Demoövn. 4

TIS LV4

Fasjämvikt och stegoperationer

VLE 4

Sökt: Jämviktssammansättning i ångfasen om sammansättningen i vätskefas är 30 mol% - EtOH, 70 mol% - H_2O. $P_{tot} = 760$ mmHg

$x_1 = 0.3$ etanol, lättflyktig

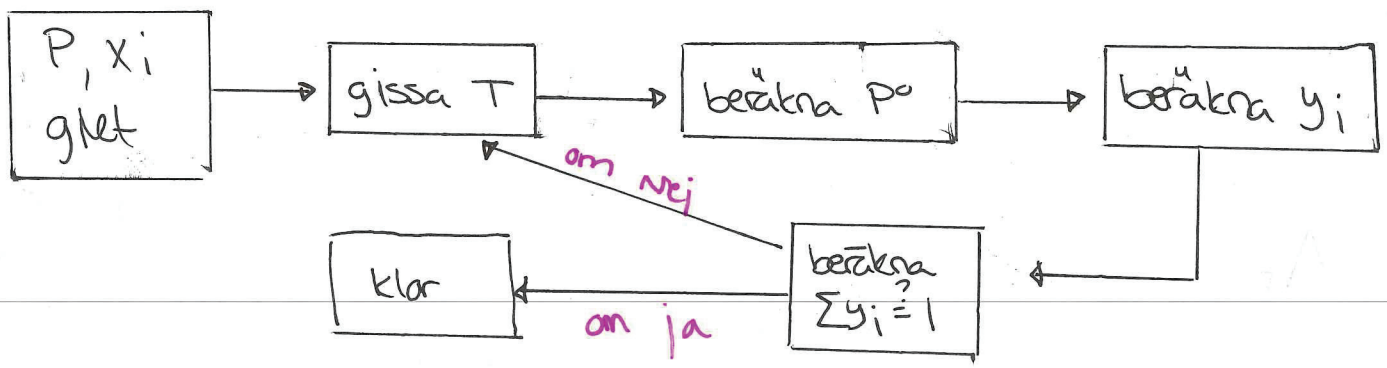
$T_b = 78°C$ bubbelpunktstemp. (kokpunkt)

$x_2 = 0.7$ vatten.

Vill alltså veta y_1, y_2

a) ideal

b) icke-ideal



(a)
Gissa temp:

- $0.3 \cdot 78 + 0.7 \cdot 100 = 93°C$
- P° Antoine

  $P_1^\circ = 1296$

- Raoult $P_i = P_i^\circ x_i$
  Dalton $P_i = y_i P_{tot}$

  $\Big\} \; y_i = \dfrac{P_i^\circ \cdot x_i}{P_{tot}}$

- $\sum y_i = 1$

T [°C]	P_1°	P_2°	y_1	y_2	$\sum y_i$
93	1296	589	0.51	0.54	1.05
90	~~#6~~ 1196	526	0.46	0.48	0.94
91.6	1232	559	0.49	0.51	1.00

(b) Raoult $P_i = \gamma_i P_i^\circ x_i$
Dalton $P_i = y_i P_{tot}$

$\Big\} \; y_i = \dfrac{x_i P_i^\circ \gamma_i}{P}$

$\Lambda_{EtOH,H_2O} = 0.2002$
$\Lambda_{H_2O,EtOH} = 0.81564$

$\Big\} \; \xi = \dfrac{A_{12}}{x_1 + \Lambda_{12} x_2} - \dfrac{\Lambda_{21}}{x_2 + \Lambda_{21} x_1} = 0.409$

Negativ!

$$\ln \gamma_1 = -\ln(x_1 + \Lambda_{12} x_2) + x_2 \left\{ \right. \longrightarrow \gamma_1 = 1.707$$

$$\ln \gamma_2 = -\ln(x_2 + \Lambda_{21} x_1) - x_1 \left\{ \right. \longrightarrow \gamma_2 = 1.197$$

T [°C]	P_1°	P_2°	y_1	y_2	Σy_i
82	860	385	0.58	0.42	1.00

VLE 6

P_{tot} = 1 atm = 760 mmHg

$x_m = 0.555$ $\quad T_b = 64.4\,^\circ C$

$x_p = 0.445$ $\quad T_b = 97.2\,^\circ C$

$T = 60\,^\circ C$

$\gamma_m = 0.9319$

$\gamma_p = 0.8042$

} Ta hänsyn till temp. beroende $RT \ln \gamma$ = konstant

Lösning

$RT \ln \gamma_m$ = konst. = −195.35

$RT \ln \gamma_p$ = ″ = −603.56

} beräknad vid 60°C

$$\gamma_m = \exp(-195.35/RT)$$

$$\gamma_p = \exp(-603.56/RT)$$

Gissa T

$T = 0.555 \cdot 64.6 + 0.445 \cdot 97.2 \approx 79\ ^\circ C$

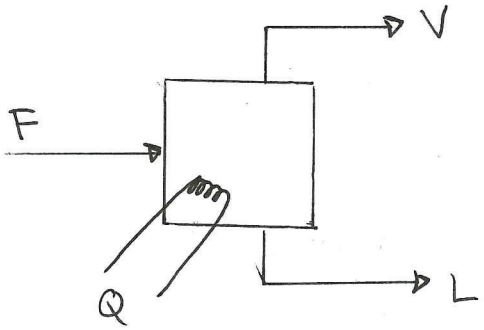
Beräkna P_i° (Antoine)

γ_i {vid givet T}

$$y_i = \frac{\gamma_i P_i^\circ x_i}{P_{tot}}$$ {Rault, Dalton}

$\sum y_i = 1$

stegop. 1



$x_{FB} = 0.6$

$x_{FÄ} = 0.4$ $\quad T_F = 20\ ^\circ C$

$y_{VB} = 0.8$ ← önskat!

$y_{VÄ} = 0.2$

sökt: $\frac{V}{F}$, $\frac{Q}{F}$

	Bensen	Ättiksyra	
c_p	1.8	2.22	$[kJ/kg \cdot ^\circ C]$
ΔH_{vap}	434	413	$[kJ/kg]$

Jämvikt: $y_B = 0.338\, x_B + 0.6$

TB: $F = L + V$

KB: $F \cdot \frac{x_{FB}}{0.6} = L\, x_{LB} + V \frac{y_{VB}}{0.8}$ {bensen}

Jämvikt:

$$y_{VB} = 0.338 \cdot x_{LB} + 0.60$$

$$x_{LB} = \frac{y_{VB} - 0.60}{0.338} = 0.5917$$

TB: $L = F - V$

KB: $F x_{FB} = V y_{VB} + (F - V) x_{LB}$ dela med F

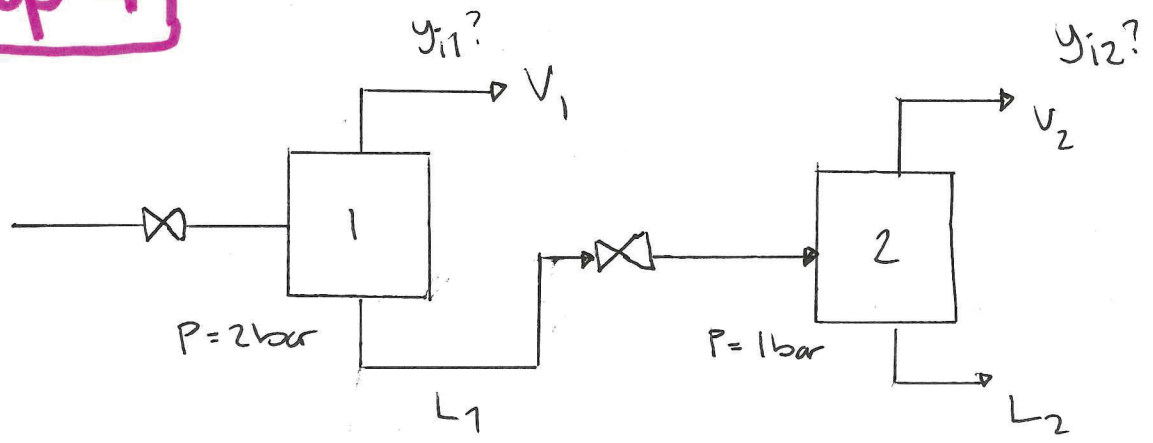
$$x_{FB} = \frac{V}{F} y_{VB} + \left(1 - \frac{V}{F}\right) x_{LB}$$

$$\rightarrow \frac{V}{F} = \frac{x_{FB} - x_{LB}}{y_{VB} - x_{LB}} = \frac{0.6 - 0.5917}{0.8 - 0.5917} \approx \underline{0.04}$$

$$\frac{Q}{F} = \frac{F}{F}\left(T_{ut} - T_{in}\right)\left(Cp_B\, x_{FB} + Cp_{Ä} \cdot x_{FÄ}\right) +$$

$$+ \frac{V}{F}\left(y_{VB} \cdot \Delta H_{vap,B} + y_{VÄ} \cdot \Delta H_{vap,Ä}\right) = 132.2\ \text{kJ/kg}$$

Steg op 4



Sökt: T_1, T_2 $\quad x_{FB} = 0.5$

y_{i1}, y_{i2} $\quad x_{FT} = 0.5$

$F = 100 \text{ kmol/h}$

$V_1 = 0.4\,F$

$V_2 = L \cdot \frac{2}{3}$

(1) TB:

$$F = V_1 + L_1$$

$100 \frac{\text{kmol}}{\text{h}}$ $\quad 0.4 \cdot F \quad \Longrightarrow \quad L_1 = 60 \text{ kmol/h}$

KB:

$$F x_{FB} = V_1 y_{1B} + L_1 \cdot x_{1B}$$

$$100 \cdot 0.5 = 40\, y_{1B} + 60\, x_{1B} \qquad (1)$$

Rault, Dalton $\longrightarrow$ $y_i = \dfrac{P_i^{\circ} x_i}{P_{tot}}$

$$y_{1B} = \frac{P^{\circ}_{1B} \, x_{1B}}{P_{tot}} \qquad (2)$$

$$y_{1T} = \frac{P^{\circ}_{1T} \cdot x_{1T}}{P_{tot}} \qquad (3)$$

$$x_{1B} + x_{1T} = 1 \qquad (4)$$

$$y_{1B} + y_{1T} = 1 \qquad (5)$$

$$P^{\circ}_{1B}(T) \qquad (6)$$

$$P^{\circ}_{1T}(T) \qquad (7)$$

Minska antalet variabler

(1) $x_{1B} = (50 - 40\, y_{1B}) \frac{1}{60}$ → (2)

$$y_{1B} = \frac{50}{\frac{60 \cdot P_{tot}}{P^{\circ}_{1B}} + 40} \qquad (8)$$

Beräkningsgång:

1) Gissa temp.
2) Beräkna P°_{1B}, P°_{1T} med Antoine
3) y_{1B} med (8)
(4) x_{1B} med (1)

5) $x_{1T} = 1 - x_{1B}$ (4)

6) y_{1T} med (3)

7) $y_{1T} + y_{1B} = 1$? Annars gissa nytt T

Temp. gissning

$T_g = T_{bB} x_{FB} + T_{bT} \cdot x_{FT} \rightarrow T_g \approx 394\ K$

$P_{tot} = 2bar = 2 \cdot 760 mmHg$

T_g	P°_{1B}	P°_{1T}	y_{1B}	y_{1T}	Σy_i
393.5	2268	994	0.6351	0.3608	1

$T_1 = 120°C$

(2) TB!

$L_1 = V_2 + L_2$, $L_1 = 60$

$60 = 60 \cdot \frac{2}{3} + L_2 \rightarrow L_2 = 20\ kmol/h$

KB:

$L_1 x_{1B} = V_2 y_{2B} + L_2 x_{2B}$

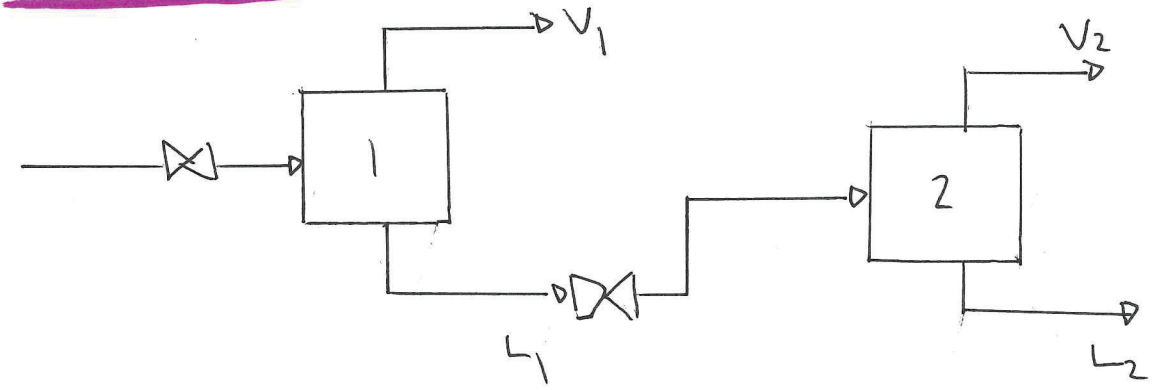
$x_{2B} = (L_1 x_{1B} - V_2 y_{2B}) \frac{1}{L_2}$

$$y_{2B} = \frac{L_1}{\frac{L_2 P_{tot}}{P^\circ_{2B}} + V_2}$$

T	P°_B	P°_T	y_{2B}	x_{2B}	y_{2T}	$\Sigma y = 1$
372.2	1316	540	0.4862	0.2808	0.5114	1

$T = 99°C$

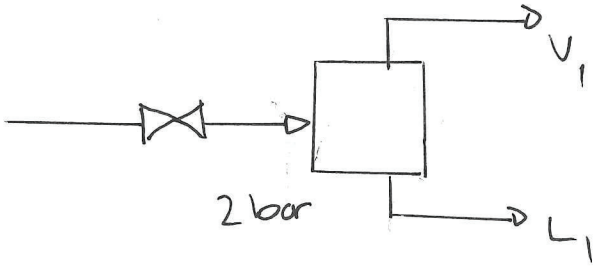
Steg op 5



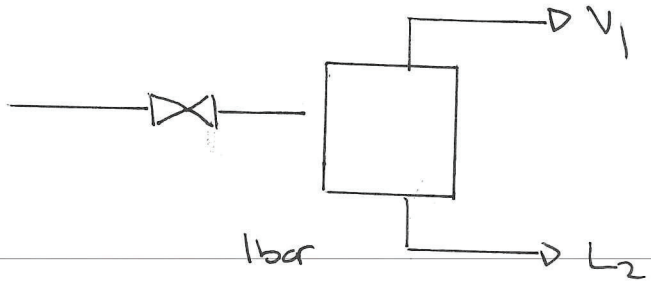
$$V_1 y_1 + V_2 y_2 = V_{tot}\, y_{tot}$$

$$V_{tot} = V_1 + V_2 = 80$$

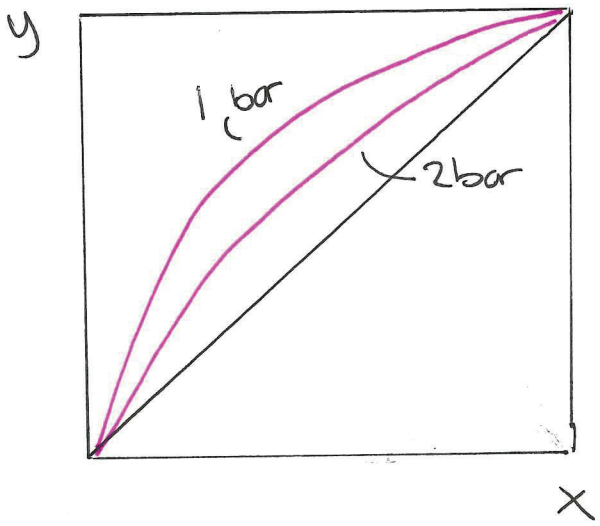
$$y_{tot} = \frac{V_1 y_1 + V_2 y_2}{V_{tot}} = \frac{40 \cdot 0.62 + 40 \cdot 0.49}{80} = 0.555$$



$y_B = 0.539$



$y_B = 0.543$


y
1 bar
2bar
x