Tutorial-2

Q.1

Key formula:

Differential distillation: $\ln \frac{F}{W} = \int_{x_W}^{x_F} \frac{dx}{y^* - x}$

Flash distillation:

$$-\frac{W}{D} = \frac{y_D - z_F}{x_W - z_F} = \frac{H_D - (H_F + Q/F)}{H_W - (H_F + Q/F)}$$

x	y^*	$\frac{1}{y^* - x}$
0.0	0.0	∞
0.145	0.521	2.66
0.254	0.701	2.24
0.398	0.836	2.28
0.594	~~0.62~~ 0.925	3.02
0.867	0.984	8.55
1.00	1.00	∞

Basis || Feed (F) = 100 mol $z_F = 0.6$

$x_W = \ldots$

$y_D = ?$

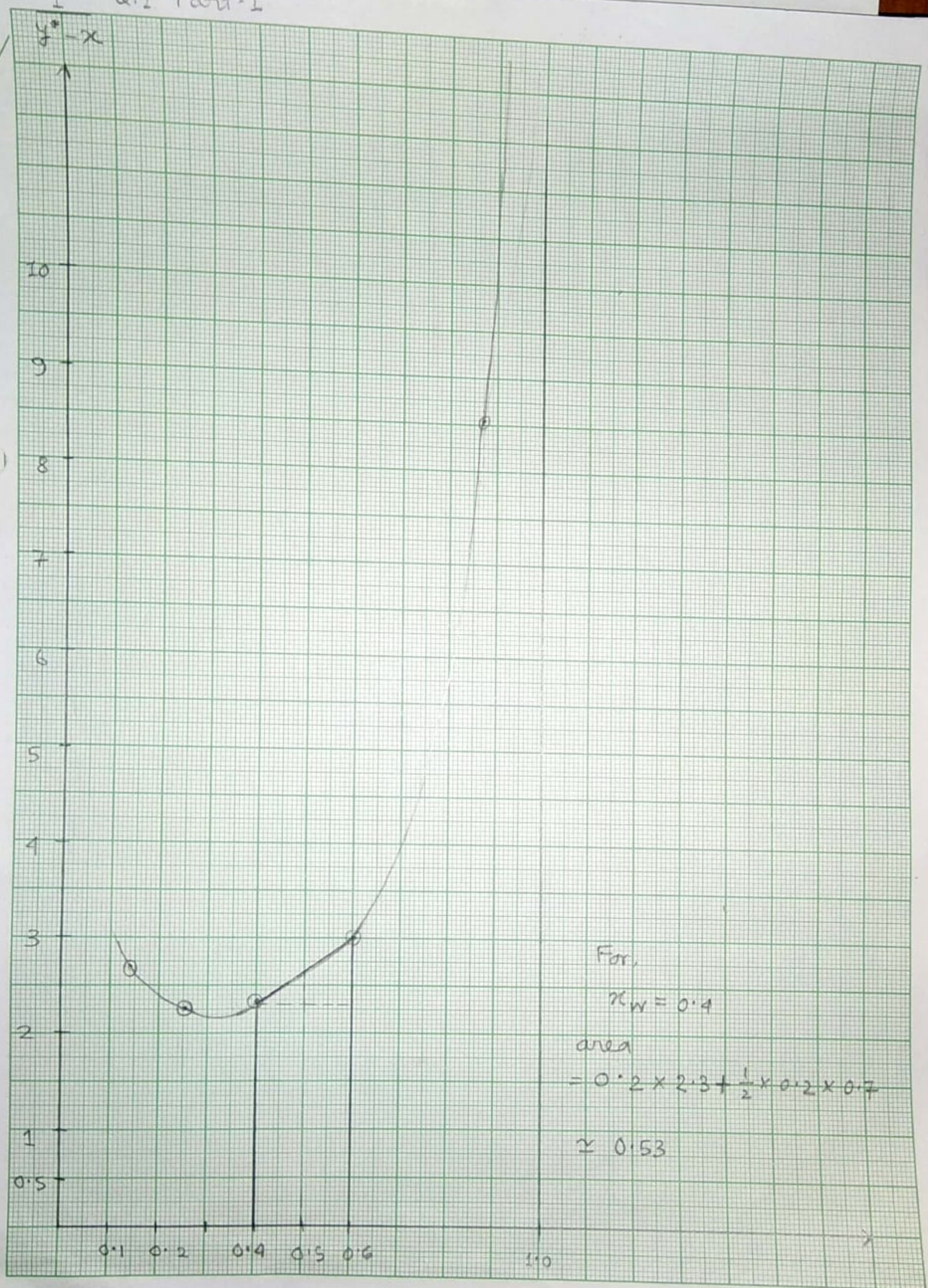
Distillate (D) = 40 mol

Residue (W) = 60 mol

$$\ln\left(\frac{F}{W}\right) = \int_{x_W}^{0.\cancel{8}6} \frac{dx}{y^* - x}$$

$$\ln\left(\frac{100}{60}\right) = 0.511 = \int_{x_W}^{0.6} \frac{dx}{y^* - x}$$

1 Q.1 Part-1



For,

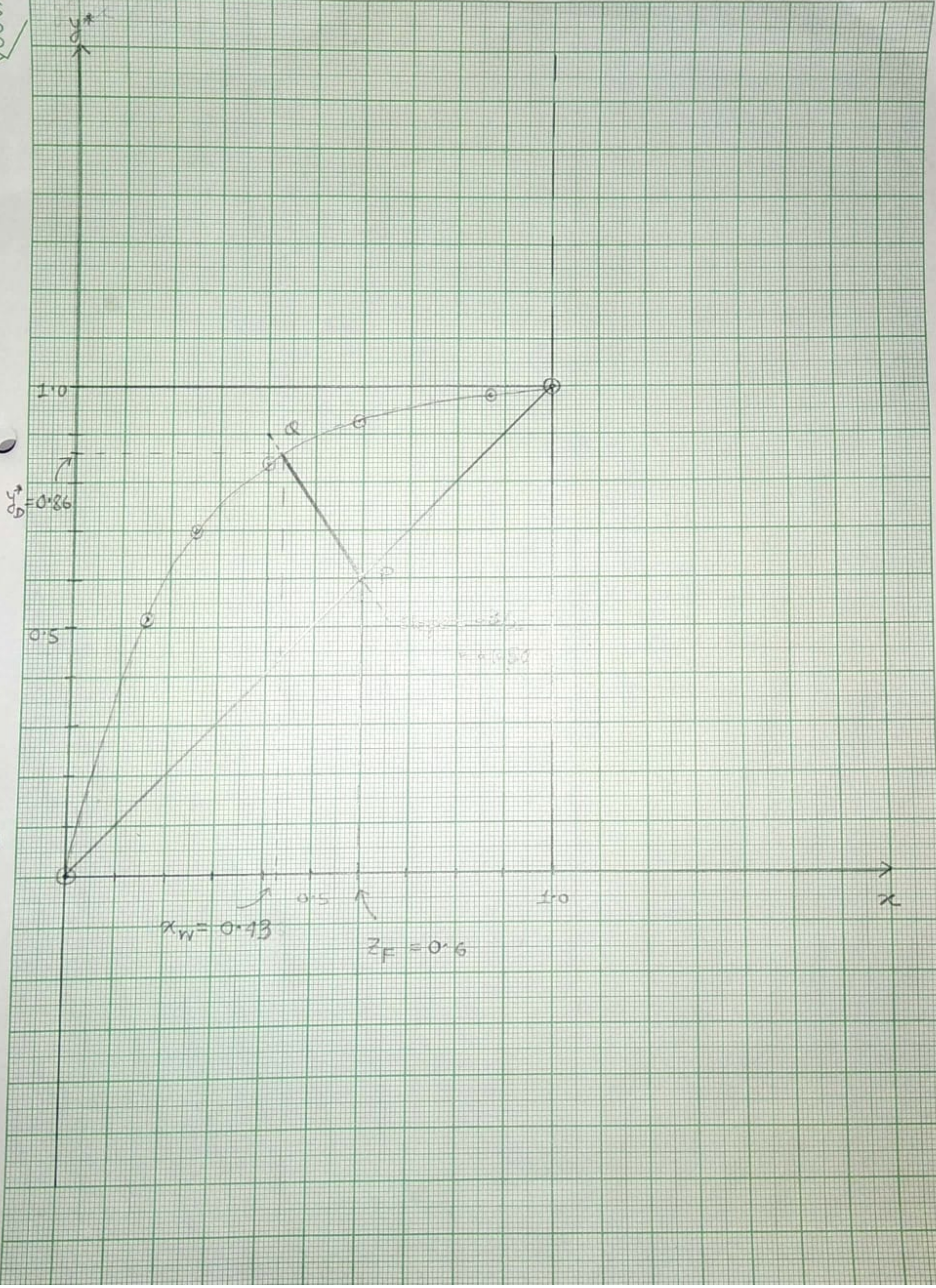
$x_W = 0.4$

area

$= 0.2 \times 2.3 + \frac{1}{2} \times 0.2 \times 0.7$

$\simeq 0.53$

Q.1 part 2



Graphically integrating,

$$x_W = 0.4 (\pm 0.01)$$

Now, $F x_F = D y_{D,av} + W x_W$

$$100 (0.6) = 40 \, y_{D,av} + 0.4 \times 60$$

$$y_{D,av} = 0.9 (\pm 0.01)$$

Equilibrium flash distillation

$$-\frac{W}{D} = -\frac{60}{40} = -\frac{3}{2}$$

Line of slope, $-3/2$ is drawn from the point (P) corresponding to $x = z_F = 0.6$ on the diagonal to the equilibrium curve at Q. Co-ordinates of Q gives x_W and y_D^*

Q.2

Basis = 100 mol of Feed

$z_F = 0.6$ $p_T = 760$ mm Hg

$F = 100$

$W = (100 \times 50/100) = 50$

$D = 50$

For Eqbm. flash vaporization

T (°C)	P_A (mm Hg)	P_B (mm Hg)	$x_A = \left(\frac{P_T - P_B}{P_A - P_B}\right)$	y_A $\left(\frac{P_A x_A}{P_T}\right)$
98·4	760	333	1	1
105	940	417	0·656	0·811
110	1050	484	0·488	0·674
115	1200	561	0·311	0·491
120	1350	650	0·157	0·279
125·6	1540	760	0	0

$$-\frac{W}{D} = -\frac{50}{50} = -1$$

From plot $x_W = 0.31$

$\cancel{Dx_D}$ $Fz_F = Dy_D + Wx_D$

$100 \times 0.4 = 50 y_D + 50 \times 0.31$

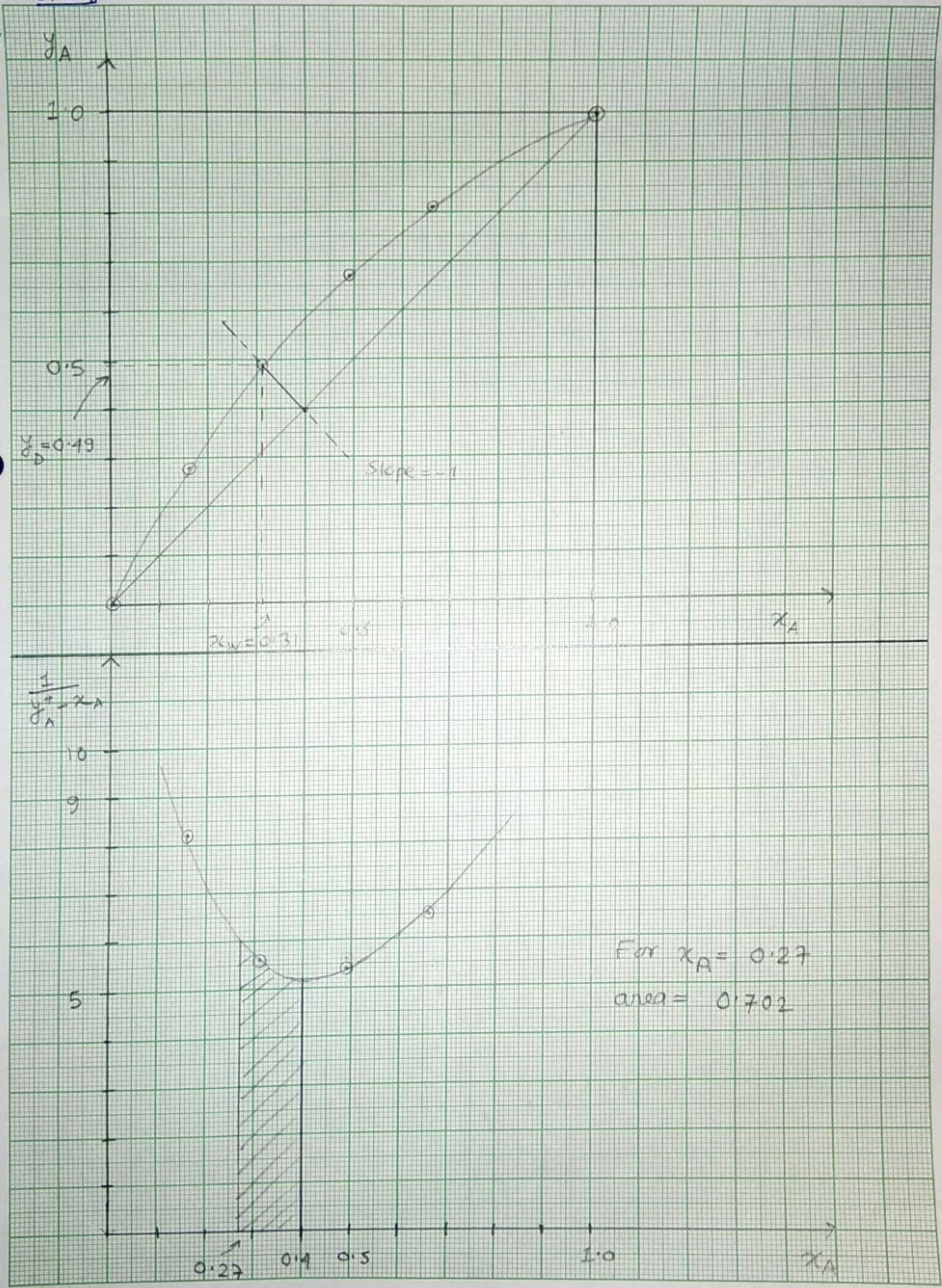
$y_D = 0.49$

For differential distillation

component

x_A	y_A	$1/(y_A - x_A)$
1	1	∞
0·656	0·811	6·452
0·488	0·674	5·376
0·311	0·491	5·556
0·157	0·279	8·197
0	0	∞

Q.2



y_A
1.0
0.5
y_D = 0.49
Slope = -1
x_W = 0.31
1.0
x_A
1/(y*_A - x_A)
10
9
5
For x_A = 0.27
area = 0.702
0.27
0.4
0.5
1.0
x_A

$\ln\left(\frac{F}{W}\right) = \ln 2 = 0.693$

$$= \int_{x_W}^{0.4} \frac{dx}{y_A^* - x_A}$$

for $x_W = 0.27$ area $\simeq 0.70$

Now,

$W x_W + D y_{D,avg} = F z_F$

$50 \times 0.27 + 50 \times y_{D,avg} = 100 \times 0.4$

$y_{D,avg} = 0.53$

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Q.31

useful formula

$$\log\left(\frac{F x_F}{W x_W}\right) = \alpha \log \frac{F(1-x_F)}{W(1-x_W)}$$

α = relative volatility

Basis = 100 mole of feed

$F = 100$ | $\alpha = 2.16$

$D = 60$ | $x_F = 0.5$

$W = 40$

$$\log\left(\frac{100\times0.5}{40 x_W}\right) = 2.16 \log\left(\frac{100\times0.5}{50(1-x_W)}\right)$$

$$\frac{\cancel{100\times0.5}\ 5\cancel{0}}{4\cancel{0} x_W} = \left(\frac{\cancel{100\times0.5}}{\cancel{40}(1-x_W)}\right)^{2.16}$$

$$\frac{5}{4x_W} = \frac{1}{[4(1-x_W)]^{2.16}}$$

~~[illegible]~~ $x_W = \cancel{0.406}\ 0.328$

$$y_{D,avg} D + W x_W = F x_F$$

$$y_{D,avg} = \frac{0.5\times100 - 40\times\cancel{0.406}\ 0.328}{60}$$

$= 0.615$

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Q.4)

$F = 100$ moles

$x_F = 0.6$

$x_W = 0.3$

Material balance

$$60 = D\, y_{D,avg.} + 0.3(100 - D)$$

$$30 = D\, y_{D,avg} - 0.3D \quad \text{--- (I)}$$

$$\ln\left(\frac{F}{F-D}\right) = \int_{0.3}^{0.6} \frac{dx}{y^* - x} \quad \text{--- (II)}$$

Given

$$y^* = 1.12x + 0.15 \quad , 0.2 \le x \le 0.4$$

$$y^* = 0.76x + 0.25, \quad 0.4 \le x \le 0.7$$

from (II)

$$\ln\left(\frac{100}{100-D}\right) = \int_{0.3}^{0.4} \frac{dx}{0.12x + 0.15} + \int_{0.4}^{0.6} \frac{dx}{0.25 - 0.24x}$$

$$\ln\left(\frac{100}{100-D}\right) = \frac{1}{0.12} \ln(0.12x + 0.15)\Big|_{0.3}^{0.4}$$

$$- \frac{1}{0.24} \ln(0.25 - 0.24x)\Big|_{0.4}^{0.6}$$

$$\ln\left(\frac{100}{100-D}\right) = 2.077$$

$$\frac{100}{100-D} = 7.983$$

$$100 = 798.3 - 7.983D$$

$$D = \frac{698.3}{7.983} = 87.473$$

from (I)

$$y_{D,avg} = 0.643$$

Q.5) Basis : 100 moles of feed

$x_{F,A} = 0.1 \qquad x_{F,B} = 0.8 \qquad x_{F,C} = 0.1$

Component	vapor pressure (P) mm Hg	$m = \frac{P}{760}$	z_F	$W/D = 2$: y_D^*	$W/D = 1.8$: y_D^*	$W/D = 1.0$: y_D^*
A	1302	1.713	0.1	0.138	0.137	0.126
B	787	1.036	0.8	0.819	0.818	0.814
C	364	0.479	0.1	0.058	0.059	0.065
				$\Sigma y_D^* = 1.015$	$\Sigma y_D^* = 1.014$	$\Sigma y_D^* = 1.005$

$$y_D^* = \frac{z_F(W/D + 1)}{1 + \frac{W}{Dm}}$$

	$\frac{W}{D} = 0.6$: y_D^*	$\frac{W}{D} = 0.7$: y_D^*	$\frac{W}{D} = 1.0$: $x_D = \frac{y_D^*}{m}$	$\frac{W}{D} = 0.9$: y_D^*
A	0.118	0.121	0.074	0.124
B	0.811	0.812	0.786	0.814
C	0.071	0.069	0.136	0.066
	$\Sigma y_D^* = 1.000$	$\Sigma y_D^* = 1.002$	$\Sigma x_D = 0.996$	$\Sigma y_D^* = 1.004$

	$\frac{W}{D} = 0.6$: x_D
A	0.069
B	0.783
C	0.148
	$\Sigma x_D = 1.000$

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By trial & error

For $\frac{W}{D} = 0.6$ $\Sigma y_i^* = 1.000$

$\Sigma x_i = 1.000$

Liquid (W) = 40 moles

Vapor (D) = 60 moles

Material balance:

A: $0.1 \times 100 = 60\, y_{D,A} + 40\, x_{W,A}$ --- (1)

B: $0.8 \times 100 = 60\, y_{D,B} + 40\, x_{W,B}$ --- (ii)

C: $0.1 \times 100 = 60\, y_{D,C} + 40\, x_{W,C}$ --- (iii)

or, from table,

In distillate	In liquid residue
$y_{D,A} = 0.118$	$x_{D,A} = 0.069$
$y_{D,B} = 0.811$	$x_{D,B} = 0.783$
$y_{D,C} = 0.071$	$x_{D,C} = 0.148$