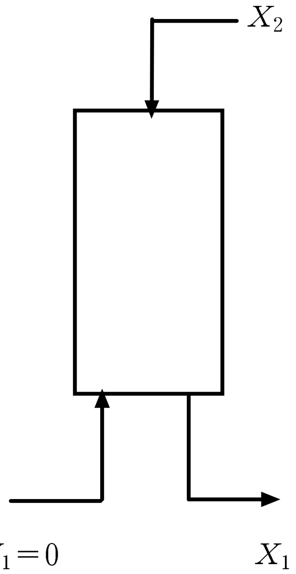
1. Benzene freed from coal gas in a scrubber is recovered by passing the benzene-wash oil solution through a tower in this stream. The entering liquid stream contains 7mole% benzene and the stream is benzene-free. It is desired to recover 85% of the benzene by using a stream rate 1.4 times minimum stream rate. A wash-oil (liquid solvent-benzene free) flow rate of 6.94 mole/s will be used. Determine the required moles of stream per second if (a) a countercurrent tower is used:

(b) a cocurrent tower is used.

Equilibrium data for the benzene-wash-oil-stream system are as follows:

$X \frac{\text{mole benzene}}{\text{mole wash oil}}$	0.00	0.02	0.04	0.06	0.08	0.10	0.12	0.14
$Y \frac{\text{mole benzene}}{\text{mole steam}}$	0.00	0.07	0.14	0.22	0.31	0.405	0.515	0.65

sol)



Benzene-wash oil (7 mol % of Bz)

$X_2 = \frac{0.07}{0.93}$ mol Bz/ mol wash oil

$L'_S = 6.94$ mol/s

Bz in $L'_S = 6.94$ mol/s × 0.075 = 0.52 mole/s

moles of Bz to be removed

= 0.52 mole/s × 0.85 = 0.442 mol/s

Moles (Bz) in Liquid = 0.52 -0.442 = 0.078 mol/s

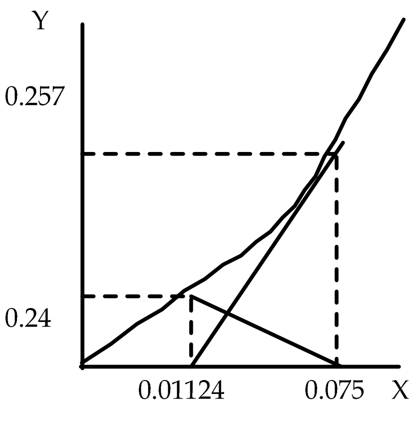
$Y_1 = \frac{0.078 mol/s\,(Bz)}{6.94 mol/s\,(washed)}$ = 0.01124

a) counercurrent

$$\frac{G_{S_{\min}}}{L_S} = \frac{X_2 - X_1}{Y^{*2} - Y_1} = \frac{0.075 - 0.0112}{0.287 - 1} = 0.222$$

$$G_{S_{\min}} = 0.222 \times L_S = 0.222 \times 0.94 = 1.54\ mol/s$$

$$G_S = 1.4 \times G_{S_{\min}} = 1.4 \times 1.54 = 2.16\ mol/s$$



b) cocurrent

$$\frac{G_{S_{\min}}}{L_S} = \frac{X_2 - X_1}{Y^{*2} - Y_1} = \frac{0.075 - 0.0112}{0.040 - 0} = 1.595$$

$$G_{S_{\min}} = 1.595 \times L_S = 1.595 \times 6.94 = 11.07\ mol/s$$

$$G_S = 1.4 \times G_{S_{\min}} = 1.4 \times 11.07 = 15.5\ mol/s$$

2. A tower, packed with 25-mm Intralox saddles, is to be designed for stripping trichloroethlyene, C_2HCl_3, from a contaminated groundwater stream. A volumetric stream of 0.0436m^3/s is to be fed to the top of the tower which will operate at 288K and $1.013*10^5$ Pa. A 0.237 m^3/s air stream, flowing countercurrent to the aqueous stream, is to reduce the TCE concentration from 50 μg/liter to 5 μg/liter. Under the stated flow conditions, the overall liquid-capacity coefficient, K_La, will be equal to 0.016

$$\frac{mole}{m^2 \cdot s \cdot (mole/m^3)} \cdot \frac{m^2}{m^3} = 0.16s^{-1}$$

At288 K, Henry's law constant for the TCE air system is $11.7*10^{-3}$ atm/(mole/m^3). Determine

(a) the partial pressure of TCE in the exiting are stream;

(b) the height of the packing required for the stripping operation.

Stripping $C_2H\,Cl_3$ from con

$$C_{A2} = \frac{50\mu g}{l} \times \frac{1000l}{m^3} \times \frac{mole}{131.5g} = 3.8 \times 10^{-4}\frac{mole}{m^3}$$

$$C_{A1} = \frac{5\mu g}{l} = 3.8 \times 10^{-4}\frac{mole}{m^3}$$

$$y_{A1} = 0$$

$$G' = \frac{\rho v}{RT} = \frac{1.013 \times 10^5 Pa}{8.314\frac{\rho a\ m^3}{moleK}} \times \frac{0.237\frac{m^3}{s}}{288K} = 10.0\frac{mole}{s}$$

$$L'(C_{A2} - C_{A1}) = G'(y_{A2} - y_A)$$

$$0.0436\frac{m^3}{s}(3.8 \times 10^{-4} - 3.8 \times 10^{-5}) = 10\frac{mole}{s}(y_{A2} - 0)$$ (.....

$$y_{A2} = 1.49 \times 10^{-6})$$

$$P_{T2} = y_{A2P} = 1.49 \times 10^{-6} atm = 0.151Pa$$

$$Z = \frac{L'}{K_{La}} \frac{(C_{A2} - C_{A1})}{\ln_m}(C_A - C_A^*)$$

at ad2

$$P_{A2} = 1.49 \times 10^{-6} atm$$

$$C'_{A2} = \frac{P_{A2}}{H} = \frac{1.49 \times 10^{-6}}{11.7 \times 10^{-3} atm/mole} = 1.27 \times 10^{-4} mole/\ m^3$$

$$(C_A - C_A^*)_2 = 3.8 \times 10^{-4} - 1.27 \times 10^{-4} = 2.53 \times 10^{-4} mole/\ m^3$$

at ad1

$$(C_A - C_A^*) = 3.8 \times 10^{-5} mole/\ m^3$$

$$(C_A - C_A^*)_{\ln} = \frac{3\times 10^{-4} - 3.8\times 10^{-5}}{\ln[\frac{2.53\times 10^{-4}}{3.8\times 10^{-4}}]} = 1.13\times 10^{-4} mole/m^3$$

$$A = \frac{\pi D^4}{4} = \frac{\pi\times (1.26m)^2}{4} = 1.247\ m^2$$

$$L' = \frac{0.0436\ m^3/s}{1.247\ m^2} = 0.035m/s$$

$$Z = \frac{L'}{K_{La}} \frac{(C_{A2} - C_{A1})}{\ln(C_A - C_A^*)} = \frac{0.035}{0.016} \times \frac{(3.8\times 10^{-4} - 9.8\times 10^{-5})}{1.13\times 10^{-4}} = 6.6m$$

$$\therefore Z = 6.6m$$

3. An absorber, packed to the height of 10 m, is being used by an industrial compant as a gas scrubber. A dilute air-ammonia mixture, containing 4.93% NH_3, is drawn through the $\frac{mole}{m^2 \cdot s}$ and the inlet NH_3-free water rate provides an actual Ls/Gs ratio that is 1.4 times the minimum Ls/Gs ratio. At the temperature and pressure of the absorber, the equilibrium concentrations are related by

$$y_{NH3} = 1.075 x_{NH3}$$

If the exiting gas stream contains 0.2% ammonia, determine

(a) the kg of ammonia absorbed per second per square meters of cross-sectional area;

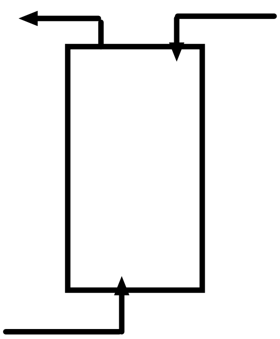
(b) the composition of the exiting liquid stream;

(c) the overall mass-transfer capacity coefficient, $K_Y a$, $\frac{mole}{m^2 \cdot s \cdot \triangle Y_A}$

packed absorber 10m ; gas scrubber

$y_2 = 0.002$

$Y_2 = 0.002/0.998$



$x_2 = 0$

$X_2 = 0$

$G_1 = 136$ mole/m^{2}s

$G_s = G_1(1-y_1) = 136 \times (1-0.0493)$

$= 129.3$ mole/m^{2}s

$y_1 = 0.0493$

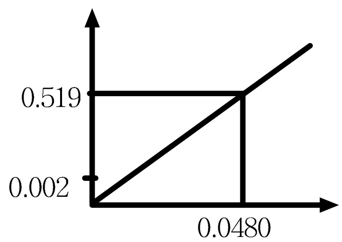
Equilibrium : $y = 1.075x$

$Y = y/(1-y)$, $X = x/(1-x)$

$Y = y/(1-y) = 0.593/0.9507$

$= 0.0519$

X	0	0.005	0.0101	0.0204	0.0309	0.0417	0.0526
x	0	0.005	0.01	0.02	0.03	0.04	0.05
y	0	0.0054	0.108	0.0215	0.0323	0.0430	0.0538
Y	0	0.0054	0.0109	0.0220	0.0333	0.0449	0.0568



$$\left(\frac{L_s}{G_s}\right)_{\min} = \frac{Y_1 - Y_2}{X_1^* - X_2} = \frac{0.519 - 0.002}{0.0408 - 0} = 1.0396$$

$$\left(\frac{L_s}{G_s}\right)_{af} = 1.4\left(\frac{L_s}{Gs}\right)_{\min} = 1.4 \times 1.0396 = 1.455$$

$$\left(\frac{L_s}{G_s}\right)_{af} = 1.455 = \frac{Y_1 - Y_2}{X_1 - X_2} = \frac{0.0519 - 0.002}{X_1 - 0} \quad \because X_1 = 0.0343$$

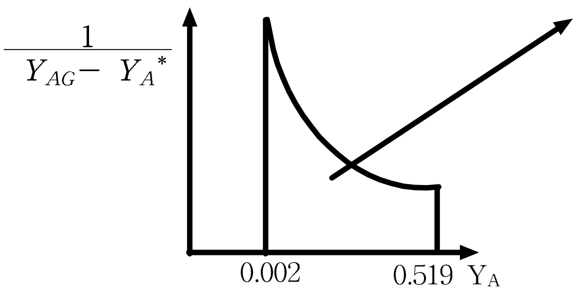
$$x_1 = \frac{X_1}{1 + X_1} = \frac{0.0343}{1.0343} = 0.033 \quad \because 3.3\%$$

$$\cdot \frac{Moles\ NH_3\ absorbed}{m^2 \cdot s} = G_s(Y_1 - Y_2)$$

$$= 129.3 \frac{moles}{m^2 \cdot s} \times (0.0519 - 0.002)$$

$$= 6.45 \frac{moles}{m^2 \cdot s} = 6.45 \times 10^{-3} \frac{\mathrm{kg}mole}{m^2 \cdot s}$$

Y_{AG}	$Y_A{}^*$	$Y_{AG} - Y_A{}^*$	$\frac{1}{Y_{AG} - Y_A{}^*}$
0.002	0.0	0.002	500
0.010	0.0057	0.0043	232.56
0.015	0.0095	0.0055	181.82
0.020	0.0132	0.0068	147.0
0.025	0.0170	0.0080	125.0
0.030	0.0268	0.0092	108.7
0.035	0.0247	0.0103	97.1
0.040	0.0284	0.0116	86.21
0.045	0.0321	0.0129	77.52
0.050	0.0358	0.0142	70.42
0.0519	0.0372	0.0147	68.03



$$area = \int \frac{dY_A}{Y_A - Y_A{}^*} = 8.266$$

$$z = 10m = \frac{G_s}{k_y a} \int_{0.002}^{0.0519} \frac{dY_A}{Y_A - Y_A{}^*}$$

$$10m = \frac{129.3 \frac{mole}{m^2 \cdot s} \times 8.266}{k_y a}$$

$$k_y a = 106.9 \frac{mole}{m^2 \cdot s \Delta Y_A}$$