(a)

(b)

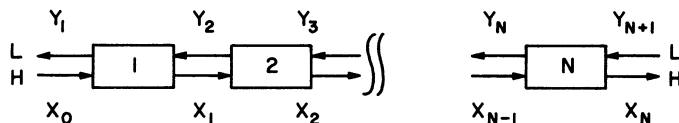**Figure 11.8.** (a) Single-stage and (b) multistage countercurrent liquid extraction systems.

Since $K_D = Y_1/X_1$, eq. 11.29 can be written as

$$X_1 = X_0 - \frac{LK_D}{H} X_1 \tag{11.30}$$

$$\frac{X_1}{X_0} = \frac{1}{1 + (LK_D/H)} = \frac{1}{1 + E} \tag{11.31}$$

where $E = LK_D/H$ is the extraction factor.

For a multistage countercurrent operation, as depicted in Fig. 11.8b, a material balance on extracted solute yields

$$R = \frac{E(E^n - 1)}{E - 1} \tag{11.32}$$

where R is the rejection ratio, which is the weight ratio of the solute leaving in the light phase to that leaving in the heavy phase, and n is the number of equilibrium stages.

The fraction of solute extracted is then

$$\% \text{ extraction} = 1 - \frac{1}{R + 1} \tag{11.33}$$

When the solute enters the system in the light phase, the rejection ratio is

$$R = \frac{E^n(E - 1)}{E^n - 1} \tag{11.34}$$