

CHAPTER 1 Chemical Bonding

SECTION 2 Ionic Bonds

BEFORE YOU READ

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

- What is ionic bonding?
- What happens to atoms that gain or lose electrons?
- What kinds of solids are formed from ionic bonds?

National Science Education Standards
PS 1b, 3a, 3e

How Do Ionic Bonds Form?

There are several types of chemical bonds. An ionic bond is one type. **Ionic bonds** form when valence electrons are transferred from one atom to another.

Like other bonds, ionic bonds form so that the outermost energy levels of the atoms are filled. To understand why ionic bonds form, you need to learn what happens when atoms gain or lose electrons. ✓

STUDY TIP

Ask Questions As you read, make a list of things you don't understand. Talk about your questions in a small group.

READING CHECK

1. Explain How does an ionic bond form?

CHARGED PARTICLES

An electron has a negative electrical charge. A proton has a positive electrical charge. An atom is neutral, or not charged, when it has an equal number of electrons and protons. The electrical charges cancel out each other.

When atoms gain or lose electrons, the numbers of protons and electrons are no longer equal. When this happens, atoms become charged particles called **ions**. ✓

READING CHECK

2. Explain How are ions different from atoms?

How Do Positive Ions Form?

Ions form when atoms gain or lose electrons. The atoms that lose electrons have more protons than electrons. That means they have positive charges as shown in the figure.

Forming a Positive Ion



Aluminum atom (Al)
13+ protons
13- electrons
0 charge



Aluminum ion (Al³⁺)
13+ protons
10- electrons
3+ charge

Here's How It Works: During chemical changes, an aluminum atom can lose its 3 electrons in the third energy level to another atom. The filled second level becomes the outermost level, so the resulting aluminum ion has 8 valence electrons.

SECTION 2 Ionic Bonds *continued*

Critical Thinking

3. Apply Concepts What is the charge of a nickel atom that has lost two electrons?

READING CHECK

4. Explain What has to happen in order for an atom to lose an electron?

STANDARDS CHECK

PS 3e In most chemical and nuclear reactions, energy is transferred into or out of a system. Heat, light, mechanical motion, or electricity might be involved in such transfers.

Word Help: chemical
of or having to do with the properties or actions of substances

Word Help: reaction
a response or change

Word Help: involve
to have as a part of

5. Identify Where does the energy needed to form positive ions come from during ionic bonding?

READING CHECK

6. Identify What kinds of atoms tend to gain electrons?

METAL ATOMS LOSE ELECTRONS

Most metal atoms have few valence electrons. As shown in the figure on the previous page, metal atoms form positive ions. Notice that the symbol for a metal ion has the charge at the upper right of the chemical symbol.

ENERGY AND LOSING ELECTRONS

For an atom to lose an electron, the attraction between the electron and the protons has to be broken. Breaking the attraction takes energy. ✓

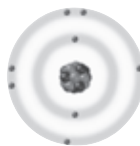
Compared with other elements, only a small amount of energy is needed for metals to lose their valence electrons. Therefore, metals are much more likely to form positive ions than nonmetals are. In the periodic table, the elements in Groups 1 and 2 are all metals. They need little energy to lose their valence electrons. Therefore, the metals in Groups 1 and 2 form ions very easily. The energy needed to make positive ions comes from forming negative ions during ionic bonding.

How Do Negative Ions Form?

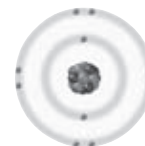
What happens to the electrons that metal atoms lose? Atoms of nonmetals gain electrons during ionic bonding. This forms ions that have more electrons than protons. These ions have a negative charge.

Forming a Negative Ion

Here's How It Works:
During chemical changes, an oxygen atom gains 2 electrons in the second energy level from another atom. An oxide ion that has 8 valence electrons is formed. Thus, its outermost energy level is filled.



Oxygen atom (O)
8+ protons
8- electrons
0 charge



Oxide ion (O²⁻)
8+ protons
10- electrons
2- charge

NONMETAL ATOMS GAIN ELECTRONS

The outermost energy level of a nonmetal is almost full. It is easier for it to fill its outer energy level by gaining electrons than by losing electrons. As a result, atoms of nonmetals tend to gain electrons from other atoms. The name of a negative ion formed from an element ends with *-ide*. ✓

Its charge is shown as at the upper right of the symbol. As shown in figure, an oxygen atom gains two electrons and becomes an oxide ion. The charge on an oxide ion is -2 because it has two more electrons than protons.

SECTION 2 Ionic Bonds *continued***ENERGY AND GAINING ELECTRONS**

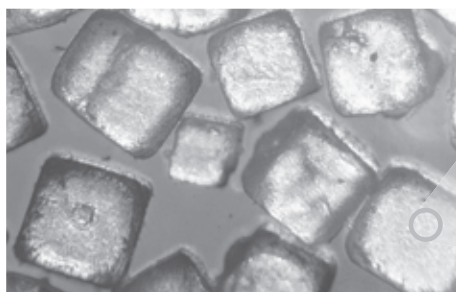
When atoms of most nonmetals gain electrons, they give off energy. The more easily an atom gains electrons, the more energy it releases. The elements in Group 17 (the halogens) are all nonmetals. Their atoms give off a lot of energy when they gain electrons. ✓

How Do Ionic Compounds Form?

Ionic bonds form because positive ions are attracted to negative ions. When ionic bonds form, the number of electrons lost by metal atoms equals the number of electrons gained by nonmetal atoms. ✓

The ions that form an ionic compound are charged, but the compound they form is neutral. That is because the charges of the two kinds of ions cancel out.

Ionic compounds form hard solids with flat faces and straight edges. These solids are called *crystals*. In a crystal, the positive and negative ions are found in a repeating three-dimensional pattern. This arrangement of ions is called a **crystal lattice**. The figure below shows an example of a crystal lattice in sodium chloride, or table salt.



This model shows a crystal lattice of sodium chloride. The sodium ions are dark gray and the chloride ions are light gray.

PROPERTIES OF IONIC COMPOUNDS

Ionic compounds form brittle solids. Something that is *brittle* breaks apart when it is hit with another object. They also have high melting points. This means they have to be heated to very high temperatures before they become liquids. Many ionic compounds also dissolve easily in water. For example, seawater tastes salty because sodium chloride and other ionic compounds are dissolved in it.

✓ **READING CHECK**

7. Describe What does a halogen atom give off when it gains an electron?

✓ **READING CHECK**

8. Explain Why do ionic bonds form?

 **Say It**

Share Observations Spread several grains of salt on a sheet of dark construction paper. Use a magnifying lens to examine the salt grains. Try to crush the grains with your fingers. Talk to your class about your observations.

Section 2 Review

NSES PS 1b, 3a, 3e

SECTION VOCABULARY

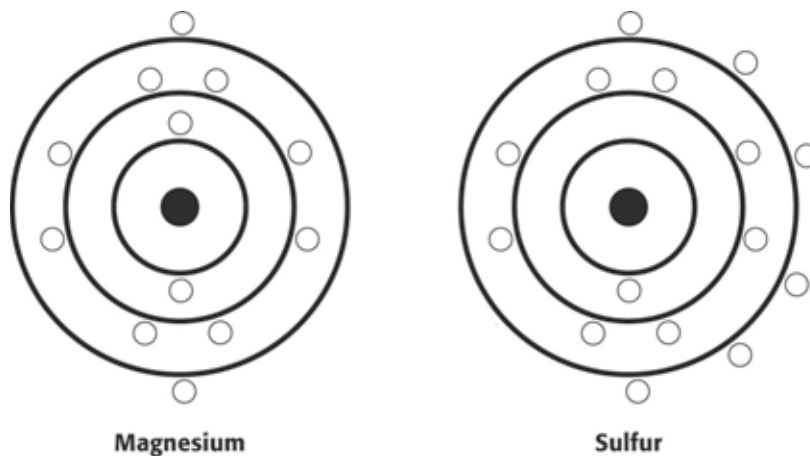
crystal lattice the regular pattern in which a crystal is arranged

ion a charged particle that forms when an atom or group of atoms gains or loses one or more electrons

ionic bond the attractive force between oppositely charged ions, which form when electrons are transferred from one atom to another

- 1. Apply Concepts** Magnesium is a metal with two electrons in its outermost energy level. When it becomes an ion, what happens to its valence electrons? What happens to its charge?

- 2. Interpret Graphics** Sulfur is a nonmetal that has six electrons in its outermost level. Using the models of a magnesium (Mg) atom and a sulfur (S) atom below, draw arrows to show the transfer of electrons.



- 3. Predict Consequences** Potassium (K) is found in Group 1. Fluorine (F) is found in Group 17. When these atoms bind, which will form the positive ion, and which will form the negative ion? Why? Hint: Refer back to the periodic table.

- 4. Name** What is the name given to the regular pattern in which an ionic compound is arranged?

Interactions of Matter Answer Key

Chapter 1 Chemical Bonding

SECTION 1 ELECTRONS AND CHEMICAL BONDING

1. Atoms gain, lose, or share electrons.
2. in energy levels outside the nucleus
3. in the outermost energy level
4. six protons, six electrons
5. two
6. six
7. to get a full outermost energy level
8. lose

Review

1. Atoms bond by losing electrons to other atoms, gaining electrons from other atoms, or sharing electrons with other atoms.
2. two dots on inner circle, seven red dots on outer circle
3. The easiest way for an atom with seven valence electrons to complete its outermost level is to gain one electron from another atom (but it may share electrons).
4. The Mg atom can give its two valence electrons to the O atom.
5. 16, 16

SECTION 2 IONIC BONDS

1. when valence electrons are transferred from one atom to another
2. Ions are atoms that have gained or lost electrons. Atoms are neutral; ions have a charge.
3. 2+
4. The attraction between the electron and the protons has to be broken.
5. from forming negative ions
6. nonmetals
7. a lot of energy
8. because positive ions are attracted to negative ions

Review

1. Magnesium loses its two electrons to a nonmetal atom. It becomes a positive ion with a charge of 2+.
2. Two arrows should be drawn from the outermost electrons in magnesium to the outermost electron levels in sulfur.

3. Potassium will become a positive ion because it will lose an electron. Fluorine will become a negative ion because it will gain an electron.
4. crystal lattice

SECTION 3 COVALENT AND METALLIC BONDS

1. Electrons are shared in covalent bonds; they are not gained or lost.
2. covalent
3. H
4. H:H
5. diatomic molecule
6. Chlorine: eight
Oxygen: eight
Nitrogen: eight
7. Chlorine: one pair
Oxygen: two pairs
Nitrogen: three pairs
8. three covalent bonds
9. four
10. It is formed by the attraction between positively charged metal ions and the electrons around the ions.
11. The electrons can move throughout the metal.
12. Valence electrons are free to move throughout the wire.
13. Ductility means being able to be shaped into long, thin wires. Malleability means being able to be hammered into sheets.

Review

1. Forms covalent bonds	Forms metallic bonds
oxygen	gold
carbon	aluminum
fluorine	copper



3. First question: You would use substances with covalent bonds as insulation.
Second question: You would use a metal to conduct heat.