

6.1.1 A2 inorganic qualitative analysis

Name: _____ Class: _____ Date: _____

Total: 19 marks

KEY WORDS precipitate • complex ion • water of crystallisation

Objective

Identify unknown salts from A2 observations: cation precipitates with their ionic and complex-ion equations, ammonia from ammonium ions, anion confirmation, and formula deduction from a molar mass. Original practice for WCH16's qualitative demands (Summer 2025 Q1).

1 Key knowledge and worked examples

■ Precipitates that change in air

With aqueous NaOH: Cu^{2+} pale blue ppt (deep blue in excess ammonia); Fe^{2+} **green** ppt browning in air; Fe^{3+} rust-brown; Mn^{2+} **pale brown ppt darkening on standing**; NH_4^+ gives no precipitate but releases NH_3 on warming (damp red litmus $\rightarrow$ blue). Either equation form scores:



■ From observations to a formula

A hydrated MnCl_2 salt with $M_r = 197.9$: water mass = $197.9 - (54.9 + 71.0) = 72.0$; $72.0/18.0 = 4 \rightarrow \text{MnCl}_2 \cdot 4\text{H}_2\text{O}$. A salt giving $\text{Fe}^{2+} + \text{NH}_4^+ + \text{SO}_4^{2-}$ responses is Mohr's salt, $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2$.

■ Confirming anions

Acidify with **nitric acid** (never HCl or H_2SO_4 – both add the very ions under test or precipitate), then silver nitrate; AgCl dissolves in dilute ammonia. For sulfate: acidified barium chloride $\rightarrow$ white BaSO_4 ($\text{Ba}^{2+} + \text{SO}_4^{2-} \rightarrow \text{BaSO}_4$).

add aqueous NaOH dropwise, then in excess:

Cu^{2+}	pale blue ppt	in excess NH_3 : deep blue solution
Fe^{2+}	green ppt, browns in air	insoluble in excess
Fe^{3+}	rust-brown ppt	insoluble in excess
Mn^{2+}	pale brown ppt, darkens in air	insoluble in excess
NH_4^+	no ppt; NH_3 turns red litmus blue	on warming

2 Practice

2.1 State the observation when sodium hydroxide solution is added to a solution containing Mn^{2+} ions, including what happens on standing. [2]

2.2 Write an ionic equation for ammonia formation when ammonium ions meet warm sodium hydroxide, and the litmus observation. [2]

2.3 A hydrated salt of magnesium and chloride has $M_r = 203.3$ ($A_r \text{ Mg} = 24.3$). Deduce its formula. [2]

2.4 Explain why nitric acid, not hydrochloric acid, acidifies the solution before the silver-nitrate test. [1]

3 Exam-style questions

3.1 Salt A (one cation, one anion) gives: a pale brown precipitate darkening in air with excess NaOH(aq); a white precipitate with acidified silver nitrate that dissolves in dilute ammonia. Its molar mass is 197.9 g mol^{-1} . Identify the cation and anion with their tests, and deduce the formula of A. [5]

3.2 Salt B contains two cations and one anion. Test 1 (excess NaOH, warmed): a green precipitate turning brown on standing, and gas turning damp red litmus blue. Test 2: acidified barium chloride gives a white precipitate. The brown precipitate dissolved in sulfuric acid to a yellow-brown solution. Write the three ionic equations, the complex ion in the yellow-brown solution, and the formula of B. [7]

Solutions

Original-task marking: M1 method, A1 accuracy, B1 reasoning.

2.1 Pale brown precipitate which darkens on standing in air.

2.2 $\text{NH}_4^+ + \text{OH}^- \rightarrow \text{NH}_3 + \text{H}_2\text{O}$; damp red litmus turns blue.

2.3 Water mass = $203.3 - (24.3 + 71.0) = 108.0$; $108.0/18.0 = 6$, so the salt is $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$.

2.4 Hydrochloric acid supplies chloride ions, which would give a white AgCl precipitate even with no halide in the sample.

3.1 Cation Mn^{2+} : pale brown precipitate darkening on standing in air. Anion Cl^- : white precipitate with acidified silver nitrate, dissolving in dilute ammonia – the reagents must be nitric acid + AgNO_3 . Water of crystallisation: $197.9 - (54.9 + 2 \times 35.5) = 72.0 = 4 \times 18.0$. Salt A is $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$.

3.2 Green ppt: $\text{Fe}^{2+} + 2\text{OH}^- \rightarrow \text{Fe}(\text{OH})_2$ (or the hexaaqua form); gas: $\text{NH}_4^+ + \text{OH}^- \rightarrow \text{NH}_3 + \text{H}_2\text{O}$; white ppt: $\text{Ba}^{2+} + \text{SO}_4^{2-} \rightarrow \text{BaSO}_4$. Yellow-brown solution: $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$. Cations Fe^{2+} and NH_4^+ with SO_4^{2-} : B is $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2$.