Tutorials 3 Thermodynamics 2, 2023/2024

Exercise 10

The density of an alcohol-water mixture (50 weight percent) is $\rho = 0.914$ g cm^{-3} at 25 °C.
The partial molar volume of water in this mixture is $V_{water} = 17.4$ cm^{3}mol^{-1}.
The molar masses of alcohol and water are $M = 46$ g/mol and $M = 18$ g/mol respectively.
Calculate the partial molar volume of alcohol in this mixture.

Exercise 11

The excess volume of a mixture is defined as $V^E \equiv V - V_{ideal}$, in which V is the real volume and V_{ideal} is the volume of an ideal mixture, i.e. a mixture in which all molecules have the same interactions, no matter the type.
A mixture of propionic acid (CH_3CH_2COOH, compound A) and oxane ($C_5H_{10}O$, compound B) has a molar excess volume of $V_m^E = x_A x_B \left(a_0 + a_1(x_A - x_B)\right)$ at a temperature T_0. $x_i = n_i/n$ represents the mole fraction of component i, $a_0 = -2.4697$ cm^3/mol and $a_1 = 0.0608$ cm^3/mol. The densities of propionic acid and oxane at T_0 are $\rho_A = 0.97174$ g cm^{-3} and $\rho_B = 0.86398$ g cm^{-3} respectively.

a) Find an expression for the partial molar volumes of a binary *ideal* mixture in terms of the molar volumes.

b) Derive an expression for the partial molar volumes of the mixture of propionic acid and oxane in terms of the molar volumes, a_0, a_1, x_A and x_B at the given temperature T_0.
Hint: First rewrite $V^E = (n_A + n_B)V_m^E$ in terms of n_A and n_B.

c) Calculate the partial molar volumes of both components in an equimolar mixture, at T_0.

Exercise 12

o-xylene and *m*-xylene form an ideal solution, and their vapour pressures at 90 °C are 18.5 kPa and 21.9 kPa, respectively. The enthalpy of vaporization of *o*-xylene and *m*-xylene are $\Delta_{vap}H = 36.24$ kJ/mol and $\Delta_{vap}H = 35.66$ kJ/mol, respectively. Assume that these enthalpies are independent of the temperature between 22 °C and 90 °C.

a) Determine the composition of the liquid mixture that boils at a temperature of 22 °C and a pressure of 1.24 kPa. Note that the above mentioned values are based on a different temperature.

b) What is the composition of the vapour of the mixture.

Exercise 13

At a partial pressure of HCl of 760 mm Hg, the HCl-gas will dissolve in benzene upto a mole fraction of 0.040.
The vapour pressure of pure benzene is 200 mm Hg.
This solution in benzene behaves like an ideal-dilute solution.
Calculate the mole fraction HCl in the solution if the total pressure of HCl-gas and benzene vapour is 760 mm Hg.