InkChemistry

ANSWER BOOK

Reactions of aqua ions with hydroxide, ammonia and carbonate

Ions in aqueous solution · Unit C15

AQA 3.2.6 · OCR A 5.3.1 (j), 5.3.2

20 questions · 65 marks

NAVY EDITION

Every question in this book has a code beside its number.
Type inklearning.co.uk/q/ followed by the code to open that question online.
© 2026 Ink Learning Ltd. All rights reserved.
inklearning.co.uk/chemistry/

SECTION A · Short, 1 to 2 marks

A1 RAI-Q3

B1 the products are $[Fe(H_2O)_4(OH)_2]$ and $2NH_4^+$. **B1** state symbols (s) for the hydroxide and (aq) for the ammonium ion. [2]

A2 RAI-Q14

B1 where the alkali enters, the hydroxide is locally in excess. **B1** any white aluminium hydroxide that forms there redissolves at once, so the precipitate is never seen. [2]

A3 RAI-Q21

B1 $[Mn(H_2O)_6]^{2+}(aq) + 2NH_3(aq) \rightarrow [Mn(H_2O)_4(OH)_2](s) + 2NH_4^+(aq)$. **B1** a light brown precipitate forms, which darkens on standing in air and does not dissolve in excess. [2]

SECTION B · Standard, 3 to 5 marks

B1 RAI-Q1

B1 a green precipitate forms from the pale green solution. **B1** the precipitate darkens, turning brown at the surface first, on standing in air. **B1** oxygen from the air oxidises iron(II) to iron(III). **B1** green $[Fe(H_2O)_4(OH)_2]$ becomes brown $[Fe(H_2O)_3(OH)_3]$, starting where the air reaches it; allow $Fe(OH)_2$ and $Fe(OH)_3$. [4]

B2 RAI-Q2

B1 $[Cu(H_2O)_6]^{2+}(aq) + 2NH_3(aq) \rightarrow [Cu(H_2O)_4(OH)_2](s) + 2NH_4^+(aq)$. **B1** a blue precipitate forms from the blue solution. **B1** with a little ammonia: an acid–base reaction, in which ammonia removes protons from the water ligands. **B1** with excess ammonia: ligand substitution, in which ammonia replaces ligands round the copper to give a deep blue solution. [4]

B3 RAI-Q7

B1 in excess, ammonia acts as a ligand rather than as a base, donating the lone pair on its nitrogen. **B1** ammonia replaces four of the ligands around copper in a ligand substitution, and the coordination number stays six. **B1** $[Cu(H_2O)_4(OH)_2](s) + 4NH_3(aq) \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+}(aq) + 2H_2O(l) + 2OH^-(aq)$. **B1** the product is a soluble charged complex, seen as a deep blue solution. [4]

B4 RAI-Q15

B1 aluminium hydroxide dissolves in excess sodium hydroxide to give a colourless solution. **B1** it does not dissolve in excess aqueous ammonia; the white precipitate remains. **B1** in excess sodium hydroxide a fourth proton is removed, forming the soluble $[Al(H_2O)_2(OH)_4]^-$ ion. **B1** ammonia is a weak base, so the hydroxide ion concentration in its solution is too low to remove that proton. [4]

© 2026 Ink Learning Ltd. All rights reserved.

B5 RAI-Q16 **B1** the plan works: the four precipitates are green, blue, brown and white, all different. **B1** the Fe(II) precipitate darkens on standing in air, so it should be observed straight away to avoid confusion with Fe(III). **B1** adding ammonia in excess would confirm copper, whose precipitate dissolves to a deep blue solution. **B1** adding sodium hydroxide in excess, or sodium carbonate, would confirm aluminium, by the amphoteric hydroxide or effervescence. [4]

B6 RAI-Q4 **B1** the starting solution is colourless. **B1** a white precipitate forms with the first drops. **B1** the precipitate dissolves in excess to give a colourless solution. [3]

B7 RAI-Q5 **B1** an amphoteric substance can react both as an acid and as a base. **B1** as an acid: $[Al(H_2O)_3(OH)_3](s) + OH^-(aq) \rightarrow [Al(H_2O)_2(OH)_4]^-(aq) + H_2O(l)$. **B1** as a base: $[Al(H_2O)_3(OH)_3](s) + 3H^+(aq) \rightarrow [Al(H_2O)_6]^{3+}(aq)$. [3]

B8 RAI-Q6 **B1** both ammonia and hydroxide ions act as Brønsted–Lowry bases. **B1** each removes three protons from the water ligands of $[Fe(H_2O)_6]^{3+}$, leaving the neutral complex $[Fe(H_2O)_3(OH)_3]$. **B1** the neutral complex is insoluble, so the same brown precipitate forms with either reagent. [3]

B9 RAI-Q9 **B1** the ion is $[Fe(H_2O)_6]^{3+}$. **B1** the brown hydroxide precipitate identifies iron(III). **B1** effervescence with carbonate shows a 3+ aqua ion, acidic enough to release carbon dioxide. [3]

B10 RAI-Q10 **M1** moles of $[Fe(H_2O)_6]^{3+} = 0.100 \times 25.0 \div 1000 = 2.50 \times 10^{-3}$ mol. **M1** three OH^- are needed per aqua ion, so moles of $OH^- = 7.50 \times 10^{-3}$ mol. **A1** volume $= 7.50 \times 10^{-3} \div 0.400 = 0.01875$ dm³, so 18.8 cm³ to three significant figures. [3]

B11 RAI-Q11 **M1** moles of $[Al(H_2O)_6]^{3+} = 0.200 \times 50.0 \div 1000 = 1.00 \times 10^{-2}$ mol. **M1** the equation gives $3CO_2$ for every 2 aqua ions, so moles of $CO_2 = 1.50 \times 10^{-2}$ mol. **A1** volume $= 1.50 \times 10^{-2} \times 24.0 = 0.360$ dm³, to three significant figures. [3]

B12 RAI-Q12 **M1** moles of Al $= 0.150 \times 20.0 \div 1000 = 3.00 \times 10^{-3}$ mol, the same as moles of $Al(OH)_3$. **M1** Mr of $Al(OH)_3 = 27.0 + 3 \times (16.0 + 1.0) = 78.0$. **A1** mass $= 3.00 \times 10^{-3} \times 78.0 = 0.234$ g, to three significant figures. [3]

B13 RAI-Q13 **B1** a white precipitate of $[Zn(H_2O)_4(OH)_2]$ forms from the colourless solution. **B1** the precipitate dissolves in excess sodium hydroxide to a colourless solution. **B1** $[Zn(H_2O)_4(OH)_2](s) + 2OH^-(aq) \rightarrow [Zn(OH)_4]^{2-}(aq) + 4H_2O(l)$, or an equivalent balanced equation. [3]

© 2026 Ink Learning Ltd. All rights reserved.

B14 RAI-Q19

B1 chromium(III) hydroxide is amphoteric, so it reacts with excess hydroxide acting as an acid. **B1** hydroxide ions remove three more protons from the water ligands, giving a soluble negative complex ion, seen as a dark green solution. **B1** $[Cr(H_2O)_3(OH)_3](s) + 3OH^-(aq) \rightarrow [Cr(OH)_6]^{3-}(aq) + 3H_2O(l)$. [3]

B15 RAI-Q20

B1 the ion is $[Co(H_2O)_6]^{2+}$: a pink solution giving a blue hydroxide that dissolves in excess ammonia points to cobalt(II), not copper(II), whose solution is blue. **B1** $[Co(H_2O)_4(OH)_2] + 6NH_3 \rightarrow [Co(NH_3)_6]^{2+} + 4H_2O + 2OH^-$, with all six ligands replaced by ammonia. **B1** state symbols (s), (aq), (aq), (l) and (aq), with the equation balanced for atoms and charge. [3]

B16 RAI-Q22

B1 a few drops give a white precipitate with either ion, aluminium hydroxide or magnesium hydroxide, so that observation alone cannot tell them apart. **B1** aluminium hydroxide is amphoteric and dissolves in excess hydroxide to a colourless solution: $[Al(H_2O)_3(OH)_3](s) + OH^-(aq) \rightarrow [Al(H_2O)_2(OH)_4]^-(aq) + H_2O(l)$. **B1** magnesium hydroxide is a basic hydroxide with no acidic character, so its white precipitate stays in excess; the difference appears only once excess has been added. [3]

SECTION C · Long, 6 marks or more

C1 RAI-Q17

Indicative content [6]

B1 put about 1 cm^3 of the solution in each of two test tubes and note that it is blue against a white tile. **B1** add sodium hydroxide dropwise with shaking: a blue precipitate, which rules out the green, brown and white hydroxides of the other ions. **B1** the equation for the first tube is $[Cu(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow [Cu(H_2O)_4(OH)_2](s) + 2H_2O(l)$, with state symbols. **B1** to the second tube add aqueous ammonia dropwise and then in excess: a blue precipitate that dissolves to a deep blue solution. **B1** the equation for the excess ammonia is $[Cu(H_2O)_4(OH)_2](s) + 4NH_3(aq) \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+}(aq) + 2H_2O(l) + 2OH^-(aq)$. **B1** excess means adding until the tube is about half full, with shaking, and eye protection is worn.

Levels

Level 3 (5–6 marks) the colour of the solution, the blue hydroxide precipitate that rules out the other three ions, the dissolving in excess ammonia to the deep blue complex and both equations with state symbols are all present, with the practical detail of dropwise addition and excess; the observations are matched to each ion excluded.

Level 2 (3–4 marks) sodium hydroxide and ammonia are used, with the blue precipitate and the deep blue solution in excess ammonia; one equation is missing or unbalanced, or the other three ions are never ruled out.

Level 1 (1–2 marks) a blue precipitate is reported with no equations, often said to dissolve in excess sodium hydroxide, and nothing shows how Fe^{2+}, Fe^{3+} or Al^{3+} would look different.

© 2026 Ink Learning Ltd. All rights reserved.

THIS BOOK ONLINE

Scan the code, or type the address, to open the questions in this book online:

inklearning.co.uk/chemistry/practise/questions/reactions-of-aqua-ions/

© 2026 Ink Learning Ltd. All rights reserved.