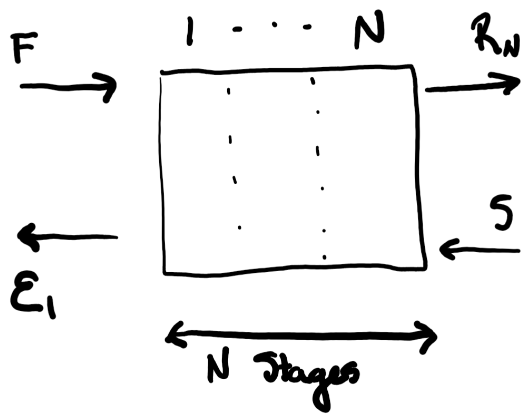
1)

a.



$x_{EG}^F = 0.20$
$x_W^F = 0.80$
$x_{EG}^R \leq 0.05$
$F = 350$ kg/hr
$S = 100$ kg/hr
(pure)

Solve:

Solving for the mixture composition ($[m_i] =$ kg/hr),

Comp.	F		S		M	
	m_i	x_i	m_i	x_i	m_i	x_i
EG	70	0.20	0.00	0.00	70	0.156
W	280	0.80	0.00	0.00	280	0.622
f	0	0.00	100	1.00	100	0.222
Tot.	350	1.00	100	1.00	450	1.00

From this, the F, S, and M composition points may be plotted on the Gibbs triangle for the system along with the desired R_N composition. The material balances around the column dictate that E_1, R_N, and M compositions lie on the same line. Thus, we draw a line through $R_N M$ and find its intersection with the equilibrium curve (E_1 exits in equilibrium). Additionally, consider the material balance around the entire column,

$$F + S = E_1 + R_N.$$

Meaning,

$$\Delta = F - E_1 = R_N - S = R_i - E_{i+1},$$

for any stage, i. Therefore, all passing streams *must* intersect at Δ. By drawing the lines through FE_1 and $R_N S$, we may extract Δ. From this, the composition is found by stepping between the tie lines and operating point.

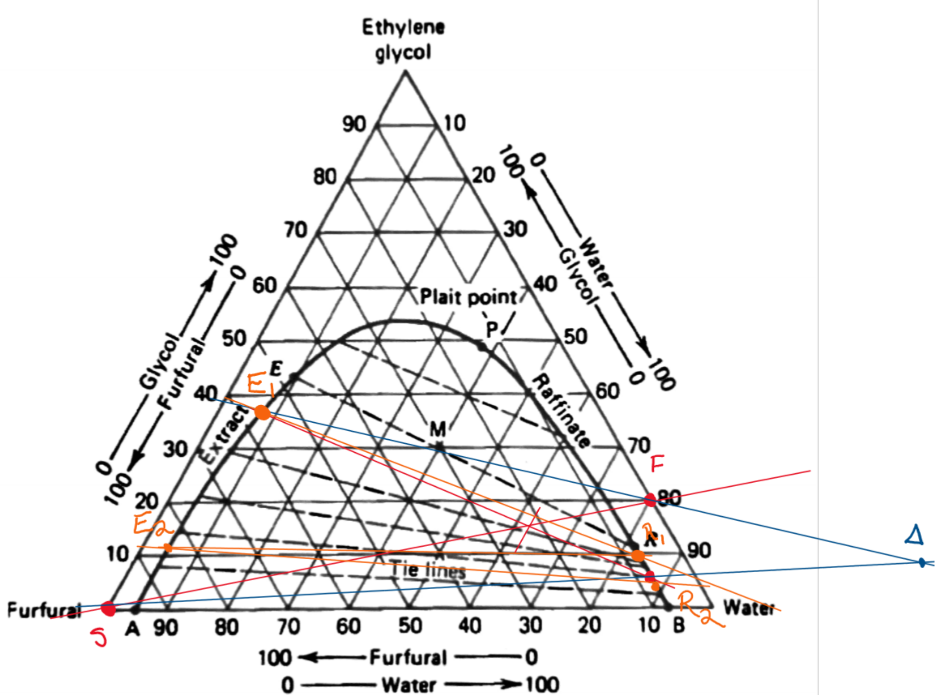


Figure 1: Gibbs triangle for a EG-W-f system

The compositions may be read off the diagram ($[m_i] = \text{kg/hr}$).

Comp.	M		E		R	
	m_i	x_i	m_i	x_i	m_i	x_i
EG	70	0.156	53.7	0.360	9.93	0.033
W	280	0.622	10.4	0.070	268	0.890
f	100	0.222	85.0	0.57	23.5	0.078
Tot.	450	1.00	149	1.00	301	1.00

Since the compositions are known from the Gibbs triangle. We may solve for R_N and E_1 using any component balance. This forms a linear system,

$$M = E_1 + R_N,$$

$$x_i^M M = x_i^E E_1 + x_i^R R_N,$$

whose solution gives a lever rule like expression,

$$\frac{R_N}{M} = \frac{x_i^M - x_i^E}{x_i^R - x_i^E}.$$

Applying this to all of the components gives 3 different values for R_N,

$$(\mathrm{EG}, \mathrm{W}, \mathrm{f}) \to R_N = (281, 303, 318) \text{ kg/hr},$$

Taking the average gives,

$$\boxed{R_N = 301 \text{ kg/hr}}.$$

Since $E_1 = M - R_N$,

$$\boxed{E_1 = 149 \text{ kg/hr}}.$$

b.

From the diagram, there are 2 tie lines, thus, at least $\boxed{N = 2}$ stages are required.

c.

Reading from the E_2 point on the diagram,

$$(x_{EG}, x_W, x_f)_{E_2} = (0.11, 0.05, 0.85),$$

which sums to 1.01. By distributing the 0.01 error,

$$\boxed{(x_{EG}, x_W, x_f)_{E_2} = (0.107, 0.047, 0.846)}.$$