

## Section 1

# Electrons and Chemical Bonding

**Key Concept** Atoms share, gain, or lose electrons when chemical bonds form.

### What You Will Learn

- Chemical bonding is the joining of atoms to form new substances.
- Valence electrons are used to form chemical bonds.
- The number of valence electrons in an atom determines whether the atom will form bonds.

### Why It Matters

Understanding chemical bonding helps explain why some elements combine and some do not.

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Have you ever stopped and thought that by using only the 26 letters of the alphabet, you make all of the words you use every day? Even though the number of letters is limited, joining the letters in different ways allows you to make a huge number of words. In the same way that words can be formed by joining letters, substances can be formed by combining atoms.

### Combining Atoms Through Chemical Bonding

Look at **Figure 1**. Now, look around the room. Everything you see is made of atoms of elements. All substances are made of atoms of one or more of the more than 100 elements. For example, the atoms of carbon, hydrogen, and oxygen combine in different patterns to form sugar, alcohol, and citric acid. **Chemical bonding** is the joining of atoms to form new substances. The properties of these new substances are different from the properties of the original elements. An interaction that holds two atoms together is called a **chemical bond**. When chemical bonds form, electrons are shared, gained, or lost.



**Figure 1** Everything you see in this photo is formed by combining atoms.

**Standards Check** What is chemical bonding?

### **Discussing Bonding Using Models**

We cannot see atoms and chemical bonds with the eye alone. Because atoms are complex, models are used to discuss how and why atoms form bonds. But the simple models that are used to discuss the electrons in an atom do not show all of the details of the structure of the atom or chemical bond.

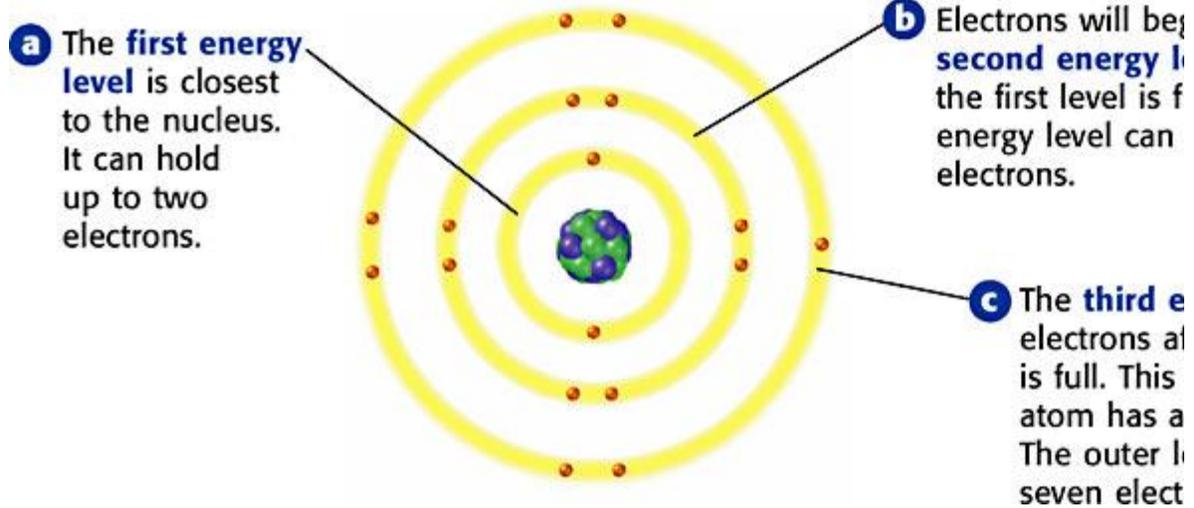


## **Electron Number and Organization**

To understand how atoms form chemical bonds, you need to know about the electrons in an atom. The number of electrons in an atom is the same as the atomic number of the element. The *atomic number* is the number of protons in an atom. But atoms have no charge. So, the atomic number also tells you the number of electrons in the atom.

Electrons in an atom are organized in energy levels. **Figure 2** shows a model of how the 17 electrons in a chlorine atom fill up the energy levels. This model and models like it are useful for counting electrons in energy levels of atoms. But these models do not show the true structure of atoms.

**Figure 2 Electron Arrangement in an Atom**



### Outer-Level Electrons and Bonding

Not all of the electrons in an atom make chemical bonds. Most atoms form bonds using only the electrons in the outermost energy level. An electron in the outermost energy level of an atom is a **valence electron**. The models in **Figure 3** show the valence electrons for two atoms.

**Figure 3 Counting Valence Electrons**

#### Oxygen

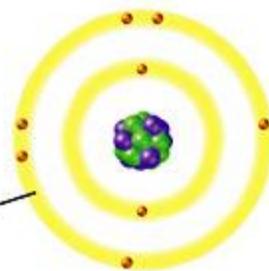
**Atomic number: 8**

**Electron total: 8**

**First level: 2 electrons**

**Second level: 6 electrons**

An oxygen atom has six valence electrons.



#### Sodium

**Atomic number: 11**

**Electron total: 11**

**First level: 2 electrons**

**Second level: 8 electrons**

**Third level: 1 electron**

A sodium atom has one valence electron.



**Standards Check** Where in the atom are the electrons that are used to form bonds located?

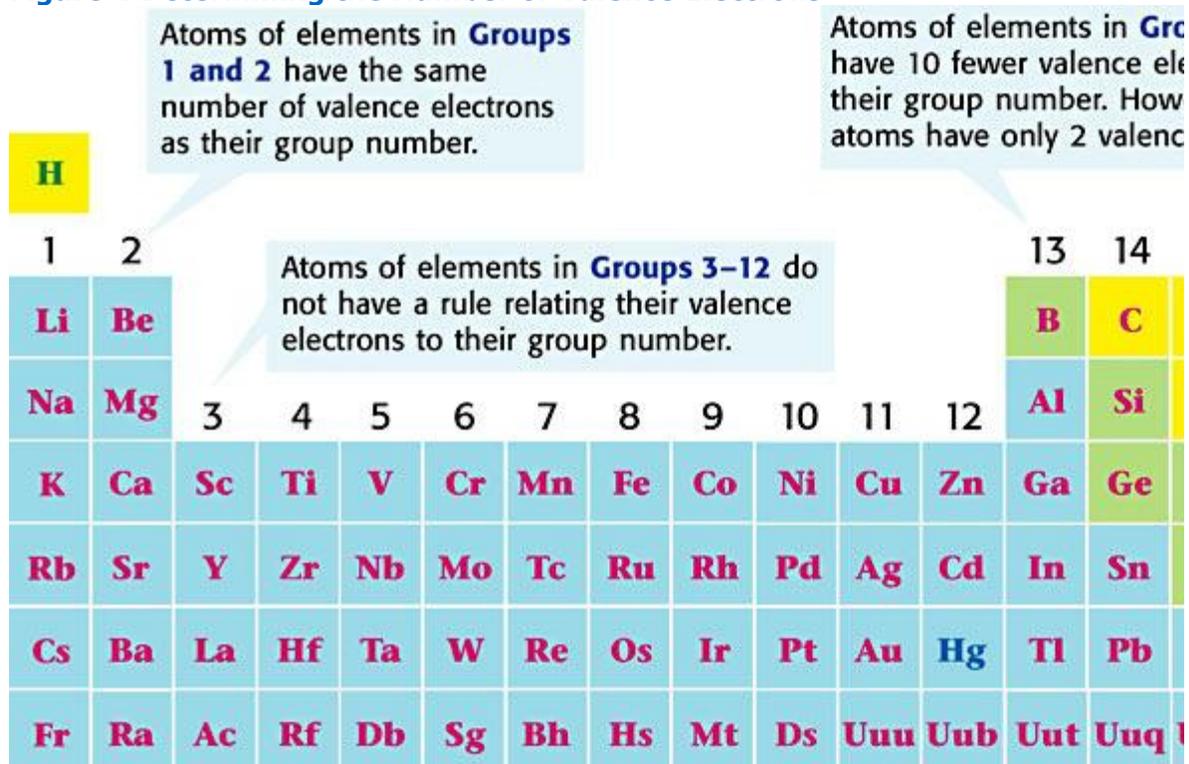


### Valence Electrons and the Periodic Table

You can use a model to find the number of valence electrons of an atom. But what if you don't have a model? For some elements, you could use the periodic table!

Elements are grouped based on similar properties. Within a group, or family, the atoms of each element have the same number of valence electrons. So, the group numbers can help you determine the number of valence electrons. **Figure 4** shows how to use the periodic table to find the number of valence electrons for some atoms.

**Figure 4 Determining the Number of Valence Electrons**



## To Bond or Not to Bond

Not all atoms bond in the same way. In fact, some atoms hardly ever bond at all! The number of valence electrons in the outermost energy level of an atom determines if an atom will form bonds.

Atoms of the noble gases (Group 18) do not usually form bonds. Atoms of Group 18 elements (except helium) have eight valence electrons. Atoms that have eight electrons in their outermost energy level are nonreactive. So, they do not tend to form bonds. The outermost energy level of an atom is full if the level contains eight electrons.

**Standards Check** The atoms of which group in the periodic table rarely form chemical bonds?

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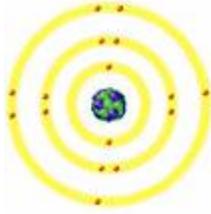
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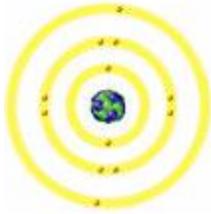
## Filling The Outermost Level

Atoms that have fewer than eight valence electrons usually form bonds. In order to fill the outermost energy level, atoms bond by gaining, losing, or sharing electrons. **Figure 5** shows how two kinds of atoms can have a full outermost energy level with eight electrons.

### Figure 5 Filling Outermost Energy Levels



**Sulfur**  
An atom of sulfur has six valence electrons. It can have eight valence electrons by sharing two electrons with or gaining two electrons from other atoms.



**Magnesium**  
An atom of magnesium has two valence electrons. It can have a full outer level by losing two electrons. The second energy level becomes the outermost energy level and has eight electrons.

### Are Two Electrons a Full Set?

Not all atoms need eight valence electrons to have a filled outermost energy level. Helium atoms need only two. The first energy level in a helium atom is also the outermost one. This level can hold only two electrons. So, the outermost energy level of a helium atom is full with only two electrons. Atoms of hydrogen and lithium also form bonds by gaining, losing, or sharing electrons so that there are two electrons in the first energy level.

### Section Summary

- Chemical bonds form when atoms join to form new substances. A chemical bond is an interaction that holds two atoms together.
- A valence electron is an electron in the outermost energy level of an atom.
- Most atoms form bonds by gaining, losing, or sharing electrons until they have eight valence electrons. Atoms of some elements need only two electrons to fill their outermost level.

