

Yet Another Equilibrium Constant - K_{sp}

Define –

solubility-product constant:

molar solubility:

Fill in the blanks –

Concentration terms represent equilibrium concentrations at _____.

The _____ of the solubility-product constant is a measure of how far to the _____ the dissolution proceeds at equilibrium.

For compounds that contain _____, we can say the higher the K_{sp} , the _____ solubility.

The presence of a common ion _____ the solubility of a slightly soluble ionic compound.

If the compound contains the _____ of a weak acid, addition of H_3O^+ _____ its solubility.

The _____ ion is so basic that it is not stable in water and reacts completely to form the _____ and the _____.

An example of the above is the dissolution of manganese (II) sulfide, which, when shaken with water, forms the following:

Examples –

1. Write the formula and the ion product expression for each of the following compounds:
 - a. Magnesium carbonate
 - b. Iron (II) hydroxide
 - c. Calcium phosphate
 - d. Silver sulfide
 - e. Calcium sulfate
 - f. Chromium (III) carbonate
 - g. Magnesium hydroxide
 - h. Arsenic (III) sulfide

Useful molecular weights: lead = 207.2 g/mol, sulfur = 32.07 g/mol, oxygen = 16.00 g/mol, fluorine = 19.00 g/mol, calcium = 40.08 g/mol, sodium = 22.99 g/mol, nitrogen = 14.01 g/mol, phosphorus = 30.97 g/mol

Lead (II) sulfate is a key component in lead-acid car batteries. Its solubility in water at 25 °C is 4.25×10^{-3} g/100 mL solution. What is the K_{sp} of lead (II) sulfate?

When lead (II) fluoride is shaken with pure water at 25 °C, the solubility is found to be 0.64 g/L. Calculate the K_{sp} of lead (II) fluoride.

2. Calcium hydroxide is a major component of mortar, plaster, and cement. Solutions of calcium hydroxide are used in industry as a cheap, strong base. Calculate the solubility of calcium hydroxide in water if the K_{sp} is 6.5×10^{-6} .

3. In the previous problem, we calculated the solubility of calcium hydroxide in water. What is its solubility in 0.10 M $\text{Ca}(\text{NO}_3)_2$?

4. To improve the quality of x-ray images used in the diagnosis of intestinal disorders, patients drink an aqueous suspension of BaSO_4 before the x-ray procedure. Since Ba^{2+} is actually toxic, the concentration is lowered by the addition of dilute Na_2SO_4 . What is the solubility of BaSO_4 ($K_{\text{sp}} = 1.1 \times 10^{-10}$) in pure water and in 0.10 M Na_2SO_4 ?

Comparing Q_{sp} to K_{sp}

When $Q_{sp} = K_{sp}$: the solution is saturated and no change occurs

When $Q_{sp} > K_{sp}$: precipitate forms until solution is saturated

When $Q_{sp} < K_{sp}$: solution is unsaturated and no precipitate forms

Examples:

5. A common laboratory method for preparing a precipitate is to mix solutions containing the component ions. Does a precipitate form when 0.100 L of 0.30 M $\text{Ca}(\text{NO}_3)_2$ is mixed with 0.200 L of 0.060 M NaF?

6. As a result of mineral erosion and biological activity, phosphate ion is common in natural waters, where it often precipitates as insoluble salts, such as $\text{Ca}_3(\text{PO}_4)_2$. If $[\text{Ca}^{2+}]_{\text{init}} = [\text{PO}_4^{3-}]_{\text{init}} = 1.0 \times 10^{-9} \text{ M}$ in a given river, will $\text{Ca}_3(\text{PO}_4)_2$ precipitate? K_{sp} of $\text{Ca}_3(\text{PO}_4)_2 = 1.2 \times 10^{-29}$