

7.11 Introduction to Solubility Equilibria

Name: _____ Class: _____ Date: _____

Total: 12 marks

KEY WORDS molar solubility • solubility product

Objective

Build the skills to answer exam questions on **solubility equilibria** and K_{sp} .

You must be able to:

- write the **solubility product** K_{sp} expression
- relate **molar solubility** to K_{sp}
- calculate one from the other

1 Key knowledge and worked examples

Study these first. Each one shows the method for a question type used later – follow the steps and you can do the Practice and Exam-style questions yourself.

■ The K_{sp} expression

For a sparingly soluble salt dissolving, e.g. $\text{AgCl}(s) \rightleftharpoons \text{Ag}^+ + \text{Cl}^-$:

$$K_{sp} = [\text{Ag}^+][\text{Cl}^-].$$

The solid is omitted.

■ Molar solubility

Let s be the moles of salt that dissolve per litre. Each formula unit gives ions according to its formula: for AgCl , $[\text{Ag}^+] = [\text{Cl}^-] = s$, so $K_{sp} = s^2$.

■ A worked calculation

If $K_{sp}(\text{AgCl}) = 1.8 \times 10^{-10}$, then $s = \sqrt{K_{sp}} = \sqrt{1.8 \times 10^{-10}} = 1.3 \times 10^{-5} \text{ M}$.

■ Salts giving more ions

For $\text{CaF}_2 \rightleftharpoons \text{Ca}^{2+} + 2\text{F}^-$: $[\text{Ca}^{2+}] = s$, $[\text{F}^-] = 2s$, so $K_{sp} = s(2s)^2 = 4s^3$.

2 Practice

Now apply the methods above.

2.1 Write the K_{sp} expression for $\text{BaSO}_4 \rightleftharpoons \text{Ba}^{2+} + \text{SO}_4^{2-}$. [1]

2.2 For a 1:1 salt with molar solubility s , write K_{sp} in terms of s . [1]

2.3 If $K_{sp} = 4 \times 10^{-10}$ for a 1:1 salt, find s . [2]

3 Exam-style questions

3.1 For $\text{AgCl} \rightleftharpoons \text{Ag}^+ + \text{Cl}^-$ with molar solubility s , $K_{sp} =$ [1]

- ☐ **A** s
B s^2
C $2s$
D $4s^3$

3.2 $\text{PbCl}_2 \rightleftharpoons \text{Pb}^{2+} + 2\text{Cl}^-$ has molar solubility s .

(a) Write $[\text{Pb}^{2+}]$ and $[\text{Cl}^-]$ in terms of s . [2]

(b) Write K_{sp} in terms of s . [2]

3.3 $K_{sp}(\text{CaF}_2) = 3.2 \times 10^{-11}$, with $K_{sp} = 4s^3$. Find the molar solubility s . [3]

Solutions

Each answer shows the steps, then the **result**.

2.1

- $K_{sp} = [\text{Ba}^{2+}][\text{SO}_4^{2-}]$

2.2

- $K_{sp} = s^2$

2.3

- $s = \sqrt{4 \times 10^{-10}} = 2 \times 10^{-5} \text{ M}$

3.1 B

- $K_{sp} = s^2$ for a 1:1 salt

3.2

(a)

- $[\text{Pb}^{2+}] = s, [\text{Cl}^-] = 2s$

(b)

- $K_{sp} = s(2s)^2 = 4s^3$

3.3

- $4s^3 = 3.2 \times 10^{-11}; s^3 = 8 \times 10^{-12}; s = 2 \times 10^{-4} \text{ M}$