4.5: Covalent Bonds in Compounds

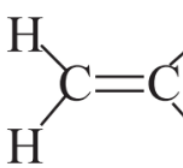
Consider next some example covalent bonds between atoms of some of the lighter elements. These are best understood in reference to Figure 3.9, the abbreviated version of the periodic table showing the Lewis symbols (outer shell valence electrons) of the first 20 elements. As is the case with ions, atoms that are covalently bonded in molecules often have an arrangement of outer shell electrons like that of the noble gas with an atomic number closest to the element in question. It was just seen that covalently bonded H atoms in molecules of H_2 have 2 outer shell electrons like the nearby noble gas helium. For atoms of many other elements, the tendency is to acquire 8 outer shell electrons— an octet— in sharing electrons through covalent bonds. This tendency forms the basis of the *octet rule* discussed in Section 4.2. In illustrating the application of the octet rule to covalent bonding Section 4.7 considers first the bonding of atoms of hydrogen to atoms of elements with atomic numbers 6 through 9 in the second period of the periodic table.

These elements are close to the noble gas neon and tend to attain a “neon-like” octet of outer shell electrons when they form covalently bonded molecules.

Covalent bonds are characterized according to several criteria. The first of these is the number of electrons involved. The most common type of covalent bond consists of 2 shared electrons and is a *single bond*. Four shared electrons as shown for the bond joining an O atom to one of the C atoms in the structure of the acetate anion above constitute a *double covalent bond*. And 6 shared electrons as shown for the very stable covalent bond joining the two N atoms in the N_2 molecule illustrated in Chapter 3, Figure 3.6 make up a *triple covalent bond*. These bonds are conventionally shown as lines in the structural formulas of molecules (large numbers of dots in a formula can get a little confusing). So the single covalent bond in H_2 is shown as

$$\mathbf{H{-}H}$$

The double bond consisting of 4 shared electrons holding the two carbon atoms together in C_2H_4 (ethylene, a hydrocarbon used to make polyethylene plastic) are shown by the following:



Ethylene (ethene) C_2H_4

And the very strong triple bond joining the two N atoms in the N_2 molecule are shown by three lines:

$$\mathbf{N{\equiv}N}$$

Figure 3.6 that each N atom has a pair of electrons that are not part of any chemical bonds. These are omitted from the structure above, and are not ordinarily shown when bonds are represented by lines.

Covalent bonds have a characteristic **bond length**. Bond lengths are of the general magnitude of the size of atoms, so they are measured in units of picometers (pm). The H-H bond in H_2 is 75pm long.

A third important characteristic of bonds is **bond energy**. Bond energy is normally expressed in kilojoules (kJ) required to break a mole (6.02×10^{23}) of bonds. (See Section 4.8 for a detailed definition of the mole.) The bond energy of the H-H bond in H_2 is equal to 435 kJ/mole. This means that an amount of energy required to break all the H-H bonds in a mole of H_2 (2.0 grams of H_2, 6.02×10^{23} molecules) is a very substantial 435 kJ.