# CHAPTER 16
# ENTROPY, FREE ENERGY, AND EQUILIBRIUM

We will spend three lecture days on this chapter.

- Day 1. Sections 1 – 7: During the first class meeting we will review enthalpy (endothermic and exothermic reactions) and introduce entropy. We will define *spontaneity* and *spontaneous reactions*. We will learn about absolute molar entropies and how to calculate changes in entropy ($\Delta S$), from $S^o$ tables. We will learn how entropy-favored reactions are associated with a + sign for $\Delta S$. We will then discuss how $\Delta S$ and $\Delta H$ work together in the form or the *free energy* (Gibbs-Helmholtz equation).
- Day 2. Sections 8 – 9: We will learn how to recognize and predict entropy-driven reactions. We will discuss the significance of $\Delta G = 0$ or $>0$ or $<0$. We will do a number of actual calculations using the Gibbs-Helmholtz equation. We will also calculate the temperature at which $\Delta G = 0$. The latter covers phase changes.
- Day 3. Sections 10 – 11: Finally, we will learn how $\Delta G$ related to equilibrium and the equilibrium constant.

**Section 16.1**
- ❑ Qualitatively determine whether simple chemical or physical changes are spontaneous.
- ❑ Do Problem 1 at the end of the section and problems 30 and 32.

**Section 16.2**
- ❑ Qualitatively predict whether the sign of $\Delta S$ is positive or negative for a chemical or physical change.
- ❑ Do Problems 2 and 3 at the end of the section and problems 36, 38 and 46(a and b)


**Skip Section 16.3. Read Sections 16.4 and 16.5:**
- ❑ Calculate the standard entropy of reaction from the standard molar entropies of products and reactants.
- ❑ Do Problem 5 and problems 50, 52, and 54.

**Section 16.6 and 16.7**
- ❑ Use the equation $\Delta G = \Delta H - T\Delta S$ to calculate the free energy of reaction and to determine the temperature at which a non-spontaneous reaction becomes spontaneous.
- ❑ Do Problems 7 – 9 and problems 20, 22 and 24, 70, 72, and 74.

**Sections 16.8 and 16.9**
- ❑ Calculate the standard free energy of reaction from enthalpies and standard entropies.
- ❑ Calculate the standard free energy of reaction from standard free energies of formation.
- ❑ Do Problems 10 – 12 and problems 26, 28, 78, 80, 82, 84, 86 (note reaction is written backwards for "decomposition" of NOCl), 88 and 90.


**Section 16.10 and 16.11**
- ❑ Calculate the free energy of reaction for a system having nonstandard pressures and concentrations.
- ❑ From the standard free energy of reaction, calculate the value of the equilibrium constant and vice versa.
- ❑ From the standard free energy of reaction, calculate a vapor pressure.
- ❑ Do Problem 13 – 17 and problems 94, 96, 98, 100, 102 and 104.