OXIDATION-REDUCTION REACTIONS

Oxidation = the loss of electrons by a substance (producing a positive charge)
Reduction = the gain of electrons by a substance (producing a negative charge)

Oxidation and reduction occur simultaneously. We can never have one substance lose electrons without another substance gaining those same electrons. Oxidation-Reduction reactions (sometimes abbreviated "Redox" reactions) therefore involve a *transfer* of electrons ITom one substance (molecule or separate atom) to another. Therefore, the total number of electrons gained will be exactly equal to the total number of electrons lost. Consider the following reaction:

$$\mathbf{2Mg + O_2 \rightarrow 2MgO}$$

The product MgO is a neutral molecule, but it contains the balanced ions Mg+2 and 0-2. We can easily analyze this electron transfer by considering the loss and gain of electrons by each type of atom separately. The Periodic Table tells us that Mg has an oxidation state of +2, while 0 has an oxidation state of -2. Therefore, by considering the number of atoms present, we get:

$$\mathbf{Mg \rightarrow Mg^{+2} + 2e^{-}\ (oxidation)}$$

$$\mathbf{O_2 + 4e^{-} \rightarrow 20^{-2}\ (reduction)}$$

When discussing redox reactions, then, oxidation numbers are positive or negative numbers assigned to atoms, compounds, or parts of compounds which allow us to track the electron transfers which take place during the reactions. Oxidation numbers are assigned according to the rules explained in the "Chemistry" handout previously provided.,

EXAMPLE: assign oxidation numbers to each of the atoms in the compound F eCl3 resulting ITom the reaction $2Fe + 3Cl_2 \rightarrow 2FeCl_3$.

Solution: Referring to the Periodic Table, we see that CI (a halogen) has an oxidation number of -1. Therefore, the ions in Cl3 will have a total oxidation number of 3 x (-1) = -3, Therefore the group is properly written as CI3-3. But what is the oxidation number for iron (Fe)? Consulting the Periodic Table doesn't tell us the answer, because iron is a metal which can have more than one oxidation state. The answer lies in the fact that the sum of oxidation numbers in a neutral compound must be zero.
Since $Cl_3 = 3\,(-1) = -3$ and $Fe = 1\,(x) = x$
Then $-3 + x = 0$, and therefore x must = 3 (because -3 + 3 = 0)
So the oxidation number for Fe in the molecule $FeCl_3$ is +3
(iron can also have an oxidation number of +2)

ACIDS & BASES IN CHEMISTRY

Acids and Bases are substances which *dissociate* (split) into their component ions when dissolved in water. By doing so they change the concentration of hydrogen ions (H^+) and hydroxide ions (OH^-) in the solution.

An *acid* is a substance which raises the hydrogen ion concentration of water. The strength of the acid depends on how completely it dissociates in solution. Hydrochloric acid (HCI) is a strong acid because over 90% of the HCI molecules in solution will dissociate into H^+ and Cl^- ions. Acids tend to have a sour taste (lemons, vinegar), can be very corrosive and damaging to surfaces, and react violently with certain metals and organic compounds. Examples:

$$\mathbf{HCI \rightarrow H^+ + Cl^-}$$

$$\mathbf{H_2C0_3 \rightarrow H^+ + HC0_3^-}$$

A base is a substance that raises the hydroxide ion concentration of water. The strength of the base is again dependant on how completely it dissociates in water solution. Sodium hydroxide (NaOH) is an example of a very strong base. Bases tend to have a bitter taste, can also be highly corrosive and damaging to surfaces, and when combined in equal strengths with acids will tend to neutralize the solution, bringing the hydrogen and hydroxide ion concentrations into balance. Such neutralization reactions are usually exothermic (heat-producing). Examples:

$$\mathbf{NaOH \rightarrow Na^+ + OH^-}$$

Salts are formed during the neutralization reaction between an acid and a base. Examples include sodium chloride (NaCl, table salt), potassium chloride (KCl), and sodium sulfate (Na_2SO_4). Salts are very important in maintaining proper chemical balances for bodily functions, including pH of body fluids, osmotic pressures in the tissues, elasticity of muscles, and activation of nerves.

pH refers to a scale used for measuring the hydrogen ion concentration in a solution, represented as $[H^+]$. Similarly, *pOH* is a measure of the hydroxide ion concentration, $[OH^-]$. Since hydrogen ions and hydroxide ions will neutralize each other (forming water, which has a neutral pH), the higher the hydrogen ion concentration, the lower the hydroxide concentration, and vice versa. The pH scale runs from a low of 0 (very strong acid) to a high of 14 (very strong base). Pure water is neutral, with a pH of 7 (the mid-point in the scale). The pH is actually the negative logarithm of the hydrogen ion concentration. In other words, a pH of 5 represents a hydrogen ion concentration of 1×10^{-5} (the -log of $1 \times 10^{-5} = 5$). The sum of the pH and the pOH must always equal 14, so for example, if the pH is 5, then the pOH must be 9 (14 - 5 = 9). Likewise, the corresponding hydrogen ion and hydroxide ion concentrations will be 1×10^{-5} and 1×10^{-9}, respectively (- 5 + -9 = -14). In practice, we usually speak of the strengths of acids and bases in terms of pH (the pOH scale is rarely used). Nevertheless, it is important to understand the concept of pOH because if you do, then by knowing only one of the four measures (pH, or pOH, or $[H^+]$, or $[OH^-]$), you will be able to determine the other three by simple subtraction. We will go through some example exercises in class.

Buffers are substances which tend to take up excess hydrogen and hydroxide ions, enabling a solution to resist a change in pH and instead remain relatively constant. A buffer system consists of a pair of components, a weak acid and the salt of that weak acid (in living systems, usually a sodium or potassium salt). Since many biochemical reactions and structures cannot exist outside a narrow range of pH, natural buffers are very important in living things. They keep the body within its normal pH limits so that it can function normally.

Litmus paper is a simple tool for determining whether a solution is acidic or basic. It consists of a strip of paper impregnated with a chemical which will react with acids and bases to produce a certain color. *Red* litmus paper turns blue in basic solution, while *blue* litmus paper turns red in acidic solution. *Neutral* litmus paper can be used to test both solutions, turning red in acid and blue in base.

pH paper is similar to litmus paper, but turns various shades of colors (from red to orange to yellow to green to blue) to indicate not only acid or base, but also approximate pH. The closer to red, the lower the pH; the closer to blue, the higher the pH; yellow is neutral (pH 7).