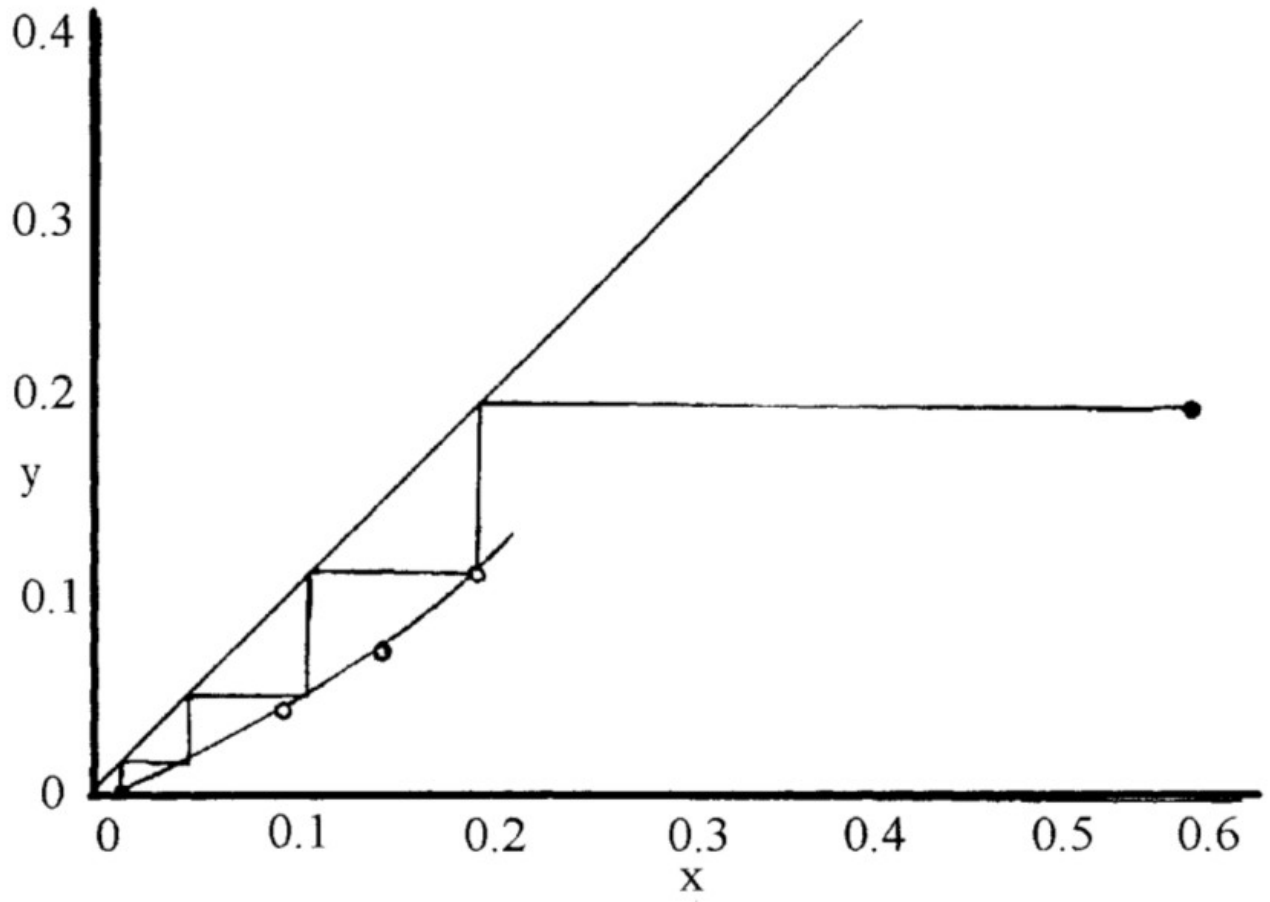
**20.4.** Oil is to be extracted from halibut livers by means of ether in a countercurrent extraction battery. The entrainment of solution by the granulated liver mass was found by experiment to be as shown in Table 20.5. In the extraction battery, the charge per cell is to be 100 lb, based on completely exhausted livers. The unextracted livers contain 0.043 gal of oil per pound of exhausted material. A 95 percent recovery of oil is desired. The final extract is to contain 0.65 gal of oil per gallon of extract.

TABLE 20.5

| Solution retained by 1 lb exhausted livers, gal | Solution concentration, gal oil/gal solution | Solution retained by 1 lb exhausted livers, gal | Solution concentration, gal oil/gal solution |
|---|---|---|---|
| 0.035 | 0 | 0.068 | 0.4 |
| 0.042 | 0.1 | 0.081 | 0.5 |
| 0.050 | 0.2 | 0.099 | 0.6 |
| 0.058 | 0.3 | 0.120 | 0.68 |

The ether fed to the system is oil free. (*a*) How many gallons of ether are needed per charge of livers? (*b*) How many extractors are needed?

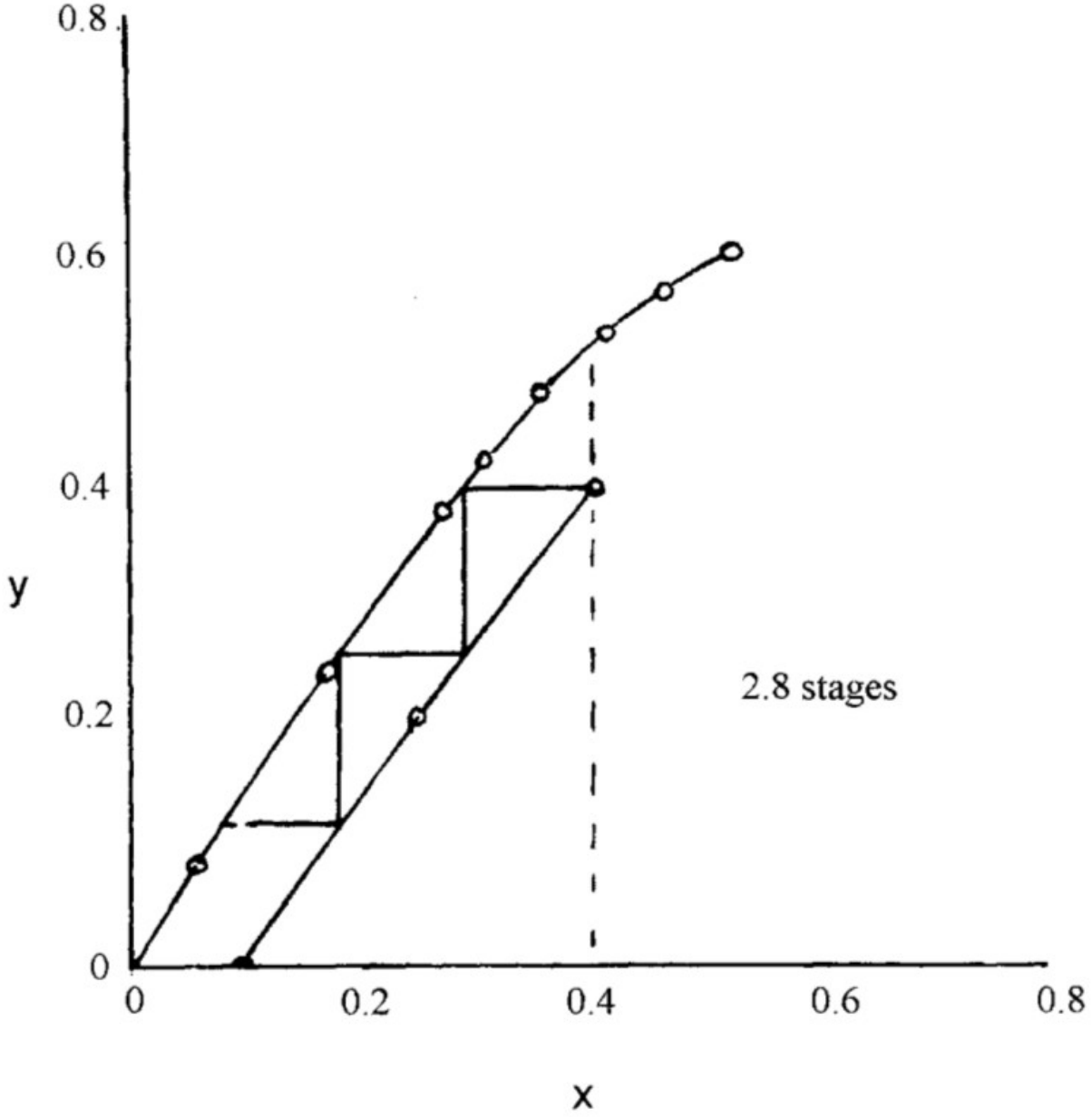

0.4
0.3
0.2
y
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
x

**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 |


0.8
0.6
0.4
0.2
0
y
0
0.2
0.4
0.6
0.8
x
2.8 stages