Tutorial - 4

1) $x_D = 0.97$ (weight), $x_B = \cancel{6}\ 1 - 0.98 = 0.02$

$R = 3.5$

$z_F\ (w/w) = 0.4 \Rightarrow z_F$ (mol/mol) $= \dfrac{\frac{0.4}{78}}{\frac{0.4}{78} + \frac{0.6}{92}} = 0.44$

Since there are no plates in stripping we can't achieve $x_W = 0.02$.

Feed rates

$F_B = \dfrac{0.4 \times 13000}{78} = 69.04$ kmol/h.

$F_{toluene} = \dfrac{0.6 \times 13 \times 10^3}{92} = 88.56$ kmol/h.

Feed total $= 158.21$ kmol/h.

Using this, $z_F = 0.44$.

x_D (mol by mol) $= \dfrac{\frac{0.97}{78}}{\frac{0.97}{78} + \frac{0.03}{92}} = 0.9745$.

Since saturated vapour enters, $q = 0 \Rightarrow$ q-line is $y = 0.44$.

~~Using~~ Also Rectification line is

$$y = \frac{R}{R+1}(x - x_D) + x_D \quad (\because \text{it passes through } (x_D, x_D))$$

Using these we find that, to obtain 97% distillate

we need $8 - 1 = \boxed{7 \text{ trays.}}$ ($\because$ last tray is partial reboiler)

a) Yes ~~it~~ is possible. (Because we have 7 trays in rectification.)

No. of theoretical trays $= \text{Actual} \times E_o = 14 \times \dfrac{1}{2} = \boxed{7}$

$\cancel{a)}$ (Also note that the last stage is very small,

~~so there could be~~ a ~~24~~ ~~vw~~

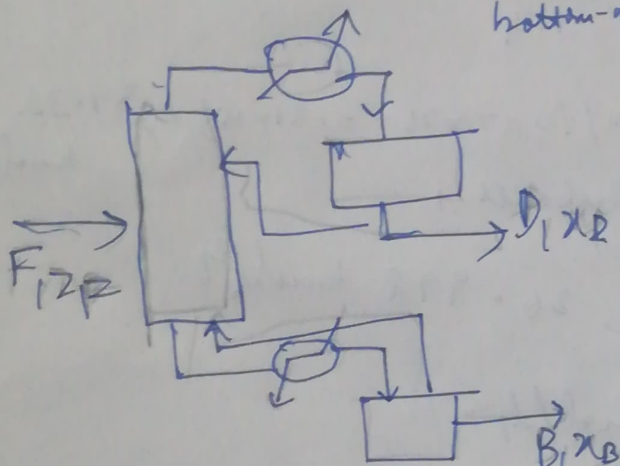
so, it could be that even 6 trays would

be enough to achieve required purity.

b) From graph, Bottoms composition can be obtained

as $x_B \simeq 0.25$ (x-coordinate of ~~the last~~

bottom-most point on the curve)



~~Upon~~

Material balance:

$$F = B + D \quad \text{—} ①$$

$$F z_F = B x_B + D x_D \quad \text{—} ②$$

$$\Rightarrow \cancel{B} = D = \frac{F(z_F - x_B)}{(x_D - x_B)}$$

$\cancel{\Rightarrow D = 44.7 \text{ kmol/h}}$.

$$\Rightarrow D = \boxed{41.25 \text{ kmol/h.}}$$

c) From part (b) we infer that

$$x_{residue} = \boxed{x_B = 0.25}$$

② $q = \frac{L-L'}{F} = 1 - \frac{G}{F} \Rightarrow q = 0.7$

$x_D = 0.95$, $z_f = 0.5$, $x_w = 0.005$.
[all in wt by wt]

$M.W_{CS_2} = 76.14$ & $M.W_{CCl_4} = 154$ g mol^{-1}

Converting all compositions to mole fraction,

$x_D = 0.975$, $z_F = \frac{\frac{0.5}{76}}{\frac{0.5}{76} + \frac{0.5}{154}} = 0.67$

$x_w = 0.01$

$F = 4000$ kg/h $= 4000/(0.67 \times 76 + 0.33 \times 154) = 39.32$ kmol/h.

Using material & species balance,

$D = F\left(\frac{z_F - x_w}{x_D - x_w}\right) = 26.998$ kmol/h

$W = F - D = 12.27$ kmol/h

∴ In kg/h, $D = 26.998 \times (76 \times 0.97 + \cancel{0.03 \times 154})$
$= \boxed{2115 \text{ kg/h.}}$

a) $W = 12.27 \times (76 \times 0.01 + 154 \times 0.99)$
$= \boxed{1880 \text{ kg/h.}}$

b) R_{min} can be obtained as follows:

i) Find intersection between q-line & eqbm curve

ii) Join that point with the distillate point (x_D, x_D)

iii) Slope of that line $= \frac{x_D R_{min}}{R_{min}+1}$

& $R_{min} = \boxed{0.9070}$

c) For min no. of theoritical trays,

$x = y$ line is the operating line

$(R \rightarrow \infty)$

the number of trays = ~~10~~ 8 (obtained from graph)

(& N_{stages} = ~~10~~ 9; includes a partial reboiler)

d) $R = 2 R_{min} = 1.814$

Use this to get rectification line.

Stripping line will be the line joining the bottoms point to the point of intersection of q-line & stripping line.

Graphs are plot & number of theoritical trays stages = $\boxed{12}$

e) Optimum feed location is a the transition stage = tray no. $\boxed{6}$