

If the solid is pure, then $X_{\text{BH}^+\text{Cl}^-(\text{s})} = 1$ and

$$S_0 = [\text{BH}^+\text{Cl}^-(\text{aq})] \quad (4.8)$$

The *dissociation constant*, K'_s , can be defined as:

$$K'_s = \frac{[\text{BH}^+][\text{Cl}^-]}{[\text{BH}^+\text{Cl}^-(\text{aq})]} = \frac{[\text{BH}^+][\text{Cl}^-]}{S_0} \quad (4.9)$$

The *solubility-product*, K_{sp} , is defined as the equilibrium expression that relates the concentrations of the final dissociated ions to the solid substance. It is an overall equilibrium quotient that reveals nothing about the concentrations of the intermediate species.

$$K_{\text{sp}} = \frac{[\text{BH}^+][\text{Cl}^-]}{X_{\text{BH}^+\text{Cl}^-(\text{s})}} = [\text{BH}^+][\text{Cl}^-] \quad (4.10)$$

Saturated Solution with No Other Sources of Either Ion

The mass balance can be expressed in either of the two ways:

$$S_T = [\text{BH}^+\text{Cl}^-(\text{aq})] + [\text{BH}^+] \quad (4.11)$$

or

$$S_T = [\text{BH}^+\text{Cl}^-(\text{aq})] + [\text{Cl}^-] \quad (4.12)$$

where S_T is the total concentration of the compound, namely its solubility. Recognizing that $[\text{BH}^+\text{Cl}^-(\text{aq})] = S_0$ and that $K_{\text{sp}} = [\text{BH}^+]^2 = [\text{Cl}^-]^2$ because $[\text{BH}^+] = [\text{Cl}^-]$, we find

$$S_T = S_0 + (K_{\text{sp}})^{1/2} \quad (4.13)$$

Saturated Solutions Containing Additional Common Ions

When the solution contains some other solute that can contribute Cl^- to the system, the dissociation of BH^+Cl^- will be partly depressed, the concentration of BH^+ and Cl^- will not be equal, the dissolution rate of the salt will be decreased (Li et al. 2005). The solubility-product itself, however, is still valid, and therefore, we may write:

$$[\text{BH}^+] = \frac{K_{\text{sp}}}{[\text{Cl}^-]_T} = \frac{K_{\text{sp}}}{[\text{BH}^+][\text{Cl}^-]_A} \quad (4.14)$$

where $[\text{Cl}^-]_T$ is the total concentration contributed both by the dissociation of BH^+Cl^- ($[\text{BH}^+]$) and by the second source of Cl^- ($[\text{Cl}^-]_A$). The solubility of the hydrochloride salt is inversely proportional to the equilibrium concentration of the Cl^- .

Saturated Solution in the Presence of Buffer Species

When the solubility of a salt, for example, the hydrochloride salt, is determined in buffer systems, the effect of the buffer species on the solubility must be taken into account. The anion of the buffer, L^- , for example, acetate, will compete with Cl^- to form a salt as illustrated in Equation 4.15.