CH2010: Chemical Engineering Thermodynamics

Assignement V

(Dated: October 21, 2020)

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1. Consider a binary mixture of n-propanol and water in vapor–liquid equilibrium (VLE). Let n-propanol be designated species 1 and water, species 2. A plot of the activity coefficients for this system at 100° C is given in figure 1a. The Lewis/Randall reference state is chosen for both species. The mole fraction of n-propanol in the liquid, x_1, is 0.2, and the temperature is 100° C. The saturation pressure of n-propanol at 100°C is 1.12 bar.

   (a) Label the curve that corresponds to the activity coefficient for n-propanol, γ_1, and the curve that corresponds to the activity coefficient for water, γ_2. Explain.

   (b) Are like or unlike interactions stronger? Explain.

   (c) Find the total pressure of the system.

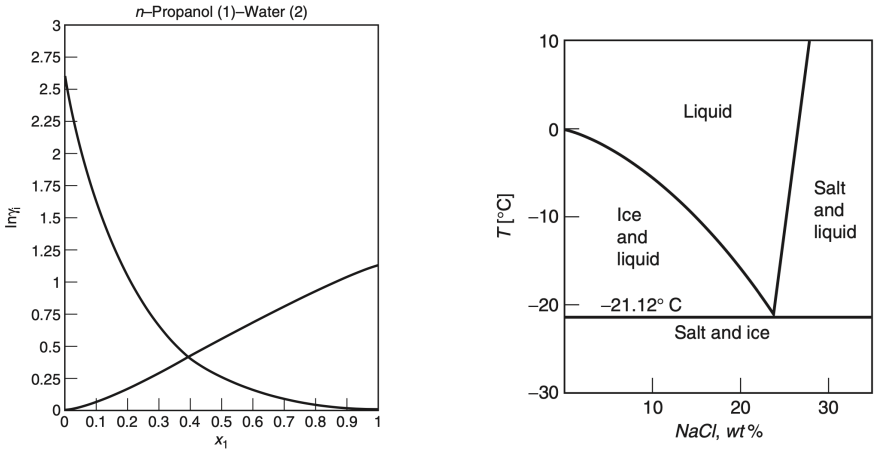
   (d) Find the mole fraction of n-propanol in the vapor phase.

   (e) Estimate the value of the Henry's law constant of n-propanol in water, $\mathcal{H}_1$.

   (f) Does this system exhibit an azeotrope? Explain.

2. A mixture of methanol (a) and ethyl acetate (b) exhibits an azeotrope at 55°C. Their saturation pressures are 68.8 and 46.5 kPa, respectively. The liquid-phase nonideality can be described by the two-suffix Margules equation, with $A = 2900$ J/mol. What is the pressure and composition of the azeotrope? Does this mixture form a maximum-boiling azeotrope or a minimum-boiling azeotrope? Explain.

3. What is the solubility of oxygen in methanol at 25°C and 100 bar? Take $\bar{V}_{O_2}^{\infty} = 4.5 \times 10^{-5}$ [m3/mol].



(a) (b)

FIG. 1

4. Consider a binary liquid mixture of hexane (1) and acetone (2). At 15°C and 300 bar, this mixture forms two partially miscible liquid phases. Phase α has 20 total moles with $x_1^\alpha = 0.2$ phase β has 10 total moles with $x_1^\beta = 0.8$. The following data are available at 15°C:

Species i	MW [g/mol]	v_i^l [cm^3/mol]	P_i^{sat} kPa
Hexane	86	130.5	12.7
Acetone	58	73.4	19.5

   (a) Draw a schematic of the system, labeling it with all the information that you have. Make your schematic as accurate as possible; for example, consider which phase belongs on top.

   (b) Are the like interactions stronger or weaker than the unlike interactions? Explain.

   (c) Calculate the value of f_1.

   (d) You wish to use the two-suffix Margules equation to describe this system. Based on the data above, come up with a value for the two-suffix Margules parameter, A.

   (e) Estimate to what temperature you need to bring the system described above to make it completely miscible, that is, to make it have only one phase present. State the important assumptions that you make.

   (f) Estimate the value of H1 at 15°C and 300 bar.

5. A binary mixture of water (a) and 1-butanol (b) exhibits vapor–liquid–liquid equilibrium at 25°C. The activity coefficients at infinite dilution are given by $\gamma_a^\infty = 7.02$ and γ_b^∞ 72.37. Determine the composition of the three phases and the system pressure at which VLLE occurs. At 25°C, the saturation pressure for 1-butanol is 875 Pa.

6. In the winter, salt is used as a deicer to imprve traction on the roads (particularly in countries where temperatures go to subzeros). Use the phase diagram in figure 1b to explain how this process works. Note that only part of the phase diagram is illustrated. How much salt would you add? To what temperature is this method effective ?

[End]