NS H1 (pg 1 of 2) **The Driving Forces in the Universe** Name_________________________ Per___

What Actually Makes all these Chemical Reactions Happen?

The Driving Forces in the Universe

The two most **fundamental** driving forces in the universe are energy and entropy (disorder).
The "stuff" in the universe is most stable at low energy and high entropy. This is easy to remember if you think of the universe as a "lazy slob": Lazy for low energy, slob for high disorder. This plays out in chemical reactions in various ways that we will take note of as we are watching and learning about different reactions.

The Forces that Drive Chemical Reactions

More specifically we have be investigating the specific driving forces that push chemical reactions.
We have studied four so far:

- Formation of solids (aka precipitates)
- Formation of water
- Formation of a gas
- Transfer of electrons

When chemicals come together, and any of these processes can occur, a reaction is likely to result.

Types of Chemical Reactions

In our attempt to understand chemical reactions we have categorized them into categories. This allows us to see patterns and thus be able to predict products.

All reactions fall into one of <u>two fundamental categories:</u>

- Oxidation Reduction (aka Redox)
- NOT Oxidation Reduction

But having only two categories doesn't help us to see some of the patterns, so we further separate reactions into <u>five types of reactions:</u>

- Double replacement reactions (never redox)
  - $AX + BY \rightarrow BX + AY$
    - Precipitation Reactions (in which a solid forms from two aqueous solutions)
    - Acid Base Reactions (in which either AX or BY is water)
- Single replacement reactions (always redox)
  - $AX + B \rightarrow BX + A$ (OR halogen replacement: $AX + Y_2 \rightarrow AY + X_2$)
- Synthesis Reactions (sometimes redox)
  - $A + X \rightarrow AX$
- Decomposition (sometimes redox)
  - $AX \rightarrow A + X$
- Combustion (always redox)
  - $A + O_2 \rightarrow AO$ (oxide product)
  - $C_?H_? + O_2 \rightarrow CO_2 + H_2O$ (if the fuel contains C and H, the products will always be CO_2 and H_2O)

Oxidation-Reduction: Redox

- Oxidation-reduction reactions are those in which electrons are "transferred."
- The element that loses electrons is said to be oxidized, and the element that gains electrons is said to be reduced.
  - To help you remember: LEO says GER to remember (Lose Electrons = Oxidation, Gain Electrons = Reduction)
  - or: OIL RIG (Oxidation Is Losing, Reduction Is Gaining)
  - or: olé (Oxidation Loses Electrons)

How can I tell if a particular reaction is a redox reaction?

- Oxidation-reduction reactions will always have at least one element (in standard form) either as a reactant or product.
- Applying oxidation numbers and watching if and how they change through the course of a reaction will tell us which elements are oxidized and which elements are reduced.

Oxidation Numbers

Chemists have devised a "bookkeeping" system to monitor which atom (if any) loses electrons, and which atom gains electrons. Each atom within a molecule (or ionicule) is assigned an oxidation number (or oxidation state). For monatomic ions (e.g. Na^+, S^{2-}) the oxidation number is quite simply, the charge of the ion. In a molecule or within a polyatomic ion, the oxidation number of each atom is a "pseudo-charge" A charge that is assigned by "pretending the covalent bond is actually ionic, with the more *electronegative* atom as the negative oxidation number) using a set of "rules" that takes into account which atoms "hog" the electrons more within a bond.

Rules for Assigning Oxidation Numbers

This list is hierarchical...meaning it is to be used in order.

1. An element in its "standard" elementary state is assigned an oxidation number = 0
2. The oxidation number of a monatomic ion is equal to the charge of the ion.
3. Hydrogen has three oxidation number options
   a. as an element, H_2 the oxidation number = 0
   b. combined with an nonmetal hydrogen's oxidation number = +1
   c. combined with a metal, hydrogen's oxidation number = −1
4. Oxygen has three oxidation state possibilities
   a. as an element, O_2 the oxidation number = 0
   b. combined with something, oxygen's oxidation number = −2
   c. if oxygen is part of a peroxide compound (you would be told) oxygen's oxidation number = −1
5. Fluorine has only two oxidation number possibilities
   a. as an element, F_2 the oxidation number = 0
   b. in all other situations, with metals or nonmetals, fluorine's oxidation state is −1
6. Work all other elements off of the information given above. When you don't seem to have enough information when deciding about two nonmetals, apply the known negative charge to the nonmetal that is further to the right and higher on the periodic table, and then apply oxidation numbers to any other remaining elements

In this course, at least, that will be more than enough to determine the oxidation state of elements.