الجامعة التكنولوجية

قسم الهندسة الكيمياوية

المرحلة الثالثة

انتقال كتلة

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$$\therefore \boxed{W = \frac{13.5}{0.72 - x_w}}$$

sub. for (W) in eq. (5) :-

$$\ln \frac{(13.5/(0.72 - x_w))}{50} = \frac{1}{4.15 - 1} \ln \left(\frac{x_w (1 - 0.45)}{0.45 (1 - x_w)} \right) + \ln \left(\frac{1 - 0.45}{1 - x_w} \right)$$

$$\boxed{\therefore x_w = 0.309}$$

$$\boxed{\therefore W = 32.85 \text{ kmol}}$$

$$\because D = F - W$$

$$= 50 - 32.85$$

$$\boxed{D = 17.15 \text{ kmol}}$$

Ex.(3):- A mixture of 100 mole containing 50% mole of n-pentane and rest is n-heptane, is distilled under differential conditions at 1 atm, until (40 mole) is distilled. What are the compositions of liquid left and total vapour distilled?

X:	1.0	0.867	0.594	0.398	0.25	0.145	0.05	0.0
y:	1.0	0.987	0.925	0.836	0.7	0.521	0.27	0.0

Sol.:- Overall M.B

$F = D + W \Rightarrow 100 = 40 + W$

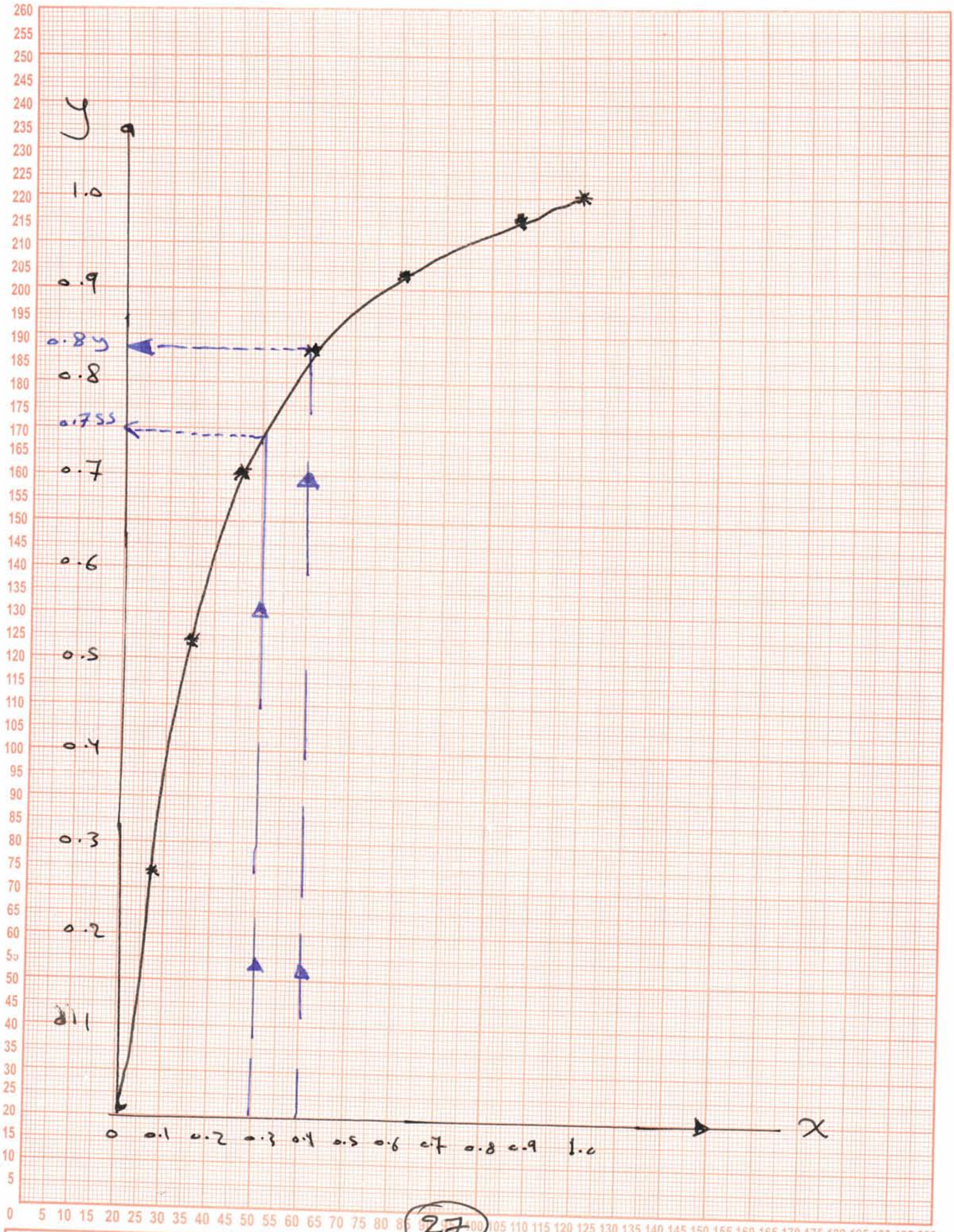
$W = 60$ mole.

$$\ln \frac{F}{W} = \int_{x_w}^{x_F} \frac{dx}{y^* - x} \Rightarrow \ln \frac{100}{60} = \int_{X_w}^{0.5} \frac{dx}{y^* - X}$$

$$0.51 = \int_{x_w}^{0.5} \frac{dx}{y^* - x}$$

assume $x_w = 0.3$, y^* from the Fig.

assume X:	0.3	0.35	0.4	0.45	0.5
from Fig. y^*:	0.755	0.8	0.84	0.86	0.89
$y^* - x$:	0.455	0.45	0.44	0.41	0.39
$\frac{1}{y^* - x}$:	2.197 (F_0)	2.22 (F_1)	2.27 (F_2)	2.44 (F_3)	2.56 (F_n)



المادة:　　الموضوع:　　٢٠١ / /

$$A = \frac{h}{3}\left[F_0 + 4\sum odd + 2\sum even + F_n\right]$$

$$A = \frac{0.05}{3}\left[2.197 + 4 * (2.22 + 2.44) + 2 * 2.27 + 2.56\right]$$

$$A = 0.47 \neq 0.51$$

Assume another $x_w = 0.277$

X:	0.277	0.333	0.389	0.444	0.5
y^*:	0.73	0.78	0.815	0.855	0.889
$y^* - x$:	0.453	0.447	0.426	0.411	0.389
$\frac{1}{y^* - x}$:	2.207	2.23	2.3474	2.433	2.57

$$h = \frac{0.5 - 0.277}{5} = 0.045$$

$$A = \frac{0.045}{3}\left[2.207 + 4 * [2.23 + 2.433) + 2 * 2.347 + 2.57\right]$$

$$A = 0.42 \quad \alpha \neq 0.51$$

$\therefore x_w = 0.3$ we take this value

$$F * x_f = W * x_w + D * y_D$$

$$100 * 0.5 = 60 * 0.3 + y_D * 40$$

$$y_D = 0.8$$

2- Flash (equilibrium) or Integral Distillation

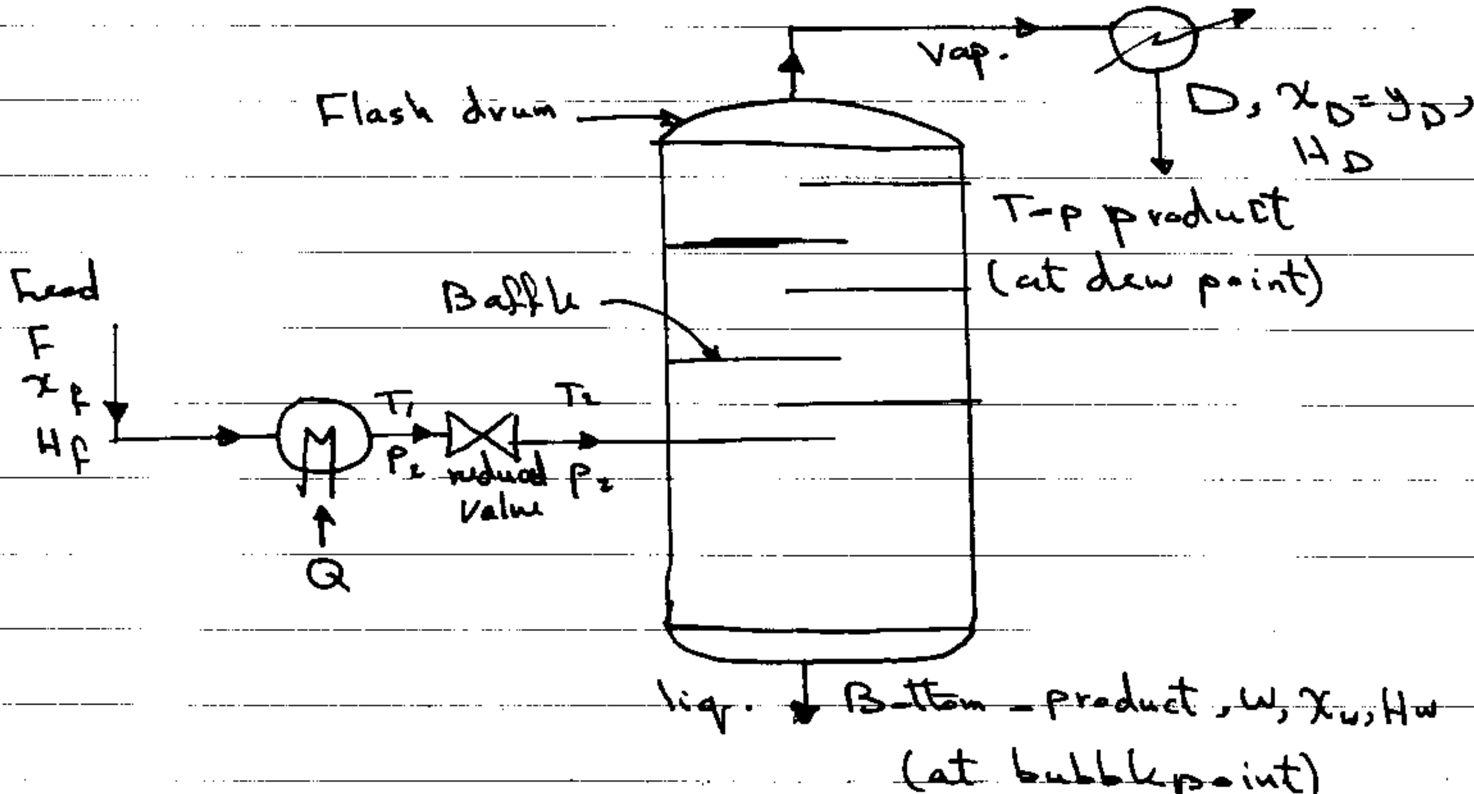
If a sufficiently hot liquid mixture is throttled into a vessel, a part of it will vaporize. The vapour produced will be richer in the M.V.C, and thus partial separation of the desired components will be achieved. This is called "flash vaporization or equilb" vaporization". The feed is first heated in a heat exchanger under pressure and then led to a flash drum by throttling where partial vaporization of the feed occurs under reduced pressure. The vapour leaves the drum at the top and is condensed to get the top product. The fraction having a higher concentration of the L.V. leaves the drum as a liquid bottom product. It is often assumed that the liquid and vapour streams leaving the flash drum are in equilibrium, therefore the process is also called "equilibrium-vaporization".

Assumption:-

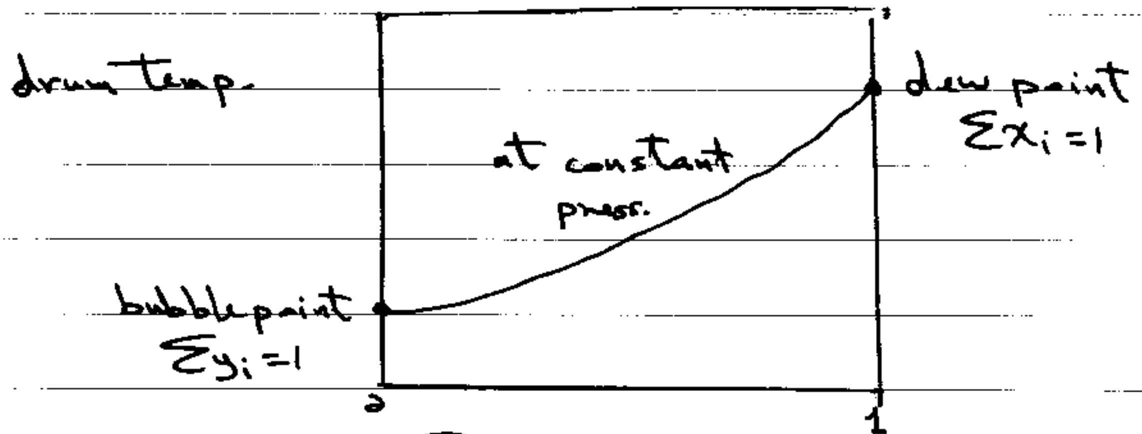
1- large contact surface between liq. and vapor, and vapor after forming should contact liquid till equilibrium occures

2- Temp. and press. of vapour out = Temp. and press. of liquid out (at equilibrium).

3- All components exisit in liquid should be exist in vapour, for vapour $\sum y_i = 1$ and liquid $\sum x_i = 1$.



" Schematic of Flash distillation Unit "



Overall M.B :-

$$F = D + W$$

$$F * x_f = D * y_D + W * x_w$$

$$F \cdot x_f = D * y_D + (F - D) x_w$$

$$x_f = \frac{D}{F} y_D + \frac{(F-D)}{F} x_w$$

$$x_f = f_v * y_D + (1 - f_v) x_w$$

$$\boxed{y_D = \frac{x_f}{f_v} - \frac{1-f_v}{f_v} x_w}$$ operating line equation for binary system.

Slope $= -\frac{1-f_v}{f_v}$, intercept with (y) axis $= \frac{x_f}{f_v}$

(*) For multicomponent system, equilib^n relation will be:-

$$y_i = k_i x_i \Rightarrow x_i = y_i / k_i \Rightarrow \text{(sub. for } x_w\text{)}:-$$

$$y_i = \frac{x_{fi}}{f_v} - \frac{1-f_v}{f_v} \frac{y_i}{k_i}$$

$$\boxed{\therefore y_i = \frac{k_i \, x_{fi}}{f_v(k_i - 1) + 1}}$$ for multi component.

Assume a value for $(f_v) < 1.0$, and calculate (y_i) for each component.

if $\sum y_i = 1$ then value assumed for (f_v) is correct.

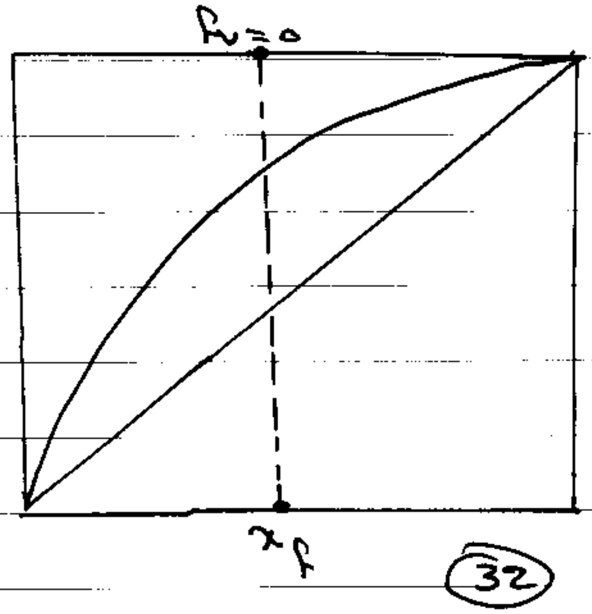
* For ideal solutions where:
$P_A = P_A^\circ \cdot x_A$ and $K_A = \dfrac{y_A}{x_A}$
then :-

$$y_i = \frac{x_{fi}}{f_v + \frac{P_T}{P_i^\circ}(1 - f_v)}$$ for ideal solutions

* if there is no-vaporization, then $D = 0$

$f_v = \dfrac{D}{F} = 0$, then slope $= \infty$

∴ Vertical line

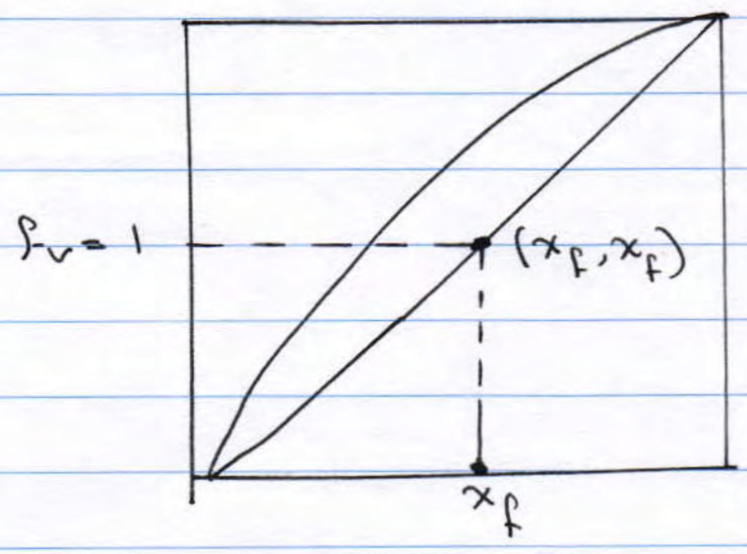


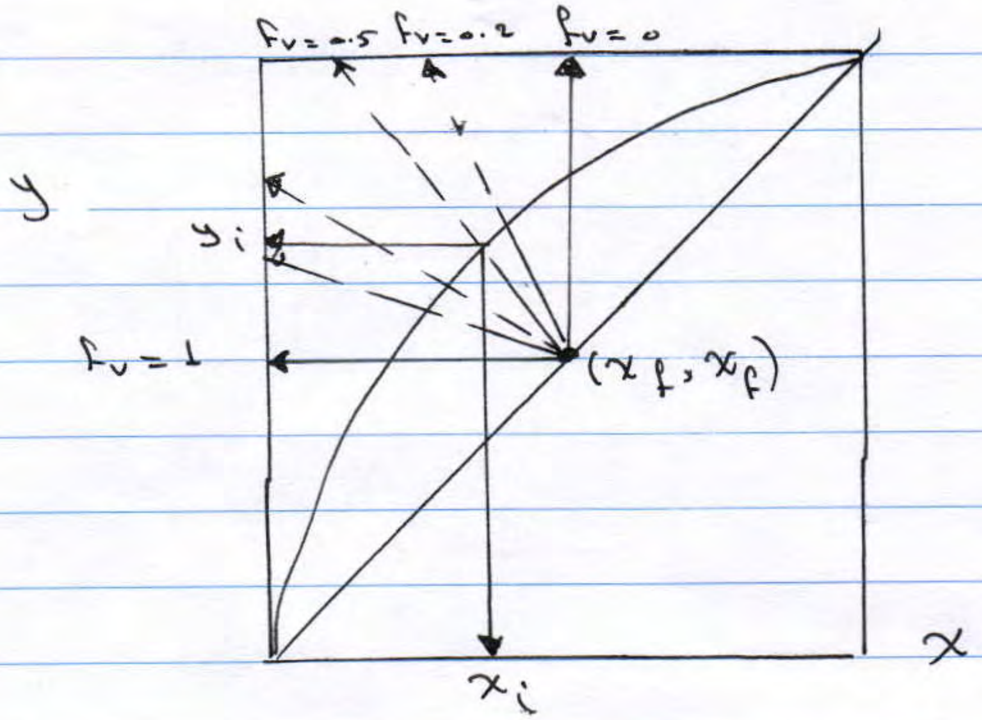
∴ composition of product = composition of feed.

* If there is total vaporization $D = F$

$\therefore \frac{D}{F} = 1$, then slope $= 0$

$\therefore$ horizontal line





Ex.(1) :- What fraction of a liquid mixture containing 10% mole propane, 65% mole n-butane, 25% mole n-pentane, would be vaporized in a flash vaporiz^{n}. process at 40°F and press. of 600 mm Hg. Assume liquid solution an ideal and vapour as an ideal.
vapour pressure at 40°F is :-

$P^{\circ}_{propane} = 3800$ mm Hg , $P^{\circ}_{n-but.} = 820$ mm Hg

$P^{\circ}_{n-pent.} = 140$ mm Hg

Sol. :- for ideal solution $\Rightarrow y_i = \dfrac{x_{fi}}{f_v + \frac{P_T}{P_i^{\circ}}(1-f_v)}$

let $f_v = 0.3$

$$y_1 = \frac{0.1}{0.3 + \frac{600}{3800}(1-0.3)} = 0.244$$

$$y_2 = \frac{0.65}{0.3 + \frac{600}{820}(1-0.3)} = 0.8$$

$$y_3 = \frac{0.25}{0.3 + \frac{600}{140}(1-0.3)} = 0.076$$

$\therefore \sum y_i = 1.119$

Assume $f_v = 0.49$

$y_1 = 0.17$, $y_2 = 0.75$, $y_3 = 0.08$

$\therefore \sum y_i = 1.0$

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Ex.(2) :- It is desired to seperate a binary mixture by distillation, the composition of the mixture 0.5 mol%. Calculate the fraction vaporized (f_v) required to obtained a top product composition 0.75 mol.fraction when using flash distillation.

Equilibrium curve $y = 1.2x + 0.3$.

with the range of liquid composition (0.3 → 0.8)

Sol. :- $y = 1.2x + 0.3$

∴ vapour in contact with liquid then :-

$y_D = 1.2\,x_w + 0.3$

for $y_D = 0.75$

∴ $0.75 = 1.2\,x_w + 0.3 \Rightarrow x_w = 0.375$

∴ We have now two points (0.75, 0.375) and (0.5, 0.5)

∴ slope of (f_v) line can be found.

$$slope = \frac{\Delta y}{\Delta x} = \frac{0.75 - 0.5}{0.375 - 0.5} = -2$$

$$\therefore \text{Slope} = -\left[\frac{1-f_v}{f_v}\right] = -2$$

$\therefore f_v = 0.33$

Ex.(3) :- It is required to vaporize 50% of the following liquid mixture :-

60% Benzene, 30% Toluene, 10% Xyelene.

what would be the composition of vapour is this mixture is subjected to flash distill^n. process at 1 atm, assuming an ideal liquid solution and gas.

Vapour - pressure data as follows:-

Temp. °C	$P^\circ_{Benz.}$	$P^\circ_{Tol.}$	$P^\circ_{xyl.}$
60		139	51
70	540	206	78
80	756	287	116
90	1008	404	168
100	1338	557	238
110	1740	741	330
120	2215	990	449

Sol. ; Hints :-

1- Take any temp. given, then multiply mole fraction (X_i) by each (P_i°) for each component and find (P_i) to each.

2- make summation (Σ) for (P_i) to find total press.

3- If this total press. = total press. given = 760 mm Hg or (1 atm), then (T) chosen is correct.

4- From this (T) found, (P_A°, P_B°, P_C°) are known.

5- Now, assume many values for (f_V) and find y_i, according to :-

$$y_i = \frac{x_i}{f_V + \frac{P_T}{P_i^\circ}(1 - f_V)}$$

6- Plot (y_i) (Vs) (f_V), and find (f_V) at ($y_i = 1$)

if we take (assume) T = 90

1- find P_1°, P_2°, P_3° from fig.

2- then calculate P_i from

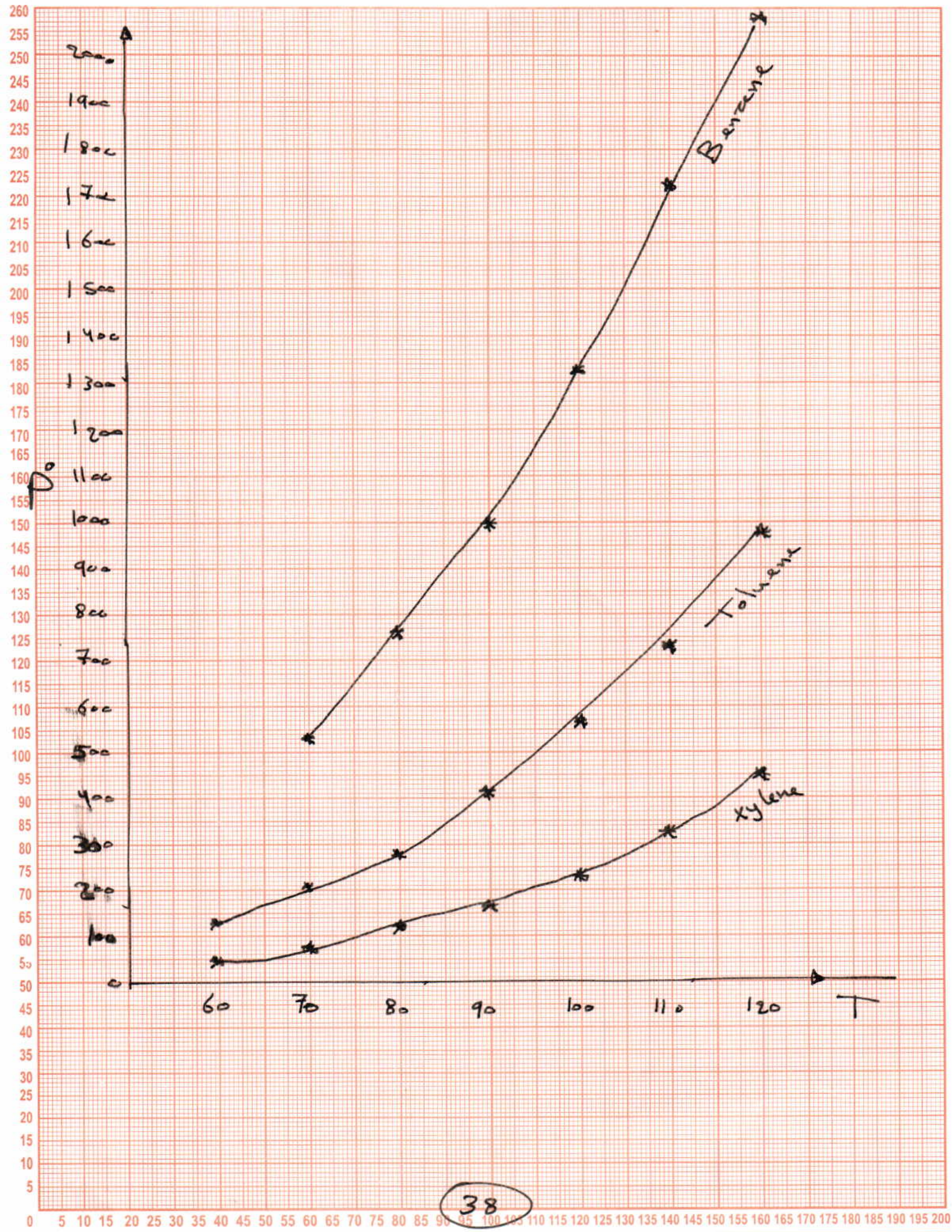
$$P_1 = P_1^\circ \cdot x_1 \leftarrow 0.6$$
$$P_2 = P_2^\circ \cdot x_2 \leftarrow 0.3$$
$$P_3 = P_3^\circ \cdot x_3 \leftarrow 0.1$$

3- then if $\sum P_i \simeq 1$ atm, then $\therefore T_{ass.}$ = correct.

4- then Take, P_1°, P_2°, P_3°, $\Rightarrow$ Assume $f_V = 0.4$

5- find y_1, y_2, y_3 from $y_i = \frac{x_i}{f_V + \frac{P_T}{P_i^\circ}(1 - f_V)}$

6- if $\sum y = 1$ $\therefore \Rightarrow$ $f_{V_{ass.}}$ = correct.


P°
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
60
70
80
90
100
110
120
T
Benzene
Toluene
Xylene