FREE SAMPLE: THE FIRST QUESTION

Question One (18 marks)

(a) The Ks of calcium carbonate, $CaCO_3$, is 3.36×10^{-9} at 25°C. (M = 100.1 g mol^{-1}.)

(i) Write the equation for the dissolving of $CaCO_3$ and the Ks expression.

(ii) Calculate the solubility of $CaCO_3$ in water in mol L^{-1} and in g L^{-1}.

(iii) Explain why $CaCO_3$ is described as 'sparingly soluble' in terms of the position of equilibrium.

[6 marks]

(b) The Ks of calcium fluoride, CaF_2, is 3.45×10^{-11}.

(i) Calculate the solubility of CaF_2 in pure water.

(ii) Calculate the solubility of CaF_2 in a 0.200 mol L^{-1} solution of NaF.

(iii) Explain why the solubility is different in the NaF solution.

[6 marks]

TEST PAPERS HUB - NOT FOR RESALE OR REDISTRIBUTION

(c) 50.0 mL of a 0.000100 mol L^{-1} solution of a soluble salt containing Ba^{2+} is mixed with 100 mL of a 0.0000150 mol L^{-1} solution of a soluble salt containing SO_4^{2-}. The Ks of $BaSO_4$ is 1.08×10^{-10}.

(i) Calculate the concentration of each ion immediately after mixing, before any reaction.

(ii) Decide whether a precipitate of $BaSO_4$ forms, showing your calculation of the ion product.

(iii) Explain how the ion product and Ks are used to make this prediction.

[6 marks]

RIBUTION

Free sample from NCEA Level 3 Chemistry 91392 Equilibrium (paper 1 of the set). Full papers with a worked solution for every question: testpapershub.c

THE WORKED ANSWER TO THAT QUESTION

Question 1 (18 marks) [Sparingly soluble salts]

(a) The Ks of calcium carbonate, $CaCO_3$, is 3.36×10^{-9} at 25°C. (M = 100.1 g mol^{-1}.) (i) Write the equation for the dissolving of $CaCO_3$ and the Ks expression. (ii) Calculate the solubility of $CaCO_3$ in water in mol L^{-1} and in g L^{-1}. (iii) Explain why $CaCO_3$ is described as 'sparingly soluble' in terms of the position of equilibrium.

(a) Answer: (i) $CaCO_3(s) \rightleftharpoons Ca^{2+}(aq) + CO_3^{2-}(aq)$; $Ks = [Ca^{2+}][CO_3^{2-}]$; (ii) $s = 5.80 \times 10^{-5}$ mol L^{-1} = 5.80×10^{-3} g L^{-1}; (iii) Ks is tiny so the equilibrium lies far towards the solid

- Evidence level: Excellence (write the Ks expression, express ion concentrations with the solubility s, and solve).
- (i) $CaCO_3(s) \rightleftharpoons Ca^{2+}(aq) + CO_3^{2-}(aq)$. $Ks = [Ca^{2+}][CO_3^{2-}]$.
- (ii) Let the solubility be s mol L^{-1}: $Ks = [Ca^{2+}][CO_3^{2-}] = 3.36 \times 10^{-9}$ so $s^2 = 3.36 \times 10^{-9}$ and $s = 5.80 \times 10^{-5}$ mol L^{-1}.
- Solubility in g L^{-1} = s × M = $5.80 \times 10^{-5} \times 100.1 = 5.80 \times 10^{-3}$ g L^{-1}.
- Achievement: (iii) States that very little of the solid dissolves.
- Merit: Links to the equilibrium: Ks is very small, so the equilibrium lies far to the left (towards the solid).
- Excellence: Full explanation: $Ks = 3.36 \times 10^{-9}$ is very small, so at equilibrium the concentrations of the dissolved ions (5.80×10^{-5} mol L^{-1}) are tiny compared with the solid present; the equilibrium ⇌ lies strongly on the side of the undissolved solid, so only a very small amount dissolves.

> **KEY TAKEAWAY**
> Ks and solubility: write Ks from the dissolving equation, put each ion concentration in terms of s (AB: s^2; AB_2 or A_2B: $4s^3$), and solve; multiply by M to convert to g L^{-1}.

(b) The Ks of calcium fluoride, CaF_2, is 3.45×10^{-11}. (i) Calculate the solubility of CaF_2 in pure water. (ii) Calculate the solubility of CaF_2 in a 0.200 mol L^{-1} solution of NaF. (iii) Explain why the solubility is different in the NaF solution.

(b) Answer: (i) 2.05×10^{-4} mol L^{-1}; (ii) 8.62×10^{-10} mol L^{-1}; (iii) the common ion shifts the equilibrium towards the solid

- Evidence level: Excellence (solve for the solubility in water and again with a common ion, then explain with Le Chatelier's principle).
- (i) In water: $Ks = [Ca^{2+}][F^-]^2$ gives $s = 2.05 \times 10^{-4}$ mol L^{-1}.
- (ii) The common ion from NaF has concentration 0.200 mol L^{-1}, so $Ks = [Ca^{2+}][F^-]^2 = 3.45 \times 10^{-11}$ with the extra ion; because s is very small compared with the common ion, the approximation gives $s = 8.62 \times 10^{-10}$ mol L^{-1}.
- Achievement: (iii) States that the solubility is lower because of the common ion.
- Merit: Links to equilibrium: adding a common ion shifts the equilibrium CaF_2 ⇌ ions to the left, reducing the amount that dissolves.
- Excellence: Full explanation: the NaF solution already contains 0.200 mol L^{-1} of the F^- ion; by Le Chatelier's principle the equilibrium shifts towards the solid to oppose the increase in the ion concentration, so less solid dissolves (the solubility falls from 2.05×10^{-4} to 8.62×10^{-10} mol L^{-1}), although Ks is unchanged.

TEST PAPERS NOT FOR RESALE OR REDISTRIBUTION

KEY TAKEAWAY

Common ion effect: the existing ion raises the ion concentration, so (since Ks is constant) the solubility falls; in the Ks expression use the common ion's total concentration (initial + dissolved), and neglect s when it is tiny.

(c) 50.0 mL of a 0.000100 mol L^{-1} solution of a soluble salt containing Ba^{2+} is mixed with 100 mL of a 0.0000150 mol L^{-1} solution of a soluble salt containing SO_4^{2-}. The Ks of $BaSO_4$ is 1.08×10^{-10}. (i) Calculate the concentration of each ion immediately after mixing, before any reaction. (ii) Decide whether a precipitate of $BaSO_4$ forms, showing your calculation of the ion product. (iii) Explain how the ion product and Ks are used to make this prediction.

(c) Answer: (i) $[Ba^{2+}] = 3.33 \times 10^{-5}$, $[SO_4^{2-}] = 1.00 \times 10^{-5}$ mol L^{-1}; (ii) $Q = 3.33 \times 10^{-10}$, so a precipitate forms; (iii) Q > Ks means a precipitate forms

- Evidence level: Excellence (dilute each ion on mixing, calculate the ion product Q, and compare with Ks).
- (i) New volume = 150 mL. $[Ba^{2+}] = 0.000100 \times 50.0 \div 150 = 3.33 \times 10^{-5}$ mol L^{-1}; $[SO_4^{2-}] = 0.0000150 \times 100 \div 150 = 1.00 \times 10^{-5}$ mol L^{-1}.
- (ii) $Q = [Ba^{2+}][SO_4^{2-}] = 3.33 \times 10^{-10}$, which is greater than Ks (1.08×10^{-10}), so a precipitate forms.
- Achievement: (iii) States that a precipitate forms if Q is greater than Ks.
- Merit: Links to saturation: Q > Ks means the solution is supersaturated with ions, so the solid forms until Q falls to Ks; Q < Ks is unsaturated.
- Excellence: Full explanation: Q uses the ion concentrations at that moment; if Q > Ks there are more dissolved ions than the equilibrium allows, so the reaction proceeds towards the solid (precipitation) until Q = Ks; if Q < Ks the solution can dissolve more solid, so nothing precipitates.

KEY TAKEAWAY

Precipitation: dilute both ions in the combined volume, calculate the ion product Q in the same form as Ks; Q > Ks gives a precipitate, Q < Ks does not.

LOS: Sparingly soluble salts (91392)

FOR RESALE OR REDISTRIBUTION

LIKED THIS SAMPLE?

The full paper is the real thing.

THIS FREE SAMPLE	THE FULL PAPER
A short extract: the opening questions of Paper 1, then their worked answers. 4 pages in all.	Three questions made of several multi-part problems answered in writing (constructed response, no multiple choice), with a worked solution for every part that shows whether it is aimed at Achieved, Merit or Excellence. 12 pages, with a worked solution for every question.

What you get with each paper

- A complete, timed paper in the real exam layout, not just a taste of it.
- A worked solution for every question: numbered steps, why each wrong option is wrong, and a key takeaway.
- 20 different papers in this set. Every one uses new questions, so each extra paper is new practice, not a repeat.
- An A4 PDF emailed straight after payment, made for printing.

Get Paper 1 now

A$11.99 one-off, instant PDF download. Tap or click here.

Or see all 20 NCEA Level 3 Chemistry 91392 Equilibrium papers:
testpapershub.com/collections/ncea-level-3-chemistry-91392-equilibrium/

Getting the most from a practice paper

1. Print it and set the timer shown on the cover. Answer every question before looking at any solution.
2. Mark it against the worked solutions and note the topics that cost you marks.
3. Retry the questions you missed a day later, then use the next paper to check the fix held.

Not sure which paper to start with, or have a question before you buy? Email support@testpapershub.com and a real person will reply, normally within one business day. These are original practice papers, not official past papers, and are not affiliated with any exam authority.