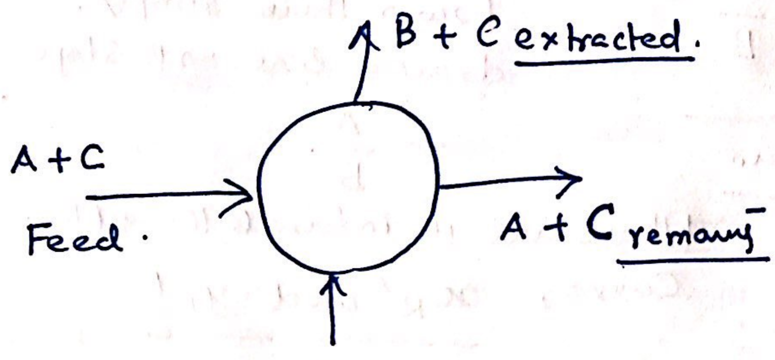
Insoluble Liquid

When the extraction solvent and the feed solution are insoluble ~~immiscible~~ (Carrier and Solvent completely insoluble), and remain so at all concentrations of the distributed solute occuring in the operation, the computations can be simplified by using x' and y' Co-ordinates. (C - Free fraction).

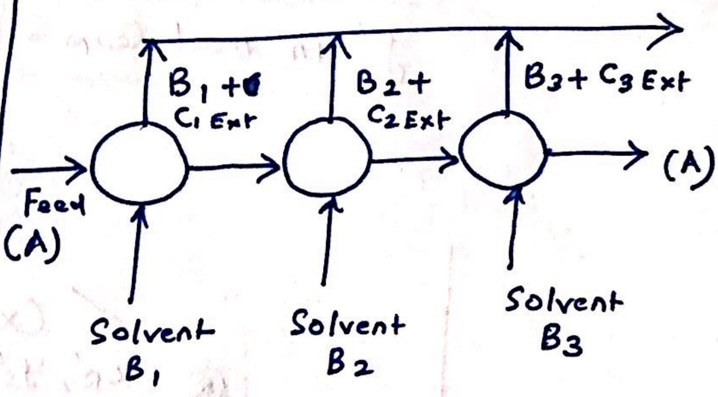
So we have
$$x' = \frac{x}{1-x}$$
$$y' = \frac{y}{1-y}.$$

Since A and B are insoluble, there-fore for a single stage process the Raffinate will contain A kg of Carrier and the extract will contain B kg of Solvent.



For Single Stage

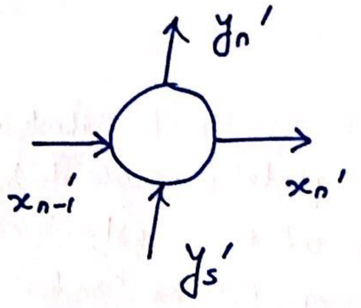
For multi stage cross flow:



$\therefore$ The Solute balance at any stage n is given as:-

$$\boxed{A \cdot x_{n-1}' + B_n y_s' = B_n y_n' + A \cdot x_n'}$$

C Balance.



x or y $= \dfrac{\text{Fraction of C. (Flow rate)}}{\text{Fraction A (Flow rate)} + \text{Fraction B Flow rate.}}$

Since A and B are insoluble,

So For all x, Fraction of B = 0 (Flow rate)

For all y, Fraction of A = 0 (Flow rate).

$$\Rightarrow \quad \frac{y_s' - y_n'}{x_{n-1}' - x_n'} = -\frac{A}{B_n}.$$

For a Single stage.

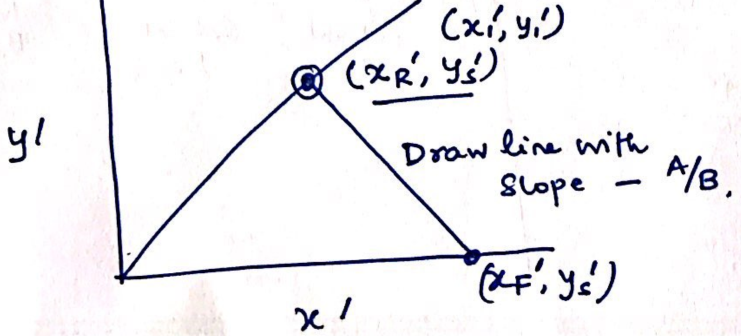
$$\frac{y_s' - y_E'}{x_F' - x_R'} = -\frac{A}{B}.$$

y_s' in most Cases is Zero

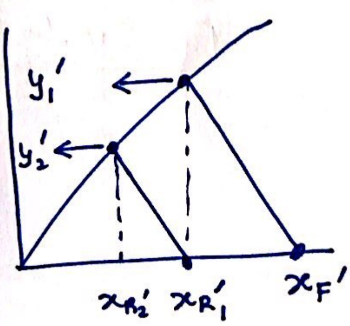
Point x_F' is known.

From there simply draw a line with slope $-\dfrac{A}{B}$.

Where ever it intersects the eqlbm. Curve, x_R' and y_E'

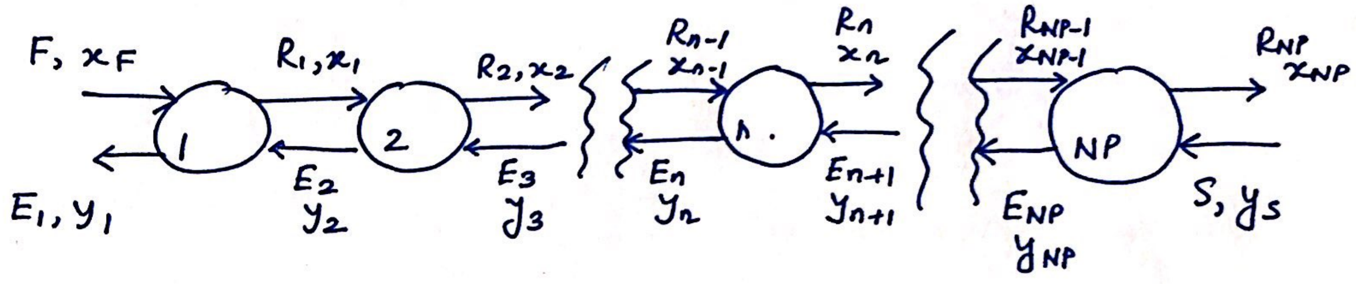


For multiple stage



Continuous Counter Current operation with insoluble Liquids

Flow Sheet remains the Same:-



Since A and B are completely insoluble,

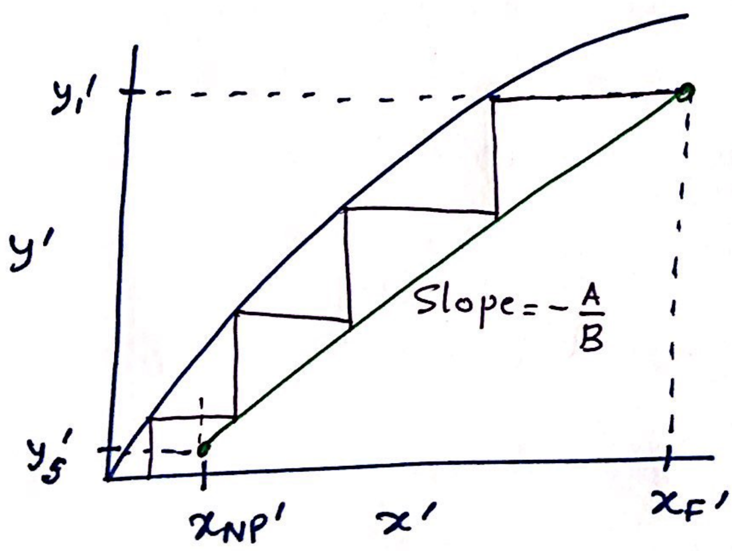
∴ Solvent content of all Extract Stream and Carrier content of all Raffinate Stream are ~~Same~~, Constant.

Consequently, The overall plant balance reduces to.

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

$$\Rightarrow \quad \frac{A}{B} = \frac{y_1' - y_s'}{x_F' - x_{NP}'}$$

Which is the eqn. of a Straight line or the operating line having Slope A/B through points. (y_1', x_F') and (y_s', x_{NP}').



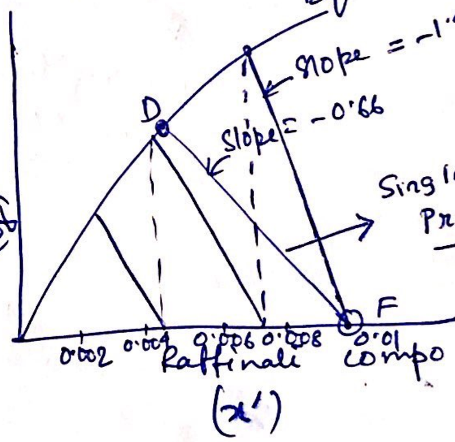
10.2) Nicotine (C) in a water (A) solution containing 1% nicotine is to be extracted with kerosene (B) at 20°C. Water and kerosene are essentially insoluble. (a) Determine the percentage extraction of nicotine if 100 kg of feed solution is extracted once with 150 kg solvent. (b) Repeat for three theoretical extractions using 50 kg solvent each.

$x' = \frac{\text{kg nicotine}}{\text{kg water}}$	0	0.001011	0.00246	0.00502	0.00751	0.00998	0.0204
$y'^{*} = \frac{\text{kg nicotine}}{\text{kg water}}$	0	0.000807	0.001961	0.00456	0.00686	0.00913	0.01870

(a) $x_F = 0.01$ wt fraction nicotine, $x'_F = \frac{0.01}{1-0.01} = 0.0101 \frac{\text{kg nicotine}}{\text{kg water}}$

$F = 100$ kg $A = 100(1-0.01) = 99$ kg water

$\frac{A}{B} = \frac{99}{150} = 0.66$



from F, line FD is drawn of slope (−0.66), intersecting the equillibrium curve at D, where $x'_1 = 0.00425$ kg nicotine / kg liquid,

$y'_1 = 0.00380$ "

The nicotine removed from the water is therefore

$99(0.0101 - 0.00425) = 0.58$ kg or 58% of that in the feed.

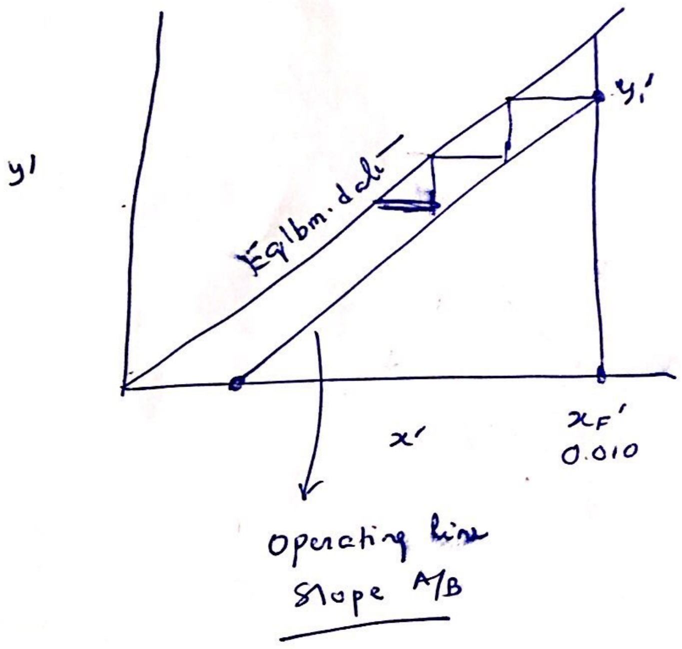
(b) For each stage, $\frac{A}{B} = \frac{99}{50} = 1{\cdot}98$,

The construction is started at F, with operating lines of slope $-1{\cdot}98$.

The final raffinate composition is $x_3' = 0{\cdot}0034$, and the nicotine extracted is $99(0{\cdot}0101 - 0{\cdot}0034) = 0{\cdot}663$ kg or 66·3% of that in the feed.

10.4 If 1000 kg/h of a Nicotine (C) – Water (A) solution containing 1% nicotene is to be counter currently extracted with Kerosene at 20°C to reduce the nicotene content to 0.1%, determine the min Kerosene rate and (b) No. of theoretical stages if 1150 kg of Kerosene is used.

Plot Eqlbm. Data.



(b)

$x_{NP} = 0.001$

$x_{NP}' = \frac{0.001}{1-0.001} = 0.001001$

$B = 1150$ kg.

$A = 1000 \times (1-0.01) = 990$ kg.

$A/B = \frac{990}{1150} = 0.86$

Now we have

$$\frac{y'-0}{x_F' - x_{NP}'} = 0.86$$

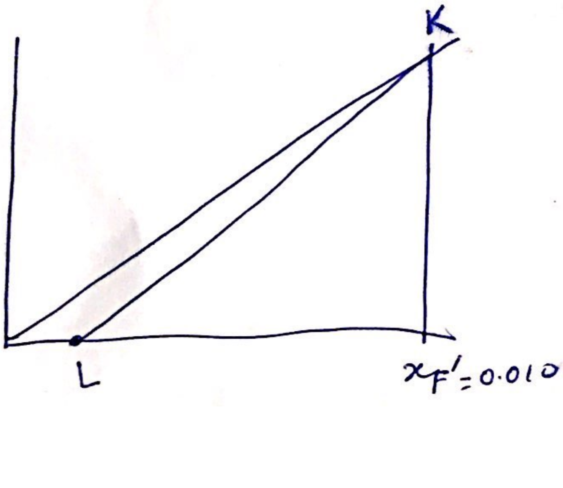
$$\Rightarrow \frac{y'}{0.0101 - 0.001001} = 0.86$$

$$\therefore y_1' = 0.00782$$

For (a)

$x_{NP} = 0.001$

$x_{NP}' = \frac{0.001}{1-0.001} = 0.001001$ $\frac{\text{Kg Nicotene}}{\text{kg Water}}$



Op line for this case starts at L ($y' = 0$ and $x' = 0.001001$) and passes through K on the equilibrium curve at x_F'. Since

$y_K = 0.0093$

$$\frac{A}{B_m} = \frac{0.0093 - 0}{0.0101 - 0.001001} = 1.021$$

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