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 H_2O, 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 H_2SO_4 is mixed with 400(lb_m) of an aqueous solution containing 30-wt% H_2SO_4 in an isothermal process at 120 °F?
c) For a 60-wt% aqueous solution of H_2SO_4 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 y_1 vs x_1 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 γ_1, γ_2, and G^E/RT, and plot ln γ_1, ln γ_2, and G^E/RT vs. x_1 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: $2M \leftrightarrow D$. 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 $\Delta G°_{298}$ = -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:

$$CH_4 + CO \rightarrow CH_3CHO$$

Methane and carbon monoxide enter the reactor in equimolar amounts, where the supply of CO contains 4 moles of N_2 for every mole of CO. If the reaction is performed at 260 ºC 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.