

Ksp, precipitation and the common ion effect

AP Chemistry · Test answers (mark scheme)

Each model answer is followed by a marking guide. Allow follow-through marks when a later step correctly uses an earlier wrong value.

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

Question 1 Writing Ksp (2 marks)

$\text{Ca}_3(\text{PO}_4)_2 \rightleftharpoons 3\text{Ca}^{2+} + 2\text{PO}_4^{3-}$. **$K_{\text{sp}} = [\text{Ca}^{2+}]^3[\text{PO}_4^{3-}]^2 = (3s)^3(2s)^2 = 108s^5$.**

Marking: 1 mark for the expression, 1 mark for $108s^5$.

Question 2 Molar solubility (3 marks)

$\text{PbF}_2 \rightleftharpoons \text{Pb}^{2+} + 2\text{F}^-$, $K_{\text{sp}} = 4s^3$. $s = \sqrt[3]{(3.3 \times 10^{-8} / 4)} = \sqrt[3]{(8.25 \times 10^{-9})} = \mathbf{2.02 \times 10^{-3} \text{ mol/dm}^3}$; $[\text{F}^-] = 2s = \mathbf{4.04 \times 10^{-3} \text{ mol/dm}^3}$.

Marking: 1 mark for $4s^3$, 1 for s , 1 for $[\text{F}^-]$.

Question 3 Ksp from mass solubility (3 marks)

$s = 0.62 / 175.3 = 3.537 \times 10^{-3} \text{ mol/dm}^3$. $[\text{Ba}^{2+}] = s$ and $[\text{F}^-] = 2s$, so $K_{\text{sp}} = 4s^3 = 4 \times (3.537 \times 10^{-3})^3 = \mathbf{1.77 \times 10^{-7}}$.

Marking: 1 mark for s , 1 for $4s^3$, 1 for the answer.

Question 4 Common ion calculation (3 marks)

$[\text{Ag}^+] \approx 0.020 \text{ mol/dm}^3$, so $s = [\text{Cl}^-] = 1.8 \times 10^{-10} / 0.020 = \mathbf{9.00 \times 10^{-9} \text{ mol/dm}^3}$. The extra Ag^+ pushes the equilibrium $\text{AgCl} \rightleftharpoons \text{Ag}^+ + \text{Cl}^-$ to the left (common ion effect), so less dissolves.

Marking: 1 mark for the substitution, 1 for the value, 1 for the explanation.

Question 5 Precipitation test (3 marks)

Total volume 100.0 cm^3 . $[\text{Ba}^{2+}] = 1.0 \times 10^{-3} \times 40.0 / 100.0 = 4.0 \times 10^{-4}$; $[\text{SO}_4^{2-}] = 2.0 \times 10^{-4} \times 60.0 / 100.0 = 1.2 \times 10^{-4} \text{ mol/dm}^3$. $Q = 4.80 \times 10^{-8}$, which is greater than K_{sp} , so **BaSO_4 precipitates.**

Marking: 1 mark for dilution, 1 for Q , 1 for the conclusion.

Question 6 Solubility in acid (2 marks)

CO_3^{2-} is a base: it reacts with H_3O^+ to give CO_2 and water, which pulls the CaCO_3 equilibrium to the right so the solid dissolves. **Cl^- is a negligible base**, so acid does not remove it.

Marking: 1 mark for the basic anion argument, 1 for the contrast with Cl^- .

Question 7 Saturated solution diagram (2 marks)

The two rates are **equal** (dynamic equilibrium), so the concentrations of M^+ and X^- stay constant.

Marking: 1 mark for equal rates, 1 for constant concentrations.

Question 8 Comparing salts (2 marks)

$s(\text{AgCl})/s(\text{AgI}) = \sqrt{(1.8 \times 10^{-10} / 8.5 \times 10^{-17})} = \sqrt{(2.118 \times 10^6)} = \text{about } 1455.$

Marking: 1 mark for using the square root, 1 for the ratio.