

Ksp, precipitation and the common ion effect

AP Chemistry · Worksheet

Name: _____ Date: _____ Class: _____

These problems train Unit 7 of AP Chemistry: writing Ksp expressions, finding molar solubility, comparing Q with Ksp, and applying the common ion and pH effects. They also suit A Level and first-year university chemistry students.

Level 1 problems use direct substitution. Level 2 problems involve stoichiometry such as $4s^3$, mixing volumes and concentrations. The last five are level 3 problems on buffered solutions, separation and multi-step reasoning.

Level: AP Chemistry · **Curriculum:** AP Chem Unit 7

Problem 1 Write the Ksp expressions (easy)

Write the dissolving equation and the Ksp expression for (a) BaSO_4 , (b) PbI_2 , (c) Ag_3PO_4 .

Problem 2 Solubility of silver bromide (easy)

Aarav in Pune looks up $K_{\text{sp}}(\text{AgBr}) = 5.4 \times 10^{-13}$. Calculate the molar solubility.

Problem 3 Precipitate or not (easy)

A mixture of Ag^+ and Cl^- has $Q = 3.0 \times 10^{-9}$. $K_{\text{sp}}(\text{AgCl}) = 1.8 \times 10^{-10}$. Decide whether a precipitate forms.

Problem 4 Ksp from mass solubility (easy)

Chiamaka in Lagos finds that 0.043 g of PbSO_4 ($M = 303.3 \text{ g/mol}$) dissolves in 1.00 dm^3 of water.

1. Calculate s in mol/dm^3 .
2. Calculate Ksp.

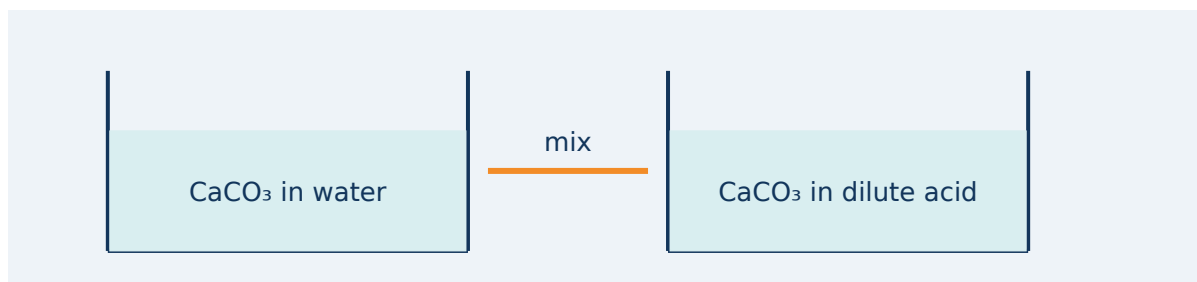
Problem 5 Ksp of calcium carbonate (easy)

The molar solubility of CaCO_3 is $7.1 \times 10^{-5} \text{ mol/dm}^3$ ($M = 100.1 \text{ g/mol}$).

1. Calculate Ksp.
2. Calculate the mass that dissolves per dm^3 .

Problem 6 Which salts like acid? (easy)

Predict which salts dissolve better in dilute nitric acid than in water: AgCl , CaCO_3 , BaSO_4 , $\text{Mg}(\text{OH})_2$.



Two beakers of the same solid.

Problem 7 Lead(II) iodide (medium)

$$K_{sp}(\text{PbI}_2) = 9.8 \times 10^{-9}.$$

1. Calculate the molar solubility.
2. Calculate $[\text{I}^-]$ in the saturated solution.

Problem 8 Silver chromate (medium)

$K_{sp}(\text{Ag}_2\text{CrO}_4) = 1.1 \times 10^{-12}$. Calculate the molar solubility and $[\text{Ag}^+]$ in a saturated solution.

Problem 9 K_{sp} of calcium hydroxide (medium)

Wanjiru in Nairobi measures the molar solubility of $\text{Ca}(\text{OH})_2$ as 0.011 mol/dm^3 . Calculate K_{sp} and the pH of the saturated solution.

Problem 10 Common ion effect (medium)

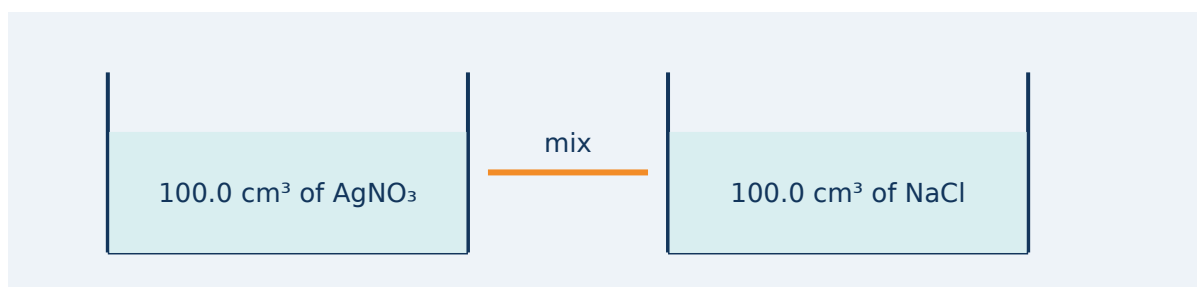
Calculate the molar solubility of AgCl in 0.050 mol/dm^3 NaCl and compare it with its solubility in pure water.

Problem 11 CaF₂ in fluoride solution (medium)

Calculate s for CaF_2 ($K_{sp} = 3.5 \times 10^{-11}$) in 0.020 mol/dm^3 NaF and compare it with pure water.

Problem 12 Mixing two solutions (medium)

Diego in Texas mixes 100.0 cm^3 of $2.0 \times 10^{-4} \text{ mol/dm}^3$ AgNO_3 with 100.0 cm^3 of $4.0 \times 10^{-4} \text{ mol/dm}^3$ NaCl . $K_{sp}(\text{AgCl}) = 1.8 \times 10^{-10}$.



Volumes mixed in Problem 12.

1. Calculate $[Ag^+]$ and $[Cl^-]$ after mixing.
2. Calculate Q .
3. Decide whether $AgCl$ precipitates.

Problem 13 Magnesium hydroxide and acid (medium)

Explain, with equations, why $Mg(OH)_2$ dissolves when dilute hydrochloric acid is added.

Problem 14 Which precipitates first? (medium)

A solution contains $0.010 \text{ mol/dm}^3 Cl^-$ and $0.010 \text{ mol/dm}^3 CrO_4^{2-}$. Solid $AgNO_3$ is added slowly (no volume change). $K_{sp}(AgCl) = 1.8 \times 10^{-10}$ and $K_{sp}(Ag_2CrO_4) = 1.1 \times 10^{-12}$.

1. Calculate $[Ag^+]$ needed to start precipitating $AgCl$.
2. Calculate $[Ag^+]$ needed to start precipitating Ag_2CrO_4 .
3. State which solid forms first.

Problem 15 Barium sulfate in a drink (medium)

Emma in Leeds shakes excess $BaSO_4$ ($K_{sp} = 1.1 \times 10^{-10}$, $M = 233.4 \text{ g/mol}$) with 500 cm^3 of water. Calculate the mass that dissolves.

Problem 16 Buffered magnesium hydroxide (hard)

$Mg(OH)_2$ has $K_{sp} = 5.6 \times 10^{-12}$.

1. Calculate s and the pH in pure water.
2. Calculate s in a buffer held at pH 10.00.
3. Explain the difference.

Problem 17 Separating by precipitation (hard)

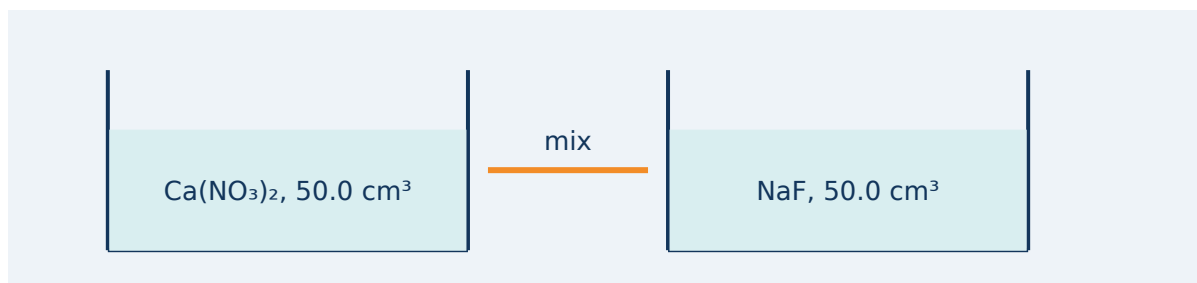
Using the data of "Which precipitates first?", Mei in Singapore keeps adding $AgNO_3$ until Ag_2CrO_4 just begins to precipitate.

1. State $[Ag^+]$ at that moment.
2. Calculate $[Cl^-]$ remaining.
3. Calculate the percentage of Cl^- still in solution and say whether the separation is good.

Problem 18 Calcium fluoride precipitation (hard)

Kofi in Accra mixes 50.0 cm³ of 0.0040 mol/dm³ Ca(NO₃)₂ with 50.0 cm³ of 0.0010 mol/dm³ NaF. $K_{sp}(\text{CaF}_2) = 3.5 \times 10^{-11}$.

1. Calculate [Ca²⁺] and [F⁻] after mixing.
2. Calculate Q and decide whether CaF₂ precipitates.
3. Calculate the minimum [F⁻] needed to start precipitation at that [Ca²⁺].



Volumes mixed in Problem 18.

Problem 19 Iron(III) hydroxide and pH (hard)

Fe(OH)₃ has $K_{sp} = 2.8 \times 10^{-39}$. In a buffered solution $\text{Fe(OH)}_3(\text{s}) \rightleftharpoons \text{Fe}^{3+} + 3\text{OH}^-$.

1. Write the K_{sp} expression.
2. Calculate [Fe³⁺] at pH 7.00.
3. Calculate [Fe³⁺] at pH 3.00.
4. Explain why iron rusts out of water but stays dissolved in acidic mine water.

Problem 20 Error in the setup (hard)

A student calculates the molar solubility of Ag₂CrO₄ ($K_{sp} = 1.1 \times 10^{-12}$) as $\sqrt{K_{sp}} = 1.0 \times 10^{-6}$ mol/dm³.

1. Identify the mistake.
2. Calculate the correct molar solubility.
3. Calculate by what factor the student's value is wrong.