Solubility Equilibrium

SECTION 4

OBJECTIVES

- Explain what is meant by *solubility product constants,* and calculate their values.
- Calculate solubilities using solubility product constants.
- Carry out calculations to predict whether precipitates will form when solutions are combined.

Ionic solids dissolve in water until they are in equilibrium with their ions. An equilibrium expression can be written from the balanced chemical equation of the solid's dissociation. Concentrations of the ions can be determined from the balanced chemical equation and solubility data. The ion concentrations can then be used to determine the value of the equilibrium constant. The numerical value for the equilibrium constant can be used to predict whether precipitation occurs when solutions of various concentrations are combined.

Solubility Product

A saturated solution contains the maximum amount of solute possible at a given temperature in equilibrium with an undissolved excess of the substance. A saturated solution is not necessarily a concentrated solution. The concentration may be high or low, depending on the solubility of the solute.

A general rule is often used to express solubilities qualitatively. By this rule, a substance is said to be *soluble* if the solubility is *greater than* 1 g per 100 g of water. It is said to be *insoluble* if the solubility is *less than* 0.1 g per 100 g of water. Substances whose solubilities fall between these limits are described as *slightly soluble.*

The equilibrium principles developed in this chapter apply to all saturated solutions of sparingly soluble salts. Silver chloride is so sparingly soluble in water that it is sometimes described as insoluble. Its solution reaches saturation at a very low concentration of its ions. All Ag^+ and Cl^- ions in excess of this concentration eventually precipitate as AgCl.

Consider the equilibrium system in a saturated solution of silver chloride containing an excess of the solid salt. This system is represented by the following equilibrium equation and equilibrium-constant expression.

$$AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$$

The equation represents a heterogeneous reaction, as described on page 599. Once again, we follow the convention of writing the equilibrium expression without including the solid species. Therefore, [AgCl] does not appear in the final expression. The resulting equilibrium expression gives the solubility product constant K_{sp}. *The* **solubility product constant** *of a substance is the product of the molar concentrations of*