Given: Mole fractions of liquid leaving flash chamber and partial condenser are 0.2 and 0.54 respectively.

Hence, from Equilibrium curve, \( y_1 = 0.57 \) and \( y_2 = 0.8 \)
locate \( (x_1, y_1) \) and \( (x_2, y_2) \) on plot.

Now, \( \frac{y_2 - 1}{y_2} = \frac{\Delta y}{\Delta x} = \frac{0.57 - 0.8}{0.57 - 0.54} = -7.6 \)
or, \( y_2 = 0.115 \)

Percent condensed = 88.5%.

\[ \frac{V_2}{V_1} = 0.115 \]

or \( \frac{100}{V_1} = 0.115 \Rightarrow V_1 = 869.56 \text{ kg mol/hr} \).

And, \( V_1 = V_2 + L_2 \Rightarrow L_2 = 769.56 \text{ kg mol/hr} \).

Mass balance across the flash for methanol:
\[ 551.5 + (769.56 \times 0.54) = (869.56 \times 0.57) + 0.2L_1 \]
or \( L_1 = 2357.12 \text{ kg mol/hr} \).

Total mass balance across the flash:
\[ F + L_2 = L_1 + V_1 \]
or \( F + 769.56 = 2357.12 + 869.56 \)
or \( F = 2367.12 \text{ kg mol/hr} \).

\[ \therefore \quad \frac{F}{V_1} = 0.233 \]
Overall feed composition for the flash chamber:

\[
\frac{551.5 + (0.54 \times 769.56)}{2364.12 + 769.56} = 0.308
\]

\[
\frac{\Psi_1 - 1}{\Psi_1} = \frac{0.308 - 0.57}{0.308 - 0.2} = -2.43
\]

or, \( \Psi_1 = 0.29 \)

% Vaporized in flash = 29%

Yield = \( \frac{0.8 \times 100}{551.5} \times 100 = 14.5\% \).
1. Locate feed and Solvent points on graph. Construct feed line for first unit operation. We know $x_B = 0.15$ for $R_1$. Hence, see which tie line goes through $R_1$. Intersection with feed line, $M_1$: $M_1 \rightarrow x_t = 0.81$, $x_B = 0.066$, $x_A = 0.124$.

2. Using mixing point $M_1$ and lever rule on feed line:
   \[
   \frac{S_1}{F} = \frac{15.25}{3.6} \Rightarrow S_1 = 847.2 \text{ kg/hr}
   \]

3. $F + S_1 = E_1 + R_1$ [Mass balance across first stage],
   or $200 + 847.2 = E_1 + R_1$
   or $1047.2 = E_1 + R_1$ .... (i)
   Lever rule on tie line:
   \[
   \frac{E_1}{R_1} = \frac{13}{14} \Rightarrow E_1 = 0.928 R_1 
   \]
   Using eqns. (i) and (ii),
   \[
   E_1 = 945.83 \text{ kg/hr} \\
   R_1 = 101.87 \text{ kg/hr}
   \]
   \[x_C = 0.88 \text{ for } E_1\]  

4. Draw feed line for stage 2 between $R_2$ and $S$. We know that $x_C = 0.91$ for $E_2$. Construct tie line that goes through $E_2$. See where it intersects feed line. This intersection point is point $M_2$. $M_2$ occurs at 0.522.
Lever rule on feed line. \( \frac{S_2}{R_1} = \frac{8}{8.6} \Rightarrow S_2 = 94.76 \text{ kg/hr} \) \( \text{[2 pm]} \)

Lever rule on 2nd tie line,
\[
\frac{E_2}{R_2} = \frac{79}{68} \Rightarrow E_2 = 1.16 R_2 \quad (\text{iii})
\]

\( R_1 + S_2 = 2.16 R_2 \)
or \( R_2 = 91.03 \text{ kg/hr} \) \( \text{[iv]} \)

From (iii) \& (iv), \( E_2 = 105.6 \text{ kg/hr} \)

Composition of \( R_2 \):
\[
\begin{align*}
\alpha_C &= 0.085 \\
\alpha_B &= 0.116 \\
\alpha_A &= 0.799
\end{align*}
\]
3) \( B \rightarrow \text{Benzoic Acid} \) \} \text{Subscripts}.

\( w \rightarrow \text{Water} \)

\( F = 1000 \ \text{Kg/hr} \)

\( Z_B = 0.1 \)

\( F_B = 100 \ \text{Kg/hr} \)

\( F_w = 900 \ \text{Kg/hr} \)

\( k'_B = 4.2 \)

\( E_B = \frac{k'_B S}{F_w} = \frac{4.2 \times 500}{900} = 2.3 \)

\[ \begin{align*}
1) \quad & \frac{X_B^F}{X_B^R} = 1 - \frac{X_B^F}{X_B^F} = 1 - \frac{1}{1 + E_B} = 0.90 \\
2) \quad & \frac{X_B^E}{X_B^F} = 1 - \frac{X_B^E}{X_B^F} = 1 - \frac{1}{\left(1 + \frac{E_B}{N}\right)^N} = 1 - \frac{1}{\left(1 + \frac{2.3}{3}\right)^3} = 0.82 \\ \\
3) \quad & \frac{X_B^E}{X_B^F} = 1 - \frac{X_B^E}{X_B^F} = 1 - \frac{1}{\sum_{n=0}^{N} E^n} = 1 - \left(\frac{1}{1 + 2.3^0 + 2.3^2 + 2.3^3}\right) = 0.95 \\
4) \quad & 1 - \frac{1}{1 + E_B} = 0.9534, \\
\text{or} \quad & 1 - \frac{1}{1 + 4.2 \times \frac{500}{900}} = 0.9534 \\
\Rightarrow \ G = 485.7 \ \text{Kg/hr} \)
\]
Problem 4) 20 points (answer each question briefly)

a) For a non-ideal binary equilibrium system with repulsive interactions between the two species in a binary mixture, construct a representative y-x equilibrium curve for this system.

\[ \sqrt{y} \]

b) What is a quick check that you can do to determine if you will have only one phase coming out of a multicomponent flash distillation?

\[ K > 1 \quad \text{Superheated Vapor} \]
\[ K < 1 \quad \text{Subcooled Liquid} \]

\( f(\alpha) > 0 \quad \text{S.L. Lk} \)
\( f(\alpha) < 0 \quad \text{S.L. Vap} \)
c) Explain briefly in words why countercurrent operation is more efficient than cocurrent and crosscurrent systems.

Because there are more driving forces for countercurrent

Optimum driving force for solute transfer between phases where you need it.

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d) When carrying out a multicomponent bubble point calculation, if a selected temperature and pressure results in the bubble point criteria being less than 1, how should you modify your pressure estimate for the next iteration assuming that the temperature remains constant and why?

\[ z_i K_i < 1 \]

Want to increase \( K \). Therefore if temp is constant, you want decrease pressure.