has a neutral charge.

**The Ionic Bond**

Atoms that lack electrons in their outer energy level seem to send out messages to attract atoms that will complete their outer energy levels, and vice versa. A bond forms when ions attract each other and form a compound. An **ionic bond** is the force of attraction between a positive ion and a negative ion in an ionic compound.

In an ionic compound, one atom gives up electrons and the other atom takes them. Electrons are not shared in ionic compounds. When an atom loses electrons, one or more atoms must gain the same number of electrons that were lost. That way, the compound stays neutral. When atoms form an ionic compound, a large amount of energy is released. This occurs because of the transfer of electrons.

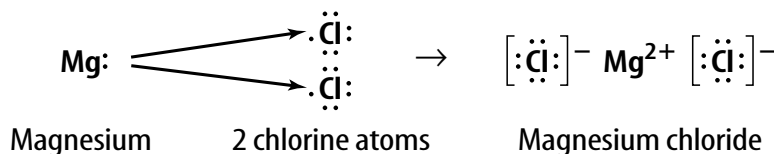
**What if many electrons are transferred?**

Potassium iodide forms an ionic bond when one electron is transferred. What happens when more than one electron is transferred? The figure below shows the formation of another ionic compound, magnesium chloride, MgCl<sub>2</sub>.

When magnesium reacts with chlorine, a magnesium atom loses the two electrons in its outer energy level. The atom becomes a positively charged magnesium ion. The symbol for this ion is Mg<sup>2+</sup> because it has lost two electrons and now has a charge of 2+.

Two chlorine atoms each take one of the electrons and complete their outer levels. Each chlorine atom becomes an ion with a 1- charge. Cl<sup>-</sup> is the symbol for the chloride ion.

In this case, the magnesium atom has two electrons to give. However, a chlorine atom can only use one electron. So, it takes two chlorine atoms to receive the two electrons from the magnesium atom and combine to form the ionic compound magnesium chloride.



## Does an ionic compound have a charge?

The ionic compound magnesium chloride is neutral. It does not have a charge. The compound is neutral because the sum of the charges on the ions is zero. The 2+ charge on the magnesium ion is equal to two 1- charges on the chloride ions. When different atoms form an ionic compound, they transfer their electrons. The total number of electrons and protons stays the same. The compound is neutral. ✓

Metals and nonmetals usually combine by forming ionic compounds. Elements on the far left side of the periodic table tend to form ionic bonds with elements on the far right. Ionic compounds are often crystalline solids with high melting points.

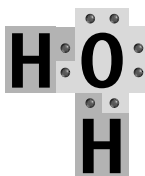
## Sharing Electrons

Some atoms of nonmetal elements become more stable when they share electrons. Look at the elements in Group 14 of the periodic table. These elements have four electrons in their outer levels. They would have to gain or lose four electrons to have a stable outer energy level. It takes a lot of energy for an atom to lose or gain that many electrons. Each time an atom loses an electron, the nucleus holds the remaining electrons even more tightly. Once one electron is removed, it takes more energy to remove a second electron. It takes even more energy to remove a third, and so on. For elements in Group 14, it is much easier for them to become stable by sharing electrons.

Atoms that share electrons form a covalent bond. A **covalent bond** is the force of attraction between two atoms that share electrons. A **molecule** is the neutral particle that forms when atoms share electrons.

## How are single covalent bonds formed?

A single covalent bond forms when two atoms share two electrons. Usually one electron comes from each atom in the covalent bond. Look at the water molecule in the figure. There are two single covalent bonds in a water molecule. In each single bond, a hydrogen atom and an oxygen atom each give one electron, which the atoms share.



Recall that ionic bonds help atoms become more stable by filling their outer energy levels. Covalent bonds also help atoms fill their outer energy levels and become more stable.

### ✓ Reading Check

4. **Explain** Why is the ionic compound magnesium chloride neutral?

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## Picture This

5. **Locate** Circle the electrons that could have belonged only to the hydrogen atoms before they bonded with the oxygen atom.

## Picture This

6. **Identify** Highlight the electrons that are being shared in the diagram of the nitrogen molecule. Circle the electrons that are not being shared.

### What are multiple bonds?

A covalent bond can have more than two shared electrons. Look at the dot diagram of the two nitrogen atoms. Each nitrogen atom has five electrons in its outer energy level. A nitrogen atom needs to gain three electrons to have a stable number of eight electrons in its outer energy level.



When two nitrogen atoms combine, they share three electrons with each other. The bond between the two atoms has six electrons, or three pairs of electrons. Each electron pair is a covalent bond. Three pairs of electrons form a triple bond. By sharing the electrons, each nitrogen atom now has eight electrons in its outer energy level. The symbol for the nitrogen molecule is  $N_2$ .

### Can double bonds occur?

Molecules also can have double bonds. A double bond is two pairs of electrons shared between two atoms. In the carbon dioxide molecule,  $CO_2$ , the carbon atom shares two electrons with one oxygen atom and two electrons with the other oxygen atom. In return, each oxygen atom shares two electrons with the carbon atom. In this way, all three atoms have eight electrons in their outer energy levels. This makes all three atoms stable.

When electrons are shared in covalent bonds by similar or identical atoms, such as in  $N_2$  or  $O_2$  molecules, the electron charge is shared equally across the bond. A **nonpolar bond** is a covalent bond in which electrons are shared equally by both atoms. Nonmetals commonly form nonpolar bonds.

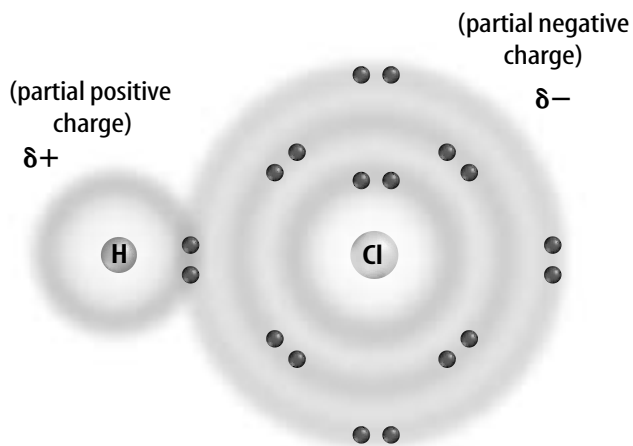
### Are electrons always shared equally?

Atoms in a covalent bond do not always share electrons equally. The positive charge of an atom's nucleus attracts the electrons in a bond. Some nuclei attract electrons more strongly than others. If a shared electron is closer to one nucleus in a bond, that nucleus could attract the electron more strongly.

You can see this with a magnet and a piece of metal. When the magnet is closer to the metal, it attracts the metal more strongly. Some nuclei have a greater positive charge than others. Nuclei with a greater positive charge attract electrons more strongly. In the same way, a strong magnet holds the metal more firmly than a weak magnet.

## How can you picture the sharing of electrons?

Imagine a game of tug-of-war. A covalent bond is like the rope in a game of tug-of-war. The shared electrons are like the knot in the center of the rope. Look at the diagram of a molecule of HCl (hydrochloric acid) below. Each atom in the molecule of HCl is attracting the shared electrons. However, the atoms are not the same size. Then what happens?



The chlorine atom pulls on the electrons more than the hydrogen atom. The chlorine atom is like the stronger team in tug-of-war. When one team is stronger, the knot in the middle of the rope moves towards the stronger team. A similar thing happens in the molecule. The shared electrons are held more closely to the atom with the stronger pull.

## What is an example of unequal electron sharing?

The covalent bond in a molecule of hydrogen chloride, HCL, is an example of unequal electron sharing. When HCL mixes with water, it becomes hydrochloric acid. Hydrochloric acid is used to clean metal in factories. It is also found in your stomach where it helps digest food.

Because of its size, the chlorine atom attracts the electrons in the bond more strongly than the hydrogen atom. That means the electrons in the bond spend more time closer to the chlorine atom than to the hydrogen atom. The chlorine atom has a partial negative charge when the bonding electrons are closer to it. The hydrogen atom then has a slight positive charge when the electrons are farther away from it. The bond is said to be polar. A **polar bond** is a covalent bond in which the electrons are unequally shared, producing a molecule with a negatively-charged end and a positively-charged end. ✓

## Picture This

7. **Label** Draw an arrow showing the pull of electrons toward the chlorine atom.

## Reading Check

8. **Apply** Why does the chlorine atom have a partial negative charge in a molecule of hydrogen chloride?

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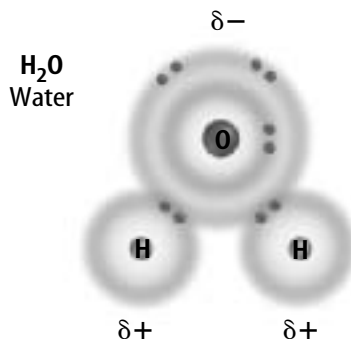
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## Picture This

9. **Identify** Highlight the parts of the water molecule that have a slight positive charge. Circle the part that has a slight negative charge.



Because it has an end that is partially positive and an end that is partially negative, water is a polar molecule. *Polar* means “having opposite ends.” A **polar molecule** is a molecule that has a slightly positive end and a slightly negative end, but the molecule itself is neutral.

When two atoms that are exactly alike form a covalent bond, they share electrons equally. In a **nonpolar molecule**, the electrons are shared equally in the bond. A nonpolar molecule does not have oppositely charged ends. Atoms of the same element can form nonpolar molecules.

## Properties of Compounds

You have just learned about ionic bonds and covalent bonds. A covalent compound is one whose atoms are held together by covalent bonds. Sugar is a covalent compound. An ionic compound is one that is held together by ionic bonds. Table salt, NaCl, is an ionic compound.

From the way they look, you might think that sugar and salt are similar compounds. They are both little white grains, and they are both used in foods. They look like they might have the same physical and chemical properties.

Both sugar and salt are used to change the taste of foods. You add sugar to lemonade or tea to make them taste sweet. Table salt is used to enhance the taste of foods such as meat and vegetables. The reason sugar and salt have different effects on the taste of foods is because they have different physical and chemical properties. ✓

### ✓ Reading Check

10. **Explain** Although sugar and salt look alike, why do they have different effects on the taste of food?

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## How are covalent and ionic compounds different?

Ionic and covalent compounds have different physical and chemical properties. These differences are due to differences in the attractive forces of the bonds.

## What are some properties of covalent compounds?

Covalent bonds are strong, but the attraction between individual molecules of a covalent compound is weak. These weak forces between individual molecules are responsible for the properties of covalent compounds. ✓

For example, melting and boiling points of covalent compounds are low, compared to those of ionic compounds. Sugar will melt at 185° C, but table salt will melt at 801° C. Covalent compounds form soft solids. They are poor electrical and thermal conductors. They do not conduct heat and electricity well.

## What are some properties of ionic compounds?

The ionic bonds between ions are relatively strong. This is why ionic compounds like table salt have high melting points. They also have relatively high boiling points. Ionic compounds are hard and brittle solids. If ionic compounds are dissolved in water, they become good conductors of electric current.

Strong attractive forces hold the ions in place in an ionic compound. Because of this strong attraction, ionic compounds are stable. When ions are drawn together, energy is released. The table below shows some of the different properties of covalent and ionic compounds.

	Covalent Compounds	Ionic Compounds
Bond Type	Electron Sharing	Electron Transfer
Melting and Boiling Points	Lower	Higher
Electrical Conductivity	Poor	Good
State at Room Temperature	Solid, liquid, or gas	Solid
Forces Between Particles	Strong bonds between atoms; weak attraction between molecules	Strong attraction between positive and negative ions

### ✓ Reading Check

- 11. Explain** Describe the strength of the forces between covalent molecules.

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### Picture This

- 12. Identify** Highlight the information in the table that shows that sugar melts at a lower temperature than salt.



## ● After You Read

### Mini Glossary

**chemical bond:** the force that holds atoms together in a compound

**covalent bond:** the force of attraction between two atoms that share electrons

**ionic bond:** the force of attraction between a positive ion and a negative ion in an ionic compound

**molecule:** the neutral particle that forms when atoms share electrons

**nonpolar bond:** a covalent bond where the electrons are shared equally

**nonpolar molecule:** a molecule in which the electrons are shared equally in a covalent bond

**polar bond:** a covalent bond where electrons are unequally shared producing charged molecules

**polar molecule:** a molecule that has a slightly positive end and a slightly negative end, but the molecule itself is neutral

1. Review the terms and definitions in the Mini Glossary. Choose two terms that are related and write a sentence that uses those two terms.

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2. Complete the outline to help you organize what you learned about chemical bonds.

#### Types of Bonds

##### I. What is an ionic bond?

A. Forms between a positive and a negative ion

B. Electrons are \_\_\_\_\_

C. Usually forms between a metal and \_\_\_\_\_

D. Forms a(n) \_\_\_\_\_ compound


##### II. What is a covalent bond?

A. \_\_\_\_\_

B. Electrons are \_\_\_\_\_

C. \_\_\_\_\_

D. Forms a \_\_\_\_\_

3.  **Mark the Text** You underlined every heading in the section that asks a question and then highlighted the answers. How did this help you learn the content of this section?

End of  
Section