



Figure 11.10. Distribution ratios for various penicillins and impurities. (With permission, from M. Sounders, G. J. Pierotti, and C. L. Dunn, *Chem. Eng. Prog. Symp. Ser.* 66, p. 40, 1970, AIChE, New York.)

the separation becomes easier (Fig. 11.10). For example, at low pH values, penicillins can be separated from other impurities by selective extraction into the organic solvent. However, the separation of similar compounds by extraction is difficult. If only nonionized species are soluble in both phases at extreme pH values and the solvents are immiscible, the aforementioned design equations can be used. However, at intermediate pH values, when compounds are partially ionized, the analysis of the system becomes more complicated. The extraction of ionized species (weak acid or bases) is known as *dissociation extraction*.

The apparent distribution coefficients for weak acids and bases are

$$\text{Weak acids: } K_D^{AP} = \frac{K_D^0[H^+]}{[H^+] + K_1} \quad \text{or} \quad \text{pH} - \text{p}K_1 = \log\left(\frac{K_D^0}{K_D^{AP}} - 1\right) \quad (11.36)$$

$$\text{Weak bases: } K_D^{AP} = \frac{K_D^0 K_1}{K_1 + [H^+]} \quad \text{or} \quad \text{p}K_1 - \text{pH} = \log\left(\frac{K_D^0}{K_D^{AP}} - 1\right) \quad (11.37)$$