DISTILLATION

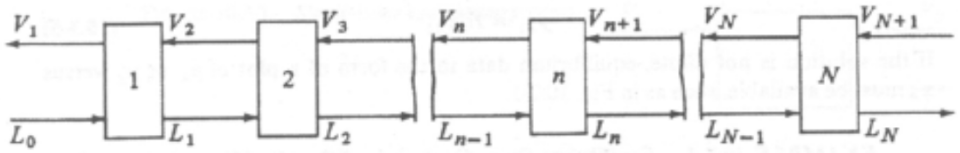
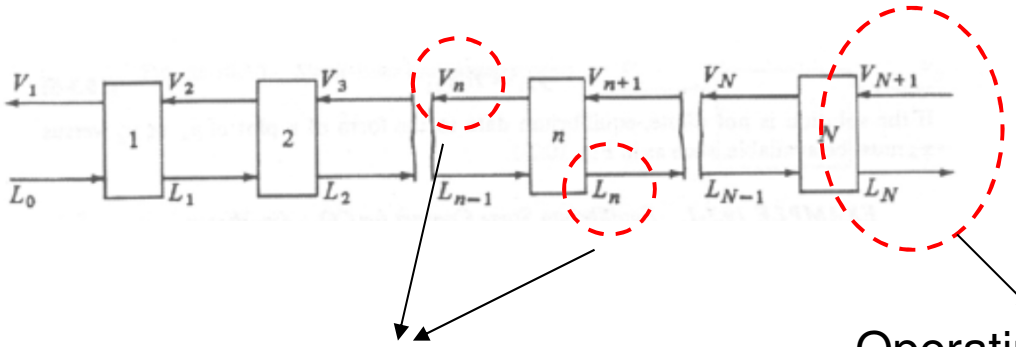


FIGURE 10.3-2. *Countercurrent multiple-stage process.*

$$L_0 x_0 + V_{N+1} y_{N+1} = L_N x_N + V_1 y_1 = M x_M$$

$$y_{n+1} = \frac{L_n x_n}{V_{n+1}} + \frac{V_1 y_1 - L_0 x_0}{V_{n+1}}$$

Operating line equation



Equilibrium

Operating streams
Passing each other

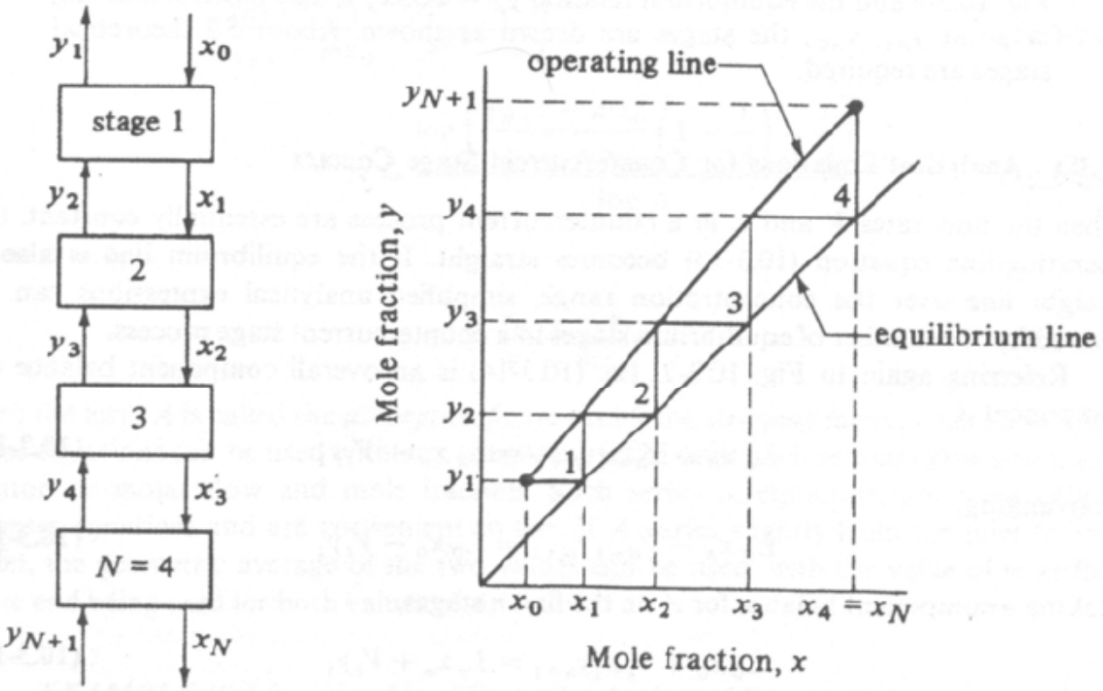


FIGURE 10.3-3. *Number of stages in a countercurrent multiple-stage contact process.*

EXAMPLE 10.3-2. Absorption of Acetone in a Countercurrent Stage Tower

It is desired to absorb 90% of the acetone in a gas containing 1.0 mol % acetone in air in a countercurrent stage tower. The total inlet gas flow to the tower is 30.0 kg mol/h, and the total inlet pure water flow to be used to absorb the acetone is 90 kg mol H_2O/h. The process is to operate isothermally at 300 K and a total pressure of 101.3 kPa. The equilibrium relation for the acetone (A) in the gas–liquid is $y_A = 2.53x_A$. Determine the number of theoretical stages required for this separation.

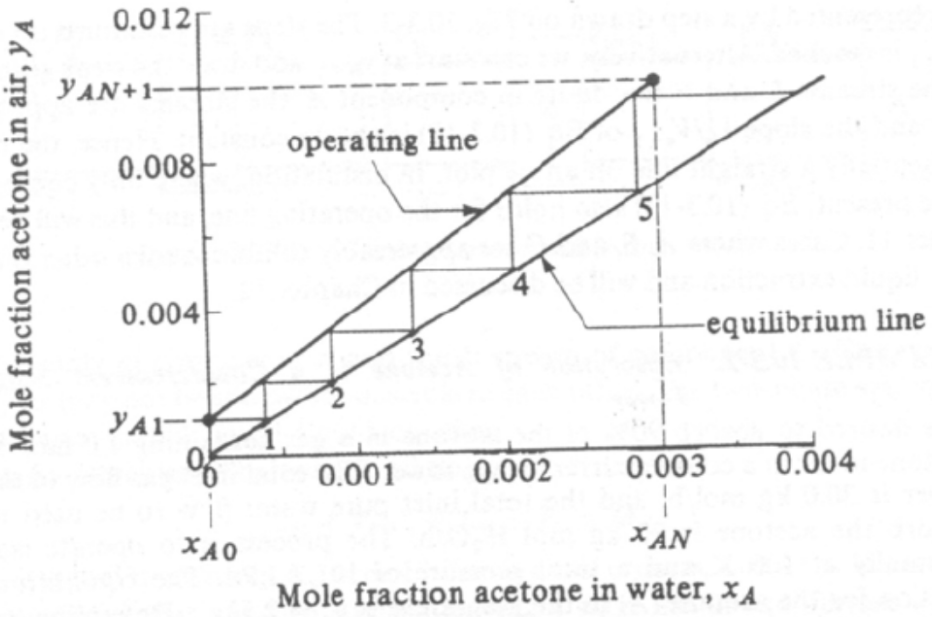


FIGURE 10.3-4. *Theoretical stages for countercurrent absorption in Example 10.3-2.*

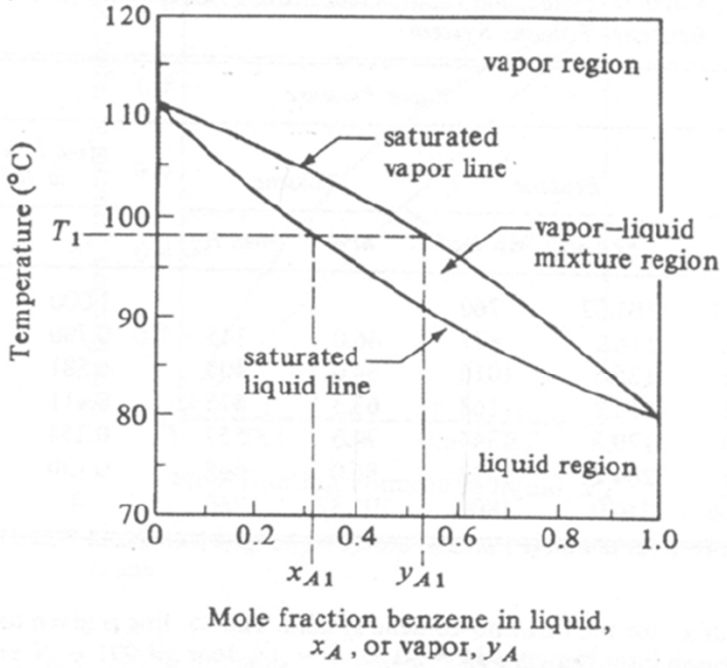


FIGURE 11.1-1. *Boiling point diagram for benzene (A)–toluene (B) at 101.325 kPa (1 atm) total pressure.*

$$p_A + p_B = P$$

$$P_A x_A + P_B(1 - x_A) = P$$

$$y_A = \frac{p_A}{P} = \frac{P_A x_A}{P}$$

EXAMPLE 11.3-2. Simple Differential Distillation

A mixture of 100 mol containing 50 mol % *n*-pentane and 50 mol % *n*-heptane is distilled under differential conditions at 101.3 kPa until 40 mol is distilled. What is the average composition of the total vapor distilled and the composition of the liquid left? The equilibrium data are as follows, where x and y are mole fractions of *n*-pentane.

x	y	x	y	x	y
1.000	1.000	0.398	0.836	0.059	0.271
0.867	0.984	0.254	0.701	0	0
0.594	0.925	0.145	0.521		

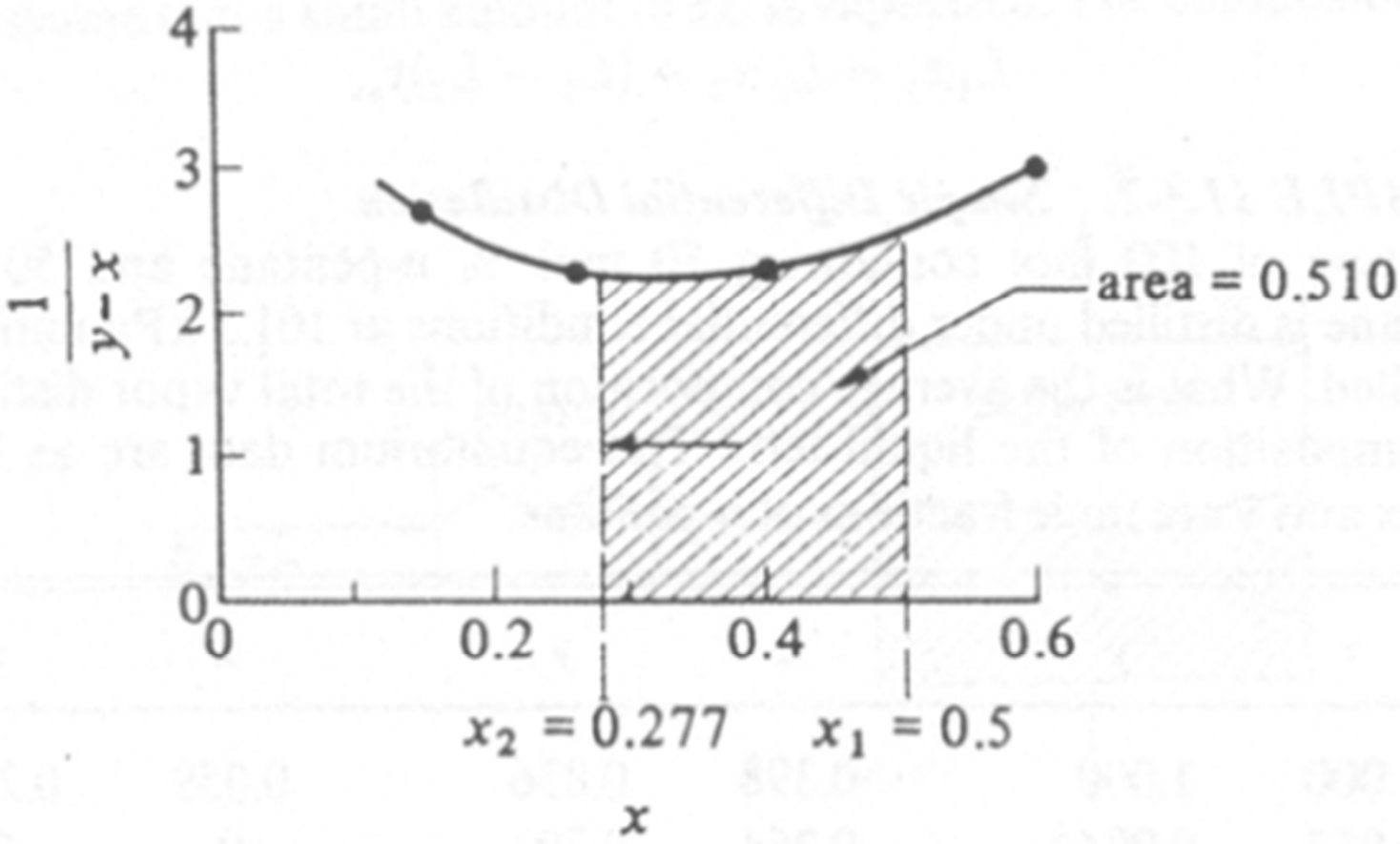


FIGURE 11.3-3. *Graphical integration for Example 11.3-2.*