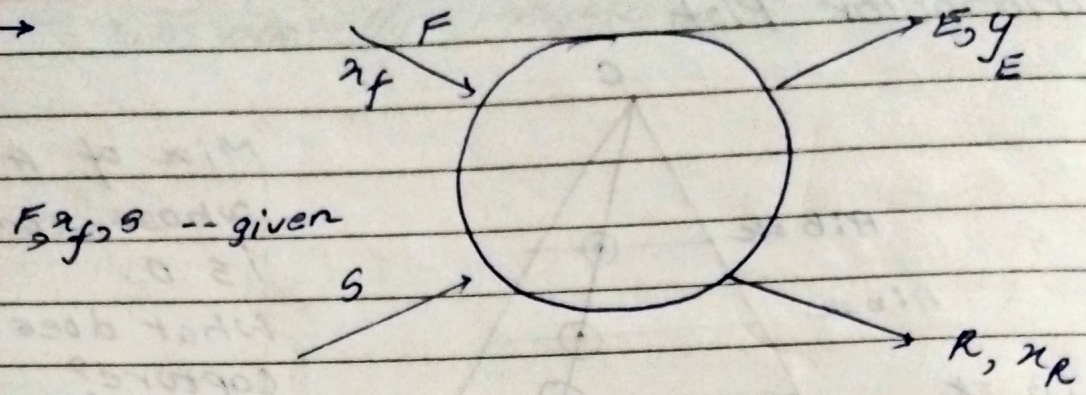
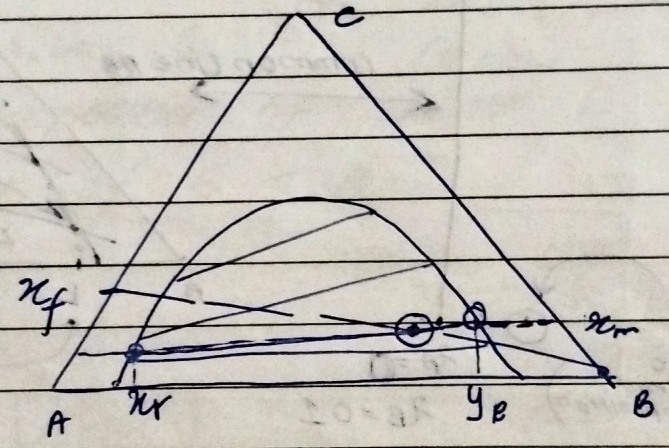


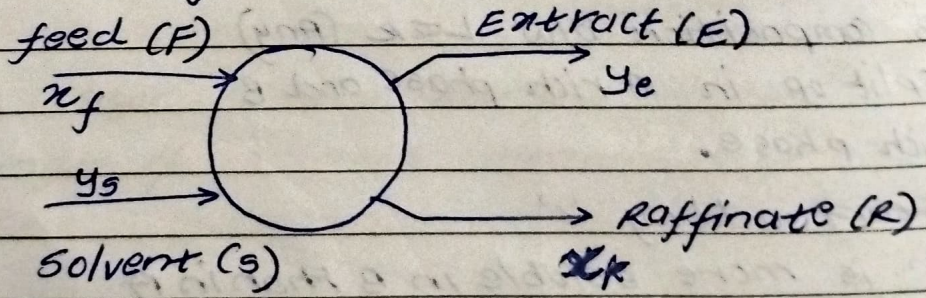

$F, x_f, S$ -- given

$F + S = M$ → known

$F x_f + S y_S = M x_m$ → known.




→ Single stage extractor:




$x_f$ → C. fraction in feed

$x_r$ → C fraction in Raffinate

$y_S$ → C fraction in solvent

$y_e$ → C fraction in extract

Overall mass balance,

$$F + S = E + R = M \quad -- \quad (1)$$

$Fx_f + Sy_s = Mx_m = Ey_e + Rx_r$ ---(2)

M → mixture point [ amount of material that container will have to handle ]

$x_m$ → mathematical composition of C at M.

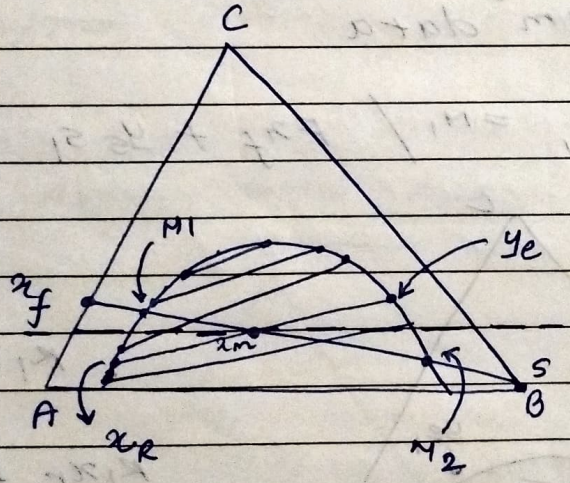
for pure solvent,

$y_s = 0$

$$\boxed{x_m = \frac{F}{M} x_f}$$ ---- from (1) & (2)

On triangular plot,

- Join F & S
- determine $x_m$, from C balance eqn
- $x_m$ lies on line FS

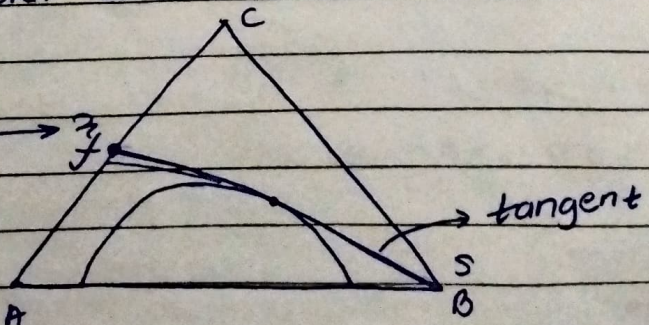



using this $y_e$ & $x_f$ find E & R.

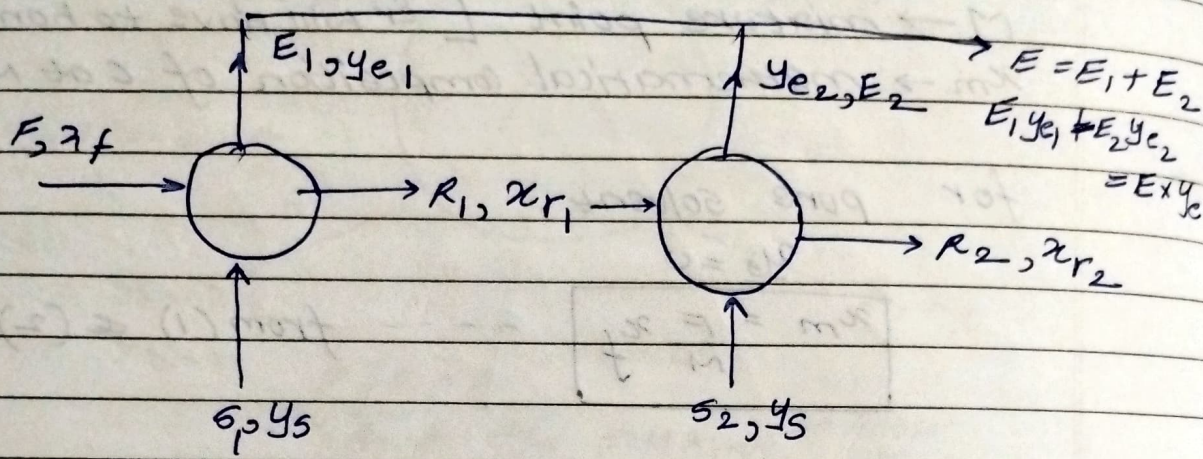
$M_1$ → minimum value of solvent

$M_2$ → maximum value of solvent

* → Is there a limiting value of $x_f$ that can be extracted by a particular extractor?

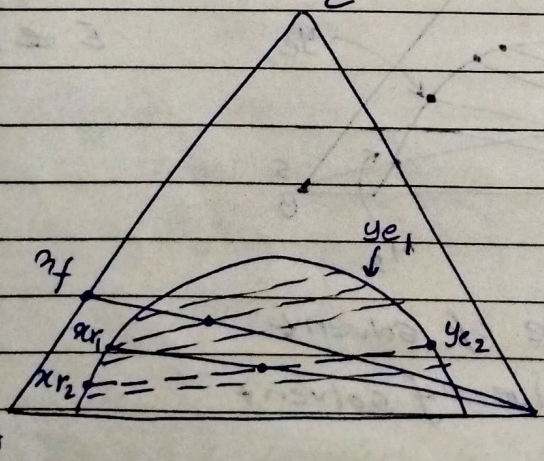


→ Multistage Cross current extractor:




known, $F, S_1, S_2, S_3 \ldots$
$x_f, y_s$
No. of stages
eqm data.

$F + S_1 = M_1$ / $F x_f + y_s S_1 = M_1 x_{m_1} = E_1 y_{e_1} + R_1 x_{r_1}$
$= E_1 + R_1$




↑ tie-lines

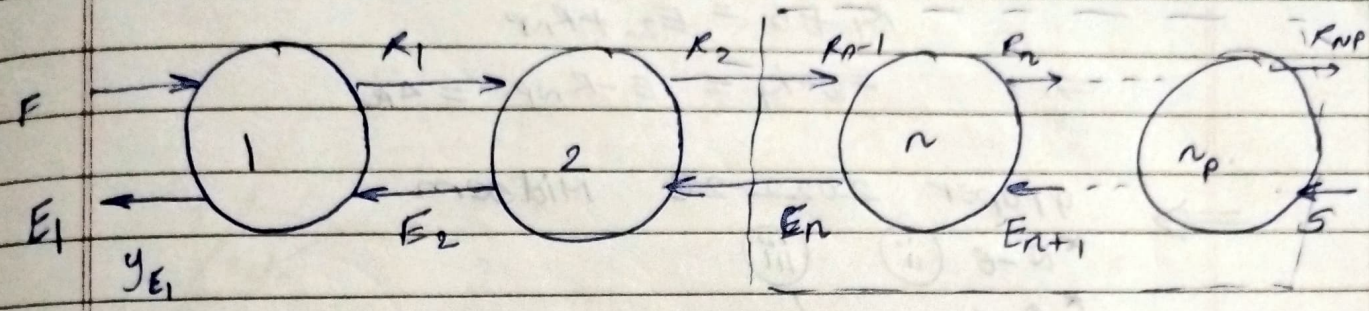
$R_1 + S_2 = M_2$
$= R_2 + E_2$

$R_1 x_{r_1} + S_2 y_s$
$= M_2 x_{m_2} = E_2 y_{e_2} + R_2 x_{r_2}$

$E = E_1 + E_2$

$E_1 y_{e_1} + E_2 y_{e_2} = E y_e$

→ Counter-current extractor: [multistage]




Overall mass balance,

$$F + S = E_1 + R_{NP} = M$$

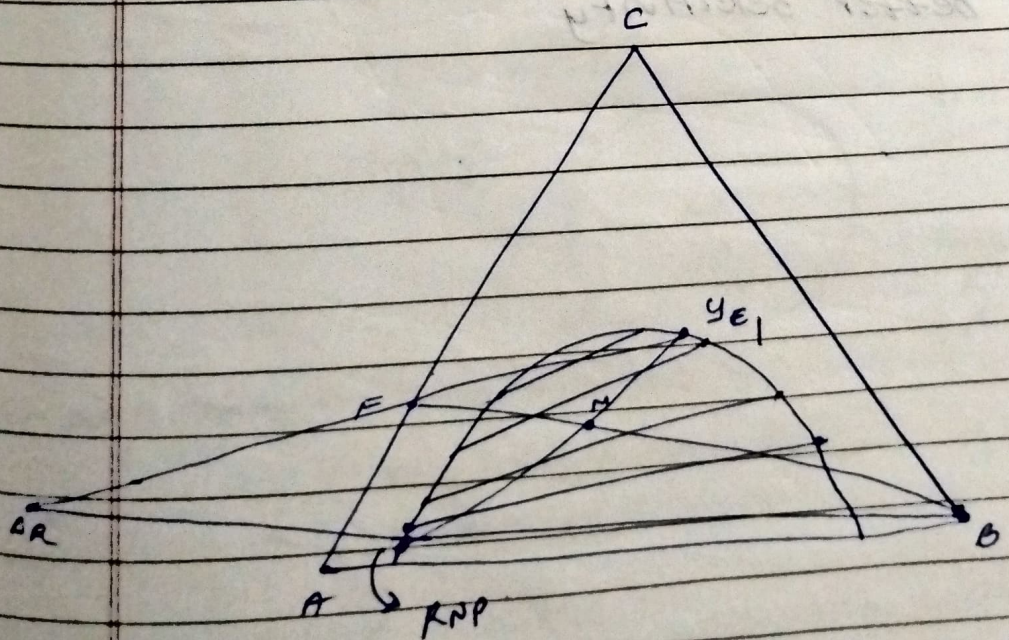
$$F - E_1 = R_{NP} - S = -\Delta_R$$

$\Delta R \Rightarrow$ Difference point.

balance from $n^{th}$ stage to $NP^{th}$ stage

$$R_{n-1} + S = E_n + R_{NP}.$$

$$R_{n-1} - E_n = R_{NP} - S$$




given:

F, $x_F$, S, $y_S$,

$y_E$

$y_{E_1}$ & $x_{R_1}$ are in eqm

$y_{E_2}$ & $x_{R_2}$ are in eqm

operating line is the laws of composition b/w two stages

Balance for n=2,

$$R_1 + S = E_2 + R_{NP}$$

$$\Rightarrow \quad E_2 - R_1 = S - R_{NP} = \Delta R$$

$\Longrightarrow$ Q paper 2022-23 Midsem.

* Q-6 (ii) (iii)
* Q-7

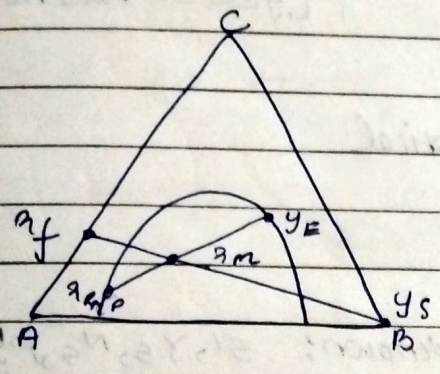
(iii) → Nature of eqn curve for extraction & distillation.

extraction
→ The curves might be linear, concave or convex depending on the system.
→ It is an isothermal curve
→ A steeper curve means better selectivity

distillation
→ with T↑ y↑
→ non-isothermal
→ rising curve.

→ B-free calculation scheme

↳ every point × / Y / N




$$y_E = \frac{C_E}{A_E + B_E + C_E}$$

$$x_R = \frac{C_R}{A_R + B_R + C_R}$$

Y = B free C fraction | $Y_E = \frac{C_E}{A_E + C_E}$

X = B free C fraction | $X_R = \frac{C_R}{A_R + C_R}$

N = B free B fraction | $N_E = \frac{B_E}{A_E + C_E}$

**Feed point**

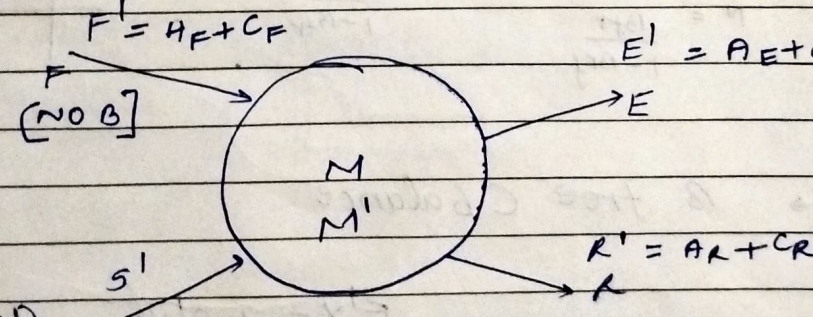
$X_F = C_F / A_F + C_F$

$N_F = B_F / A_F + C_F$

**Solvent point**

$Y_S = C_S / A_S + C_S$ | 0

$N_S = B_S / B_S + C_S$ | $\to \infty$




(for pure solvent B = 100 / 1)

$S = A_S + B_S + C_S$

$S' = A_S + C_S$

$B_S = S$ ; $S'_{(pure)} = 0$

[E → physical entity
E' ⇒ mathematical entity]

overall ballance

$S + F = M = E + R$

$N_S = \frac{B_S}{A_S + C_S} \to 0$

B-Free balance

$S' + F' = M' = E + R'$ ... [combined component balance]

$S' + F' = M'$

'0' pure solvent

$F' = M'$

maximind®

→ $M' = C_M + A_M$ ; $F' = F$ (feed has no B)

$= S + A_S + A_F + C_F$

$\boxed{F = F' = M'}$ → Mathematical

↓ physical

→ 5 points:

$(S', Y_S, N_S)$ known: $S', Y_S, N_S, F', M'$

$(F', X_F, N_F)$

$(M', X_M, N_M)$

$(E', Y_E, N_E)$

$(R', X_R, N_R)$

$X_F = C_F$

$N_F = \frac{S_F}{A_F + C_F}$

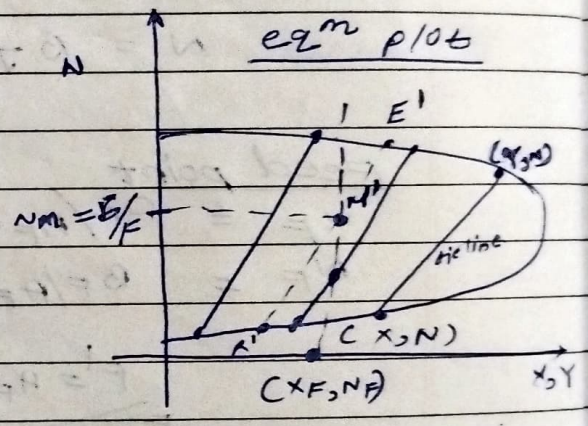
→ $(x, B_{fr} \mid y, B_{fr})$

$x, N$ ; $y, N$

$X = \frac{x}{1 - B_{fr}}$ ; $y = \frac{y}{1 - B_r}$

$N = \frac{B_{fr}}{1 - B_{fr}}$ ; $N = \frac{B_{fr}}{1 - B_{rf}}$

eqm plot




→ B free C balance

$F'X_F + S'Y_S = E'Y_E + R'X_R$

$0 = M'X_M$

$\therefore X_F = X_M$

→ B free B balance,

$F' \times \frac{B_F}{A_F + C_F} N_F + S'N_S = N'X_M$

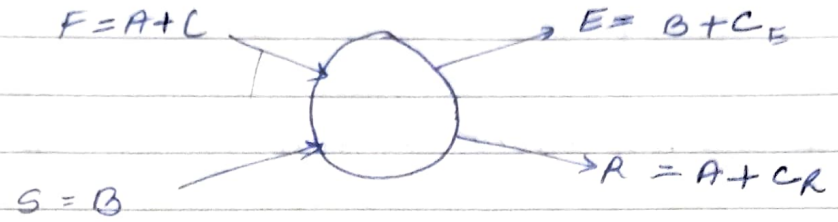
$S + N_F' = N_M \times M'$

$\boxed{N_M = N_F + S/F}$

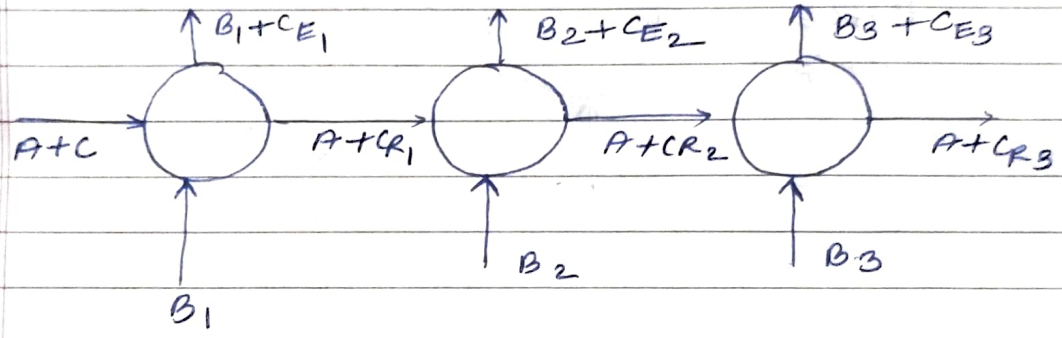
$0$

→ Special case:

A & B are totally immisible




- Cross flow reactor:

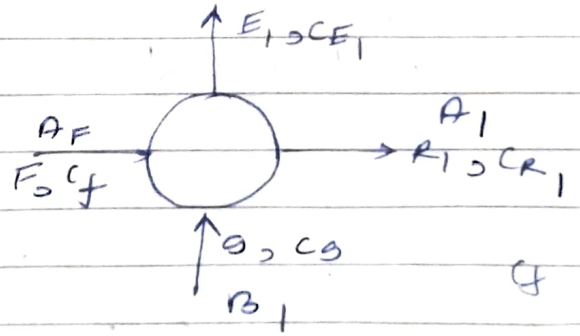



Free co-ordinate system,

$$x' = \frac{x}{1-x}$$

$$y' = \frac{y}{1-y}$$

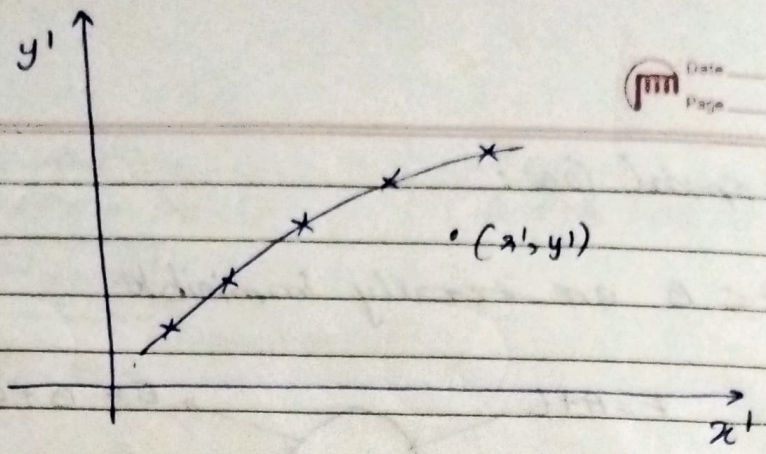
Solute balance,



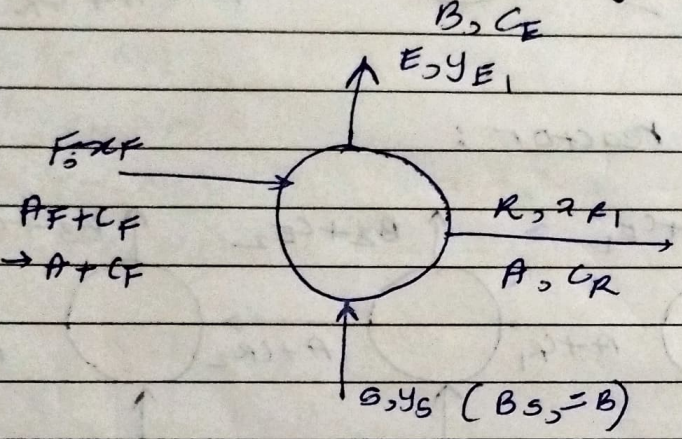

$$C_F + C_S = C_{E_1} + C_{R_1}$$

$$B_1 y_S' + A_F x_f' = B_1 y_{E_1}' + A_1 x_{R_1}'$$

$$\frac{y_S' - y_{E_1}'}{x_F' - x_{R_1}'} = -\frac{A}{B}$$



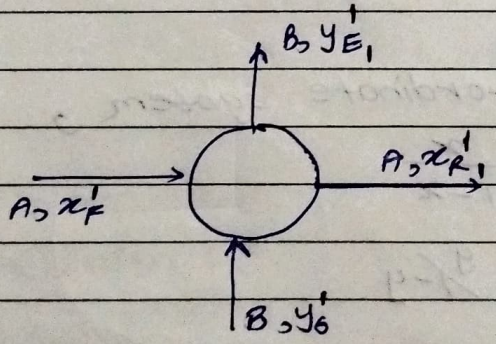

→ Carrier and the solvent are totally immiscible




$x' = \frac{x}{1-x}$

$y' = \frac{y}{1-y}$

C free basis




C balance

$$A x'_F + B y'_S = B y'_{E_1} + A x'_{R_1}$$

$$E_1 y_{E_1} \Rightarrow (A_E + B_E + C_E)\left[\frac{C_E}{A_E + B_E + C_E}\right]$$

⇒ on a C free basis

$$\left[\frac{A_E + B_E}{}\right] \times \left[\frac{C_E}{A_E + B_E}\right]$$

A & B are completely immiscible

∴ no A in extract

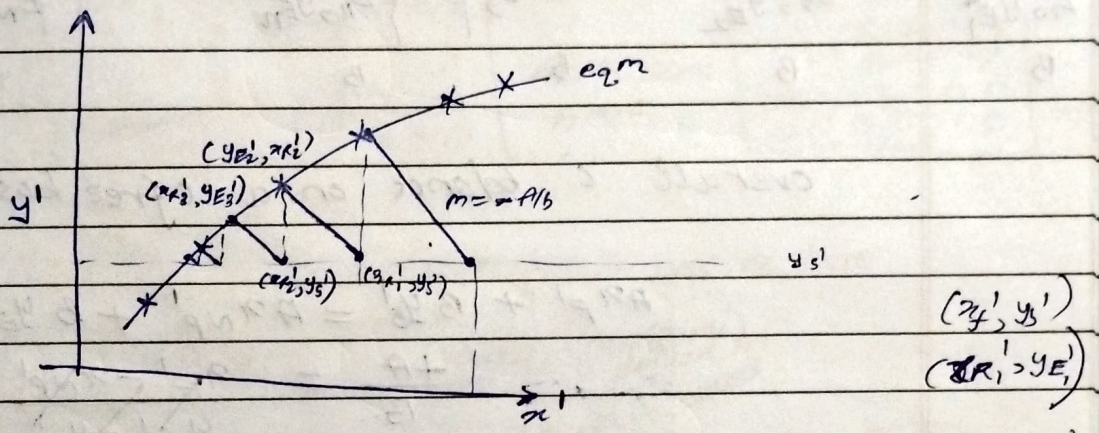
$$= B_E \times \frac{C_E}{B_E} = B \times \frac{C_B}{B} = B \times y'_E$$

Cross flow:

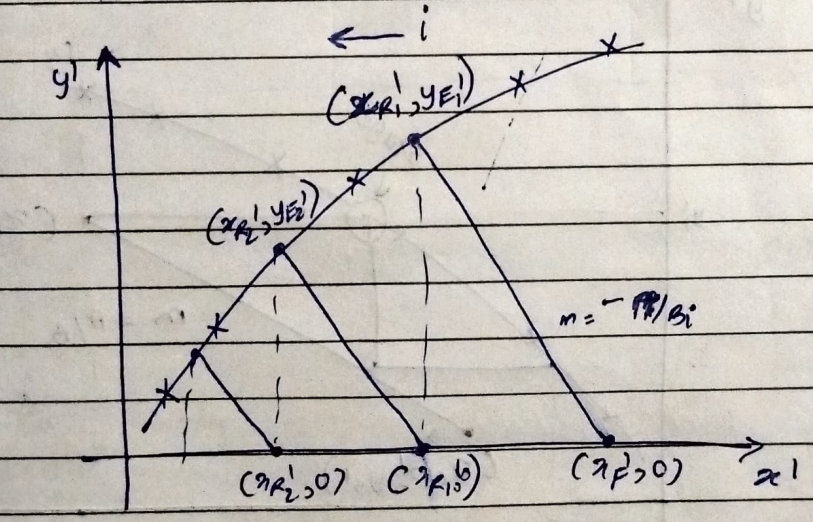
$$A x_F' + B y_S' = A x_{R_1}' + B y_{E_1}'$$

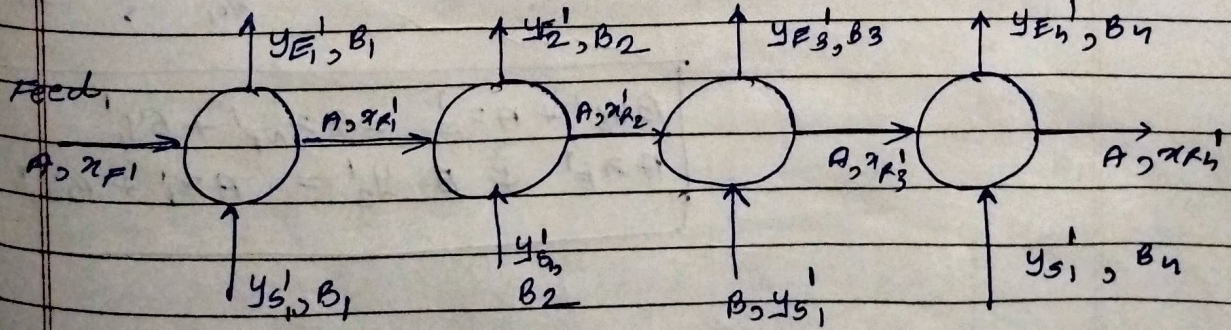
$$\Rightarrow A(x_F' - x_{R_1}') = -B(y_S' - y_{E_1}')$$

$$\frac{y_S' - y_{E_1}'}{x_F' - x_{R_1}'} = -\frac{A}{B}$$

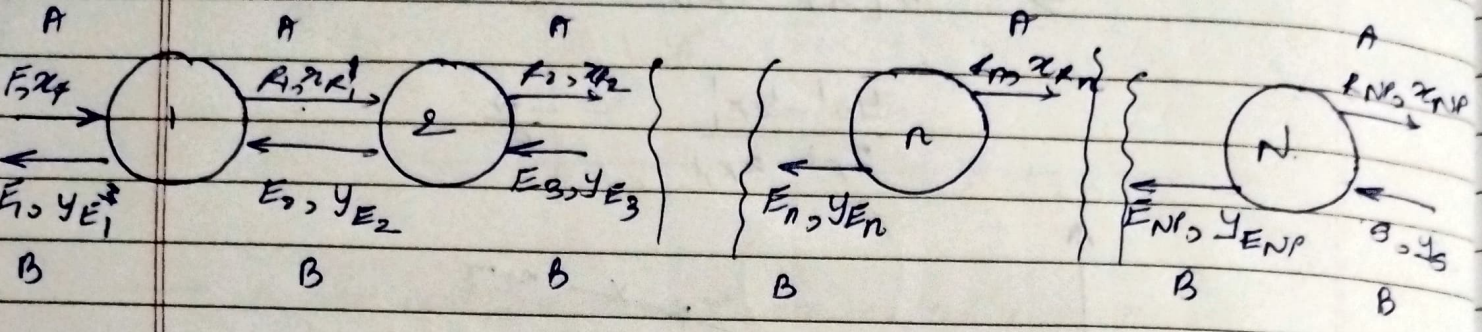



for $y_S' = 0$



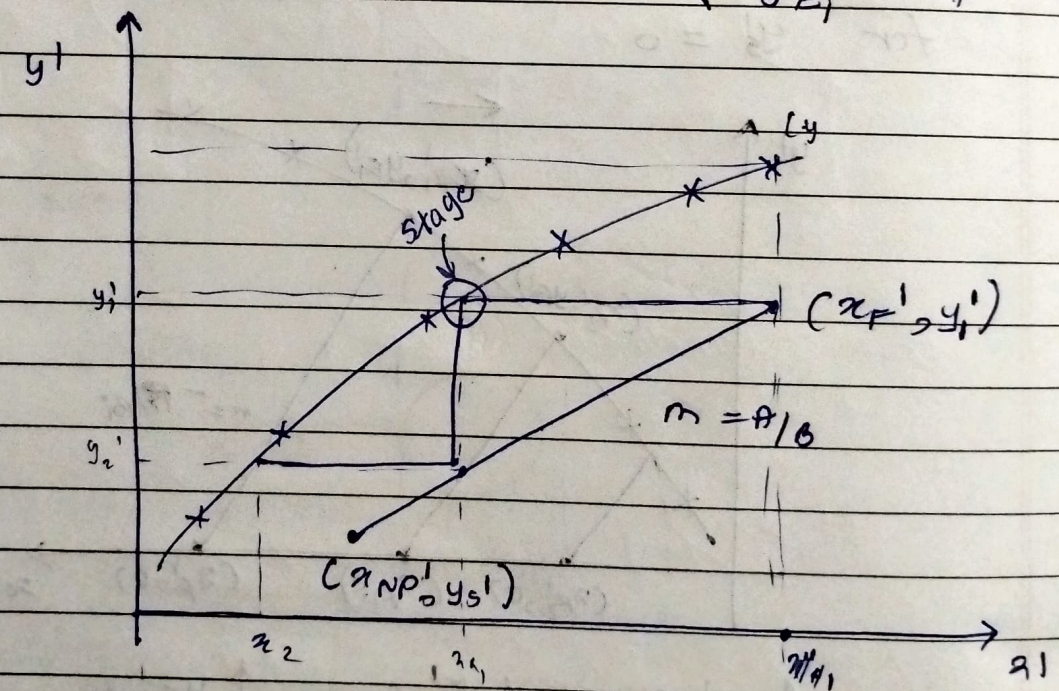
→ Counter flow:




overall 'c' balance on a free basis

$$A x_F' + B y_S' = A x_{NP}' + B y_{E_1}'$$

$$\frac{+A}{B} = \frac{x_F' - x_{NP}'}{y_S' - y_{E_1}'} \quad \frac{-y_S' + y_{E_1}'}{x_F' - x_{NP}'}$$




$$B y_S' + A x_F' = A x_{NP}' + B y_1'$$

$$A x_F' + B_2 y_2' = A x_1' + B y_1'$$

# Leaching

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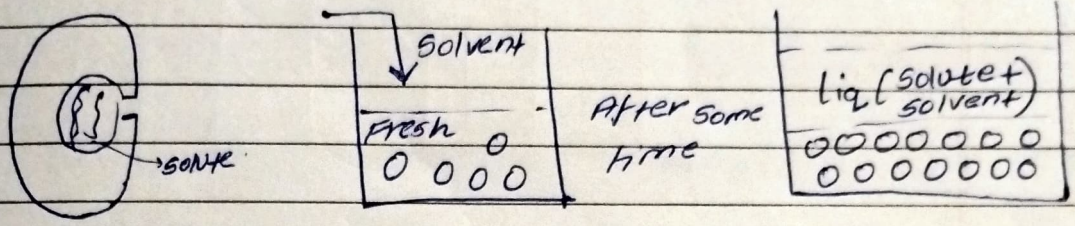
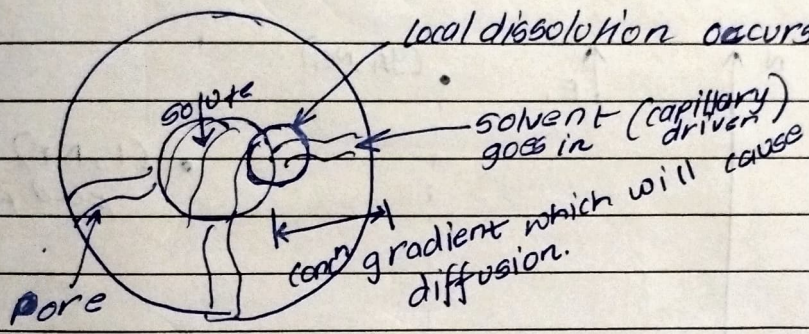
Page

| Extraction | Leaching |
|---|---|
| • Carrier | • Insolubles (solid) |
| • Solute | • Solute |
| • Solvent | • Solvents |



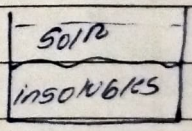

Notations:

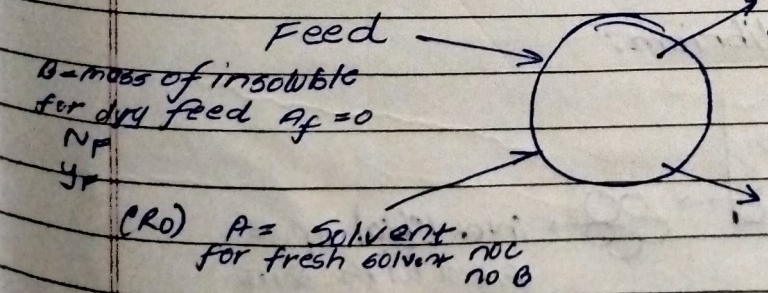
A → solvent

B → ~~solute~~ insoluble.

C → solute.

Output:




$a_{R_1} = \frac{C_{R_1}}{A_{R_1} + C_{R_1}}$

$N_{R_1} = \frac{B_{R_1}}{A_{R_1} + C_{R_1}} = 0$

$N_{E_1} = \frac{B_{E_1}}{A_{E_1} + C_{E_1}} = 1$

$y_{E_1} = \frac{C_{E_1}}{A_{E_1} + C_{E_1}} = \frac{0}{0}$

N-x-y: (B free basis)

$N_F = \frac{a_f}{c_f + a_f} \neq 0$ | $N_F = \frac{B_F}{A_F + C_F} = \frac{B_F}{C_F}$

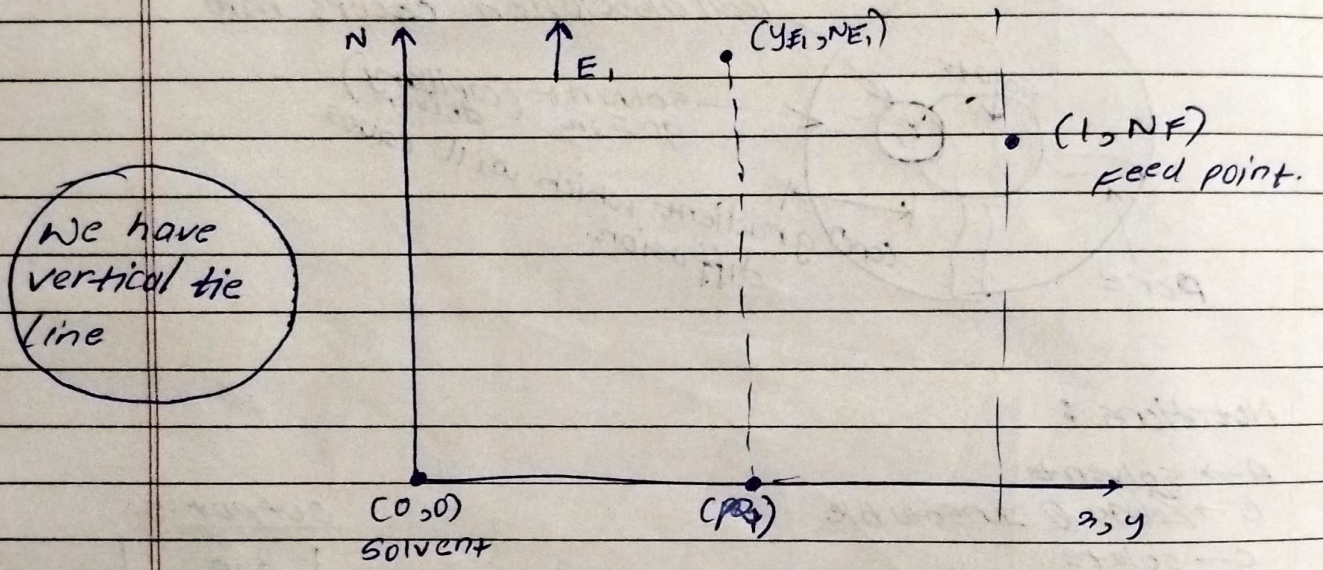
$y_f = \frac{c_f}{a_f + c_f} = 1$

$N_0 = \frac{B_0^{\,0}}{A_0 + C_0} = 0$

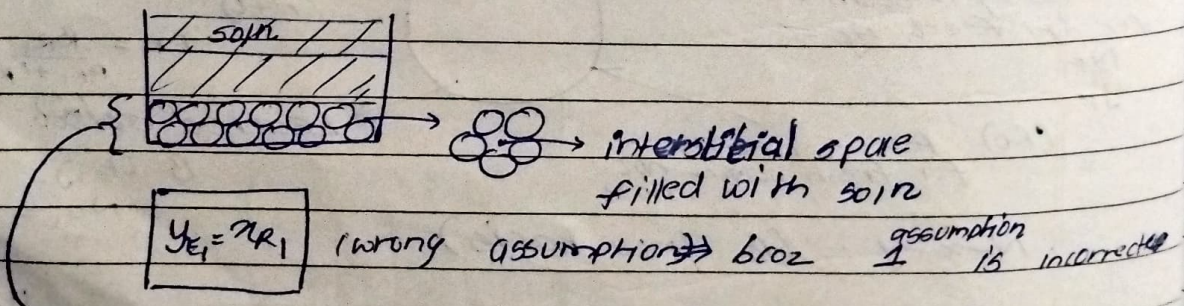
$x_0 = \frac{C_0^{\,0}}{A_0 + C_0} = 0$

Assumptions:

1. All solutes have leached out.
2. The insoluble is dry and has no solute left.




# Practical Equilibrium:



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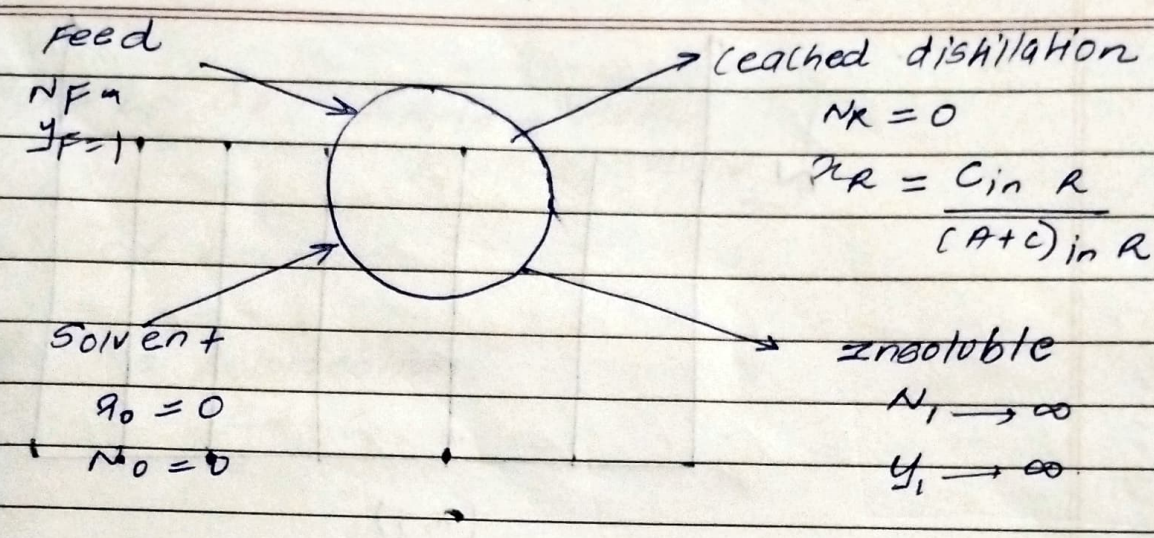
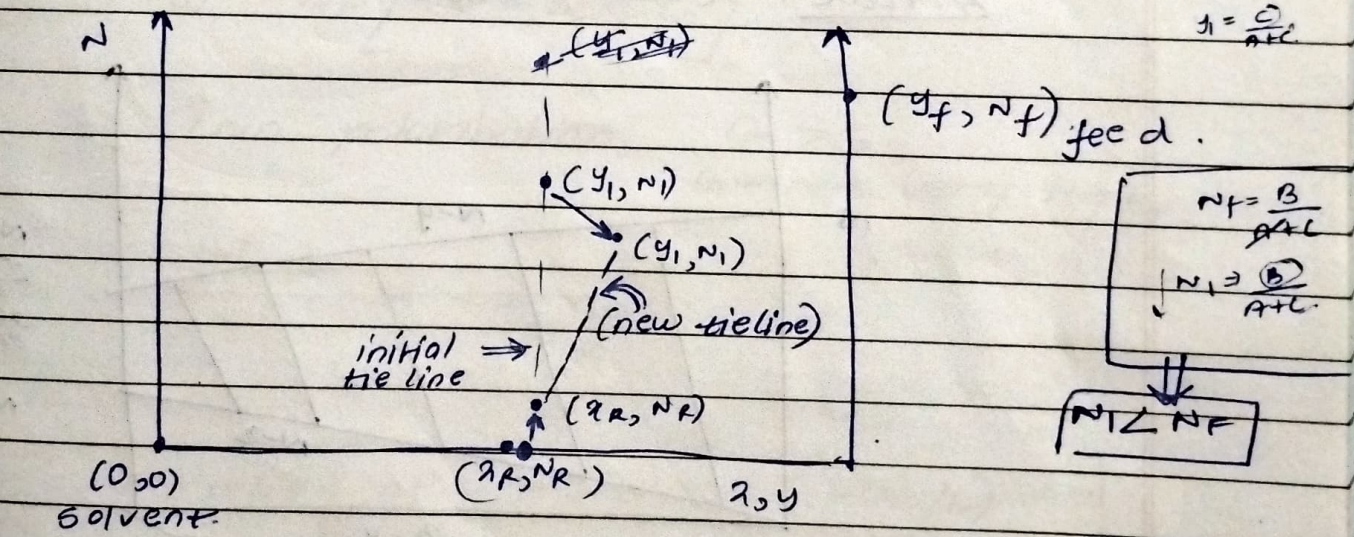



(A)

B → insoluble
C → solute

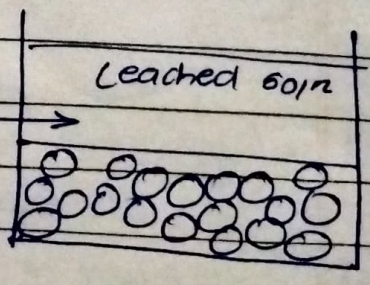



$N_1 \downarrow$ (bcoz assp ① is wrong, there will be C remaining in insoluble)

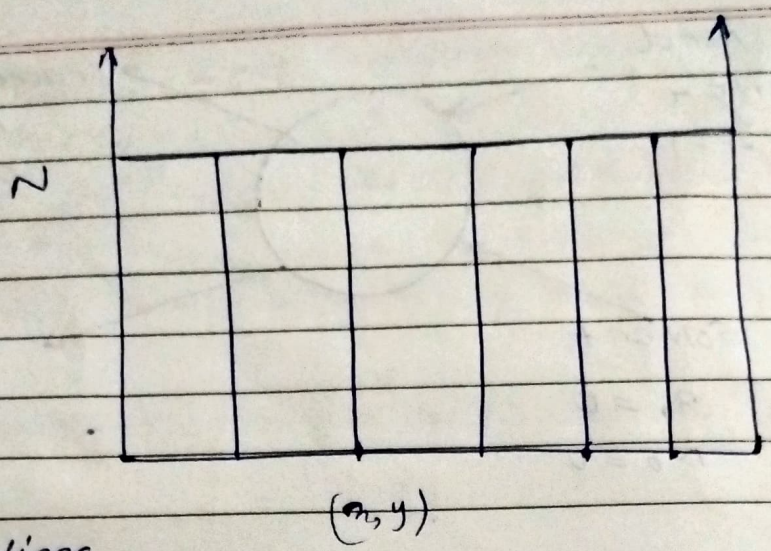
$y_1 \uparrow$ slightly

tie-line
[line which connects comp of two phases in eqm]

finer B particles to remain in soln

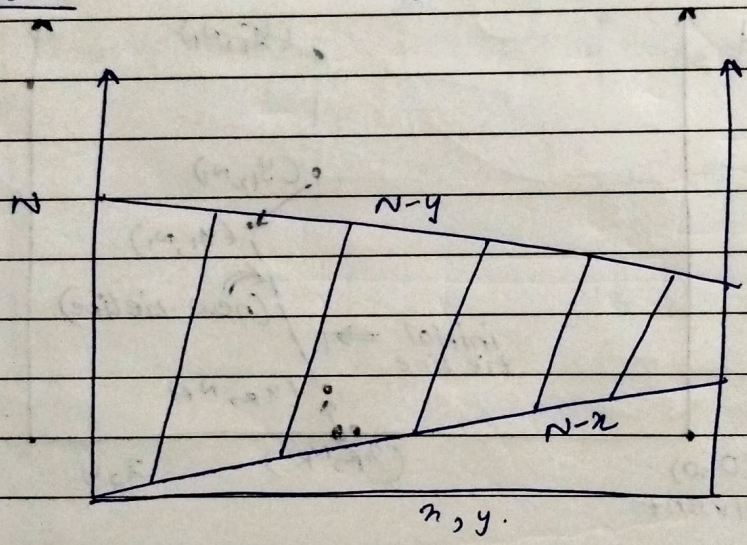



$\therefore N_R \uparrow$




Tielines based on practical eqm →

Actual : (Real condition)




N-y ⇒ ve - slope [amount of C stuck increase as C increase during extt]

N-x ⇒ vet slope

Solute loading ↑

Impractical assumption taken: No solubility limit for A (Solvent)