AP CHEMISTRY • EXERCISE SHEET

7.11 Introduction to Solubility Equilibria

Name: _____ Class: _____ Date: _____ **Total: 12 marks**

Objective

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

You must be able to:

- write the **solubility product** 溶度积 K_{sp} expression
- relate **molar solubility** 摩尔溶解度 to K_{sp}
- calculate one from the other

1 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 Ksp expression

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

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

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, $[\mathrm{Ag^+}] = [\mathrm{Cl^-}] = s$, so $K_{sp} = s^2$.

A worked calculation

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

Salts giving more ions

For $\mathrm{CaF_2} \rightleftharpoons \mathrm{Ca^{2+}} + 2\mathrm{F^-}$: $[\mathrm{Ca^{2+}}] = s$, $[\mathrm{F^-}] = 2s$, so $K_{sp} = s(2s)^2 = 4s^3$.

2 Practice

Now apply the methods above.

2.1 Write the K_{sp} expression for $BaSO_4 \rightleftharpoons Ba^{2+} + SO_4^{2-}$. [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 $AgCl \rightleftharpoons Ag^+ + Cl^-$ with molar solubility s, $K_{sp} =$ [1]

- **A** s
- **B** s^2
- **C** $2s$
- **D** $4s^3$

3.2 $PbCl_2 \rightleftharpoons Pb^{2+} + 2Cl^-$ has molar solubility s.

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

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

3.3 $K_{sp}(CaF_2) = 3.2 \times 10^{-11}$, with $K_{sp} = 4s^3$. Find the molar solubility s. [3]

4 Go further

You are now ready for the real exam questions on this subtopic:

- work through the **7.11 Introduction to Solubility Equilibria** lesson on the **Learn** page;
- read the **Introduction to Solubility Equilibria** section of the AP Chemistry hand-out on the **Know** page.

Solutions

2.1 $K_{sp} = [\mathrm{Ba}^{2+}][\mathrm{SO}_4^{2-}]$.

2.2 $K_{sp} = s^2$.

2.3 $s = \sqrt{4 \times 10^{-10}} = 2 \times 10^{-5}$ M.

3.1 B —$K_{sp} = s^2$ for a 1:1 salt.

3.2 (a) $[\mathrm{Pb}^{2+}] = s$, $[\mathrm{Cl}^-] = 2s$. (b) $K_{sp} = s(2s)^2 = 4s^3$.

3.3 $4s^3 = 3.2 \times 10^{-11}$; $s^3 = 8 \times 10^{-12}$; $s = 2 \times 10^{-4}$ M.