Homework #7
Problems (#41-#55)
Section Questions: Q8.5, Q8.9, Q8.17(typo in text), Q9.13

41. ✶ *(optional)* E&R$_{4th}$ P7.13 **(for only 100 bar, and 500 bar)**

42. *(adapted from <u>Physical Chemistry</u> by Tinoco, Sauer, Wang, and Puglisi, pub by Prentice-Hall)* In living biological cells the sodium ion concentration inside the cell $[Na^+]_i$ is kept at a lower concentration than that outside $[Na^+]_o$ by an active transport pump powered by ATP hydrolysis. The mechanism of the pump requires that each mol of ATP discharge 3 moles of Na^+. In the following questions assume that T=310K (37C).

    a. For Na^+ (inside, 0.05M) → Na^+ (outside, 0.20M) calculate $\Delta\mu$ approximating the ion activities by their molarity. Will the reaction proceed spontaneously?

    b. What would be ΔG for 3 pumping moles of Na^+ at these concentrations?

    c. What is $\Delta\mu$ if the $[Na^+]_i=[Na^+]_o$?

    d. ***(optional)**
    For the reaction:
    ATP + H_2O → ADP + phosphate $\Delta\mu°=-31.3$ kJ mol^{-1} at 1 atm, 310 K
    For [ADP]/[ATP] = 0.10 , what would be the phosphate concentration [P] required to yield $\Delta\mu=-40$ kJ mol^{-1} ? (assume activity coefficients are unity)

    e. ***(optional)** Would the free energy of hydrolysis of 1 mole of ATP under the conditions of part d, be sufficient to account for the transport of Na^+ in part b?

43. For the reaction $3H_2(g) + N_2(g) \rightleftarrows 2NH_3(g)$ the gaseous species have the following fugacity coefficients: $\gamma_{H_2} = 1.11 \quad \gamma_{N_2} = 1.04 \quad \gamma_{NH_3} = 0.968$.
    If $\Delta\bar{G}_f^0(NH_3) = -16.5\times10^3\ J\ mol^{-1}\ at\ 298.15K$ what is P_{N_2} in an equilibrium mixture where $P_{H_2} = 10^{-1}\ bar$ and $P_{NH_3} = 1\ bar$?

44. [Adapted from Raff #6.1, p282]
    At 298K $\mu_f^0 = 7.2\ kJ\ mol^{-1}$ and $S^0 = 39.55\ J\ mol^{-1}$ *for* $Al(\ell)$. Using the data for Al(s) in Appendix A, calculate the melting temperature of Al(s) at P=1 bar. Assume that the difference in entropies of Al(s) and Al(ℓ) is a constant, equal to the value at 298K. Compare your result to the experimental value in Table 2.3 (p. 627) E&R$_{4th}$.

45. E&R$_{4th}$ P8.1
    NOTE: The critical point is at T_c=31.1°C and P_c= 72.8 atm.
    for part b :
    b. As pressure on a cylinder containing pure CO_2 is increased from **5** to 80. atm, no interface delineating liquid and gaseous phases is observed. *(note the 5 atm here differs from E&R$_{4th}$ USE THIS VALUE, it makes more sense)*

46. E&R$_{4th}$ P8.21

47.✶**(optional)** E&R$_{4th}$ P8.26 (**b part only**);.

Note: the text's equation: $\Delta H_{sub}(T) = \Delta H_{sub}(T_0) + \Delta C_p\left(T - T_0\right)$

should be $\Delta H_{vaporization}(T) = \Delta H_{vaporization}(T_0) + \Delta C_p\left(T - T_0\right)$

48. [Adapted from Raff #6.28, p285]
Two crystalline forms, A and B, of a compound are in equilibrium. The density of A is greater than the density of B. The conversion of A to B is exothermic.
   a. If one wishes to shift the equilibrium towards crystal B, should one raise or lower the temperature? Should one raise or lower the pressure? Explain
   b. Which is more ordered, A or B? Explain.

49. E&R$_{4th}$ P8.28

50. E&R$_{4th}$ P9.6

51.✶**(optional)** [adapted from Raff #8.3, p403]

A and B form an ideal solution.
   a. Derive an equation in terms of $P_A^\bullet$ and $P_B^\bullet$ that gives the mole fraction $X_A^{(\ell)}$ at which P_A=P_B.
   b. Show that the total pressure, P_T, over a solution with P_A=P_B is

$$P_T = \frac{2P_A^\bullet P_B^\bullet}{P_A^\bullet + P_B^\bullet}$$

52. E&R$_{4th}$ P9.8
Use the data in this problem
A solution is prepared by dissolving 54.0 g of a non-volatile solute in 150 g of water. The vapor pressure above the solution is 22.97Torr and the vapor pressure of pure water is 23.76 Torr at this temperature.
but do the calculations for
   a. Calculate molecular mass from data in problem assuming the non-volatile solute was a molecular solute (as in text).
   b. What would be the molecular mass if the solute was an ionic salt $M^{2+}(X^-)_2$ and was completely dissociated?

53. [Adapted from Raff #8.13]
Seventy-five grams of CCl_4 are mixed with 10 grams of $CHCl_3$ at 298K to form a solution. If the solution is ideal, calculate ΔG_{mixing}, ΔS_{mixing}, ΔH_{mixing}, ΔU_{mixing}, ΔV_{mixing}, and ΔA_{mixing}.

54.★**(optional)** Prove that for a mixture of two substances A and B, the maximum entropy of mixing occurs for X_A =0.5.

55. E&R$_{4th}$ P 9.29 ***(part a only)***