

# CHAPTER 7

# Chemical Bonding

## Chapter Outline

- 7.1 INTRODUCTION TO CHEMICAL BONDS
- 7.2 IONIC BONDS
- 7.3 COVALENT BONDS
- 7.4 METALLIC BONDS
- 7.5 REFERENCES





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## Chemical Compounds

Water (H<sub>2</sub>O) is an example of a chemical compound. Water molecules always consist of two atoms of hydrogen and one atom of oxygen. Like water, all other chemical compounds consist of a fixed ratio of elements. It doesn't matter how much or how little of a compound there is. It always has the same composition.

### Chemical Formulas

Elements are represented by chemical symbols. Examples are H for hydrogen and O for oxygen. Compounds are represented by **chemical formulas**. You've already seen the chemical formula for water. It's H<sub>2</sub>O. The subscript 2 after the H shows that there are two atoms of hydrogen in a molecule of water. The O for oxygen has no subscript. When there is just one atom of an element in a molecule, no subscript is used. **Table 7.1** shows some other examples of compounds and their chemical formulas.

Name of Compound	Electron Dot Diagram	Numbers of Atoms	Chemical Formula
Hydrogen chloride	$\text{H}:\ddot{\text{Cl}}:$	H = 1 Cl = 1	HCl
Methane	$\begin{array}{c} \text{H} \\ \vdots \\ \text{H}:\text{C}:\text{H} \\ \vdots \\ \text{H} \end{array}$	C = 1 H = 4	CH <sub>4</sub>
Hydrogen peroxide	$\text{H}:\ddot{\text{O}}:\ddot{\text{O}}:\text{H}$	H = 2 O = 2	H <sub>2</sub> O <sub>2</sub>

### Types of Compounds

There are different types of compounds. They differ in the nature of the bonds that hold their atoms together. The type of bonds in a compound determines many of its properties. Three types of bonds are ionic, covalent, and metallic bonds. You will read about these three types in later lessons. You can also learn more about them by watching this video: <http://www.youtube.com/watch?v=hEFeLYWTKX0> (7:18).

## 7.2 Ionic Bonds

### Lesson Objectives

- Describe how ionic bonds form.
- List properties of ionic compounds.

### Lesson Vocabulary

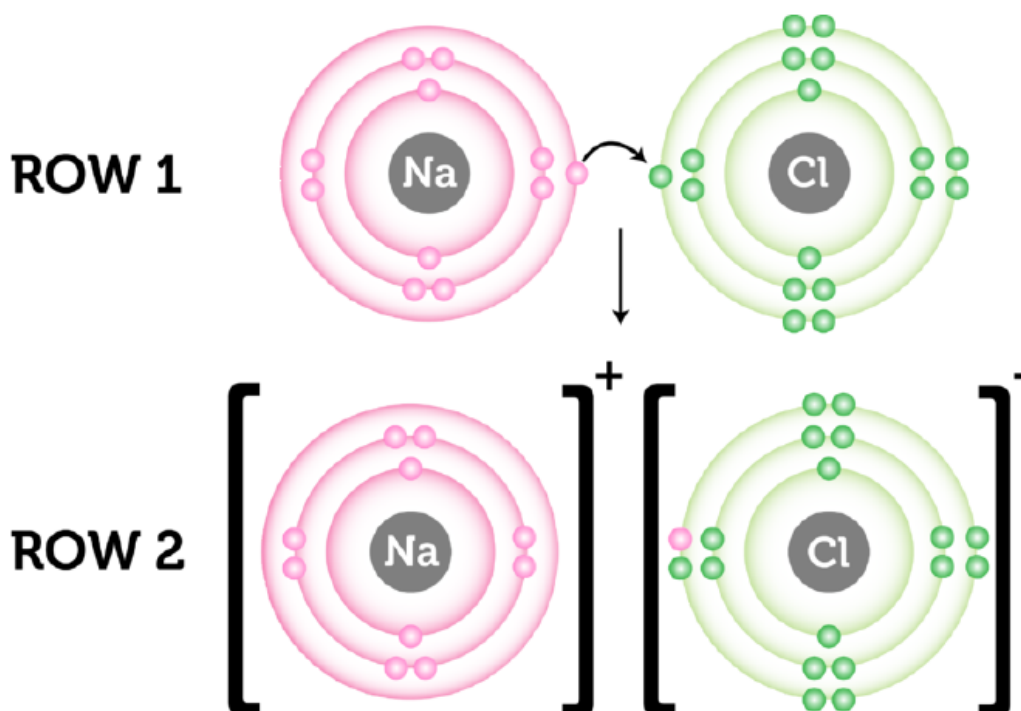
- ionic bond
- ionic compound

### Formation of Ionic Bonds

An **ionic bond** is the force of attraction that holds together positive and negative ions. It forms when atoms of a metallic element give up electrons to atoms of a nonmetallic element. **Figure 7.3** shows how this happens.

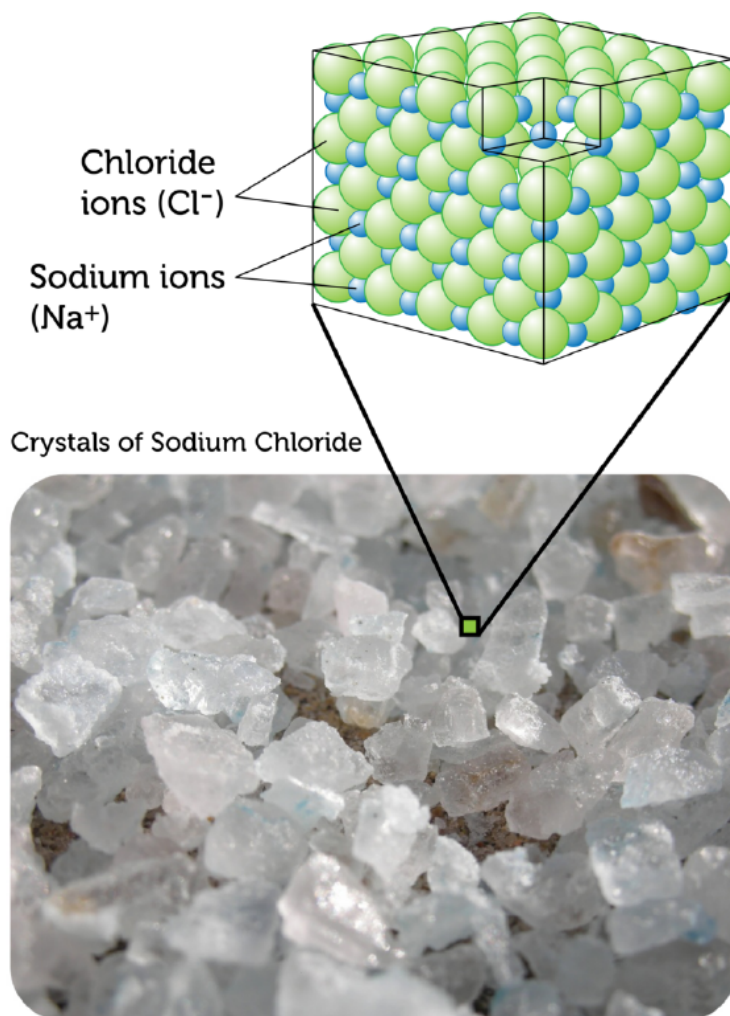
In row 1 of **Figure 7.3**, an atom of sodium donates an electron to an atom of chlorine (Cl).

- By losing an electron, the sodium atom becomes a sodium ion. It now has one less electron than protons, giving it a charge of +1. Positive ions such as sodium are given the same name as the element. The chemical symbol has a plus sign to distinguish the ion from an atom of the element. The symbol for a sodium ion is  $\text{Na}^+$ .
- By gaining an electron, the chlorine atom becomes a chloride ion. It now has one more electron than protons, giving it a charge of -1. Negative ions are named by adding the suffix *-ide* to the first part of the element name. The symbol for chloride is  $\text{Cl}^-$ .



## Ionic Compounds

Ionic compounds contain ions of metals and nonmetals held together by ionic bonds. Ionic compounds do not form molecules. Instead, many positive and negative ions bond together to form a structure called a crystal. You can see an example of a crystal in **Figure 7.5**. It shows the ionic compound sodium chloride. Positive sodium ions ( $\text{Na}^+$ ) alternate with negative chloride ions ( $\text{Cl}^-$ ). The oppositely charged ions are strongly attracted to each other.



### Properties of Ionic Compounds

The crystal structure of ionic compounds is strong and rigid. It takes a lot of energy to break all those strong ionic bonds. As a result, ionic compounds are solids with high melting and boiling points (see **Table 7.2**). The rigid crystals are brittle and more likely to break than bend when struck. As a result, ionic crystals tend to shatter. You can learn more about the properties of ionic compounds by watching the video at this URL: [http://www.youtube.com/watch?v=buWrSgs\\_ZHk&feature=related](http://www.youtube.com/watch?v=buWrSgs_ZHk&feature=related) (3:34).

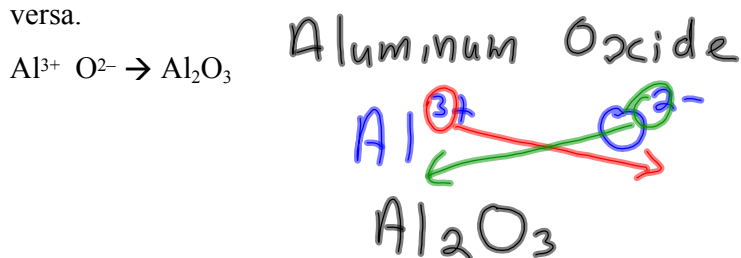
Ionic Compound	Melting Point ( $^{\circ}\text{C}$ )	Boiling Point ( $^{\circ}\text{C}$ )
Sodium chloride ( $\text{NaCl}$ )	801	1413
Calcium chloride ( $\text{CaCl}_2$ )	772	1935
Barium oxide ( $\text{BaO}$ )	1923	2000
Iron bromide ( $\text{FeBr}_3$ )	684	934

## Writing Names of Formulas of Binary Ionic Compounds

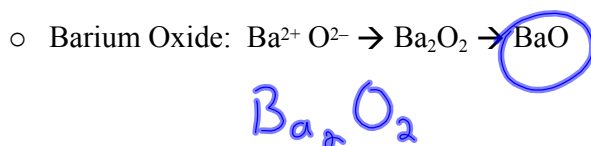
- ⇒ Binary compound consist of only two elements.
- ⇒ Cations have the same name as the element.
- ⇒ Anions are named by changing their element name to end with “ide”
  - $F^-$  → Fluoride
  - $O^{2-}$  → Oxide
  - $CO_2$  → carbon dioxide
  - $Cl^-$  → chloride
- ⇒ Name the following compounds (name of cation and anion):
  - $LiO$  → Lithium Oxide
  - $MgO$  → Magnesium Oxide
  - $K_2S$  → Potassium Sulfide
  - $KN_3$  → Potassium Nitride
  - $AlBr_3$  → Aluminum Bromide

## Writing the Formulas of Binary Ionic Compounds

⇒ Create formulas and check for a balanced charge using the “cross-over” method. The charge of the cation becomes the subscript for the anion, and vice-versa.

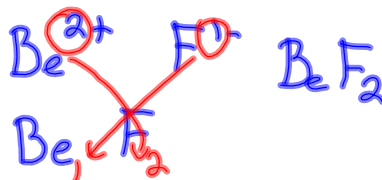


⇒ When the metal and non-metal have the same charge (different sign), always write the simplest ratio.



⇒ Use the “cross-over” method to write the formula of each of the following:

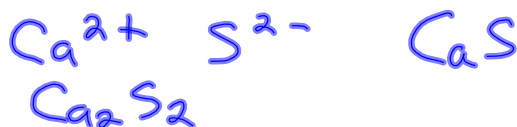
- Beryllium fluoride



- Sodium nitride



- Calcium sulfide



- Aluminum chloride

- Lithium oxide

- Magnesium nitride

- Gallium sulfide

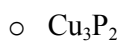
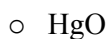
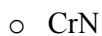
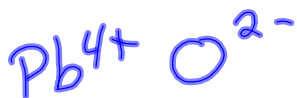
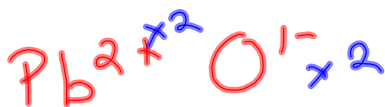
- Barium bromide

⇒ The Stock Naming System: For use with *transition metals*.

- The charge on the cation is written, in parenthesis, as a Roman numeral after the name of the metal.
- Transition metals can bond with different amounts of electrons (can have a different ionic charge), but remember that the anions will always gain the same number of electrons no matter what the compound is.
- $\text{FeCl}_3 \rightarrow \text{Fe}^{3+} \text{Cl}^- \rightarrow$  iron (III) chloride



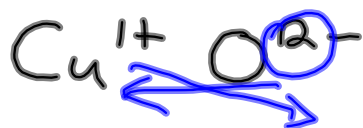
⇒ Name the following compounds:



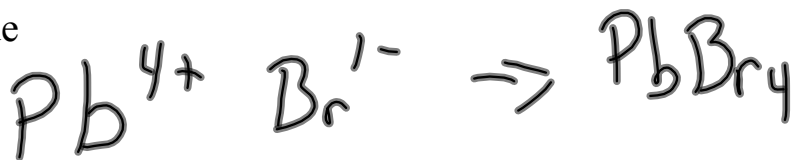


⇒ Write the chemical formulas for each of the following compounds:

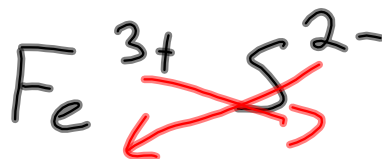
- Copper(I) oxide



- Lead(IV) bromide



- Iron(III) sulfide



- Nickel(III) fluoride

- Manganese(IV) sulfide