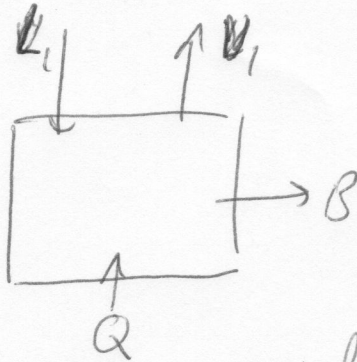


Question 3.7

① Sketch Process & Label Streams



ϕ = Benzene

ϕ^{cl} = Chlorobenzene

② Make table of streams

	moles ^(a)	moles mole fraction ϕ ^(b)	moles mole fraction ϕ^{cl} ^(b)	T °K	moles ϕ	moles ϕ^{cl}
L_1	1	0.1	0.9	395.2	0.1	0.9
V_1	0.41	0.127	0.873	401.1	0.0521	0.358
B	0.59	0.081	0.919	401.1	0.0478	0.542

MOLE FRACTION

① $L_1 = V_1 + B = 1 \text{ mole}$

$\frac{V_1}{B} = 0.7$ $V_1 = 1 - B$ so $\frac{1 - B}{B} = 0.7 \text{ mole}^{-1}$

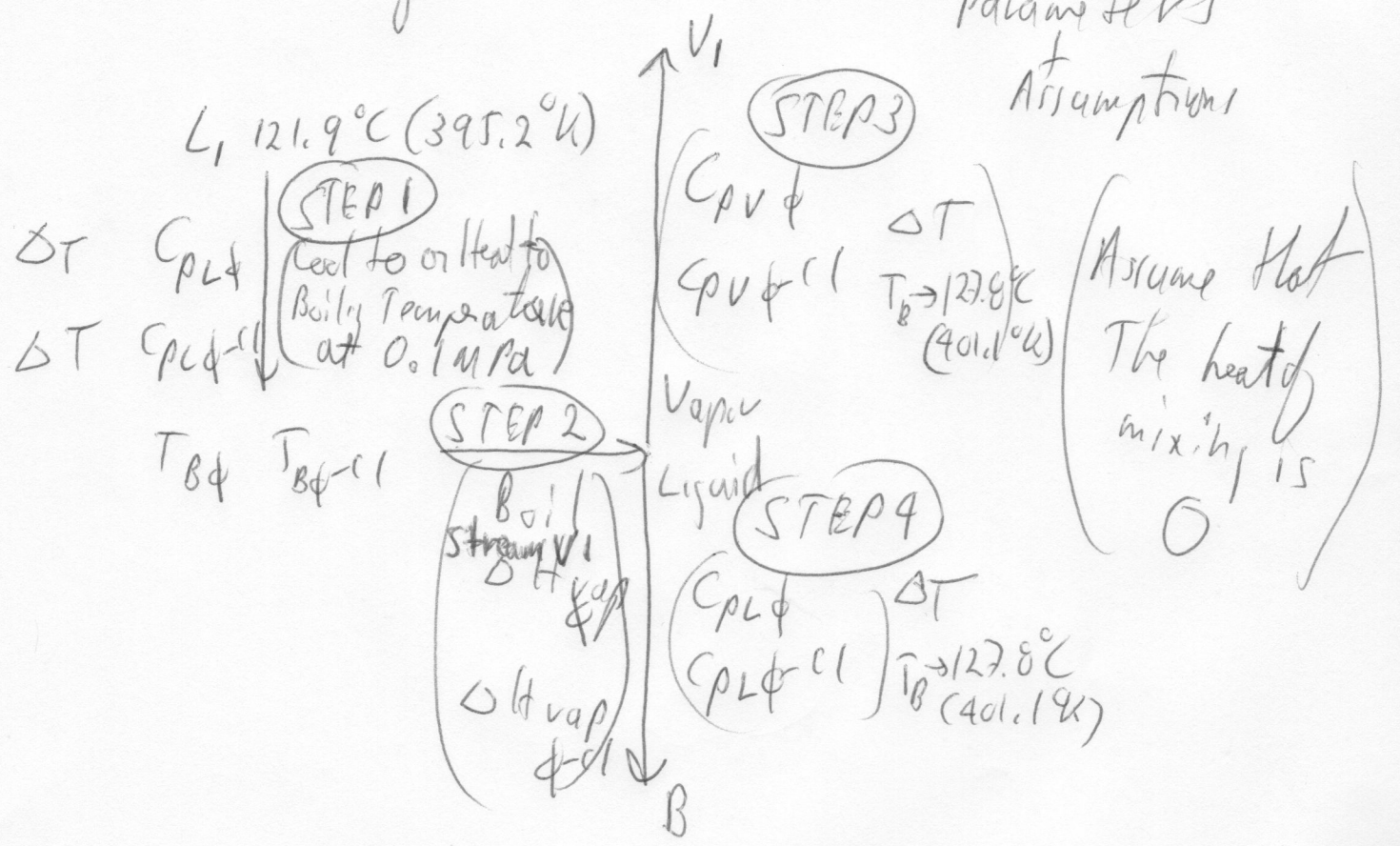
$\frac{1}{B} = 1.7 \text{ mole}^{-1}$ $B = 0.59 \text{ mole}$ $V_1 = 0.41 \text{ mole}$

② 0.127 0.873 given for V_1 (mole fraction)

$0.081 = \frac{0.1 \text{ moles} - 0.41 \cdot 0.127 \text{ moles}}{0.59 \text{ moles}}$

$0.919 = \frac{0.9 \text{ moles} - 0.41 \text{ moles} \cdot 0.127}{0.59 \text{ moles}}$

③ Make a Sketch of the Calculations Steps + Needed Parameters + Assumptions



④ Make Table of materials Parameters

	ϕ	ϕ^{cl}
T_B °K	353.3	404.9
ΔH_V kJ/mole @ T_B	30.8	41
$\frac{J}{\text{mole} \cdot ^\circ\text{K}}$ C_{pL}	136	150
$\frac{J}{\text{mole} \cdot ^\circ\text{K}}$ C_{pV}	30.8	41
C_{pV} A	-33.9	-33.9
C_{pV} B	0.474	0.563
C_{pV} C	$-3.02e-4$	$-4.52e-4$
C_{pV} D	$7.13e-8$	$1.43e-7$

← From Problem
 } From Table E.1

⑤ Calculate ΔH for each step (using 1 mole C_6H_6 , Boiling) ③

STEP 1 Heat to T_B

$$\phi \quad 395.2^\circ\text{K} \rightarrow 353.3^\circ\text{K} \quad (T_B \phi)$$

$$C_{pL} = 136 \frac{\text{J}}{\text{mole}^\circ\text{K}}$$

$$\Delta H_{\phi} = 0.1 \text{ mole} \left(136 \frac{\text{J}}{\text{mole}^\circ\text{K}} \right) (-37.9 \text{ K}^\circ) = -515 \text{ J}$$

$$\phi^{cl} \quad 391.2^\circ\text{K} \rightarrow 404.9^\circ\text{K} \quad (T_B \phi^{cl})$$

$$\Delta H_{\phi^{cl}} = 0.9 \text{ mole} \left(150 \frac{\text{J}}{\text{mole}^\circ\text{K}} \right) (+13.7) = 1850 \text{ J}$$

$$\Delta H_{\text{①}} = 1330 \text{ J} \quad (1.33 \text{ kJ})$$

STEP 2 Boil / Stream V_1

$$\Delta H_{\text{②}} = 0.05 \text{ mole} \left(30.8 \frac{\text{kJ}}{\text{mole}} \right) + 0.36 \text{ mole} \left(41 \frac{\text{kJ}}{\text{mole}} \right)$$

ϕ ϕ^{cl}

$$= 16.3 \text{ kJ}$$

(4)

STEP 3

Heat ϕ & ϕ^{-1} vapor to 401.1 K
(cool)From T_B & $T_{B^{-1}}$

Use Table B.1 Values ABCD

 ϕ $T_B = 353.3$ so heat to 401.1

$$\Delta H_{\phi} = 0.127 \text{ mole} \left[-33.9 \left(\frac{\text{K}}{\text{K}} \right) (401.1 - 353.3) + \frac{0.474}{2} (401.1^2 - 353.3^2) \right. \\ \left. - \frac{3.02 \times 10^{-9}}{3} (401.1^3 - 353.3^3) + \frac{7.13 \times 10^{-8}}{4} (401.1^4 - 353.3^4) \right]$$

$$= 0.127 \text{ mole} \cdot (-3.97 \text{ kJ/mole})$$

$$= -0.504 \text{ kJ}$$

$$\Delta H_{\phi^{-1}} = 0.873 \text{ mole} \left[-33.9 (401.1 - 404.9) + \frac{0.563}{2} (401.1^2 - 404.9^2) \right. \\ \left. - \frac{9.52 \times 10^{-9}}{3} (401.1^3 - 404.9^3) + \frac{1.43 \times 10^{-7}}{4} (401.1^4 - 404.9^4) \right]$$

 $T_B = 404.9$ so cool

$$= 0.873 \text{ mole} (1.75 \text{ kJ/mole}) = 1.53 \text{ kJ}$$

$$\Delta H_{\text{total}} = 1.02 \text{ kJ}$$

STEP 4 Cool/Heat Liquid for B to 401.1 K
 from T_B
 Use Liquid C_p

$$\Delta H = 0.081 \cdot 0.59 \text{ moles} (136 \frac{\text{J}}{\text{mol} \cdot \text{K}}) (401.1 \text{ K} - 353.3 \text{ K})$$

$$+ 0.919 \cdot 0.59 \text{ moles} (150 \frac{\text{J}}{\text{mol} \cdot \text{K}}) (401.1 \text{ K} - 404.9 \text{ K})$$

$$= 0.969 \text{ J}$$

or

$$0.001 \text{ kJ} \approx 0$$

5) Sum the steps for $\Delta H = Q$

$$0 + 1.02 \text{ kJ} + 16.3 \text{ kJ} + 1.33 \text{ kJ} +$$

$$\Delta H = Q = 18.7 \text{ kJ}$$