$$\log \gamma_i^v = (V_i \phi_v^2 / 2.3\ RT)(\delta_i - \delta_v)^2 \qquad [2]$$

Because transport through skin is a diffusion process that depends on a concentration gradient, the application of calculated solubilities, derived in part from δ, to predict the concentration gradients and, hence, diffusion is a logical progression. Fick's first law for diffusion (Eq. 3) contains terms for the concentrations of the drug in the membrane (C_i^{s1} and C_i^{s2}) that constitute the concentration gradient (Fig. 1). They are difficult to determine. Hence, Fick's first law is usually expanded into a form (Eq. 4) that contains contributions from more readily measured terms, where $J_i^{s,v}$ is the flux of drug (i) delivered from vehicle (v) through a membrane that, here, is skin (s), D_i^s is the diffusion coefficient of the drug in the skin, h_s is the thickness of the skin membrane, C_i^{s1} and C_i^{s2} are the concentrations of the drug in that layer of the skin next to the vehicle and receptor phase or plasma (p), respectively, C_i^v is the concentration of the drug in the vehicle, and $K_i^{s,v}$ is the distribution or partition coefficient of the drug between the vehicle and skin equal to C_i^{s1}/C_i^v. In proceeding from Eq. 3 to Eq. 4, $K_i^{s,v} C_i^v$ has been substituted for C_i^{s1} and C_i^{s2} has been assumed to approach zero, because sink conditions are maintained on the plasma side of the membrane, that is, $C_i^p = 0$ (see Fig. 1).

$$J_i^{s,v} = (D_i^s / h_s)(C_i^{s1} - C_i^{s2}) \qquad [3]$$

$$J_i^{s,v} = (D_i^s / h_s) K_i^{s,v} C_i^v \qquad [4]$$

The partition coefficient for the distribution of the drug between two phases (here, vehicle and skin) to form saturated, nonideal solutions is given by Eq. 5. Because the activity coefficients can be calculated from Eq. 2, the partition coefficient can be calculated by substituting the identities for γ_i^v and γ_i^s from Eq. 2 into Eq. 5 to give Eq. 6. If it is assumed that the drug is not very soluble in either the vehicle or the skin, ϕ_s^2 and ϕ_v^2 approach a value of 1 and Eq. 6 reduces to Eq. 7.

$$\log K_i^{s,v} = \log \gamma_i^v / \gamma_i^s \qquad [5]$$

$$\log K_i^{s,v} = [(\delta_i - \delta_v)^2 V_i \phi_v^2 / 2.3\,RT] - [(\delta_i - \delta_s)^2 V_i \phi_s^2 / 2.3\,RT \qquad [6]$$