

Section 1

Ionic and Covalent Compounds

Key Concept The properties of ionic compounds are different from the properties of covalent compounds.

What You Will Learn

- The physical properties of a compound are determined by the type of bonding in the compound.
- Ionic compounds tend to be brittle, have high melting points, dissolve in water, and often conduct electric current in solution.
- Many covalent compounds tend to be insoluble in water, have low melting points, are not water soluble, and often do not conduct electric current in solution.

Why It Matters

The properties of a compound determine how the compound can be used.

Compounds can be grouped by the kind of chemical bond they have. A **chemical bond** is an interaction that holds atoms and ions together. Bonding happens between valence electrons of different atoms. *Valence electrons* are electrons in the outermost energy level of an atom. The type of compound that forms depends on what happens to the valence electrons.

Ionic Compounds and Their Properties

An *ionic bond* is an attraction between oppositely charged ions. Compounds that have ionic bonds are called **ionic compounds**. The properties of ionic compounds are a result of strong attractive forces. Ionic compounds can be formed by the reaction of a metal with a nonmetal. Metal atoms become positively charged ions when electrons are transferred from the metal atoms to the nonmetal atoms. This transfer of electrons also causes the nonmetal atom to become a negatively charged ion. Sodium chloride, or *table salt*, is an ionic compound.

Standards Check Name the ions in sodium chloride.



Brittleness

Ionic compounds tend to be brittle solids at room temperature. So, they

often break apart when hit. They break because their ions are arranged in a repeating three-dimensional pattern called a *crystal lattice*, shown in **Figure 1**. Each ion in a lattice is bonded to the surrounding ions of the opposite charge. When an ionic compound is hit, the ions move and the pattern changes. Ions that have the same charge line up and repel one another, which causes the crystal to break.



Figure 1 Sodium chloride crystals have a regular cubic shape because of the way sodium and chloride ions are arranged in the crystal lattice.



High Melting Points

Because of the strong bonds that hold ions together, ionic compounds have high melting points. These high melting points are the reason that most ionic compounds are solids at room temperature. For example, solid sodium chloride must be heated to 801°C before it will melt. The melting points of two other ionic compounds are given in **Figure 2**.



Figure 2 Ionic compounds have high melting points.

Solubility and Electrical Conductivity

Many ionic compounds are highly soluble in water. So, they dissolve easily in water. Water molecules attract each of the ions of an ionic compound and pull the ions away from one another. The solution that forms when an ionic compound dissolves in water can conduct an electric current, as shown in **Figure 3**. The solution can conduct an electric current because the ions are charged and are able to move freely past one another. However, an undissolved crystal of an ionic compound does not conduct an electric current.

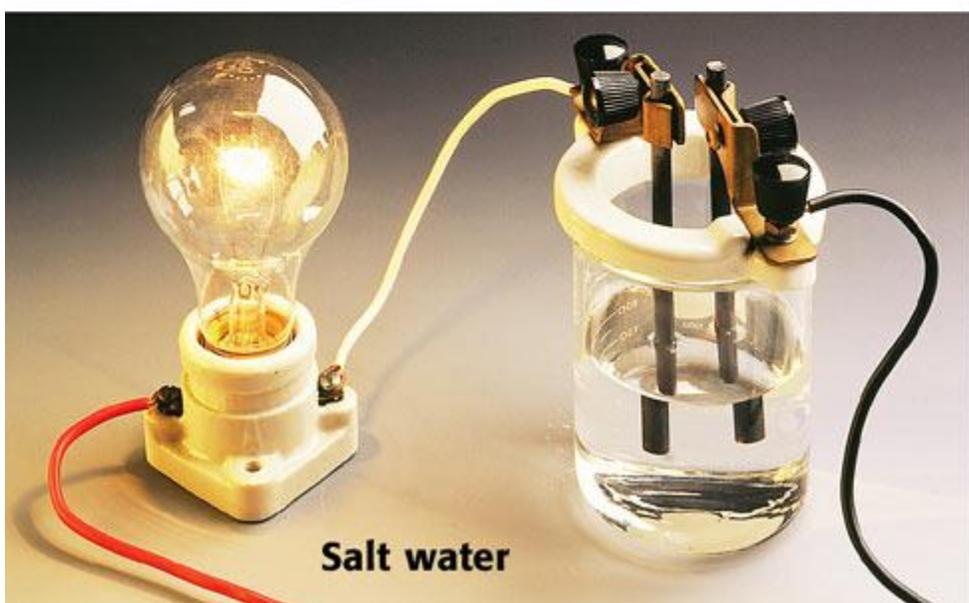
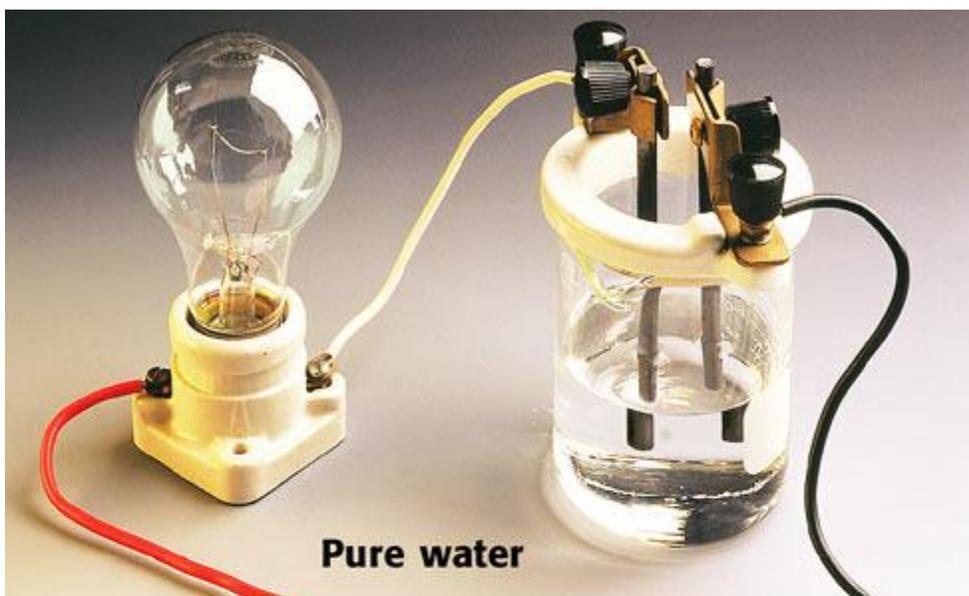


Figure 3 The pure water does not conduct an electric current. However, the solution of salt water conducts an electric current, so the bulb lights up.

Standards Check Why do solutions of ionic compounds dissolved in water conduct an electric current?





Covalent Compounds and Their Properties

Like most compounds, many of the compounds in your body are covalent compounds. **Covalent compounds** are compounds that form when atoms share electrons. A *covalent bond* forms as a result of this sharing of electrons. By sharing valence electrons, atoms fill their outermost energy level. The group of atoms that make up a covalent compound is called a molecule. A *molecule* is the smallest particle into which a covalently bonded compound can be divided and still be the same compound. Properties of covalent compounds are very different from the properties of ionic compounds.

Solubility

Some covalent compounds are not soluble in water. So, they do not dissolve well in water. Before you use a bottle of oil-based salad dressing, you shake the bottle to mix the oil and water. The oil separates from the water because it contains covalent compounds that are not soluble in water. When the attraction between water molecules is stronger than their attraction to the molecules of the other covalent compound, the water molecules tend to stay together. So, the molecules of water and the covalent compound do not mix.

Standards Check Explain why some covalent compounds won't dissolve in water.



Low Melting Points

The forces of attraction between the molecules in solids of covalent compounds are much weaker than the bonds holding

ionic solids together. Less heat is needed to separate the molecules of covalent compounds, so these compounds have much lower melting and boiling points than ionic compounds do.

Electrical Conductivity

Although many covalent compounds don't dissolve in water, some do. Most of the covalent compounds that dissolve in water form solutions that have uncharged molecules. Sugar is a covalent compound that dissolves in water. But, it does not form ions. So, a solution of sugar and water does not conduct an electric current, as shown in **Figure 4**. However, some covalent compounds do form ions when they dissolve in water. Many acids, for example, form ions in water. Acidic solutions, like ionic solutions, conduct an electric current.

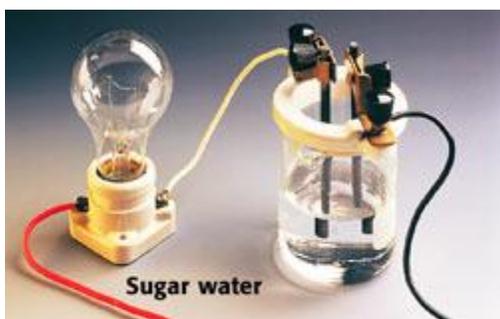


Figure 4 This solution of sugar, a covalent compound, and water does not conduct an electric current because the molecules of sugar are not charged. **How is this different from solutions of ionic compounds?**

Standards Check Why do the melting points of covalent compounds tend to be lower than those of ionic compounds?



Section Summary

- Ionic compounds have ionic bonds between ions of opposite charges.
- Ionic compounds are usually brittle, have high melting points, dissolve in water, and often conduct an electric current in solution.
- Covalent compounds have covalent bonds and consist of particles called *molecules*.
- Many covalent compounds have low melting points, do not dissolve in water, and do not conduct an electric current in

solution.

