

UNIT 4 - CHEMICAL SYSTEMS & EQUILIBRIUM

Lesson 7

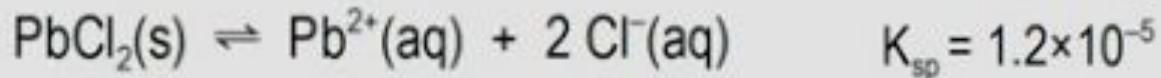
Solubility Calculations

Learning Goals

- ❑ I will be able to use the solubility product constant to calculate the solubility of a solute in water, and vice versa.

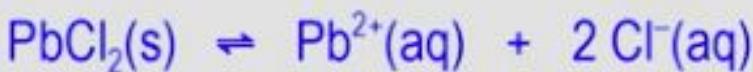
Example 1

Calculate the molar solubility of lead(II) chloride in water at 25°C.



$X_{\text{ICE table}}$ = molar solubility

Step 1: ICE Table



INITIAL CONCENTRATION	—	0	0
CHANGE IN CONCENTRATION	—	+X	+2X
EQUILIBRIUM CONCENTRATION	—	X	2X

SOLUBILITY PRODUCT CONSTANTS	
Compound	K_{sp}
barium carbonate	2.6×10^{-9}
barium chromate	1.2×10^{-11}
barium sulfate	1.1×10^{-10}
calcium carbonate	5.0×10^{-9}
calcium hydroxide	5.0×10^{-6}
calcium phosphate	2.1×10^{-33}
calcium sulfate	7.1×10^{-5}
copper(I) chloride	1.7×10^{-7}
copper(I) iodide	1.3×10^{-12}
copper(II) iodate	6.9×10^{-8}
copper(II) sulfide	6.0×10^{-37}
iron(III) hydroxide	4.9×10^{-17}
iron(III) sulfide	6.0×10^{-19}
iron(III) hydroxide	2.6×10^{-39}
lead(II) bromide	6.6×10^{-6}
lead(II) chloride	1.2×10^{-5}
lead(II) iodate	3.7×10^{-13}
lead(II) iodide	8.5×10^{-9}
lead(II) sulfate	1.8×10^{-3}
magnesium carbonate	6.8×10^{-6}
magnesium fluoride	6.4×10^{-9}
magnesium hydroxide	5.6×10^{-12}
silver bromate	5.3×10^{-5}
silver bromide	5.4×10^{-13}
silver carbonate	8.5×10^{-12}
silver chloride	1.8×10^{-10}
silver chromate	1.1×10^{-12}
silver iodate	3.2×10^{-8}
silver iodide	8.5×10^{-17}
strontium carbonate	5.6×10^{-10}
strontium fluoride	4.3×10^{-9}
strontium sulfate	3.4×10^{-7}
zinc hydroxide	7.7×10^{-17}
zinc sulfide	2.0×10^{-25}

EQUILIBRIUM
CONCENTRATION

—

x

2x

Step 2: Calculate x

$$K_{sp} = [\text{Pb}^{2+}][\text{Cl}^-]^2$$

$$1.2 \times 10^{-5} = (x)(2x)^2$$

$$1.2 \times 10^{-5} = 4x^3$$

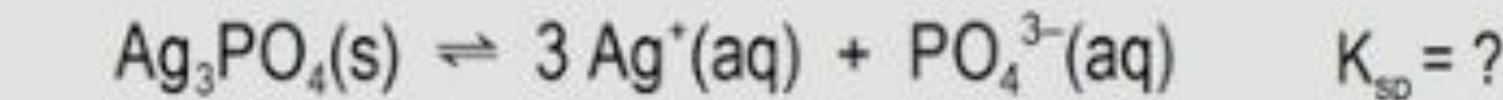
$$\sqrt[3]{\frac{1.2 \times 10^{-5}}{4}} = x$$

$$0.014422\dots = x$$

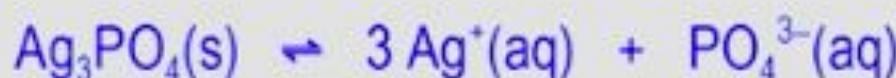
Therefore, the molar solubility of lead(II) chloride in water at 25 °C is 0.014 mol/L.

Example 2

A saturated aqueous solution of silver phosphate at 25°C has a concentration of 4.26×10^{-5} mol/L. Calculate the solubility product constant for silver phosphate at 25°C.



Step 1: ICE Table



INITIAL CONCENTRATION	—	0	0
CHANGE IN CONCENTRATION	—	+3x	+x
EQUILIBRIUM CONCENTRATION	—	3x	x

X ICE Table

EQUILIBRIUM
CONCENTRATION

—

3x

x

Step 2: Calculate K

$$\begin{aligned}K_{sp} &= [\text{Ag}^+]^3 [\text{PO}_4^{3-}] \\&= (3x)^3(x) \\&= 27x^4 \\&= 27(4.26 \times 10^{-5})^4 \\&= 8.8920 \dots \times 10^{-17}\end{aligned}$$

Therefore, the solubility product constant for silver phosphate at 25°C is 8.89×10^{-17} .

Success Criteria

- ❑ I can use the solubility product to calculate the solubility of a solute in water, and vice versa.

PRACTICE:

- Worksheet: 'PRACTICE: **SOLUBILITY CALCULATIONS**'