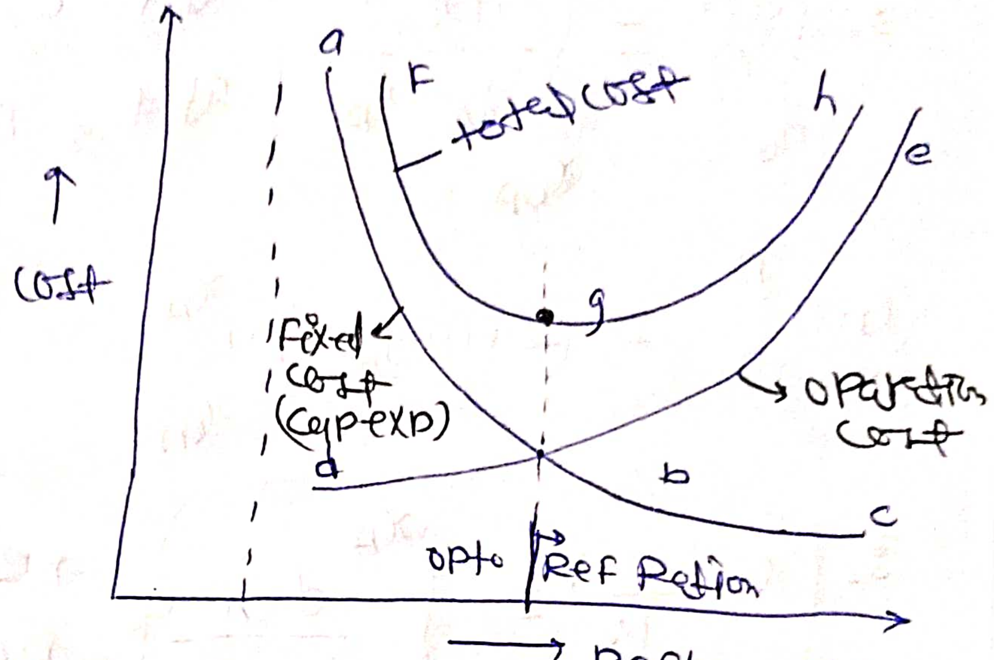
Lect.(15)

Opt Ref Ratio



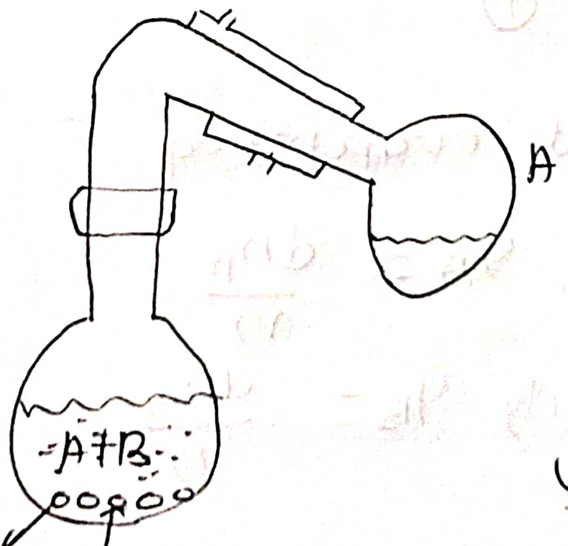
total cost = capital expenditure + operational expenditure

$R = (1.1 \text{ to } 1.5\, R_{opt})$

R — Reflux ratio

Batch process

differential



Solid to prevent bumping of liquid or turbulence

A+B — initially

$n \rightarrow dn$

$\downarrow y_A$

$d\, n x_A \rightarrow$ Amount of A

$\therefore y_A dn = d(x_A n)$

$y_A dn = n dx_A + x_A dn$

$(y_A - x_A) dn = n dx_A$

$$\therefore \int_{n_0}^{n} \frac{dn}{n} = \int_{x_{0A}}^{x_A} \frac{dx_A}{y_A - x_A} \quad \Bigg| \begin{array}{lll} \text{at } t=0, & n_0, & x_{0A} \\ \text{at } t, & n & x_A \end{array}$$

$$(\ln n)_{n_0}^{n} = \cancel{\left(-\ln(y_A - x_A)\right)_{x_{0A}}^{x_A}}$$

$$\therefore \boxed{\ln\left(\frac{n}{n_0}\right) = \int_{x_{0A}}^{x_A} \frac{dx_A}{y_A - x_A}} \rightarrow \text{~~Rayleigh~~ ~~Rayleig~~ Rayleigh eqn}$$

Area under the curve or equilibrium data.

$\alpha_{AB} \neq F(T)$

$$\frac{y_A}{y_B} = \alpha_{AB} \frac{x_A}{x_B} \quad (1)$$

dn — amount evaporated

$y_A dn = dn_A \Rightarrow y_A = \frac{dn_A}{n}$

Amount of A

similarly $y_B = \frac{dn_B}{n}$

$$x_A = \frac{n_A}{n_A + n_B} \qquad \therefore \frac{x_A}{x_B} = \frac{n_A}{n_B}$$

$$x_B = \frac{n_B}{n_B + n_A}$$

$$\frac{\frac{dn_A}{n}}{\frac{dn_B}{n}} = \alpha_{AB}\frac{n_A}{n_B}$$

$\boxed{\text{Note } \alpha \uparrow \Rightarrow P \downarrow}$

$$\Rightarrow \frac{dn_A}{dn_B} = \alpha_{AB}\frac{n_A}{n_B} \Rightarrow \frac{dn_A}{n_A} = \alpha_{AB}\frac{dn_B}{n_B}$$

After integrating

$$\ln\frac{n_A}{n_{0A}} = \alpha_{AB}\ln\frac{n_B}{n_{0B}}$$

$$\Rightarrow \frac{n_B}{n_{0B}} = \left(\frac{n_A}{n_{0A}}\right)^{\frac{1}{\alpha_{AB}}}$$

$$\frac{D}{F} = \frac{x_F - x_B}{x_D - x_B}$$

$$\frac{B}{F} = \frac{x_D - x_F}{x_D - x_B}$$

..ter distillations:

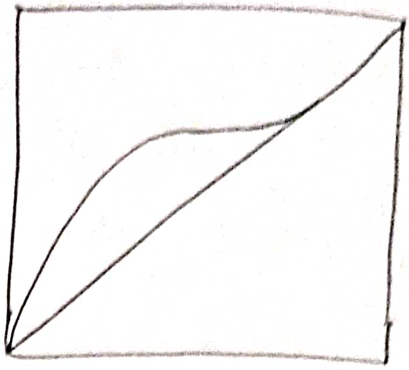
① Steam distillation

For miscible (A+B) $P = P_A + P_B$ partial pressure

For immiscible $P = P_A^\circ + P_B^\circ$ vapor pressure

② Azeotropic distillation

- constant boiling mixture
- ~~BP~~



High boiling

ex. Benzene (B) + cyclo HX (A)

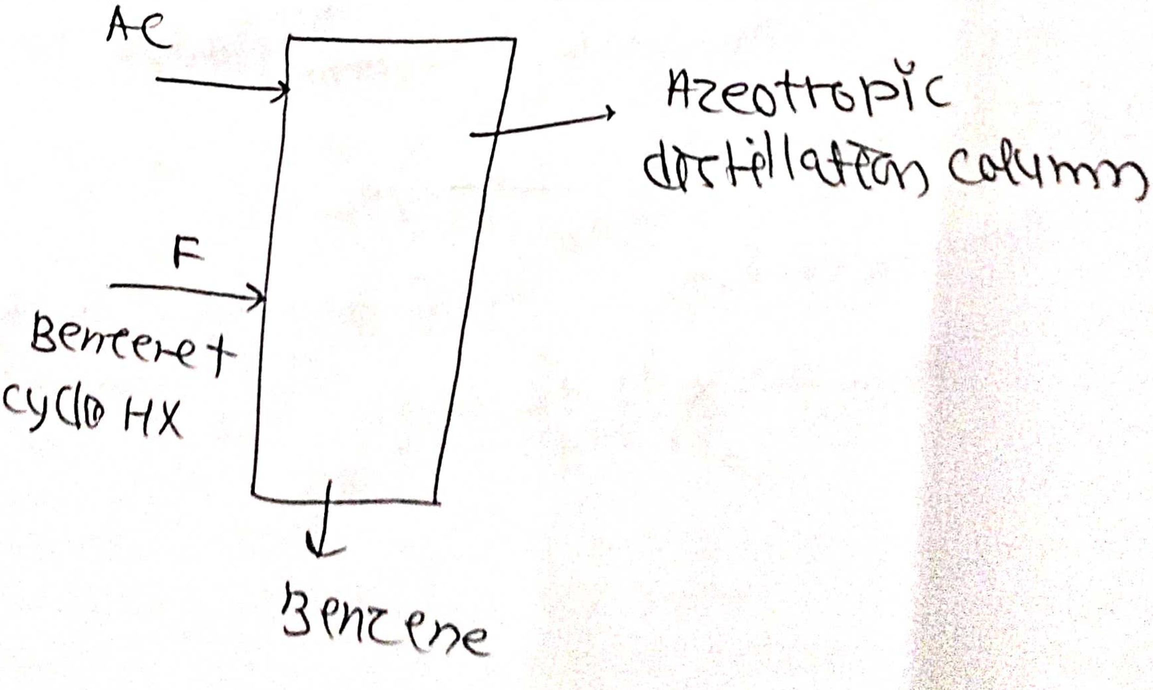
+ AC (C) → Entrainer

low boiling

Cyclo HX + AC + Benzene

H_2O

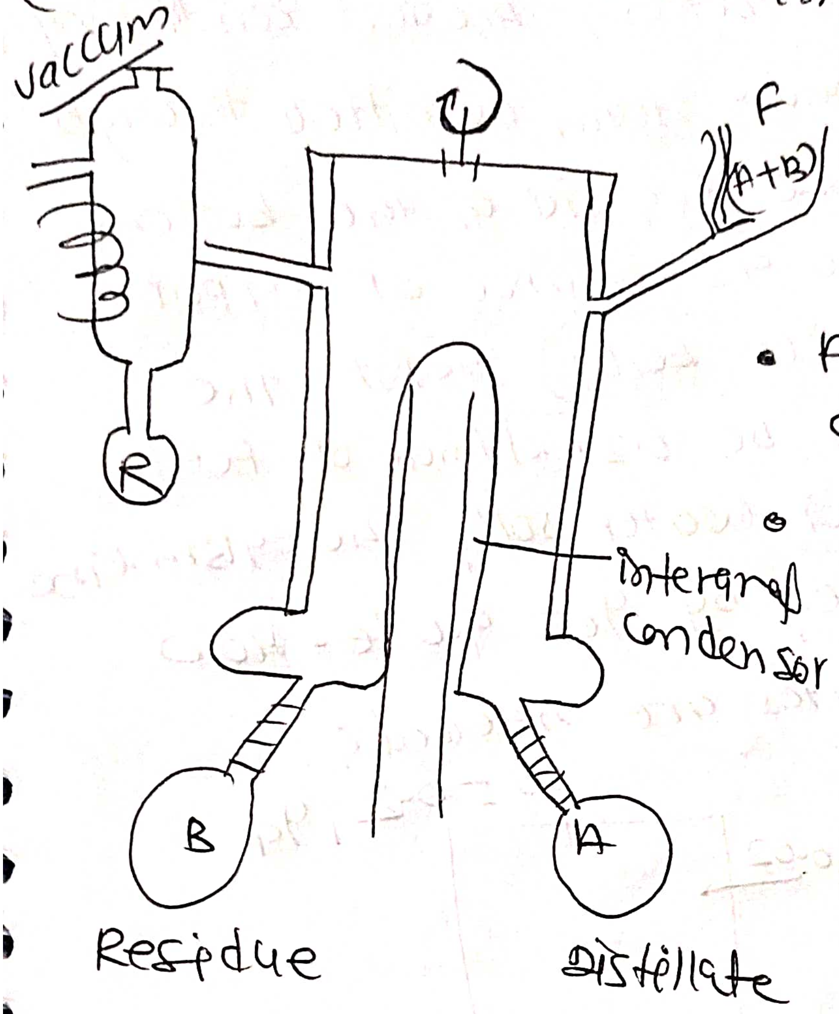
AC + H_2O ← AC + H_2O ← Cyclo HX + Benzene



lect (17)

molecular distillation

(short free path distillation)



- Free path ↑ 10mm due to vaccum.
-

Langmuir Eqn

Rate of evaporation -

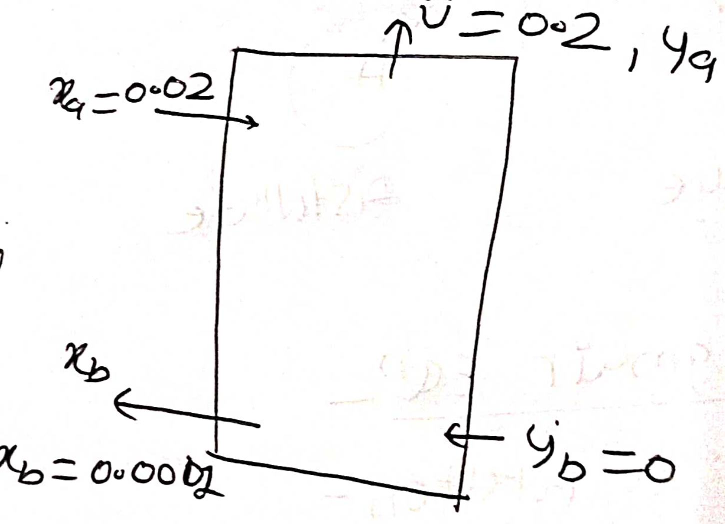
$$N_A = 0.006\, P_A \left(\frac{1}{2\pi m_A RT}\right)^{0.5}$$

i.e. $$\frac{N_A}{N_B} = \left(\frac{P_A / m_A^{0.5}}{P_B / m_B^{0.5}}\right) = \frac{P_A}{P_B}\sqrt{\frac{m_B}{m_A}}$$

Q.2 A mixture of 2 mole percent ethanol & 98 mole %. water is to be stripped in a plate column to a bottom product containing 0.01 mol%. of ethanol. Steam admitted through an open coil in the liquid on the bottom plate, is to be used as source of vapor. The feed is at its boiling point. The steam flow is to be 0.2 mol/mole of feed. For dilute ethanol water soln, the eqBm line is straight & given by $y_e = 9.0 x_e$. How many ideal plates are needed?

Ans

$q = 1$



Assuming Feed

$F = 1$ mol/sec

$\therefore \bar{L} = 1$ mol/sec $\quad \bar{V} = 0.2$ mol/s

As $y_a^* = 9 x_a$, $y_a^* = 9 \times 0.02 = 0.18$

$y_b^* = 9 \times x_b = 0.0009$

$$N = \frac{\ln\left((y_a - y_a^*)/(y_b - y_b^*)\right)}{\ln\left((y_b^* - y_a^*)/(y_b - y_a)\right)}$$

overall balance-

$$\bar{V}(y_a - \cancel{y_b}^{\to 0}) = \bar{L}(x_a - x_b)$$

$$y_a = \frac{2}{0.2} \times (0.02 - 0.0001)$$

$$y_a = 0.0995$$

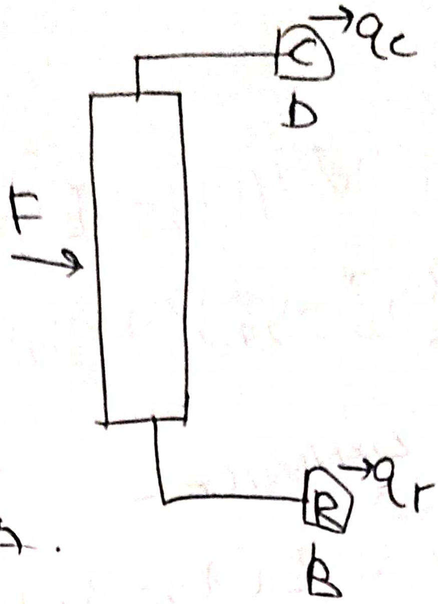
$$N = \frac{\ln\left[(0.0995 - 0.18)/(0 - 0.0009)\right]}{\ln\left((0.0009 - 0.18)/(0 - 0.0995)\right)}$$

$$N = \frac{\ln(89.44)}{\ln(1.8)} = \frac{4.4935}{0.587} = 7.65$$

$$\boxed{N \simeq 8}$$

Overall balance

$F = B + D$



Enthalpy balance
For component A.

$$\boxed{F H_F = D H_D + B H_B}$$

$+q_r \qquad +q_c$

$\Rightarrow q_r = q_c$

Supplied heat

Recovering heat