Chemistry 2290, Winter 2012, G. Schreckenbach
Practice problems –5–

Second Law: Free Energies

Engel and Reid, 2nd ed.:

Questions on concepts: Q6.5, Q6.7

Problems: P6.5a, P6.8a, P6.14, P6.16 *(use* $w_{rev} = \int F \cdot dl$ *and the force given in the question)*, P6.20, P6.32, P6.33

Second Law: Free Energies

Practice problems from Laidler/ Meiser

(Problems adapted from Laidler, Meiser, Sanctuary, Physical Chemistry, 4th ed., Houghton Mifflin)

LM29. The latent heat of vaporization of water at 100 ºC is 40.6 kJ mol^{-1} and when 1 mol of water is vaporized at 100 ºC and 1 atm pressure, the volume increase is 30.19 L. Calculate the work done by the system, the change in internal energy ΔU, the change in Gibbs energy ΔG, and the change in entropy, ΔS.

LM30. At 25.0 ºC, 1.00 mol of an ideal gas is expanded isothermally from 2.0 dm^3 to 20.0 dm^3. Calculate ΔU, ΔH, ΔS, ΔA, and ΔG. Do the values depend on whether the process is reversible or irreversible?

LM31. The values of ΔH and ΔS for a chemical reaction are –85.2 kJ mol^{-1} and –170.2 J K^{-1} mol^{-1}, respectively, and the values can be taken to be independent of temperature.

(a) Calculate ΔG for the reaction at 300. K, 600. K, and 1000. K.

(b) At which temperature would ΔG be zero?

LM32. The heat of vaporization of water at 25.0 ºC is 44.01 kJ mol^{-1}, and the equilibrium vapor pressure at that temperature is 0.0313 atm. Calculate ΔS, ΔH, and ΔG when 1.00 mol of liquid water is converted into vapor at 25.0 ºC and a pressure of $1.00 \cdot 10^{-5}$ atm, assuming the vapor to behave ideally.

LM33. For each of the following processes, state which of the quantities ΔU, ΔH, ΔS, ΔA, and ΔG are equal to zero:

(a) Isothermal reversible expansion of an ideal gas.

(b) Adiabatic reversible expansion of a non-ideal gas.

(c) Vaporization of liquid water at 80 ºC and 1 bar pressure.

(d) Vaporization of liquid water at 100 ºC and 1 bar pressure.

(e) Reaction of H_2 and O_2 in a thermally insulated reaction chamber.

(f) Reaction between H_2SO_4 and NaOH in dilute aqueous solution at constant T and P.

LM34. Calculate the change in molar Gibbs energy, ΔG_m, of liquid mercury initially at 1.00 bar pressure if a pressure of 1000. bar is applied to it. The process occurs at the constant temperature of 25 ºC, and the mercury may be assumed to be incompressible and to have a density of 13.5 g cm^{-3}.

LM35. The entropy of argon is given to a good approximation by the expression

$$S_m / J\ K^{-1}\ mol^{-1} = 36.36 + 20.79 \ln (T/K)$$

Calculate the change in molar Gibbs energy argon if it is heated at constant pressure from 25.0ºC to 50.0ºC. *(You will probably have to look up the integral.)*

LM36. Initially at 300 K and 1.00 bar pressure, 1.00 mol of an ideal gas undergoes an irreversible isothermal expansion in which its volume is doubled, and the work it performs is 500 J. What are the values of q, ΔU, ΔH, ΔS, and ΔG? What would be q and w if the expansion occurred rev