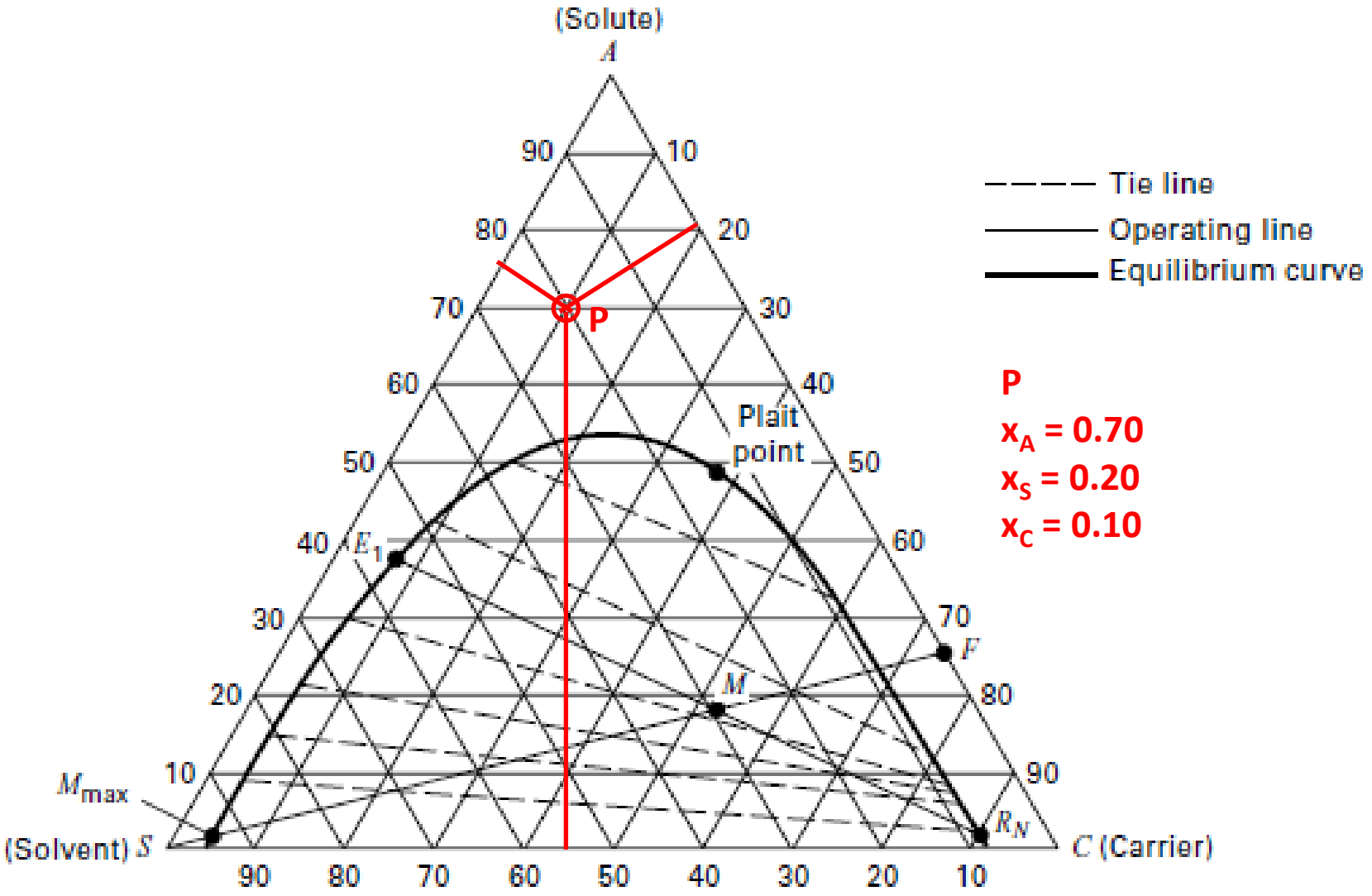

(Solute)
A
90
10
80
20
70
30
60
40
50
50
40
60
30
70
20
80
10
90
P
Plait point
E_1
M
F
R_N
M_{max}
(Solvent) S
C (Carrier)
90 80 70 60 50 40 30 20 10
Tie line
Operating line
Equilibrium curve
P
$x_A = 0.70$
$x_S = 0.20$
$x_C = 0.10$

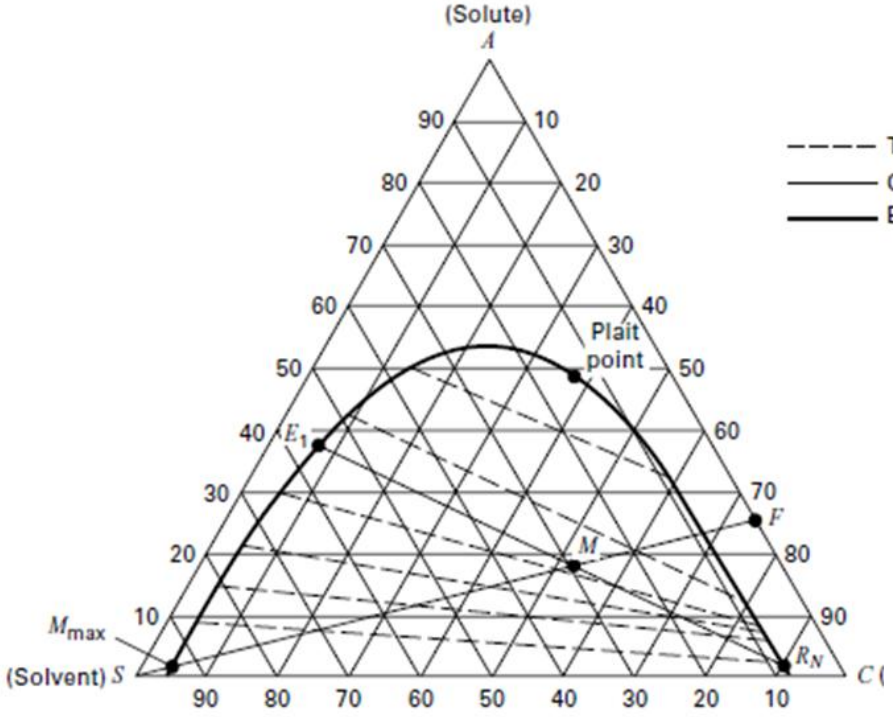
Feed	Solvent
$F = 250\,\text{kg}$	$S = 100\,\text{kg}$
$(x_A)_F = 0.24$	$(x_A)_S = 0.00$
$(x_C)_F = 0.76$	$(x_C)_S = 0.00$
$(x_S)_F = 0.00$	$(x_S)_S = 1.00$

By material balances, composition M of combined F and S is:

$$\begin{aligned} M &= F + S = 250 + 100 = 350\,\text{kg} \\ (x_A)_M M &= (x_A)_F F + (x_A)_S S \\ &= 0.24(250) + 0(100) = 60\,\text{kg} \\ (x_A)_M &= 60/350 = 0.171 \end{aligned}$$

$$\begin{aligned} (x_C)_M M &= (x_C)_F F + (x_C)_S S \\ &= 0.76(250) + 0(100) = 190\,\text{kg} \\ (x_C)_M &= 190/350 = 0.543 \end{aligned}$$

$$\begin{aligned} (x_S)_M M &= (x_S)_F F + (x_S)_S S \\ &= 0(250) + 1(100) = 100\,\text{kg} \\ (x_S)_M &= 100/350 = 0.286 \end{aligned}$$



Feed	Solvent
$F = 250\,\text{kg}$	$S = 100\,\text{kg}$
$(x_A)_F = 0.24$	$(x_A)_S = 0.00$
$(x_C)_F = 0.76$	$(x_C)_S = 0.00$
$(x_S)_F = 0.00$	$(x_S)_S = 1.00$

By material balances, composition M of combined F and S is:

$$M = F + S = 250 + 100 = 350\,\text{kg}$$

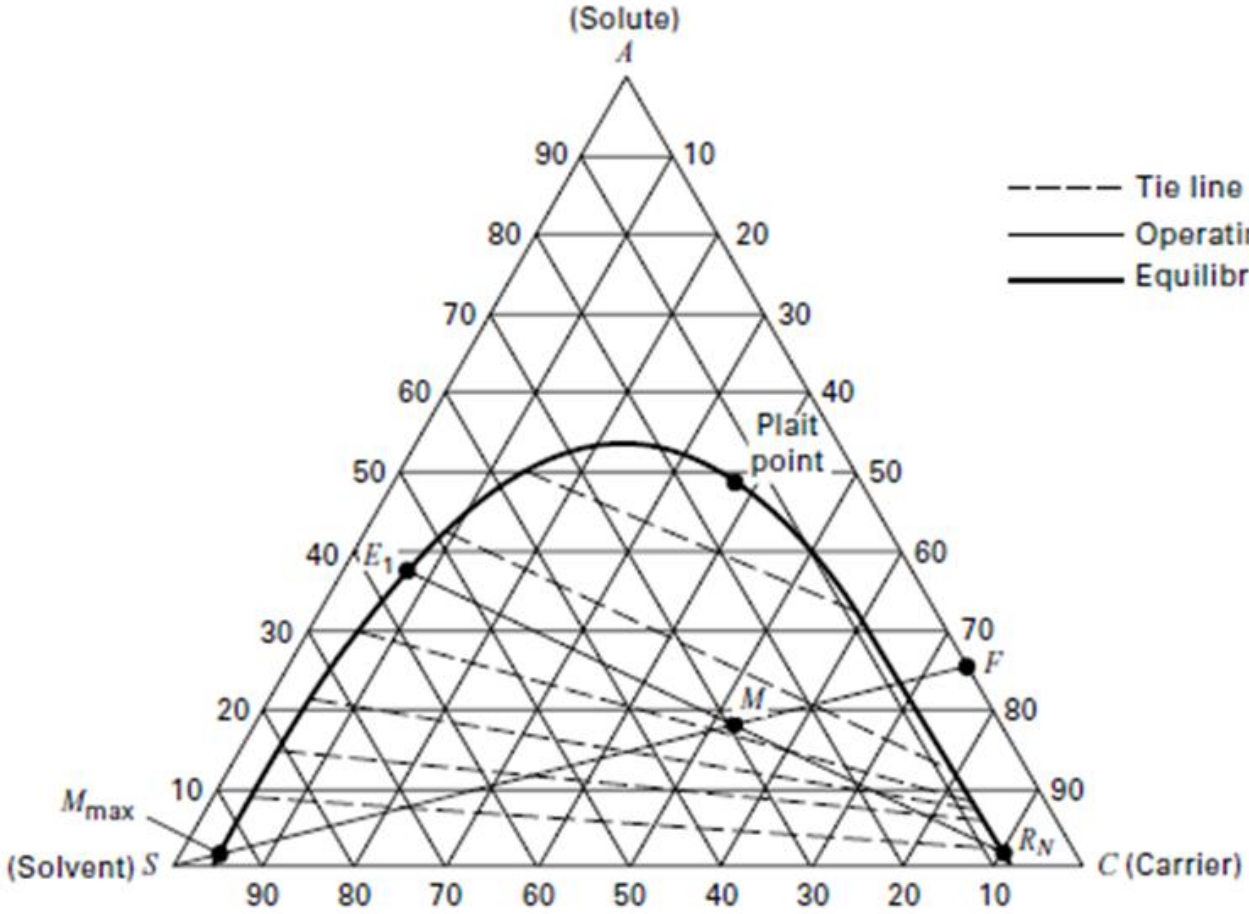
$$(x_A)_M M = (x_A)_F F + (x_A)_S S$$
$$= 0.24(250) + 0(100) = 60\,\text{kg}$$
$$(x_A)_M = 60/350 = 0.171$$

$$(x_C)_M M = (x_C)_F F + (x_C)_S S$$
$$= 0.76(250) + 0(100) = 190\,\text{kg}$$
$$(x_C)_M = 190/350 = 0.543$$

$$(x_S)_M M = (x_S)_F F + (x_S)_S S$$
$$= 0(250) + 1(100) = 100\,\text{kg}$$
$$(x_S)_M = 100/350 = 0.286$$

$$S/F = \overline{MF}/\overline{MS} = 100/250 = 0.400$$

$$S/M = \overline{MF}/\overline{SF} = 100/350 = 0.286$$

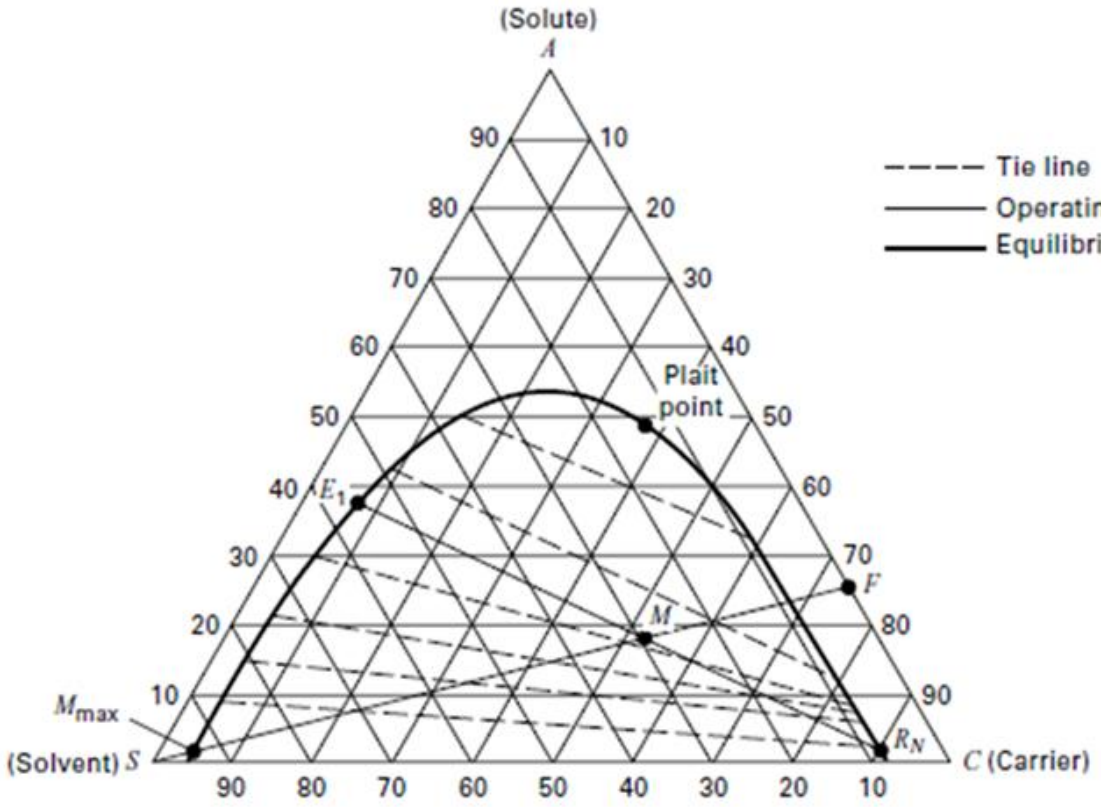


$$M = R_N + E_1 = 350\,\text{kg}$$

$$(x_A)_M M = 60 = (x_A)_{R_N} R_N + (x_A)_{E_1} E_1$$

$$(x_C)_M M = 190 = (x_C)_{R_N} R_N + (x_C)_{E_1} E_1$$

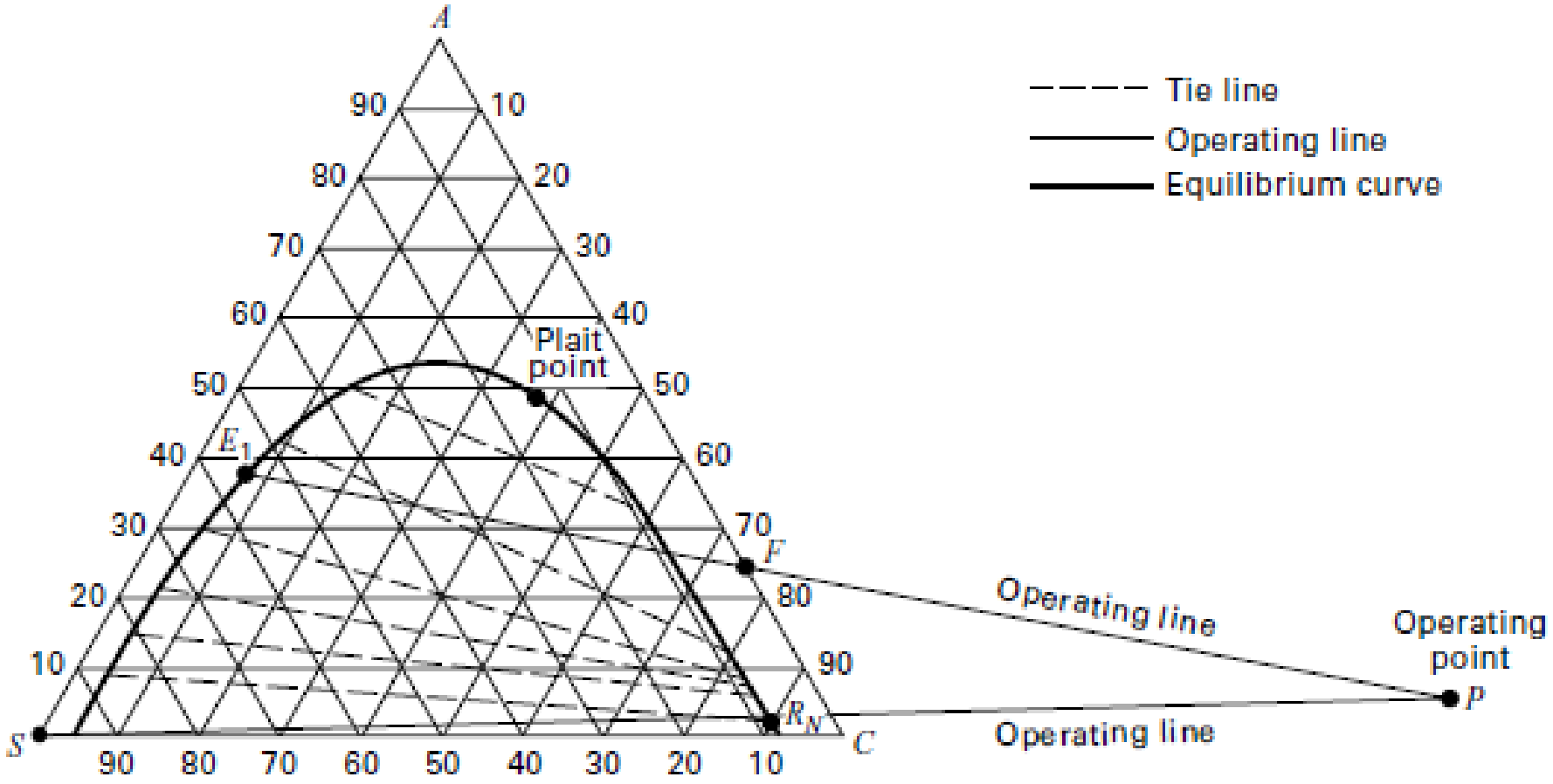
$$(x_S)_M M = 100 = (x_S)_{R_N} R_N + (x_S)_{E_1} E_1$$



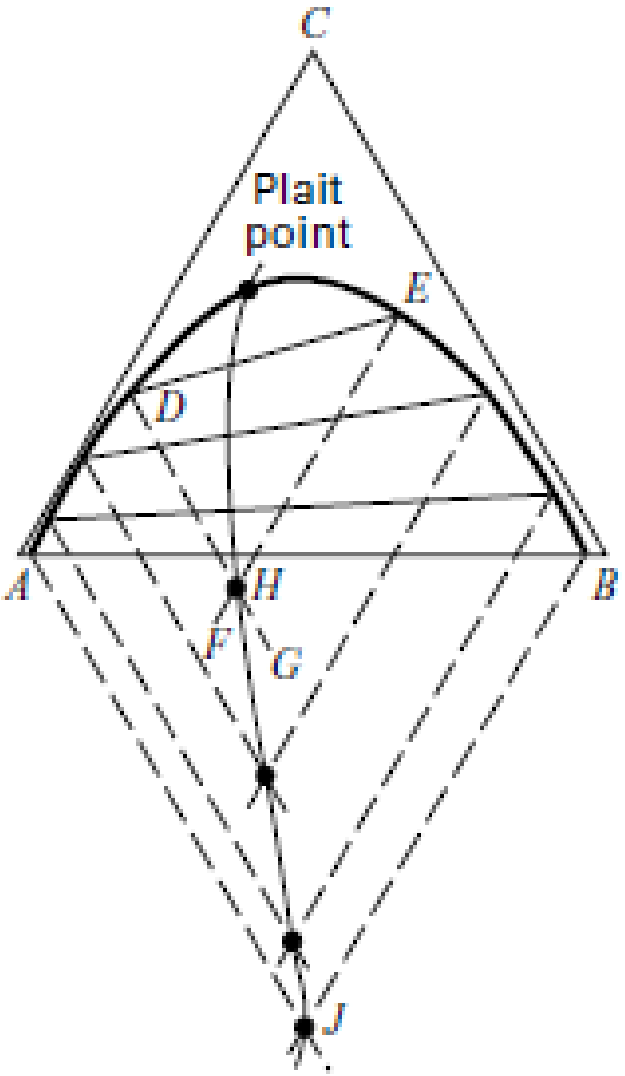
$$E_1/M = \overline{MR}_N/\overline{E_1R_N}$$
$$R_N/M = \overline{ME}_1/\overline{E_1R_N}$$

with $M = 350$ kg. By either method the results are:

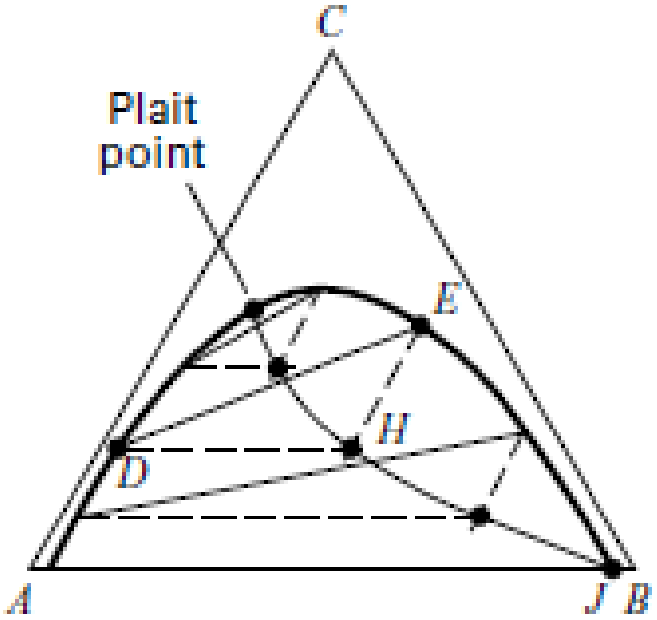
Raffinate Product	Extract Product
$R_N = 198.6$ kg	$E_1 = 151.4$ kg
$(x_A) = 0.025$	$(x_A) = 0.364$
$(x_C) = 0.90$	$(x_C) = 0.075$
$(x_S) = 0.075$	$(x_S) = 0.561$



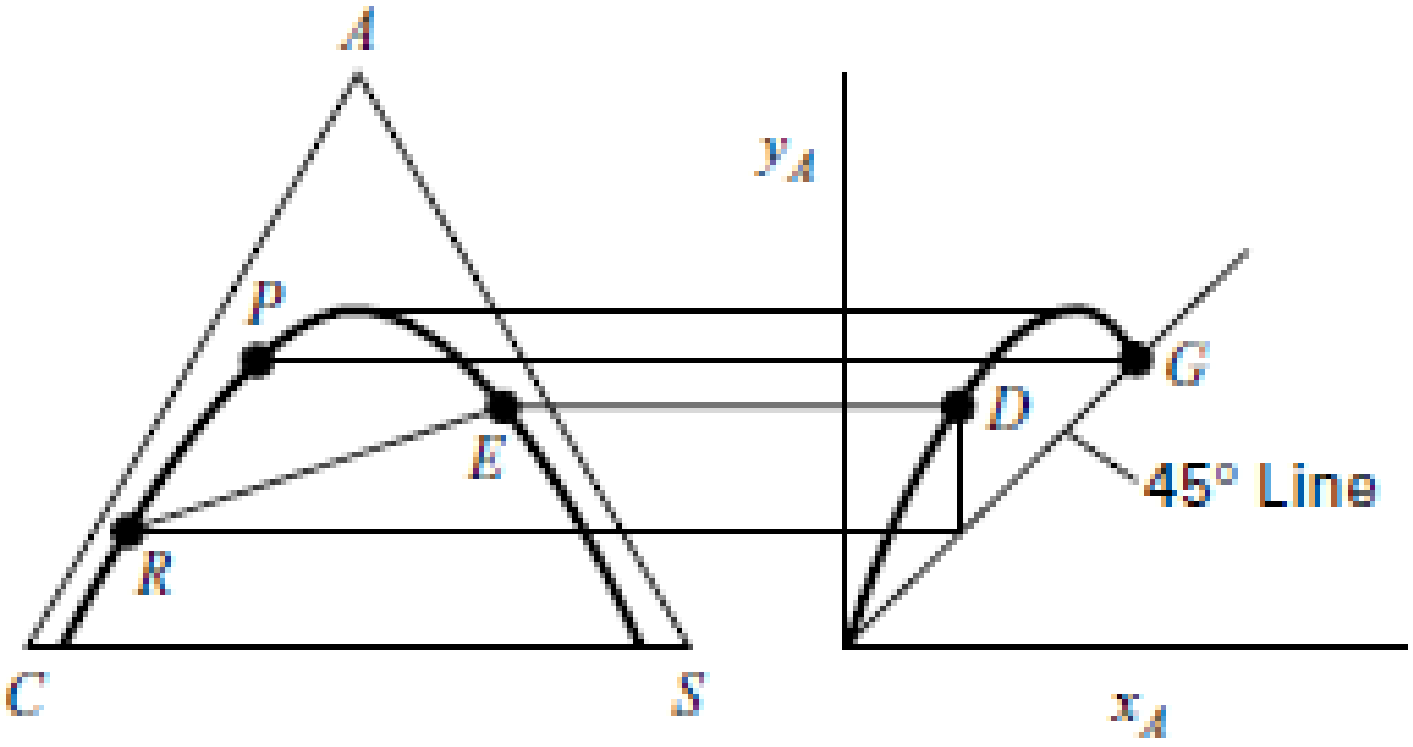
$F - E_1 = P$ is rewritten as $F = E_1 + P$,. $\dfrac{\overline{E_1P}}{\overline{FP}} = \dfrac{E_1 + P}{E_1} = \dfrac{F}{E_1}$

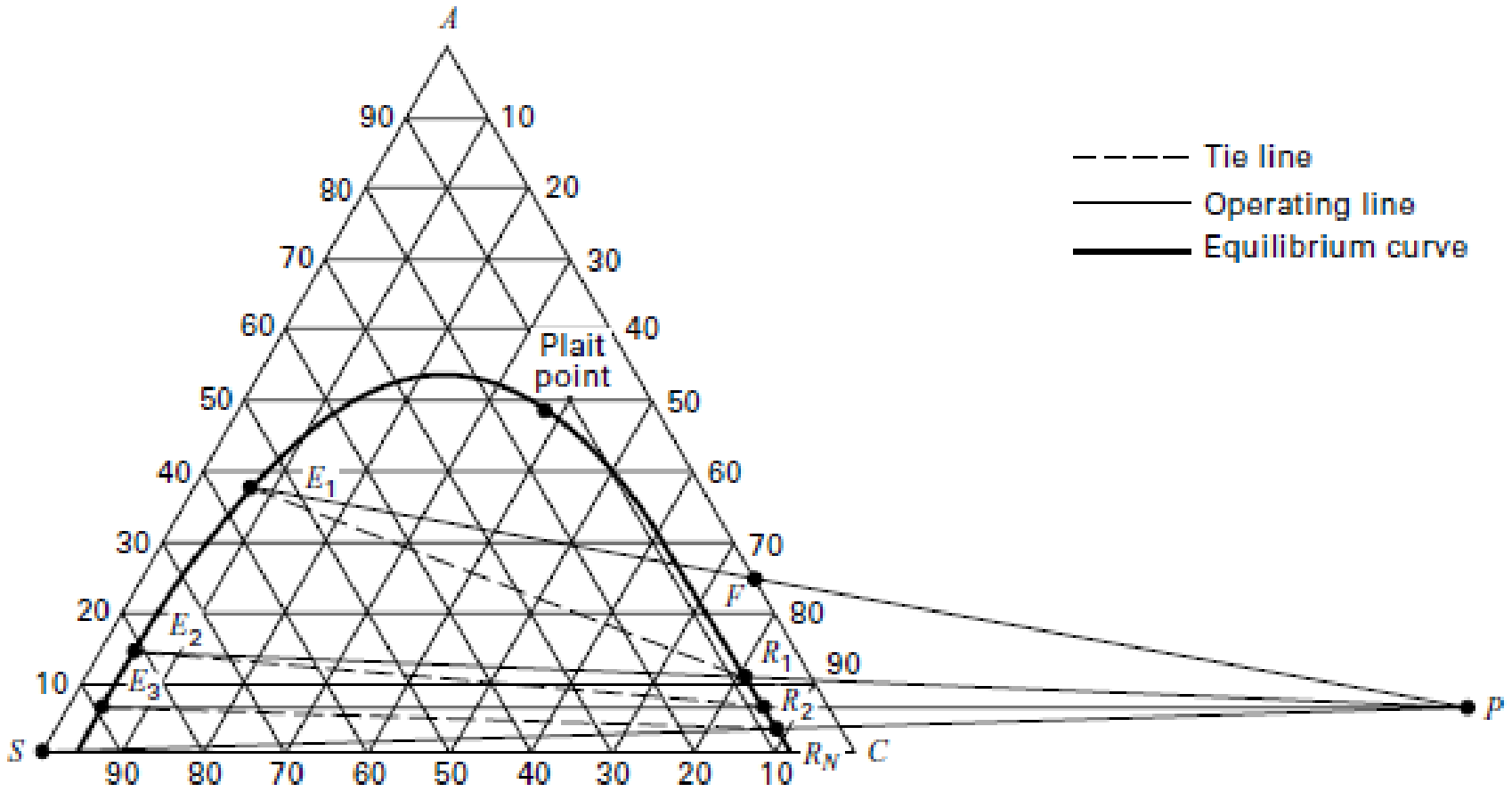


(a)

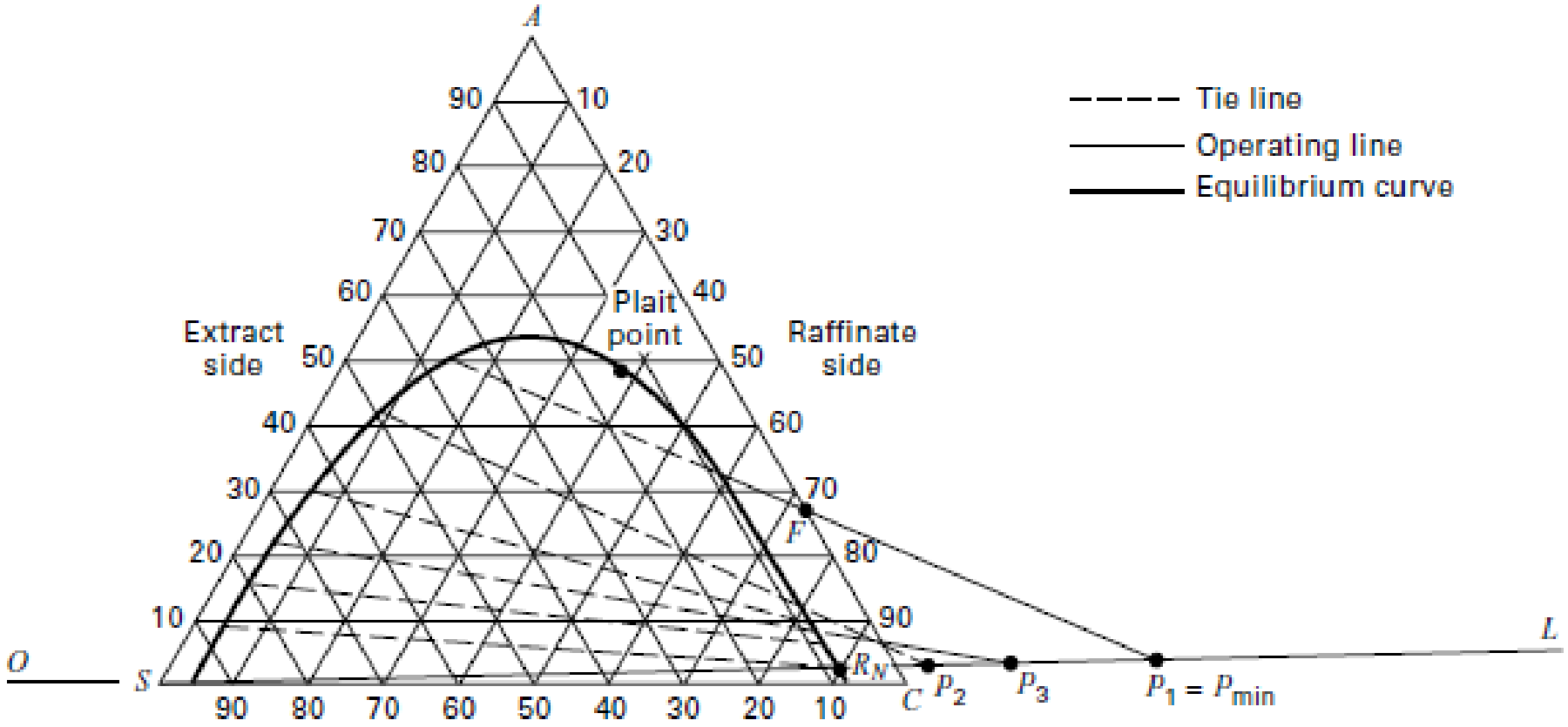


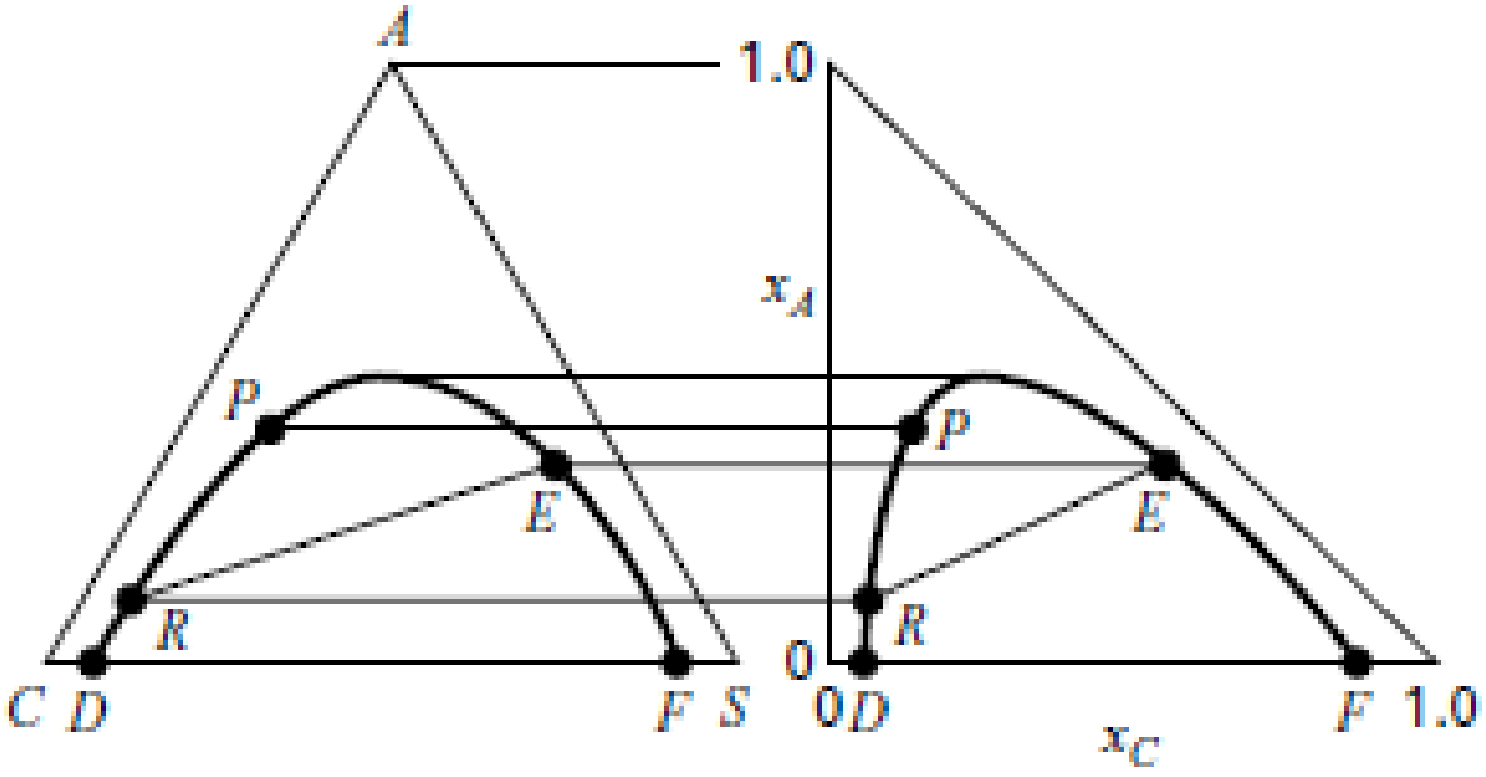
(b)


A
P
E
R
C
S
y_A
G
D
45° Line
x_A

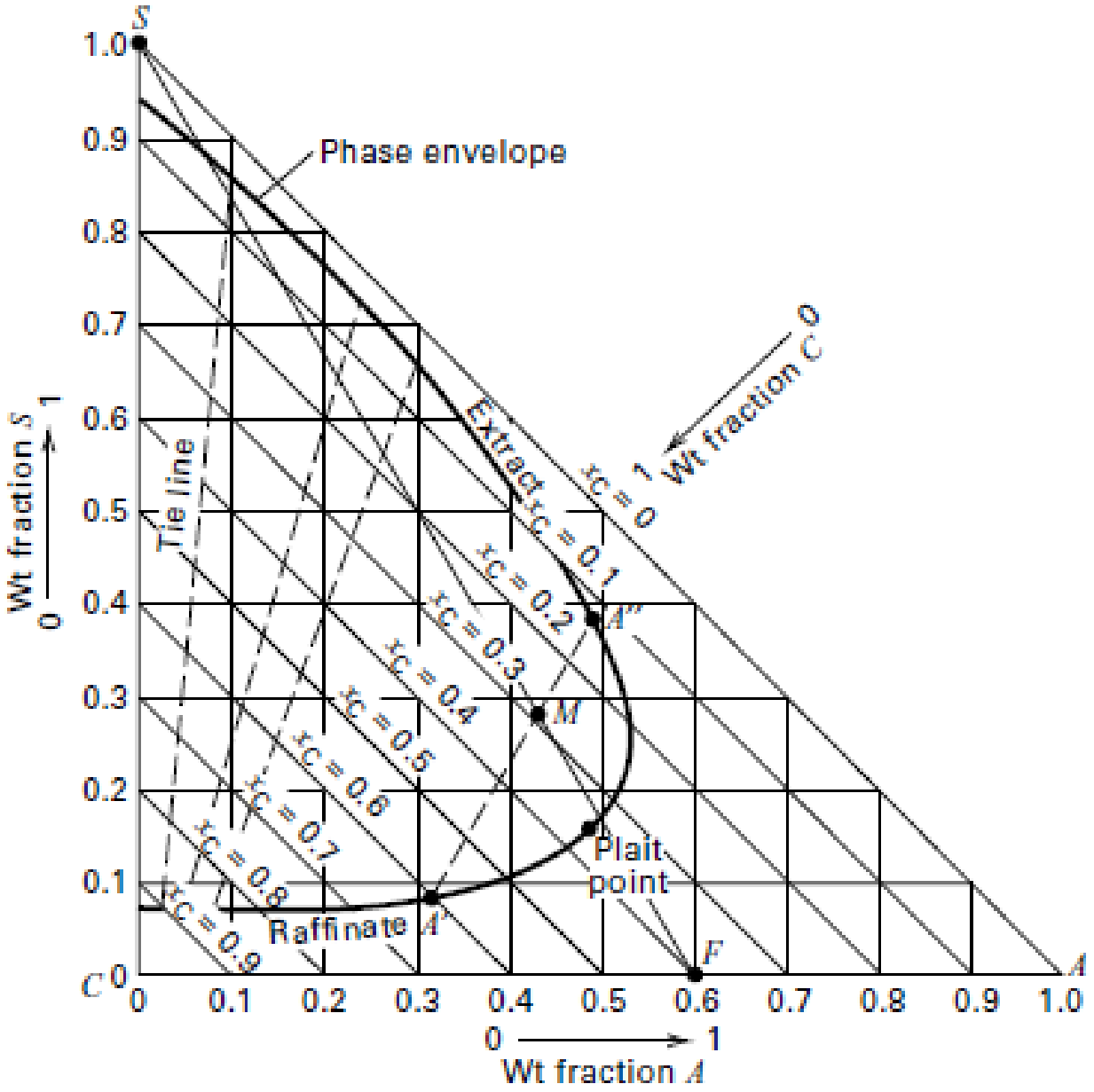

A
90
10
80
20
70
30
60
40
50
50
40
60
30
70
20
80
10
90
Plait point
E_1
E_2
E_3
F
R_1
R_2
R_N
S
C
P
90 80 70 60 50 40 30 20 10
Tie line
Operating line
Equilibrium curve

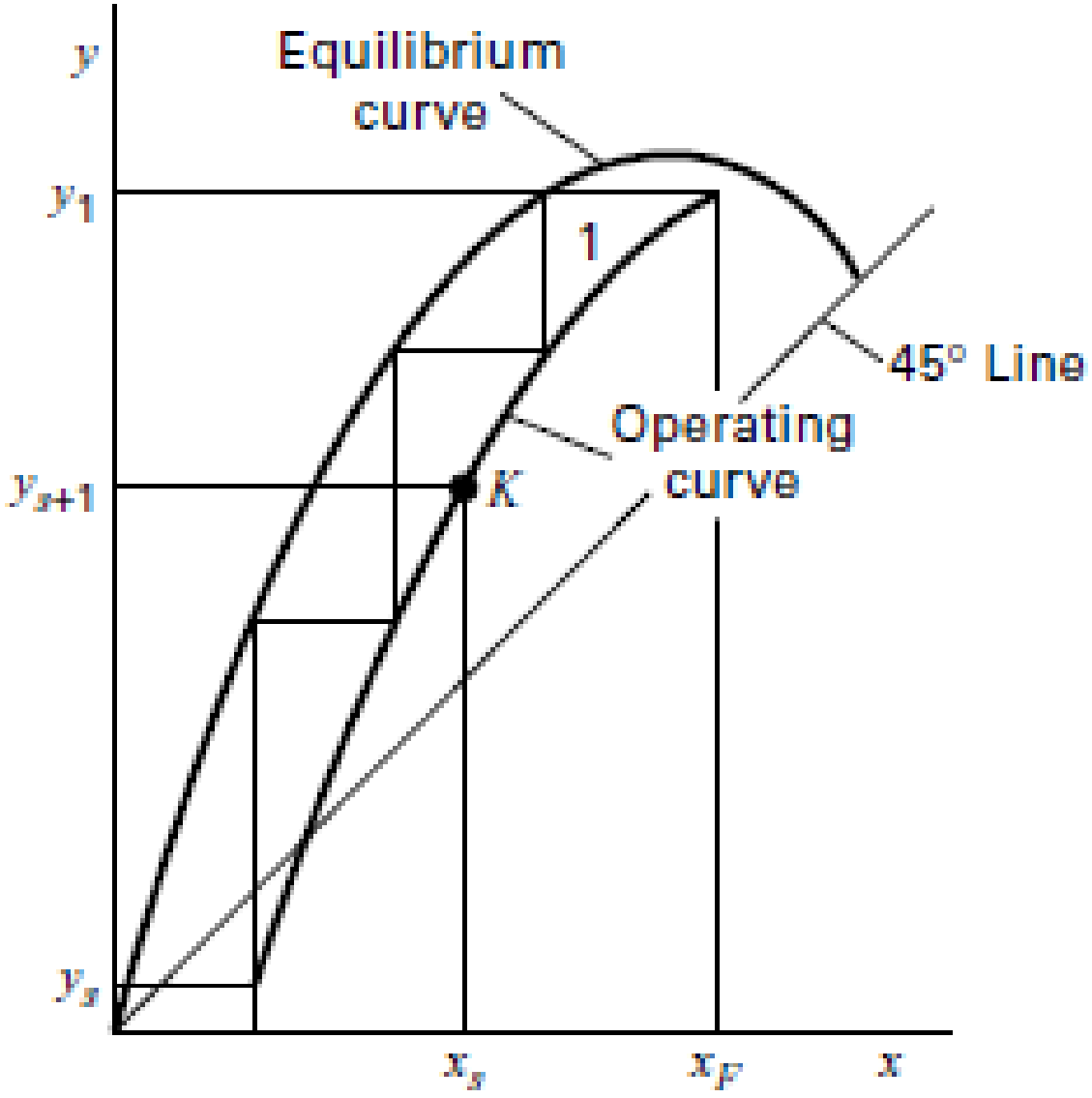
$$\frac{\overline{E_1P}}{\overline{FP}} = \frac{E_1 + P}{E_1} = \frac{F}{E_1}$$

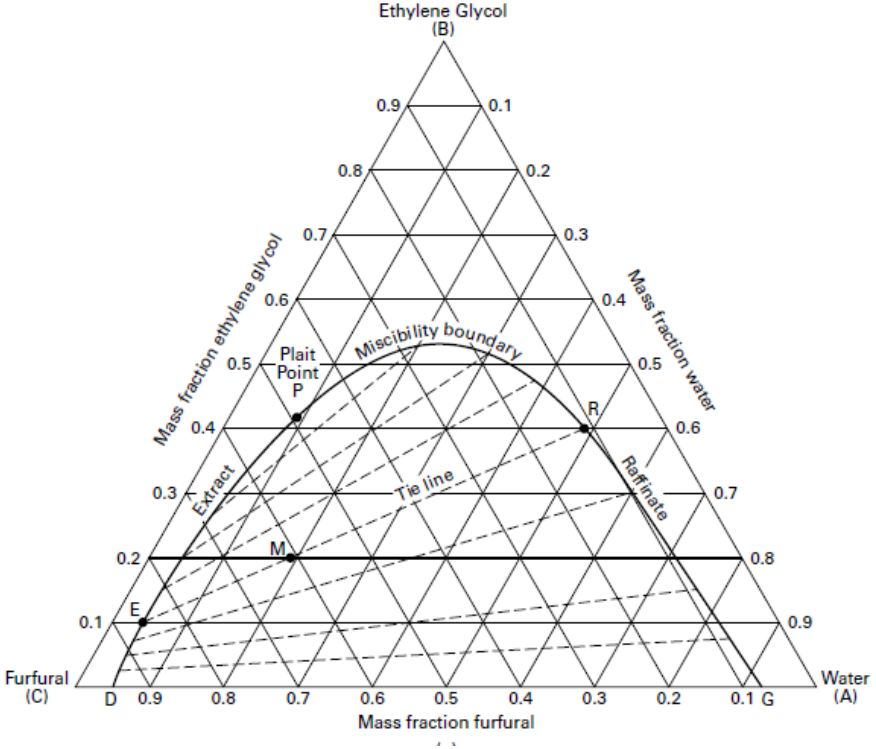


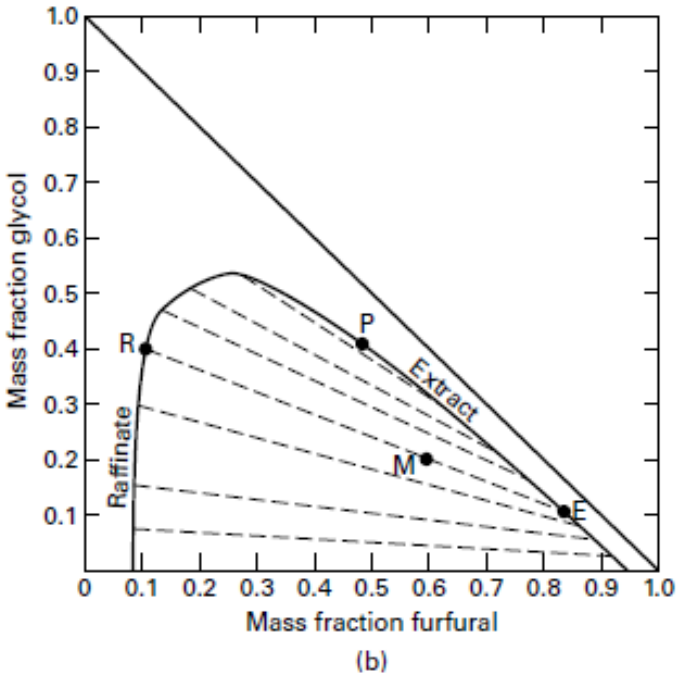


(a)

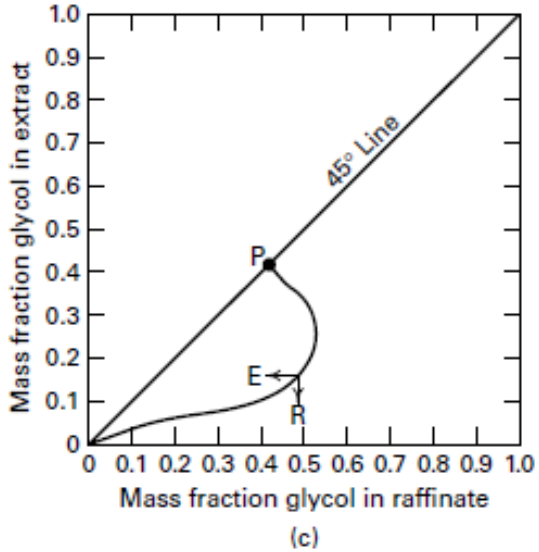

S
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
C 0
Wt fraction S
0 → 1
Phase envelope
Tie line
Extract
xC = 0.1
xC = 0.2
xC = 0.3
xC = 0.4
xC = 0.5
xC = 0.6
xC = 0.7
xC = 0.8
xC = 0.9
xC = 1
xC = 0
0
Wt fraction C
A''
M
Plait point
F
Raffinate
A'
A
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
0 → 1
Wt fraction A


y
Equilibrium
curve
y_1
1
45° Line
Operating
curve
y_{s+1}
K
y_s
x_s
x_F
x

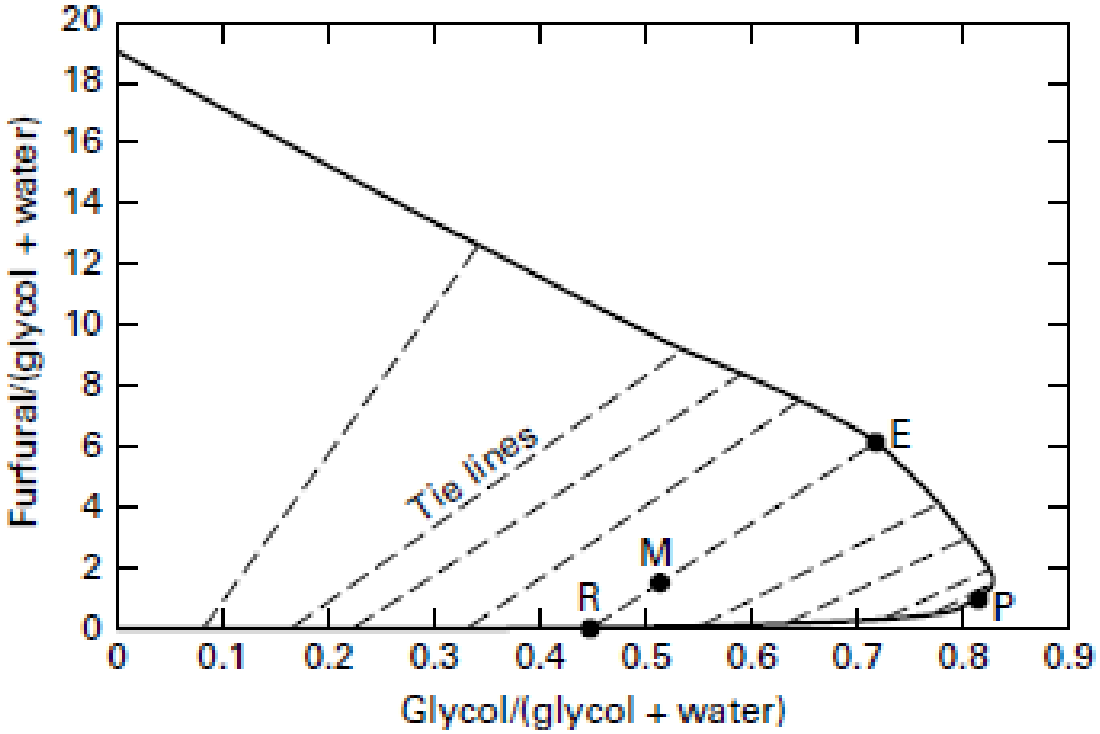

Ethylene Glycol
(B)
Mass fraction ethylene glycol
Mass fraction water
Miscibility boundary
Plait
Point
P
R
Extract
Tie line
Raffinate
M
E
Furfural
(C)
Water
(A)
D
G
Mass fraction furfural

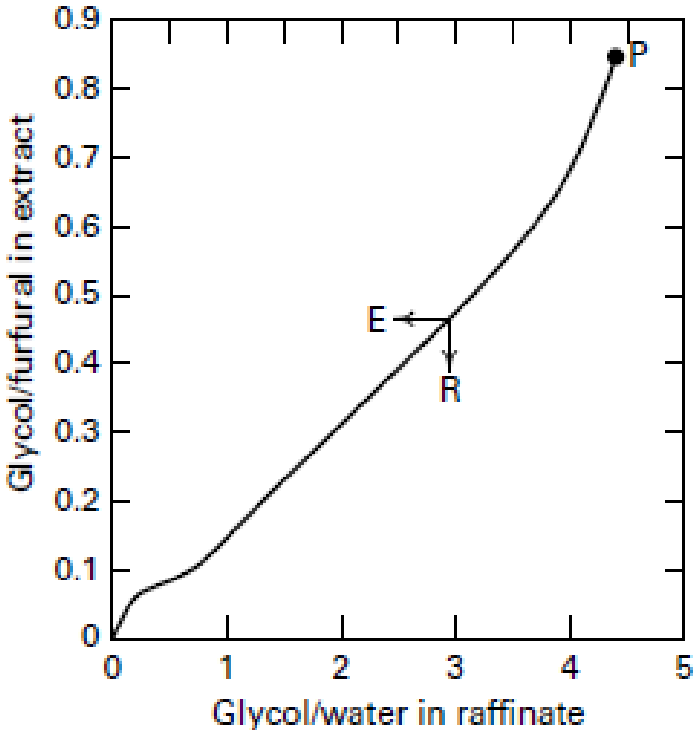

Mass fraction glycol
R
P
Extract
M
E
Raffinate
Mass fraction furfural

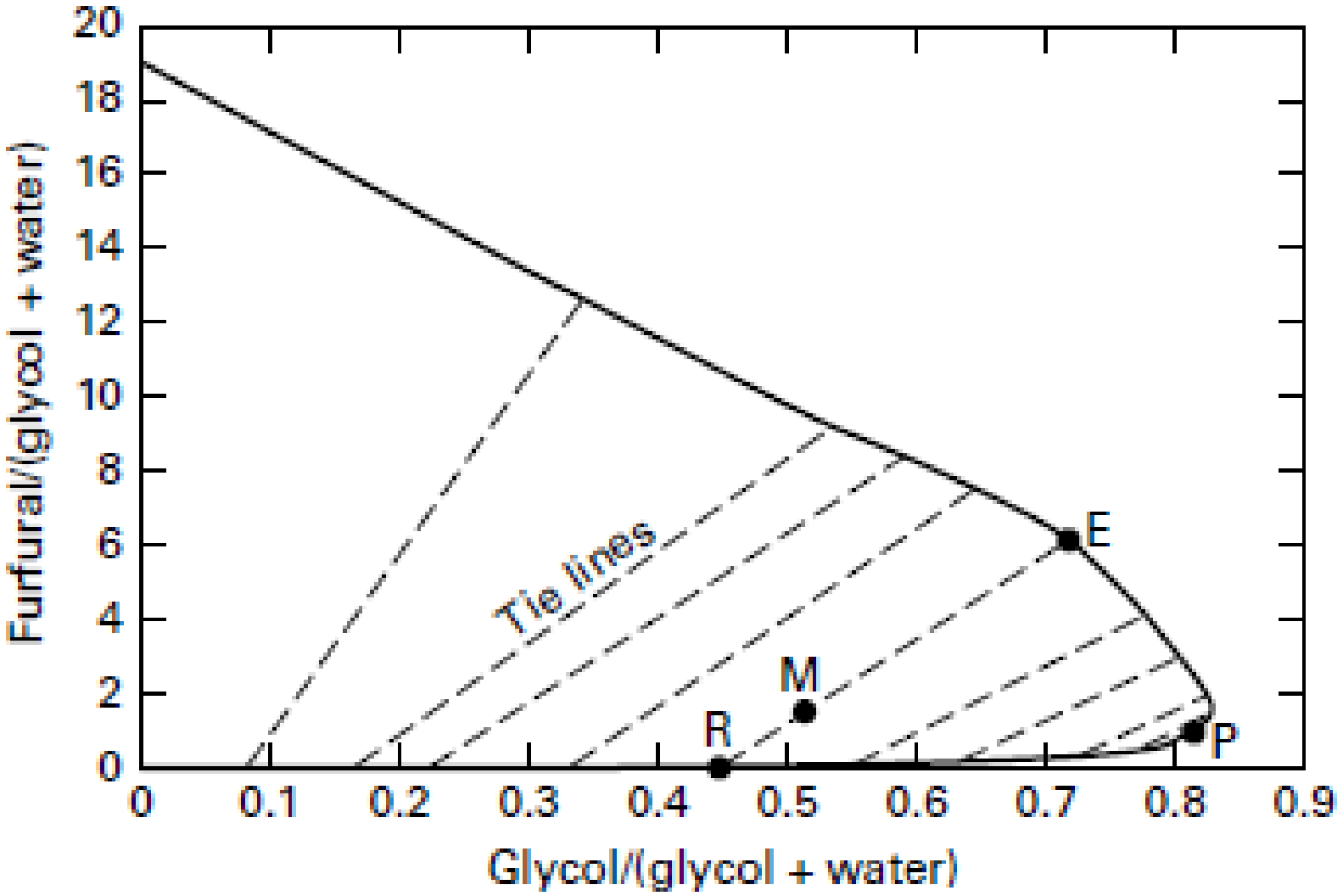
(b)


Mass fraction glycol in extract
45° Line
P
E
R
Mass fraction glycol in raffinate

(c)


Furfural/(glycool + water)
Glycol/(glycol + water)
Tie lines
E
M
R
P
0
2
4
6
8
10
12
14
16
18
20
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9


Glycol/furfural in extract
Glycol/water in raffinate
P
E
R
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5


Furfural/(glycol + water)
Glycol/(glycol + water)
Tie lines
E
M
R
P
0
2
4
6
8
10
12
14
16
18
20
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9