Midterm Review 2

January 21, 2022

This is a checklist based on the lecture and textbook materials. It is not expected to be an all encompassing study guide and provides a guideline for your studies.

- Review real-world applications (lecture, quiz and textbook materials)

Entropy and 2nd Law of Thermodynamics

- Quantify irreversibility/"quality loss" of energy

  $\Delta S = \frac{Q_{\text{rev}}}{T}$

- Clausius Inequality

  $\Delta S^{\text{sys}} \geq \frac{Q_{\text{rev}}}{T}$

- Entropy dependence on
  - Temperature
  - Volume and pressure (Ideal Gas)
- 3rd Law of Thermodynamics
- Gibbs-Duhem Equation
- Equilibrium and thermodynamic potentials - $S(U, V)$ is maximal, $U(S, V)$ and $H(S, P)$ are minimal
- Gibbs free energy $G = H - TS$
  - Spontaneity
  - Exergonic and endergonic
  - Free energies of reaction $\Delta G = \Delta H - T\Delta S$
  - Temperature dependence - enthalpy and entropy driven
  - Pressure dependence $G(P) = G^\circ + nRT \ln \frac{P}{P^\circ}$
  - Ideal gas mixtures

Chemical Equilibrium

- Free energy of mixture vary with composition for all states $G_i = G_i^\circ + n_i RT \ln a_i$ where a_i is activity (dimensionless)

- Relating reaction quotient Q and free energy ΔG
- Law of Mass Action
- Properties of equilibrium constants
- Direction of reaction and "driving force" in terms of thermodynamic quantities

Statistical Thermodynamics

- Microstates and macrostates
- Boltzmann statistics $S = k_b \ln W$
- Estimating entropy changes in chemical reactions
- Equipartition Theorem - In thermal equilibrium, the average energy per quadratic degree of freedom in the energy is $\frac{1}{2}k_bT$

Phase Equilibria

- Vapor Pressure for liquid-gas equilibrium e.g. water
- Thermodynamics of vaporization
- Clausius-Clapeyron Equation - Vapor Pressure Curves

$P_f = P_i e^{-\frac{\Delta H_v}{R}(\frac{1}{T_f} - \frac{1}{T_i})}$