Reversible reactions are those that can go in either direction. In reversible reactions, reactants turn into products, but when the product's concentration goes beyond a certain threshold, some of these products convert back into reactants. This back and forth continues until a certain relative balance between reactants and products occur, a state called equilibrium. A chemical equation with a double-headed arrow pointing towards both the reactants and products often denote these reversible reaction situations.

For example, in human blood, excess hydrogen ions (H^+) bind to bicarbonate ions (HCO_3^-) forming an equilibrium state with carbonic acid (H_2CO_3). If we added carbonic acid to this system, some of it would convert to bicarbonate and hydrogen ions.

$$\mathbf{HCO_3^- + H^+ \leftrightarrow H_2CO_3}$$

Chemical Bonds

Chemical bonds are interactions between two or more atoms that result in the formation of molecules. An atom can donate, accept, or share electrons with other atoms to fill its outer shell and satisfy the octet rule.

There are three types of bonds or interactions that will be discussed: ionic, covalent, and hydrogen bonds. Ionic and covalent bonds are strong interactions that require a large input of energy to break the bonds apart. Hydrogen bonds are considered weak bonds because they require less energy to break them apart.

Ions and Ionic Bonds

When an atom does not contain equal numbers of protons and electrons, it is called an **ion**. Because the number of electrons does not equal the number of protons, each ion has a net charge. Positive ions are formed by losing electrons and are called **cations**. Negative ions are formed by gaining electrons and are called **anions**.

For example, sodium only has one electron in its outermost shell. It takes less energy for sodium to donate that one electron than it does to accept seven more electrons to fill the outermost shell. If sodium loses an electron, it now has 11 protons and only 10 electrons, leaving it with an overall charge of +1. It is now called a sodium ion, Na^{+1} (Figure 2.14a and b).

The chlorine atom has seven electrons in its outer shell. Again, it is more energy-efficient for chlorine to gain one electron than to lose seven. Therefore, it tends to gain an electron to create an ion with 17 protons and 18 electrons, giving it a net negative (–1) charge. It is now called a chloride ion, Cl^{-1} (Figure 2.14a and b). This movement of electrons from one element to another is referred to as **electron transfer**.

As Figure 2.14 illustrates, a sodium atom (Na) only has one electron in its outermost shell, whereas a chlorine atom (Cl) has seven electrons in its outermost shell (Figure 2.14a). A sodium atom will donate its one electron to empty its shell, and a chlorine atom will accept that electron to fill its shell, becoming chloride. Both ions now satisfy the octet rule and have complete outermost shells. Because the number of electrons is no longer equal to the number of protons, each is now an ion and has a +1 (sodium) or –1 (chloride) charge.

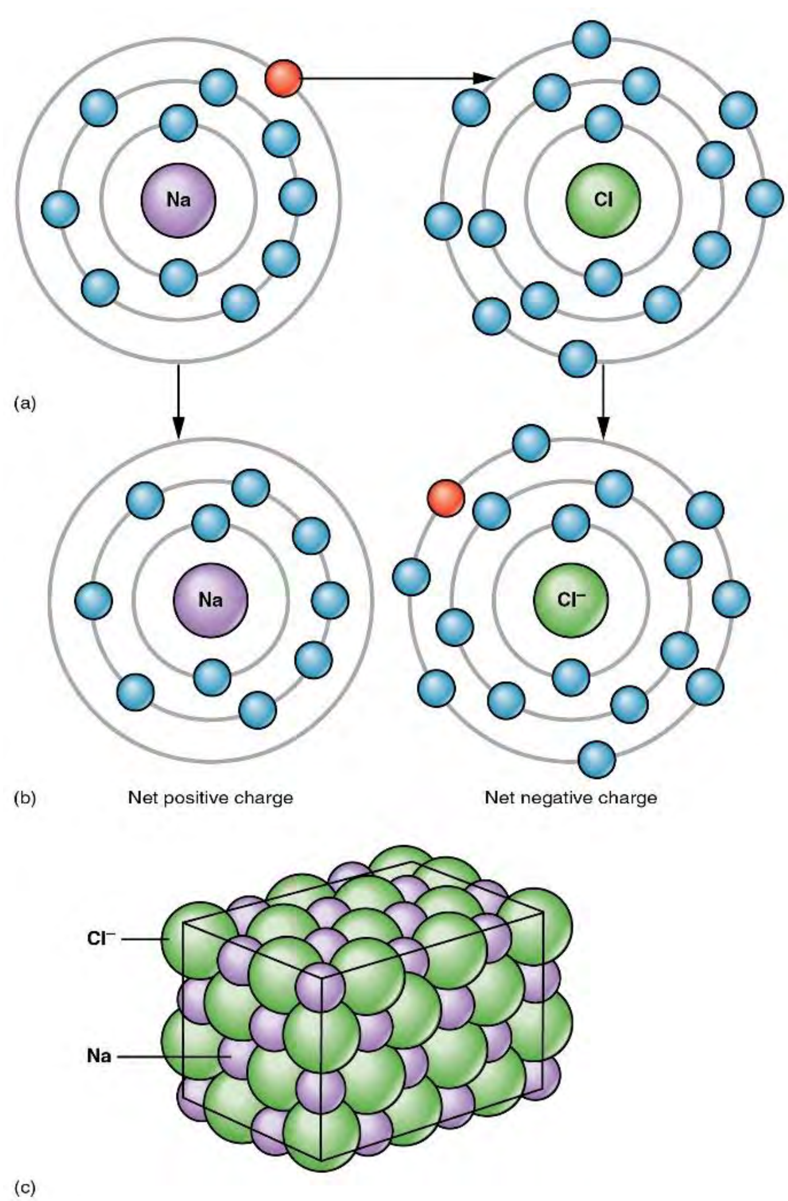

Figure 2.14 Ionic Bonding (a) Sodium donates the electron in its valence shell to chlorine, which needs only one electron to have a full valence shell. (b) The opposite electrical charges of the resulting sodium cation and chloride anion result in the formation of an ionic bond. (c) The attraction of many sodium and chloride ions results in the formation of large groupings called crystals. (credit: Betts et al./Anatomy and Physiology OpenStax)

When an element donates an electron from its outer shell, as in the sodium atom example above, a positive ion is formed. The element accepting the electron is now negatively charged. Because cations and anions are attracted to one another, these ions stay together and form an **ionic bond** or a bond between ions. When proportional amounts of Na^+ and Cl^- ions combine they produce the ionic compound, NaCl, in a crystallized form (Figure 2.14c). The sodium and chloride ions attract each other in a lattice of ions with a net-zero charge forming what is commonly known as table salt Figure 2.15.

Figure 2.15 Edible salt. (credit: Miansari66 / Public Domain)

Covalent Bonds

A covalent bond is another example of a strong chemical bond that can occur between two or more atoms. A **covalent bond** forms when one or more pairs of electrons are shared between atoms. These are some of the strongest and most commonly formed chemical bonds in living organisms. Their strength is greatly attributed to the fact that large amounts of energy are required to break these bonds apart.

For example, the hydrogen atoms and oxygen atom that combine to form water molecules are bound together by covalent bonds. Each atom participating in a covalent bond must share at least one electron. The electron shared by the hydrogen atom divides its time between the outer shell of the hydrogen atom and the outer shell of the oxygen atom. To fill the outer shell of an oxygen atom, two electrons from two hydrogen atoms are needed, hence the subscript "2" in H_2O.

There are two types of covalent bonds: polar and nonpolar. **Nonpolar covalent bonds** form between two atoms that share the electrons equally. For example, an oxygen atom can bond with another oxygen atom to fill their outer shells. This bond is nonpolar because the electrons will be equally distributed between each of the oxygen atoms. Two covalent bonds form between two oxygen atoms because oxygen requires two shared electrons to fill its outermost shell (Figure 2.16).

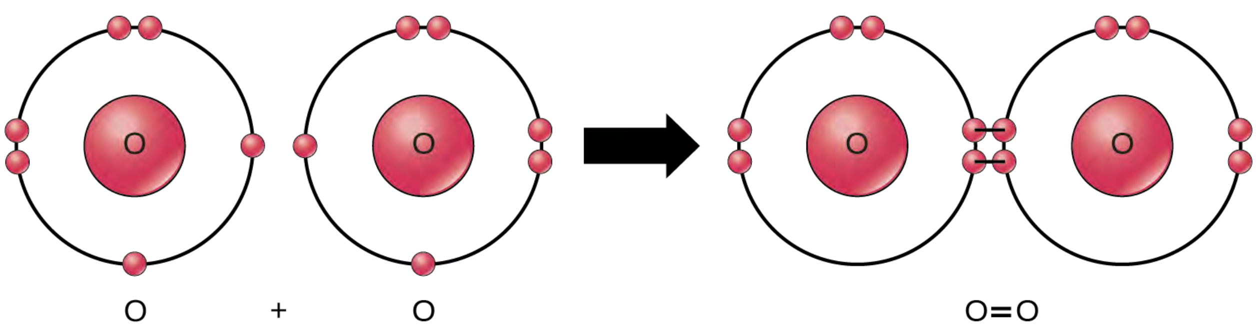

Figure 2.16 A nonpolar covalent bond joins the oxygen atoms in an O_2 molecule. (credit: Clark et al./Biology 2E OpenStax)