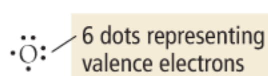
4.4: The Lewis Model: Representing Valence Electrons with Dots

Key Concept Video **The Lewis Model for Chemical Bonding**

Bonding theories (or models) are central to chemistry because they explain how atoms bond together to form molecules. These theories explain why some combinations of atoms are stable and others are not. For example, bonding theories explain why table salt is NaCl and not $NaCl_2$ and why water is H_2O and not H_3O. Bonding theories also predict the shapes of molecules—a topic in our next chapter—which in turn determine many of the physical and chemical properties of compounds. The bonding model we introduce here is the **Lewis model**, named after the American chemist G. N. Lewis (1875–1946). In the Lewis model, we represent valence electrons as dots and we draw **Lewis electron-dot structures** (or simply **Lewis structures**) to depict molecules. These structures, which are fairly simple to draw, have tremendous predictive power. With minimal computation, we can use the Lewis model to predict whether a particular set of atoms will form a stable molecule and what that molecule might look like. We will also examine more advanced theories for chemical bonding in Chapter 6, but the Lewis model remains the simplest model for making quick, everyday predictions about most molecules.

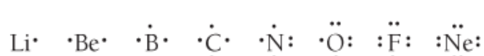
The Lewis model focuses on valence electrons because chemical bonding involves the transfer or sharing of valence electrons between two or more atoms. Recall from Chapter 3 that, for main-group elements, the valence electrons are those in the element's outermost principal energy level. In a **Lewis symbol**, we represent the valence electrons of main-group elements as dots surrounding the abbreviation for the element. For example, the electron configuration of O is:

And its Lewis symbol is:



> Remember, the number of valence electrons for any main group is equal to the group number of the element (except for helium, which is in group 8A but has only two valence electrons).

Each dot represents a valence electron. The dots are placed around the element's symbol with a maximum of two dots per side. We draw the Lewis symbols for all of the period 2 elements in a similar way:



> While the exact location of dots is not critical, in this book we first place dots singly before pairing (except for helium, which always has two paired dots signifying its duet).

Lewis symbols provide a simple way to visualize the number of valence electrons in a main-group atom. Notice that atoms with eight valence electrons—which are particularly stable because they have a full outer principal level—are easily identified because they have eight dots, an **octet**.

Helium is an exception. Its electron configuration and Lewis symbol are:

$1s^2$ He:

The Lewis symbol of helium contains only two dots (a **duet**). For helium, a duet represents a stable electron configuration because the $n = 1$ quantum level fills with only two electrons.

In the Lewis model, a chemical bond is the sharing or transfer of electrons to attain stable electron configurations for the bonding atoms. If electrons are transferred, as occurs between a metal and a nonmetal, the bond is an *ionic bond*. If the electrons are shared, as occurs between two nonmetals, the bond is a *covalent bond*. In either case, the bonding atoms obtain stable electron configurations; since the stable configuration is usually eight electrons in the outermost shell, this is known as the **octet rule**. When applying the Lewis model, we do not try to calculate the energies associated with the attractions and repulsions between electrons and nuclei on neighboring atoms. The energy changes that occur because of these interactions are central to chemical bonding (as we just discussed in Section 4.2), yet the Lewis model ignores them because calculating these energy changes is extremely complicated. Instead the Lewis model uses the simple octet rule, a practical approach that accurately predicts what we see in nature for a large number of compounds—this accounts for the success and longevity of the Lewis model.