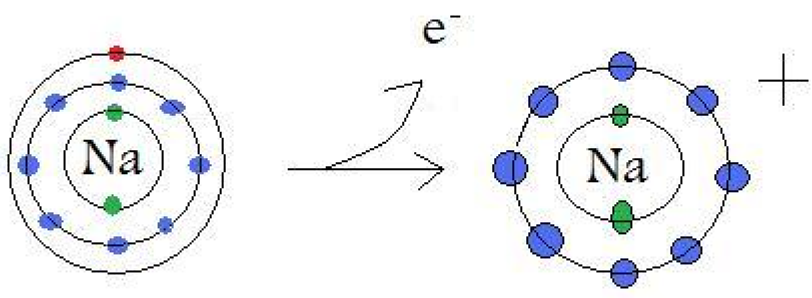
Ionic and Covalent Bonds

There are many types of chemical bonds and forces acting together to bind molecules together. The two most basic types of bonds are characterized as either ionic or covalent. In ionic bonding, atoms transfer electrons to each other. Ionic bonds require at least one electron donor and one electron acceptor. In contrast, atoms that have the same electronegativity share electrons in covalent bonds since donating or receiving electrons is unfavorable.

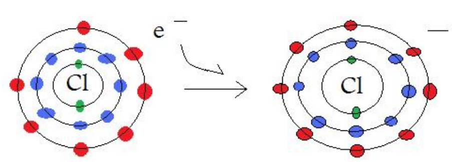
Introduction

Ionic bonding is the complete transfer of valence electron(s) between atoms. It is a type of chemical bond that generates two oppositely charged ions. In ionic bonds, the metal loses electrons to become a positively charged cation, whereas the non-metal accepts those electrons to become a negatively charged anion. Ionic bonds require an electron donor, metal, and an electron acceptor, nonmetal.

Ionic Bonding is observed because metals have few electrons in its outer-most orbital. By losing those electrons, these metals can achieve noble-gas configuration and satisfy the octet rule. Similarly, nonmetals that have close to 8 electrons in its valence shell tend to readily accept electrons to achieve its noble gas configuration. In ionic bonding, more than 1 electron can be donated or received to satisfy the octet rule. The charge on the anion and cation corresponds to the number of electrons donated or received. In ionic bonds, the net charge of the compound must be zero.

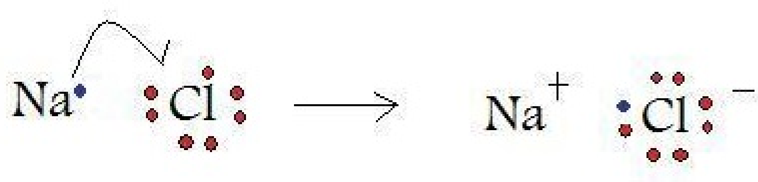


This sodium molecule donates the lone electron in its valence orbital in order to achieve octet configuration. This creates a positively charged cation due to the loss of electron.

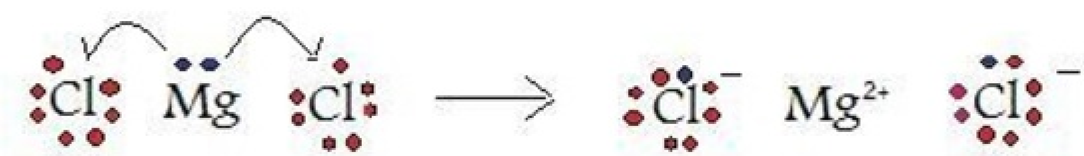


This Chlorine molecule receives one electron to achieve its octet configuration. This creates a negatively charged anion due to the addition of one electron.

The predicted overall energy of the ionic bonding process, which includes the ionization energy of the metal and electron affinity of the nonmetal, is usually positive, indicating that the reaction is endothermic and unfavorable. However, this reaction is highly favorable because of their electrostatic attraction. At the most ideal inter-atomic distance, attraction between these particles releases enough energy to facilitate the reaction. Most ionic compounds tend to dissociate in polar solvents because they are often polar. This phenomenon is due to the opposite charges on each ions.



In this example, the Sodium molecule is donating its 1 valence electron to the Chlorine molecule. This creates a Sodium cation and a Chlorine anion. Notice that the net charge of the compound is 0.

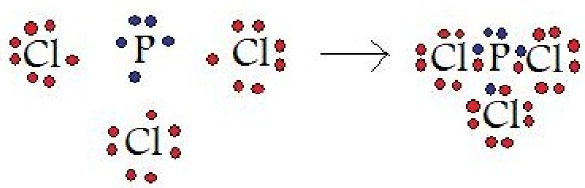


In this example, the Magnesium molecule is donating both of its valence electrons to Chlorine molecules. Each Chlorine molecule can only accept 1 electron before it can achieve its noble gas configuration; therefore, 2 molecules of Chlorine is required to accept the 2 electrons donated by the Magnesium. Notice that the net charge of the compound is 0.

Covalent Bonding

Covalent bonding is the sharing of electrons between atoms. This type of bonding occurs between two of the same element or elements close to each other in the periodic table. This bonding occurs primarily between nonmetals; however, it can also be observed between nonmetals and metals as well.

When molecules have similar electronegativity, same affinity for electrons, covalent bonds are most likely to occur. Since both atoms have the same affinity for electrons and neither is willing to donate them, they share electrons in order to achieve octet configuration and become more stable. In addition, the ionization energy of the atom is too large and the electron affinity of the atom is too small for ionic bonding to occur. For example: Carbon does not form ionic bonds since it has 4 valence electrons, half of an octet. To form ionic bonds, Carbon molecules must either gain or lose 4 electrons. This is highly unfavorable; therefore, Carbon molecules share their 4 valence electrons through single, double, and triple bonds so that each atom can achieve noble gas configurations. Covalent bonds can include interactions of the sigma and pi orbitals; therefore covalent bonds lead to formation of single, double, triple, and quadruple bonds.



In this example, a Phosphorous molecule is sharing its 3 unpaired electrons with 3 Chlorine atoms. In the end product, all four of these molecules have 8 valence electrons and satisfy the octet rule.

Bonding in Organic Chemistry

Ionic and Covalent bonds are the two extremes of bonding. Polar covalent is the intermediate type of bonding between the two extremes. Some ionic bonds contain covalent characteristics and some covalent bonds are partially ionic. For example, most Carbon-based compounds are covalently bonded but can also be partially ionic. Polarity is a measure of the separation of charge in a compound. A compound's polarity is dependent on the symmetry of the compound as well as differences in electronegativity between atoms. Polarity occurs when the electron pushing elements, left side of the periodic table, exchanges electrons with the electron pulling elements, right side of the period table. This creates a spectrum of polarity, with ionic(polar) at one extreme, covalent(nonpolar) at another, and polar covalent in the middle.

Both of these bonds are important in Organic Chemistry. Ionic bonds are important because they allow the synthesis of specific organic compounds. Scientists can manipulate ionic properties and these interactions in order to form products they desire. Covalent bonds are especially important since most carbon molecules interact primarily through covalent bonding. Covalent bonding allows molecules to share electrons with other molecules, creating long chains of compounds and allowing more complexity in life.

Source: http://chemwiki.ucdavis.edu/Organic_Chemistry/Fundamentals/Ionic_and_Covalent_Bonds