ChE 3173 EXAM 1 February 21, 1985

1. 25 points

In a binary solution, a certain partial molar property, m, for each component can be written:

$$\bar{m}_1 = A x_2^2$$
$$\bar{m}_2 = B x_1^2$$

where A & B are constants.

a. 15 points
How must A be related to B?

b. 10 points
What is m (the molar property of the solution) in terms of x_1, x_2, and A?

2. 50 points

a. 40 points
On the attached graph paper, draw the P versus x_1 & y_1 for the mixture carbon tetrachloride (1)/chloroform (2) system at 100°C given the pure component vapor pressures:

$$\log_{10} P = (-0.2185\ A/K) + B$$

where:

P = torr (mmHg absolute)
A = const
B = const
K = temperature in °K

	A	B
carbon tetrachloride (1)	7628.8	7.586045
chloroform (2)	7500.5	7.735083

Assume Ra~~po~~oult's Law holds. Label the vapor and liquid curves.

b. 10 points
Four moles of carbon tetrachloride and six moles of chlorofrom are mixed and the system equilibrated at 100°C and 2.~~35~~ 40 atm. What is the composition of the vapor and the liquid? How many moles of chloroform are in the vapor and how many in the liquid?

3. 25 points
Calculate the fugacity of liquid chloroform at 100°C and 100 atm. The density of liquid chloroform at 100°C is 1.4 gr/cm^3 (independent of pressure), the molecular weight is 119.4 gr/mole, and the fugacity coefficient of chloroform vapor at 100°C and 2.900 atm is 0.9.

CONFI6/H1

Solution:

1.a. $x_1 d\bar{m}_1 + x_2 d\bar{m}_2 = 0$

$$\cancel{x_1}\, 2A \cancel{x_2}\, dx_2 + \cancel{x_2}\, 2B \cancel{x_1}\, dx_1 = 0$$

$$A\,dx_2 + B\,dx_1 = 0$$

$$dx_1 = -dx_2$$

$$\therefore \quad A = B$$

b. $M = \sum n_i \bar{m}_i = n_1 \bar{m}_1 + \bar{m}_2 n_2$

$$M = n_1 A x_2^2 + n_2 A x_1^2$$

$$\frac{M}{n_T} = A x_1 x_2^2 + A x_2 x_1^2$$

$$m = A x_1 x_2 (x_2 + x_1)$$

$$m = A x_1 x_2$$

2. $x_1 P_1^s = y_1 P$

$$\underline{x_2 P_2^s = y_2 P}$$

$$P = x_1 P_1^s + x_2 P_2^s$$

$$P = P_2^s + (P_1^s - P_2^s) x_1$$

$$P = \frac{P_1^s P_2^s}{(P_2^s - P_1^s) y_1 + P_1^s}$$

$P = 1.731 x_1 + 2.900 - 2.900 x_1$

$P = 2.900 - 1.169 x_1$

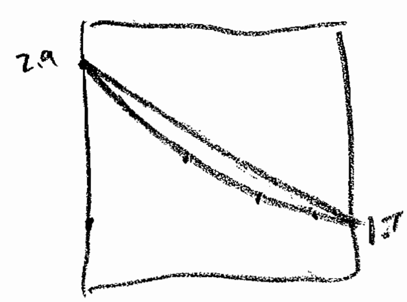
$$P = \frac{5.0199}{1.169 y_1 + 1.731}$$

at 100 °C

$P_1^s = 1315.47 = 1.731$ atm

$P_2^s = 2204.16 = 2.900$ atm

x_1, y_1	$P(x_1)$	$P(y_1)$	
0	2.900	2.900	
0.2	2.666	2.555	1.9698
0.4	2.432	2.283	2.1986
0.6	2.200	2.064	2.4324
0.8	1.965	1.883	2.6662
1.0	1.731	1.731	



b. from graph at $P = 2.4$ & $x_1 = .4$

vapor : $y_1 = .309$

Liquid : $x_1 = .425$

$$\frac{n_L}{n_V} = \frac{9.1}{2.5} = 3.64 \Rightarrow n_L = 3.64\, n_V$$

$$\frac{(x_1 + x_2)\, n_L}{(y_1 + y_2)\, n_V} = 3.64$$

$$n_L + n_V = 4 + 6 = 10$$

$$4.64\, n_V = 10$$

$$n_V = 2.155$$

$$n_L = 7.845$$

$(2.155)(1 - .309) = 1.489$ moles CCl_3H in vap

$(7.845)(1 - .425) = 4.511$ moles CCl_3H in liq.

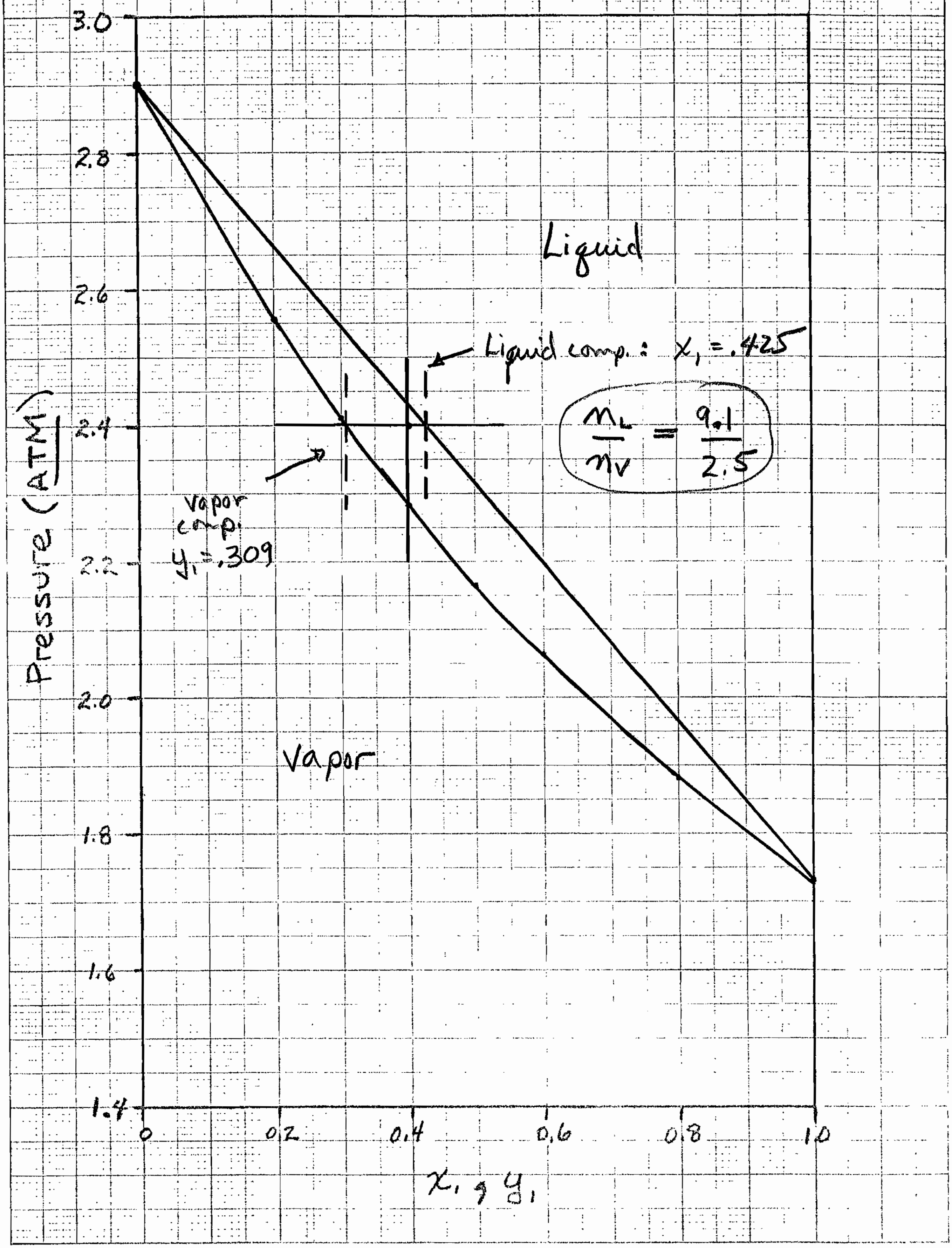
6.000

3. $$f_1 = P_1^s\, \phi_1^s \exp\left(\frac{\bar{V}_L (P - P_1^s)}{RT}\right)$$

$$\frac{1.4\ \cancel{gr}}{\cancel{cm^3}} \times \frac{1\,\text{mole}}{119.4\ \cancel{gr}} \times \frac{1000\ \cancel{cm^3}}{lt} = 11.73\ \frac{\text{moles}}{lt}$$

$$f_1 = (2.900\ \text{atm})(0.9) \exp\left(\frac{\left(\frac{1}{11.73}\right)(100 - 2.9)\ \frac{lt\text{-atm}}{\text{mole}}}{0.08205\ \frac{lt\text{-atm}}{\text{mole}\,^\circ K} \times 373.16\ \cancel{^\circ K}}\right)$$

$$\underline{f_1 = 3.42\ \text{atm}}$$



3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
0
0.2
0.4
0.6
0.8
1.0
Pressure (ATM)
x_1, y_1
Liquid
Vapor
Liquid comp.: $x_1 = .425$
vapor comp. $y_1 = .309$
$\frac{n_L}{n_V} = \frac{9.1}{2.5}$