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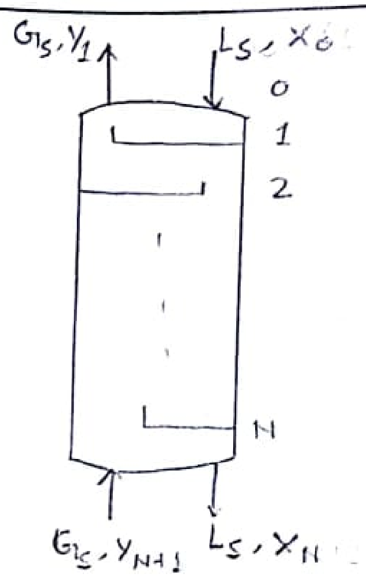
SHEET NO. 01

x	X	y	Y
0	0	0	0
5.64×10^{-4}	5.64×10^{-4}	0.0112	0.0113
8.42×10^{-4}	8.43×10^{-4}	0.0185	0.0188
1.403×10^{-3}	1.405×10^{-3}	0.0342	0.0354
1.965×10^{-3}	1.968×10^{-3}	0.0513	0.0541
2.79×10^{-3}	2.798×10^{-3}	0.0775	0.08
4.2×10^{-3}	4.22×10^{-3}	0.121	0.1377
6.98×10^{-3}	7.03×10^{-3}	0.212	0.269



a) From plot

$$\frac{L_{s,min}}{G_s} = \frac{Y_{N+1} - Y_1}{X_N - X_0} = \frac{0.25 - 0.02}{6.65 \times 10^{-3} - 0} = 34.5864$$

$$G_s = 0.8 \frac{PV}{RT} = \frac{180 \text{ m}^3 \times 101325 \text{ Pa}}{8.314 \text{ J mol}^{-1} \text{K}^{-1} \; 298 \text{K}} \times 0.8$$

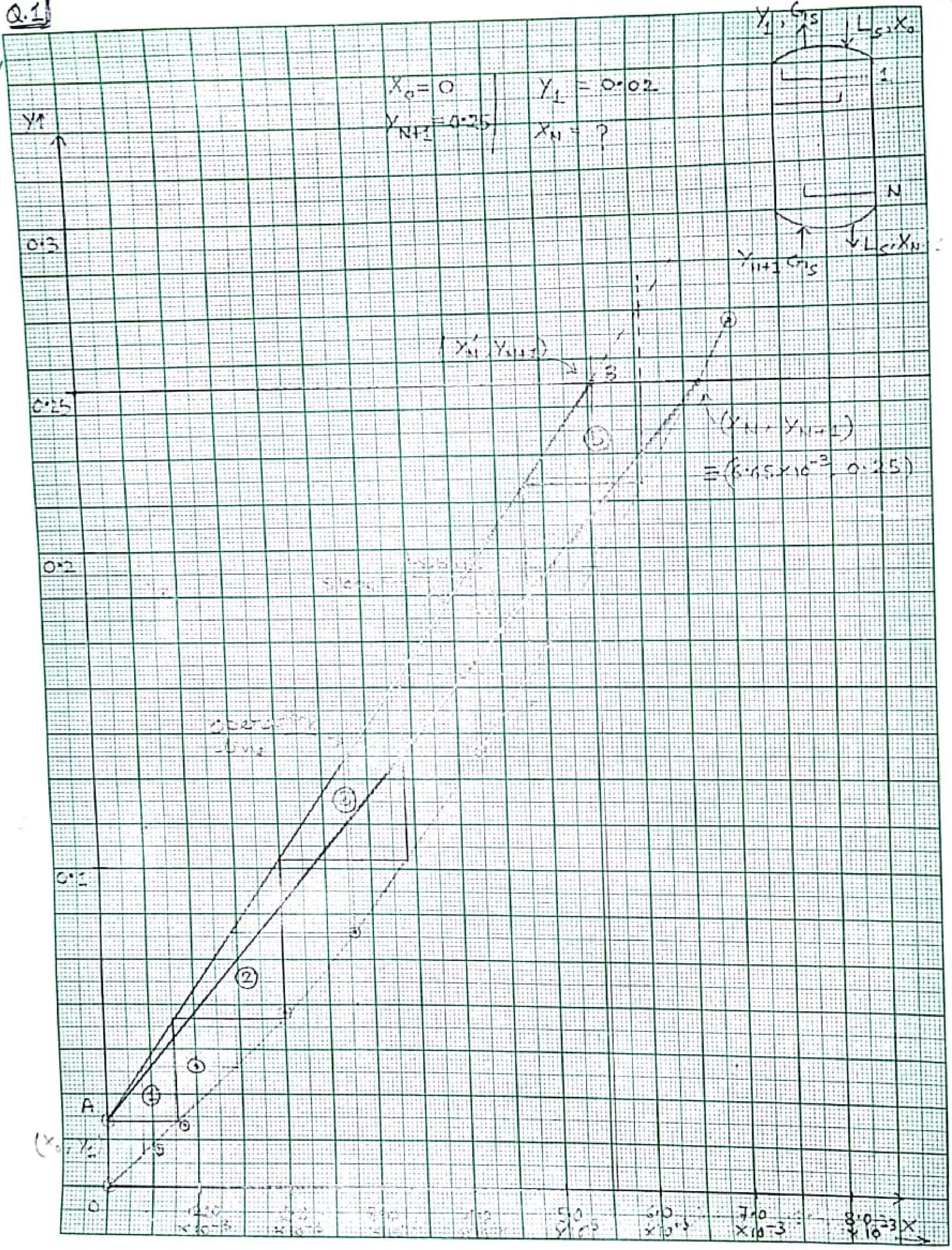
$$G_s = 5993.51 \frac{\text{moles}}{\text{hr}}$$

$$L_{s,min} = (5993.51 \times 34.5864) = \cancel{3731} \; 207293.83 \frac{\text{moles}}{\text{hr}}$$

$$L_{s,min} = (207293.83 \times 18 \times 10^{-3}) \text{ kg/hr}$$

$$\boxed{L_{s,min} = 3731 \frac{\text{kg}}{\text{hr}}}$$

Q.1)



X0 = 0
YN+1 = 0.25
Y1 = 0.02
XN = ?
Y1 , Gs
Ls , X0
1
N
YN+1 Gs
Ls , XN
Y↑
0.3
0.25
0.2
0.1
(X'N , YN+1)
(XN , YN+1)
= (6.65×10^-3 , 0.25)
A
(X0 , Y1)
0
1
2
3
4
5
X

b) $L_s = 1.2 L_{s,min} = 248752.596 \ \frac{\text{moles}}{\text{hr.}}$

$$\frac{L_s}{G_s} = 41.50$$

let, operating line passes through $(x_N', 0.25)$

$$41.50 = \frac{0.25 - 0.02}{x_N' - 0}$$

$$x_N' = 5.542 \times 10^{-3}$$

c) From plot,

Number of ideal trays

$= 4 + \frac{21}{36}$

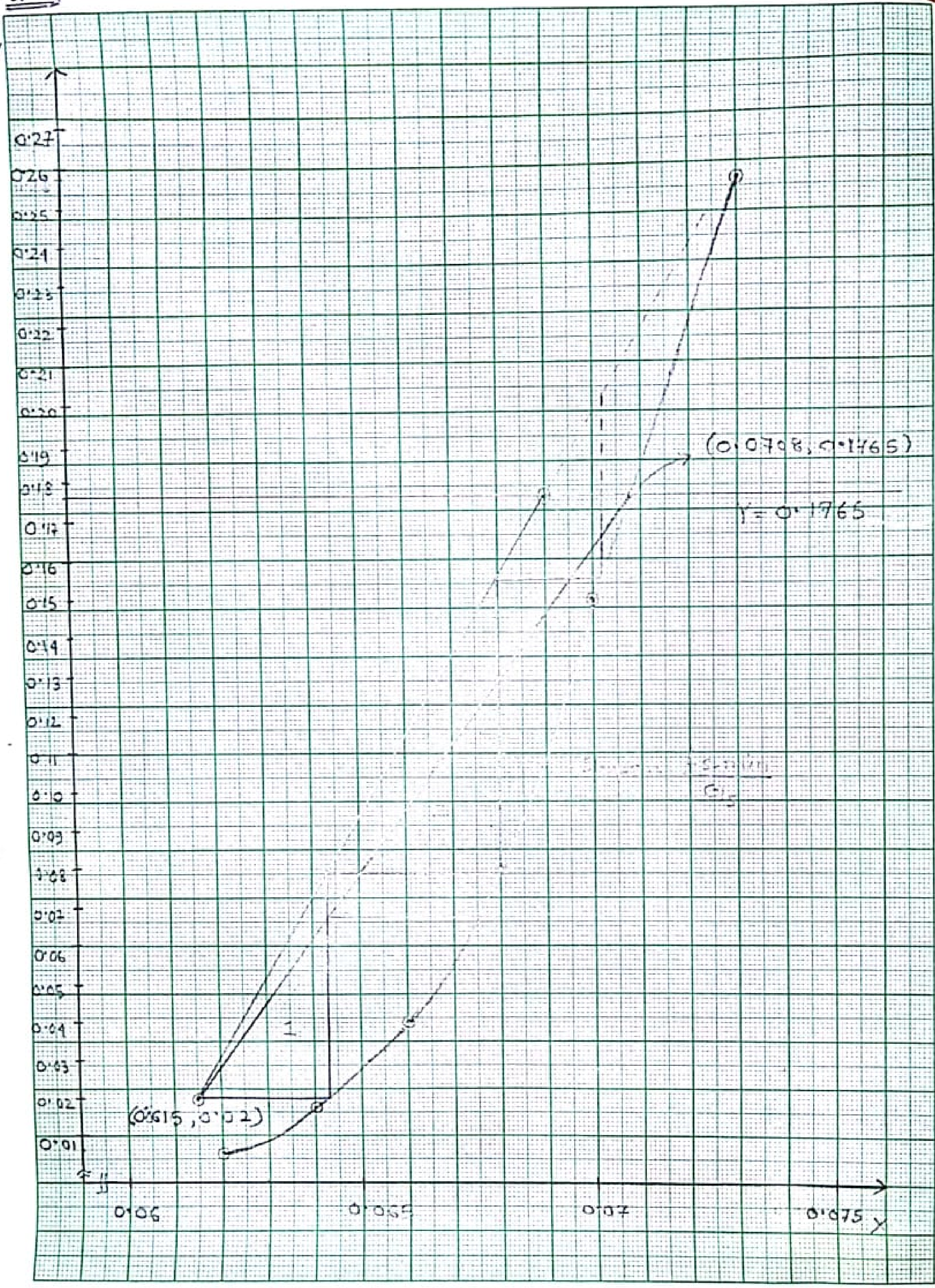
$\simeq 4.583$

No. of real trays $= \dfrac{\text{theoretical no. of trays}}{\text{mechanical efficiency}} = \dfrac{4.583}{0.5}$

$= 9.17$

$\Rightarrow$ Required number of Real trays $= 10$

Q.2"

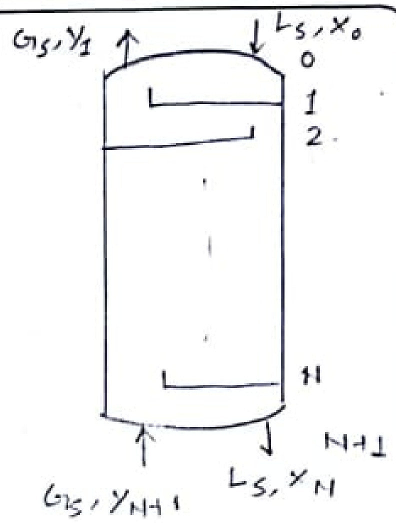


0·27
0·26
0·25
0·24
0·23
0·22
0·21
0·20
0·19
0·18
0·17
0·16
0·15
0·14
0·13
0·12
0·11
0·10
0·09
0·08
0·07
0·06
0·05
0·04
0·03
0·02
0·01
(0·0708, 0·1765)
Y = 0·1765
(0·615, 0·02)
1
0·06
0·065
0·07
0·075
X

2

Q.2 ||

$\frac{\text{Mole } CO_2}{\text{mole soln}}$	P_{CO_2} (mm Hg)	x	y
0.058	5.6	0.062	7.423×10^{-3}
0.060	12.8	0.064	0.017
0.062	29.0	0.066	0.0397
0.064	56.0	0.068	0.0795
0.066	98.7	0.070	0.149
0.068	155.0	0.073	0.256



Given : $X_0 = 0.615$

$Y_1 = 0.02$

$Y_{N+1} = 0.176$

a) from plot : $X_N' = 0.0708$

$$\frac{L_{s,min}}{G_s} = \frac{Y_{N+1} - Y_1}{X_N' - X_0} = \frac{0.176 - 0.02}{0.0708 - 0.0615}$$

$$\frac{L_{s,min}}{G_s} = 16.77$$

b) $\frac{L_s}{G_s} = 1.2 \frac{L_{s,min}}{G_s} = 20.124$

$$G_s = 0.85 \times \frac{1\,m^3 \times 101325\,Pa.}{8.314\,J\,mol^{-1}K^{-1}\,298\,K} = 34.76\,\frac{mol}{hr.}$$

$$L_s = 699.56\,\frac{mol}{hr.}$$

$L_N = [L_S + 0.0058 L_S] = 740.13$ mol/hr.

$$20.124 = \frac{0.176 - 0.02}{x_N - 0.0615}$$

$x_N = 0.069$

$L_N = \left[L_S \times \frac{100}{\frac{30}{61} + \frac{70}{18}} + 0.058 \times L_S \times 44\right]$

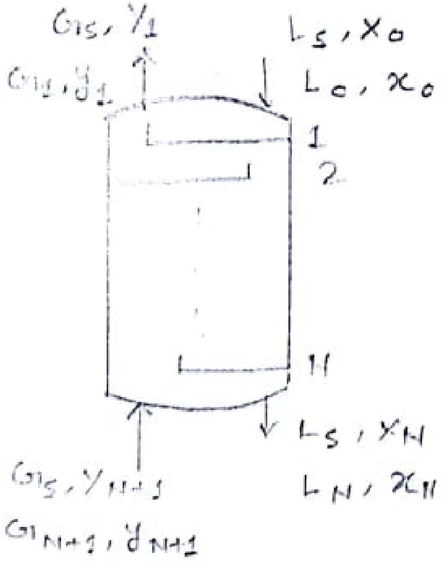
$L_N = 17751$ g/hr

$L_N = 17.751$ kg/hr.

c) Using $x_N = 0.069$

from plot no. of ideal stages $= 2.43$

3) For dilute (gas) system



$$G_S \simeq \frac{G_1 + G_{N+1}}{2}$$

$x \simeq X$

$y \simeq Y$

$$L_S \simeq \frac{L_0 + L_N}{2}$$

Equilibrium curve:

$X_0 = x_0 = 0.0001$

$$y_1 = Y_1 = \frac{0.01 \times 0.02}{0.99 + 0.01 \times 0.02} = 2.019 \times 10^{-4}$$

$y_{N+1} = Y_{N+1} = 0.01$

a) $$\frac{L_{s,min}}{G_s} = \frac{0.01 - 2.019\times10^{-4}}{9.36\times10^{-3} - 0.0001} = 1.0581$$

$$G_1 = \cancel{(240\times0.98)}(240 \times 0.9902) = 237.648 \ \frac{kmol}{hr.}$$

$$G_{N+1} = 240 \ \frac{kmol}{hr.}$$

$$G_s = \frac{240+237.648}{2} \ \frac{kmol}{hr.} = 238.824 \ \frac{kmol}{hr.}$$

$$L_{s,min} = 252.699 \ \frac{kmol}{hr.}$$

b) Using Kremser equation for absorption

$$N = \frac{\log\left[\frac{y_{N+1} - mx_0}{y_1 - mx_0}\left(1-\frac{1}{A}\right)+\frac{1}{A}\right]}{\log A}$$

$$A = \frac{L}{mG} = \frac{252.699}{1.0682\times 238.824} = 1.981$$

$$N = 5.781$$

c) $$y = 1.0682x$$

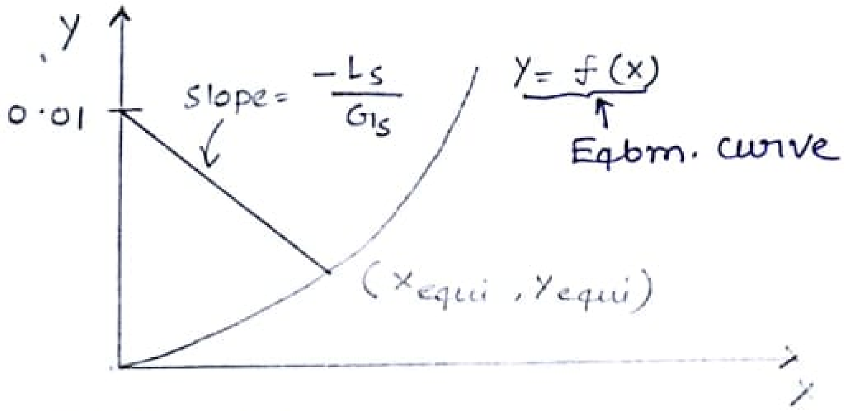
$$\frac{Y}{1+Y} = \frac{1.0682\,X}{1+X}$$

$$Y + XY = 1.0682X + 1.0682XY$$

$$Y = 1.0682X + 0.0682XY$$

$$Y = X(1.0682 + 0.0682Y)$$

$x = Y/(1.0682 + 0.0682Y)$



$$\frac{0.01 - Y}{0 - \frac{Y}{(1.0682 + 0.0682Y)}} = -2.116$$

$Y_{equi} = 3.355 \times 10^{-3} \simeq y_{equili}$

$x_{equi} = 3.14 \times 10^{-3} \simeq x_{equili}$

% absorption in one ideal eqbm. stage

$$= \left(\frac{0.01 - y_{equi}}{0.01 - 2.019 \times 10^{-4}}\right) \times 100$$

$$= 0.678 \times 100$$

$$= 67.8\ \%$$

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Q.4) Given: $y = 26x$

$$S = \frac{m G_s}{L_s}$$

$$G_s = \frac{G_1 + G_2}{2}$$

$$L_s = \frac{L_1 + L_2}{2}$$

$$L_s = \left(\frac{600 + 600 \times 0.9505}{2}\right) = 585.15$$

$$G_s = \left(\frac{25 + 25 + 600 \times 0.0495}{2}\right) = 39.85$$

$$S = \frac{26 \times 39.85}{585.15} = 1.771$$

Given: $x_0 = 0.05$ $\quad x_N = 0.005$

$y_{N+1} = 0$

For stripping

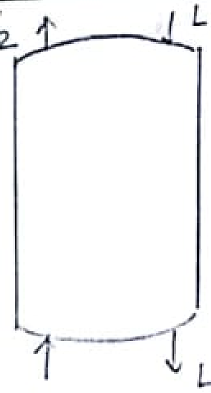
$$N = \frac{\log\left[\frac{x_0 - \frac{y_{N+1}}{m}}{x_N - \frac{y_{N+1}}{m}}\left(1 - \frac{1}{S}\right) + \frac{1}{S}\right]}{\log S}$$

$$= \frac{\log\left[\frac{0.05}{0.005}\left(1 - \frac{1}{1.771}\right) + \frac{1}{1.771}\right]}{\log(1.771)}$$

$$= 2.793$$

·5

$$y^* = \frac{1.02x}{1-x}$$



$$L_s X_2 + G_s Y_1 = G_s Y_2 + L_s X_1$$

$$G_s = 0.9 \times \left(\frac{600\,m^3 \times 101325\,Pa}{8.314\,J.mol^{-1}K^{-1} \times 298\,K}\right)$$

$$= 22084.323 \text{ moles}$$

Given that

$y_1 = 0.002 \qquad y_2 = 0.1 \quad , Y_1 = 0.111, \quad Y_2 = 0.002$

using $X = \frac{x}{1-x}$

$$Y^* = 1.02\,X$$

Now, $\dfrac{L_{s,min}}{G_s} = \dfrac{0.111 - 0.002}{0.109 - 0} \simeq 1$

Given that $\dfrac{L_s}{G_s} = 2\,\dfrac{L_{s,min}}{G_s} = 2$

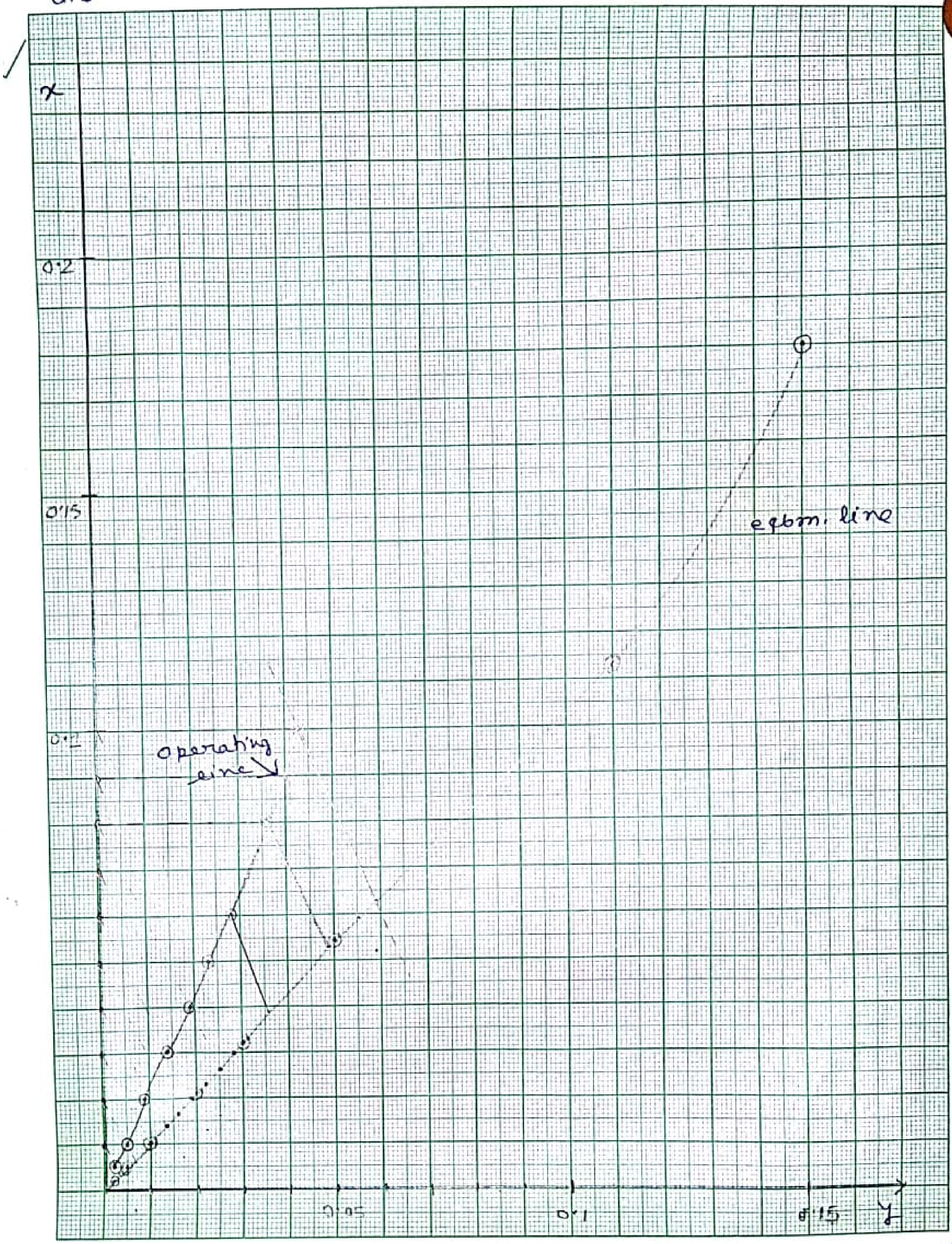
$$\frac{Y_2 - Y_1}{X_2 - X_1} = 2$$

$$X_1 = 0.055$$

again

$$\frac{Y_1 - \frac{y}{1-y}}{X_1 - \frac{x}{1-x}} = 2$$

Q.5



Obtained operating line can be represented as

$$\frac{y}{1-y} = \frac{2x}{1-x}$$

For obtaining y_i,

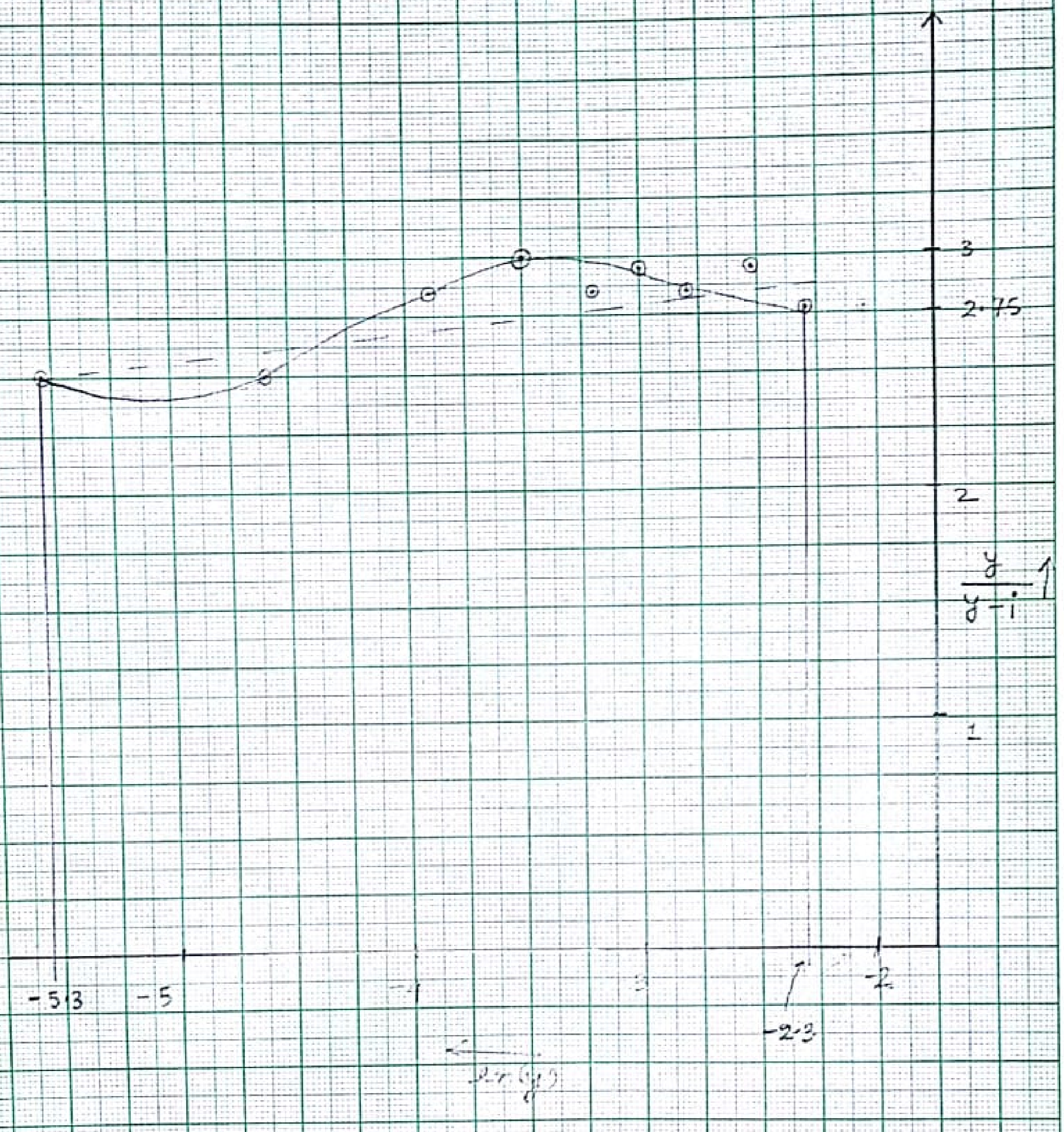
$$\frac{0.1 - \frac{1.02x}{1-x}}{x_i - x} = -\frac{k_x}{k_y} = -\frac{325}{150} = -2.167$$

Following table is required for evaluation of N_{tG}

x	y	x_i	y_i	$\frac{y}{y-y_i}$	$\ln y$
2.48×10^{-3}	0.005	0.003	0.003	2.5	−5.3
4.92×10^{-3}	0.01	0.006	0.006	2.5	−4.6
9.71×10^{-3}	0.02	0.013	0.013	2.86	−3.9
0.014	0.03	0.019	0.02	3	−3.5
0.019	0.04	0.025	0.026	2.86	−3.2
0.023	0.05	0.031	0.033	2.94	−2.99
0.028	0.06	0.037	0.039	2.86	−2.81
0.036	0.08	0.049	0.053	2.96	−2.53
0.023	0.1	0.059	0.064	2.78	−2.3

$$N_{tG} = \int_{y_2}^{y_1} \frac{dy}{y - y_i} + \frac{1}{2} \ln\left(\frac{1-y_2}{1-y_1}\right)$$

2.5|| Graphical Integration



Area ≃ (2.85 × 3) = 8.55 sq units

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$$N_{tG} = \int_{\cancel{\ln}\, y_2}^{\cancel{\ln}\, y_1} \frac{y}{y-y_i}\, d(\ln y) + \frac{1}{2}\ln\left(\frac{1-y_2}{1-y_1}\right)$$

$\int_{\cancel{\ln}\, y_2}^{\cancel{\ln}\, y_1} \frac{y}{y-y_i}\, d(\ln y)$ can be obtained by numerical integration or by graphical integration.

From graphical integration;

$$\int_{\cancel{\ln}\, y_2}^{y_1} \frac{y}{y-y_i}\, d(\ln y) = 8.55$$

$$H_{tg} = \frac{G'}{k_y a\, (1-y_i)_m}$$

For dilute system,

$$(1-y_i)_M \simeq \frac{(1-y_i)+(1-y)}{2}$$

$(y_{iM})_1 = 0.9335$

$(y_{iM})_2 = 0.9958$

$(y_i)_M = 0.96465$

$H_{tG} = 0.366$

$Z = 3.13\ m$

$$G' = \frac{600 \times 101325 \times 4}{298 \times 8.314 \times (0.768)^2 \pi}$$

$= 52269.91\ \frac{mol}{m^2.hr.}$

P.R.E.

Q.6

By question : $m = 1.4$

$$N_{toG} = \frac{\ln\left[\frac{y_1 - mx_2}{y_2 - mx_2}\left(1 - \frac{1}{A}\right) + \frac{1}{A}\right]}{1 - \frac{1}{A}}$$

Considering ideal gas behavior

$y_1 = 0.06$

$y_2 = 0.0005$

Considering $L_s = \frac{L_1 + L_2}{2}$; $G_s = \frac{G_1 + G_2}{2}$

$L_2 = 250 \text{ kg/hr} = \frac{250}{18} = 13.88 \frac{\text{kmol}}{\text{hr}}$

$L_1 = (13.88 + 0.3374) \frac{\text{kmol}}{\text{hr}}$

$= 14.22 \frac{\text{kmol}}{\text{hr}}$

$L = 14.05 \frac{\text{kmol}}{\text{hr}}$

$G_1 = 6.1345 \frac{\text{kmol}}{\text{hr}}$ $\quad G_2 = 5.797 \frac{\text{kmol}}{\text{hr}}$

$G = \frac{G_1 + G_2}{2} = 5.966 \frac{\text{kmol}}{\text{hr}}$

$A = \frac{L}{mG} = \frac{14.05}{1.4 \times 5.966} = 1.69$

$$N_{toG} = \frac{\ln\left[\frac{0.06}{0.0005}\left(1 - \frac{1}{1.1682}\right) + \frac{1}{1.1682}\right]}{\left(1 - \frac{1}{1.1682}\right)} = 9.611$$

$$H_{tOG} = \frac{G'}{K_G a (1-y)_M} \qquad G' = \frac{4G}{\pi \times (0.3)^2}$$

$$(1-y_o)_M \simeq 1$$

$$H_{tOG} = 0.378$$

$$Z = H_{tOG} N_{tOG} = 3.63 \text{ m}$$

1.7

$$G_1 = 14.0 \ \frac{\text{kmol}}{\text{hr.}}$$

$$L_2 = 45.56 \ \frac{\text{kmol}}{\text{hr.}}$$

$$L_1 = [45.56 + G_1 \times 0.021] = 45.56 + 0.294$$

$$L_1 = 45.854$$

$$L = \frac{L_1 + L_2}{2} = 45.707 \ \frac{\text{kmol}}{\text{hr.}}$$

$$G = \frac{G_1 + G_2}{2} = 13.853 \ \frac{\text{kmol}}{\text{hr.}}$$

Eqbm. relation: $y = 1.186x$

$$N_{tOG} = \frac{y_1 - y_2}{(y-y^*)_M}$$

$$(y-y^*)_M = \frac{(y_1 - y_1^*) - (y_2 - y_2^*)}{\ln\left(\frac{y_1 - y_1^*}{y_2 - y_2^*}\right)}$$

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$x_1 = 0$ $\qquad y_1^* = 0.0076$

$x_2 = 0.0064$ $\qquad y_2^* = 0$

$$(y-y^*)_M = \frac{(0.026-0.0076) - (0.005-0)}{\ln\left(\frac{0.026-0.076}{0.005}\right)}$$

$$(y-y^*)_M = 0.0103$$

$$N_{toG} = \frac{0.026-0.005}{0.0103} = 2.04$$

Again

$$\frac{1}{K_y a} = \frac{1}{k_y a} + \frac{1}{m k_x a}$$

$$K_y a = 0.025$$

$$H_{toG} = \frac{G'}{K_y a (1-y_*)_M} = \frac{13.853}{0.186 \times 0.025 \times 3600}$$

$$= 0.87$$

$$Z = (2.04 \times 0.87) = 1.7748 \text{ m}$$

P.R.E.

Q.8// Basis: duration of operation

$G_1 = 20$ kmol

$G_2 = 20 + 260\,(0.03 - 0.002)$ kmol

$= 27.28$ kmol

$G = \frac{G_1 + G_2}{2} = 23.64$ kmol

$L_1 = 252.72$ kmol

$L_2 = 260$ kmol

$L = \frac{L_1 + L_2}{2} = 256.36$ kmol

$A = \frac{L}{mG} = \frac{256.36}{22.5 \times 23.64} = 0.482$

$$N_{toL} = \frac{\ln\left[\frac{x_2 - y_1/m}{x_1 - y_1/m}(1-A) + A\right]}{(1-A)}$$

$x_2 = 0.03$

$y_1 = 0$

$x_1 = 0.002$

$N_{toL} = 4.074$

$$\frac{1}{K_y a} = \frac{1}{k_y a} + \frac{m}{k_x a}$$

$$K_y a = \frac{1}{\frac{1}{0.06 \times 3600} + \frac{1}{22.5 \times 0.04 \times 3600}}$$

$= 202.5$

$$H_{toL} = \frac{L}{K_x a (1-x_1)_M}$$

$$= 1.673$$

$$Z = H_{toL} \, N_{toL}$$

$$= 6.82 \ m$$

—— x ——