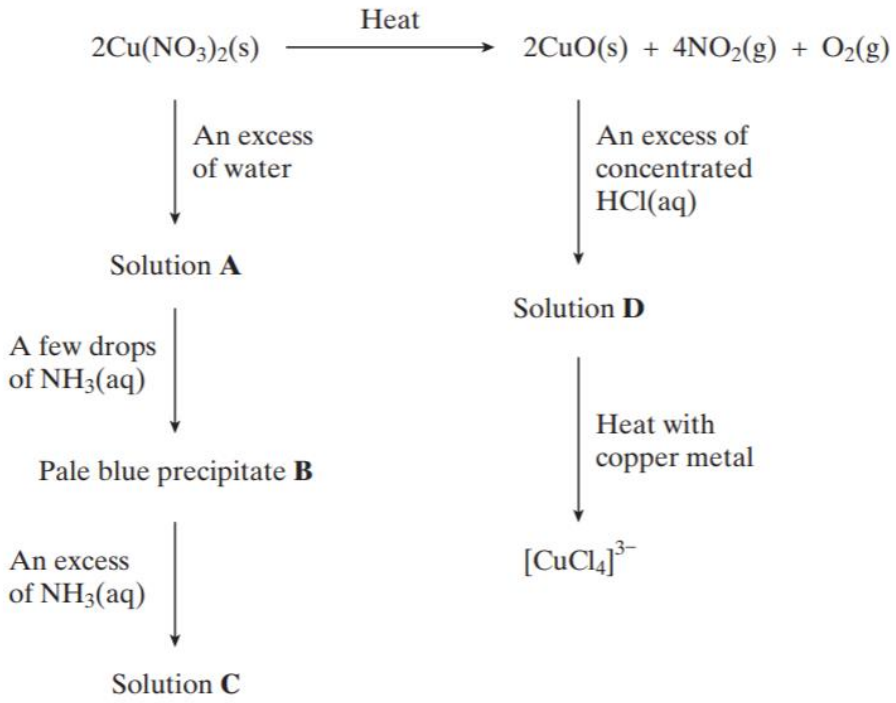
CHAPTER 24 REACTIONS OF INORGANIC IONS IN AQUEOUS SOLUTION

1 Consider the reaction scheme below and answer the questions which follow.



(a) A redox reaction occurs when $Cu(NO_3)_2$ is decomposed by heat. Deduce the oxidation state of nitrogen in $Cu(NO_3)_2$ and in NO_2 and identify the product formed by oxidation in this decomposition.

Oxidation state of nitrogen in $Cu(NO_3)_2$ .....

Oxidation state of nitrogen in NO_2 .....

Oxidation product .....

(3 marks)

(b) Identify and state the shape of the copper-containing species present in solution **A**.

Copper-containing species .....

Shape .....

(2 marks)

(c) (i) Identify the pale blue precipitate **B** and write an equation, or equations, to show how **B** is formed from the copper-containing species in solution **A**.

*Identity of precipitate **B*** .....

Equation(s) .....

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(ii) In what way does the NH_3 behave as a Brønsted–Lowry base?

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(3 marks)

(d) (i) Identify the copper-containing species present in solution **C**. State the colour of this copper-containing species and write an equation for its formation from precipitate **B**.

Identity .....

Colour .....

Equation .....

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(ii) In what way does the NH_3 behave as a Lewis base?

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(4 marks)

(e) Identify the copper-containing species present in solution **D**. State the colour and shape of this copper-containing species.

Identity .....

Colour .....

Shape .....

(3 marks)

(f) The oxidation state of copper in $[CuCl_4]^{3-}$ is +1.

(i) Give the electron arrangement of a Cu^+ ion.

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(ii) Deduce the role of copper metal in the formation of $[CuCl_4]^{3-}$ from the copper-containing species in solution **D**.

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(2 marks)

2 (a) State what is observed when aqueous ammonia is added dropwise, until present in excess, to a solution of cobalt(II) chloride, and the mixture obtained is then left to stand in air.
Give the formula of each cobalt-containing species formed. Explain the change which occurs when the mixture is left to stand in air. *(8 marks)*

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(b) Explain why separate solutions of iron(II) sulphate and iron(III) sulphate of equal concentration have different pH values.
State what is observed when sodium carbonate is added separately to solutions of these two compounds. Give the formula of each iron-containing species formed.
(9 marks)

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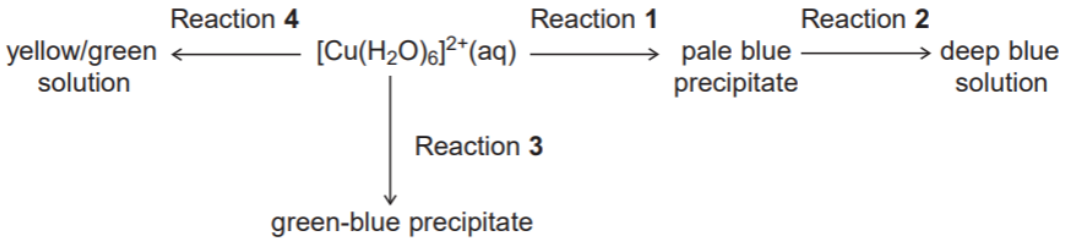
3 Consider the following reaction scheme that starts from aqueous $[Cu(H_2O)_6]^{2+}$ ions.



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**

[3 marks]

Reagent .....

Copper-containing species .....

Equation .....

(b) Reaction **2**

[3 marks]

Reagent .....

Copper-containing species .....

Equation .....

(c) Reaction **3**

[3 marks]

Reagent .....

Copper-containing species .....

Equation .....

(d) Reaction **4**

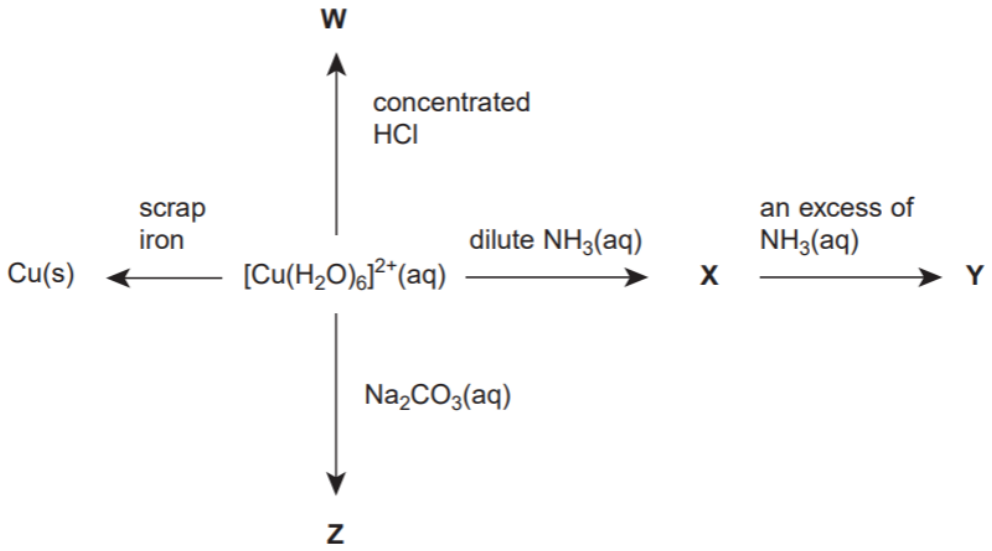
[3 marks]

Reagent .....

Copper-containing species .....

Equation .....

4 The scheme below shows some reactions of copper(II) ions in aqueous solution. **W**, **X**, **Y** and **Z** are all copper-containing species.



(a) Identify ion **W**. Describe its appearance and write an equation for its formation from $[Cu(H_2O)_6]^{2+}(aq)$ ions.

Ion **W** .....

Appearance .....

Equation .....

(3 marks)

(b) Identify compound **X**. Describe its appearance and write an equation for its formation from $[Cu(H_2O)_6]^{2+}(aq)$ ions.

Compound **X**.....

Appearance .....

Equation .....

(3 marks)

(c) Identify ion **Y**. Describe its appearance and write an equation for its formation from **X**.

Ion **Y** .....

Appearance .....

Equation .....

(3 marks)

(d) Identify compound **Z**. Describe its appearance and write an equation for its formation from $[Cu(H_2O)_6]^{2+}(aq)$ ions.

Compound **Z** .....

Appearance .....

Equation .....

(3 marks)

(e) Copper metal can be extracted from a dilute aqueous solution containing copper(II) ions using scrap iron.

(i) Write an equation for this reaction and give the colours of the initial and final aqueous solutions.

Equation .....

Initial colour .....

Final colour .....

(3 marks)

(ii) This method of copper extraction uses scrap iron. Give **two** other reasons why this method of copper extraction is more environmentally friendly than reduction of copper oxide by carbon.

Reason 1 .....

Reason 2 .....

(2 marks)