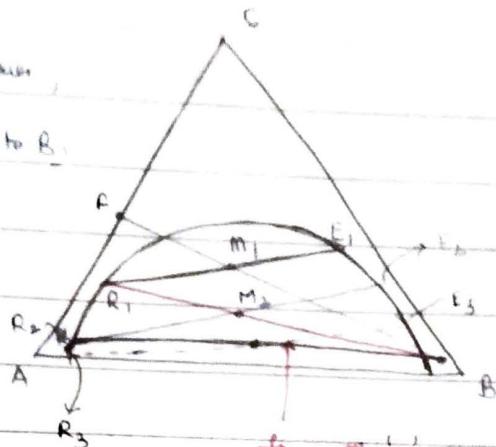
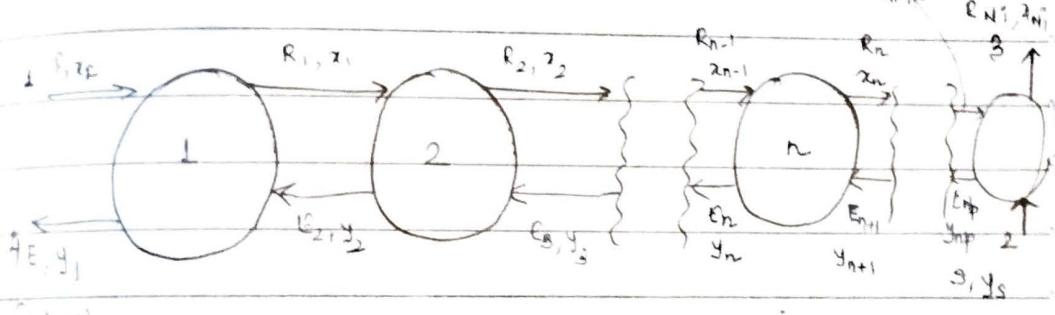


Raffinate is moving down & down

M will be moving close to B.



* Continuous Counter flow Current Multistage Extraction :- R_{NP-1}



Overall balance :-

$$F + S = E_1 + R_{NP-1} \dots (1)$$

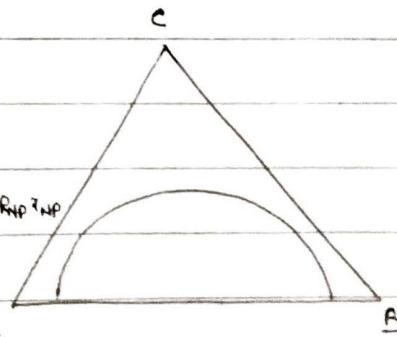
$$R_{NP-1} - S = F - E_1 = \Delta R \dots (2)$$

net flow of ΔR

last stage on first stage

Solute Balance

$$F_{xp} + S_{ys} = E_1 y_1 + R_{NP-1} x_{NP} \\ = M x_m$$



Raffinate

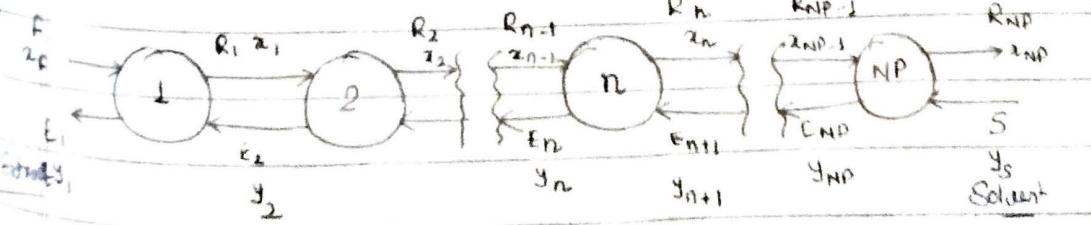
R_{NP}

x_{NP}

S

y_{NP}

Solvent



mass balance:- $F + S = E_1 + R_{NP} = M$

Component balance:- $F_{xp} + S_{ys} = E_1 y_1 + R_{NP} x_{NP} \\ = M x_m$

$$F - E_1 = R_{NP} - S = \Delta R =$$

for 1st ↓ for last
Stage — Stage

— net flow in or out

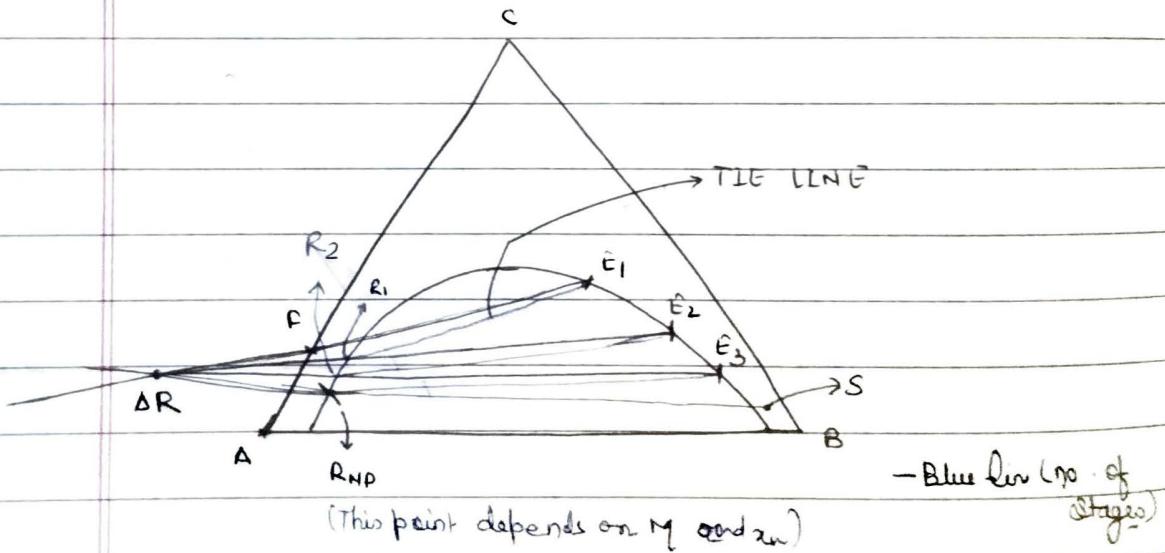
for nth Stage to last Stage,

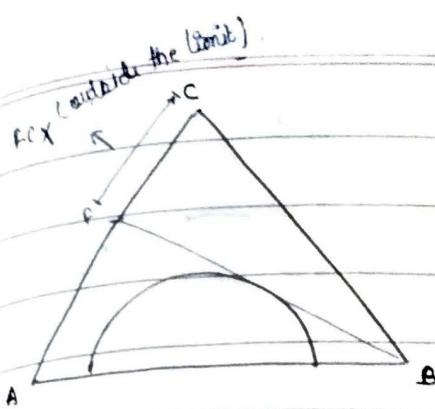
$$R_{n-1} + S = F_{NP} + E_n$$

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

Also, $R_{NP} - S = F - E_1 = \Delta R$

$$\therefore R_{n-1} - E_n = \Delta R$$

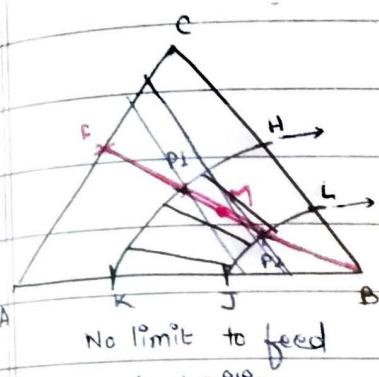




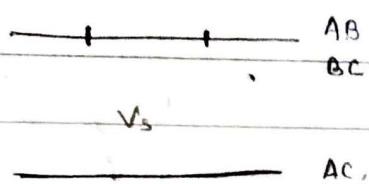
A - C completely miscible.

A - B partially miscible

B - C also partially miscible.



No limit to feed composition.



P2 - Extract

P1 - Raffinate

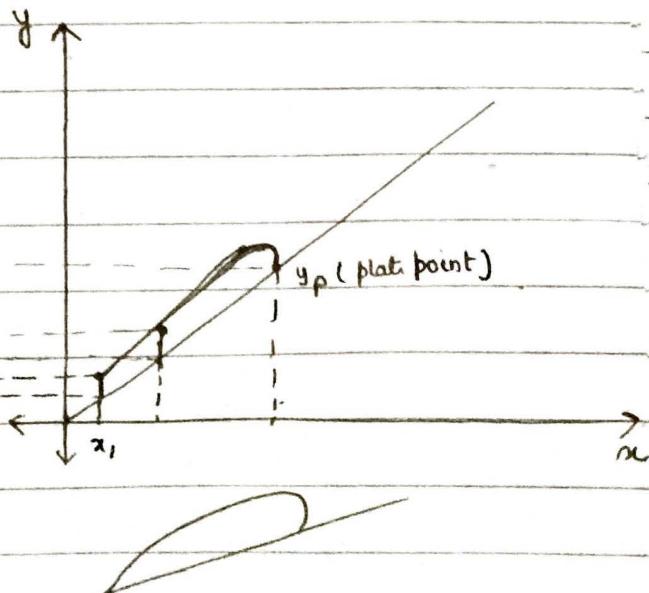
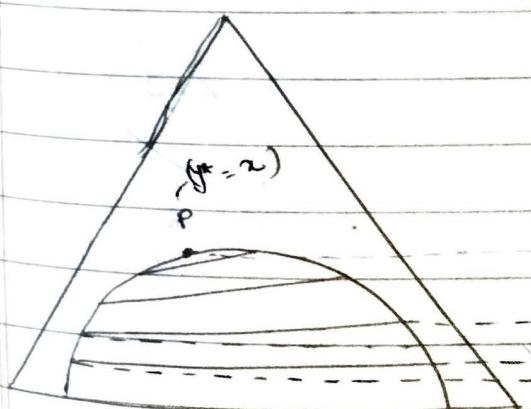
{ choosing Extract here, does not depend on high composition of C. *

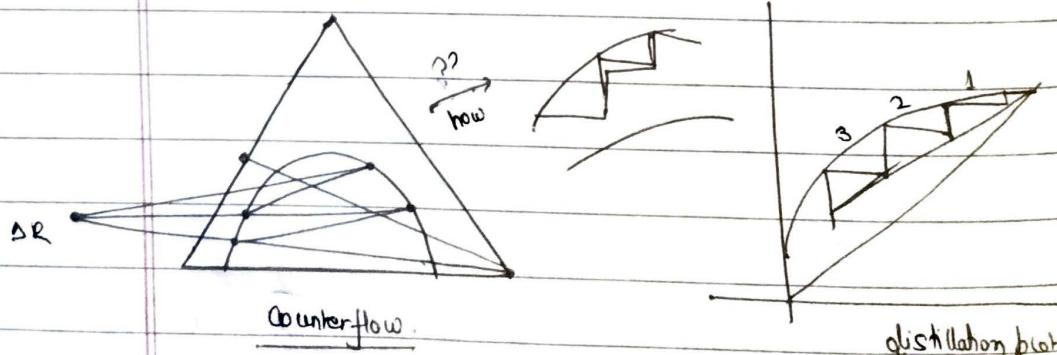
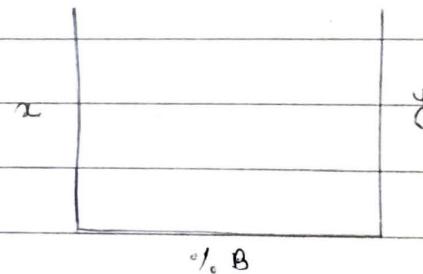
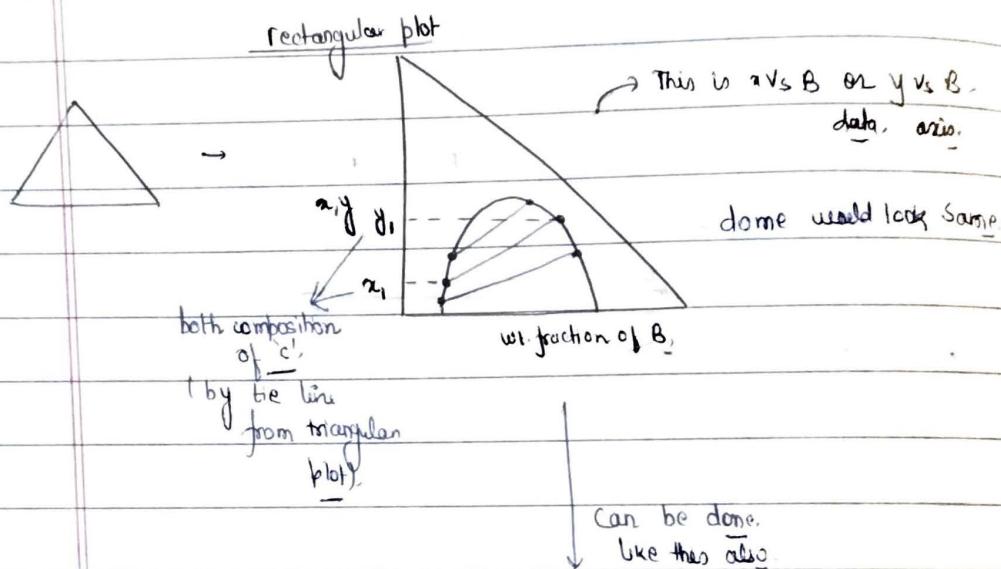
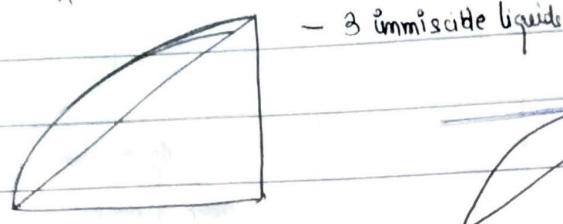
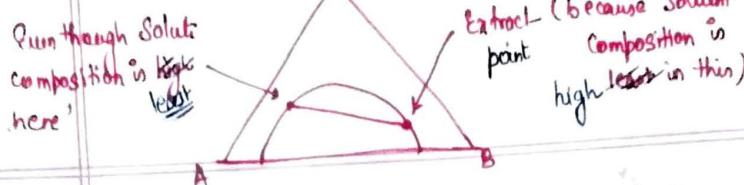
rather, we chose the Extract and Raffinate point by the leanest composition of A.

* Composition of carrier in Extract

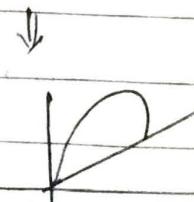
(carrier)

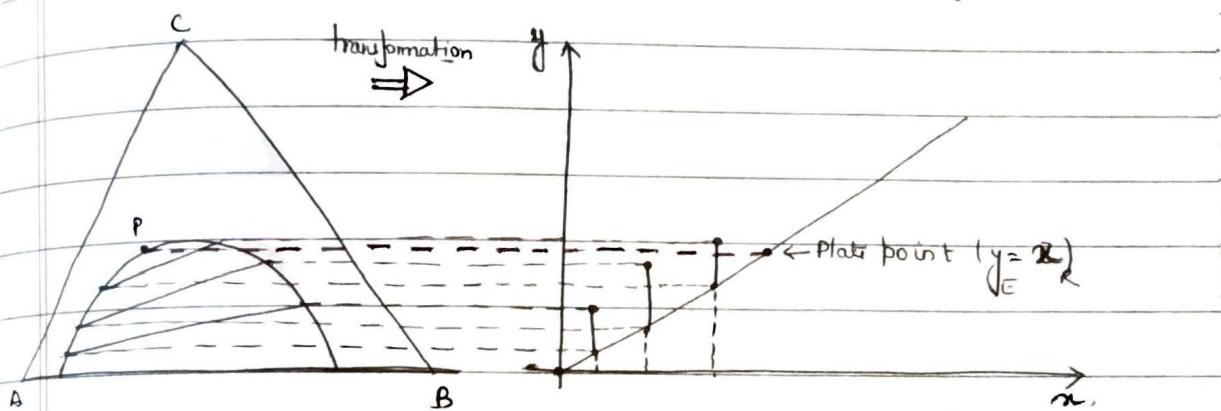
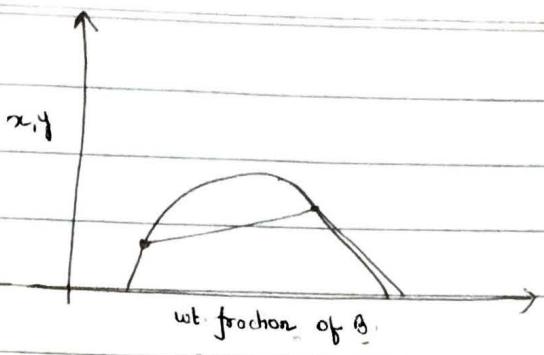
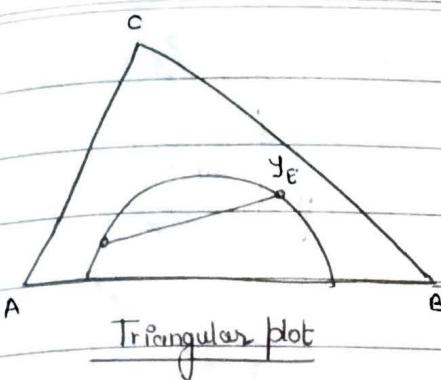
Should be as low as possible



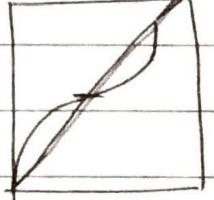
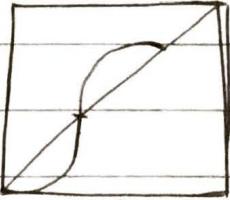
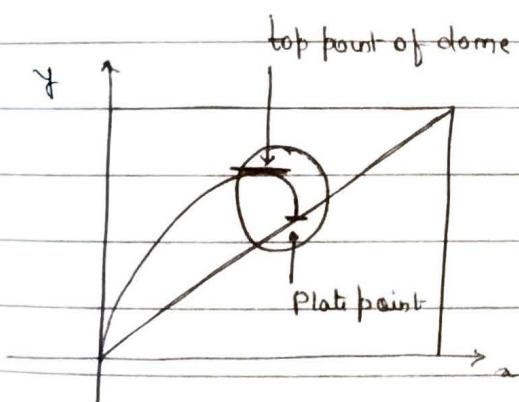


To convert this we
need
operating lines!!





$\hookrightarrow \underline{x} \rightarrow$ will go upto composition
of Raffinate at plate point



first tie lines

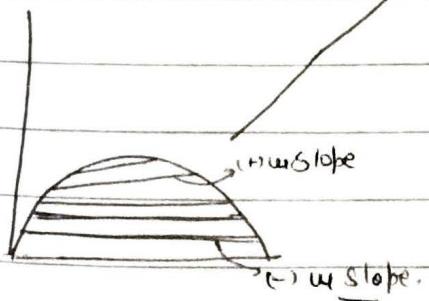
are as usual

then become

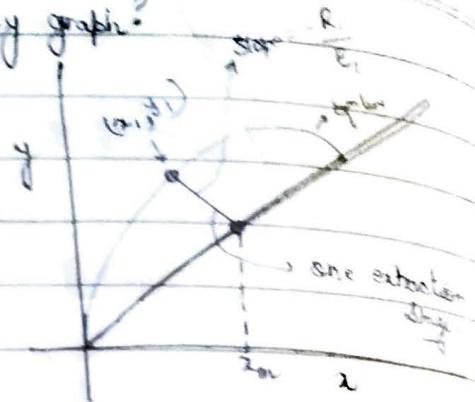
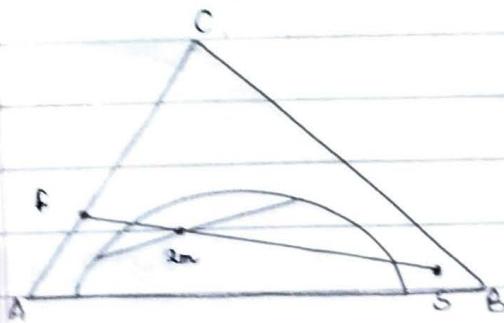
parallel to

A-B then goes to

negative slope.



how do we show the phases in x-y graph?



* Every point on an eqm line is a tie line

x, y, N

$$F + S = M$$

$$F_x + S_y = M x_{F,S} \rightarrow 2m \text{ is known}$$

$$F_x y_1 + S_y x_1 = M x_m$$

$$\Rightarrow y_1 = -\frac{R_1}{E_1} x_1 + \frac{M}{E_1} x_m$$

Knowns: F, S, x_F, y_S

$$F + S = M = R_1 + E_1$$

$$F x_F + S y_S = M x_m = R_1 x_{R_1} + E_1 x_{E_1}$$

$$x = \frac{c_R}{C_R + A_R + B_R}$$

$$y = \frac{c_E}{C_E + A_E + B_E}$$

Solute

free basis

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

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

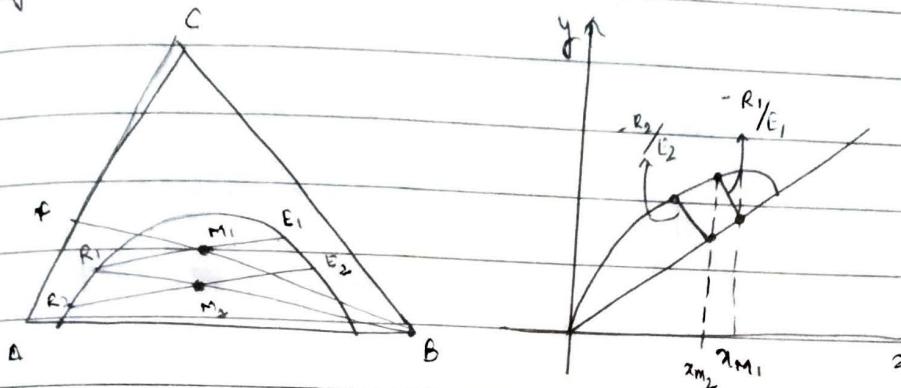
Solvent
free basis

$$x = \frac{c_B}{C_B + A_B}$$

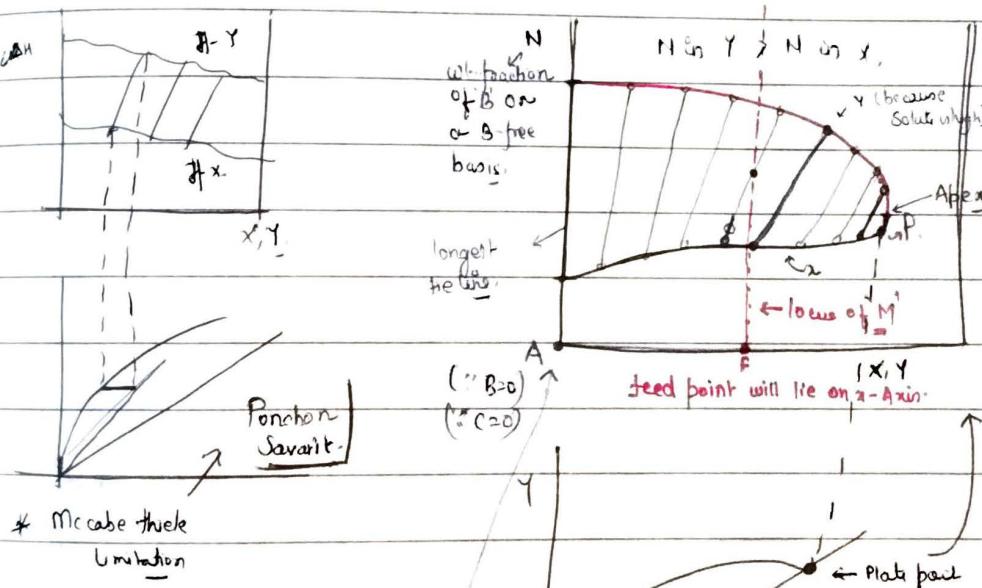
$$y = \frac{c_E}{C_E + A_E}$$

N \rightarrow wt fraction of
B on a B-free
basis

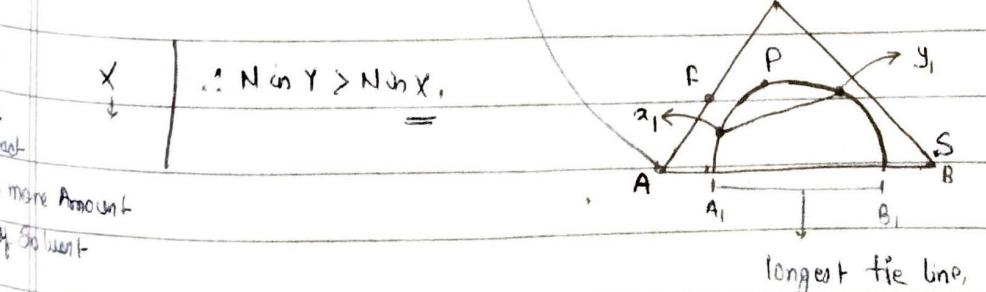
Multistage Cross flow :-



How Single Stage extractor ~~works~~ looks as on a Solvent free basis



Extract :- Always Solvent rich
or leaner of A



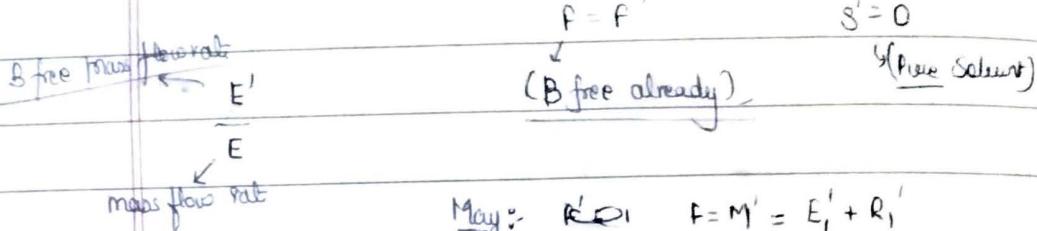
* Where will Solvent point lie??

in N vs X, Y Pure solvent, N → ∞ ($\because A = C = 0$)

(not located)

Pure feed, Pure Solvent

Material Balance $F' + S' = M' = E'_i + R'_i$
(B Free Basis)

C - Component balance,

$$F' x_F + S' Y_S = M' x_M = E' Y_i + R'_i X_i$$

$$\Rightarrow x_{M_i} = x_F \checkmark$$

Line of M is the vertical line from E.

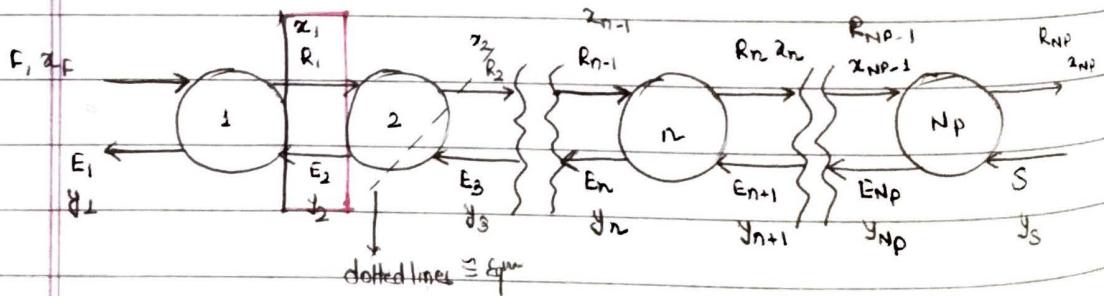
* B-component balance,

! Moment we got impossibility point (not particularly located) !

$$F' N_F + S' N_S = M' N_M = E' N_E + R'_i N_R$$



M = has physical significance (that tells the ^{total} capacity of drum)

Counter-current, Multistage Retraction

$$F + S = M = E_i + R_{Np}$$

here 'M' is no longer a design parameter. No physical significance.

C - Component balance,

$$F x_F + S y_S = M x_M = E_i y_i + R_{Np} x_{Np}$$

$$R_{Np} - S = F - E_i = \Delta R$$

$$R_1 - E_2 = \Delta R$$

liquid phase 1wt fr Aliquid phase 2wt fraction of A

x

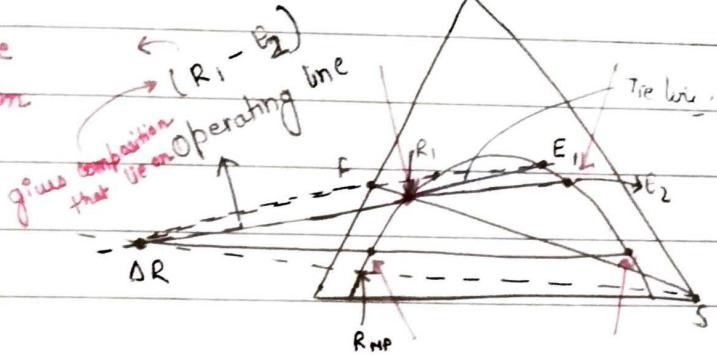
x

x

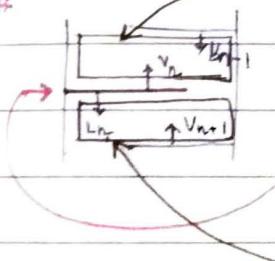
x

stem
ton)

* Inter Stage
Composition



##



'tip' this is stage

gives the composition
at inter stage
* operating line given
~~operating line~~

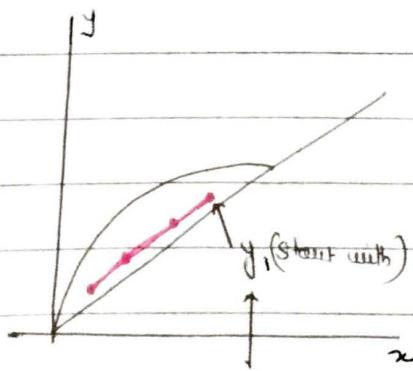
* Regn line :- gives composition on
the stage.

Zone b/w two stages, if ~~changed~~, ~~flow~~ a totally different operating
line.

on triangular plot

* the points which are marked with RED arrows,

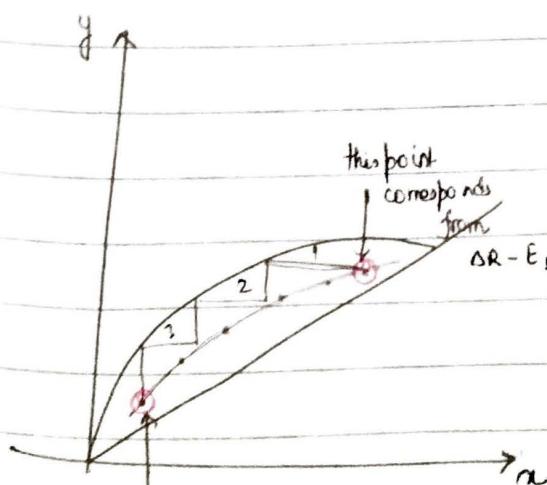
may or may not be end point of
stages



this point
corresponds
from
OR-E₁

OR-E₁

Operating line may go upto tangent
from OR to dome, but it is geometrically
correct not PHYSICALLY!



this point

comes from OR-S (see last stage)

It is out of our working zone

Age of portion of bone & fat layer

200

1	2	3	4	5	6	7	8
4.3	4.2	4	3.75	3.5	3.3	3.1	2.9
0.001	0.01	0.02	0.03	0.04	0.05	0.06	0.07
4.15	4.05	3.95	3.85	3.75	3.65	3.55	3.45
3.95	3.85	3.75	3.65	3.55	3.45	3.35	3.25
3.85	3.75	3.65	3.55	3.45	3.35	3.25	3.15
3.75	3.65	3.55	3.45	3.35	3.25	3.15	3.05
3.65	3.55	3.45	3.35	3.25	3.15	3.05	2.95

Plot graph on same scale

2.5 3.0 3.5

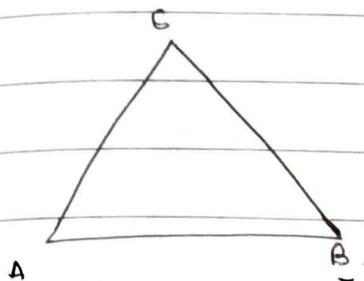
4.0 4.5 5.0

5.5 6.0 6.5

7.0 7.5 8.0

A and B are completely Insoluble)

$A \rightarrow$ Carrier & Solvent $\leftarrow B$



$x' \quad y' \rightarrow C$ free system
(fraction)

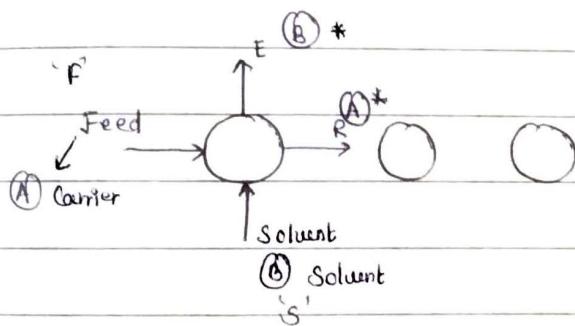
$$y' = \frac{x}{1-x}$$

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

$x, y \rightarrow B$ -free

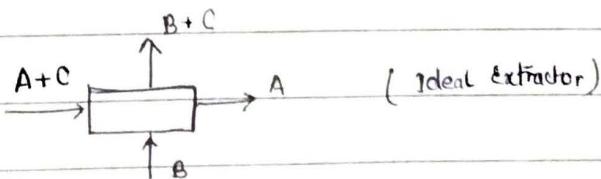
$x, y \rightarrow A$ -free

$A \rightarrow$ carrier $B \rightarrow$ Solvent



• Extract will contain whole solvent 'B'

• Raffinate will contain whole carrier 'A'



Solute Balance (C) Balance :-

$$Ax'_f + B y'_s = B y'_i + A x'_i$$

A \rightarrow Amount of Carrier in Feed.

B \rightarrow Amount of Solvent in Solvent Stream

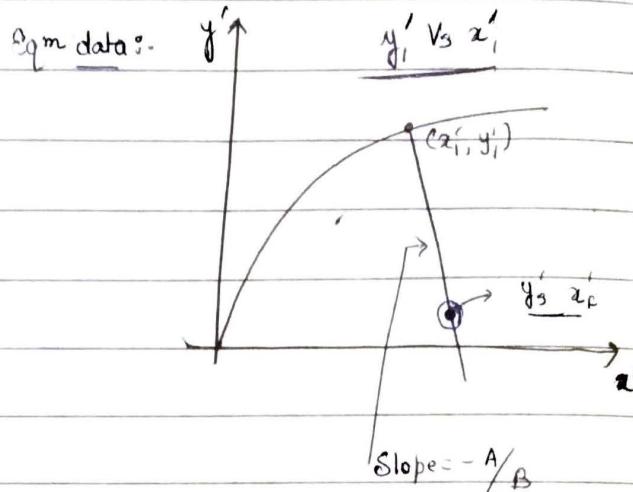
$$x'_f = \frac{x_f}{1-x_f}$$

$$x'_i = \frac{c}{A+c}$$

$$1-x_f = \frac{A}{A+c}$$

$$x'_f = \frac{c}{A} \quad \checkmark$$

$$\frac{A}{B} = \frac{y_s' - y_1'}{x_f' - x_1'}$$



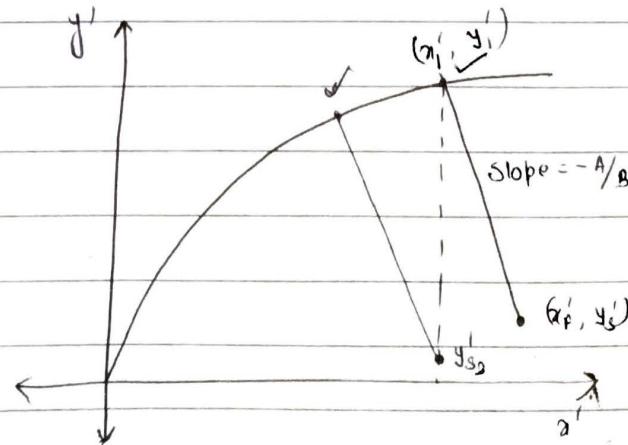
x_1', y_1' → unknown.

So, $-A/B$ (slope) of a line ← draw from point (x_f', y_f')

for general Cross Flow,

Solute balance :-

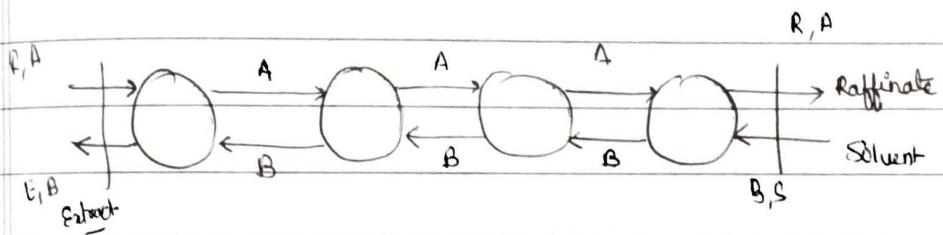
$$A x_{n-1}' + B_n y_{n-1}' = B_n y_n' + A x_n'$$



α'	0	0.001011	0.00246	0.00502	0.00751	0.00998	0.0204
γ'	0	0.000801	0.001961	0.00456	0.00686	0.00913	0.01870

Nootion 9.

$$B\gamma'_S + A\alpha'_F = A\alpha'_{NP} + B\gamma'_I$$



$$\frac{A}{B} = \frac{\gamma'_I - \gamma'_S}{\alpha'_F - \alpha'_{NP}}$$

Slope of operating line,

$$\alpha'_{NP} = \frac{0.001}{1 - 0.001} = 0.00100 \quad \gamma'_S = 0 \\ (\text{pure Solvent})$$

H.W.

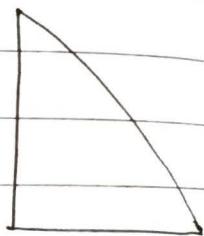
Ex: 10.1 (Tray-bal)

(Addition A) = 10.0 g ... (final g A).

①

water layer

<u>wt%, Acetic Acid</u>	<u>water</u>	<u>Isopropyl Ether</u>
100.0		
0.69	98.1	1.2
1.41	97.1	1.5
2.89	95.5	1.6
6.42	91.7	1.9
13.30	84.4	2.3
25.50	71.7	3.4
36.70	58.9	4.4
44.30	45.1	10.2
46.40	37.1	16.5

draw on triangular pHIsopropyl Ether Side

<u>AA</u>	<u>Water</u>	<u>Isopropyl Ether</u>
0.18	0.5	99.3
0.37	0.7	98.9
0.79	0.8	98.4
1.93	1.0	97.1
4.82	1.9	93.3
11.40	3.9	84.7
21.60	6.9	71.5
31.10	10.8	58.1
36.20	15.1	48.7

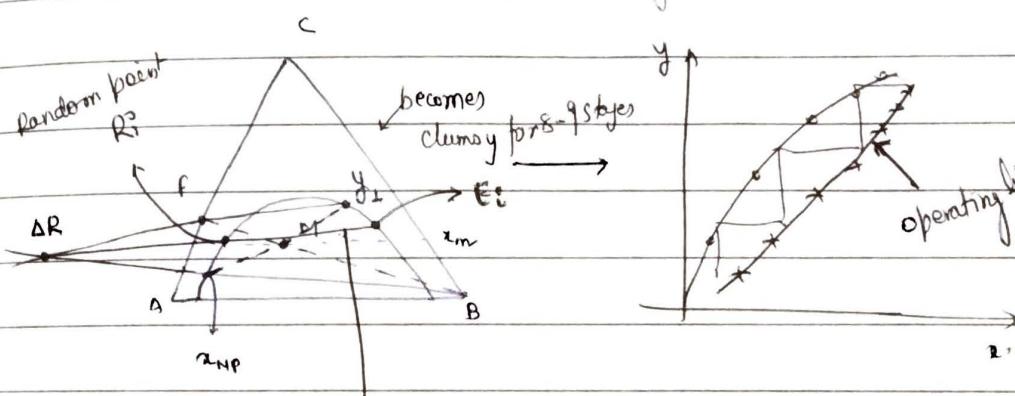
If 8000 kg/hr of an Acetic Acid (C) + water Sol^f (A) containing 30%.

Acid is to be Counter - Currently extracted with Isopropyl Ether (B) to reduce Acid concentration to 2% in Solvent free raffinate product.

- (i) Determine the no. of theoretical stages. If 20,000 kg/hr solvent is used.

$$x_{NP} = 2\%$$

$f - y_1$, $2 - x_{NP} - B$ joined to get ΔR .



x_M - value calculated

M - intersection point of F-B \leftrightarrow

and $(x_{NP} - y_1)$

If it would be a single stage

gives component balance

(for operating lines point).

comes from
total mass balance).

Leaching

CLASS WORK
Date _____
Page _____

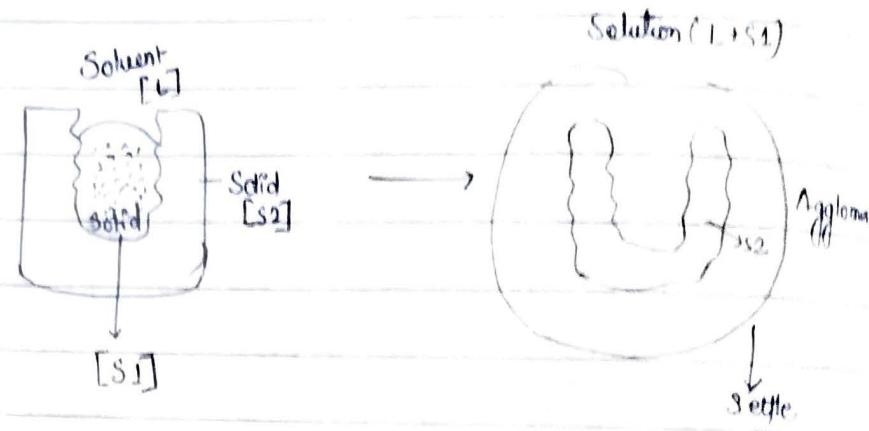
Solvent

to

Extract

a Solute (S_1)

from a Solution ($\text{C}_{\text{initial}}(L) + \text{Solute}(L)$)



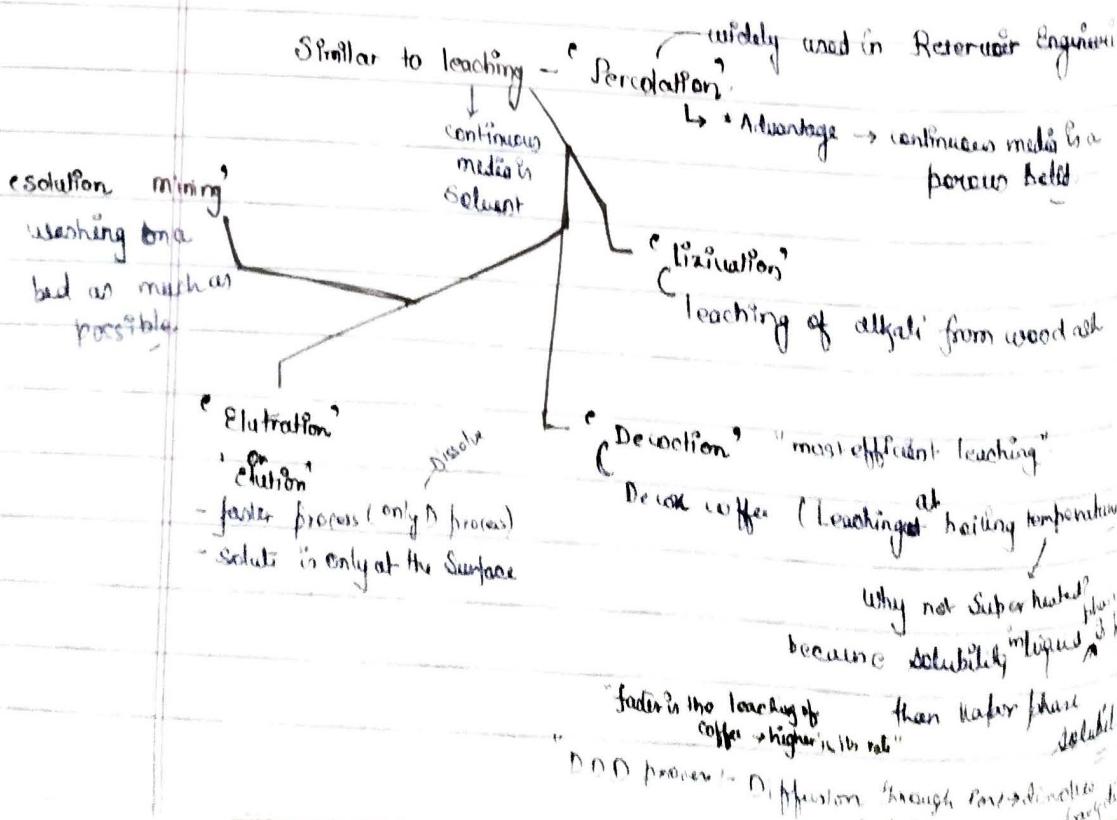
Dispersion at molecular level; Solution

Should

Solvent \rightarrow dissolve S_1 and not S_2 .

Leaching is favored at high temperature

\hookrightarrow Solubility increases with temp



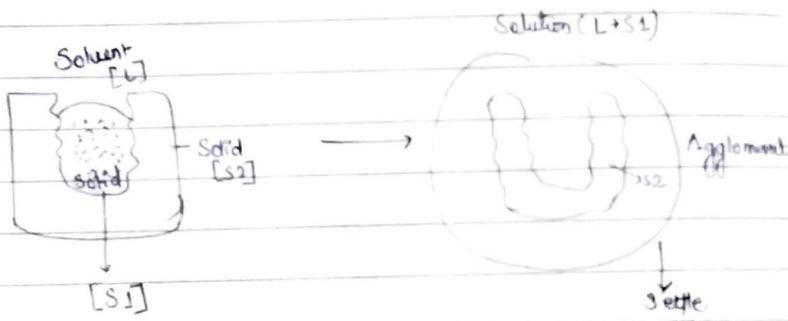
Leaching

classmate

Date _____

Page _____

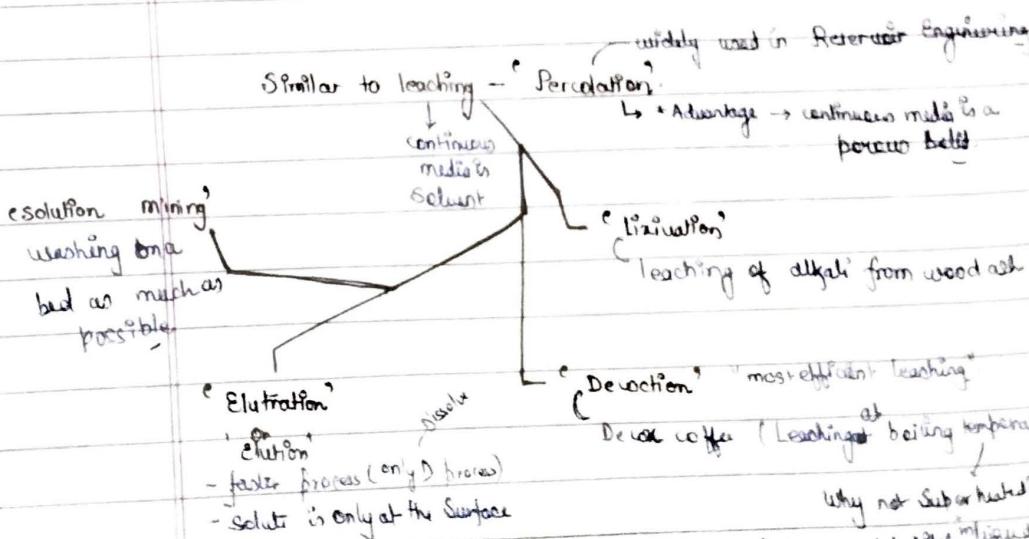
Solvent
to
Extract
a Solute (A_1g_1)
from a Solution ($\text{C}_{\text{arter}}(\text{L}) + \text{Solute}(\text{A})$)



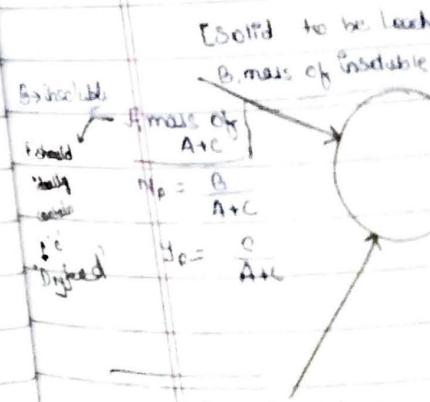
Dispersion at molecular level: Solvation

Solvent dissolves S_1 and not S_2 .

Leaching is favored at high temperature
↳ Solubility increases with temp.



- * Tie lines for May P
- Problems in leaching
 - No. 1: 100% dissolution
 - No. 2: insoluble reaction
 - No. 3: insolubles might +
 - No. 4: Problem of redox
 - No. 5: may the Solutes and reactants +



Leaching Solvent

A_0 , mass of film

$x_0 = \frac{C}{A+C}$

$M_0 = \frac{B_0}{A+C}$

$D_0 = \frac{D_0}{A+C}$

Why not Subcritical? because solubility in liquid is higher

"faster in the leaching of coffee than water phase" (coffee \rightarrow higher solubility)

CO2 present - CO2 diffusion through non-dissolved Solutes and then back diff.

Graph

Graph \rightarrow Time

Structure

Bottom & Bottom

• The time it takes for a task can all be unified

• Factors to consider -

- no

• Diff. duration

• One module implements some tasks in a sequence

• Involves more effort initially which is

• Factor by reusability

• May be useful to reduce initial activity with the best procedure
and reusability factor in one function is bottom time required

Bottom is re usable

Ex:

• Time by iteration

Planning Beta 1

Iteration 116 (2)

• Time by

B = time to calculate

- iteration 116 (3)

$$B = \frac{1}{10}$$

$$B = \frac{1}{10} \quad B = \frac{1}{10} + \frac{1}{10}$$

$$= \text{reusable 4}$$

$$B = \frac{1}{10}$$

• 1st hour

• reusable duration 2

• 1st iteration

$$B = \frac{\text{Time } 2}{10}$$

$$= 1.16 \text{ hours}$$

initial

in iteration

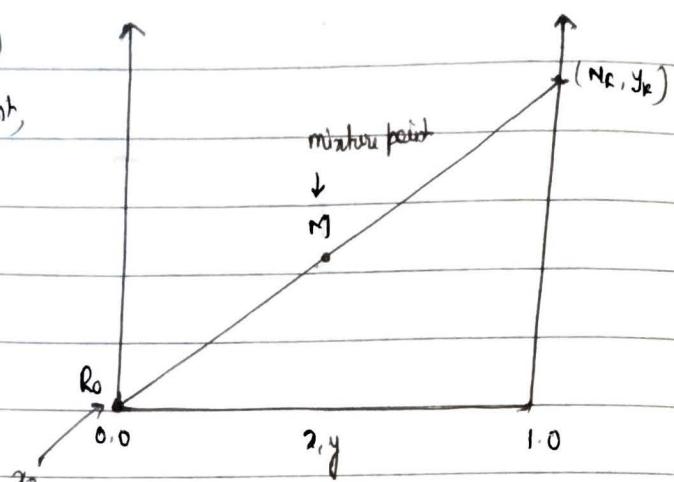
• Time by iteration

• Time by iteration

$$B = \frac{1}{10}$$

$$B = \frac{1}{10}$$

dry
for pure few
and pure Solvent,



$x_0 \rightarrow$ If shifts along x - has some Solute (C)
 $y_c \rightarrow$ If shifts along y - has dispersed 'B'
 If shifts in quadrant - has both

y_c can only shift in quadrant

Leaching :-

Solid to be

Leached

B, mass of Insoluble

f, mass of A+C

$$N_f = \frac{B}{A+C}$$

$$y_f = \frac{f}{A+C}$$

One theoretical

Stage

Leached Solid (E)

B, Mass of Insoluble

E₁, mass of (A+C)

$$N_i = \frac{B}{E_1}$$

$$y_i = \frac{c \text{ in } E_1}{E_1} = \frac{c \text{ in } G_1}{E_1}$$

Leached Soln (F)

R₁, Mass of Soln

$$x_i = \frac{\text{mass of } F}{\text{mass of } A+C}$$

$$N_i = \frac{c \text{ in } F}{A+C}$$

Leaching Solvent

R₀, mass of Soln (A+C)

$$x_0 = \frac{c}{A+C}$$

$$N_0 = 0$$

In leaching,

A \rightarrow Solvent

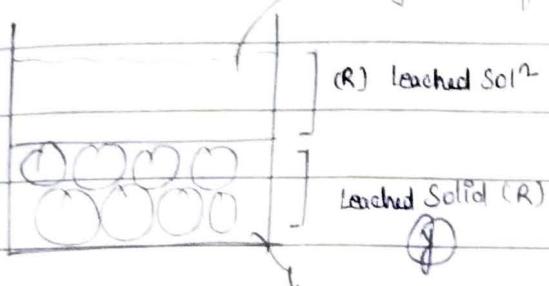
B \rightarrow Insoluble

C \rightarrow Soluti.

B can only disperse in R' (leached soln)

② fraction of Solns in the sol² Ptotally should not dissolve

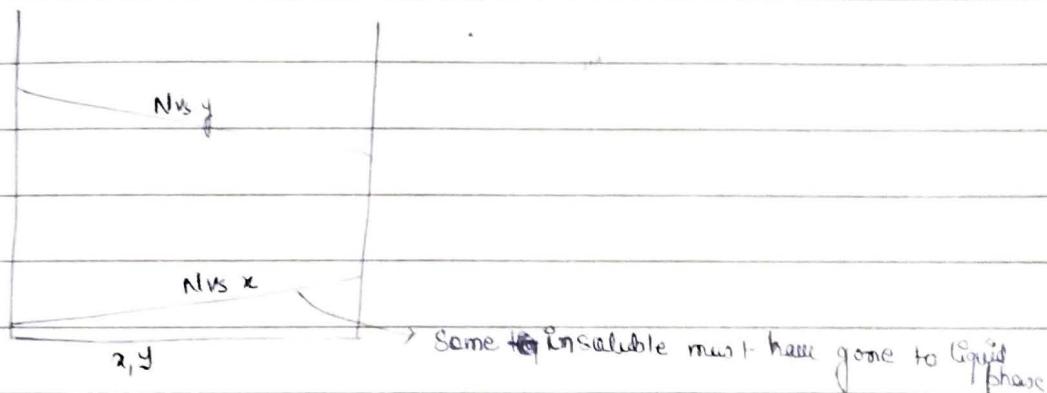
'B' (#)



Liquid entrapped which can't be leached out,

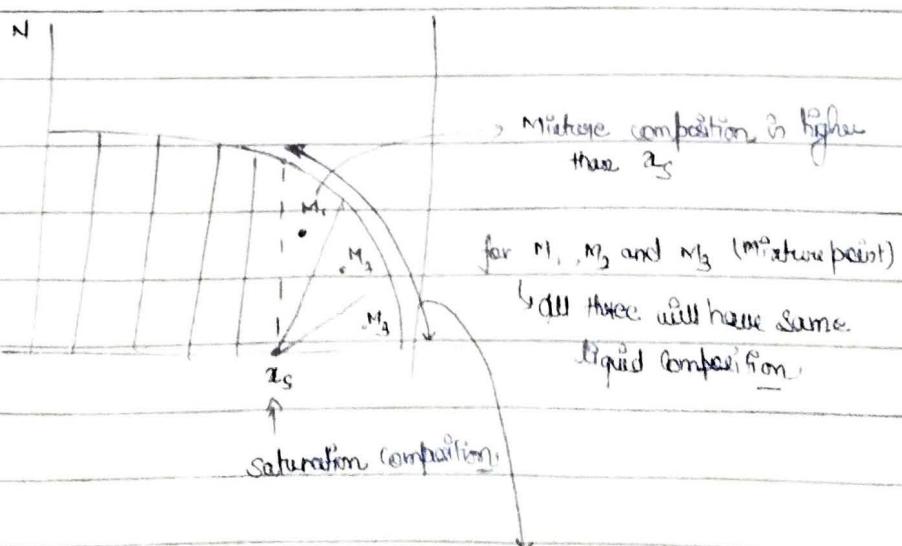
(due to No Slip condition b/w Solid & liquid attached to it).

Tie line is vertical ($\because y = z$ (same))



N vs z - plot - coincides with z axis: Liquid phase doesn't have any 'B'

when 'R' gets saturated



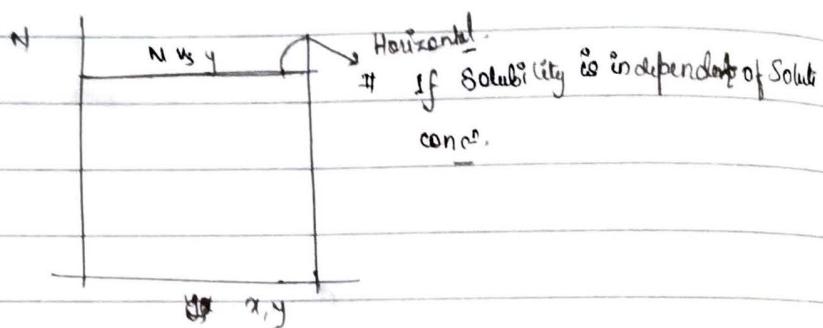
It is decreasing (N)

because after saturation 'Y' would directly go to leached solid phase thus E would be at N_{tot}

R'
 (will never reach saturation) \propto soluble \rightarrow (x, y) axis (I)

Saturation \rightarrow x_s (x, y) axis (II)

Vertical tie line's implies there is no undissolved 'c' in solid phase
 bracketed



Balance Equations:-

$$B = N_p \cdot f = E_1 \cdot N_1$$

• Solute Balance (c) Balance :-

$$f y_f + R_c x_0 = E_1 y_1 + R_1 x_1$$

• Solvent Balance :-

$$f(1-y_f) + R_0(1-x_0) = E_1(1-y_1) + R_1(1-x_1)$$

• Solution Balance :-

$$f + R_0 = E_1 + R_1 = M$$

$$N_{M_1} = \frac{B}{f + R_0} = \frac{B}{M_1}$$

$$y_{M_1} = \frac{y_f f + R_0 x_0}{f + R_0}$$

~~18/8/2023~~

Q) Caustic Soda is made by treatment of Ca(OH)_2 with a solution of sodium carbonate. The resulting slurry contains particles of Na_2CO_3 suspended in a 10% solution of NaOH with 0.125 kg solid suspended solid/kg solution. This is settled and clear NaOH sol⁰ is withdrawn and is replaced with equal weight of water and the mixture is thoroughly agitated. After repeating this procedure (clean water wash) twice what fraction of original NaOH remains unRecovered?

Egm Data:-

$x = \text{wt. fraction of NaOH in clear SCl}^0$	$x = \text{wt. fraction N = kg CaCO}_3$ kg Solution in Settled Sludge	$y^* = \text{wt. fr. of NaOH in SCl}^0 \text{ of the Settled Sludge}$
0.09	0.495	0.0917
0.07	0.525	0.0762
0.0473	0.568	0.0608
1	1	1
1	1	1
1	1	1
1	1	1
0.00450	0.666	0.01015

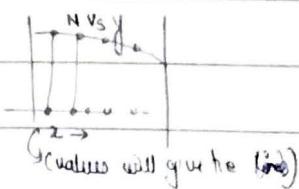
Sol⁰:

Basic is 1 kg Sol⁰:

$$10\% \text{ NaOH} \rightarrow (= 0.1 \text{ kg}) \quad (\text{NaOH})$$

$$A = 0.9 \text{ kg} \quad (\text{water})$$

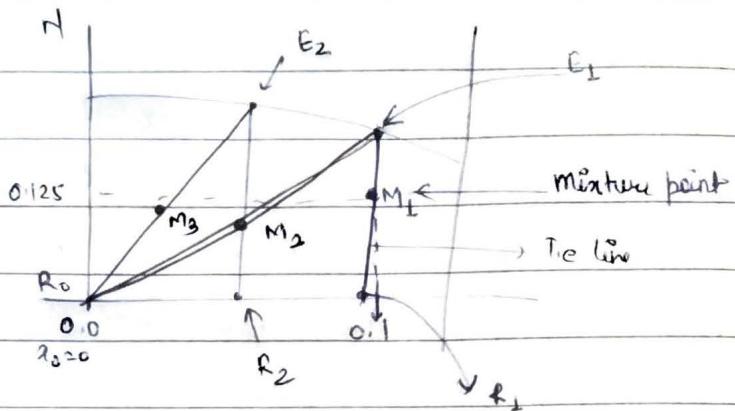
$$B = 0.125 \text{ kg} \quad (\text{Ca CO}_3)$$



Find $y_{M_1} = ?$ $N_{M_1} = ?$ [Solution Balance]

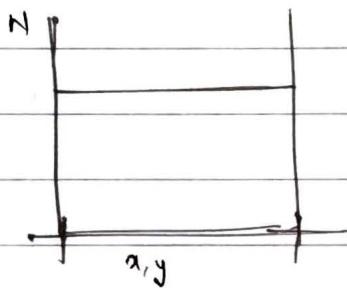
$$y_{M_1} = 0.1 \quad N_{M_1} = \frac{0.125}{0.1 + 0.9} = 0.125$$

Mixture point is given.



from next stage pure water is added,

Re added for 2nd Stage (known that is pure), $x_0 = 0$.



If tie lines are vertical

- only one N-data would be needed. (we do not need the x-y* com data)