Extra Material (From Dr. Orfan Shouakar-Stash)

Chemical Bonding

Chemical compounds are formed by the joining of two or more atoms. A stable compound occurs when the total energy of the combination has lower energy than the separated atoms. The bound state implies a net attractive force between the atoms ... a chemical bond. The two extreme cases of chemical bonds are:

Covalent bond: bond in which one or more pairs of electrons are shared by two atoms.

Ionic bond: bond in which one or more electrons from one atom are removed and attached to another atom, resulting in positive and negative ions which attract each other.

Other types of bonds include metallic bonds and hydrogen bonding. The attractive forces between molecules in a liquid can be characterized as van der Waals bonds.

STORY (Analogy)

The way I look at covalent and ionic bonds is like this.

When two people are sharing a business equally where every one of them owns 50% of the business we call that a covalent bond.

If these two people share a business unequally (e.g. 60% to 40% or 80% to 20%) we call that a polar covalent. The larger the difference between the shares of the two owners the more polar the bond is.

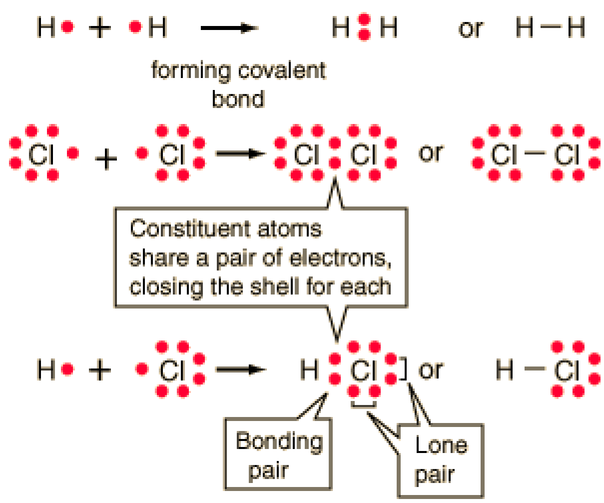
When a person takes over the business we call the relation an ionic bond, where one of the owners gives up his share and the other takes it all.

Some people say that when one of the owners gives up his share of the business he becomes free and he can tour the whole world and enjoy life and that is why he is positively charged. On the other hand, the other owner, who takes over the entire business becomes a workaholic and ends up working day and hight trying to keep his business up and running. Consequently, this gets him into losing his family and dying young and that is why he is charged negatively.

Covalent Bonds

Covalent chemical bonds involve the sharing of a pair of valence electrons by two atoms, in contrast to the transfer of electrons in ionic bonds. Such bonds lead to stable molecules if they share electrons in such a way as to create a noble gas configuration for each atom.

Hydrogen gas forms the simplest covalent bond in the diatomic hydrogen molecule. The halogens such as chlorine also exist as diatomic gases by forming covalent bonds. The nitrogen and oxygen which makes up the bulk of the atmosphere also exhibits covalent bonding in forming diatomic molecules.



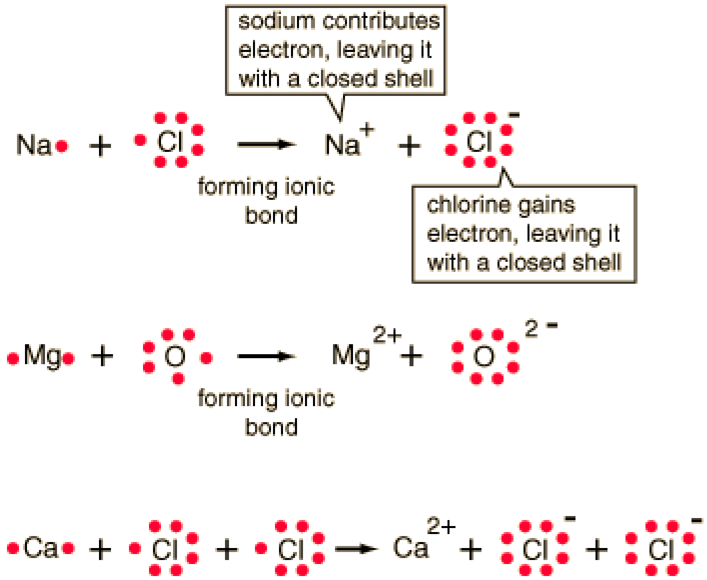
Polar Covalent Bonds

Covalent bonds in which the sharing of the electron pair is unequal, with the electrons spending more time around the more nonmetallic atom, are called polar covalent bonds. In such a bond there is a charge separation with one atom being slightly more positive and the other more negative, i.e., the bond will produce a dipole moment. The ability of an atom to attract electrons in the presense of another atom is a measurable property called electronegativity.

Ionic Bonds

In chemical bonds, atoms can either transfer or share their valence electrons. In the extreme case where one or more atoms lose electrons and other atoms gain them in order to produce a noble gas electron configuration, the bond is called an ionic bond.

Typical of ionic bonds are those in the alkali halides such as sodium chloride, NaCl.



Comparison of Properties of Ionic and Covalent Compounds

Because of the nature of ionic and covalent bonds, the materials produced by those bonds tend to have quite different macroscopic properties. The atoms of covalent materials are bound tightly to each other in stable molecules, but those molecules are generally not very strongly attracted to other molecules in the material. On the other hand, the atoms (ions) in ionic materials show strong attractions to other ions in their vicinity. This generally leads to low melting points for covalent solids, and high melting points for ionic solids. For example, the molecule carbon tetrachloride is a non-polar covalent molecule, CCl_4. It's melting point is -23°C. By contrast, the ionic solid NaCl has a melting point of 800°C.

Ionic Compounds

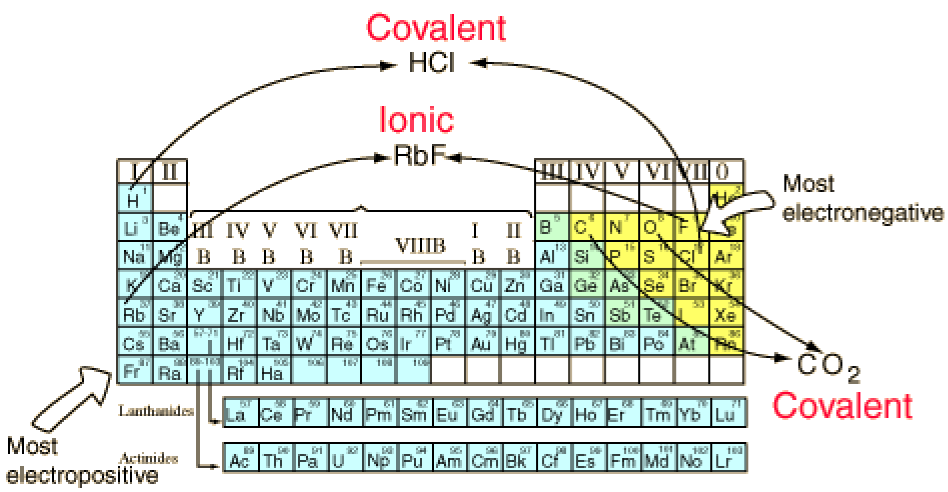
1. Crystalline solids (made of ions)
2. High melting and boiling points
3. Conduct electricity when melted
4. Many are soluble in water but not in nonpolar liquid (NaCl)

Covalent Compounds

1. Gases (O_2), liquids (H_2O), or solids (SiO_2 and Diamond) (made of molecules)
2. Low melting and boiling points
3. Poor electrical conductors in all phases
4. Many soluble in nonpolar liquids but not in water (Acetylene)

You can anticipate some things about bonds from the positions of the constituents in the periodic table. Elements from opposite ends of the periodic table will generally form ionic bonds. They will have large differences in electronegativity and will usually form positive and negative ions. The elements with the largest electronegativities are in the upper right of the periodic table, and the elements with the smallest electronegativities are on the bottom left. If these extremes are combined, such as in RbF, the dissociation energy (the amount of energy which is required to homolytically fracture a chemical bond) is large. As can be seen from the illustration below, hydrogen is the exception to that rule, forming covalent bonds.

Elements which are close together in electronegativity tend to form covalent bonds and can exist as stable free molecules. Carbon dioxide is a common example.

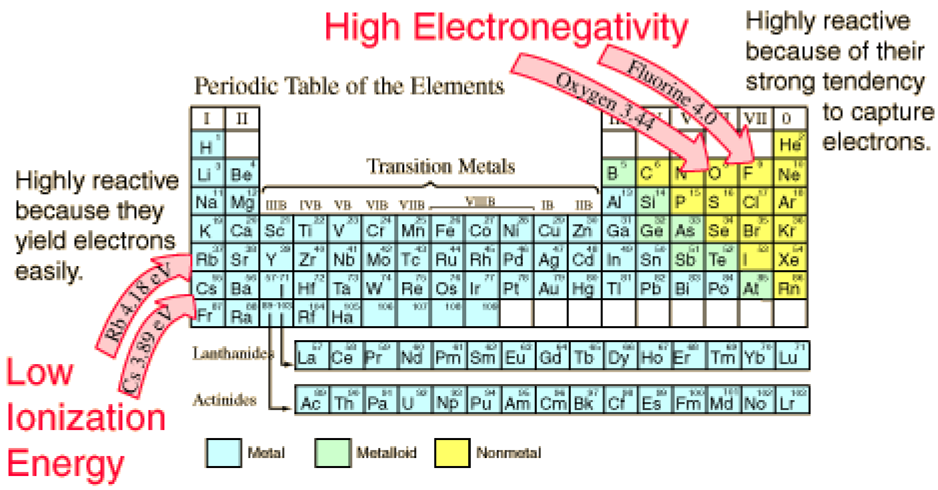


Electronegativity

Electronegativity is a measure of the ability of an atom in a molecule to draw bonding electrons to itself. The most commonly used scale of electronegativity is that developed by Linus Pauling in which the value 4.0 is assigned to fluorine, the most electronegative element. Lithium, at the other end of the same period on the periodic table, is assigned a value of 1. Electronegativity generally increases from left to right on the periodic table and decreases from top to bottom. Metals are the least electronegative of the elements. The Pauling electronegativities for the elements are often included as a part of the chart of the elements.

An important application of electronegativity is in the prediction of the polarity of a chemical bond. Because hydrogen has an electrognegativity of 2.1 and chlorine has an electronegativity of 3.0, they would be expected to form a polar molecule with the chlorine being the negative side of the dipole. The difference between the electronegativities of Na(0.9) and Cl(3.0) are so great that they form an ionic bond. The hydrogen molecule on the other hand, with zero electronegativty difference, becomes the classic example of a covalent bond.

After fluorine, oxygen is the next highest in electronegativity at 3.44, and this has enormous consequences in practice. Since oxygen is the most abundant element on the Earth, its high chemical activity makes it a part of most common substances. It's electronegativity leads to the polar nature of the water molecule and contributes to the remarkable properties of water.



The highly reactive corners of the Periodic Table

Chemical Bond Energy Considerations

A chemical bond forms when it is energetically favorable, i.e., when the energy of the bonded atoms is less than the energies of the separated atoms. Some of the types of tabulated data associated with chemical bonds are:

Ionization energy: the energy required to remove an electron from a neutral atom.

Electron affinity: the energy change when a neutral atom attracts an electron to become a negative ion.

Electronegativity: the ability of an atom in a molecule to draw bonding electrons to itself. Basically, Electronegativity is a combination of electron affinity and ionisation potential. Like an average of their affects. As you go from left to right of the table the electronegativity increases. From top to bottom it decreases.

Right	Strong attraction for electrons
Left	Weak attraction for electrons
Bottom part	Large atoms - large number of shells - weak attraction
Top part	Small atoms - small number of shells - strong attraction