Handin Homework 1: Chemical Reactivity

1. In an osmotic pressure determination, the difference in height of the solution on one side of the membrane and the pure solvent on the other is 6.76 cm at 25.0°C. The density of the solution is 1.017 g mL^{-1}. (a). Calculate the osmotic pressure, π. (b). The osmotic pressure and solution concentration are related by $\pi = cRT$. Calculate the solution concentration in mol L^{-1}. If the pressure is in bar, the appropriate value of R is 0.083145 bar L K^{-1} mol^{-1}.

2. The mass of air in a 100.0 mL bulb at 20.0°C is 0.118 g. Calculate the mass density, the molar density, and the pressure in the bulb, in bar. Assume that the gas is ideal.

3. Air is not exactly an ideal gas. A good representation of the equation of state for air is:

$$PV = \left(1 + \frac{BP}{RT}\right) nRT$$

with B a small constant. Show that the pressure at altitude h for a gas behaving according to this equation of state is given by:

$$\ln\left(\frac{P}{P_o}\right) + \frac{B}{RT}(P - P_o) = -\frac{\mathcal{M}gh}{RT}$$

[Hint: try back-of-the chapter problem, Chapter 1 problem 17, first.]

4. Two definitions of a reversible process are:

(a). A reversible process is one in which the system never deviates from equilibrium by more than an infinitesimal amount.

(b). A reversible process is not a real process, but a hypothetical succession of equilibrium states.

Consider the addition of 1.0 mol of HCl to a solution containing both 1.0 M acetic acid and 1.0 M sodium acetate at 20°C:

$$H^+ (aq) + CH_3COO^- (aq) \rightleftarrows CH_3COOH (aq)$$

Describe precisely how the reaction to form one mole of acetic acid can be run without deviating from equilibrium by more than an infinitesimal amount and as a sequence of equilibrium states. You can use any volume of solutions necessary and any concentration of HCl. Explain how your chosen conditions satisfy the restrictions required for a reversible process. [Hint: try back-of-the chapter problem, Chapter 1 problem 26, first.]