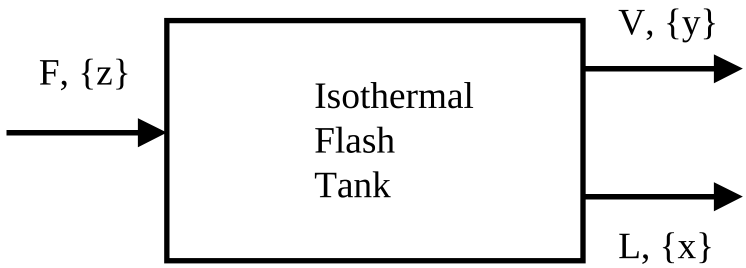
Exam III
Administered: Thursday, November 7, 2014
22 points

Problem 1. (10 points)
Consider an isothermal flash tank:



This unit takes a pressurized liquid, two-component feed stream and exposes it to a low pressure vessel maintained under isothermal conditions. The net result is that some of the fluid is vaporized, while some fluid remains liquid. The compositions of the liquid and vapor phase are determined by the combined analysis of mass balances and Raoult's Law for vapor-liquid equilibrium. The temperature in the flash tank is $T = 298K$ and the pressure in the tank is $P = 101kPa$.

$F = 100\, mol/hr$	$V = 40\, mol/hr$	$L = F - \mathrm{V}\ mol/hr$
$z_A = 0.4$	$y_A = ?$	$x_A = ?$
$z_B = 0.6$	$y_B = ?$	$x_B = ?$

You have four unknowns, the compositions of the liquid stream, x_A and x_B, and the composition of the vapor stream, y_A and y_B.

You also have four equations.

material balance on moles of A:	$0 = Fz_A - Lx_A - Vy_A$	
liquid mole fraction constraint:	$1 = x_A + x_B$	
vapor mole fraction constraint:	$1 = y_A + y_B$	
one equilibrium constraint:	$x_A P_A^{vap} = y_A P$	(Raoults' law for vapor-liquid equilibrium)

where $P_A^{vap} = 60\, kPa\ @\ T = 298K$

(a) Is the system of equations linear or nonlinear in the unknowns?
(b) Solve for the four unknown mole fractions. Show your work. Emphasize the steps in the procedure.

(over)

Problem 2. (10 points)

Consider the same system given in Problem 1. In a more realistic version of the problem, not only are the the compositions of the liquid stream, x_A and x_B , and the composition of the vapor stream, y_A and y_B , unknown, but the liquid and vapor stream flowrates, *L* and *V* respectively are also unknown. In this case, you have six unknowns and six equations. The equations are

material balance on total moles:	$0 = F - L - V$
material balance on moles of A:	$0 = Fz_A - Lx_A - Vy_A$
liquid mole fraction constraint:	$1 = x_A + x_B$
vapor mole fraction constraint:	$1 = y_A + y_B$
equilibrium constraint on A:	$x_A P_A^{vap} = y_A P$ (Raoults' law for A)
equilibrium constraint on B:	$x_B P_B^{vap} = y_B P$ (Raoults' law for B)

where $P_A^{vap} = 60\,kPa \ @\ T = 298K$ and $P_B^{vap} = 140\,kPa \ @\ T = 298K$

(a) Is this set of equations linear or nonlinear in the unknowns?
(b) Come up with a good set of initial guesses for the solution.
(c) Solve for the flowrates and compositions of the liquid and vapor streams. Show your work. Emphasize the steps in the procedure.

Problem 3. (2 points)

An even more realistic version of this problem occurs when the flash tank is operated under adiabatic rather than isothermal conditions. In this case, the temperature of the system is unknown. Discuss briefly how one might solve this problem. What kind of equation would be added to account for the new variable? What kind of additional parameters would be needed? What technique could you use to solve this?