Chapter Summary: Thermodynamics

Spontaneous change: a change that occurs without external action.
If the forward reaction is spontaneous then reverse is non spontaneous.
(note: spontaneous does not mean fast)

Entropy: degree of orderliness of a system. (Represented by ΔS). E.g. entropy increases when ice melts to liquid and liquid vaporizes to steam.
Second Law of Thermodynamics: all spontaneous process increase the entropy of the universe.
Third Law of Thermodynamics: entropy of a pure, perfect crystal can be taken to be 0 at 0K.

Standard Molar Entropy (S^o): entropy of a mole of substance in its standard state.
Standard entropy of a reaction (ΔS^o) can be calculated by:
$\Delta S = \sum n_p \, S_f^{\,o} \text{ (products)} - \sum n_f \, S_f^{\,o} \text{ (reactants)}$

Free Energy and Free Energy Change (ΔG): Gibbs free energy determines the spontaneity of a process.

$$\Delta G = \Delta H - T\Delta S$$

hence
if $\Delta G < 0$ then process is spontaneous
if $\Delta G > 0$ then non spontaneous and
if $\Delta G = 0$ then process is in equilibrium.

Standard free energy of a system (ΔG^o) is when all reactants and products are in their standard states (P = 1 atm, solids and liquids are pure, etc.). It predicts the direction of the equilibrium.
$\Delta G^o = \Delta H^o - T\Delta S^o$
$-\Delta G^o$ indicates large K value (products favored)
$+\Delta G^o$ indicates small K value (reactants favored)

Standard free energy of formation ($\Delta G_f^{\,o}$) is free energy change that occurs in the formation of one mole of substance in their standard state.

Standard free energy of a reaction can be calculated by:
$\Delta G^o = \sum n_p \, G_p^{\,o} \text{ (products)} - \sum n_r \, G_r^{\,o} \text{ (reactants)}$

Relationship between ΔG and ΔG^o
$$\Delta G = \Delta G^o + RT \ln Q$$
(R = gas constant = 8.314 J/K, T = temp in K, Q = reaction quotient)
Use this equation to figure out if reaction is spontaneous at a particular temp. at specific concentrations of reactants and products.

Relationship between ΔG and K
$\Delta G = 0$ at equilibrium and Q = K at equilibrium
So the equation above becomes:
$$\Delta G^o = - RT \ln K$$

Value of ΔG^o still predicts direction of reaction not spontaneity of reaction.