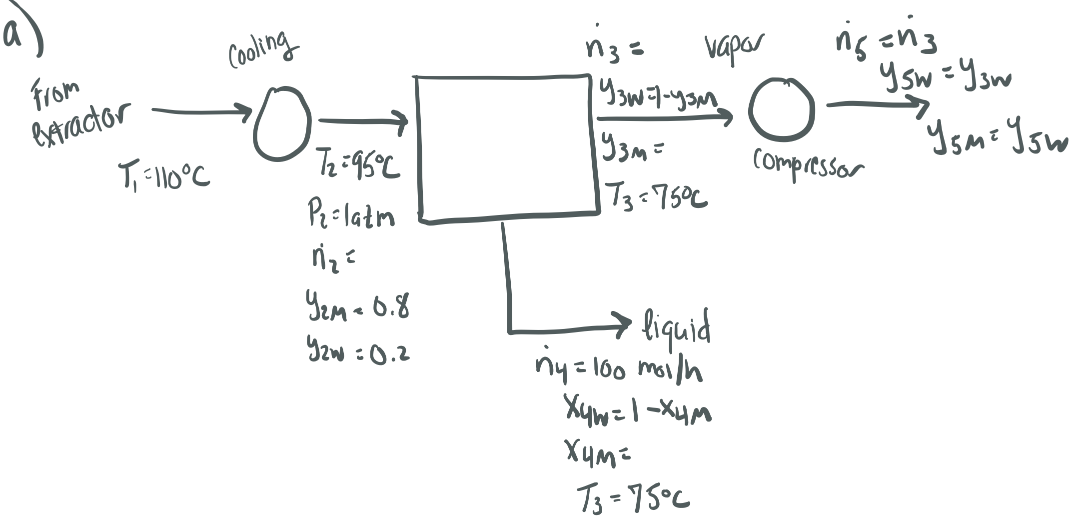
a)



Additional Equations:

Bubble Point: $P_3 = x_M P_M^{sat} + x_W P_W^{sat}$ (*)

Dew Point: $1 = \dfrac{y_{3M} P_3}{P_M^{sat}} + \dfrac{y_{3W} P_3}{P_W^{sat}}$ (**)

b) Txy Diagram generated in excel.

1. Guess a T in a cell
2. calculate P_M^{sat} and P_W^{sat}
3. use (*) to calculate x_M where $x_M = \dfrac{P - P_W^{sat}}{P_M^{sat} - P_W^{sat}}$
4. use solver to set $x_M = 0$ by changing T. This is the pure boiling point of water.
5. In a new row, use solver to set $x_W = 0$ by changing T - this should be the pure boiling point of menthol.

These are the endpoints of the Txy Diagram

To construct the diagram – use a table.

1. Designate a column for T
2. Calculate P_M^{sat}, referencing T
3. calculate P_W^{sat}, referencing T
4. Use ⊛ to calculate x_M
5. Use Raoult's Law to calculate $y_M = \frac{x_M P}{P_M^{sat}}$
6. Click + drag all formulas
7. Plot 2 data series: T vs. x_M, T vs. y_M

c) Read from the diagram

at 75°C $\quad x_M = 0.64$

348K $\quad y_M = 0.86$

d) Want to know: $\dot{n}_3$ $\quad$ y_{3M} y_{3W} x_{4M} x_{4W} → known from Txy

$$\begin{array}{l} 2 \text{ unknowns } (\dot{n}_2, \dot{n}_3) \\ \underline{-2 \text{ material balances}} \\ 0 \text{ DOF.} \end{array}$$

Can solve for $\dot{n}_3$ from material balances.

$$M: \; y_{2M}\dot{n}_2 = \dot{n}_3 y_{3M} + \dot{n}_4 x_{4M}$$
$$W: \; y_{2W}\dot{n}_2 = \dot{n}_3 y_{3W} + \dot{n}_4 x_{4W}$$
$$\text{total: } \; \dot{n}_2 = \dot{n}_3 + \dot{n}_4$$

Plug total balance into M – solve for $\dot{n}_3$!

$$y_{2M}(\dot{n}_3 + \dot{n}_4) = \dot{n}_3 y_{3M} + \dot{n}_4 x_{4M}$$
$$y_{2M}\dot{n}_3 + y_{2M}\dot{n}_4 = \dot{n}_3 y_{3M} + \dot{n}_4 x_{4M}$$
$$\dot{n}_3(y_{2M} - y_{3M}) = \dot{n}_4(x_{4M} - y_{2M})$$

$$\dot{n}_3 = \frac{\dot{n}_4 (x_{4M} - y_{2M})}{y_{2M} - y_{3M}}$$

$$\dot{n}_3 = \frac{100 \text{ mol/h} (0.64 - 0.8)}{(0.2 - 0.86)}$$

$$\boxed{\dot{n}_3 = 24 \text{ mol/h}}$$

e) What if $y_{3M} = 0.05$ - What temp should it operate at?

$$P = x_{4M} P_M^{sat} + x_W P_W^{sat} \rightarrow x_M = \frac{P - P_W^{sat}}{P_M^{sat} - P_W^{sat}}$$

1. use spreadsheet to guess T
2. calculate P_M^{sat}, P_W^{sat} referencing that T
3. calculate x_M referencing P_M^{sat}, P_W^{sat}
4. calculate y_M using Raoult's

$$y_{3M} = \frac{P_M^{sat} x_{4M}}{P}$$

5. use solver to set $y_M = 0.95$ (because $y_W = 0.05$) by changing T.

Then $\boxed{T = 68\ °C}$