Energy and Enthalpy

- **Enthalpy** is a measure of heat in the system, measured in Joules (J).
- When a chemical reaction happens, a substance can become warmer or colder. As a result, heat will flow to things around it, or from things around it, until its temperature is the same again. If the pressure stays the same, this amount of heat tells how much the enthalpy changed.
- **$H = U + PV$**

  where H is the enthalpy value, U is the amount of internal energy, and P and V are pressure and volume of the system. This system works really well for gases.
- For example, if gasoline is burned in the open air, heat comes off the burned gasoline until it has cooled off again. If 100 kilojoules of heat come off it, then the enthalpy of the gasoline became less by 100 kilojoules. The enthalpy of the reaction was therefore $\Delta H = -100$ kJ.

  Δ means delta and it indicates a <u>change</u>, so ΔH means change in enthalpy
- If a chemical reaction gives off heat, and warms up things around it, the enthalpy becomes less. The value of ΔH is negative. This kind of reaction is called exothermic.
- If a chemical reaction uses up heat, and cools down things around it, the enthalpy becomes more. The value of ΔH is positive. This kind of reaction is called endothermic.
- The enthalpy is directly proportional to the amount of substance you have. Chances are if you have more of a substance, you have more energy. If you visualize on a large scale, you can compare the enthalpy in a glass of water to the enthalpy in the ocean. The ocean has more total energy.

Energy and Entropy

- **Entropy** is a measure of the random activity in a system. The entropy of a system depends on your observations at one moment. How the system gets to that point doesn't matter at all. Here and now is all that matters in entropy measurements.
- When we say random, we mean energy that can't be used for any work. It's wild and untamed. Scientists use the formula:

  $\Delta S = \Delta Q / \Delta T$

  where "S" is the entropy value, "Q" is the measure of heat, and "T" is the temperature of the system measured in Kelvin degrees.

  Δ (delta) stands for the change. Delta T would be the change in temperature (the original temperature subtracted from the final).
- If you increase temperature, you increase entropy. More energy put into a system excites the molecules and the amount of random activity.
- As a gas expands in a system, entropy increases. This one is also easy to visualize. If an atom has more space to bounce around, it will bounce more. Gases and plasmas have large amounts of entropy when compared to liquids and solids.
- When a solid becomes a liquid, its entropy increases.

- When a liquid becomes a gas, its entropy increases. We just talked about this idea. If you give atoms more room to move around, they will move. You can also think about it in terms of energy put into a system. If you add energy to a solid, it can become a liquid. Liquids have more energy and entropy than solids.
- Any chemical reaction that increases the number of gas molecules also increases entropy. A chemical reaction that increases the number of gas molecules would be a reaction that pours energy into a system. More energy gives you greater entropy and randomness of the atoms.

Free Energy

- The equation for Gibbs Free Energy is: $\Delta G = \Delta H - T\Delta S$
- For a reaction to be spontaneous, the sign for ΔG has to be negative.
- ΔH represents the heat of reaction. ΔS is the change in entropy. T is temperature in Kelvins.
- A negative value for ΔH means that the reaction is exothermic. That means that heat is released. A positive value for ΔH means that the reaction is endothermic. That means that heat is absorbed. A negative value for ΔS means that the products are more ordered than the reactants. A positive value for ΔS means that the products are less ordered than the reactants.