Problema 1

Pretende-se extrair o ácido acético contido em 800 g de uma solução aquosa com 55 % (percentagem mássica de ácido acético) (T = 20 ºC), adicionando-se 400 g de éter isopropílico, sem variação de temperatura.

a) Determinar as composições e massas das fases em equilíbrio, depois da adição do éter;

b) Para a remoção do ácido ainda existente na fase refinada obtida da operação anterior, adiciona-se éter isopropílico na proporção de 1:1. Determine as composições e as massas das novas fases em equilíbrio.

Dados:

Para o sistema ternário éter isopropílico – água – ácido acético, as fases conjugadas têm a 20 ºC as seguintes composições:

Fase Orgânica			Fase aquosa		
Éter isopropílico	Ácido acético	Água	Éter isopropílico	Ácido acético	Água
98.80	0.00	1.20	0.80	0.00	99.20
87.50	10.00	2.50	1.70	5.00	93.30
76.20	20.00	3.80	2.10	10.00	87.90
60.00	30.00	10.00	2.50	15.00	82.50
39.00	41.50	19.50	3.30	25.00	71.70
27.50	45.00	27.50	3.50	30.00	66.50
19.70	46.80	33.50	4.20	35.00	60.80
13.00	46.00	41.00	5.60	40.00	54.40

Problem 1

The aim is to extract the acetic acid contained in 800 g of an aqueous solution with 55 % (mass percentage of acetic acid) (T = 20 ºC), by adding 400 g of isopropyl ether without varying the temperature.

a) Determine the compositions and masses of the phases in equilibrium, after the addition of ether;

b) To remove the acid still present in the raffinate phase obtained from the previous operation, isopropyl ether is again added in a 1:1 ratio. Determine the compositions and masses of the new phases at equilibrium.

<u>Experimental data:</u>

For the isopropyl ether – water – acetic acid ternary system, the conjugated phases have the following compositions at 20 ºC:

Organic phase			Aqueous phase		
Isopropyl ether	Acetic acid	water	Isopropyl ether	Acetic acid	water
98.80	0.00	1.20	0.80	0.00	99.20
87.50	10.00	2.50	1.70	5.00	93.30
76.20	20.00	3.80	2.10	10.00	87.90
60.00	30.00	10.00	2.50	15.00	82.50
39.00	41.50	19.50	3.30	25.00	71.70
27.50	45.00	27.50	3.50	30.00	66.50
19.70	46.80	33.50	4.20	35.00	60.80
13.00	46.00	41.00	5.60	40.00	54.40

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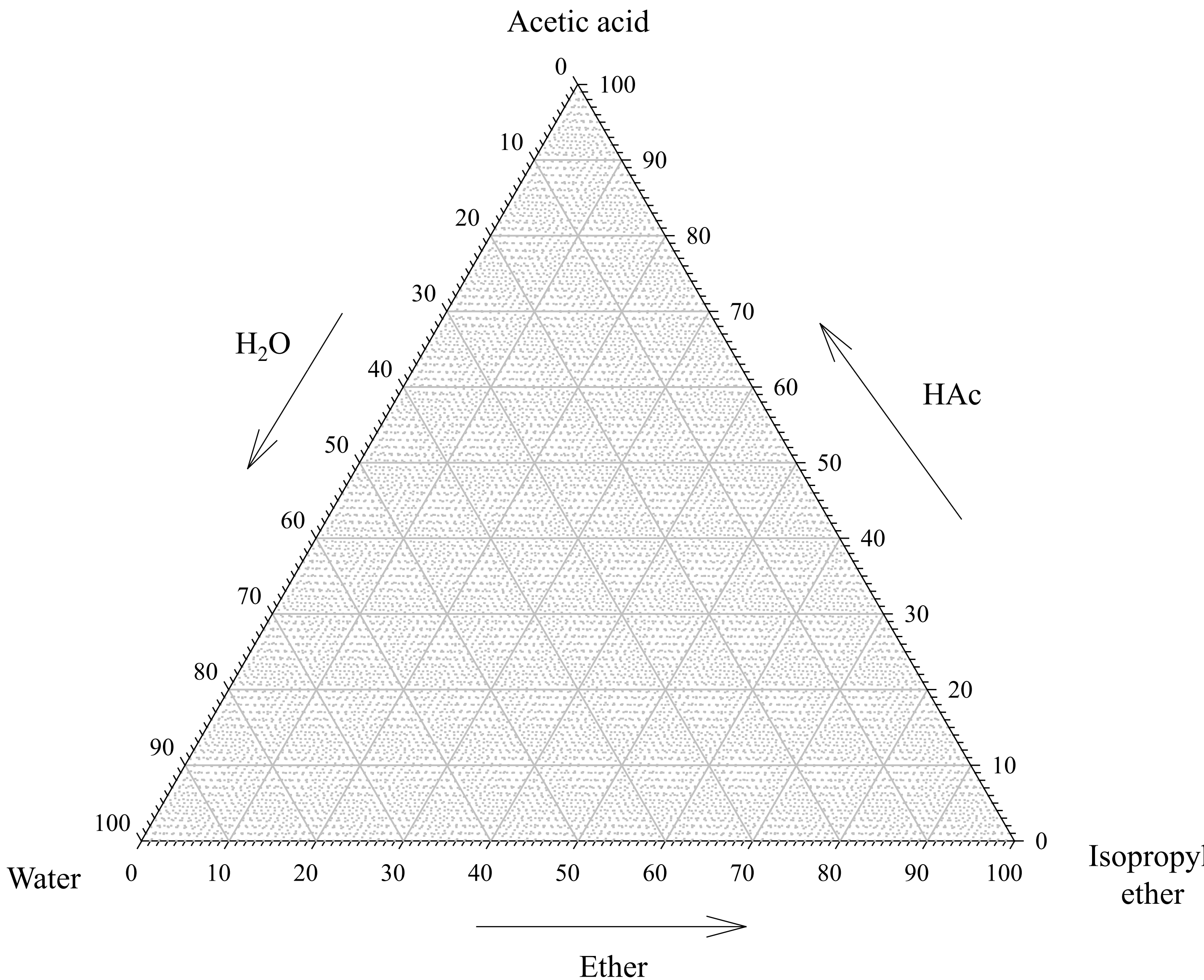
98.80	0.00	1.20	0.80	0.00	99.20
87.50	10.00	2.50	1.70	5.00	93.30
76.20	20.00	3.80	2.10	10.00	87.90
60.00	30.00	10.00	2.50	15.00	82.50
39.00	41.50	19.50	3.30	25.00	71.70
27.50	45.00	27.50	3.50	30.00	66.50
19.70	46.80	33.50	4.20	35.00	60.80
13.00	46.00	41.00	5.60	40.00	54.40

Ternary system – 20 ºC



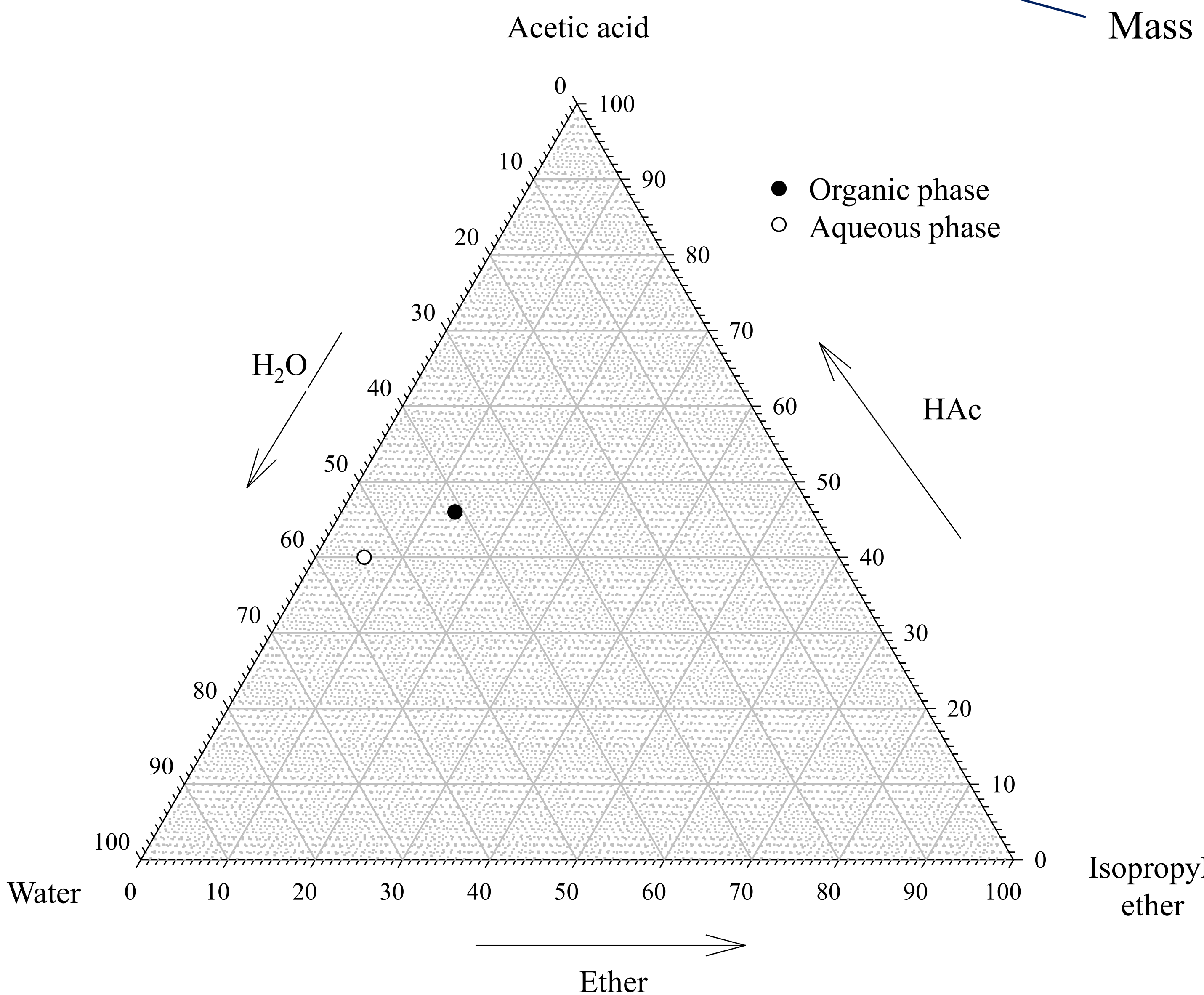
Problem resolution

1. Mark the experimental points on the ternary diagram

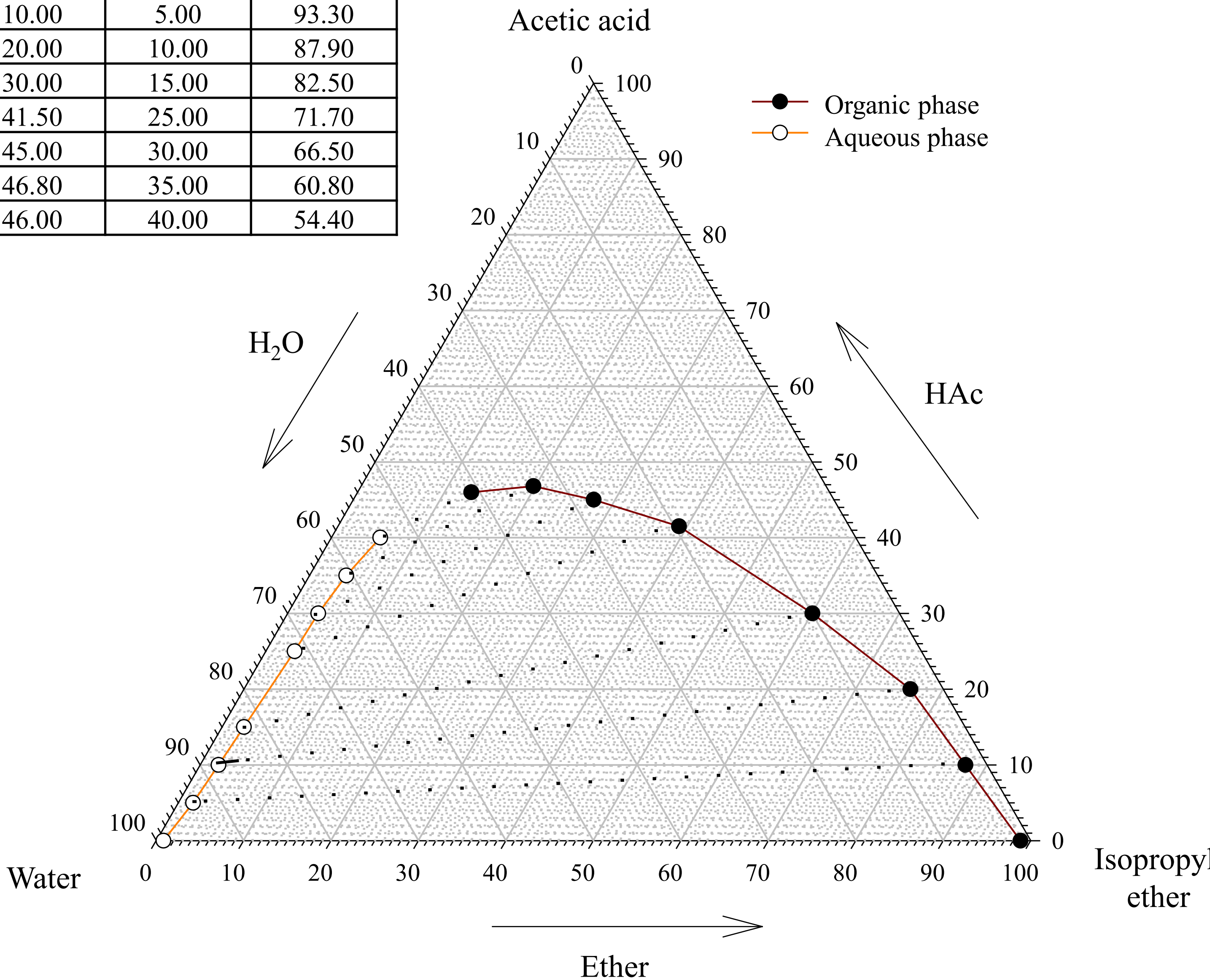
Example:

Organic phase			Aqueous phase		
Ether	Acid	water	Ether	Acid	water
13.00	46.00	41.00	5.60	40.00	54.40

Mass %!

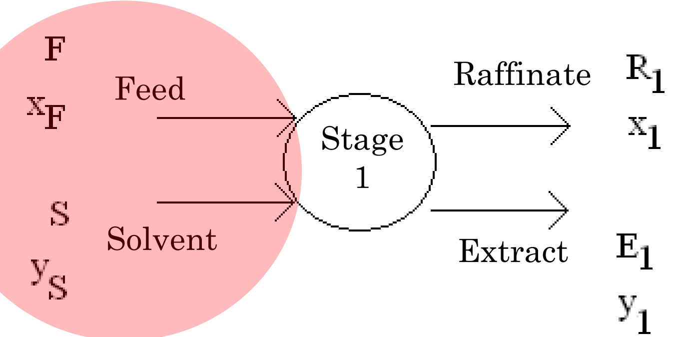


Organic phase		Aqueous phase	
Isopropyl ether	Acetic acid	Acetic acid	water
98.80	0.00	0.00	99.20
87.50	10.00	5.00	93.30
76.20	20.00	10.00	87.90
60.00	30.00	15.00	82.50
39.00	41.50	25.00	71.70
27.50	45.00	30.00	66.50
19.70	46.80	35.00	60.80
13.00	46.00	40.00	54.40



Problem resolution

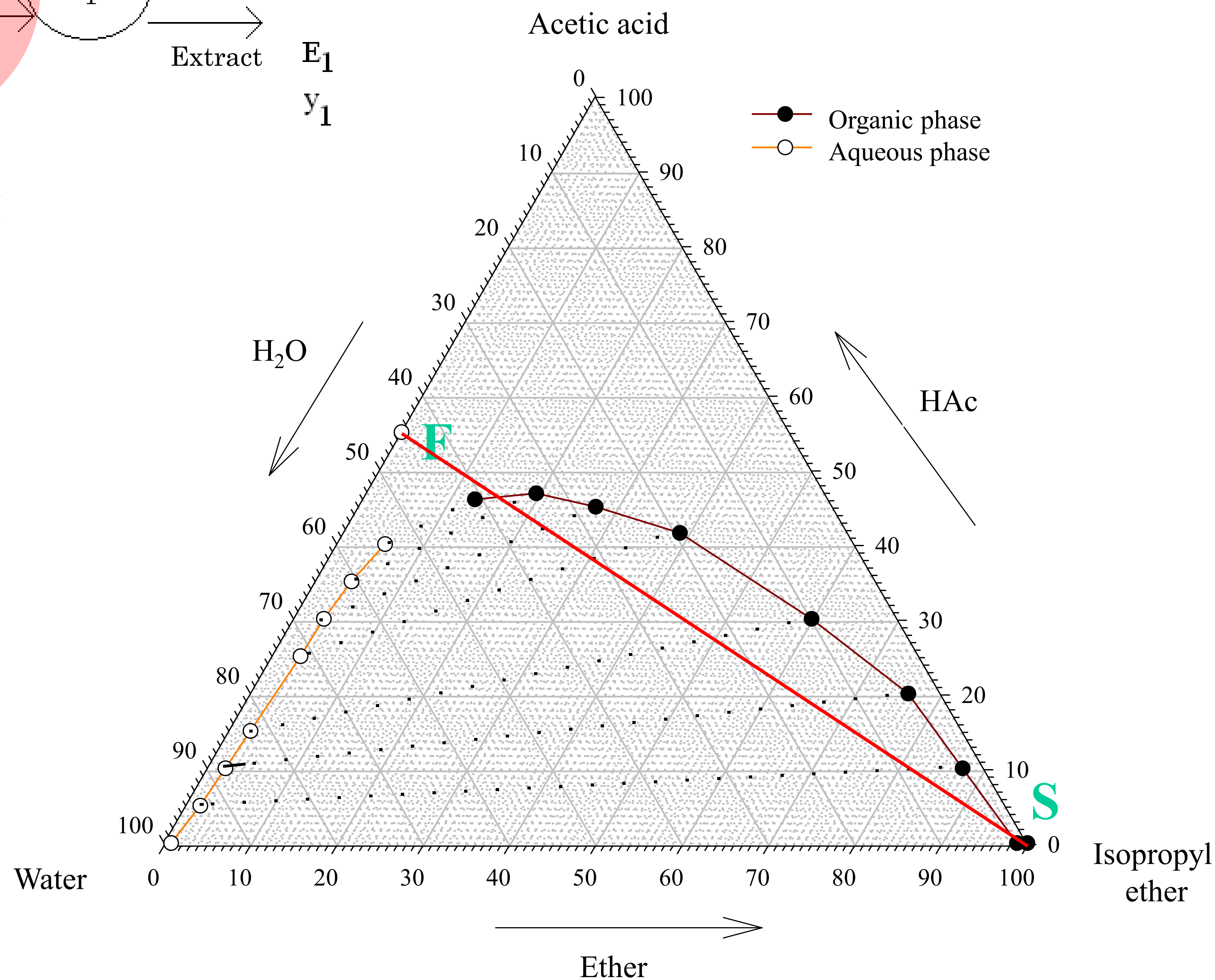
2. Solve the equilibrium stage

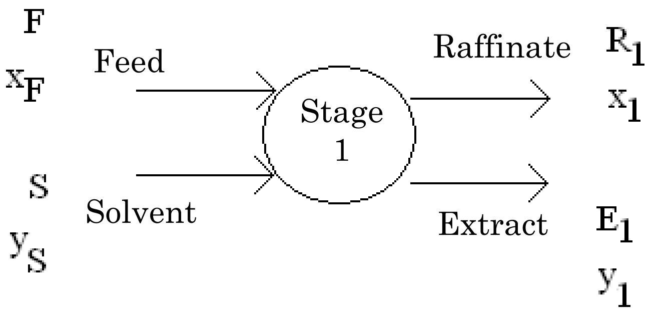


$x_F = 55\%$; $y_S = 0\%$

F= 800g; S = 400g

$F + S = M$



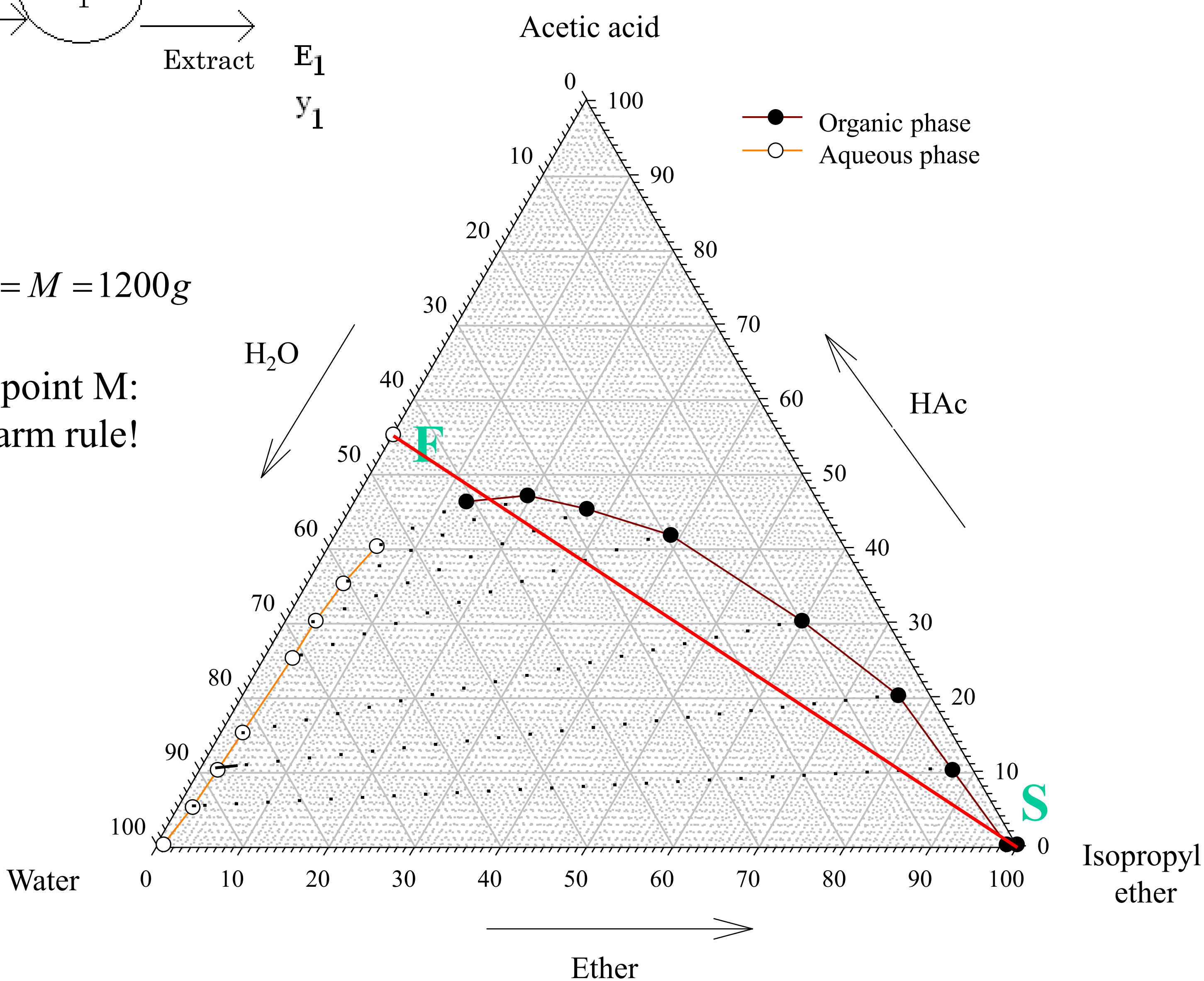


x_F= 55%; y_S = 0%   F= 800g; S = 400g

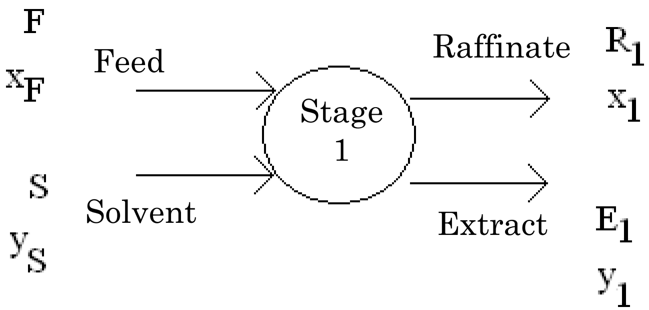
$$F + S = M$$

$$800g + 400g = M = 1200g$$

Position of point M:
→ level-arm rule!



$x_F = 55\%;\ y_S = 0\%$ $F = 800g;\ S = 400g$



$$F + S = M$$

$$800g + 400g = M = 1200g$$

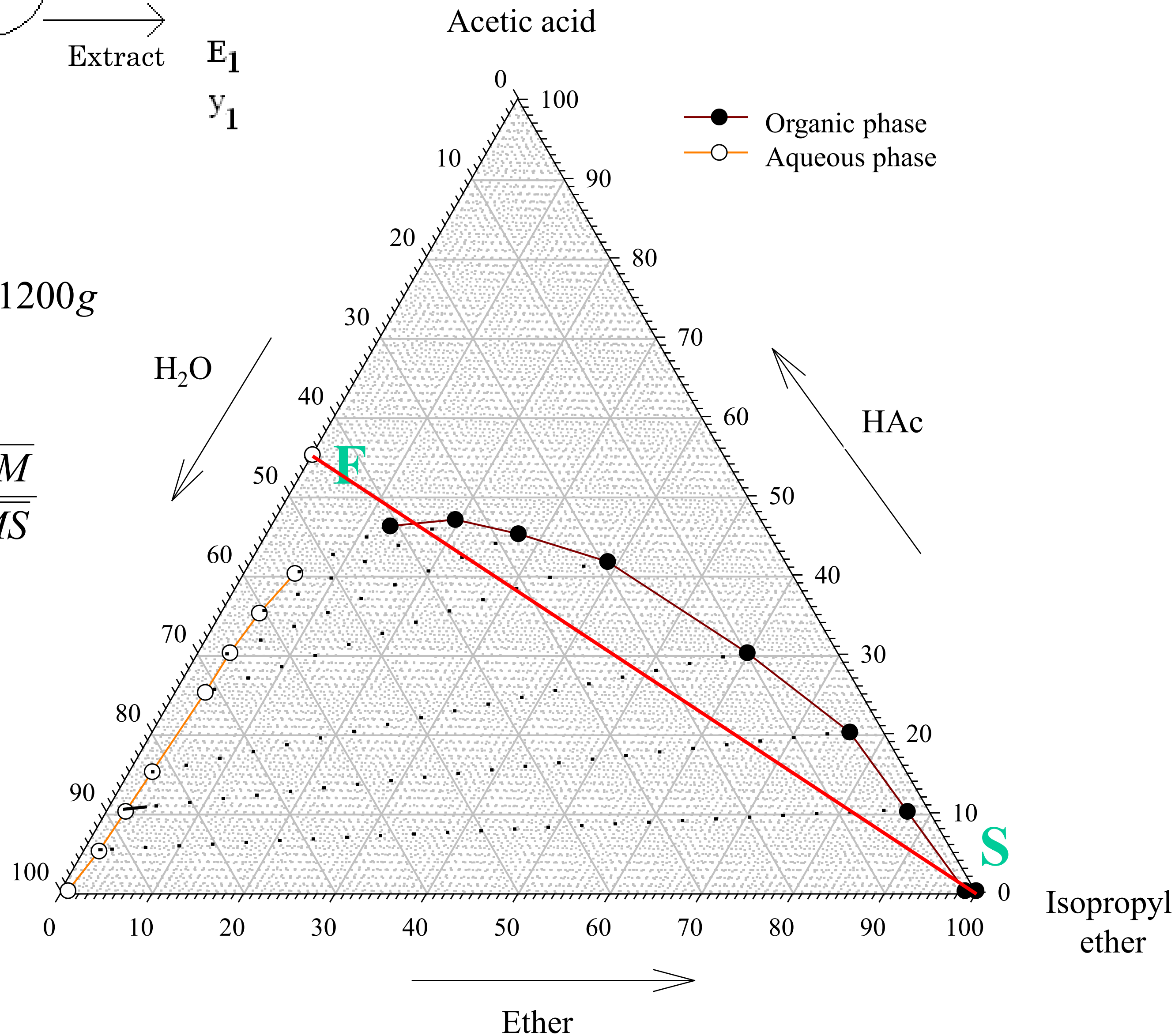
$$\Downarrow$$

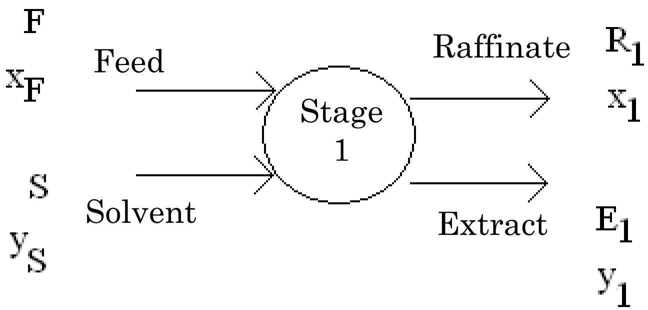
$$\frac{S}{F} = \frac{x_F - x_M}{x_M - y_S} = \frac{\overline{FM}}{\overline{MS}}$$

$$\Downarrow$$

$$\frac{400}{800} = \frac{55 - x_M}{x_M - 0}$$

$$\Rightarrow x_M = 37\%$$





$x_F = 55\%;\ y_S = 0\%$ $\quad$ $F = 800g;\ S = 400g$

$$F + S = M$$

$$800g + 400g = M = 1200g$$

$$\Downarrow$$

$$\frac{S}{F} = \frac{x_F - x_M}{x_M - y_S} = \frac{\overline{FM}}{\overline{MS}}$$

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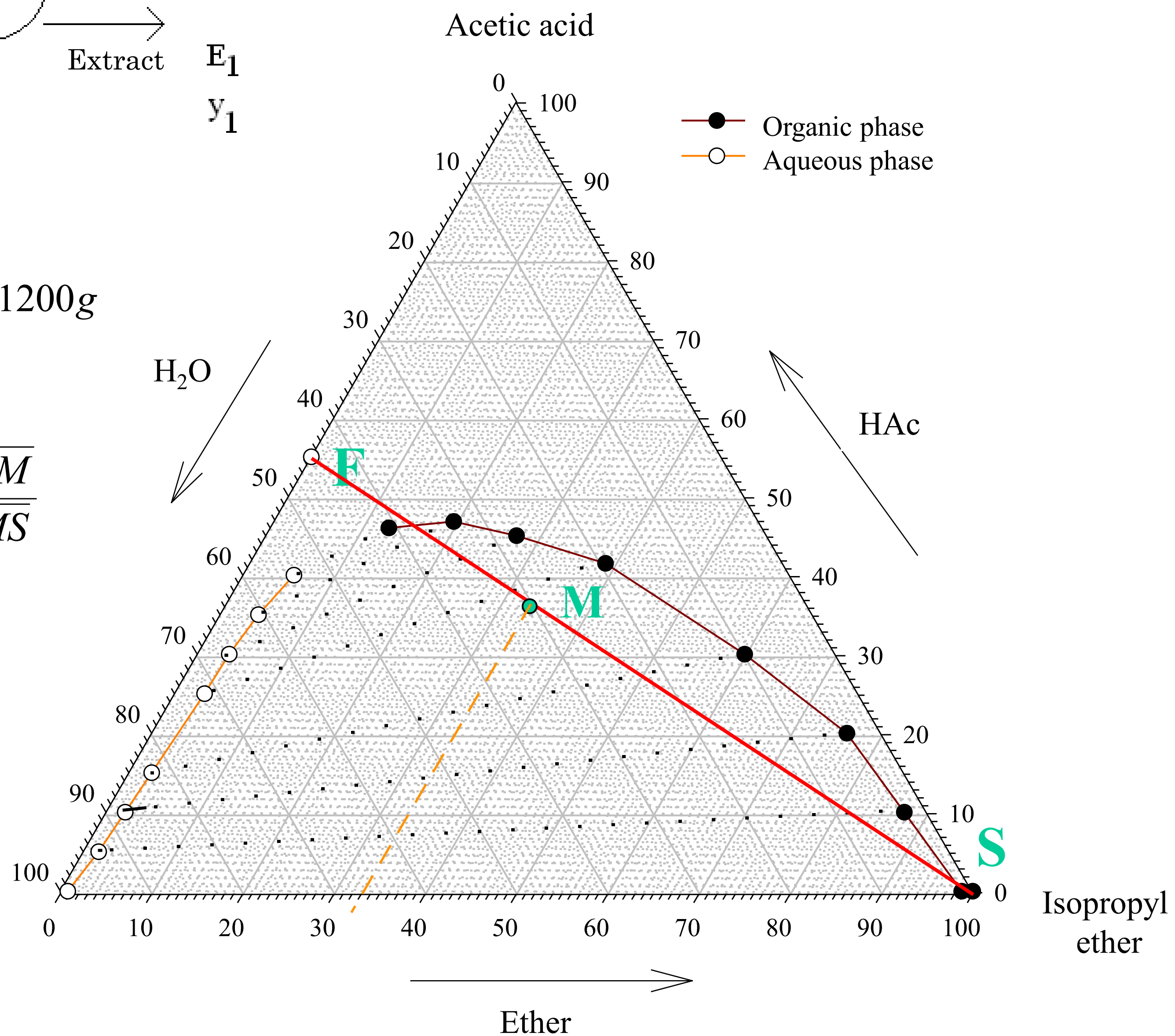
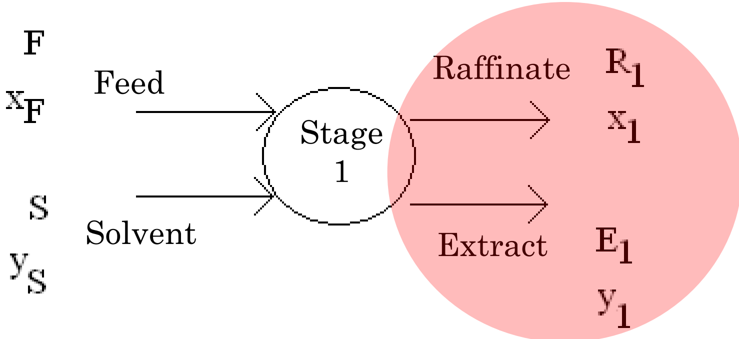
$$\Rightarrow x_M = 37\%$$



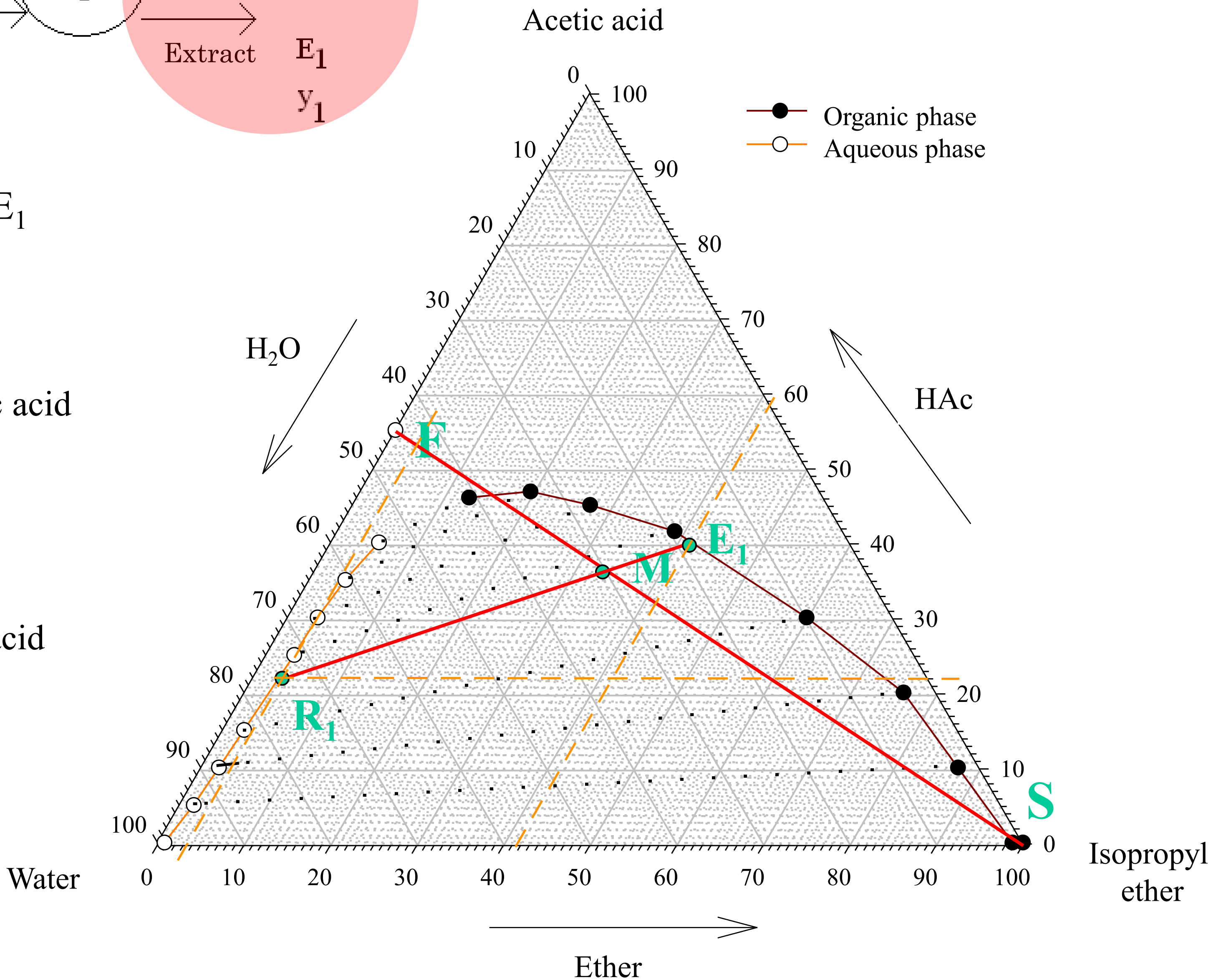


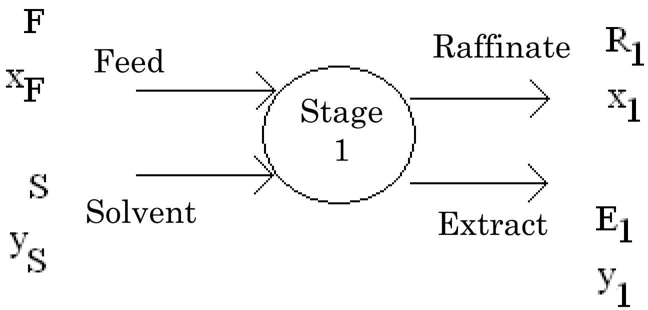
$x_F = 55\%$; $y_S = 0\%$ F= 800g; S = 400g

$$M = R_1 + E_1$$

R_1
22.5% Acetic acid
75.5% Water
2% Ether

E_1
40% Acetic acid
41% Ether
19% Water





$x_F = 55\%$; $y_S = 0\%$ F= 800g; S = 400g

$$M = R_1 + E_1$$

$$\Downarrow$$

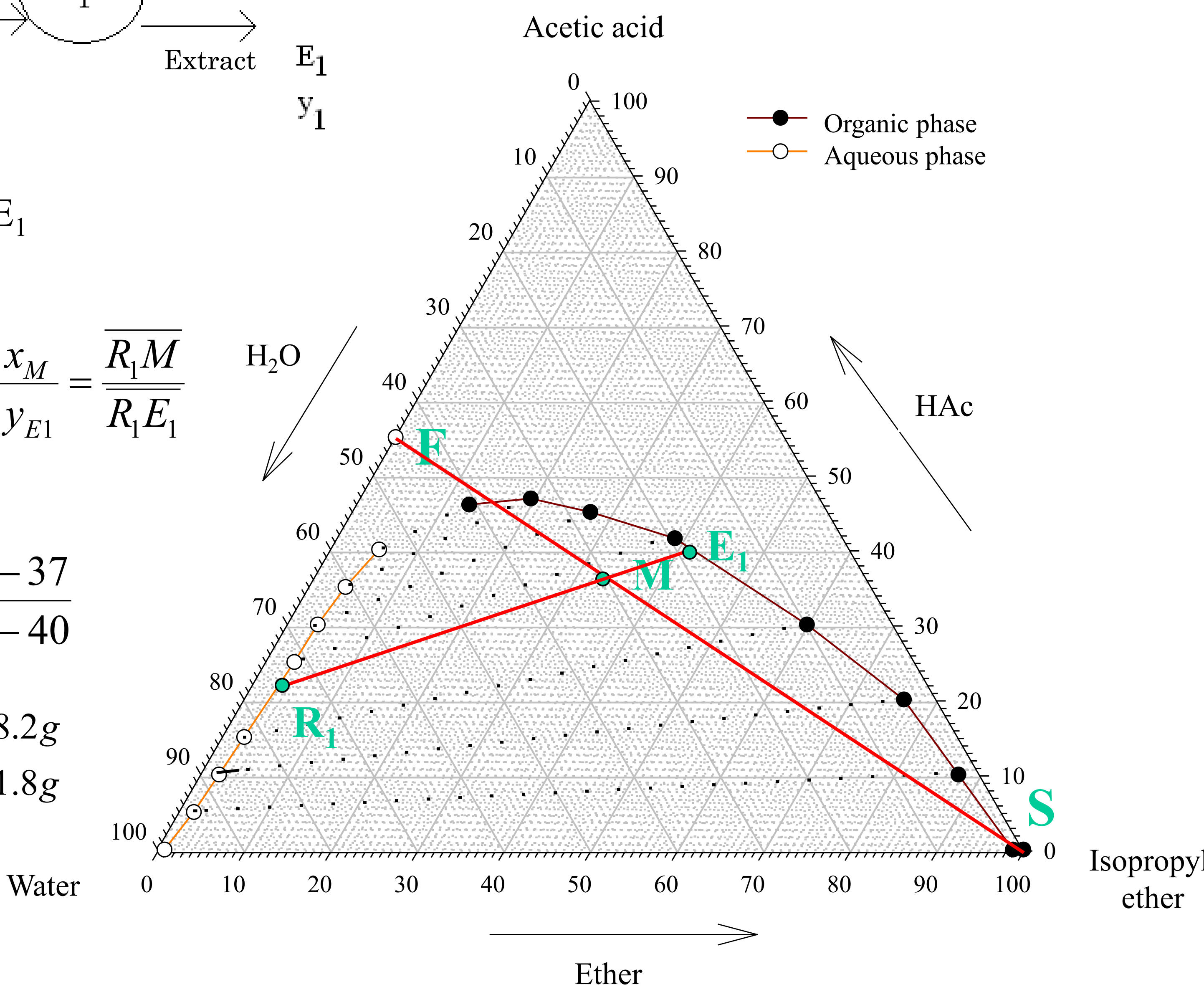
$$\frac{E_1}{M} = \frac{x_{R1} - x_M}{x_{R1} - y_{E1}} = \frac{\overline{R_1 M}}{\overline{R_1 E_1}}$$

$$\Downarrow$$

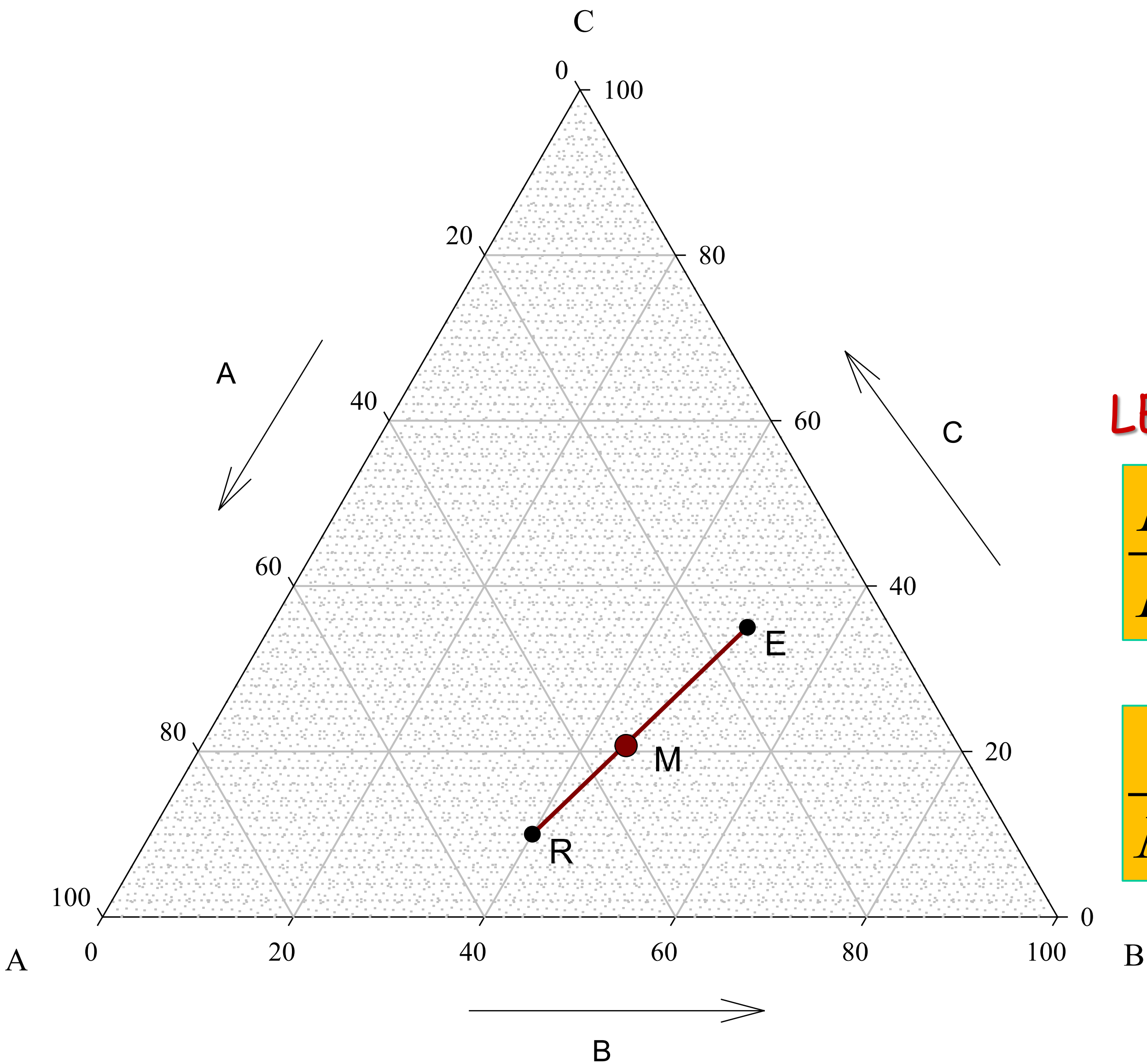
$$\frac{E_1}{1200} = \frac{23 - 37}{23 - 40}$$

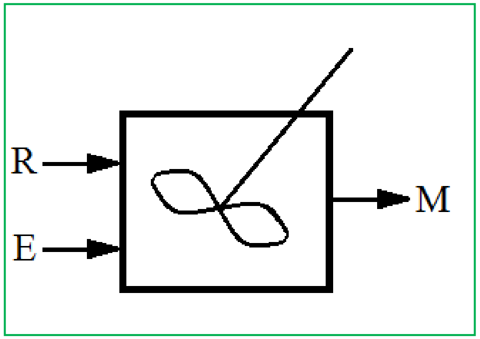
$$\Rightarrow \quad E_1 = 988.2g$$

$$R_1 = 211.8g$$



Mixing operation - Calculations





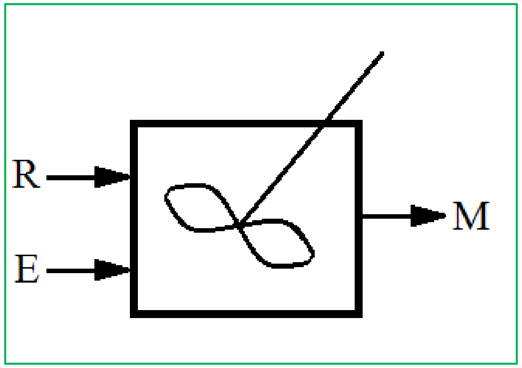
$$R + E = M$$

LEVEL-ARM RULE

$$\frac{R}{E} = \frac{\overline{ME}}{\overline{RM}} = \frac{x_M - y_E}{x_R - x_M}$$

$$\frac{R}{M} = \frac{\overline{ME}}{\overline{RE}} = \frac{x_M - y_E}{x_R - y_E}$$

LEVEL-ARM RULE

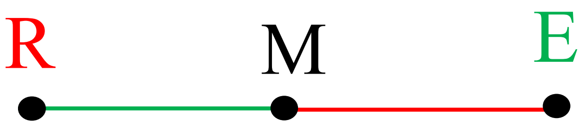


B.M. global

B.M. partial to C

$$\begin{cases} R + E = M \\ Rx_R + Ey_E = Mx_M \end{cases}$$

$$Rx_R + Ey_E = (R+E)x_M$$



$$R(x_R - x_M) = E(x_M - y_E)$$

$$\frac{R}{E} = \frac{x_M - y_E}{x_R - x_M} = \frac{\overline{ME}}{\overline{RM}}$$

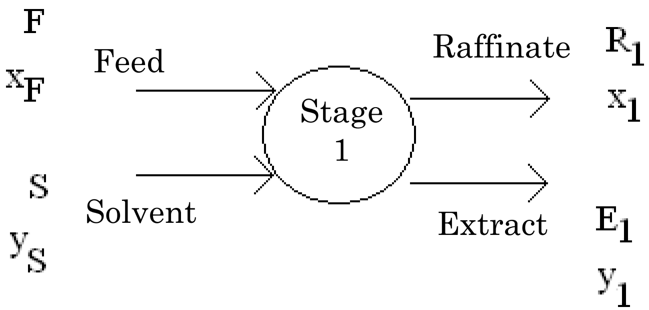
Problem 1

Pretende-se extrair o ácido acético contido em 800 g de uma solução aquosa com 55 % (percentagem mássica de ácido acético) (T = 20 ºC), adicionando-se 400 g de éter isopropílico, sem variação de temperatura.

b) Para a remoção do ácido ainda existente na fase refinada obtida da operação anterior, adiciona-se éter isopropílico na proporção de 1:1. Determine as composições e as massas das novas fases em equilíbrio.

The aim is to extract the acetic acid contained in 800 g of an aqueous solution with 55 % (mass percentage of acetic acid) (T = 20 ºC), by adding 400 g of isopropyl ether without varying the temperature.

b) To remove the acid still present in the raffinate phase obtained from the previous operation, isopropyl ether is again added in a 1:1 ratio. Determine the compositions and masses of the new phases at equilibrium.



x_F= 55%; y_S = 0%   F= 800g; S = 400g

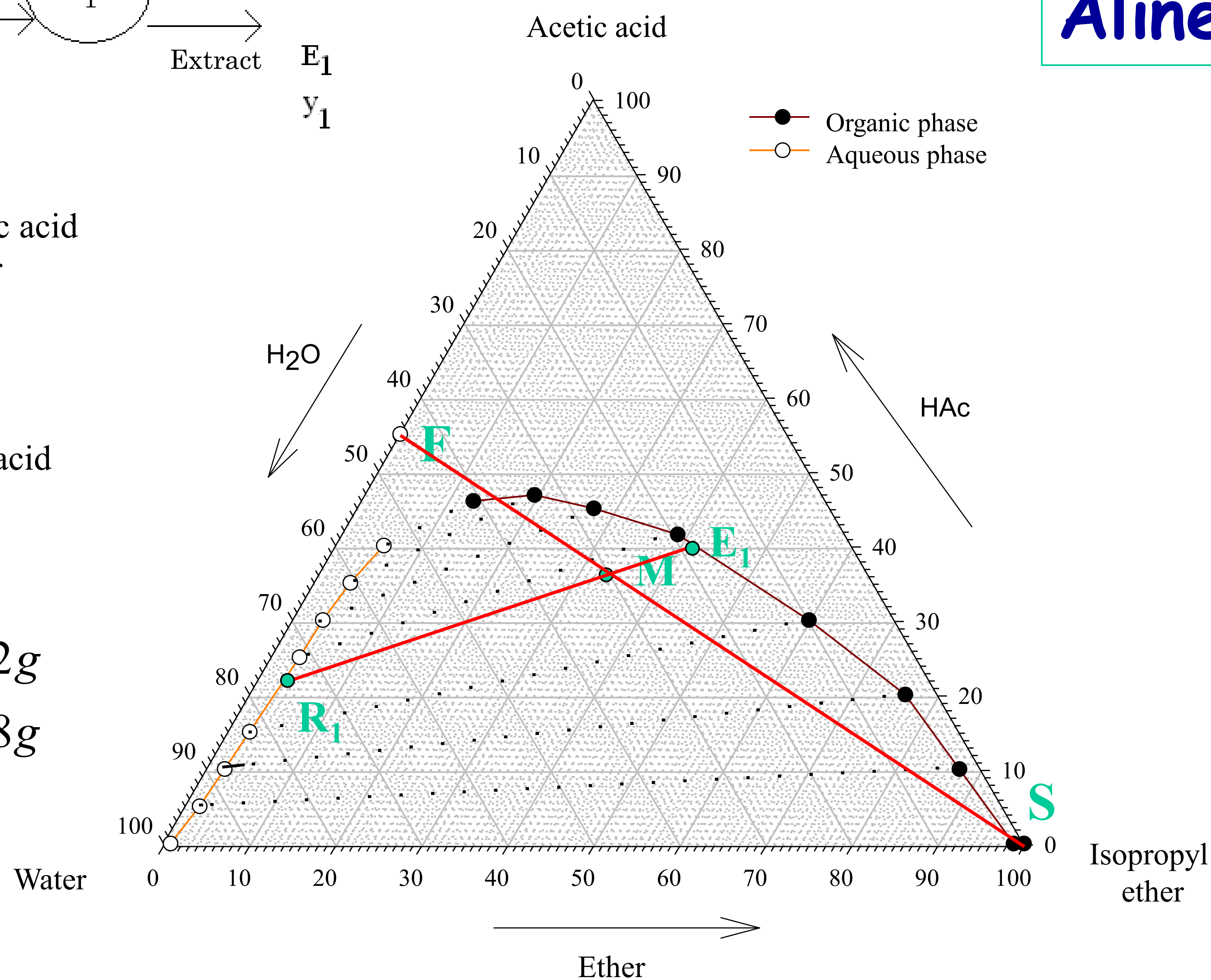
Alínea a

R_1
22.5% Acetic acid
75.5% Water
2% Ether

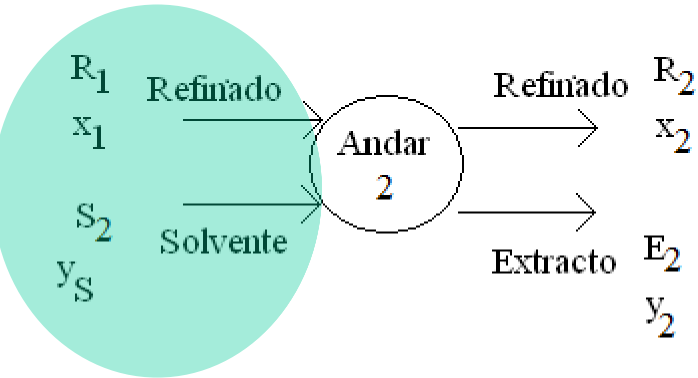
E_1
40% Acetic acid
41% Ether
19% Water

$$E_1 = 988.2g$$

$$R_1 = 211.8g$$



b) To remove the acid still present in the raffinate phase obtained from the previous operation, isopropyl ether is again added in a 1:1 ratio. Determine the compositions and masses of the new phases at equilibrium



R_1
22.5% Acetic acid
75.5% Water
2% Ether

$$R_1 = 211.8g$$

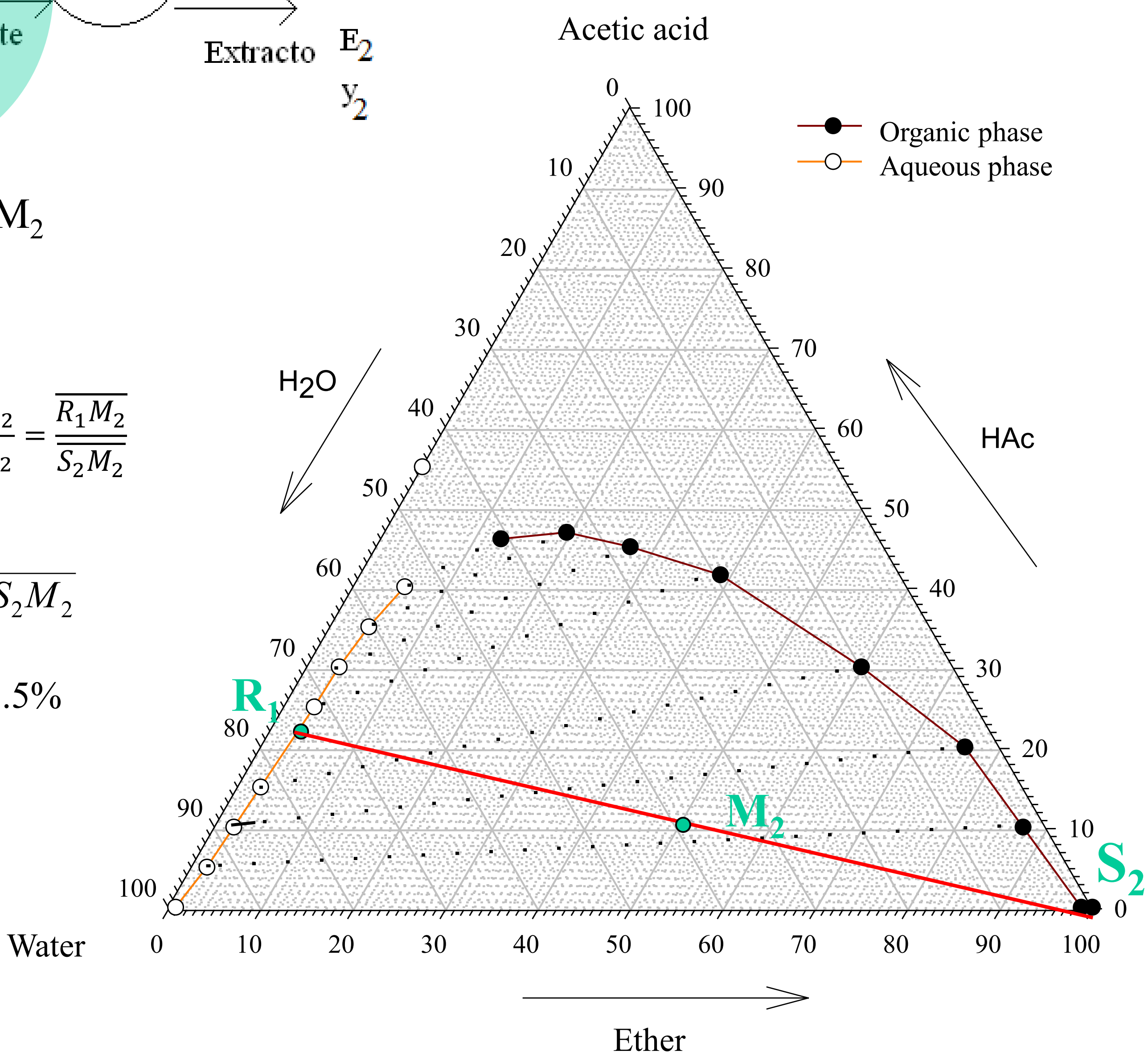
$$R_1 + S_2 = M_2$$

$$S_2 = R_1$$

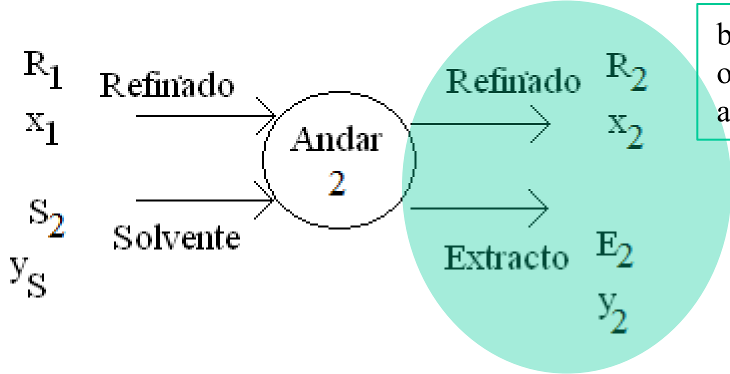
$$\frac{S_2}{R_1} = \frac{x_{R1} - x_{M2}}{x_{M2} - y_{S2}} = \frac{\overline{R_1M_2}}{\overline{S_2M_2}}$$

$$=> \quad \overline{R_1M_2} = \overline{S_2M_2}$$

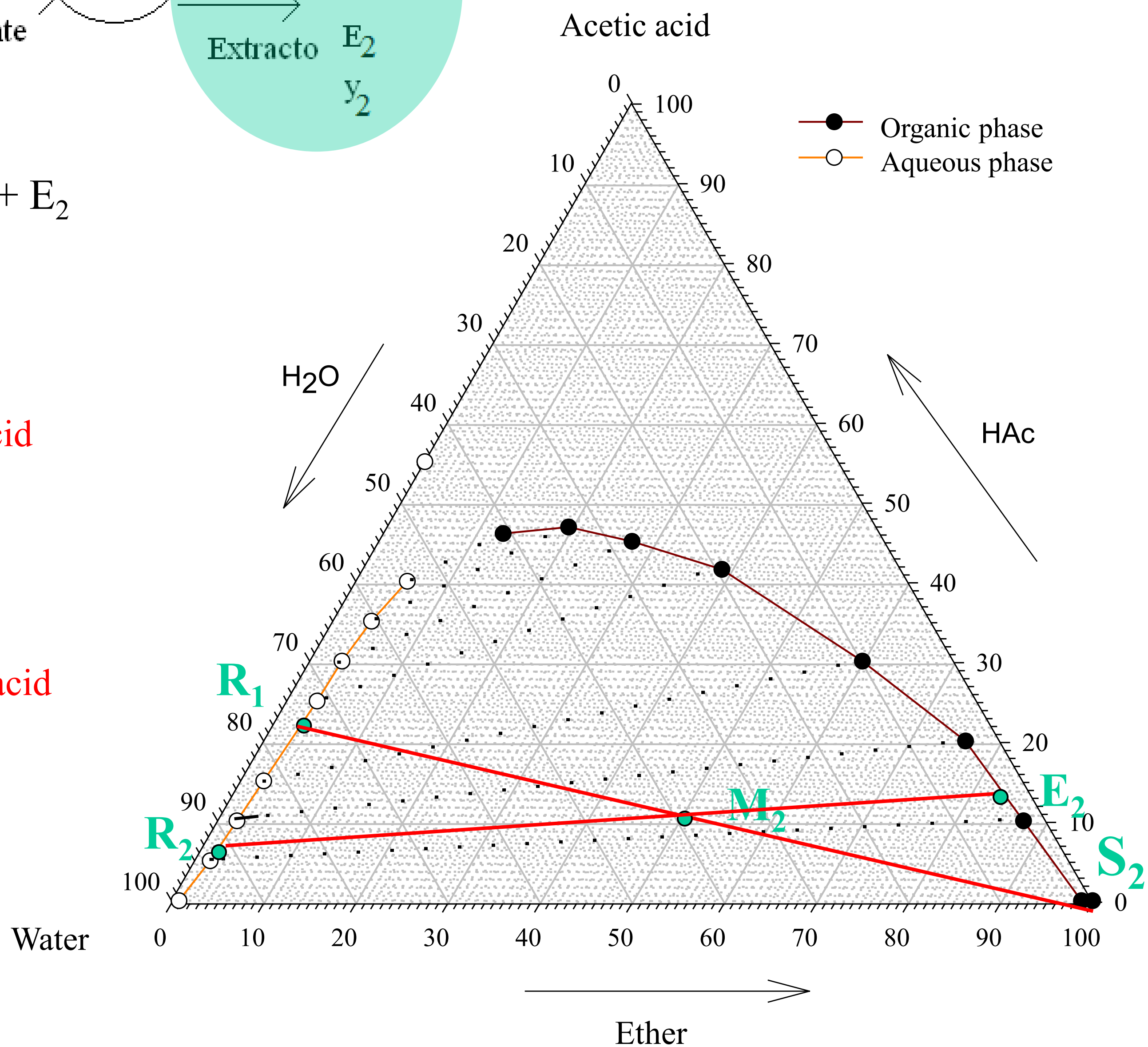
$$=> \quad x_M = 11.5\%$$



b) To remove the acid still present in the raffinate phase obtained from the previous operation, isopropyl ether is again added in a 1:1 ratio. Determine the compositions and masses of the new phases at equilibrium



$$M_2 = R_2 + E_2$$

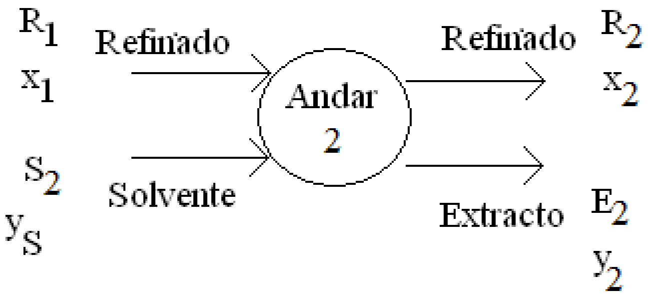


R_1
23% Acetic acid
75% Water
2% Ether

E_1
40% Acetic acid
41% Ether
19% Water

R_2
7% Acetic acid
91% Water
2% Ether

E_2
14% Acetic acid
83% Ether
3% Water

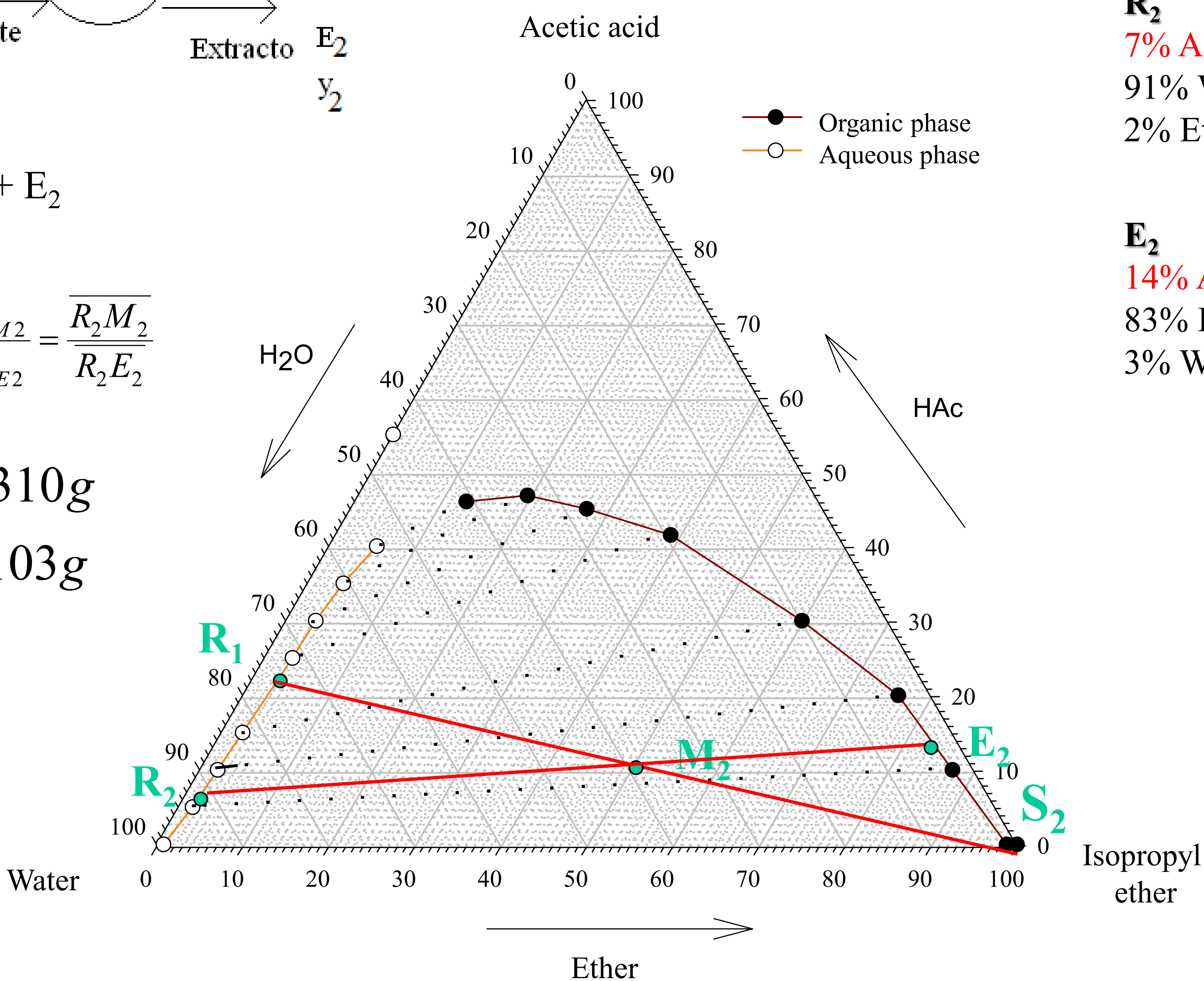


b) To remove the acid still present in the raffinate phase obtained from the previous operation, isopropyl ether is again added in a 1:1 ratio. Determine the compositions and masses of the new phases at equilibrium

$$M_2 = R_2 + E_2$$

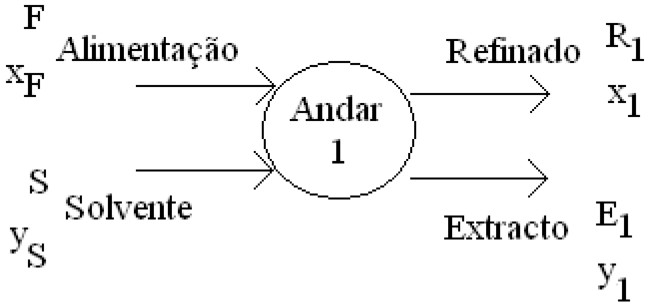
$$\frac{E_2}{M_2} = \frac{x_{R2} - x_{M2}}{x_{R2} - y_{E2}} = \frac{\overline{R_2 M_2}}{\overline{R_2 E_2}}$$

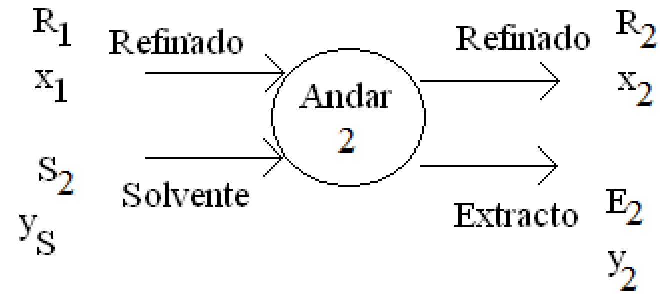
$$\Rightarrow \quad E_2 = 310g \qquad R_2 = 103g$$



R_2
7% Acetic acid
91% Water
2% Ether

E_2
14% Acetic acid
83% Ether
3% Water



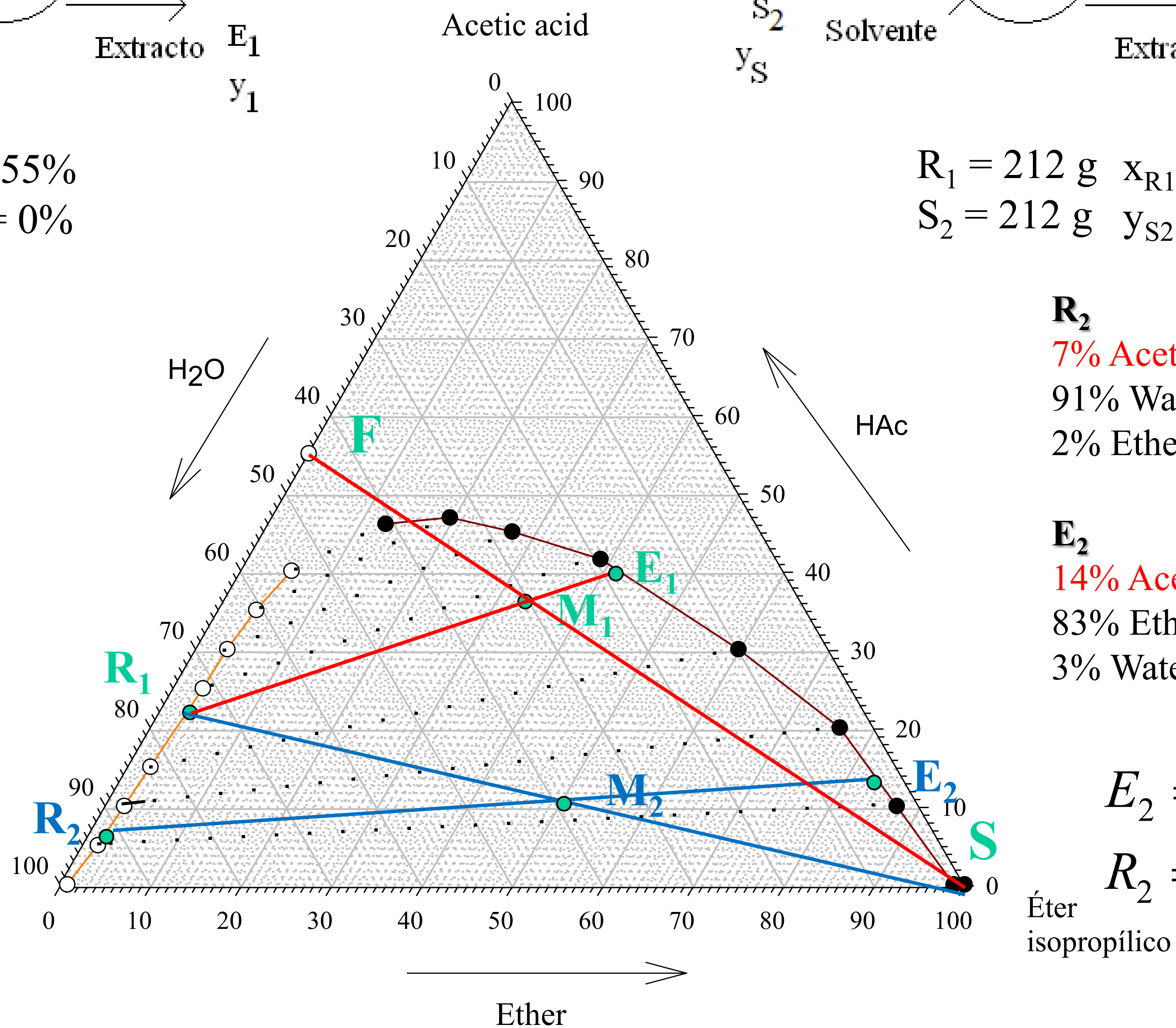


$F = 800$ g $\quad x_F = 55\%$

$S_1 = 400$ g $\quad y_{S1} = 0\%$

$R_1 = 212$ g $\quad x_{R1} = 22.5\%$

$S_2 = 212$ g $\quad y_{S2} = 0\%$



R_1

23% Acetic acid

75% Water

2% Ether

E_1

40% Acetic acid

41% Ether

19% Water

$$E_1 = 988.2g$$

$$R_1 = 211.8g$$

R_2

7% Acetic acid

91% Water

2% Ether

E_2

14% Acetic acid

83% Ether

3% Water

$$E_2 = 310g$$

$$R_2 = 103g$$

Problema 2

Pretende-se recuperar acetona de uma solução aquosa a 30 ºC usando acetato de etilo, $CH_3COOCH_2CH_3$, como solvente.

A corrente de alimentação, contendo 25 % de acetona e 75 % de água, entra no topo da coluna de extracção a um caudal de 250 kg/h. O solvente, puro, entra na base a um caudal de 97 kg/h. Deseja-se um produto refinado com 10 % de acetona. Calcule:

a) A concentração e o caudal da corrente de extracto;

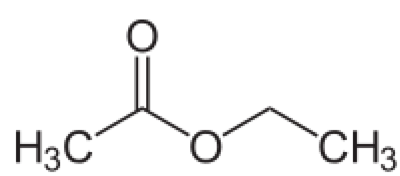
b) O número de andares de equilíbrio necessários para esta separação.

Dados:

Dados de equilíbrio		
Acetato de etilo	Acetona	Água
7.4	0.0	92.6
8.0	7.6	84.4
9.9	16.1	74.0
11.9	21.1	67.0
13.6	24.3	62.1
15.5	27.0	57.5
17.4	29.2	53.4
19.2	31.1	49.7
24.0	33.8	42.2
25.5	34.6	39.9
29.0	36.0	35.0
36.7	37.0	26.3
44.4	36.1	19.5
47.6	35.0	17.4
55.0	32.0	13.0
62.5	27.5	10.0
70.0	22.4	7.6
77.0	17.0	6.0
83.7	11.2	5.1
96.5	0.0	3.5

Fase orgânica			Fase aquosa		
Acetato de etilo	Acetona	Água	Acetato de etilo	Acetona	Água
91.0	4.8	4.2	8.3	3.2	88.5
85.6	9.4	5.0	8.0	6.0	86.0
80.5	13.5	6.0	8.3	9.5	82.2
77.2	16.6	6.2	9.2	12.8	78.0
73.0	20.0	7.0	9.8	14.8	75.4
70.0	22.4	7.6	10.2	17.5	72.3
65.0	26.0	9.0	12.2	19.8	68.0
62.0	27.8	10.2	11.8	21.2	67.0
54.0	32.6	13.4	15.0	26.4	58.6

Acetato de etilo



Densidade (líquido)	0.897 g/cm³
Ponto de ebulição	77 °C

Problem 2

The aim is to recover acetone from an aqueous solution at 30 ºC using ethyl acetate, CH3COOCH2CH3, as solvent.

The feed stream, containing 25% acetone and 75% water, enters the base of the extraction column at a flow rate of 250 kg/h. The pure solvent enters at the top of the column at a flow rate of 97 kg/h. A raffinate product with 10% acetone is desired. Calculate:

a) The concentration and flow rate of the extract stream;

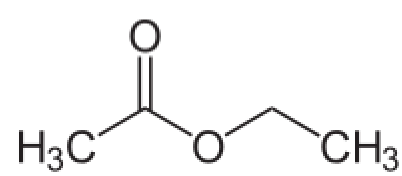
b) The number of equilibrium stages required for this separation.

<u>Experimental data:</u>

Equilibrium data		
Ethyl acetate	Acetone	Water
7.4	0.0	92.6
8.0	7.6	84.4
9.9	16.1	74.0
11.9	21.1	67.0
13.6	24.3	62.1
15.5	27.0	57.5
17.4	29.2	53.4
19.2	31.1	49.7
24.0	33.8	42.2
25.5	34.6	39.9
29.0	36.0	35.0
36.7	37.0	26.3
44.4	36.1	19.5
47.6	35.0	17.4
55.0	32.0	13.0
62.5	27.5	10.0
70.0	22.4	7.6
77.0	17.0	6.0
83.7	11.2	5.1
96.5	0.0	3.5

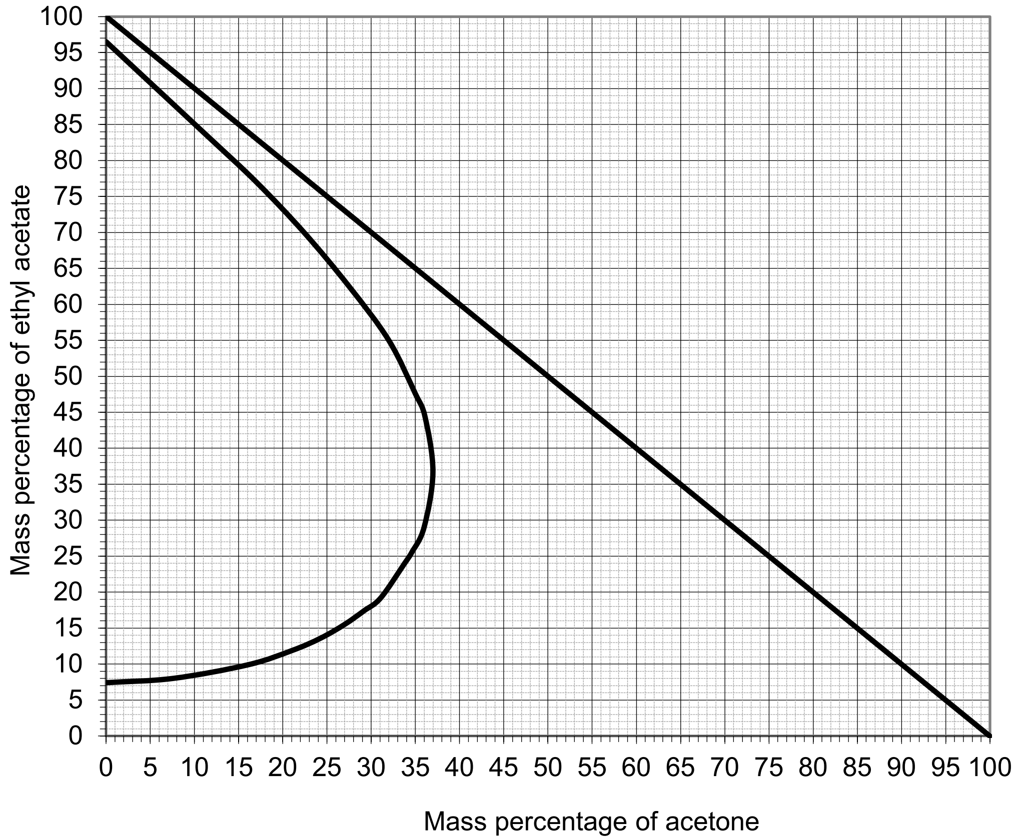
Organic phase			Aqueous phase		
Ethyl acetate	Acetone	Water	Ethyl acetate	Acetone	Water
91.0	4.8	4.2	8.3	3.2	88.5
85.6	9.4	5.0	8.0	6.0	86.0
80.5	13.5	6.0	8.3	9.5	82.2
77.2	16.6	6.2	9.2	12.8	78.0
73.0	20.0	7.0	9.8	14.8	75.4
70.0	22.4	7.6	10.2	17.5	72.3
65.0	26.0	9.0	12.2	19.8	68.0
62.0	27.8	10.2	11.8	21.2	67.0
54.0	32.6	13.4	15.0	26.4	58.6

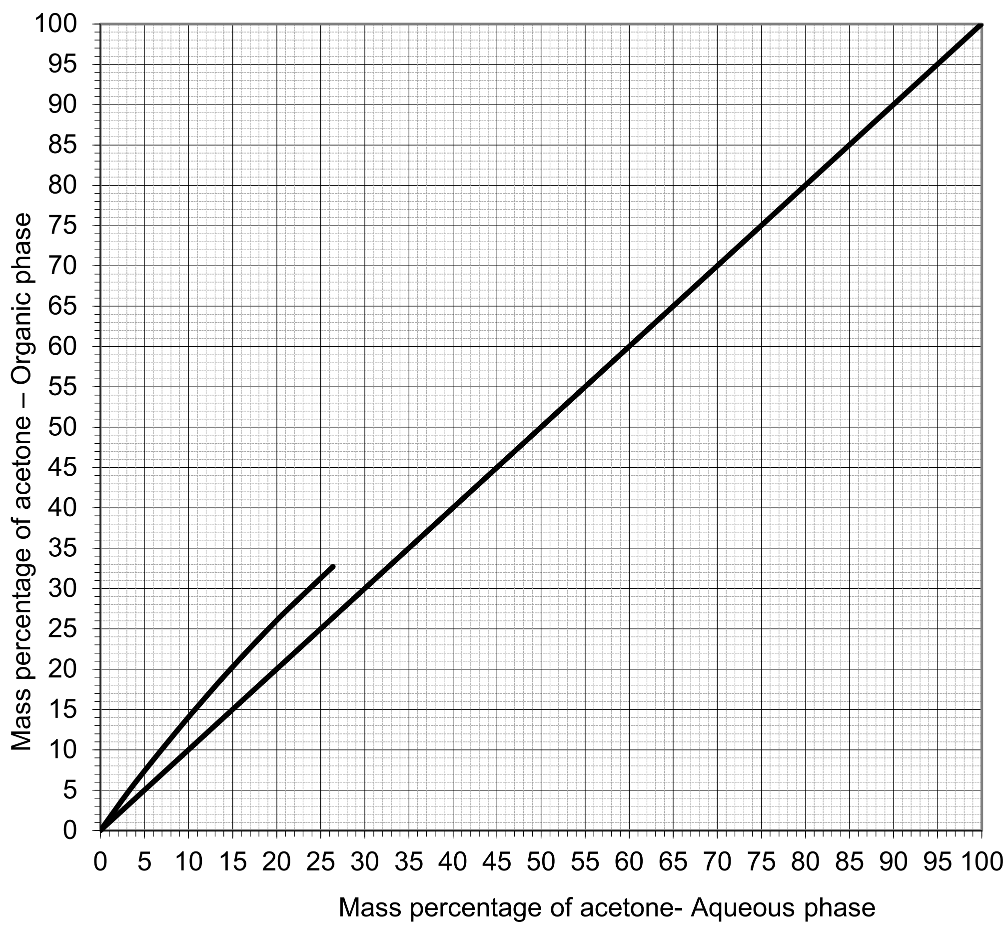
Ethyl acetate



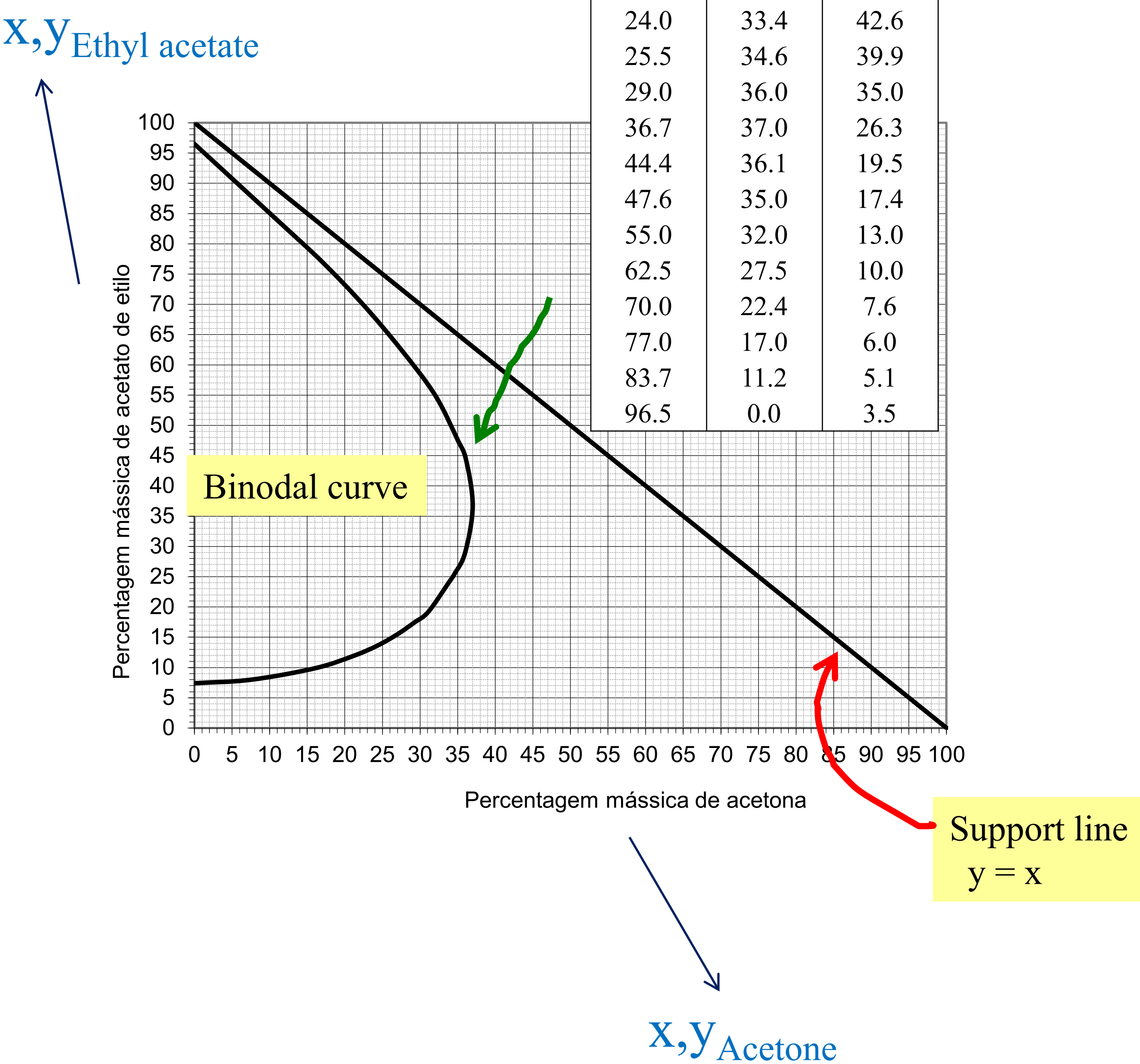
Density (liquid)	0.897 g/cm³
Boiling point	77 °C

Equilibrium diagram for the system
Water, Acetone, Ethyl acetate



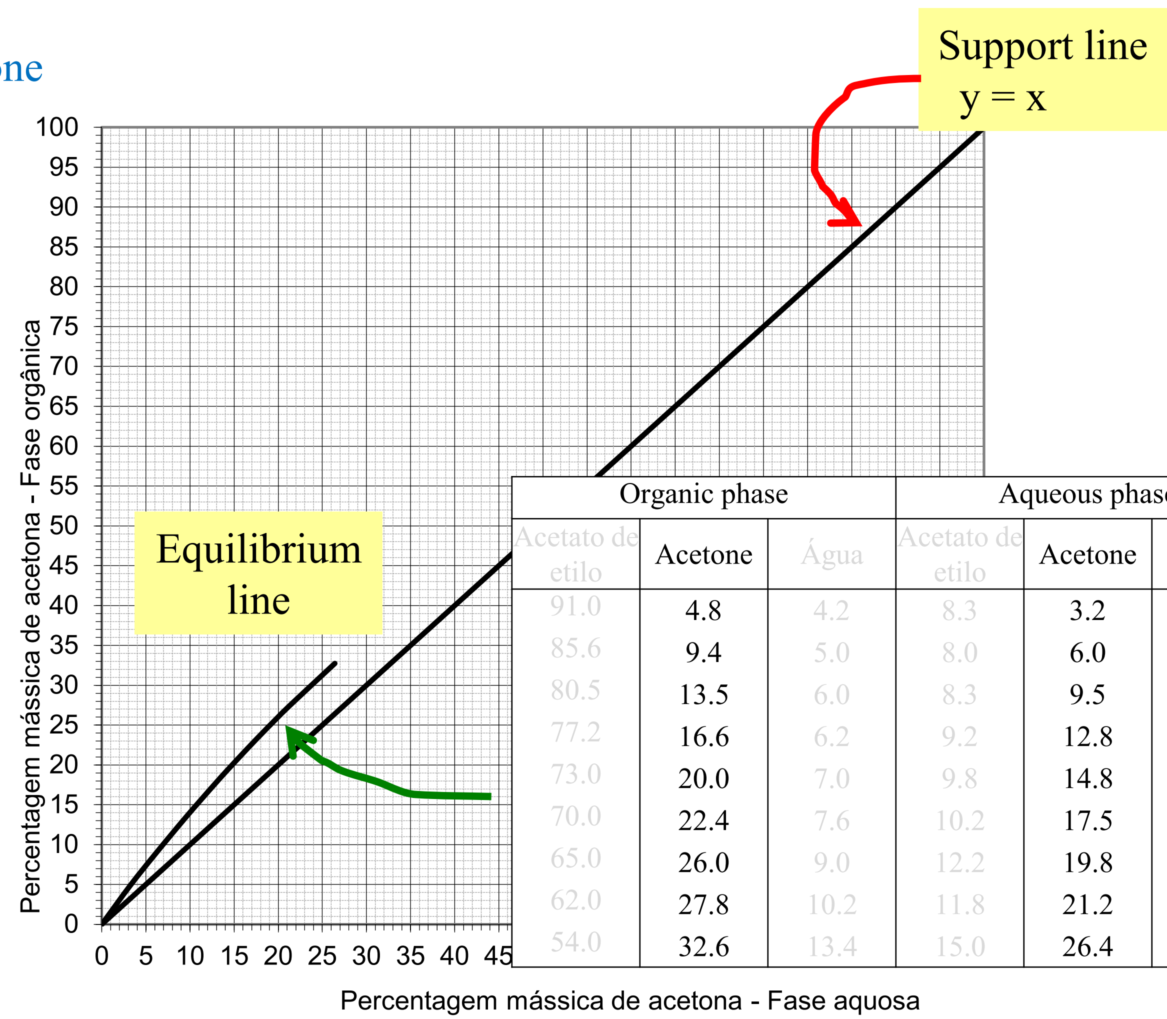


Equilibrium data		
Ethyl acetate	Acetone	Water
7.4	0.0	92.6
8.0	7.6	84.4
9.9	16.1	74.0
11.9	21.1	67.0
13.6	24.3	62.1
15.5	27.0	57.5
17.4	29.2	53.4
19.2	31.1	49.7
24.0	33.4	42.6
25.5	34.6	39.9
29.0	36.0	35.0
36.7	37.0	26.3
44.4	36.1	19.5
47.6	35.0	17.4
55.0	32.0	13.0
62.5	27.5	10.0
70.0	22.4	7.6
77.0	17.0	6.0
83.7	11.2	5.1
96.5	0.0	3.5



A: Water (diluent)
C: Acetone (solute)
B: Ethyl acetate (solvent)

$y_{acetone}$



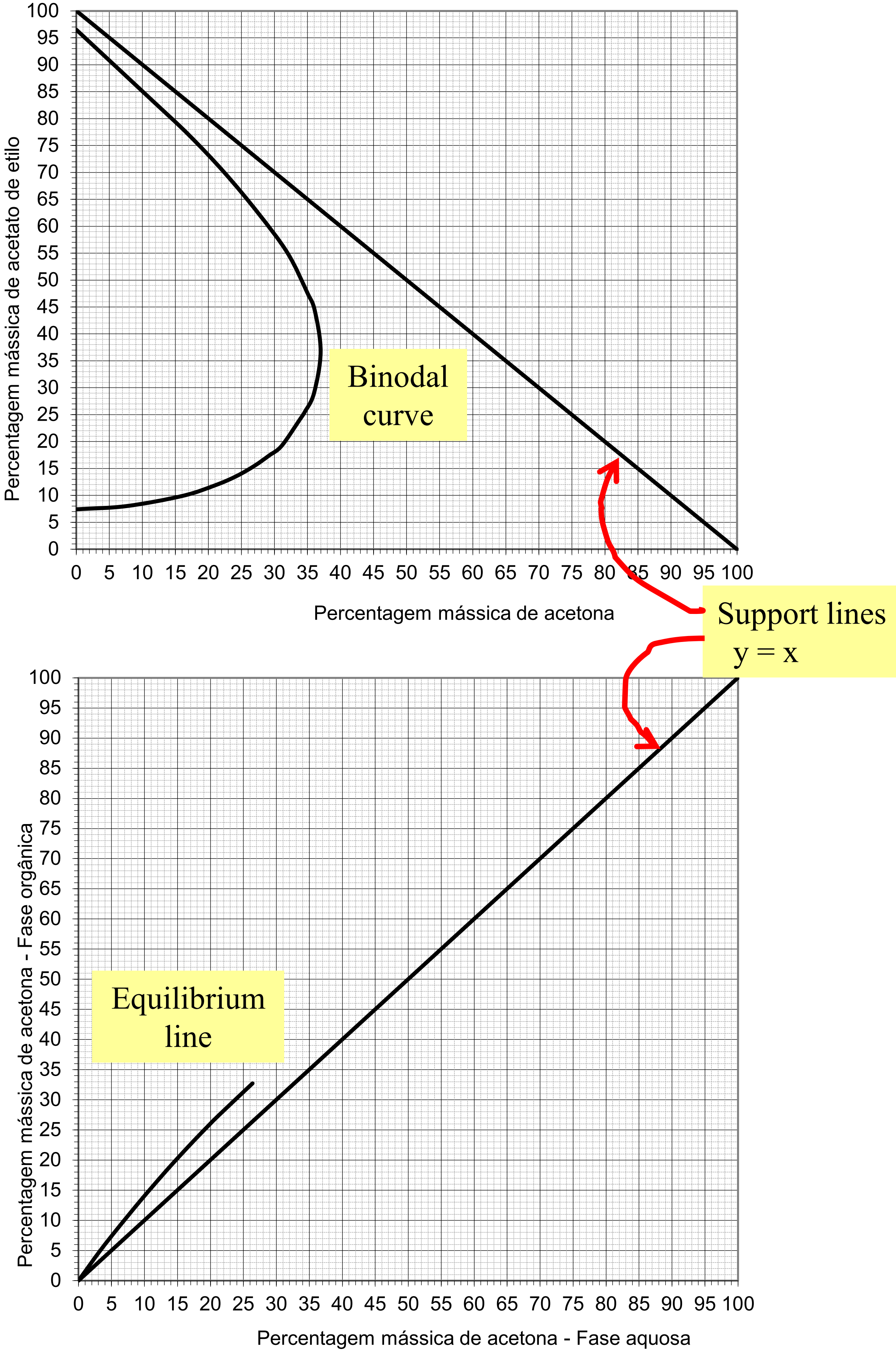
Organic phase			Aqueous phase		
Acetato de etilo	Acetone	Água	Acetato de etilo	Acetone	Água
91.0	4.8	4.2	8.3	3.2	88.5
85.6	9.4	5.0	8.0	6.0	86.0
80.5	13.5	6.0	8.3	9.5	82.2
77.2	16.6	6.2	9.2	12.8	78.0
73.0	20.0	7.0	9.8	14.8	75.4
70.0	22.4	7.6	10.2	17.5	72.3
65.0	26.0	9.0	12.2	19.8	68.0
62.0	27.8	10.2	11.8	21.2	67.0
54.0	32.6	13.4	15.0	26.4	58.6

$x_{acetone}$

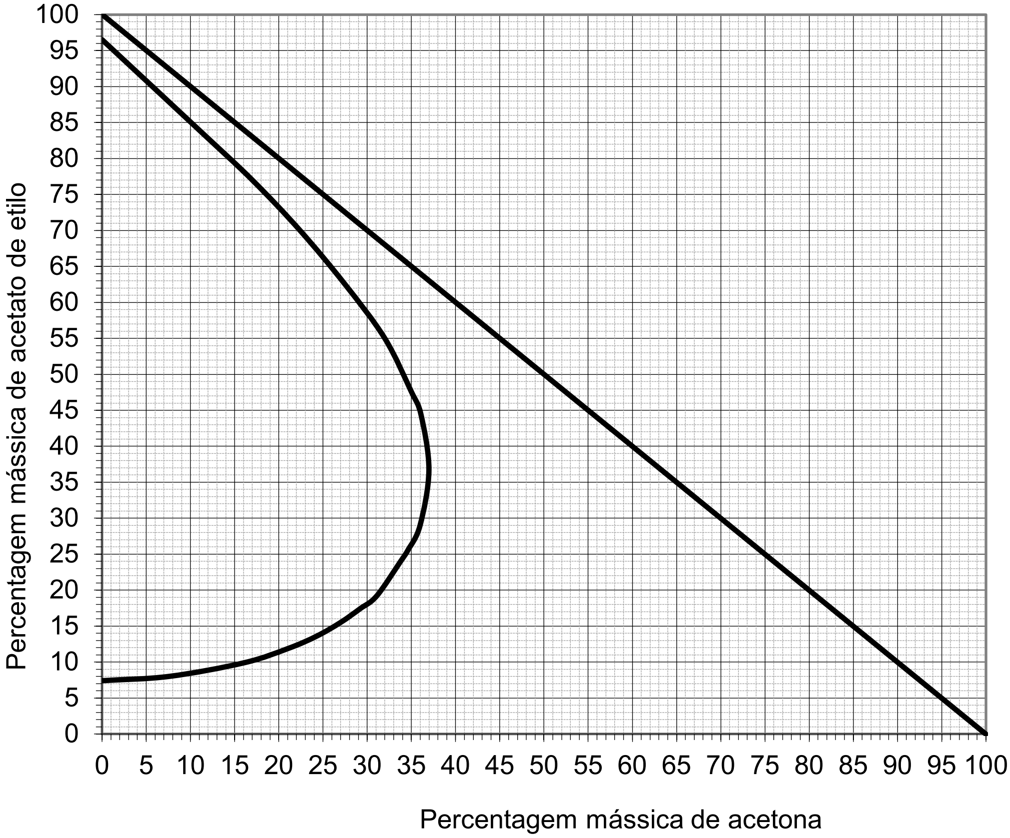
A: Water (diluent)

C: Acetone (solute)

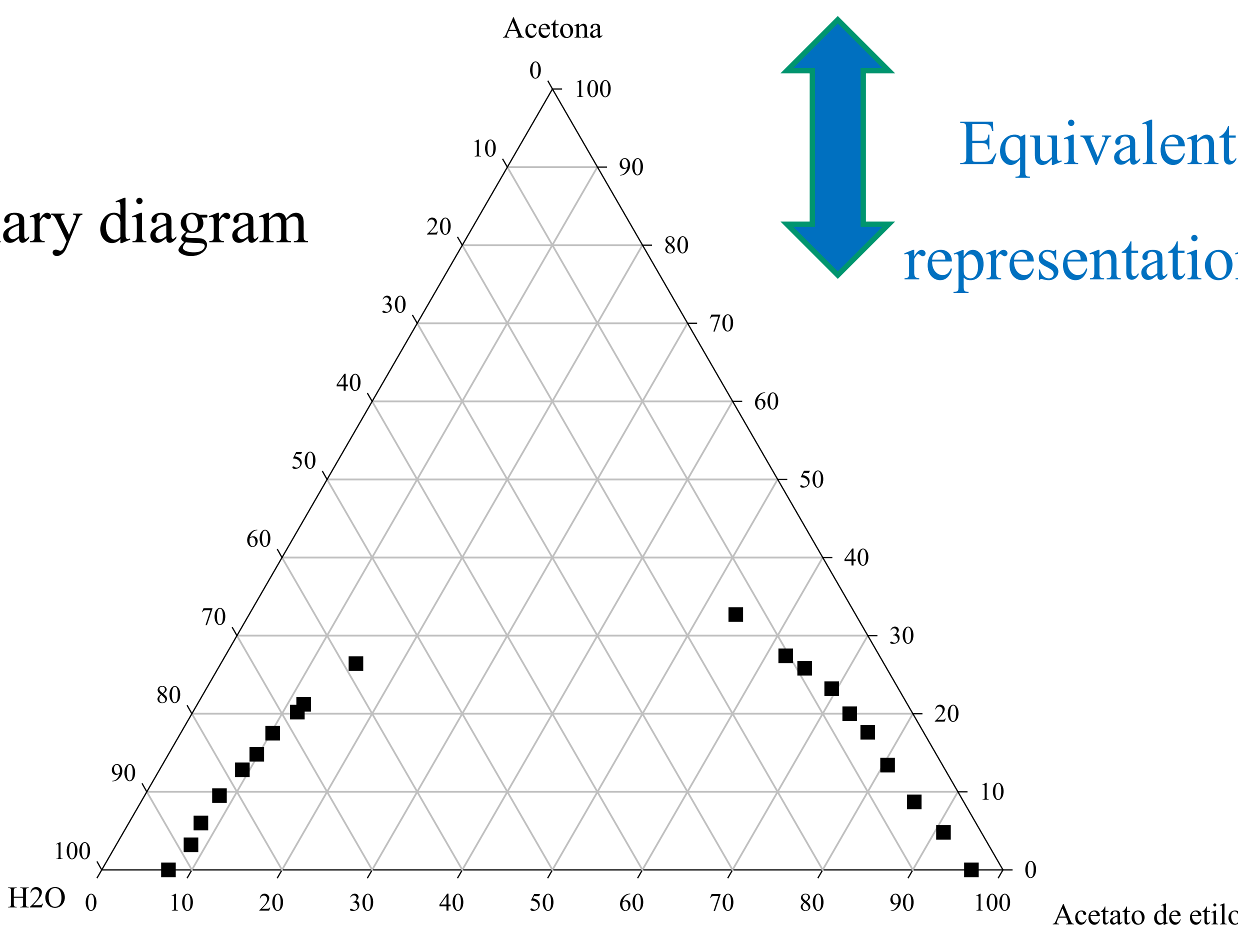
B: Ethyl acetate (solvent)


Binodal curve
Support lines
y = x
Equilibrium line
Percentagem mássica de acetato de etilo
Percentagem mássica de acetona
Percentagem mássica de acetona - Fase orgânica
Percentagem mássica de acetona - Fase aquosa

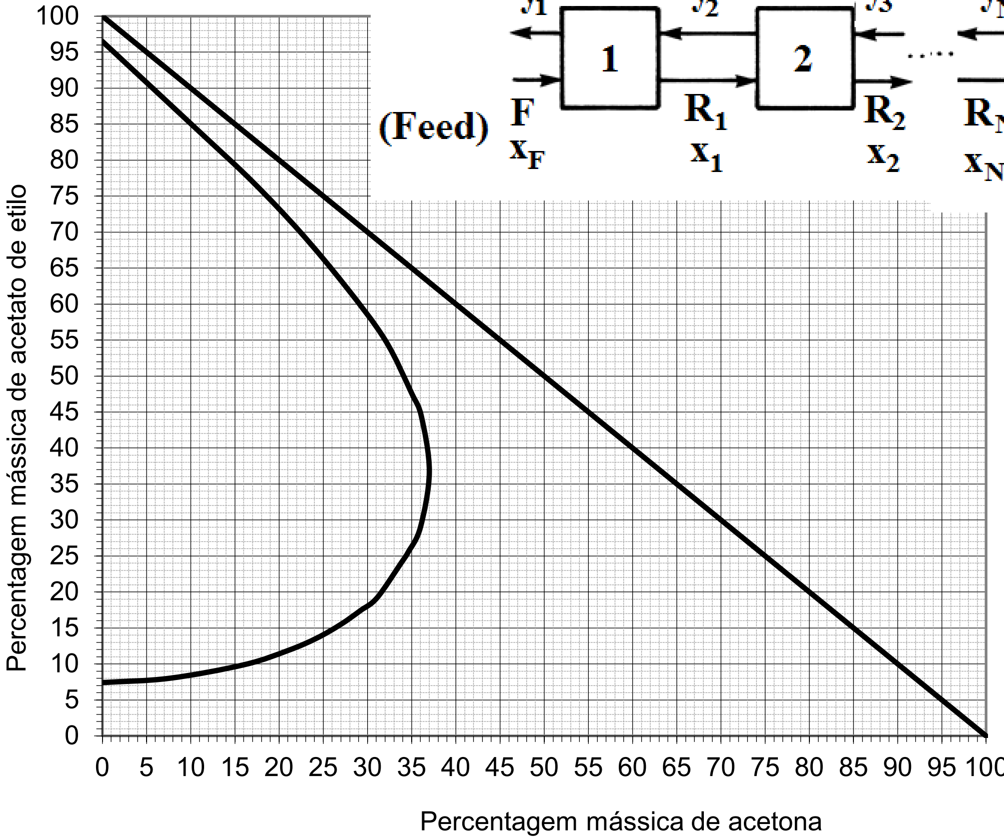
Rectangular diagram



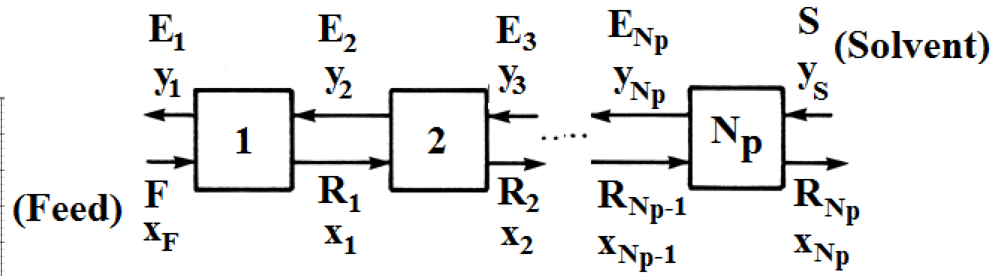
Ternary diagram



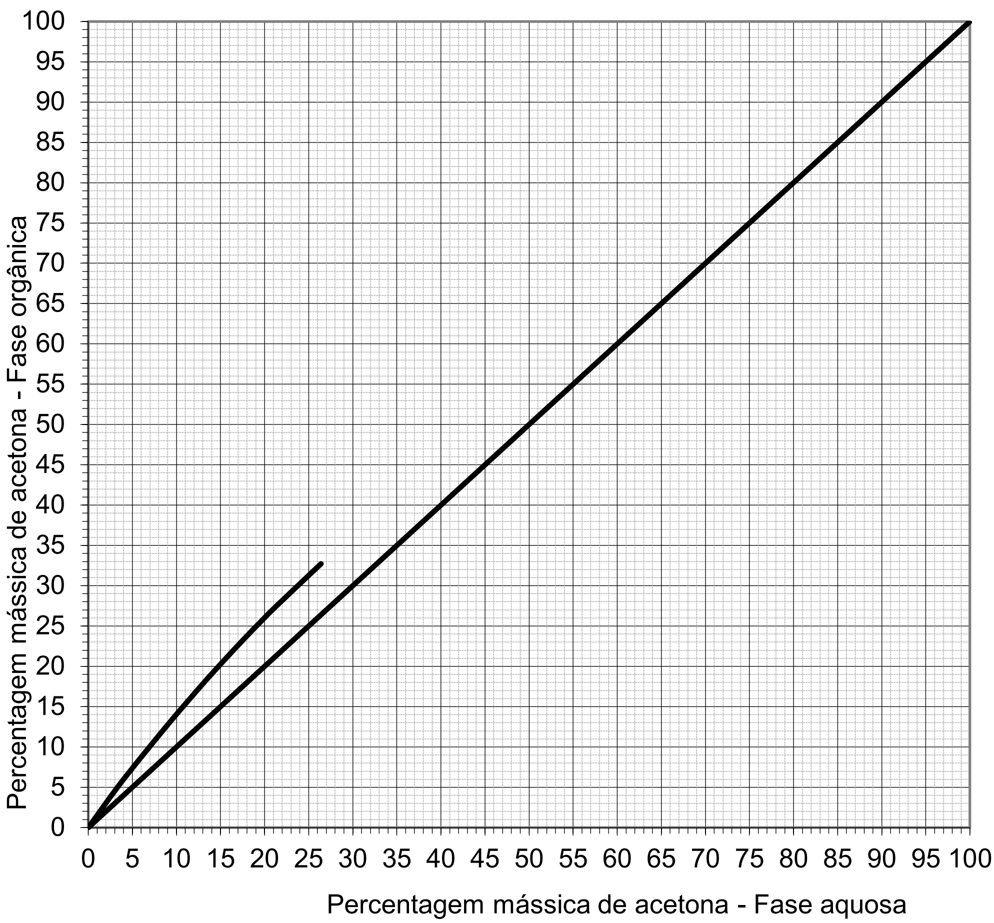
Equivalent representations



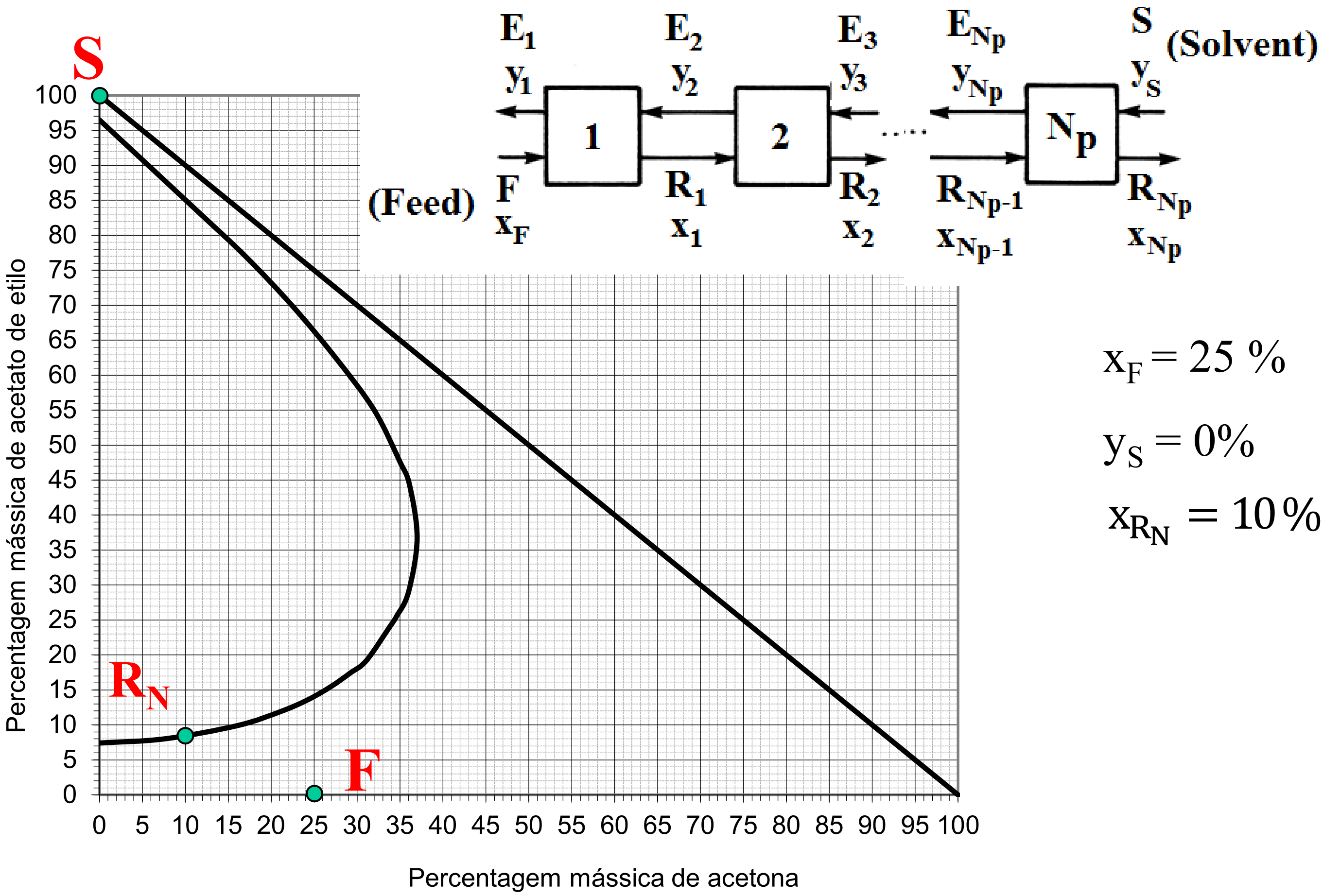
Percentagem mássica de acetato de etilo
Percentagem mássica de acetona



E1 y1
E2 y2
E3 y3
ENp yNp
S (Solvent) yS
(Feed) F xF
R1 x1
R2 x2
RNp-1 xNp-1
RNp xNp
1
2
Np



Percentagem mássica de acetona - Fase orgânica
Percentagem mássica de acetona - Fase aquosa



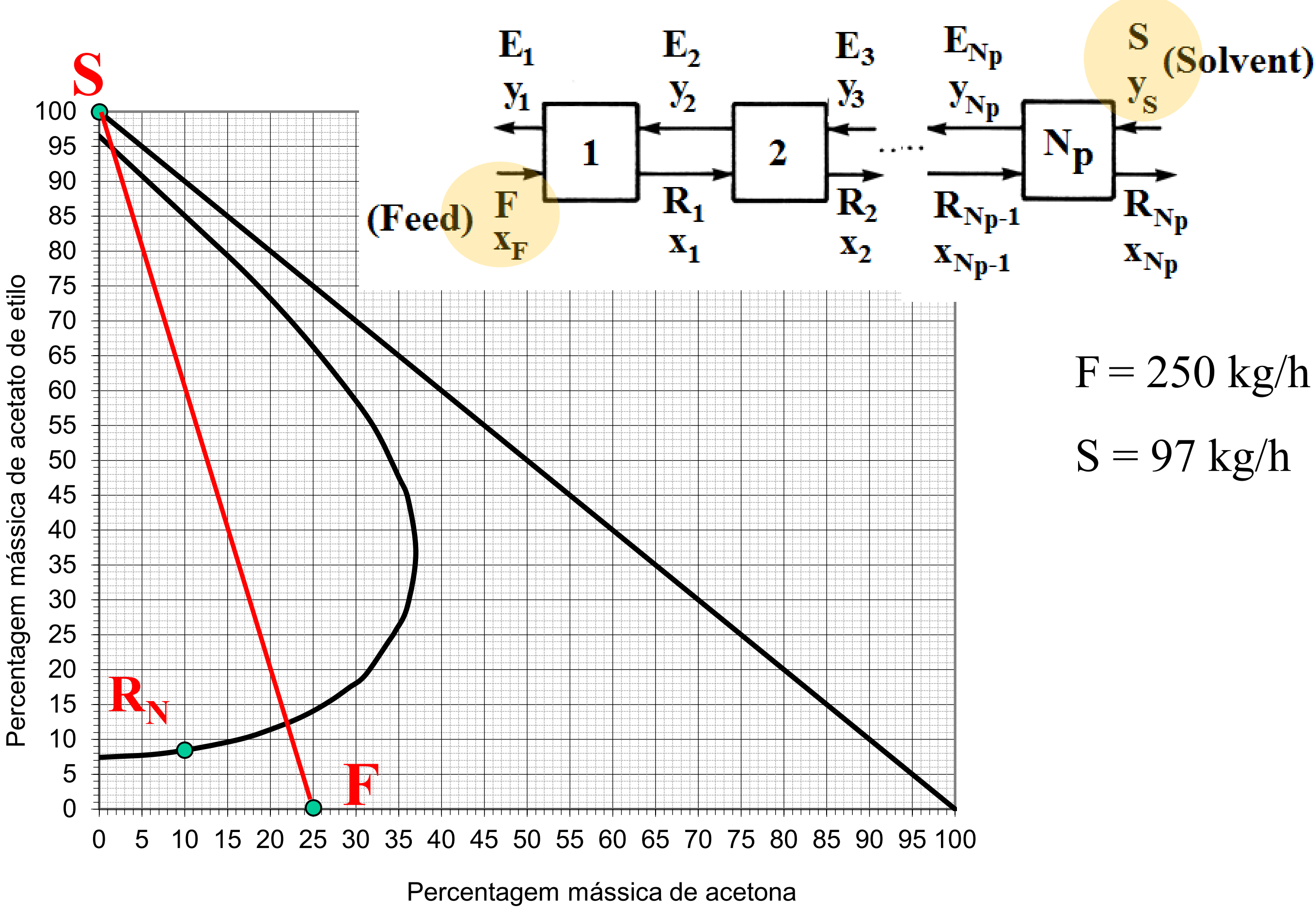
$x_F = 25\ \%$

$y_S = 0\%$

$x_{R_N} = 10\%$

1. Mark the points **F**, **S**, $\mathbf{R_N}$

The feed stream, containing 25% acetone and 75% water, enters the base of the extraction column at a flow rate of 250 kg/h. The pure solvent enters at the top of the column at a flow rate of 97 kg/h. A raffinate product with 10% acetone is desired.

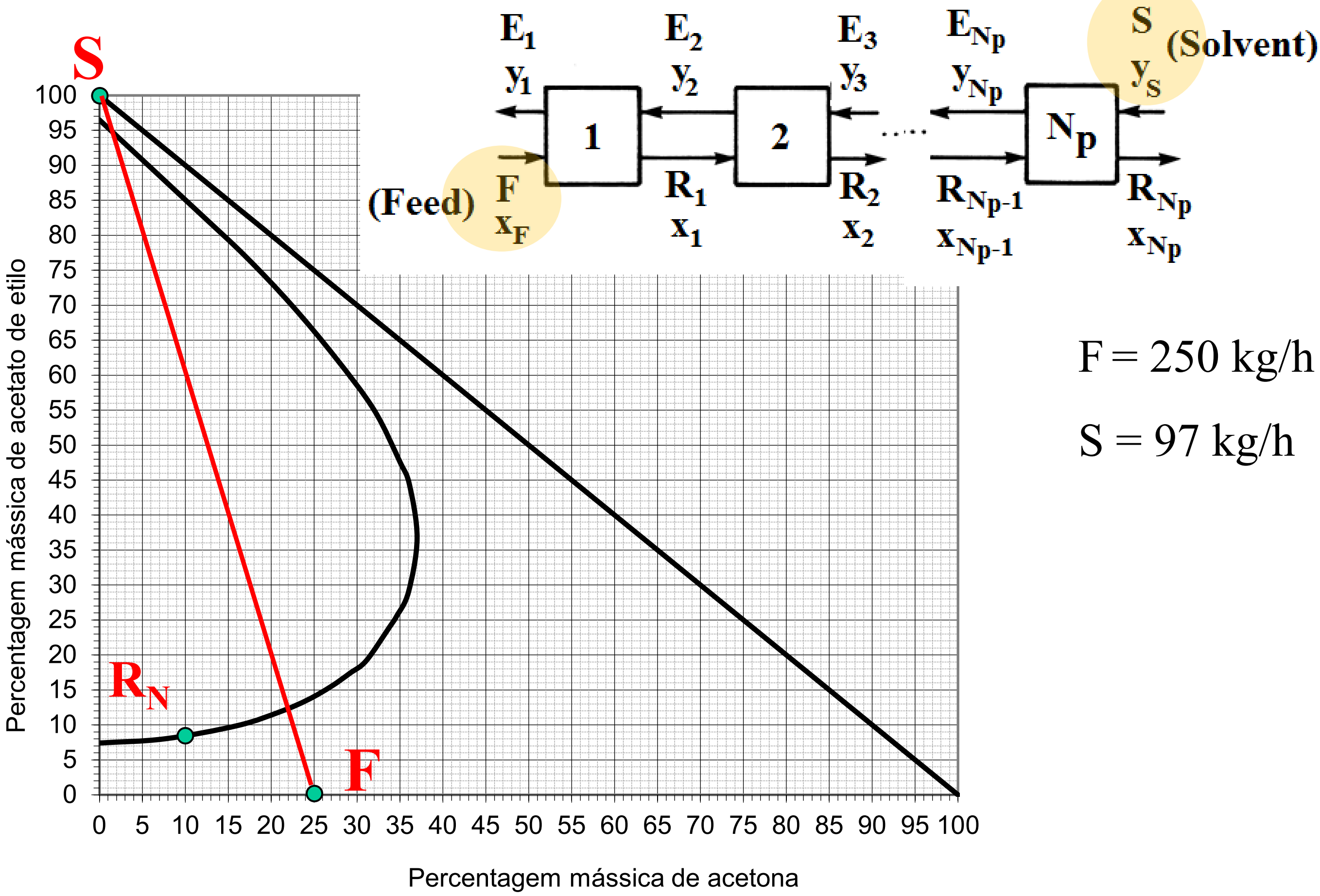


F = 250 kg/h

S = 97 kg/h

2. <u>Input</u> balance: **F + S = M**

The feed stream, containing 25% acetone and 75% water, enters the base of the extraction column at a flow rate of 250 kg/h. The pure solvent enters at the top of the column at a flow rate of 97 kg/h. A raffinate product with 10% acetone is desired.



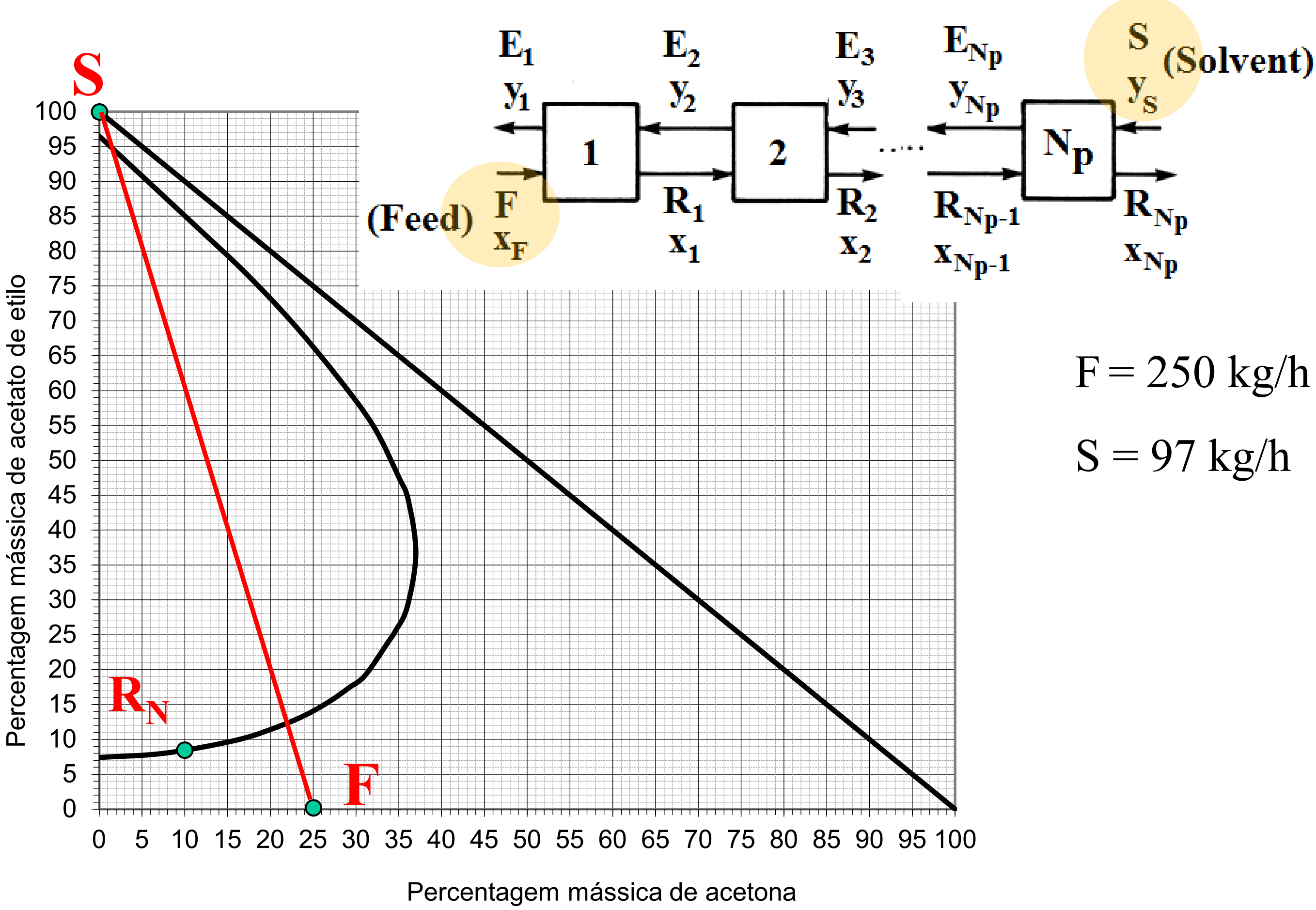
$F = 250$ kg/h

$S = 97$ kg/h

3. Calculate **M**

→ level-arm rule!

The feed stream, containing 25% acetone and 75% water, enters the base of the extraction column at a flow rate of 250 kg/h. The pure solvent enters at the top of the column at a flow rate of 97 kg/h. A raffinate product with 10% acetone is desired.



F = 250 kg/h

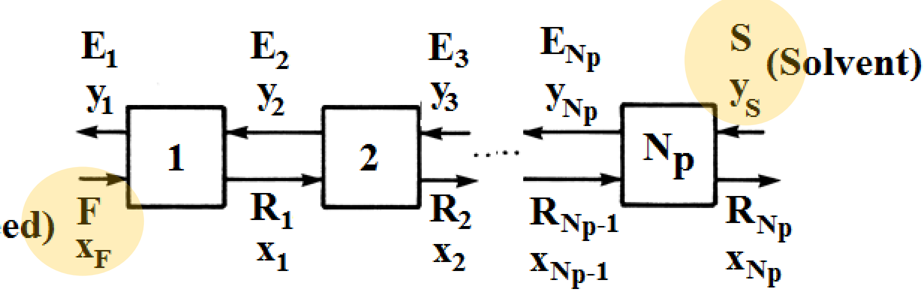
S = 97 kg/h

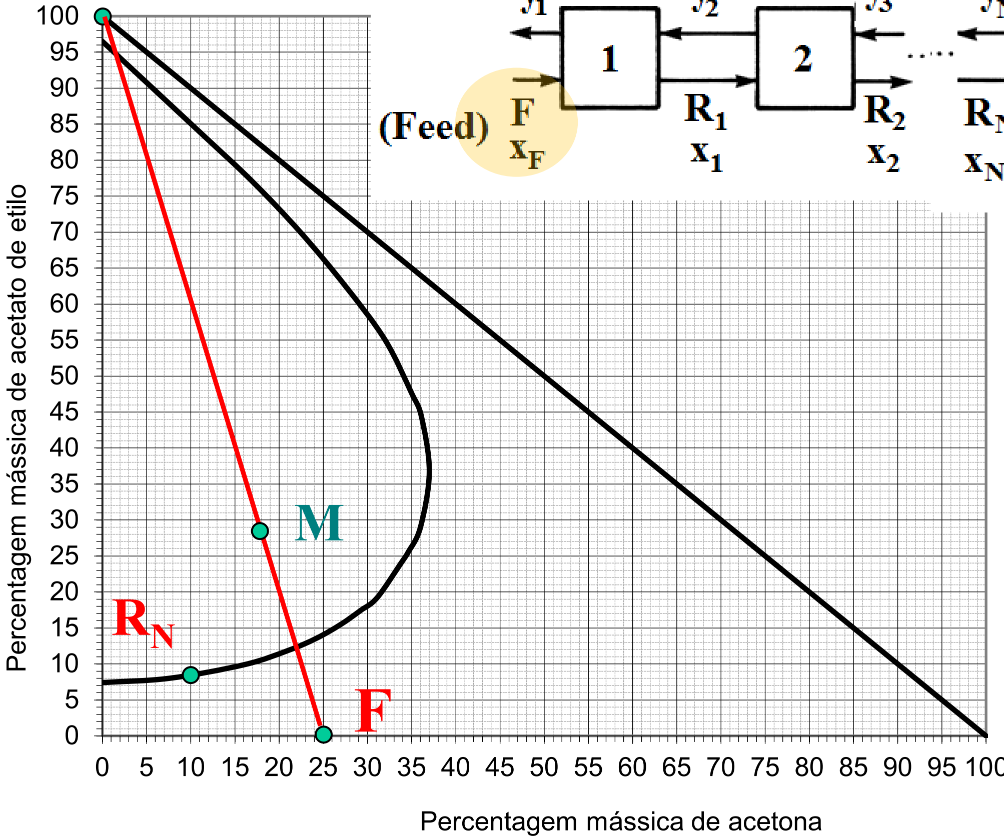
$$F + S = M$$

$$250 \text{ kg/h} + 97 \text{ kg/h} = \text{M} = 347 \text{ kg/h}$$

$$\frac{S}{F} = \frac{x_F - x_M}{x_M - y_S} = \frac{\overline{FM}}{\overline{SM}}$$

$$=> \quad \frac{97}{250} = \frac{25 - x_M}{x_M - 0} \Rightarrow \quad x_M = 18\ \%$$





F = 250 kg/h

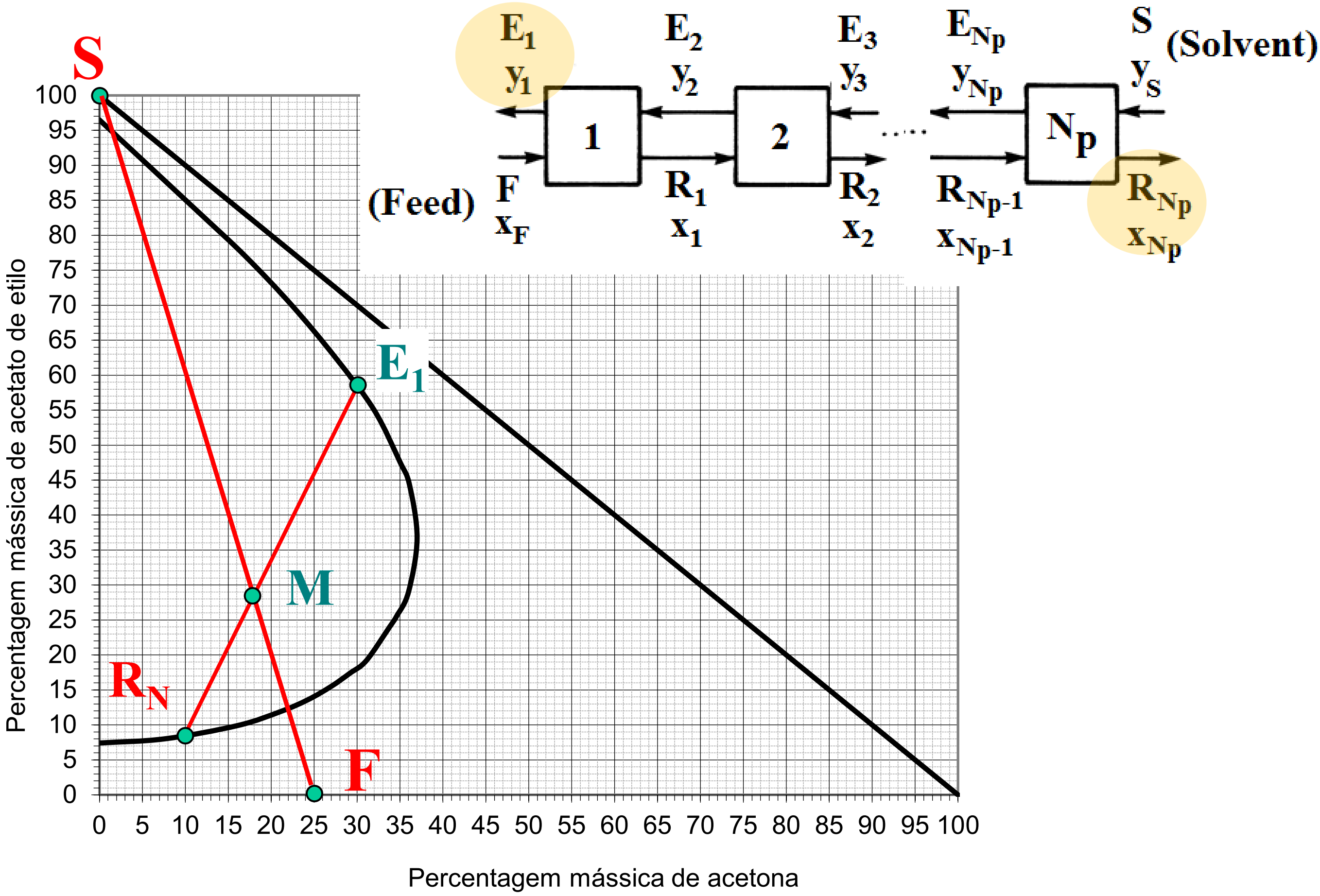
S = 97 kg/h

$$F + S = M$$

$$250 \text{ kg/h} + 97 \text{ kg/h} = \text{M} = 347 \text{ kg/h}$$

$$\frac{S}{F} = \frac{x_F - x_M}{x_M - y_S} = \frac{\overline{FM}}{\overline{SM}}$$

$$=> \quad \frac{97}{250} = \frac{25 - x_M}{x_M - 0} \Rightarrow \quad x_M = 18\ \%$$



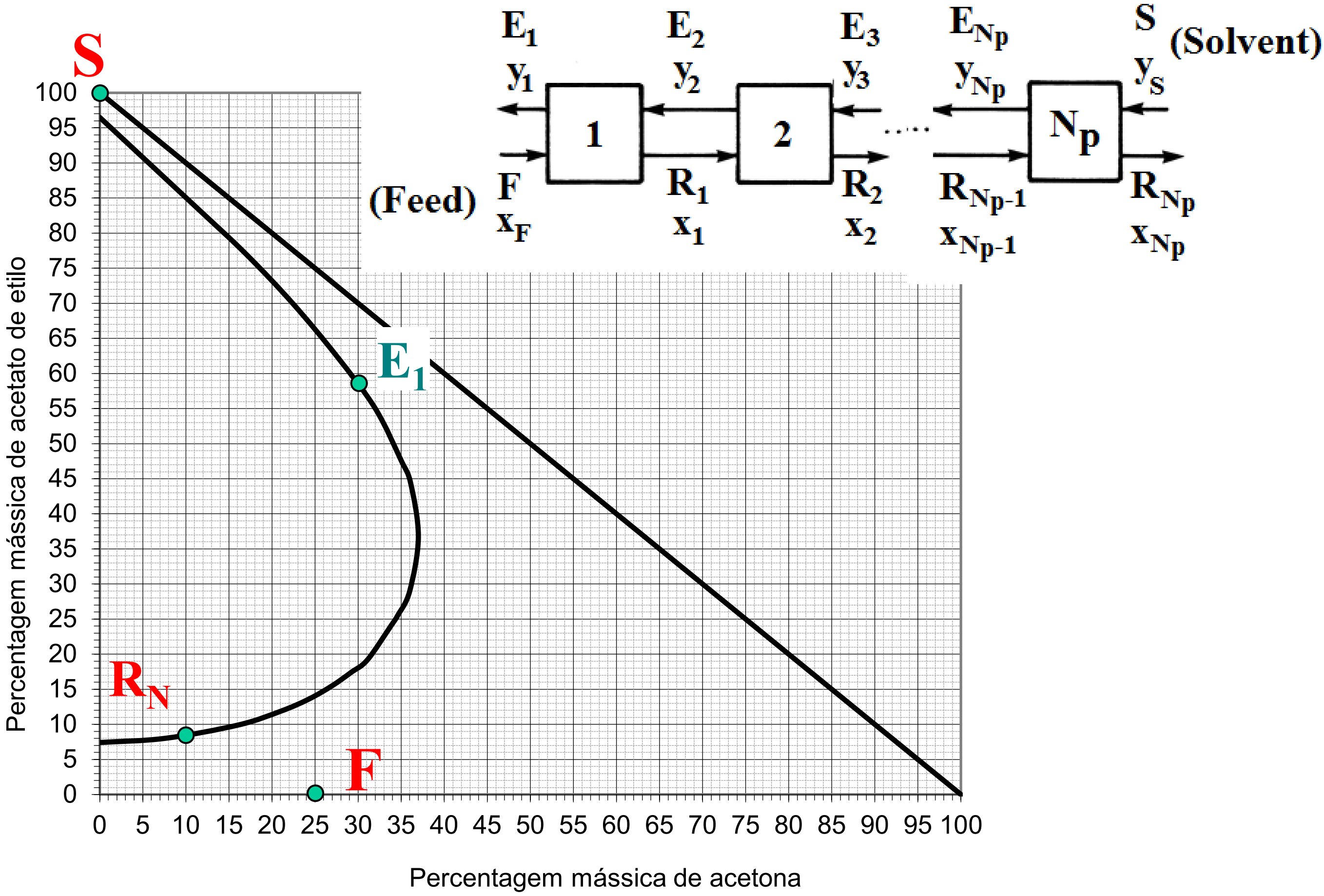
4. <u>Output</u> balance: $\mathbf{M = R_N + E_1}$

$$\Rightarrow y_1 = 30\ \%$$

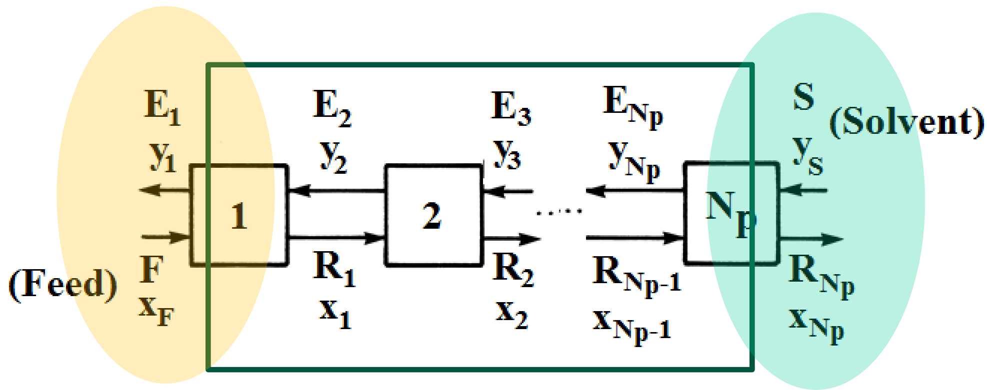
$$\frac{E_1}{M} = \frac{\overline{R_N M}}{\overline{R_N E_1}} = \frac{x_{R_N} - x_M}{x_{R_N} - y_{E_1}}$$

$$\Rightarrow \quad \frac{E_1}{347} = \frac{10-18}{10-30} \Rightarrow E_1 = 139\ \mathrm{kg/h}$$

$$R_{Np} = 208\ \mathrm{kg/h}$$



5. Calculate Δ



Overall material balance to the column

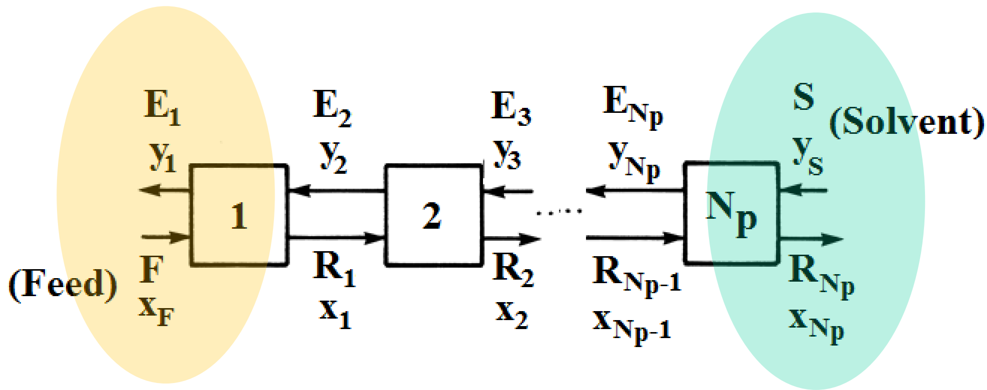
$$\boxed{F + S = E_1 + R_{Np}}$$

Rearranging:

$$R_{Np} - S = F - E_1 = \Delta$$

That is:

(R_{Np}, S and Δ) and (F, E_1 and Δ) are collinear with each other



Overall material balance to the column

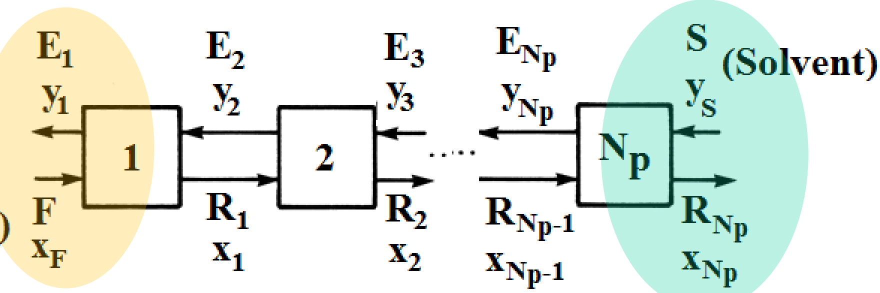
$$\boxed{F + S = E_1 + R_{Np}}$$

Rearranging:

$$R_{Np} - S = F - E_1 = \Delta$$

On the other hand:

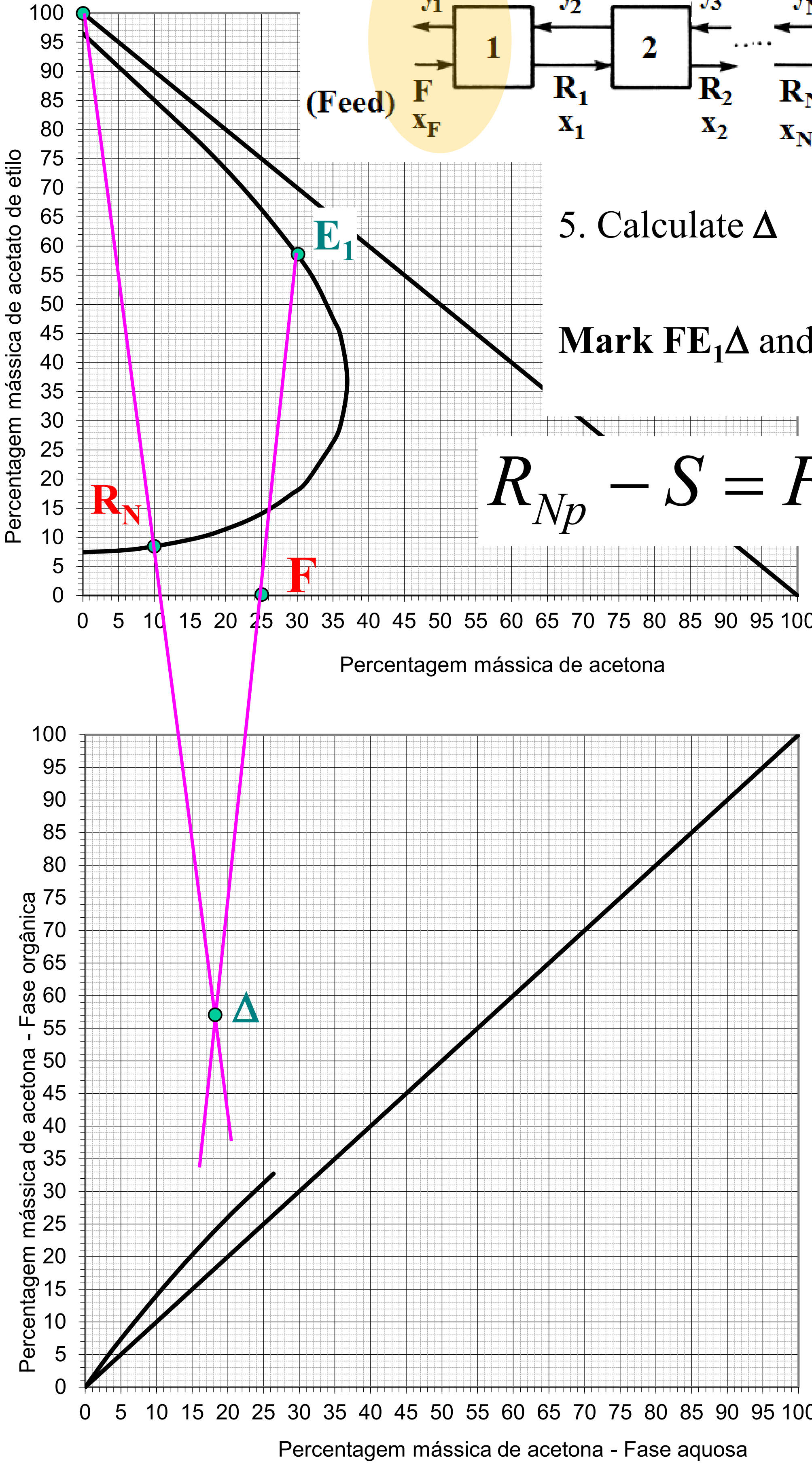
$$F - E_1 = R_1 - E_2 = R_2 - E_3 = \ldots = \Delta$$



5. Calculate Δ

Mark $FE_1\Delta$ and $R_NS\Delta$

$$R_{Np} - S = F - E_1 = \Delta$$



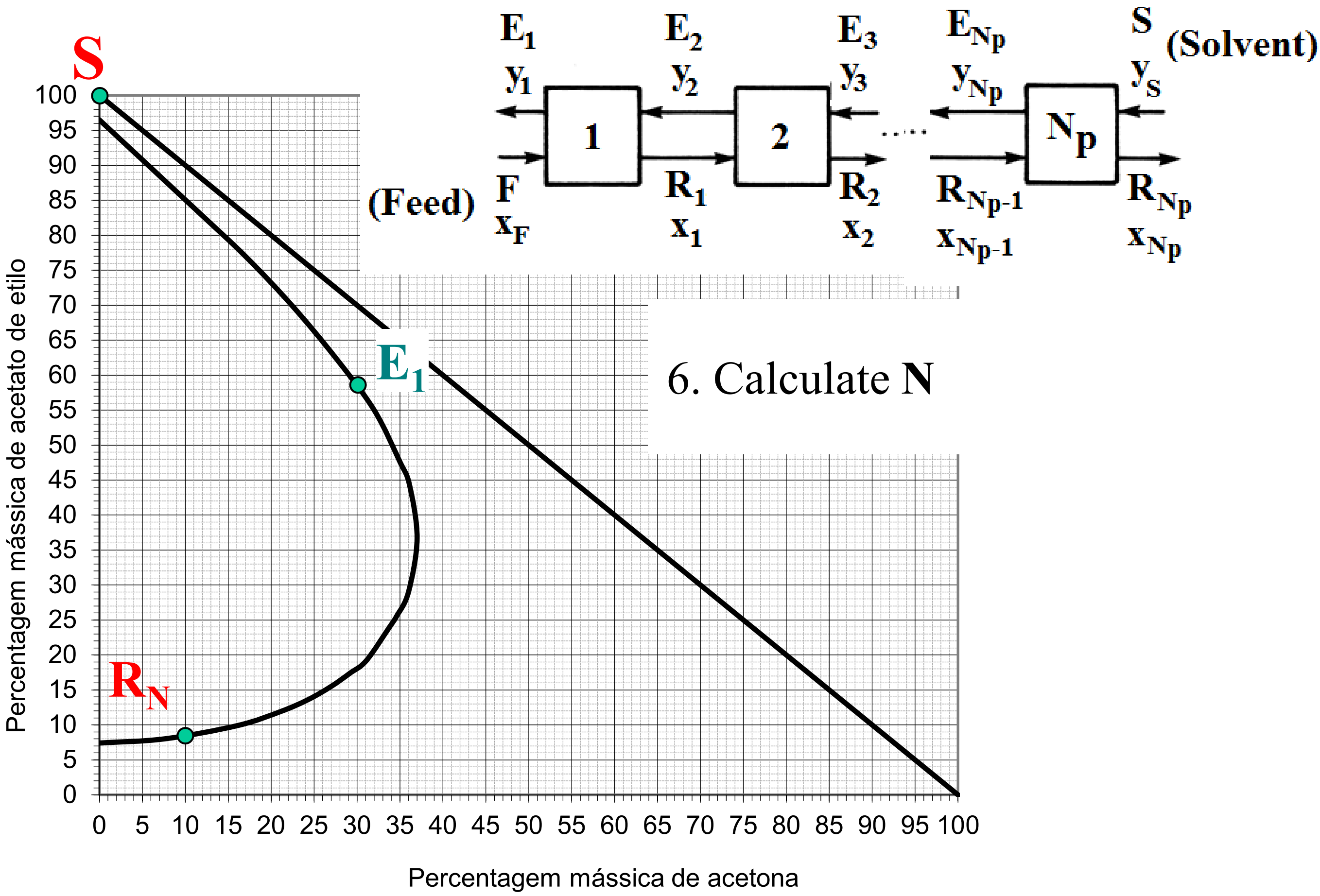
F = 250 kg/h

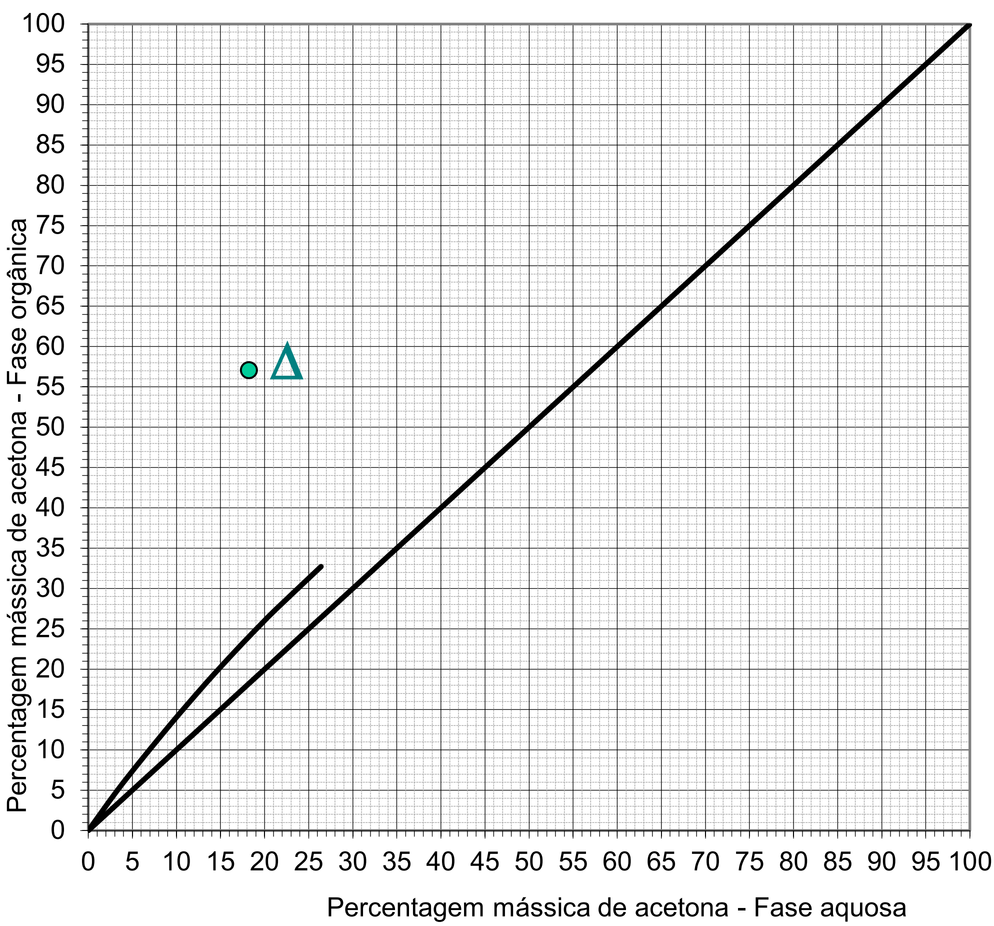
S =97 kg/h

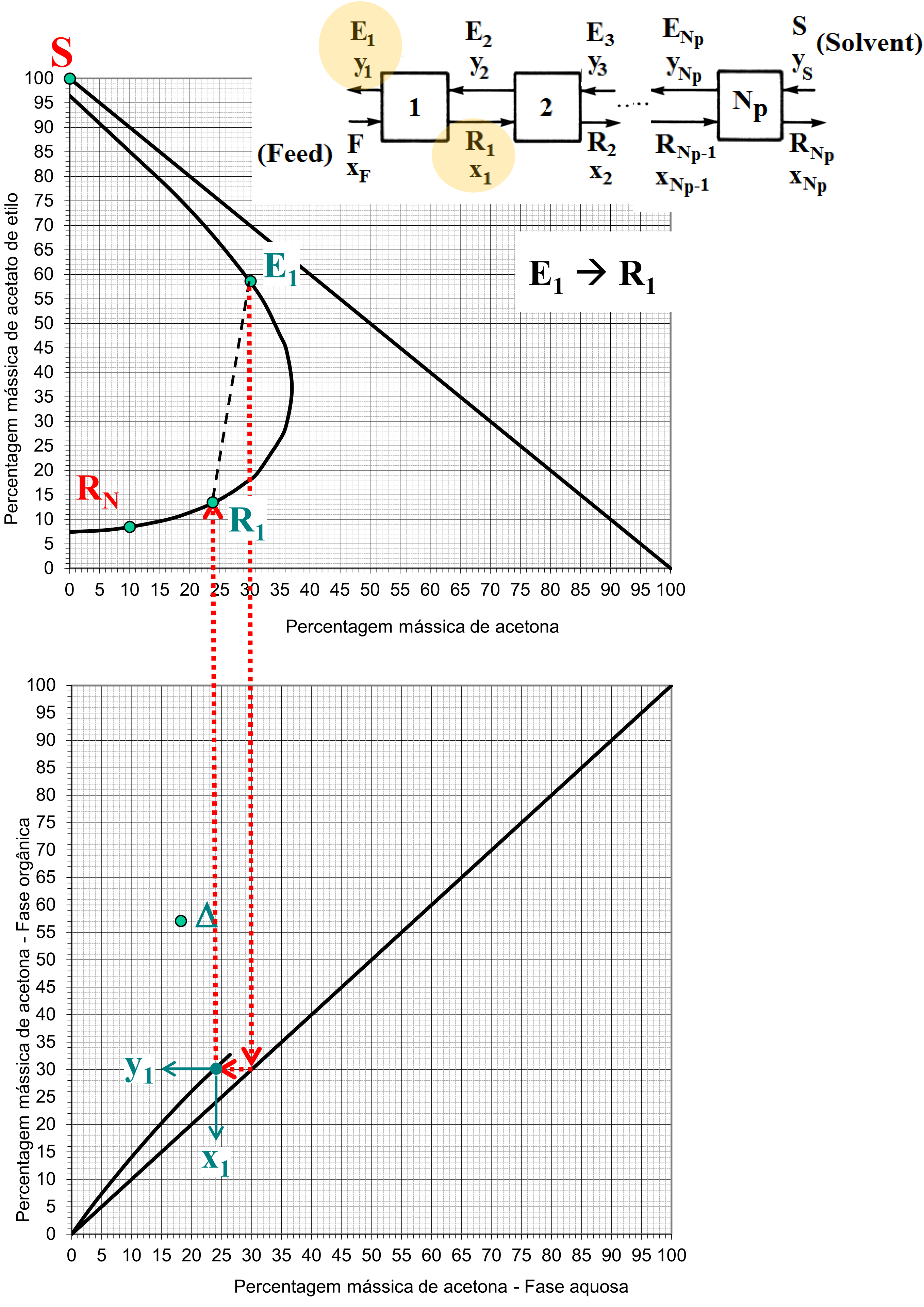
E_1 = 139 kg/h

R_N = 208 kg/h

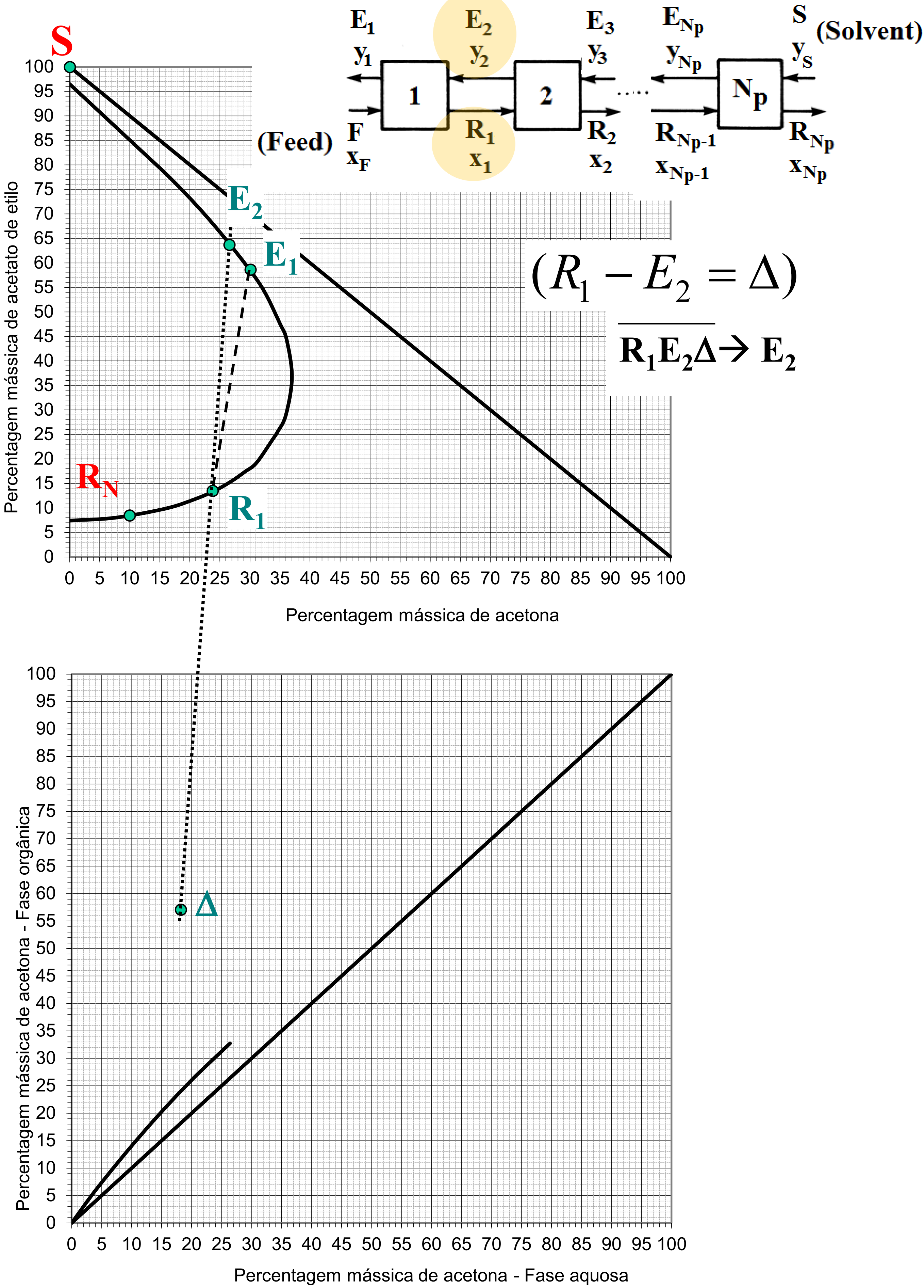
6. Calculate **N**



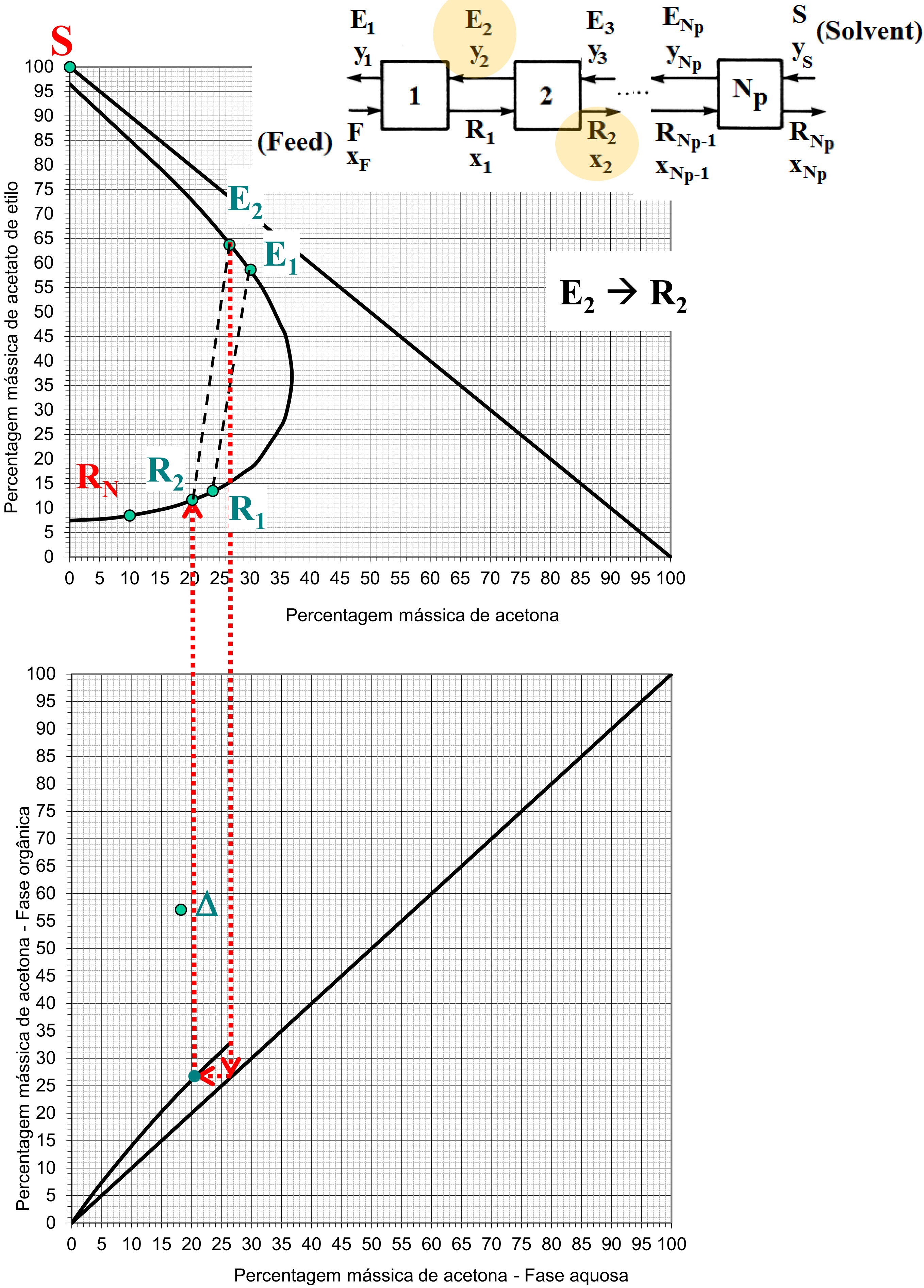


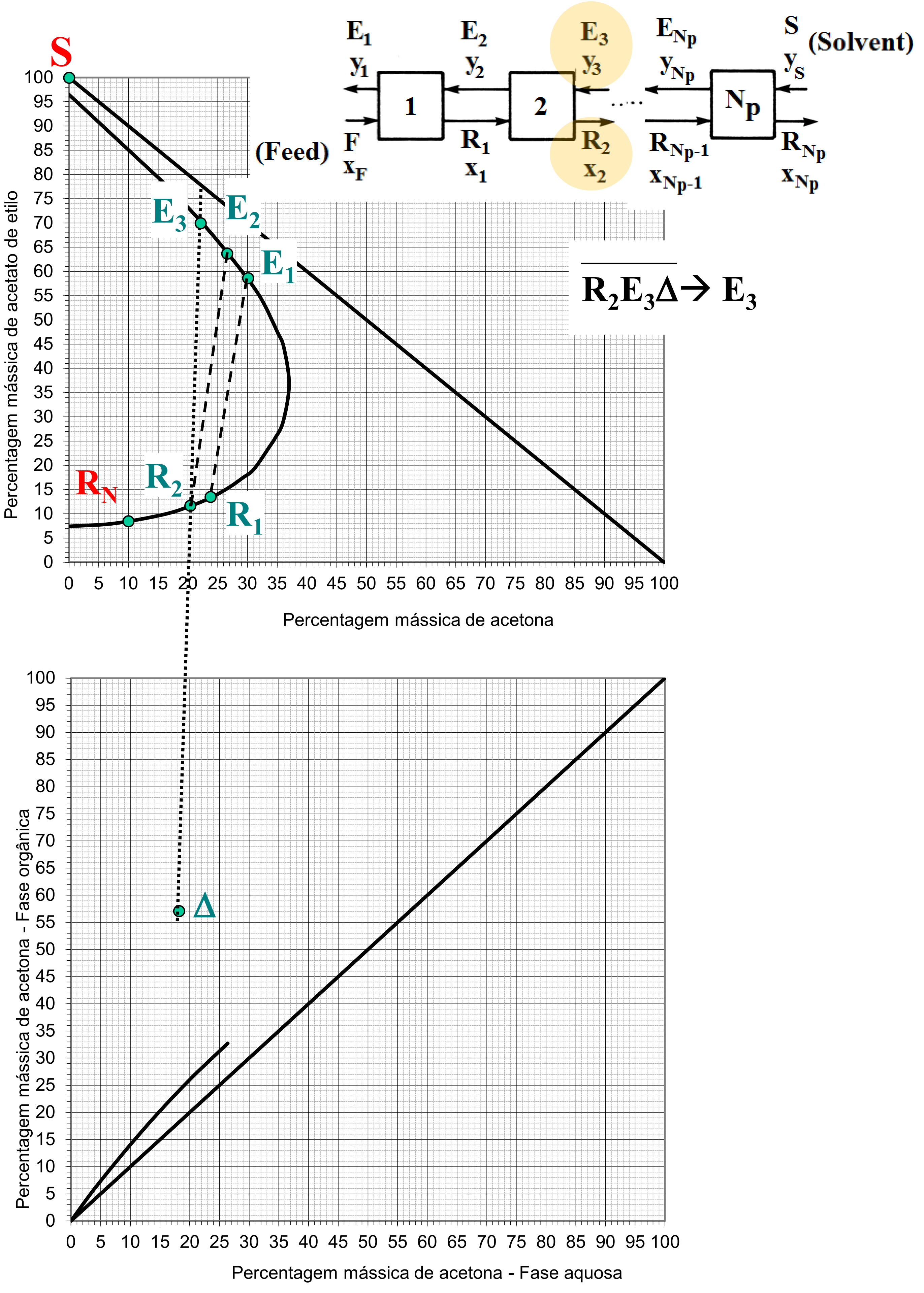


E1 y1
E2 y2
E3 y3
ENp yNp
S yS (Solvent)
1
2
Np
(Feed) F xF
R1 x1
R2 x2
RNp-1 xNp-1
RNp xNp
S
E1
E1 → R1
RN
R1
Percentagem mássica de acetato de etilo
Percentagem mássica de acetona
Δ
y1
x1
Percentagem mássica de acetona - Fase orgânica
Percentagem mássica de acetona - Fase aquosa

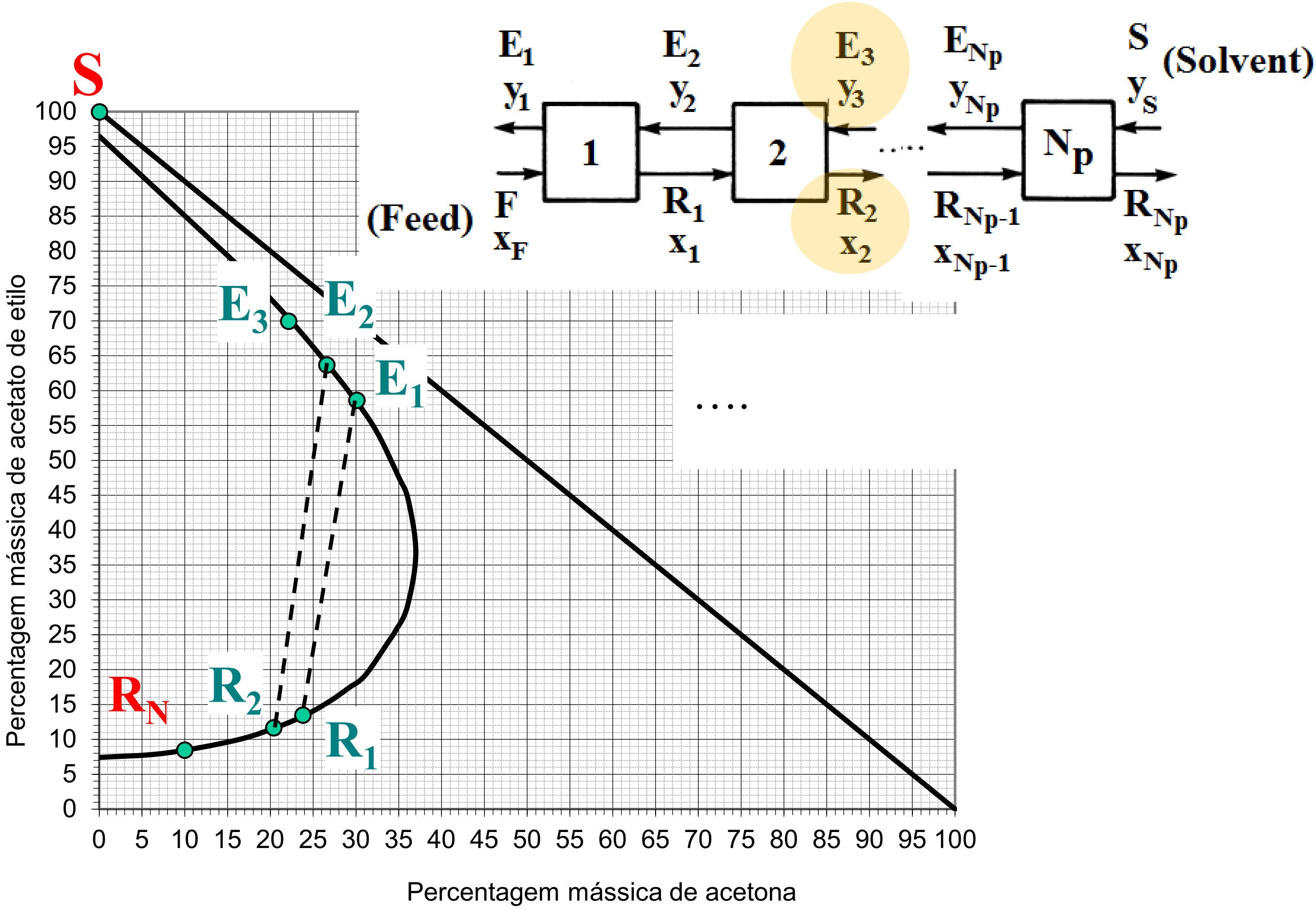


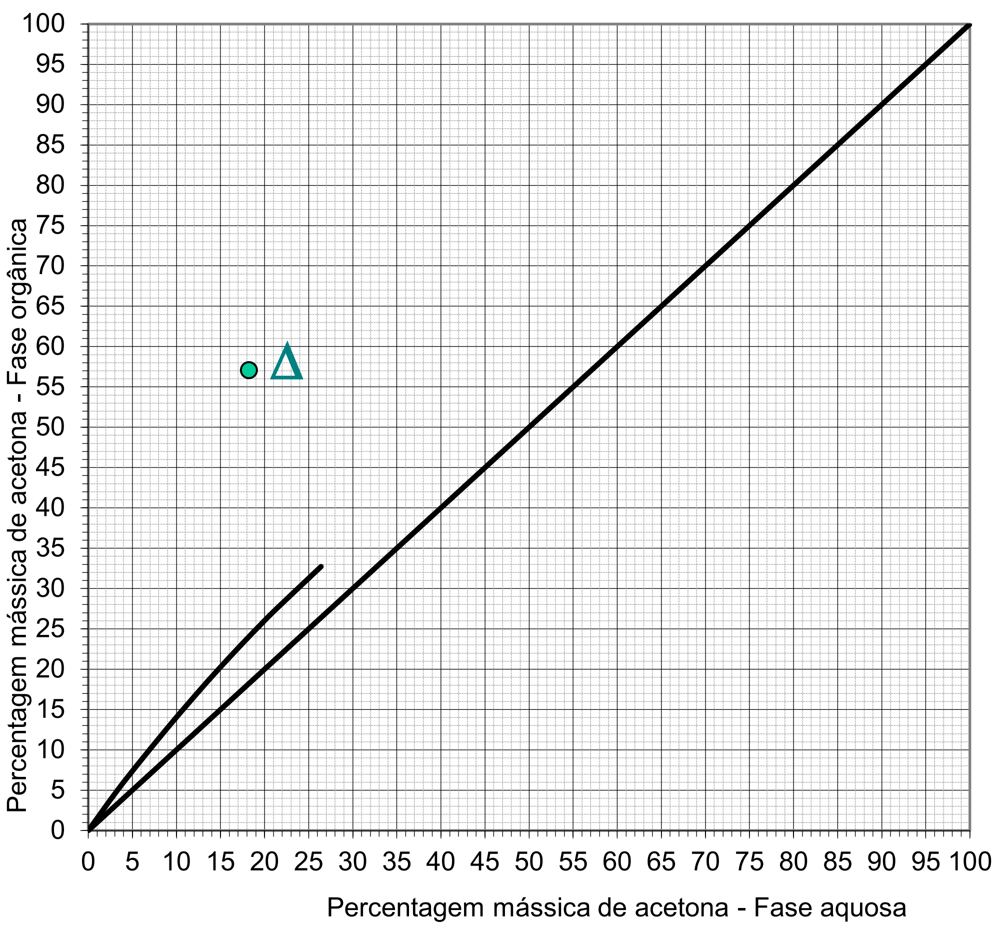
E1 y1
E2 y2
E3 y3
ENp yNp
S yS (Solvent)
1
2
Np
(Feed) F xF
R1 x1
R2 x2
RNp-1 xNp-1
RNp xNp
S
E2
E1
R1
RN
$(R_1 - E_2 = \Delta)$
$\overline{R_1E_2\Delta} \rightarrow E_2$
Percentagem mássica de acetato de etilo
Percentagem mássica de acetona
Δ
Percentagem mássica de acetona - Fase orgânica
Percentagem mássica de acetona - Fase aquosa


S
(Solvent)
(Feed)
E_1 y_1
E_2 y_2
E_3 y_3
E_{Np} y_{Np}
S y_S
1
2
N_p
F x_F
R_1 x_1
R_2 x_2
R_{Np-1} x_{Np-1}
R_{Np} x_{Np}
E_2
E_1
R_N
R_2
R_1
$E_2 \rightarrow R_2$
Percentagem mássica de acetato de etilo
Percentagem mássica de acetona
Δ
Percentagem mássica de acetona - Fase orgânica
Percentagem mássica de acetona - Fase aquosa



S
E1 y1
E2 y2
E3 y3
ENp yNp
S yS (Solvent)
1
2
Np
(Feed) F xF
R1 x1
R2 x2
RNp-1 xNp-1
RNp xNp
E3
E2
E1
RN
R2
R1
R2E3Δ → E3
Percentagem mássica de acetato de etilo
Percentagem mássica de acetona
Δ
Percentagem mássica de acetona - Fase orgânica
Percentagem mássica de acetona - Fase aquosa


S
E1
y1
E2
y2
E3
y3
ENp
yNp
S
yS
(Solvent)
1
2
Np
(Feed)
F
xF
R1
x1
R2
x2
RNp-1
xNp-1
RNp
xNp
E3
E2
E1
RN
R2
R1
Percentagem mássica de acetato de etilo
Percentagem mássica de acetona


Δ
Percentagem mássica de acetona - Fase orgânica
Percentagem mássica de acetona - Fase aquosa

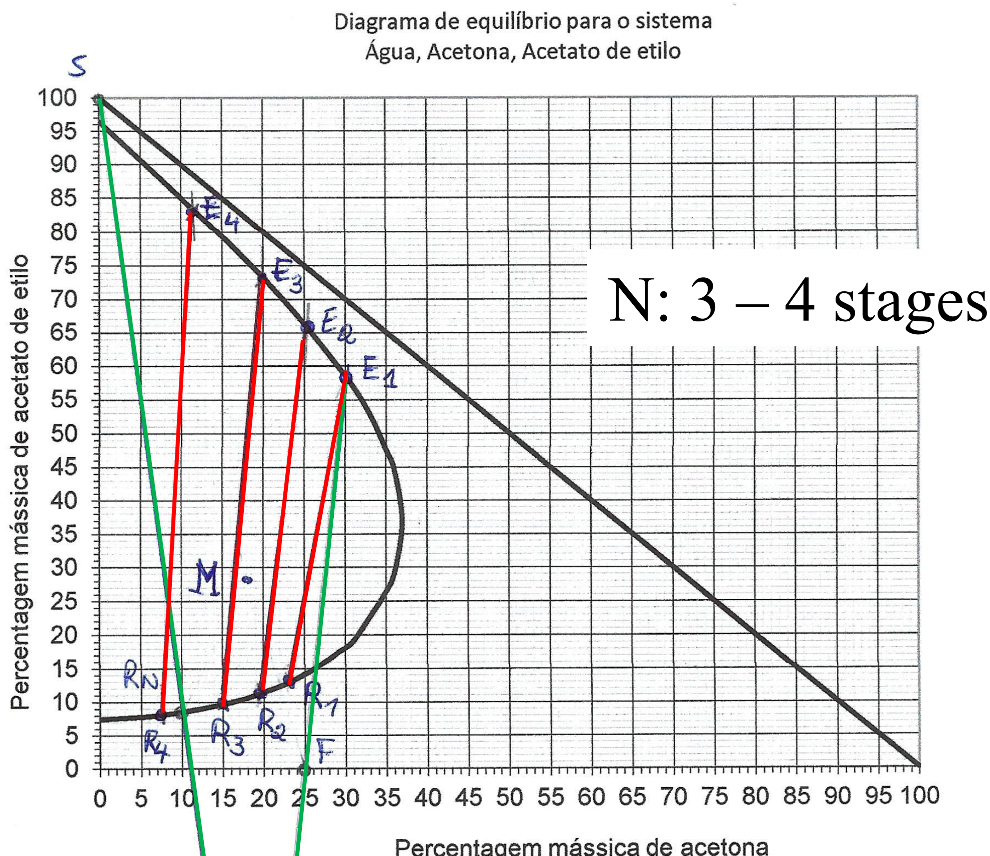
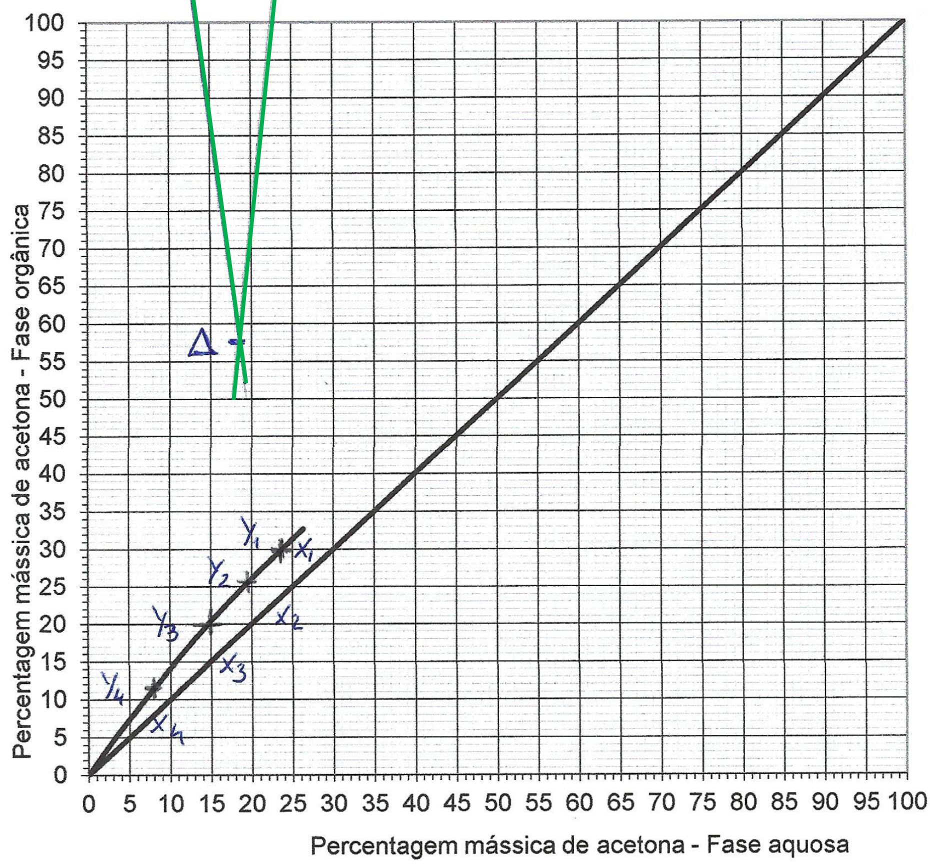


Diagrama de equilíbrio para o sistema
Água, Acetona, Acetato de etilo
Percentagem mássica de acetato de etilo
Percentagem mássica de acetona
S
E4
E3
E2
E1
M
RN
R4
R3
R2
R1
F
N: 3 – 4 stages


Percentagem mássica de acetona - Fase orgânica
Percentagem mássica de acetona - Fase aquosa
Δ
Y1
X1
Y2
X2
Y3
X3
Y4
X4

Problema 3. Nicotina é extraída de uma solução aquosa usando querosene como solvente. A água e o querosene são imiscíveis.

a) Se tiver uma solução aquosa com 1% (percentagem mássica) de nicotina determine a percentagem de extracção usando 150kg de solvente por cada 100kg de alimentação;

b) Qual a percentagem de extracção se forem usados 3 andares de equilíbrio e 50kg de solvente em cada.

Dados: Curva de equilíbrio

x' (kg nicotina/kg de água)	y' (kg nicotina/kg de água)
0.0	0.0
0.00101	0.000807
0.00246	0.001961
0.00502	0.004560
0.00751	0.006860
0.00998	0.009130
0.02040	0.01870

A : água B : querosene C : nicotina

Problem 3. Nicotine is extracted from an aqueous solution using kerosene as a solvent. Water and kerosene are immiscible.

a) If you have an aqueous solution with 1% (mass percentage) of nicotine, determine the extraction percentage using 150 kg of solvent per 100 kg of feed;

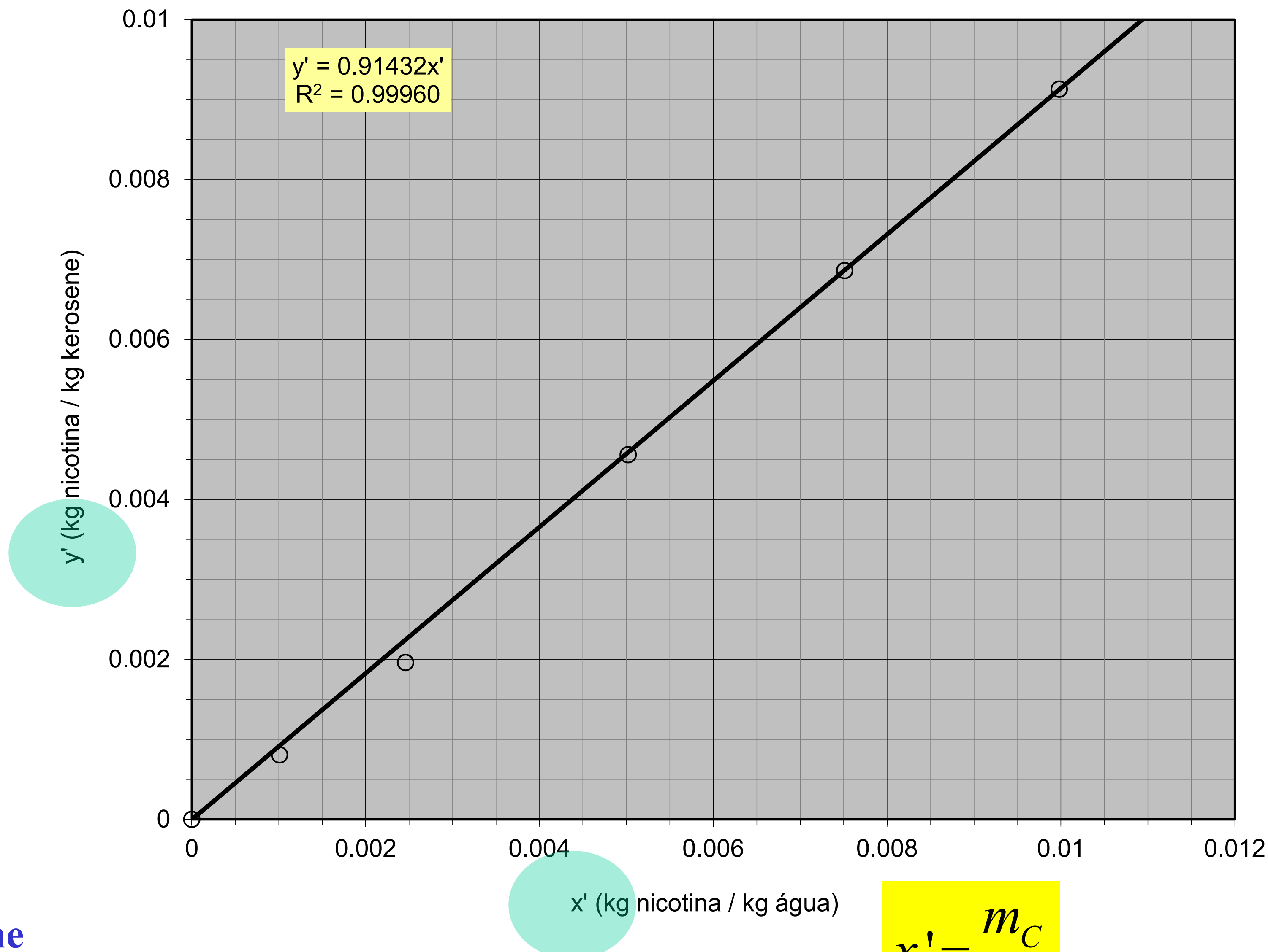
b) What is the extraction percentage if 3 equilibrium stages and 50 kg of fresh solvent are used in each stage.

Dados: Curva de equilíbrio

x' (kg nicotine/kg water)	y' (kg nicotine/kg water)
0.0	0.0
0.00101	0.000807
0.00246	0.001961
0.00502	0.004560
0.00751	0.006860
0.00998	0.009130
0.02040	0.01870

A : water B : kerosene C : nicotine

$$y' = \frac{m_C}{m_B}$$



$$x' = \frac{m_C}{m_A}$$

A – **Water**
C – **Nicotine**
B – **kerosene**

Operating line: $-\dfrac{A}{B_1} = \dfrac{y'_S - y'_1}{x'_F - x'_1}$

F: 100 kg (1% of C) S: 150 kg (100% of B)

A – **Water**
C – **Nicotine**
B – **kerosene**

Calculate:

$$A = 100 \times 0.99 = 99\,kg$$

$$B_1 = 150\,kg$$

$$-\frac{A}{B_1} = -\frac{99}{150} = -0.66$$

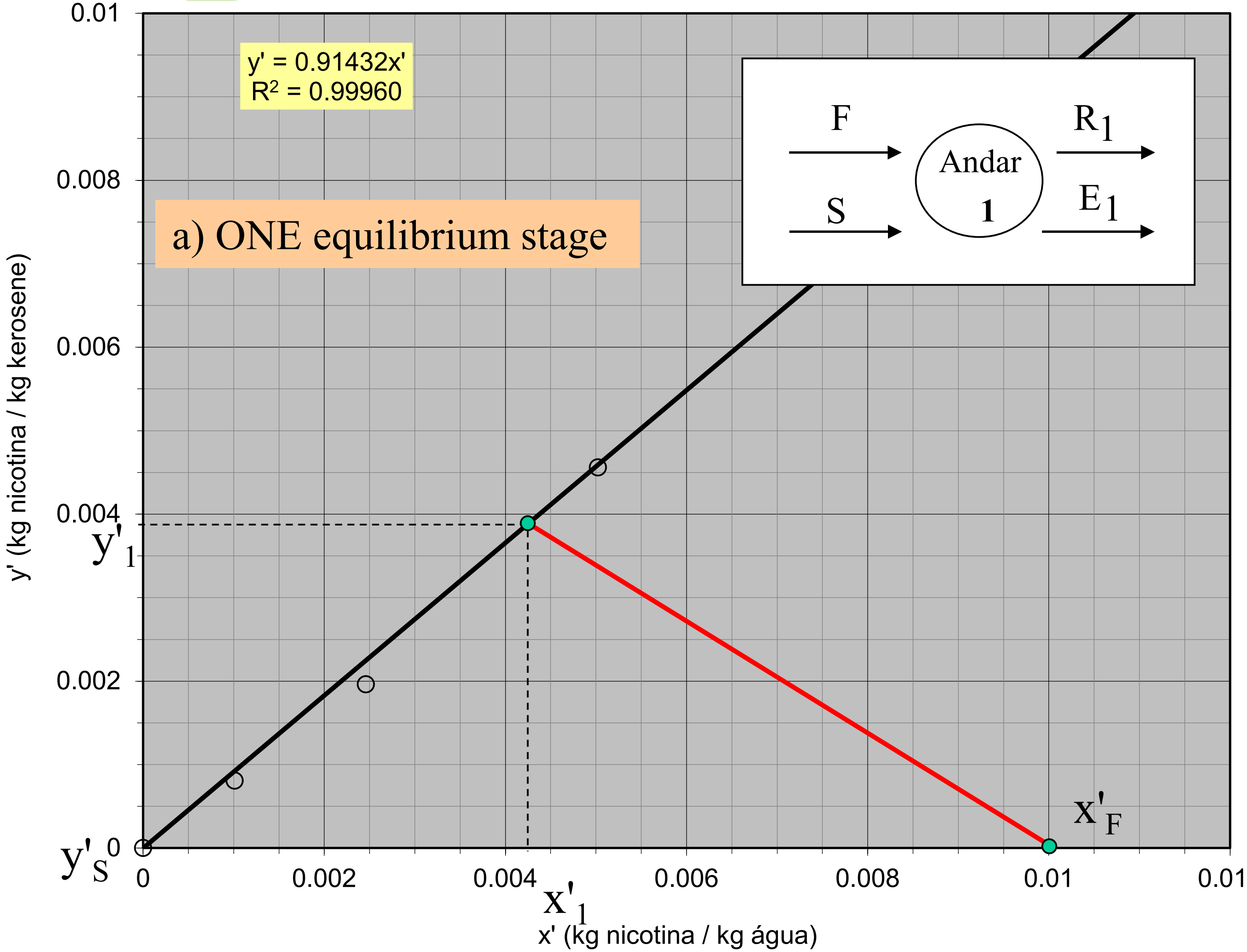
$$x'_F = \frac{0.01}{1-0.01} = 0.0101$$

$$y'_S = 0$$

$$-0.66 = \frac{0 - y'_1}{0.0101 - x'_1} = \frac{0 - (0.91432\,.\,x'_1)}{0.0101 - x'_1}$$

$$x'_1 = 0.0042$$

$$\Rightarrow \quad y'_1 = 0.0038$$



Operating line: $$-\frac{A}{B_i}=\frac{y'_S-y'_i}{x'_F-x'_i}$$

F: 100 kg (1% de C) S: 150 kg (100% de B)

A – Water
C – Nicotine
B – kerosene

Calculate:

$$A=100\times0.99=99\,kg$$

$$B_i=50\,kg$$

$$-\frac{A}{B_i}=-\frac{99}{50}=-1.98$$

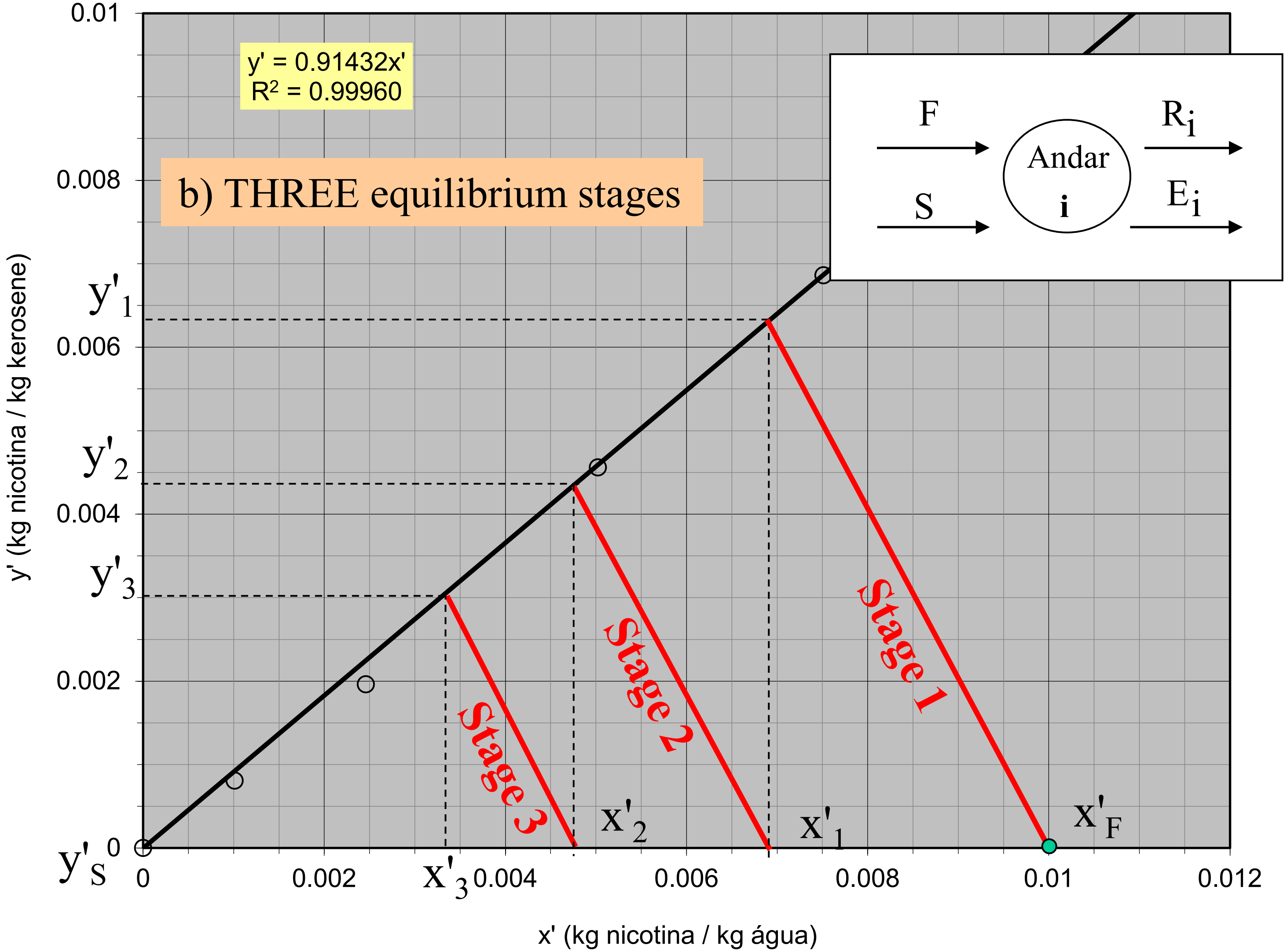
$$x'_F=\frac{0.01}{1-0.01}=0.0101$$

$$y'_S=0$$

$$-1.98=\frac{0-y'_1}{0.0101-x'_1}=\frac{0-(0.91432\;.\;x'_1)}{0.0101-x'_1}$$

$$x'_1=0.0069$$

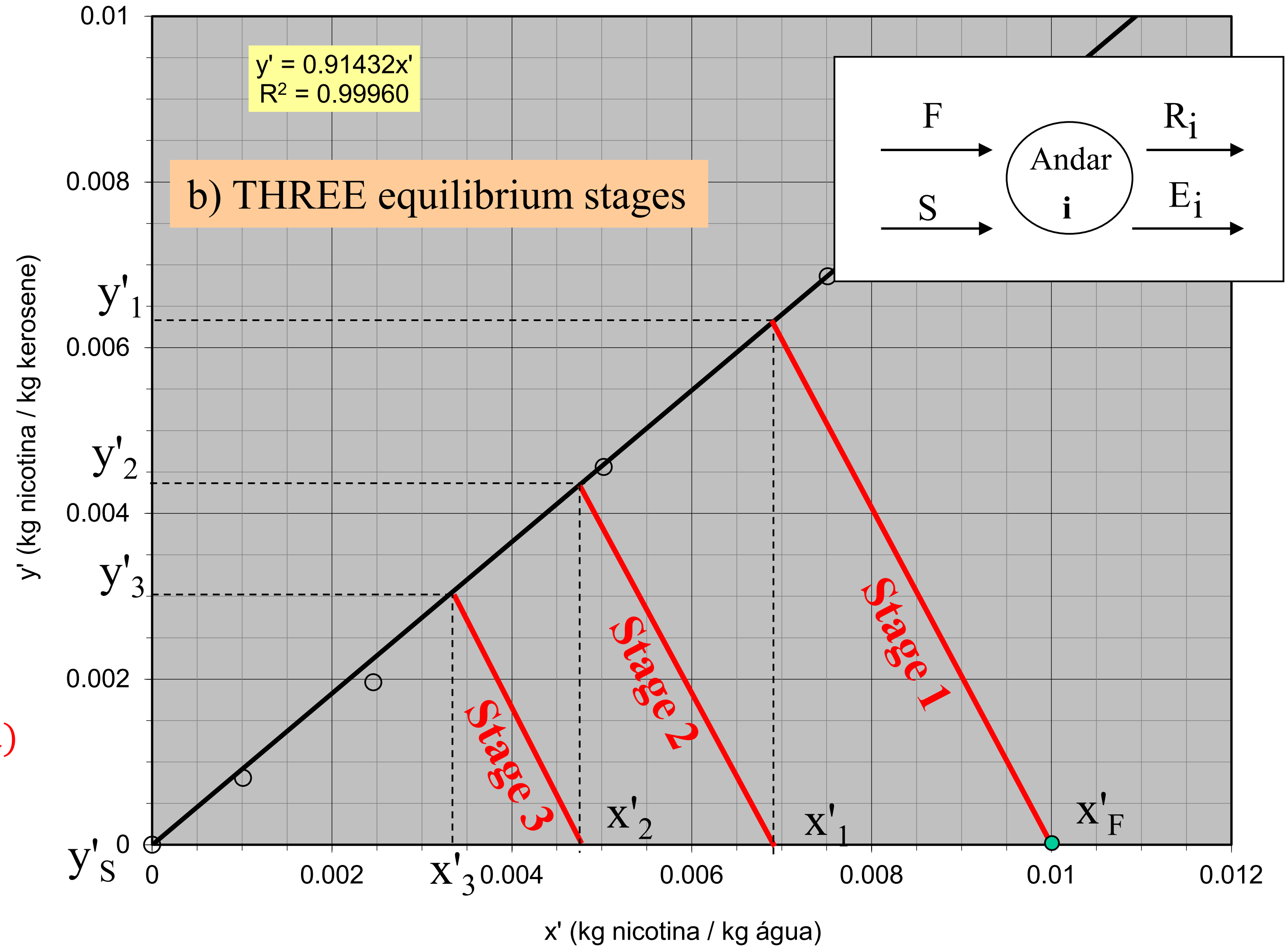
$$=>\quad y'_1=0.0063$$



Operating line: $-\dfrac{A}{B_i} = \dfrac{y'_S - y'_i}{x'_F - x'_i}$

F: 100 kg (1% de C) S: 150 kg (100% de B)

A – Water
C – Nicotine
B – kerosene



3 stages

$x'_3 = 0.0034$

$(ca. 1/3\ redution)$

1 stage

$x'_1 = 0.0042$

$(ca. 1/2.4\ redution)$

Problema 4. Se 1000 kg/h de uma solução aquosa contendo 1% de nicotina for contactada com querosene a 20 ºC para reduzir o teor em nicotina para 0.1% determine:

a) O caudal mínimo de solvente;

b) O número de andares necessários, se o caudal de solvente for de 1150 kg/h.

Dados: Curva de equilíbrio

x' (kg nicotina/kg de água)	y' (kg nicotina/kg de água)
0.0	0.0
0.00101	0.000807
0.00246	0.001961
0.00502	0.004560
0.00751	0.006860
0.00998	0.009130
0.02040	0.01870

A : água B : querosene C : nicotina

Problem 4. If 1000 kg/h of an aqueous solution containing 1% nicotine is contacted with kerosene at 20 ºC to reduce the nicotine content to 0.1% determine:

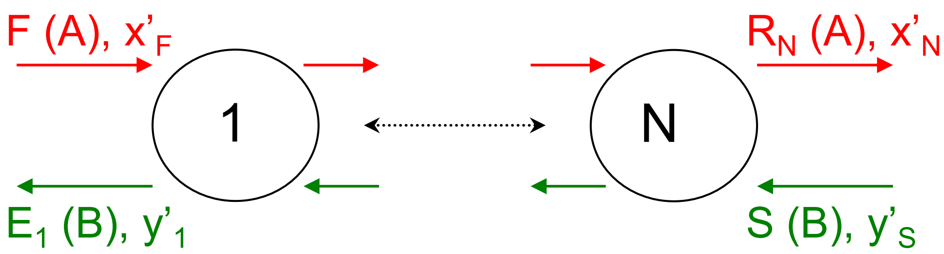
a) The minimum solvent flow rate;

b) The number of stages required if the solvent flow rate is 1150 kg/h.

Dados: Curva de equilíbrio

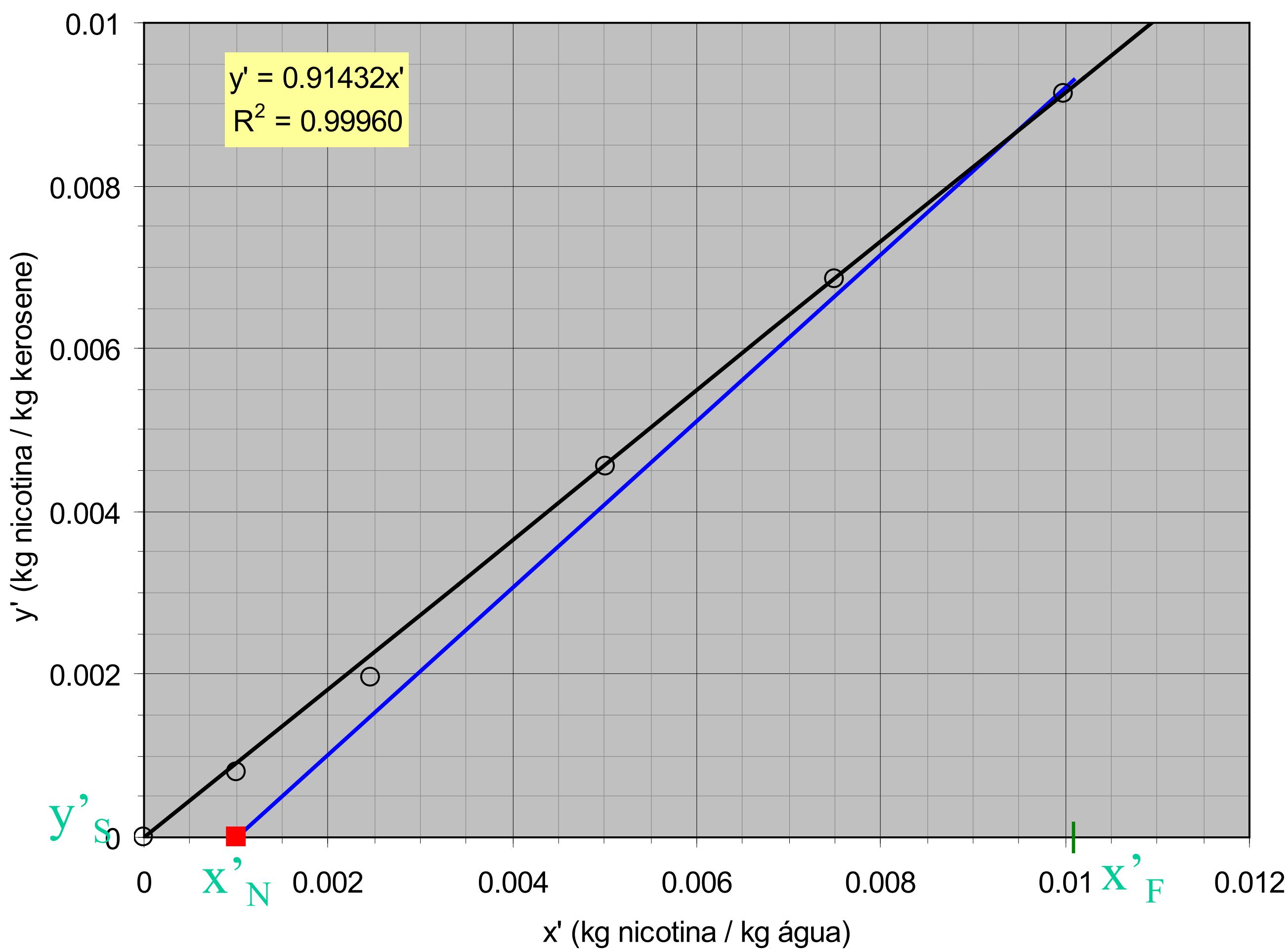
x' (kg nicotina/kg de água)	y' (kg nicotina/kg de água)
0.0	0.0
0.00101	0.000807
0.00246	0.001961
0.00502	0.004560
0.00751	0.006860
0.00998	0.009130
0.02040	0.01870

A : água B : querosene C : nicotina



Operating line:

$$\frac{A}{B} = \frac{y_1' - y_S'}{x_F' - x_N'}$$



Calculate:

1. A

$$A = 1000 \times 0.99 = 990\,\text{kg/hr}$$

2. x'_F; y'_S; x'_N

$$x_F' \approx x_F = 0.01$$

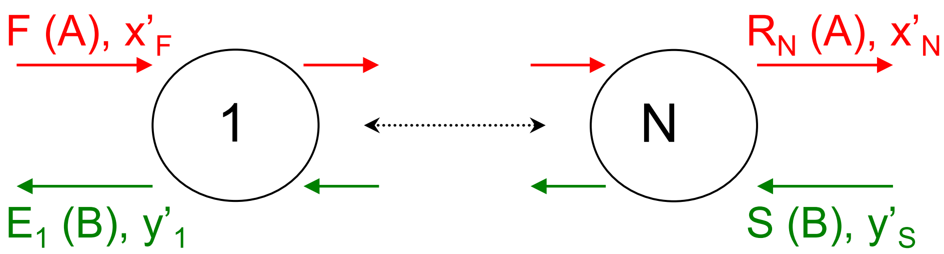
$$x_N' \approx x_N = 0.001$$

$$y_S' = 0$$

3. $S_{minimum}$ $(N \rightarrow \infty)$

$$\frac{A}{B_{min}} = \frac{0.91432 \times 0.01 - 0}{0.01 - 0.001}$$

$$B_{min} = 969\,\text{kg/h}$$

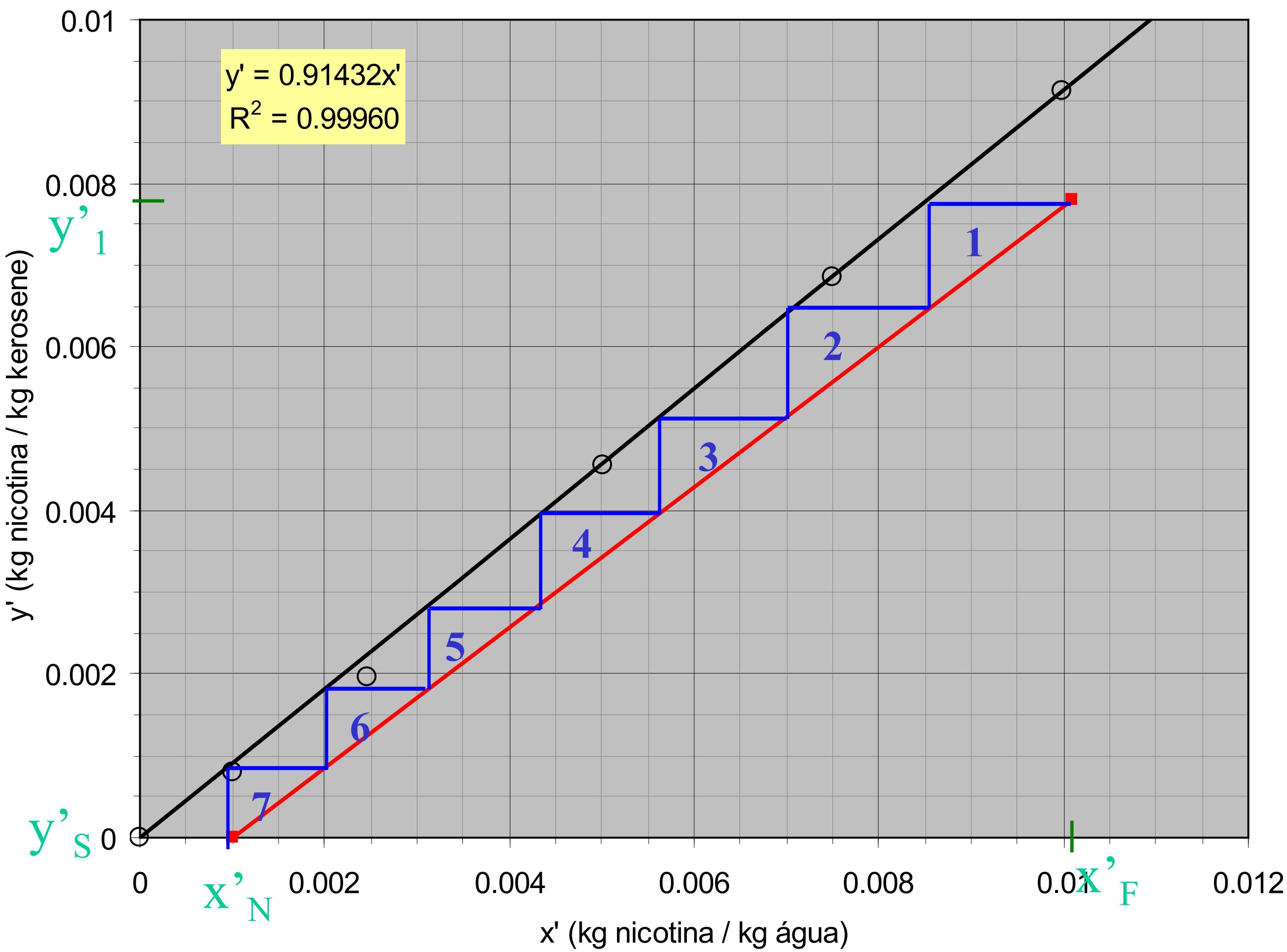


Operating line: $$\frac{A}{B} = \frac{y_1' - y_S'}{x_F' - x_N'}$$

Real operating line

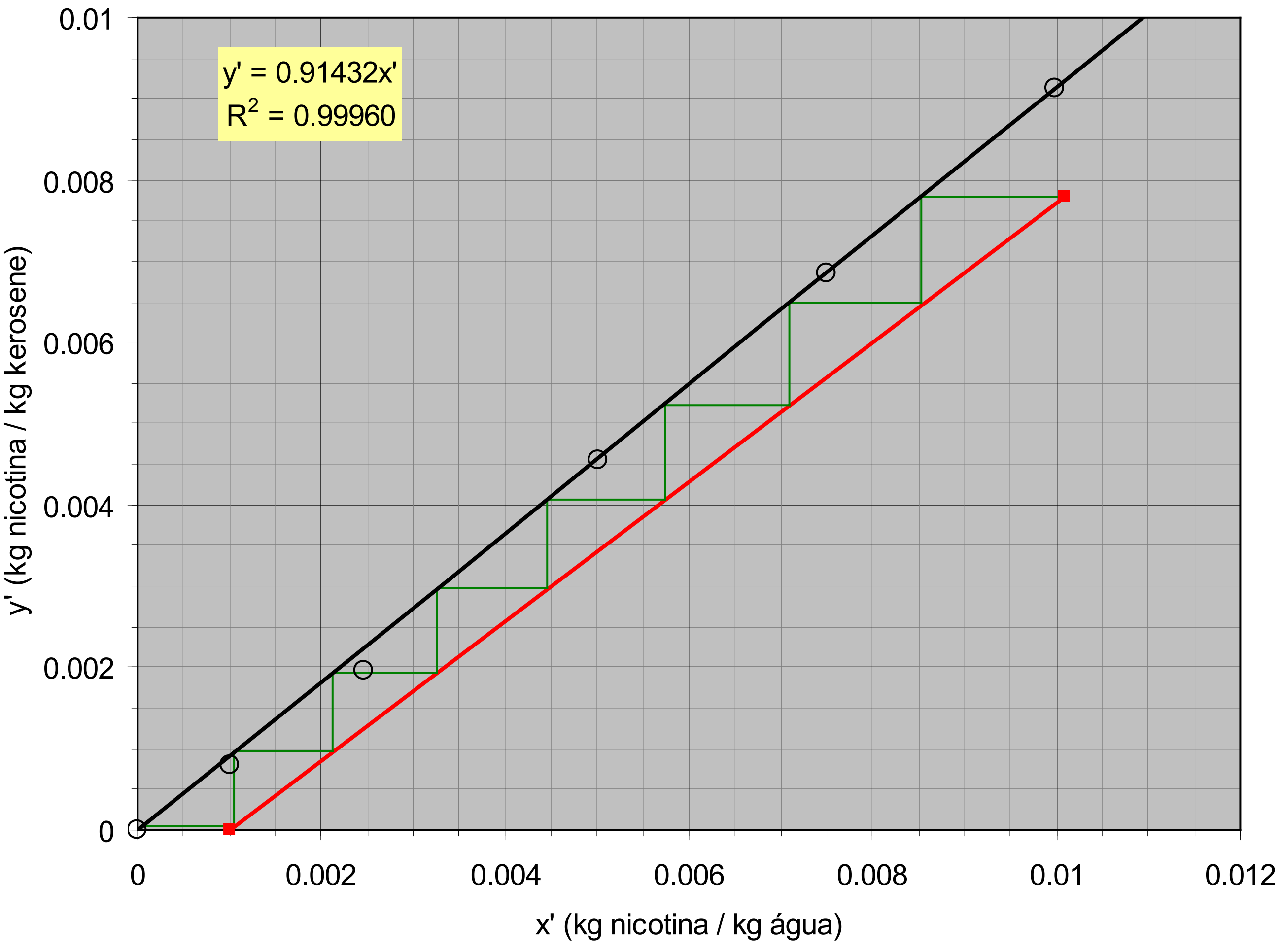
$$\frac{990}{1150} = \frac{y_1' - 0}{0.01 - 0.001}$$

$$\Rightarrow \quad y_1' = 0.0078$$



5. $N_{equilibrium}$

N = 7-8 equilibrium stages



y' = 0.91432x'
R2 = 0.99960
0.01
0.008
0.006
0.004
0.002
0
0
0.002
0.004
0.006
0.008
0.01
0.012
y' (kg nicotina / kg kerosene)
x' (kg nicotina / kg água)