Homework Assignment 4

Practice Solved Problems

1. Smith, J. M., Van Ness, H. C., & Abbott, M. M. (2005). Introduction to Chemical Engineering Thermodynamics, 7th ed.

   - Chapter 11: 11.9, 11.10
   - Chapter 12: 12.1, 12.2

HW Problems (Due 5th March 2020)

1. [10 points] A binary gas mixture contains 25 mol% A and 75 mol% B. At 50 bar total pressure and 100 °C, the fugacity coefficients of A and B in this mixture are, respectively, 0.65 and 0.90. What is the fugacity of the gaseous mixture?

2. [10 points] It was shown by Zawidski that mixtures of benzene and ethylene chloride obey Raoult's law quite accurately. At 50°C their vapor pressure as pure liquids are 268.0 and 236.2 mmHg, respectively. At this temperature calculate the total pressure and the composition of the vapor which is in equilibrium with the liquid containing mole fractions of 0.25, 0.50 and 0.75 of benzene.

3. [20 points] Consider a binary mixture of components 1 and 2. The molar Helmholtz free energy change upon going isothermally from the standard state (pure, unmixed, ideal gas at 1 bar) to the molar volume, v, is

$$\frac{\Delta a}{RT} = \ln\left(\frac{v}{v-b}\right) - y_1 \ln\left(\frac{v}{y_1 RT}\right) - y_2 \ln\left(\frac{v}{y_2 RT}\right), \tag{1}$$

   where v is the molar volume of the mixture and b is a parameter depending only on the composition, as given by

$$b = y_1 b_1 + y_2 b_2 \tag{2}$$

   Derive an expression for f_1, the fugacity of the component 1 in the mixture.

4. [20 points] Consider an aqueous mixture of sugar at 25°C and 1 bar pressure. The activity coefficient of water is found to obey a relation of the form

$$\ln \gamma_w = A(1 - x_w)^2 \tag{3}$$

   where γ_w is normalized such that $\gamma_w \to 1$ as $x_w \to 1$ and A is an empirical constant dependent only on temperature. Find an expression for γ_s, the activity coefficient of sugar normalized such that $\gamma_s \to 1$ as $x_w \to 1$ (or equivalently as $x_s \to 0$). The mole fractions x_w and x_s refer to water and sugar, respectively.

5. [20 points] The activity coefficients of the components of certain binary mixtures are given by the relations, $RT \ln \gamma_1 = \alpha x_2^2$ and $RT \ln \gamma_2 = \alpha x_1^2$, where α is a function of pressure only. Obtain expressions for the increase in the Gibbs function and enthalpy in the process of mixing the pure components at constant temperature and pressure.