



Solubility Product Constant, K_{sp}



Solubility Product Constant, K_{sp}

The solubility product constant, K_{sp} , is the equilibrium constant for a solid substance dissolving in an aqueous solution. It represents the level at which a solute dissolves in solution. The more soluble a substance is, the higher the K_{sp} value it has.

Consider the general dissolution reaction below (in aqueous solutions):



To solve for the (K_{sp}) it is necessary to take the molarities or concentrations of the products (cC and dD) and multiply them. If there are coefficients in front of any of the products, it is necessary to raise the product to that coefficient power (and also multiply the concentration by that coefficient). This is shown below:

$$K_{sp} = [C]^c [D]^d \tag{2}$$

Note that the reactant, aA, is not included in the (K_{sp}) equation. Solids are not included when calculating equilibrium constant expressions, because their concentrations do not change the expression; any change in their concentrations are insignificant, and therefore omitted. Hence, (K_{sp}) represents the maximum extent that a solid that can dissolved in solution.

Exercise 1: Magnesium Floride

What is the solubility product constant expression for (MgF_2) ?

Solution

The relevant equilibrium is



so the associated equilibrium constant is

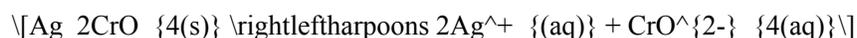
$$K_{sp} = [Mg^{2+}][F^{-}]^2$$

Exercise 2: Silver Chromate

What is the solubility product constant expression for (Ag_2CrO_4) ?

Solution

The relevant equilibrium is



so the associated equilibrium constant is

$$K_{sp} = [Ag^{+}]^2[CrO_4^{2-}]$$

Important effects

- For highly soluble ionic compounds the ionic [activities](#) must be found instead of the concentrations that are found in slightly soluble solutions.

- **Common Ion Effect:** The solubility of the reaction is reduced by the common ion. For a given equilibrium, a reaction with a common ion present has a lower K_{sp} , and the reaction without the ion has a greater K_{sp} .
- **Salt Effect (diverse ion effect):** Having an opposing effect on the K_{sp} value compared to the common ion effect, uncommon ions increase the K_{sp} value. Uncommon ions are ions other than those involved in equilibrium.
- **Ion Pairs:** With an ionic pair (a cation and an anion), the K_{sp} value calculated is less than the experimental value due to ions involved in pairing. To reach the calculated K_{sp} value, more solute must be added.

References

1. Petrucci, Ralph H., et al. General Chemistry: Principles and Modern Applications. Upper Saddle River, NJ: Prentice Hall 2007.

Outside Links

- Clark, Roy W.; Bonicamp, Judith M. "Solubility and Solubility Products (about J. Chem. Educ. 1998, 75, 1179-1181 and J. Chem. Educ. 1998, 75, 1182-1185)." *J. Chem. Educ.* **2000** 77 1558.
- Euler, William B.; Kirschenbaum, Louis J.; Ruekberg, Ben. "Determination of K_{sp} , ΔG^0 , ΔH^0 , and ΔS^0 " *J. Chem. Educ.* **2000** 77 1039.
- Martin, R. Bruce. "Solubility and Solubility Products (about J. Chem. Educ. 1998, 75, 1179-1181 and J. Chem. Educ. 1998, 75, 1182-1185)." *J. Chem. Educ.* **2000** 77 1558.

Contributors

- Kathryn Rashe, Lisa Peterson