*Chemistry

As we begin our study of minerals and rocks, it would be worth our while to review some very basic chemistry in order to better understand some of the fundamental properties of the various earth materials we will be examining.

A good place to start is with the periodic table as illustrated in Figure 1. The table lists the elements in order of their atomic number and shows a periodic variation based on a rule of eight. We can illustrate the periodicity if we look at the second row of the table starting with the element Lithium (Li). This element has three electrons, two of which are in an inner shell and one is in the outer shell and is available for bonding. It is said to have a valence of +1 and this valance is the same for all elements in the first column. The next element is beryllium (Be) and it has two valence electrons and we thus proceed to the right to boron (B) with three outer electrons, carbon with four and hence, on to neon with two electrons in the inner shell and eight in the outer shell. Eight electrons in this shell is very stable and elements in this column are not inclined to gain or lose electrons and they are therefore inert or unreactive. They are all gases and do not react with other atoms; they are often referred to as the noble gases. The whole table is arranged on this principle and elements in the same column tend to have similar properties to others in the column because they have the same number of outer electrons which are the ones involved in chemical reactions.

The periodic table, giving the charge and radius (in Å) of the commoner ions

H																	He
Li^{1} 0.68	Be^{2} 0.35	B^{3} 0.23	C^{4} 0.16											N^{5} 0.13	O^{-2} 1.40	F^{-} 1.36	Ne
Na^{1} 0.97	Mg^{2} 0.66	Al^{3} 0.51	Si^{4} 0.42											P^{5} 0.35	S^{6} 0.30 S^{-2} 1.84	Cl^{-} 1.81	A
K^{1} 1.33	Ca^{2} 0.99	Sc^{3} 0.81	Ti^{4} 0.68	V^{5} 0.59 V^{3} 0.74	Cr^{6} 0.52 Cr^{3} 0.63	Mn^{4} 0.60 Mn^{2} 0.80	Fe^{3} 0.64 Fe^{2} 0.74	Co^{3} 0.63 Co^{2} 0.72	Ni^{2} 0.69	Cu^{2} 0.72 Cu^{1} 0.96	Zn^{2} 0.74	Ga^{2} 0.62	Ge^{4} 0.53	As^{5} 0.46	Se^{6} 0.42	Br^{-} 1.95	Kr
Rb^{1} 1.47	Sr^{2} 1.12	Y^{3} 0.92	Zr^{4} 0.79	Nb^{5} 0.69	Mo^{6} 0.62		Ru^{4} 0.67	Rh^{3} 0.68	Pd^{2} 0.80	Ag^{1} 1.26	Cd^{2} 0.97	In^{3} 0.81	Sn^{4} 0.71	Sb^{5} 0.62 Sb^{3} 0.76	Te^{6} 0.56	I^{-} 2.16	Xe
Cs^{1} 1.67	Ba^{2} 1.34	La^{3}- 1.14 Lu^{3} 0.85	Hf^{4} 0.78	Ta^{5} 0.68	W^{6} 0.62	Re^{4} 0.72	Os^{6} 0.69	Ir^{4} 0.68	Pt^{2} 0.80	Au^{1} 1.37	Hg^{2} 1.10	Tl^{1} 1.47	Pb^{4} 0.84 Pb^{2} 1.20	Bi^{3} 0.96			
			Th^{4} 1.02		U^{4} 0.97												

Figure 1

*Most of this summary was compiled by Dr John Grace, Professor Emeritus, WMU

A complexity in the rule of eight occurs in the fourth row of the table where beginning with the element scandium electrons being added to each succeeding element fill up an inner shell rather than the outermost shell. This phenomenon continues until we reach element 31, gallium and from then on the electrons fill the outer shell as before. These intervening groups of elements are all metallic elements and are referred to as transition metals. They have somewhat variable valences and indeed may have several common valences; iron is a classic example with both +2 (ferrous) and +3 (ferric) configurations.

Some elements are relatively unreactive and may exist on the earth's surface uncombined with any other element. Gold is an example of a metal that can behave in this way and sulfur is a non-metal that also can exist uncombined with other elements. These are called native elements and will be discussed in the chapter four. It is much more common for elements to combine with others to form compounds, or as earth scientists would say; minerals. The process whereby one element combines with another is called bonding and we shall now discuss the various types of bonding found in the mineral world. Perhaps the most common type of bonding is described as the exchange of electrons from a positive ion (cation or metal) with a negative ion (anion or nonmetal). A classic example is the bonding of Na^+ with Cl^- to form NaCl. This type of bonding is called ***ionic bonding*** and it is a model of bonding we can use for most minerals.

Covalent bonding is a type of bonding in which electrons are shared between atoms in order to achieve a stable configuration. The bonding of carbon in diamond is a good example and it can be illustrated as shown below:

C

..

C : C : C

..

C

Four other carbon atoms surround each carbon atom so that each atom "sees" a stable outer shell of eight electrons.

A special case of covalent bonding occurs in metals and is called metallic bonding. Here the outer electrons are free to move from one atom to another and indeed can move a considerable distance through the lattice. Each atom senses enough electrons nearby so that it is satisfied but the mobile electrons give metallic substances like native copper their high heat and electrical conductivity and their metallic luster.

Two very weak bonding types only occasionally experienced in the mineral world is van der ***Waal's bond*** and the ***hydrogen bond***. The bonding between inert gases is van der Waal's bonding and bonding in many organic compounds is in part hydrogen bonding.

The size of ions plays an important part in the arrangement of atoms within a crystal lattice. Some ionic radii are given in figure 2 for some common cations and anions found in earth materials. In general terms we can think of larger anions surrounding somewhat smaller cations in typical mineral structures. The number of anions surrounding a cation is referred to as the coordination number. We'll talk lot's more about this.

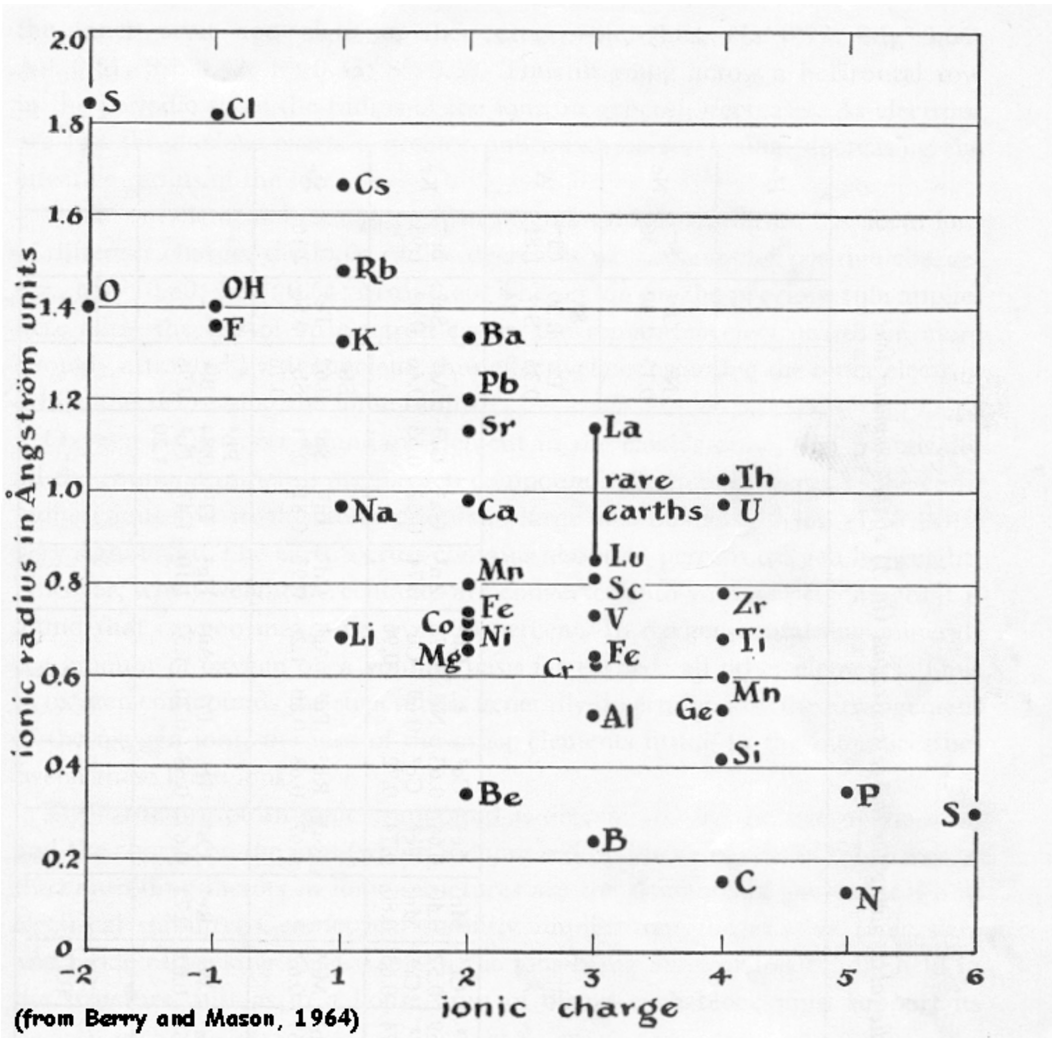

Figure 2