

Exercise walk-through

7.11

Introduction to Solubility Equilibria

AP Chemistry

Solubility equilibria

A sparingly soluble salt has a **solubility product** K_{sp} (solid left out):



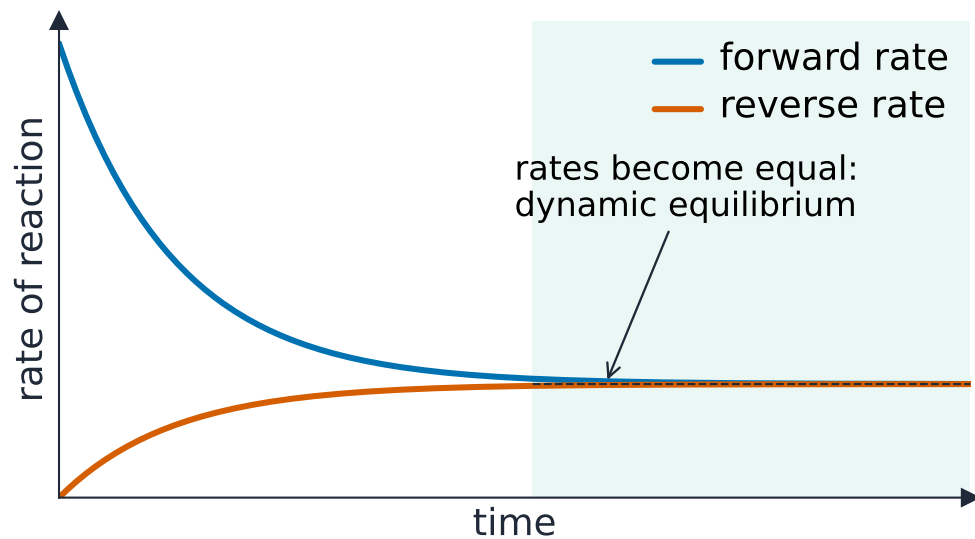
$$K_{sp} = [\text{Ag}^+][\text{Cl}^-] = s^2$$

$$s = \sqrt{1.8 \times 10^{-10}} = 1.3 \times 10^{-5} \text{ M.}$$

Common-ion effect :
adding a shared ion shifts dissolving **backward** – less dissolves (K_{sp} unchanged).

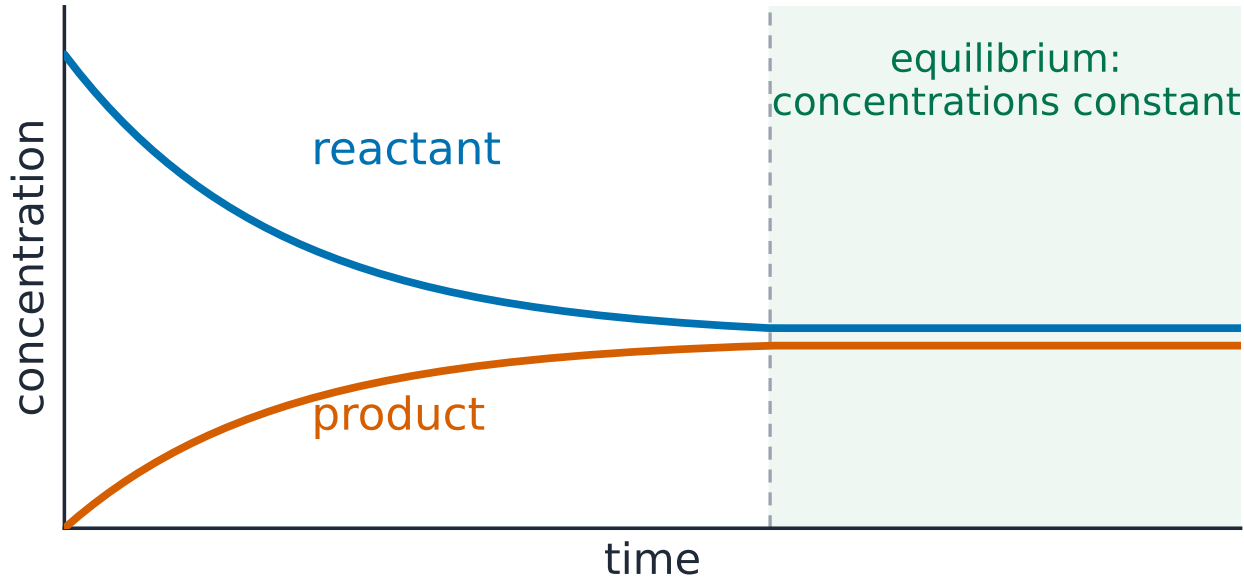
In 0.10 M NaCl, AgCl solubility drops to $1.8 \times 10^{-9} \text{ M.}$

Introduction to Equilibrium



Dynamic equilibrium: the forward and reverse rates become equal

Reactant and product concentrations change



$$\text{at equilibrium: } r_f = r_r \cdot K_c = \frac{[\text{products}]}{[\text{reactants}]}$$

Reactant and product concentrations change, then hold constant once equilibrium is reached

Direction of Reversible Reactions

At equilibrium the amounts of reactants and products are fixed but usually **not** equal.

Whether the mixture favors products or reactants depends on the reaction; you compare the current state to the equilibrium condition to predict which way it shifts.

Introduction to Le Chatelier's Principle

the equilibrium shifts to *oppose* the change you make

increase [reactant]  towards the **products**

increase pressure  to the **fewer-gas-molecules** side

increase temperature  in the **endothermic** direction

a **catalyst** speeds both directions equally, so it gives *no shift*

Le Chatelier's principle: the equilibrium shifts to oppose the change made

Exercises 2.1-2.3

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]

Exercises 2.1-2.3

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

2.1

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

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

2.2

- $K_{sp} = s^2$

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

2.3

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

Exercise 3.1

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 $4s^3$

Exercise 3.1

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 $4s^3$

3.1 B

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

Exercise 3.2 (a)

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]

Exercise 3.2 (a)

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]

(a)

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

Exercise 3.2 (b)

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

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

[2]

Exercise 3.2 (b)

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

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

[2]

(b)

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

Exercise 3.3

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

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3.3

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