

**10.213 Chemical Engineering Thermodynamics
Spring 2002**

Problem Set K

Due Friday, May 10, 2002 in lecture

Problem 36

- a) If a liquid solution of HCl in water, containing 1 mol of HCl and 3 mol of H₂O, absorbs an additional 1 mol of HCl(g) at the constant temperature of 25 °C, what is the heat effect?
- b) What is the heat effect when 175(lb_m) of H₂SO₄ is mixed with 400(lb_m) of an aqueous solution containing 30-wt% H₂SO₄ in an isothermal process at 120 °F?
- c) For a 60-wt% aqueous solution of H₂SO₄ at 100 °F, what is the excess enthalpy H^E in (Btu)(lb_m)⁻¹?

Problem 37

The following VLE data were collected for acetone(1)/methanol(2) at 55 °C:

P (kPa)	x ₁	y ₁	P (kPa)	x ₁	y ₁	P (kPa)	x ₁	y ₁
68.728	0.0000	0.0000	93.206	0.3579	0.4779	100.467	0.7327	0.7383
72.278	0.0287	0.0647	95.017	0.4050	0.5135	100.999	0.7752	0.7729
75.279	0.0570	0.1295	96.365	0.4480	0.5512	101.059	0.7922	0.7876
77.254	0.0858	0.1848	97.646	0.5052	0.5644	99.877	0.9080	0.8959
78.951	0.1046	0.2190	98.462	0.5432	0.6174	99.799	0.9448	0.9336
82.528	0.1452	0.2694	99.811	0.6332	0.6772	96.885	1.0000	1.0000
86.762	0.2173	0.3633	99.950	0.6605	0.6926			
90.088	0.2787	0.4184	100.278	0.6945	0.7124			

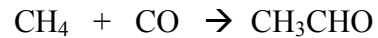
- a) Plot y₁ vs x₁ identifying the location of the azeotrope.
- b) Generate a P-xy diagram, noting the values of the saturation pressures for acetone and methanol at 55 °C.
- c) Determine values of γ₁, γ₂, and G^E/RT, and plot ln γ₁, ln γ₂, and G^E/RT vs. x₁ on one graph.
- d) Determine the parameters that best fit the data by the Margules equation. Prepare a P-xy diagram that compares the experimental points with the curves determined by this correlation.
- e) Determine the parameters that best fit the data by the van Laar equation. Prepare a P-xy diagram that compares the experimental points with the curves determined by this correlation.
- f) Determine the composition of the azeotrope using the parameters obtained for the Margules and van Laar equations.

Problems 38

The following dimerization reaction occurs in the liquid phase at 25 °C: 2M ↔ D. In a process to generate D, the initial feed to the reactor is pure M and 20 mole-percent of M is converted to D in achieving equilibrium. The non-ideal solution behavior of the liquid can be described by the relationship $G^E/RT = A x_M x_D$. If $\Delta G^\circ_{298} = -1,000$ J/mole D produced, determine the value of A that satisfies the relationship $G^E/RT = A x_M x_D$.

Problems 39

Acetaldehyde is produced in a gas-phase catalytic process using methane and carbon monoxide as reactants:



Methane and carbon monoxide enter the reactor in equimolar amounts, where the supply of CO contains 4 moles of N₂ for every mole of CO. If the reaction is performed at 260 °C and 100 bar (where the gases form an ideal solution but exhibit non-ideal behavior), determine

- (a) expressions for the final compositions of the reaction mixture as functions of ε
- (b) the equilibrium compositions.

Practice Problem for Next Week

In Problem 38, determine whether the resulting product mixture exists as a single phase or two phases.