



- 1) Draw process
- 2) Fill in values
- 3) Add needed variables

Given $I = 2M$
 $W = 2E$

Use Basis of $F = 1 \text{ kg/s}$

Balance around first unit

$$F = M + I$$

as $I = 2M$

$$F = 2M + 2M = 3M$$

$$M = \frac{1}{3} F ; I = 2M = \frac{2}{3} F$$

Balance around second unit

$$I = E + W$$

As $I = \frac{2}{3} F ; W = 2E$

$$\frac{2}{3} F = E + 2E$$

$$\frac{2}{3} F = 3E$$

$$E = \frac{2}{9} F ; W = 2E = \frac{4}{9} F$$

Feed: F
 Ethanol-rich: $E = \frac{2}{9} F$
 Waste: $W = \frac{4}{9} F$
 In-between: $I = \frac{2}{3} F$
 Methanol-rich: $\frac{1}{3} F$

Balance around first unit

Ethanol: Input = Output

(No generation or accumulation)

$$X_{E,F} F = X_{E,M} M + X_{E,I} I$$

$$0.5F = 0.1\left(\frac{1}{3}F\right) + X_{E,I}\left(\frac{2}{3}F\right)$$

$$1.5 = 0.1 + 2X_{E,I}$$

$$1.4 = 2X_{E,I}$$

$$X_{E,I} = 0.7$$

$$\text{as } X_{E,I} + X_{M,I} = 1$$

$$X_{M,I} = 0.3$$

} In between is
0.7 ethanol
0.3 methanol.

Balance around second unit

Ethanol:

$$X_{E,I} I = X_{E,E} E + X_{E,W} W$$

$$(0.7)\left(\frac{2}{3}F\right) = (0.9)\left(\frac{2}{9}F\right) + (X_{E,W})\left(\frac{4}{9}F\right) \quad \times 9$$

$$4.2 = 1.8 + 4X_{E,W}$$

$$2.4 = 4X_{E,W}$$

$$X_{E,W} = 0.6$$

$$\text{as } X_{E,W} + X_{M,W} = 1$$

$$X_{M,W} = 0.4$$

} Waste is
0.6 ethanol
0.4 methanol.