Chemistry Addendum to Physical Geology
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As the chemical formation of the Earths rock, minerals, and organic resources in the context of physical geology is a complex science in itself, it becomes difficult to put into text the complex forces and reactions that take place chemically during the processes that take place during the creation of the rocks, minerals, and the organic resources that we have on our Earth today. These processes start deep in matter itself. To be able to explain these processes, one must examine the basic building blocks of the materials around us.

All types of material, whether it be solid, liquid, gaseous, metallic, or non metal is composed of what the scientists consider to be matter. What the scientists consider matter is a substance that occupies space and that it also has weight (density). Matter consists of single elements or a combination of two or more elements which make up compounds. In other words you must have two or more elements to make up a compound.

So what is an element? It is all the basic pure substances that we know of that exists around us and our known universe. Scientists consider them to be the basic building blocks of everything that exists. These are the pure substances that cannot be broken down into simpler pure substances by chemical means.

Over one hundred elements have been identified. Some of these are already familiar to most people. For example Oxygen, Hydrogen, Nitrogen, Gold, Silver, and Copper are just a few to name.

Elements are further comprised of smaller particles known as atoms. If we were to combine two or more atoms the product would be known as a molecule. The molecule is therefore the smallest component of an element or compound and the atom is the smallest component of a molecule. Each atom in an element is identical. However, if two or more atoms of a different type are combined the result would be substance known as a compound.

The atom therefore, is considered to be the smallest particle of an element. And, that is why there are as many different elements as there are atoms. An atom cannot be broken down chemically. They can only be smashed by some electro / magnetic process. It is for this reason that an atom is considered as the unit particle and therefore a pure particle. Since an element is comprised of atoms of a single type, the element would therefore be a pure substance.

Atoms are composed of smaller subatomic particles. They are the makeup of the atom itself. Half of the atom is made up of neutrons and protons. These form the nucleus or centre of the atom. The outer half is composed of electrons.

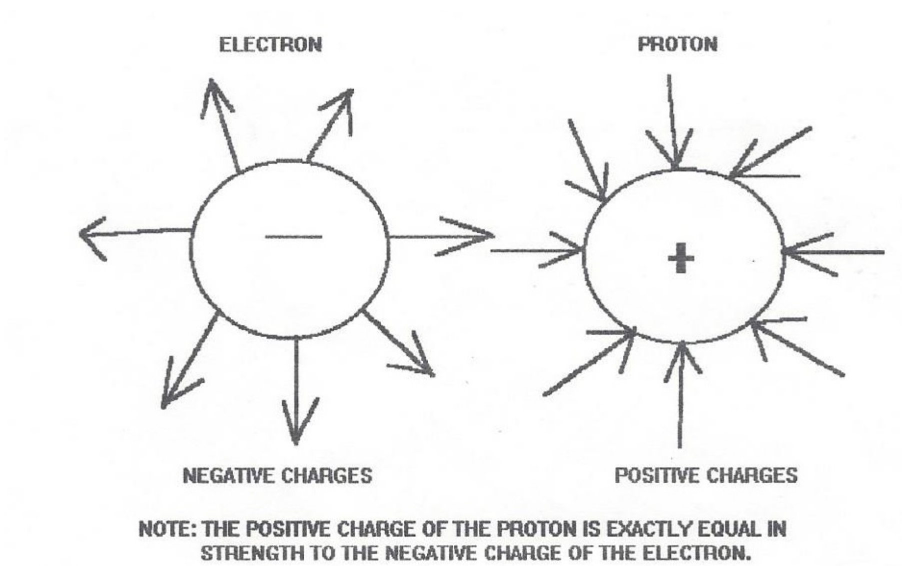
A proton is considered to be a positively charged particle of electricity and therefore is considered to be positive like the north pole of a magnet but electrically positive. The neutron is an electrically neutral particle within the nucleus. Its weight is approximately the same as a proton. The combined weight of the protons and neutrons give the atomic weight of the atom. It is the neutrons that define the atom as being an isotope. The science around isotopes is a subject beyond this addendum and will not be mentioned again within this text.

Electrons are negatively charged particles of electricity. These particles are approximately 1,845 time lighter than the protons, but three times larger in diameter. These particles revolve at high speed in erratic orbits around the nucleus of the atom in what is referred to as a cloud of negatively charged particles. It is for this reason they are known as planetary electrons. It is the electrons, which is of the most interest as it is the electron that can be easily dislodged from the atom.

As already mentioned, there are over one hundred elements identified. Since elements are pure substances, it stands to reason that there are over one hundred different types of atoms. To keep track of these atoms for identification, each atom has been given a number. This is the atomic number or identification number for the atom. It is always referred to as the atomic number. This number is directly related to the number of protons that the atom contains in its nucleus. Hydrogen for example has one proton, Helium has two, Oxygen has 8, Radon has 86, and so on. Therefore, Hydrogen has the atomic number 1, Oxygen has the number 8, and radon has 86.

As already mentioned, every atom has an atomic weight. Since the neutrons add weight to the atom and the weight of the neutron is approximately the same of that as the proton, the combined weight is therefore the weight of the atom. This is the atomic weight of the atom. Oxygen has eight protons and eight neutrons; its atomic weight is 16. An element with fewer protons and neutrons would be light and therefore, would be a gas. An atom containing a greater amount of Protons and neutrons would therefore be a metal. Lead for example, has an atomic number of 82. It has an atomic weight of 207. This equates to the atom having 82 protons and 125 neutrons which verifies the previous statement that not all atoms have an equal number of protons and neutrons.

Electrons exert equal but opposite force upon each other. This is due to their opposite electrical charges. Protons being positive in nature and electrons being negative. These are electrical charges which produce strain lines of force known as electro-static lines of force. These lines spread out in all directions from the charged particle. In essence these charged particles are capable on influencing and being influenced by other charged particles through their associated electro-static line of force in accordance with the law of charges.



The law of charges states "that like charges repel and unlike charges attract". Any motion resulting from these forces will be electron motion because electrons are the lightest of the two charged particles and also they are situated at the surface of the atom, hence they are more easily influenced. Coulombs law states "that the force of attraction or repulsion will increase if the amount of either or both of these charges is increased or the distance between these two charges is decreased".

Under normal conditions the number of electrons revolving around the nucleus of the atom is equal to the number of protons in the nucleus. In this state the atom is balanced or neutral and displays no electrical charge. However, if an atom either gains or loses one or more electrons it will become unbalanced and take on a charge. A negative ion is an atom with more electrons than protons whereas a positive ion is an atom with more protons than electrons orbiting the nucleus. Therefore ions act somewhat like electron and protons in that they also have the ability to attract and repel other charged particles in accordance with the law of charges.

The planetary electrons erratically revolve at high speed about the positive nucleus in orbits or shells, and only the right number of shells will be formed by the electrons needed to equalize the positive charge of the nucleus. An atom can have no more than seven shells. Each shell is indicated by a number or letter and can contain only so many electrons. The maximum number of electrons is equal to the shell number squared times two.

Example: Shell #1 or "K" shell has 1X1X2 or 2 electrons
Shell #2 or "L" shell has 2X2X2 or 8 electrons
Shell #3 or "M" shell has 3x3x2 or 18 electrons
Shell # 4 or "N" shell has 4x4x2 or 32 electrons
Shell # 5 or "O" shell has 5x5x2 or 50 electrons
Shell #6 or "P" shell has 6x6x2 or 72 electrons
Shell #7 or "Q" shell has 7x7x2 or 98 electrons

These shells are further subdivided into subshells. The main shell number indicates the number of subshells it will contain. The "L" shell for example (shell #2) will contain 2 subshells and the "P" shell (shell #6) will contain 6 subshells. These subshells are designated by the letters "s", "p", "d", "f", "g", "h", and "I" respectively. These subshells are further subdivided into orbitals. An orbital can contain no more than two electrons. The maximum number of orbitals a subshell can contain is as follows:

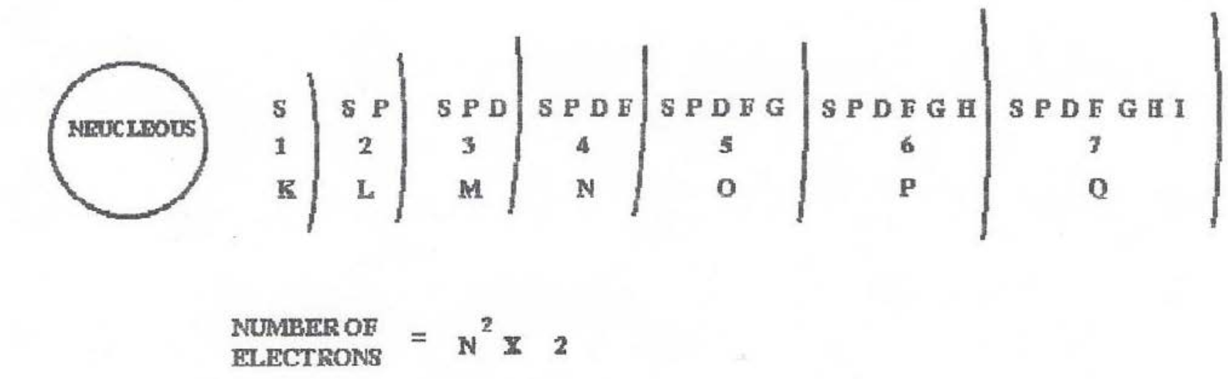
S=1, p=3, d=5, f=7, g=9, h=11, i=13

Note: the maximum number of orbitals in a main shell is equal to the main shell # squared. Using the "Q" shell for example: "Q" shell = 7x7= 49 orbitals = the total of 98 electrons.

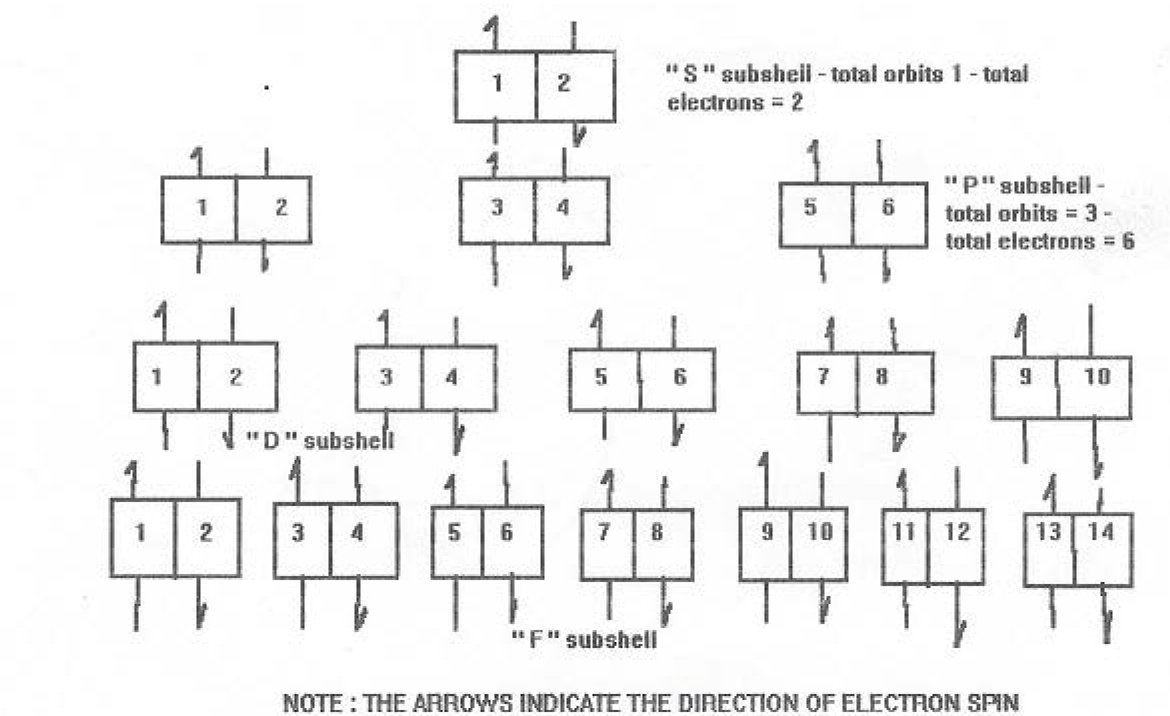
Because there can be no more than 2 electrons per orbital the maximum number of electrons per subshell is as follows:

S=2, p=6, d= 10, f=14, g=18, h=22, i=26

The "s" and "p" subshells of the next higher main shell will fill before some of the lower subshells. Therefore, some of the subshells will range from completely empty to completely full.

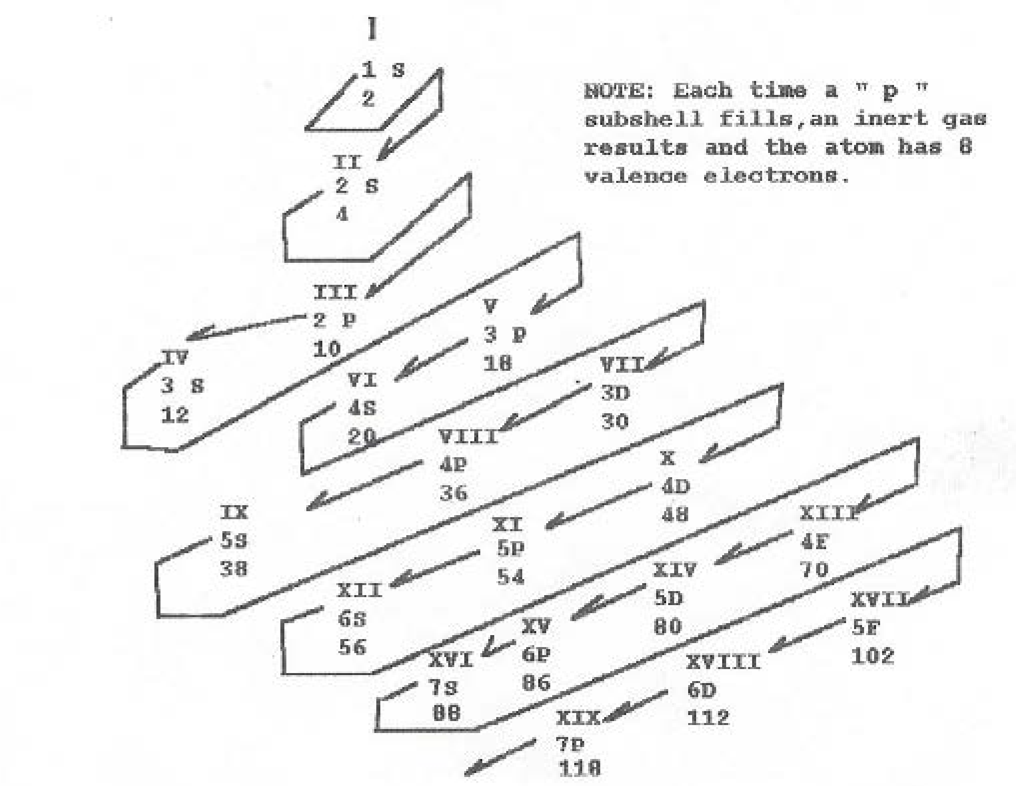


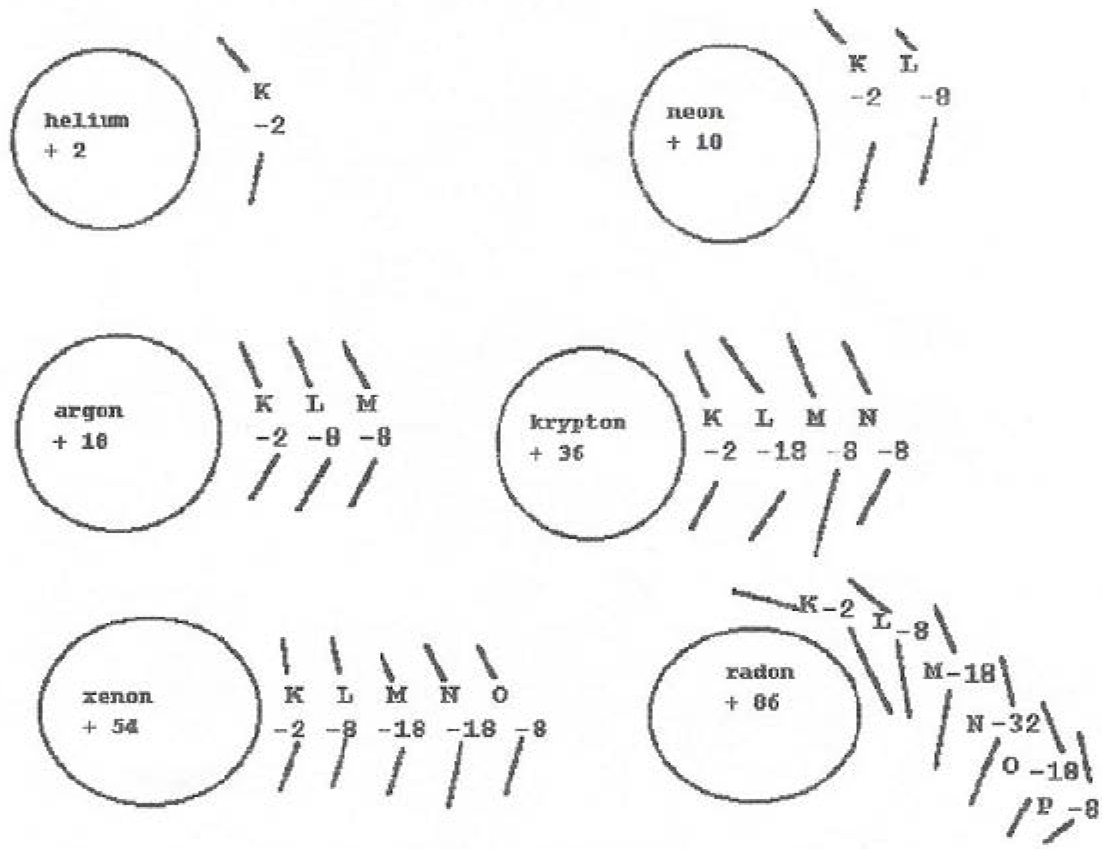
The two electrons in the same orbital spin in opposite direction to one another on their own axis like two tops as they revolve around the nucleus of the atom Each spinning electron produces a magnetic field about itself. The magnetic field about each electron is neutralized by the opposite spin of the two electrons in the same orbital. These two electrons are said to be paired. All orbitals in the same subshell must take on one electron before the electron pairing can take place in that subshell. Therefore an electron will generate and can be influenced by a magnetic field as well as an electro-static field. The orbitals in the various subshells will fill in the following order:



The outer most occupied main shell of the atom is known as the valence shell. This involves only the “s” and “p” subshells of the outer most main shell (Q or shell #7).Therefore the valence shell can contain no more than eight electrons. The further an electron orbits from the nucleus the less firmly it is held by the nucleus and the greater the electrons energy will be. Those electrons orbiting the valence shell are termed the valence electrons. These are the first to be influenced by any outside force and the last to be influenced by the positive nucleus. The number of valence electrons an atom contains determines its electrical and chemical characteristics.

If the valence shell contains its full quota of eight valence electrons the atom is both chemically and electrically stable and will resist any change, therefore it will not easily give up or take on any electrons to become ionized. Such atoms are of the inert or stable gasses. These are Helium, Neon, Argon, Krypton, Xenon, and Radon.





THE INERT GASES

NOTE: only the main shells are shown.
helium is an exeption having only 2 valence electrons.

Inert Gases

Atomic # and Name						
	1 /K	2/L	3/M	4/N	5/O	6/P
$Helium_2$	S 2 ***2***	S/P	S/P/D	S/P/D/F	S/P/D/F/G	S/P/D/F/G/H
$Neon_{10}$	S 2 ***2***	S/P 2/6 ***8***	S/P/D	S/P/D/F	S/P/D/F/G	S/P/D/F/G/H
$Argon_{18}$	S 2 ***2***	S/P 2/6 ***8***	S/P/D 2/6/0 ***8***	S/P/D/F	S/P/D/F/G	S/P/D/F/G/H
$Krypton_{36}$	S 2 ***2***	S/P 2/6 ***8***	S/P/D 2/6/10 ***18***	S/P/D/F 2/6/0/0 ***8***	S/P/D/F/G	S/P/D/F/G/H
$Xenon_{54}$	S 2 ***2***	S/P 2/6 ***8***	S/P/D 2/8/10 ***18***	S/P/D/F 2/8/10/0 ***18***	S/P/D/F/G 2/6 ***8***	S/P/D/F/G/H
$Radon_{86}$	S 2 ***2***	S/P 2/6 ***8***	S/P/D 2/6/10 ***18***	S/P/D/F 2/6/10/14 ***32***	S/P/D/F/G 2/6/10/0/0 ***18***	S/P/D/F/G/H 2/6/0/0/0/0 ***8***

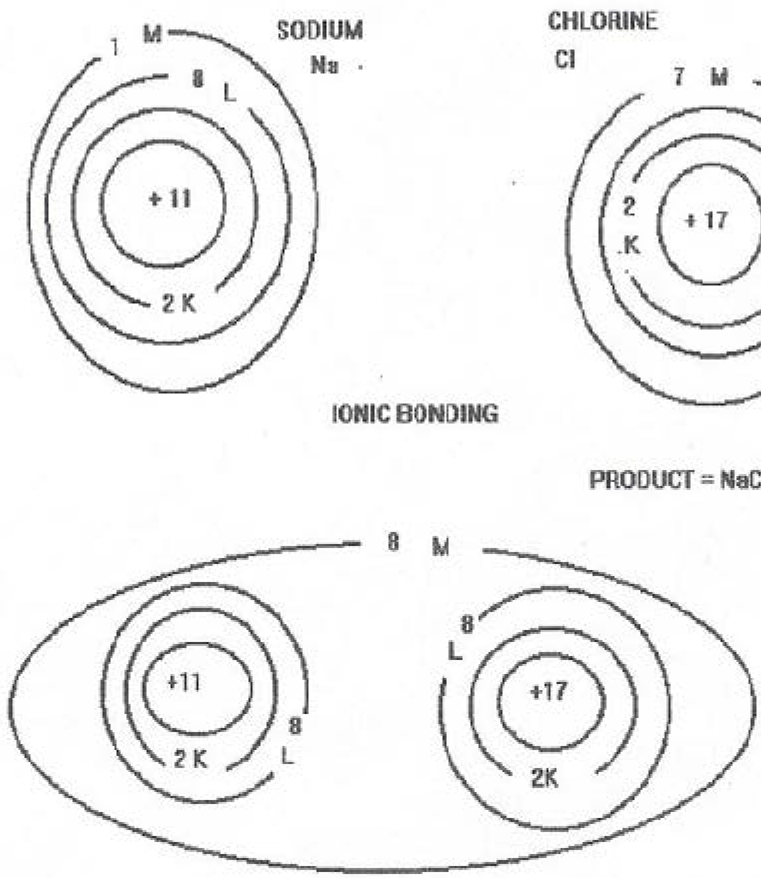
Note: Bold italicized figures are main shell values, all other are subshell values.

Although all other atoms are electrically stable or neutral because they have an equal number of electrons and protons, they are not chemically stable because their valence shell is not completely full. Such atoms will strive to fill their valence shells by rapidly ionizing as follows. An atom with six or seven valence electrons will oppose any move to give them up, and instead will attempt to take on additional electrons to fill its valence shell, thereby becoming a negative ion. An atom with one or two valence electrons will tend to rid itself of them so that the shell underneath can become the new valence shelf resulting in the formation of a positive ion.

The oppositely charged ions will be attracted to and combine with one another to form a molecule that will contain a total of eight valence electrons. This molecule, and therefore the compound it forms will resist any change because it will be both electrically and chemically stable. Therefore, the characteristics of most compounds are similar to those of the inert gasses.

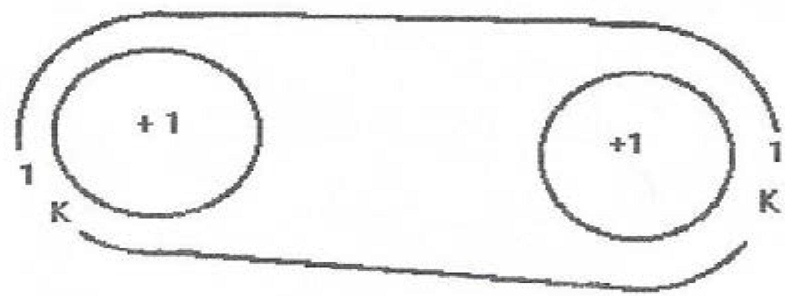
Atoms bond to each other in two ways; ionic bonding and covalent bonding. Consider a sodium atom (Na). It’s atomic number is 11 meaning that it has 11 protons. To be a stable sodium atom it must also contain 11 orbiting electrons. In this case the "K" shell will be completely full with 2 electrons. The "L" shell will contain its full quota of 8 electrons, however the "M" shell will contain only 1 electron. Even though this atom is electrically stable, it is not chemically stable and will try to rid itself of the electron.

Now let's consider a chlorine atom (Cl), Its atomic number is 17. It too is electrically stable, however it contains only 7 valence electrons. The chlorine atom is therefore chemically unstable and will attempt to take on an electron.



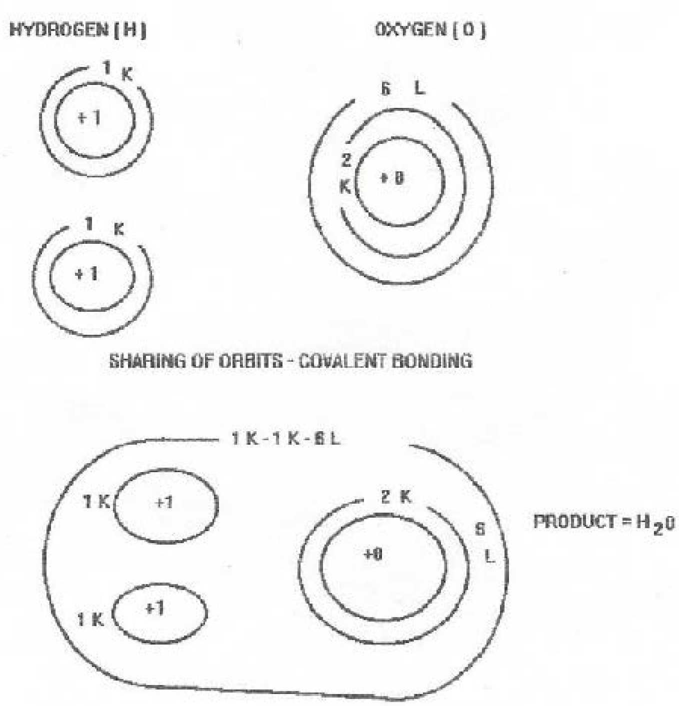
Under certain conditions the 2 atoms (ions) will bond together. The sodium atom will give up its electron to the chlorine atom. The chlorine atom will readily accept the electron thereby fill its valence shell. Now both of these atoms are chemically stable but not electrically stable. The sodium atom now has 10 electrons making the atom a positive ion and the chlorine atom now has 18 electrons making it a negative ion. The atoms are now held in place by the electro-static field in accordance with the law of charges. The new molecule formed is the smallest part of the compound sodium chloride (NaCl) or rock known as Halite to a Geologist. The rest of us know as table salt. As a new compound, the atoms are now both chemically and electrically stable and will resist any further change. This holds true for the molecule. This form of bonding is known as ionic bonding. The atoms that bond in this manner are of the inorganic or metallic substances.

The other form of bonding involves the bonding of organic substances, hence the term organic bonding. It is the sharing of electrons which holds the bond together, and is therefore termed covalent or covalent bonding. Let's first consider the simple atom known as hydrogen. It has 1 proton and only 1 electron. Of course it will attempt to take on 1 electron to fil its valence shell (the "s" subshell) thereby making the "K" shell complete.



covalent or electron sharing

The sharing process leaves us with a chemically and electrically stable hydrogen molecule. Now consider an oxygen atom. It has only 6 electrons in its valence shell. It also has the 2 electrons in its "K" shell which makes it electrically stable but chemically unstable. It will readily try to take on 2 more electrons to fill its valence shell In the presence of hydrogen it will attempt to take on 2 electrons. As the hydrogen molecule is stable, the oxygen molecule will share its electrons with the oxygen molecule valence shells, thereby chemically stabilizing the oxygen atom. A new chemically and stable molecule is now formed. This is water (H_2O).



As atoms combine with one another they begin to form molecules. A molecule is not much more than the combination of two or more identical or different types of atoms. If the molecule is composed of two or more different atoms it becomes a compound rather than an element. Molecules that comprise of two identical atoms, these molecules are termed as diatomic molecules. Compounds will always have a set number of atoms in a never changing relationship. This is known as the law of constant composition. A water molecule for example will always contain 2 hydrogen atoms and 1 oxygen atom

As previously mentioned there are over one hundred different elements identified. In order to identify the elements in a shortened form, a symbol was given to each element and placed into what is known as the periodic table. Some common elemental examples are given below:

Oxygen – “O”; sodium- “Na”; Nitrogen- “N” iron- “Fe”

The elements listed in the periodic table are listed in the order by the atomic number. To simplify the information about a molecule a chemical formula was devised. Water for example would be shown as H-O-H but as simply put as H_2O. Other examples are:

Ethyl Alcohol

```
     H  H
     |  |
H—C-C—O—H
     |  |
      H  H
```

C_2H_6O

Methylene Chloride

```
      H
      |
Cl—C—Cl
      |
      H
```

CH_2Cl

Propane

```
     H   H   H
     |   |   |
H—C—C—C—H
     |   |   |
     H   H   H
```

C_3H_8

A binary compound is a compound which contains two different elements. As already stated a molecule which is ionically bonded has one metal atom and one nonmetal atom. The metal ion is always named first and the nonmetal ion is named second. The nonmetal ending is changed with the letters "ide". One such ionic molecule would be sodium chloride. The sodium is the positive metal ion and the chlorine is the negative nonmetal ion.

When we have binary molecules which contain more than one atom in its makeup, we use prefixes to indicate the number of atoms a molecule has. These prefixes are:

1: mono or np prefix	2: di
3: tri	4: tetra
5: penta	6: hexa
7: hepta	8: octa

Carbon disulfide (CS_2)	Phosphorous Pentasulfide (P_2S_5)
Ethylene Dichloride ($C_2H_4CL_2$)	Tetraethyl Lead ($(C_2H_5)_4Pb$)
Arsenic Trioxide (As_2O_3)	Carbon Tetrachloride (CCl_4)

A binary acid is a makeup of hydrogen and some other element. When this compound is mixed with water, it will release hydrogen ions and become an acid. The binary acid is named by shortening hydrogen to hydro and placing it in front of the name of the second element. The second element is then shortened and the letter "ic" is placed at the end of it. An example is the combination of hydrogen and chlorine. The binary resulting acid would be hydrochloric acid.

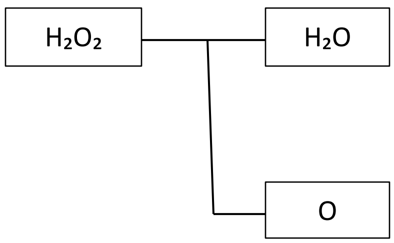
Compounds which contain three elements are referred to as ternary compounds. Hydroxides and Oxy acids are of this family of compounds. Hydroxides are Alkalis. Alkalis are known as bases. When mixed with water these bases will release an ion molecule of oxygen and hydrogen. The term hydroxide root is used to describe the hydrogen-oxygen ion (OH). The hydroxides are named by adding the word hydroxide to the end of the element that combines with the hydroxide root. An example would be calcium hydroxide ($Ca(OH)_2$).

Hydrogen, oxygen, and a third element will create an Oxy Acid. If the third element has the ending "ic" at the end, it has more oxygen atoms than the similar compound with the ending "ous". Example are:

1. H_2SO_4 and H_2SO_3 (sulfurous acid)
2. H_3PO_4 and H_3PO_3 (phosphorous acid)
3. $HClO_3$ and $HClO_2$ (Chlorous acid)

As bonds are created or broken changes take place. These are changes to the molecular composition and properties of the material or substance. Chemical changes occur because of the chemical reactions between the different atoms within the molecules that make up the substance. The nucleus of the atoms don't change, it's the electrons that effect the change due to the forces of repulsion and attraction which is placed upon them either electrically or chemically (either ironical or covalently). Changes occur as atoms are redistributed during a chemical reaction. Bonds are broken and new bonds must be formed. There are four basic chemical reactions. These are combination, decomposition, replacement, and multiple replacement / displacement. As two or more substances are formed to create a more complex compound (synthesis) a combination reaction had to take place. Using copper and oxygen as an example, the more complex compound formed is copper oxide.

Decomposition is the reaction where the substance or compound is broken down to a simpler compound or element. Breaking down hydrogen peroxide (H_2O_2) will result in leaving the product of oxygen (O) and water (H_2O).



By combining iron with sulfuric acid the hydrogen atoms in the sulfuric acid would be released and the product would be iron sulfide. This reaction is termed as a replacement reaction as the hydrogen was replaced by the iron to give us a new compound thus the new product (iron sulfide).

If we combine propane (C_3H_8) with oxygen the carbon atom would be displaced. The oxygen atom will replace the carbon atom thereby creating a water molecule. The carbon atoms will then combine with the remaining oxygen atoms thereby forming carbon dioxide (CO_2). This combination of displacement and replacement is known as the multiple displacement / replacement reaction.

To represent the reaction of substances a system was developed for this purpose It is an equation in shorthand which shows or represents matter and accounts for the origin and destination of each and every atom. Ie:

2 molecules of hydrogen atoms + 2 oxygen atom = H_2O

$$2H_2 + O_2 \longrightarrow 2H_2O$$

It becomes apparent, since the nucleus of the atom is not affected and only the electrons are influenced by the changes; matter cannot be created or destroyed. Therefore the number of atoms must balance on both sides of a chemical equation.

A certain amount of energy is required to break a chemical bond. Once a bond is broken the energy is released. This energy is in the form of heat, light, and invisible radiation. A molecule will absorb energy to a point where it can no longer sustain the strain caused by the energy it was absorbing and the bonds will begin to break down between the atoms that were holding them together. This reaction is termed an endothermic reaction. Once the bonds break, energy is then released to the surrounding environment usually in the form of heat, light, and invisible radiation. This has been termed an exothermic reaction. These are the heats of reaction.

$$2H_2 + O_2 \longrightarrow 2H_2O$$

By examining the above equation you should notice that the product, being two molecules of water, has the same number of atoms as the original molecules contained before the reaction. The number of electrons still remained the same. It is important to note that the atoms were neither created nor destroyed. The law of conservation of matter states that the mass of a chemically reacting system will remain constant throughout the reaction.

Matter can be converted to energy,. The mass of the reacting system can have a slight mass difference between reactant and product due to the absorbtion and release of energy. The amount of the energy either released or absorbed is equal to the change in the mass of the atoms. Therefore mass and energy can be considered to be the same, thus matter can be converted to energy and vice versa in a chemical reaction.

Since atoms combine with each other to form molecules and the molecules further combine with like molecules to form substances, it is the state or form of the substance which is of special interest. Matter in itself as we know is anything which has mass or has inertia and which also occupies space (it has volume). Therefore anything that has volume must take on some form of physical state.

There are three possible states that exist. They are solids, liquids, or gasses. Some substances such as water can exist in all three states. Because matter has mass or stated in another way, mass has inertia, the molecules of all substances must be continually in motion due to the energy that they have.

Solids are substances who’s molecules are held tightly together by their cohesive forces. They are locked together in a crystalline pattern. The molecules of these structures are held so tightly together that they cannot freely move about, however, due to their energy are in constant vibration. In other words, these molecules are free to vibrate but are not able to freely move in any direction.

Liquid molecules are not so tightly held together. Their cohesive bonds are weaker than those holding together the solids, therefore the molecules of liquids are free to randomly glide over one another within a substance. This is why a liquid does not have a definite shape and is free to flow and take on the shape of any container.

The molecules of a gas have even weaker cohesive forces. Like liquids these molecules randomly move with far less cohesive restriction. There may be considerable distance between the molcules. For this reason alone gasses do not readily take on shape as a liquid. Gasses are compressible and if not confined will readily disperse.

As a substance heats up, its molecular activity increases. The electrons will become elevated in their movements (more agitated). Another way of putting it, is they become excited. Some molecules will actually break free and escape into the atmosphere. This is considered as evaporation. A good example is water turning into steam. In fact all substances are capable of evaporating if there is sufficient heat applied. Thermal stability refers to the resistance of a substance to decompose when heated in a vacuum.

Matter therefore can change state from one form to another if there is sufficient temperature or pressure or both applied to a substance. A substance can melt such as ice to water when heated or solidify when cooled sufficiently, a process known as solidifications. A state of vaporation from a liquid to a gas can occur if sufficient heat is applied to a liquid. A case in point would be water to steam or water vapor. Condensation occurs when a vapor or gas is cooled. Sublimation is the term used for the conversion between a solid to a gas and vice versa.

Temperature and heat must be defined in relation to molecular reactivity. Temperature is a measurement of the relative intensity of the molecular motion of the molecules within a substance, whereas heat is the amount or quantity of thermal energy within a substance. The lowest achievable temperature is 0 degrees Kelvin. This would relate to -273.15 degrees Fahrenheit. Heat is measure in B>T>U>’s, calories, or joules, and represents the amount of molecules in a substance that are moving. The more agitated the molecules are, the greater the heat.

As molecules come into contact with each other their energies can be transferred. The law of heat flow states that heat will flow from an object of higher temperature to an object of lower temperature until both objects are of equal temperature. The amount of heat does not determine the flow. It is the intensity of the molecular activity which determines the flow of heat. As heat is added to the material, the temperature of the material will increase, or in other words, the movement of the molecules in the substance increases. As the molecules become more exited they start to push away from each other and their cohesive bonds become weaker and begin to move instead of vibrate. A good example would be ice turning to water. As more heat is added, the molecules will become further exited and start to break away or disperse such as a gas. This could be water turning to steam. In retrospect, temperature indicates the capability of a substance to transfer heat to another substance, whereas a substance may have more thermal energy than another but may not have a higher temperature. An example would be a large bowl of luke warm soup that takes longer to coll down than a small cup of tea due to the bowl of soup having a greater quantity of thermal energy.

All atoms, molecules, and substances in general undergo some form of reaction due to the heating process. It must be understood that the term reactivity only reflects a substances tendency to chemically react with another substance without the addition of heat.

As the temperature of a substance heats up the molecules become more exited. The covalent or ionic bonds holding the molecules together will break and the atoms comprising the molecules will become free to join thereby creating new molecules. It takes energy to form these bonds and it takes further energy to excite these molecules. All the energy used is stored within the molecule until it no longer can contain the energy being absorbed. At that instant the molecule loses its bond releasing that stored energy in the form of heat and light. As an example of this process that can be observed is fire. The speed of which these bonds break depends on the intensity of the energy source, the size of the area affected by this energy input, and the nature of the material upon which the energy is impinging.

Most material will contain carbon atoms. Carbon atoms will always form four bonds with other atoms. That includes other carbon atoms. Different atoms can form different amount of bons. Depending on the atom that carbon is bonded to, there may be a single bond, a double, or even a triple bond between them. Other atoms such as silicon can also form four bonds and therefore are of the same family. Hydrogen, fluorine, and chlorine can have only one bond, oxygen and sulfer can form two, and nitrogen can form three.

There is always some breakdown of substance happening at all times due to the reactivity of the molecules caused by normal heating or by the slow reactance to oxygen (oxidation). However with the accelerated breakdown of the bonds due to the input of more heat but yet too slow to cause ignition (fire) is the process known as pyrolysis. It can be stated as the evaporation of a solid due to increased heating. It is interesting to note that the speed of reaction will double with every 10 degrees centigrade or 18 degrees Fahrenheit increase of temperature of the reactants involved. Therefore, the greater number of bonds, the greater the energy stored will result in the greater amount of energy released when the bonds are broken. This does not mean that thing are hotter only that the total amount of heat will be will be higher or the quantity of heat will be higher.

As already discussed the atomic bonds that bind substances together; these would be the bonds between two or more atoms, and as we have discussed the storing of energy during the making of the bonds, and concluded with the subsequent release of energy when the bonds are broken; as bonds are broken, one electron will remain with the atom. This produces a molecular fragment which is very if not extremely reactive. The atom becomes very unbalanced due to being or representing only half of a bond. This excited fragment must be neutralized or in other words must be stabilized. It must combine with another atom. In doing so, it will stabilize in its new configuration thereby forming a new particle. Thus matter cannot be created nor can it be destroyed, just changed.

These exited fragments are extremely reactive, hence given the name “free Radicle”. Free radicles cannot exist in a half ionic or covalent state for any considerable length of time. They must join with another in order t become chemically and electrically stable. This is a law of nature. It is the free radicle formation which is involved in the metamorphoses of rocks and crystals.