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CHEMISTRY WORKSHEET

MIXED SOLUBILITY EQUILIBRIUM PRACTICE

Course: SCH4U Grade 12 Chemistry

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50 Practice Problems with Answers and Detailed Solutions

FULL worksheet contains 50 representative problems on:

✓ Ksp expressions and ion stoichiometry, ✓ molar solubility in pure water, ✓ common ion effect calculations, ✓ Qsp precipitation predictions after mixing, ✓ maximum ion concentration before precipitation, ✓ mass of precipitate with limiting ions, ✓ selective precipitation, ✓ pH-controlled hydroxide precipitation

All problems are designed to reflect style and difficulty commonly seen on quizzes, tests, and final exams. Detailed solutions are included to help students understand the reasoning behind every step.

PART A - FUNDAMENTAL PROBLEMS Problems 1-15. Simple calculations and basic applications	**PART B - INTERMEDIATE PROBLEMS** Problems 16-30. Typical unit test questions involving multiple steps
PART C - ADVANCED PROBLEMS Problems 31-40. More challenging calculations requiring deeper understanding	**PART D - CHALLENGE PROBLEMS** Problems 41-50. Difficult exam-style questions combining multiple concepts

SUITABLE FOR:
quizzes, unit tests and final exam preparation

Section 1: Essential Information

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Section 2: Practice Problems

Part A: Foundations and Direct K_{sp} Calculations

Problem 8 Calculate the molar solubility of magnesium hydroxide in pure water if $\mathbf{K_{sp} = 5.6 \times 10^{-12}}$

$$Mg(OH)_{2(s)} \rightleftharpoons Mg^{2+}_{(aq)} + 2OH^{-}_{(aq)}$$

Part B: Common Ion Effect and Precipitation Predictions

Problem 16 Calculate the molar solubility of AgCl in 0.10 mol/L NaCl. Use $\mathbf{K_{sp} = 1.8 \times 10^{-10}}$

Part C: Selective Precipitation and pH Connections

Problem 32 At what pH does $Fe(OH)_3$ just begin to precipitate from a solution containing $[Fe^{3+}] = 1.0 \times 10^{-3}$ mol/L. Use $\mathbf{K_{sp} = 2.8 \times 10^{-39}}$

Part D: Mixed Challenge Problems

Problem 45 A saturated CaF_2 solution is analyzed and found to contain $[Ca^{2+}] = 2.15 \times 10^{-4}$ mol/L. Calculate $\mathbf{K_{sp}}$ for CaF_2

Section 3: Solutions

Problem 8 Solution

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

Find: The molar solubility of $Mg(OH)_2$ in pure water.

Each mole of $Mg(OH)_2$ produces one mole of Mg^{2+} and two moles of OH^-.

$$Mg(OH)_{2(s)} \rightleftharpoons Mg^{2+}_{(aq)} + 2OH^-_{(aq)}$$

ICE table:

State	$[Mg^{2+}]$	$[OH^-]$
Initial	0	0
Change	+s	+2s
Equilibrium	s	2s

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

$$s = (5.6 \times 10^{-12}/4)^{1/3} = 1.1 \times 10^{-4} \text{ mol/L}$$

The answer is reported to 2 significant figures.

Final answer: $s = 1.1 \times 10^{-4}$ mol/L

Problem 16 Solution

Given: $K_{sp}(AgCl) = 1.8 \times 10^{-10}$ and the solution initially contains 0.10 mol/L Cl^- from NaCl.

Find: The molar solubility of AgCl.

NaCl dissociates completely, so chloride is already present before AgCl dissolves. This common ion shifts the dissolution equilibrium toward the solid.

$$AgCl_{(s)} \rightleftharpoons Ag^+_{(aq)} + Cl^-_{(aq)}$$

ICE table:

State	$[Ag^+]$	$[Cl^-]$
Initial	0	0.10
Change	+s	+s
Equilibrium	s	0.10 + s

$$K_{sp} = s(0.10 + s)$$

Because the expected solubility is extremely small compared with 0.10 mol/L, $0.10 + s \approx 0.10$.

$$s = (1.8 \times 10^{-10})/(0.10) = 1.8 \times 10^{-9} \text{ mol/L}$$

The approximation is valid because $s/0.10 = 1.8 \times 10^{-8}$, far below 5%.

The answer is reported to 2 significant figures.

Final answer: $s = 1.8 \times 10^{-9}$ mol/L

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Problem 32 Solution

Given: $[Fe^{3+}] = 1.0 \times 10^{-3}$ mol/L and $K_{sp}(Fe(OH)_3) = 2.8 \times 10^{-39}$.

Find: The pH at which $Fe(OH)_3$ just begins to precipitate.

At the onset of precipitation, $[Fe^{3+}]$ is still approximately its initial concentration.

$K_{sp} = [Fe^{3+}][OH^-]^3$

$[OH^-] = ((2.8 \times 10^{-39})/(1.0 \times 10^{-3}))^{1/3} = 1.41 \times 10^{-12}$ mol/L

$pOH = -\log(1.41 \times 10^{-12}) = 11.85$

$pH = 14.00 - 11.85 = 2.15$

The extremely small K_{sp} means $Fe(OH)_3$ can begin precipitating even in an acidic solution.

The pH is reported to 2 decimal places.

Final answer: $Fe(OH)_3$ begins to precipitate at pH = 2.15.

Problem 45 Solution

Given: A saturated CaF_2 solution has $[Ca^{2+}] = 2.15 \times 10^{-4}$ mol/L.

Find: K_{sp} for CaF_2.

In pure water, each dissolved mole of CaF_2 produces twice as much fluoride as calcium. Therefore, $[F^-] = 2[Ca^{2+}]$.

$[F^-] = 2(2.15 \times 10^{-4}) = 4.30 \times 10^{-4}$ mol/L

$K_{sp} = [Ca^{2+}][F^-]^2$

$K_{sp} = (2.15 \times 10^{-4})(4.30 \times 10^{-4})^2 = 3.98 \times 10^{-11}$

The result is reported to 3 significant figures because the measured calcium concentration has 3 significant figures.

Final answer: $K_{sp} = 3.98 \times 10^{-11}$

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Section 4: Answer Key

Problem	Answer	Problem	Answer
8	s = 1.1×10^{-4} mol/L	32	pH = 2.15
16	s = 1.8×10^{-9} mol/L	45	$K_{sp} = 3.98 \times 10^{-11}$

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