

Q1.(a) A sample of solid chromium(III) hydroxide displays amphoteric character when treated separately with dilute hydrochloric acid and with dilute aqueous sodium hydroxide.

Write an ionic equation for each of these reactions. Include the formula of each complex ion formed.

Describe the changes that you would observe in each reaction.

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(b) Aqueous solutions of copper(II) sulfate and cobalt(II) sulfate undergo ligand substitution reactions when treated separately with an excess of dilute aqueous ammonia.

Write equations for these reactions. Include the formulae for any complex ions. Describe the changes that you would observe in each reaction.

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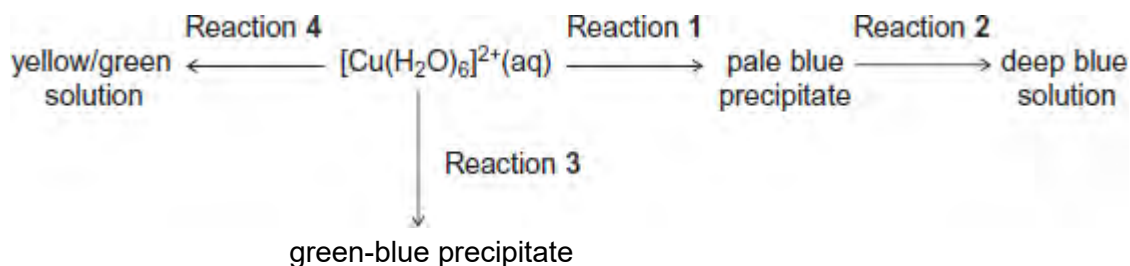
(6)
(Total 11 marks)

Q2. What is the final species produced when an excess of aqueous ammonia is added to aqueous aluminium chloride?

- A $[\text{Al}(\text{NH}_3)_6]^{3+}$
- B $[\text{Al}(\text{OH})_3(\text{H}_2\text{O})_3]$
- C $[\text{Al}(\text{OH})_4(\text{H}_2\text{O})_2]^-$
- D $[\text{Al}(\text{OH})(\text{H}_2\text{O})_5]^{2+}$

(Total 1 mark)

Q3. Consider the following reaction scheme that starts from aqueous $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ ions.



For each of the reactions 1 to 4, identify a suitable reagent, give the formula of the copper-containing species formed and write an equation for the reaction.

(a) Reaction 1

Reagent

Copper-containing species

Equation

(3)

(b) Reaction 2

Reagent

Copper-containing species

Equation

(3)

(c) Reaction 3

Reagent

Copper-containing species

Equation

(3)

(d) Reaction 4

Reagent

Copper-containing species

Equation

(3)

(Total 12 marks)

Q4.A green solution, **X**, is thought to contain $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ ions.

(a) The presence of these ions can be confirmed by reacting separate samples of solution **X** with aqueous ammonia and with aqueous sodium carbonate.

Write equations for each of these reactions and describe what you would observe.

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- (b) A 50.0 cm³ sample of solution **X** was added to 50 cm³ of dilute sulfuric acid and made up to 250 cm³ of solution in a volumetric flask.

A 25.0 cm³ sample of this solution from the volumetric flask was titrated with a 0.0205 mol dm⁻³ solution of KMnO₄

At the end point of the reaction, the volume of KMnO₄ solution added was 18.70 cm³.

- (i) State the colour change that occurs at the end point of this titration and give a reason for the colour change.

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- (ii) Write an equation for the reaction between iron(II) ions and manganate(VII) ions.

Use this equation and the information given to calculate the concentration of iron(II) ions in the original solution **X**.

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Q5. Which compound gives a colourless solution when an excess of dilute aqueous ammonia is added?

- A** MgCl_2
- B** AgCl
- C** CuCl_2
- D** AlCl_3

(Total 1 mark)

Q6. What forms when a solution of sodium carbonate is added to a solution of gallium(III) nitrate?

- A** A white precipitate of gallium(III) carbonate.
- B** A white precipitate of gallium(III) hydroxide.
- C** A white precipitate of gallium(III) carbonate and bubbles of carbon dioxide.
- D** A white precipitate of gallium(III) hydroxide and bubbles of carbon dioxide.

(Total 1 mark)

Q7.(a) A co-ordinate bond is formed when a transition metal ion reacts with a ligand.

Explain how this co-ordinate bond is formed.

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- (b) Describe what you would observe when dilute aqueous ammonia is added dropwise, to excess, to an aqueous solution containing copper(II) ions. Write equations for the reactions that occur.

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- (c) When the complex ion $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$ reacts with 1,2-diaminoethane, the ammonia molecules but not the water molecules are replaced.

Write an equation for this reaction.

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- (d) Suggest why the enthalpy change for the reaction in part (c) is approximately zero.

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- (e) Explain why the reaction in part (c) occurs despite having an enthalpy change that is approximately zero.

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(Total 11 marks)