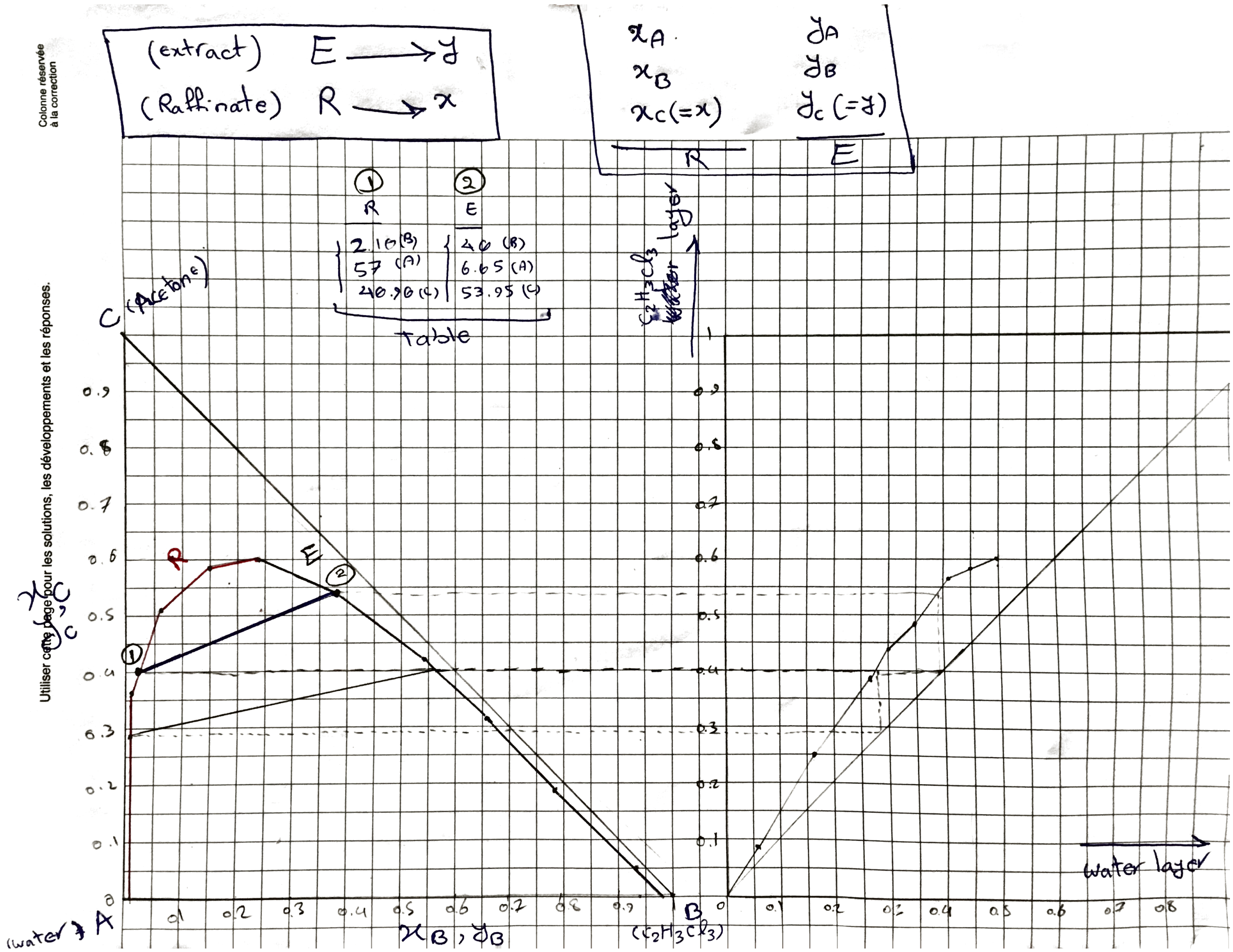
20.5. In a continuous countercurrent train of mixer-settlers, 100 kg/h of a 40:60 acetone-water solution is to be reduced to 10 percent acetone by extraction with pure 1,1,2-trichloroethane at 25°C. (*a*) Find the minimum solvent rate. (*b*) At 1.8 times the minimum (solvent rate)/(feed rate), find the number of stages required. (*c*) For conditions of part (*b*) find the mass flow rates of all streams. Data are given in Table 20.6.

TABLE 20.6
Equilibrium data

Limiting solubility curve		
$C_2H_3Cl_3$, wt %	Water, wt %	Acetone, wt %
94.73	0.26	5.01
79.58	0.76	19.66
67.52	1.44	31.04
54.88	2.98	42.14
38.31	6.84	54.85
24.04	15.37	60.59
15.39	26.28	58.33
6.77	41.35	51.88
1.72	61.11	37.17
0.92	74.54	24.54
0.65	87.63	11.72
0.44	99.56	0.00

Tie lines					
Weight % in water layer			Weight % in trichloroethane layer		
$C_2H_3Cl_3$	Water	Acetone	$C_2H_3Cl_3$	Water	Acetone
0.52	93.52	5.96	90.93	0.32	8.75
0.73	82.23	17.04	73.76	1.10	25.14
1.02	72.06	26.92	59.21	2.27	38.52
1.17	67.95	30.88	53.92	3.11	42.97
1.60	62.67	35.73	47.53	4.26	48.21
2.10	57.00	40.90	40.00	6.05	53.95
3.75	50.20	46.05	33.70	8.90	57.40
6.52	41.70	51.78	26.26	13.40	60.34


(extract) E → y
(Raffinate) R → x
x_A y_A
x_B y_B
x_C(=x) y_C(=y)
R E
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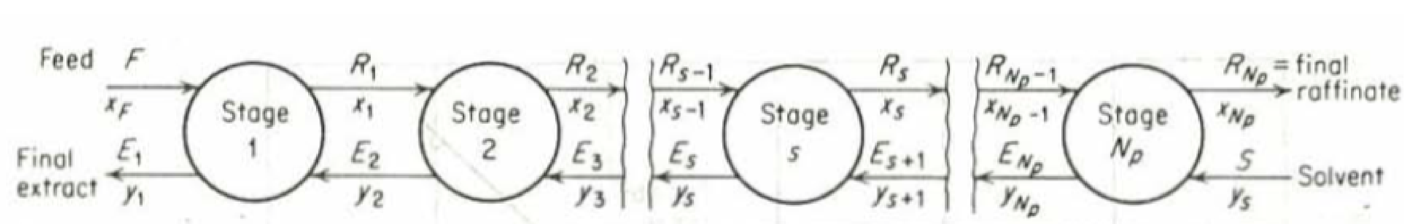
① R
2.10 (B)
57 (A)
40.90 (C)
② E
40 (B)
6.65 (A)
53.95 (C)
Table
C (Acetone)
(water) A
B (C2H3Cl3)
x_B, y_B
x_C, y_C
R
E
water layer
C2H3Cl3 layer

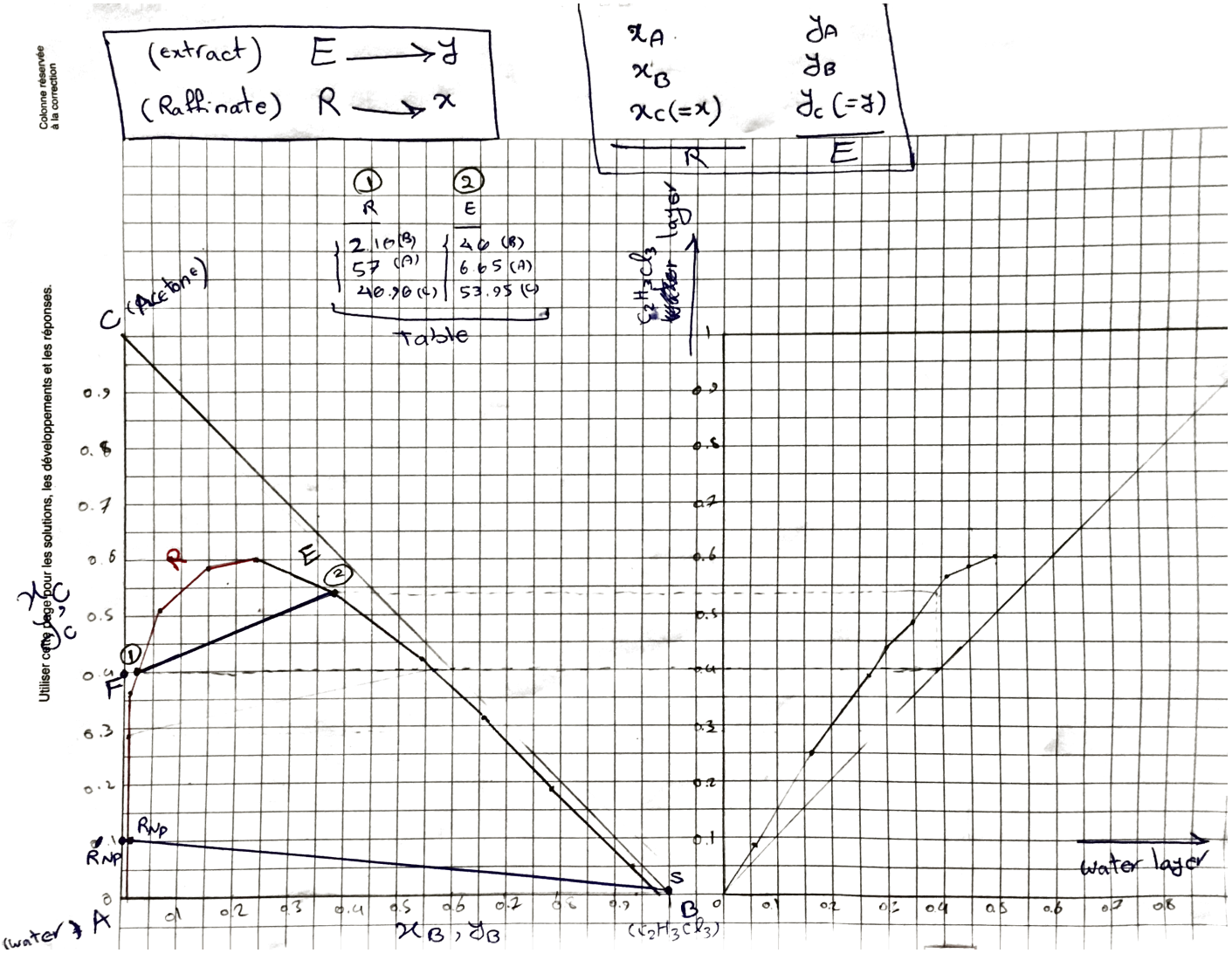

Feed F x_F
Final extract E_1 y_1
Stage 1
R_1 x_1
E_2 y_2
Stage 2
R_2 x_2
E_3 y_3
R_s-1 x_s-1
E_s y_s
Stage s
R_s x_s
E_s+1 y_s+1
R_Np-1 x_Np-1
E_Np y_Np
Stage N_p
R_Np = final raffinate x_Np
S y_s Solvent

$$\text{Feed} : F = 100\ \frac{kg}{h},\ x_F = 0.4,\ x_{B,F} = 0,\ x_{A,F} = 0.6$$

$$\text{Final raffinate} : x_{Np} = 0.1$$

$$\text{Solvent} : y_s = 0$$

$$Fx_F + Sy_s = Ey_1 + Rx_1 = Mx_M$$



$$F + S = M$$

$$F x_F + S y_s = M x_M$$
$$F x_F + 0 = M x_M$$

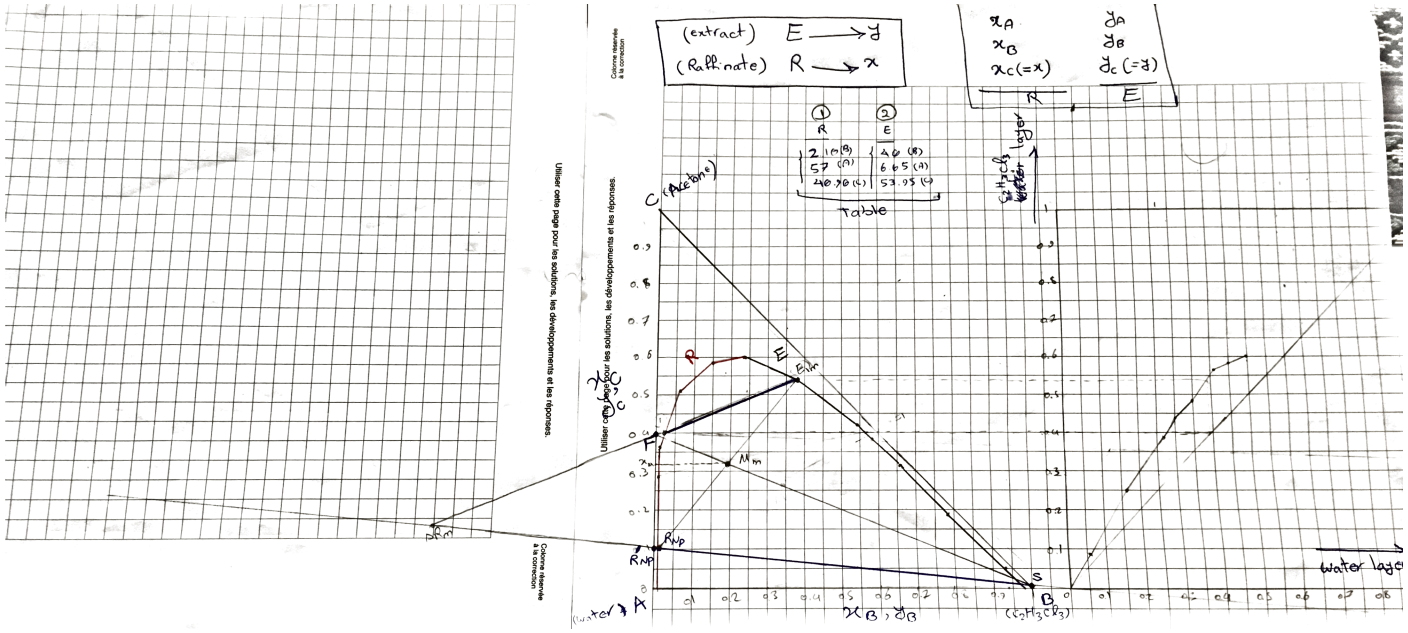
$$F x_F = (S + F) \times x_M$$

$$x_M = \frac{F x_F}{S + F}$$

$$S = \frac{F x_F}{x_M} - F$$

For Minimum solvent:

$$S_{min} = \frac{F x_F}{x_{M,min}} - F$$



$$\boxed{x_{M,min} = 0.32}$$

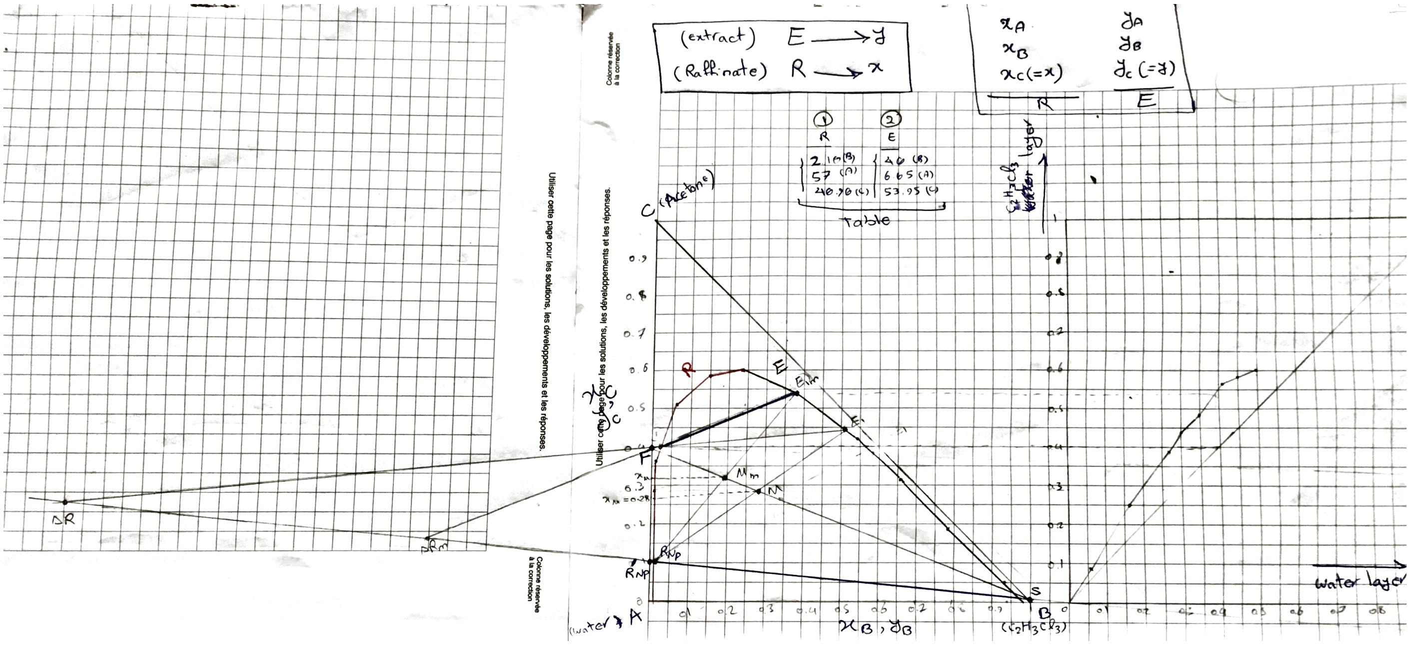
$$S_{min} = \frac{F x_F}{x_{M,min}} - F$$

$$S_{min} = 25 \ \frac{kg}{h}$$

$$x_M = \frac{F x_F}{S + F}$$

$$x_M = \frac{100 \times 0.4}{1.8 \times S_{min} + 100}$$

$$x_M = 0.275$$


(extract) E → y
(Raffinate) R → x
x_A y_A
x_B y_B
$x_C(=x)$ $y_C(=y)$
R E
Table
C (Acetone)
(water) A
B ($C_2H_3Cl_3$)
x_B, y_B
water layer
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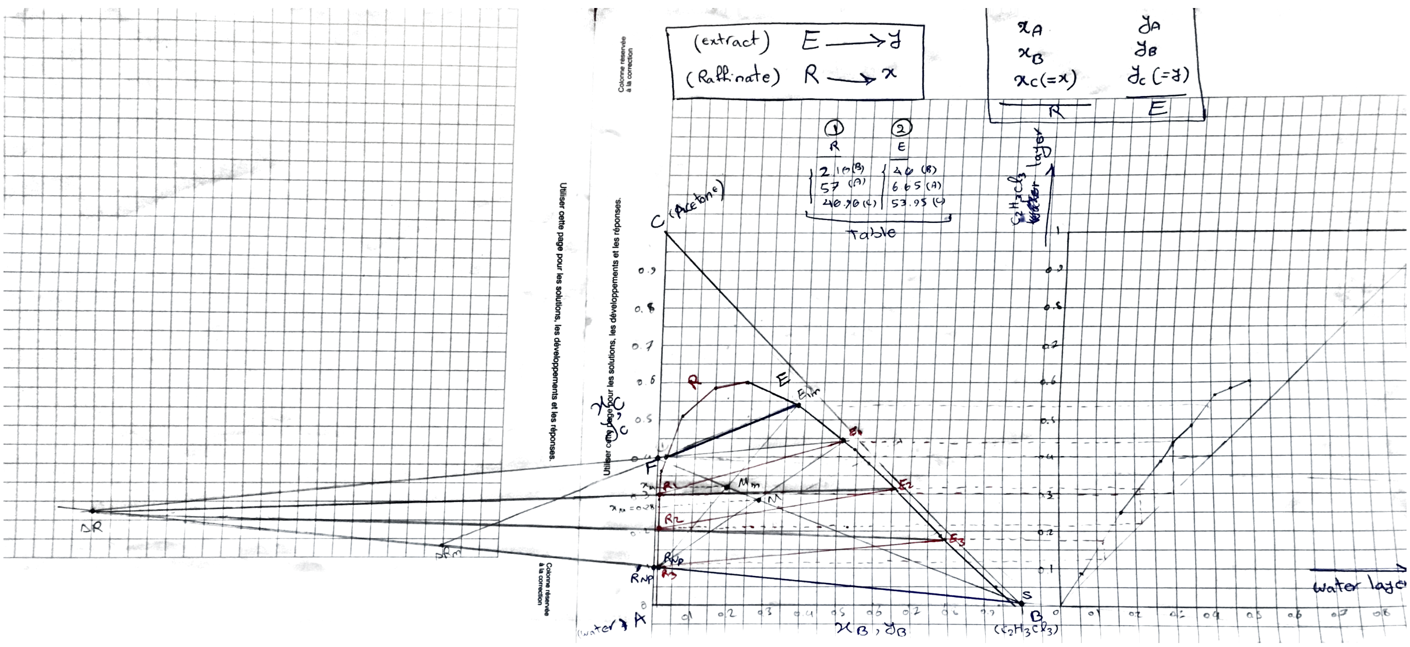
(extract) E → y
(Raffinate) R → x
x_A y_A
x_B y_B
$x_C(=x)$ $y_C(=y)$
R E
Table
C (Acetone)
(water) A
B ($C_2H_3Cl_3$)
x_B, y_B
water layer
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Colonne réservée à la correction