PRACTICE PRELIM 2

VERSION: DELTA-2

NAME:

1. Prelim 2 has *two* problems and is worth a total of XX points.
2. You may use your course notes (on the computer, iPad, etc., or paper) or other course materials, e.g., discussion problems, to formulate your solutions.
3. Do not consult with any other person regarding the prelim (except the TAs or JV), or use *any form of electronic communication* to discuss the prelim questions. Violation of this policy will result in a ZERO for the prelim.
4. Do not consult the interwebs to search for the prelim questions/solutions. Violation of this policy will result in a ZERO for the prelim.
5. Show your work and state all assumptions or simplifications.
6. Good luck!

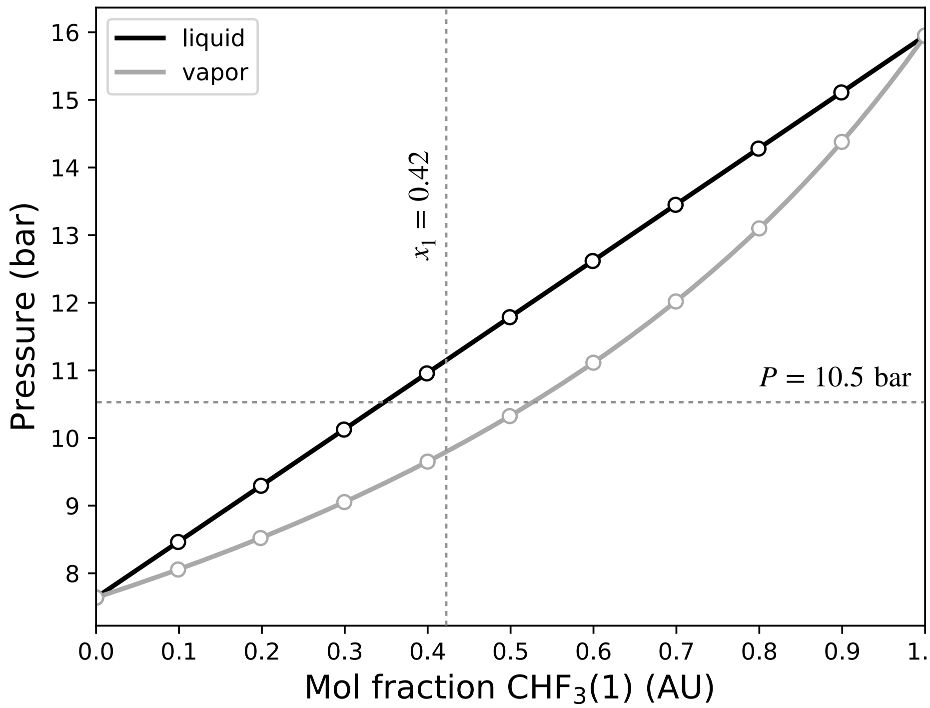

Figure 1: Pressure (bar) versus composition (x_1 and y_1) for a binary mixture of CHF_3(1)/C_2F_6(2) computed assuming ideal liquid and vapor phases.

1. (XX points) Cornell Inc. was hired to design a flash separation process for a binary ($\mathcal{M}$ = 2) mixture of CHF_3(1)/C_2F_6(2). The engineering team performed initial design calculations using Raoult's law for z_1 = 0.42 (Fig. 1). Let the saturation pressure of component i be described by the Antoine equation:

$$\log_{10}\left(P_i^{sat}\ [\text{bar}]\right) = A - \frac{B}{C + T[K]} \tag{1}$$

where the Antoine parameters are given by:

Table 1: Antoine parameters for the Flash problem.

Species	A	B	C
CHF_3	4.45	718.1	-22.01
C_2F_6	3.980	677.1	-24.51

Assumptions: (i) the Flash drum operates at steady-state; (ii) vapor-liquid equilibrium occurs everywhere inside the drum at some (T,P); (iii) treat both the vapor and liquid phases as ideal; (iv) the Flash drum is well-mixed; (v) a single liquid feed (stream 1) enters, and a vapor (stream 2) and liquid (stream 3) exit the drum; (vi) R = 8.314×10^{-2} L bar K^{-1} mol^{-1}.

a) (XX points) What temperature T (K) is the Flash drum operating at? (place your estimated T in Table 2).

b) (XX points) *Graphically* estimate the mising values in Table 2 assuming the Flash drum operates at P = 10.5 bar with a input feed rate of $\dot{F}$ = 10 mol/t and z_1 = 0.42.

c) (XX points) *Analytically* check the graphical estimates of $\dot{L}$ and $\dot{V}$ using the pressure summation expression:

$$\sum_{i\in\mathcal{M}} z_i \left[\frac{P_i^{sat}}{P}\left(\frac{\dot{V}}{\dot{F}}\right)+\frac{\dot{L}}{\dot{F}}\right]^{-1} = 1 \qquad (2)$$

If this expression is *significantly* different than 1 (greater than $\pm$ 10% difference), please re-estimate your values (show your work).

Table 2: State table for the Flash problem.

Stream	State	T (K)	$\dot{n}_{s,T}$ (mol/t)	x_1 or y_1	x_2 or y_2	P (bar)
1	L	N/A	10	0.42	0.58	N/A
2	V					
3	L					

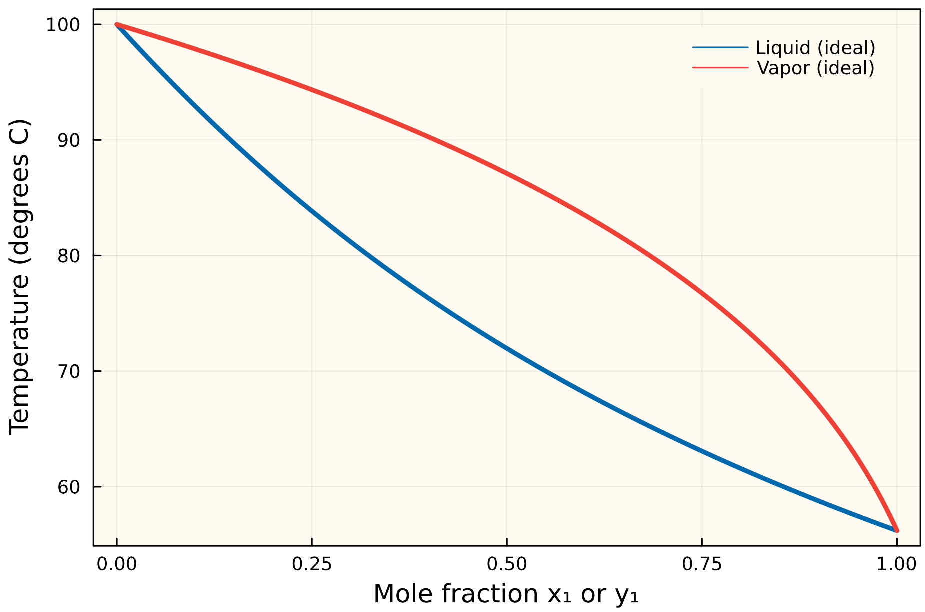

Figure 2: Temperature ($^{\circ}C$) versus composition (x_1 or y_1) for a binary mixture of Acetone(1)/Water(2) computed assuming ideal liquid and vapor phases.

2. (XX points) Cornell Inc. was hired to design a flash separation process for a binary ($\mathcal{M}$ = 2) mixture of Acetone(1)/Water(2). The engineering team performed initial design calculations assuming an ideal liquid and vapor phase for z_1 = 0.50 (Fig. 2).

   Let the saturation pressure of component i be described by the Antoine equation:

$$\ln\left(P_i^{sat}\right) = A - \frac{B}{C+T} \tag{3}$$

   where P_i^{sat} has units of kPa and the temperature T has units of $^{\circ}C$. The Antoine parameters are given by:

   Table 3: Antoine parameters for the Acetone/Water flash problem.

Species	A	B	C
Acetone	14.31	2756.22	228.06
Water	16.39	3885.7	230.17

   Assumptions: (i) the Flash drum operates at steady-state; (ii) vapor-liquid equilibrium occurs everywhere inside the drum at some (T,P); (iii) treat both the vapor and liquid phases as ideal; (iv) the Flash drum is well-mixed; (v) a single liquid feed (stream 1) enters, and a vapor (stream 2) and liquid (stream 3) exit the drum; (vi) R = 8.314 L kPa K^{-1} mol^{-1}.

a) (XX points) What pressure is the Flash drum operating at? (place your estimated pressure value in Table 4).

b) (XX points) Estimate the missing values in Table 4 assuming the Flash drum operates at at T = 80°C with a input feed rate of $\dot{F}$ = 10 mol/t and z_1 = 0.50.

Table 4: State table for the Acetone/Water flash problem.

Stream	State	P (kPa)	$\dot{n}_{s,T}$ (mol/t)	x_1 or y_1	x_2 or y_2	T ($^\circ$C)
1	L	N/A	10	0.50		N/A
2	V					
3	L					