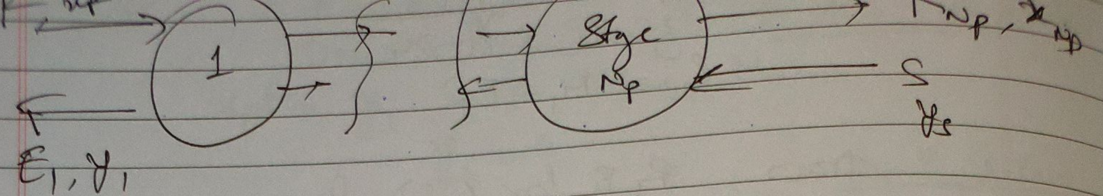

Leaching

Leaching — percolation of liquid through a bed of solid

Leaching of alkali from wood ashes

Solid-liquid extraction

Decoction — use of solvent at boiling temperature.

If solute is on surface — elution / elutriation

Ind operations (1) $CuSO_4$ from ores — H_2SO_4 / ammoniacal solutions

Gold — NaCN solutions
Leaching of ores to extract its products
for → Al, Co, Manganese, Ni, Zn

Sugar from sugar canes — leaching using water as solvent

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Vegetable seeds :- organic solvents

Tannin :- wood barks of tree using water

Bollaman extractor

Basket type m/c

Solids are taken in perforated baskets. The baskets are attached to a chain conveyor. The conveyor takes the baskets down on the right and up on the left as per the arrangement shown in fig.

It is a continuous operation of contact between solids & solvent.

As the baskets move downwards, leaching of solute by solvent continues in a parallel flow by dilute solution. The solution is collected at the bottom of the vertical held column. This miscella is pumped and raised to spray over the basket at the top. The liquid solvent percolates through the solids from basket to basket.

On the other side, when the baskets are rising, the solids are leached counter currently by a spray of fresh solvent to produce half miscella. A short drainage time is provided at the top. This provision is below the solvent spraying sections.

Leaching

Recovery of solute from a feed (solid) using a liquid solvent

Three components system

Solid feed contains solid + solute

Solid is insoluble in solvent

Solute is soluble

Notations:

Insoluble solid — B

Solute — C

Solvent — A.

Ternary diagram — can be used

Crowding of the construction into one corner of such a system is the disadvantage for leaching system.

Hence rectangular diagram is used coordinate system is used

Notations:

Concentration of insoluble 'B' will be enforced as

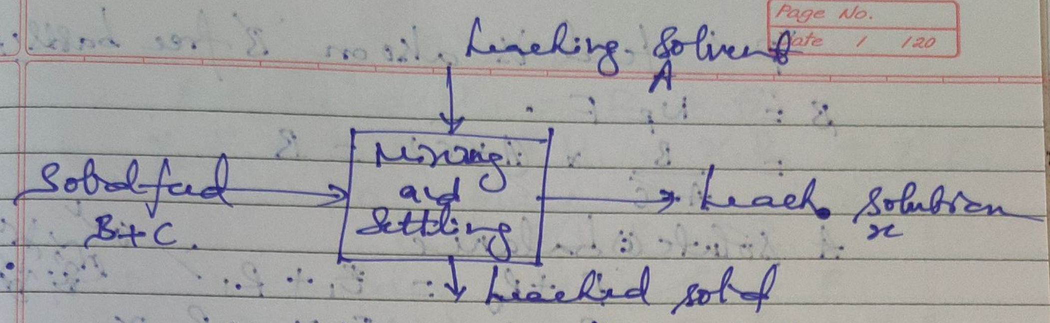
$$N = \frac{\text{Mass of } B}{\text{Mass } (A+C)}$$

The solid may be wet with liquid or not, $N = (B/A+C)$

x = wt. fraction 'C' in effluent solution on 'B' free basis

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

y = wt. fraction 'C' in Solid/Slurry $= \frac{C}{A+C}$



'y' — wt. fr. of 'C' in leached solid includes

(a) All solute C associated with the moisture — dissolved in adhering solution as well as undissolved or adsorbed solute

Before operation if the solid is dry

$N = \frac{B}{A+C}$ ∴ $A = 0$ ~~$C = 0$~~ } A & C are soluble substances

$N = \frac{B}{0+C} = B/C$

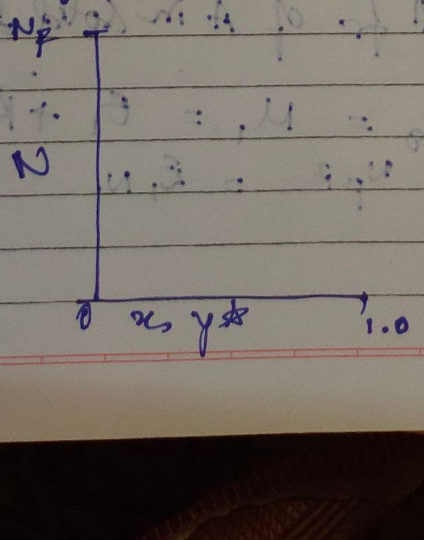
$y = \frac{C}{A+C} = \frac{C}{C} = 1$

For pure solvent used in the operation

~~N = 0, no, no B in it, N =~~

$N = 0$ since $B = 0$, ∴ $N = B/A+C = 0$

$x = \frac{C}{A+C} = 0$



F : feed is also on 'B' free basis, $F = A + C$

$B = N_F F$

$= \frac{B}{A+C} \times (A+C) = B$

A solute (C) balance

$F + R_0 = E_1 + R_1$ — on 'B' free basis (approx)

$F y_F + R_0 x_0 = E_1 y_1 + R_1 x_1$

R_0 — is the notation used for solvent

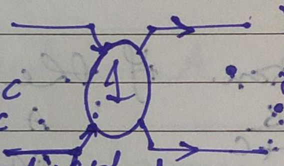
Solid to be leached

B - insolubles

F — A+C

$N_F = B/A+C$

$y_F = C/A+C$



Leaching solvent

$R_0 = A+C$

$x_0 = C/A+C$

Leached solid

B = insolubles

$E_1 = A+C$

$N_1 = B/A+C$

$y_1 = C/A+C$

Leach solution

$R_1 = A+C$

$x_1 = C/A+C$

Single stage operation

Wt fr of C + Wt fr of A = 1.0

x + ( ) = 1.0

Wt fr of A = 1 − x

Wt fr of C in solid = y

Wt fr of A in solid = 1 − y

$F + R_0 = M_1 = E_1 + R_1$

$B = N_F F = E_1 N_1$

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$$B = N_p F = N_1 E_1$$

$$F + R_0 = M_1 = R_1 + E_1$$

$$y_p F + x_0 R_0 = y_1 M_1 = x_1 R_1 + y_1 E_1$$

To replace R_1

~~Replace~~ $(M_1 - E_1) = R_1$

Consider $M_1 = R_1 + E_1$

$$y_{M_1} M_1 = x_1 R_1 + y_1 E_1$$

$$y_{M_1} M_1 = x_1 (M_1 - E_1) + y_1 E_1$$

$$y_{M_1} M_1 = M_1 x_1 + E_1 (y_1 - x_1)$$

$$E_1 = \frac{M_1 (y_{M_1} - x_1)}{(y_1 - x_1)}$$

Hence find $R_1 = M_1 - E_1$

$$y_{M_1} = \frac{y_p F + x_0 R_0}{M_1} \quad \text{where } M_1 = F + R_0$$

Leaching

Equilibrium Curves

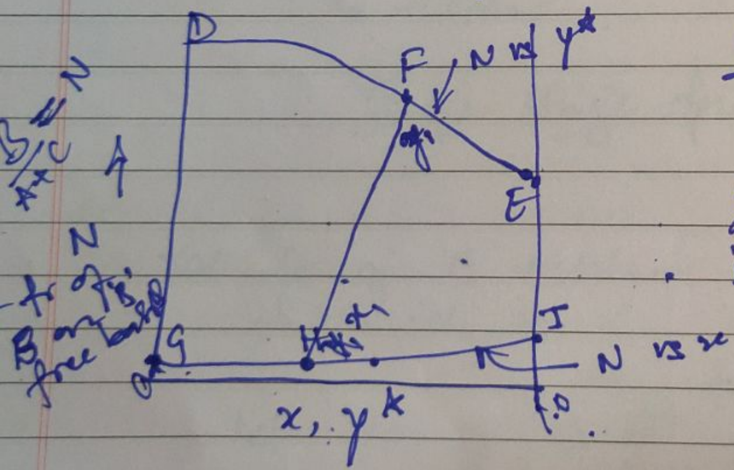
Case i. Solute C is infinitely soluble in the solvent A.

x and y values may have values over the range 0 — 1.0

x – wt fr in leach solution
y – wt fr in leached solid

Ex : Soyabean oil (C)
Soyabean seed (B)
Hexane (A)

oil (C) and Hexane (A) are infinitely soluble



The curve GHJ is leach solution data

The curve DFE is leached solid data

The curve GHJ lies above x-axis i.e. above N = 0.

Above N = 0 means that

- Either solid (B) is partially soluble in the solvent (A) OR an incompletely settled liquid has been withdrawn

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~~Note that~~ Note that
N = 0 represent
no solid is soluble in solvent A
And also clear liquid is withdrawn

The Tie lines such as FH are not vertical, means $x \neq y$
And as in figure $y^* > x$
This will result when:
(i) If insufficient time of contact with leaching solvent to dissolve all solute is permitted.

(ii) If preferential adsorption of the solute occurs (some solute C is adsorbed & cannot be leached by washing / requires reducing the pressure or increasing the temperature to desorb)

(iii) If the solute (C) is soluble in the solid B and distributes unequally between the liquid and the solid phases at equilibrium.

Case ii) No adsorption of solute (C) on solid (B):

i. The leach solution and the solution associated with the leached solid (after separation of two layers) have same composition.

ii. $x = y$; the tie lines are vertical.

iii. N in leach solution is zero, hence merges with x-axis (N vs x)

iv. N in leached solid is constant 'for all the data of leached solid phase'

N vs y^*

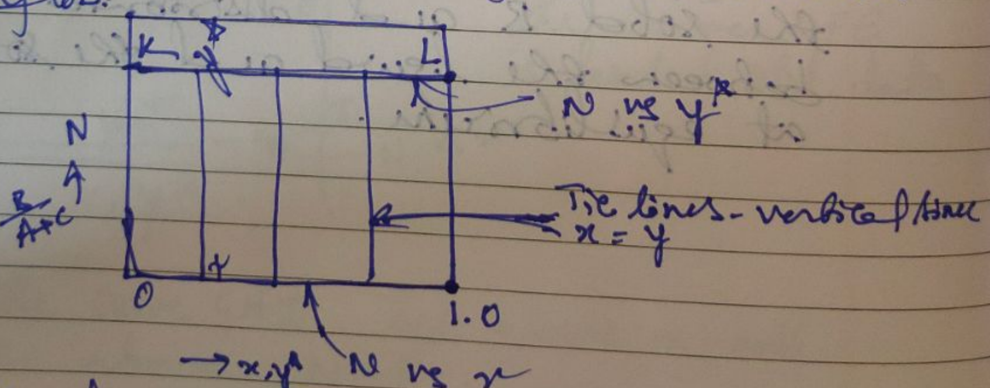
$\therefore N = \text{constant}$

$\therefore$ The distribution co-efficient $= \frac{y^*}{x}$

$= 1.0$

Hence KL (N vs y^*) is horizontal

This condition is referred as "constant overflow".



Constant overflow refers to the solids are settled or drained to the same extent at all solute concentrations.

The leach solution contains no solid (B) either dissolved or suspended.

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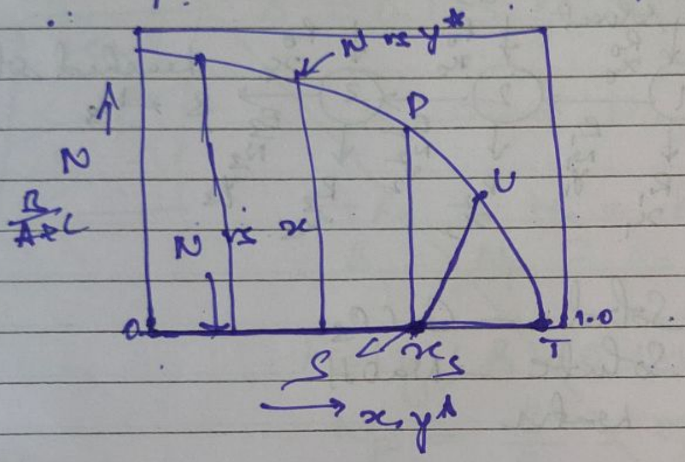
Case iii) Substance B is either dissolved or suspended in solvent A.



Unsaturated solution

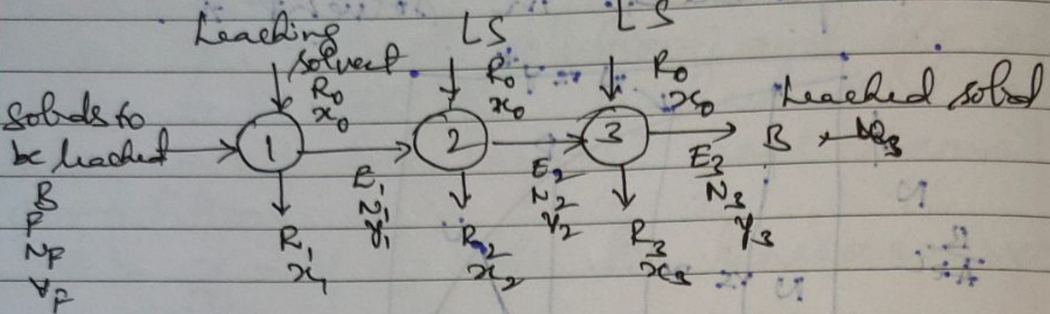
i. The solute C has limited solubility in the solvent A.

ii. No clear solution stronger than x_s
Any leach solution with concentration of C greater than x_s do not exists as the solubility of 'C' in solvent is limited.

$\frac{23 \text{ g of solute C}}{100 \text{ g solution (A+C)}} \Rightarrow x_s$

'C' can be dissolved in the solution (A+C)

Multistage Cross current operation



Solid – $CaCO_3$

Solute – NaOH

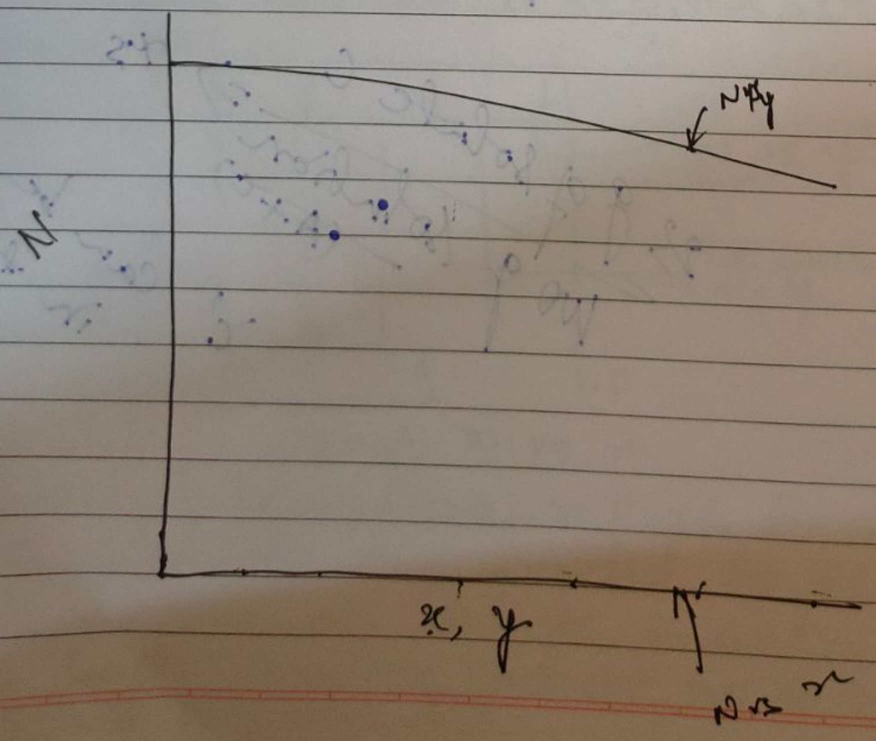
Solvent – water

N = 0 since $CaCO_3$ is insoluble in water chosen as the solvent. Enough time is given to settle & separate, so that clear liquid is withdrawn as 'R' stream, And hence 'N' is 'R' phase is zero for all the cases

N vs y in 'E'

N vs x in 'R'

N = 0 for 'R'

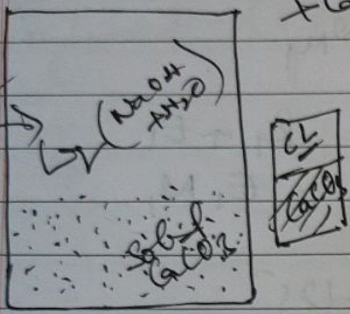


F = 1 kg solution in the original mixture ; 0.125 kg $CaCO_3$ / kg soln

$Ca(OH)_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaOH$

↓ water + $Ca(OH)_2$

A liquid solution of 10% NaOH + 90% water



$M_1 = 1 kg$

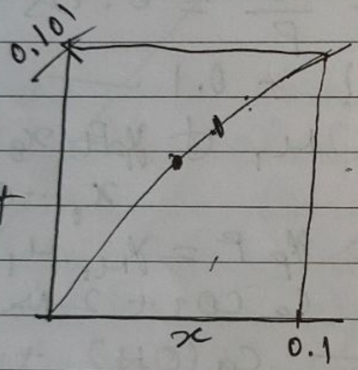
$y_{M_1} = 0.1$; $N_{M_1} = \frac{B}{A+C} = 0.125$

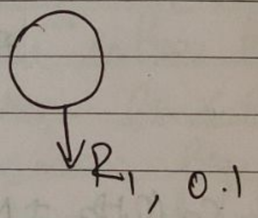
$B = N_F F$

$B = 0.125$ kg / kg solution

$N_F = B/F = \frac{0.125}{1} = 0.125$

$M_1 = 1 kg$, $F = 1 kg$





$F + R_0 = M_1 = R_1 + E_1$

$R_0 + E_1 = M_2 = R_2 + E_2$

$E_1 = \frac{B}{N_1}$

$N_{M_2} = \frac{B}{E_1 + R_0} = \frac{B}{M_2} = \frac{0.125}{1.0}$

~~Locate M_2 using~~ N_{M_2} on R_0E_1 line

$E_2 = B/N_2 = \frac{0.125}{0.62}$

$R_0 + E_2 = M_3 = R_3 + E_3$

$N_{M_3} = \frac{0.125}{1} = 0.125$

$y_{M_3} = \frac{C}{A+C} =$

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$B_3 y_3 = 0.189 \text{ kg } (0.012) = 0.00227 \text{ kg}$

$\frac{0.00227}{0.1 \text{ kg NaOH}} \times 100 = 2.27\%$

Stages : Illustration 13.2

Given Data — Not call

i. $F = 1$ kg (On 'B free basis')

ii. $M_1 = 1$ kg (0.1 kg NaOH + 0.9 kg solution)

iii. $y_F = y_{M_1} = 0.1$

iv. Fresh solvent in second & third stage

$x_0 = 0$

R_0 is equal to R_1

Hence $M_1 = M_2 = M_3$

v. $B = 0.125$ kg / kg solution

vi. $N_{M_1} = \frac{B}{F} = \frac{0.125}{1} = 0.125$

vii. Given N (in E), y^* and x

viii. Given $CaCO_3$ is insoluble in water

Hence 'B in 'R' is zero

$N = (B/A+C)_{in\ R} = 0$

for all the conditions N vs x is merging with x-axis.

ix. Draw N vs y^* and N vs x on the same graph sheet

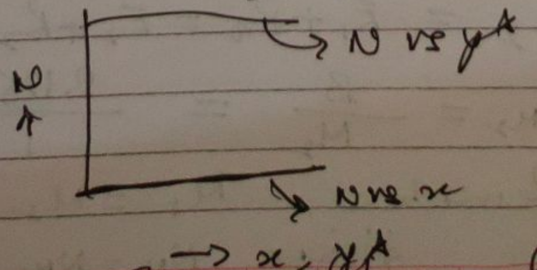
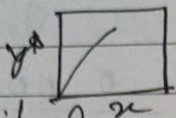


Fig 1: Equilibrium diagram

x. Draw y^* vs x on a separate graph



$y^* > x$ (Curve above 45° line)

~~Stage 1:~~ Fig 2: Distribution curve

~~xi.~~ Locate M using $x_{M_1} = 0.1$

$N_{M_1} = 0.125$

xii. Find y^* & x from distribution curve, when joined on equilibrium curve (Fig 1), should pass ~~through~~ through M_1.

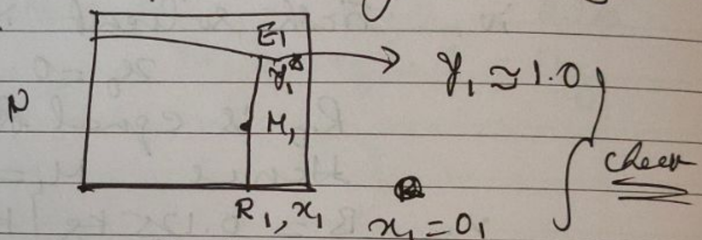


Fig 3: x, y^* Solution

xiii. Read y-axis value corresponding to E_1 located on N vs y^*, to get $N_1 = 0.47$ & $y_1 = 0.1001$.

Find $E_1 = \frac{B}{N_1}$ ($B = N_F F = E_1 N_1 = E_2 N_2 = E_3 N_3$) since 'B' is insoluble and no 'B' in 'R' ($R_0 / R_1 / R_2 / R_3$)

$E_1 = \frac{0.125}{0.47} = 0.2664$ kg

xiv. $R_1 = M_1 - E_1 = 1 - 0.266 = 0.734$ kg

Stage 2:

xv. $M_2 = E_1 + R_0 = E_2 + R_2 = 1.0 = 0.266 + 0.734$

$N_{M_2} = \frac{B}{M_2} = \frac{0.125}{1} = 0.125$

Remember $M_1 = M_2 = M_3 = 1.0$ kg

Hence $N_{M_1} = N_{M_2} = N_{M_3} = 0.125$

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Since $E_1 + R_0 = M_2$
Locate M_2 on 'E_1R_0' line
at $N_{M_2} = 0.125$

(Read optional, not required for calculation $y_{M_2} =$)

xvi. Find y^*, x from Fig 2 to pass through 'M_2' point, locate E_2 at y^* & R_2 at x

xvii. Join $R_0 E_2$ since R_0 is feed to E_2

Read N_2 (y-axis value of E_2); $y^* = y_2$, $E_2 = B/N_2 = \frac{0.125}{0.035} = 0.202$ kg

xviii. Locate M_3 on R_0E_2 line at $N_{M_3} = 0.125$

xix. Find y^* & x from ~~Fig~~ Fig 2 to locate R_3 at x and E_3 at y^*

$y^* = y_3$ $y_3 = 0.012$

Read N_3, Find $E_3 = B/N_3$, $E_3 = \frac{0.125}{0.0662} = 0.0189$

xx. $E_3 y_3 = 0.0189(0.012)$
$= 0.00227$

% NaOH unrecovered $= \frac{0.00227}{0.1 \text{ kg NaOH in feed}} \times 100$

$= \underline{\underline{2.27\ \%}}$