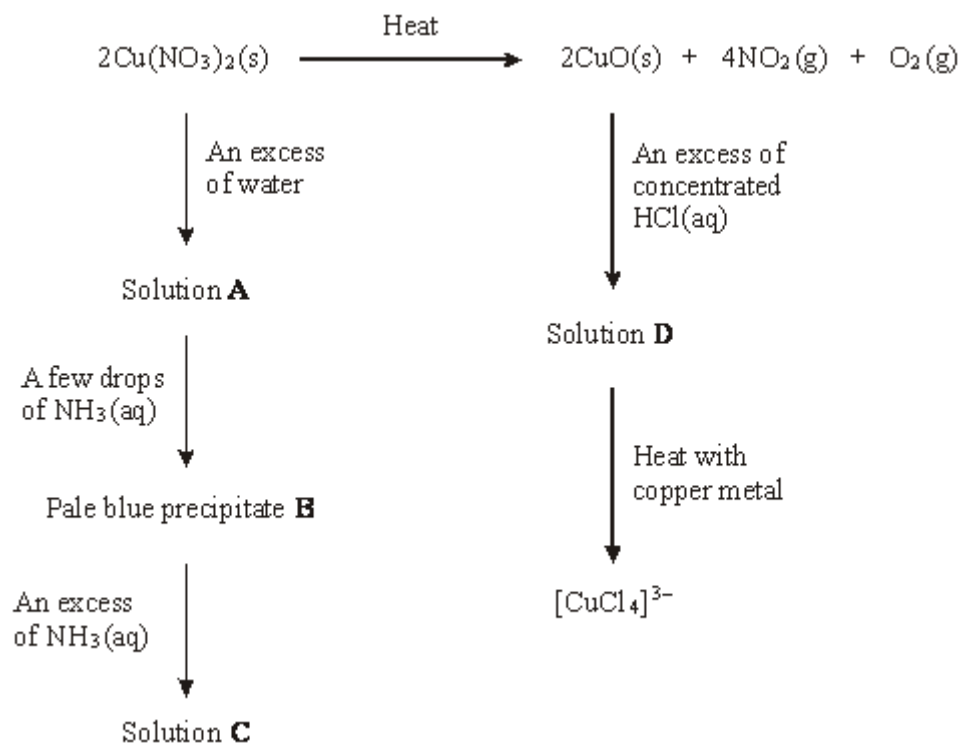


Q1. Consider the reaction scheme below and answer the questions which follow.



- (a) A redox reaction occurs when $\text{Cu}(\text{NO}_3)_2$ is decomposed by heat. Deduce the oxidation state of nitrogen in $\text{Cu}(\text{NO}_3)_2$ and in NO_2 and identify the product formed by oxidation in this decomposition.

Oxidation state of nitrogen in $\text{Cu}(\text{NO}_3)_2$

Oxidation state of nitrogen in NO_2

Oxidation product

.....

(3)

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

Copper-containing species

Shape

(2)

- (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)

.....

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

.....

(3)

(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

.....

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

.....

(4)

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

Identity

Colour

Shape

.....

(3)

(f) The oxidation state of copper in $[\text{CuCl}_4]^{3-}$ is +1.

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

.....

- (ii) Deduce the role of copper metal in the formation of $[\text{CuCl}_4]^{3-}$ from the copper-containing species in solution **D**.

.....

(2)

(Total 17 marks)

- Q2.** (a) Octahedral and tetrahedral complex ions are produced by the reaction of transition metal ions with ligands which form co-ordinate bonds with the transition metal ion.
Define the term *ligand* and explain what is meant by the term *co-ordinate bond*.

(3)

- (b) (i) Some complex ions can undergo a ligand substitution reaction in which both the co-ordination number of the metal and the colour change in the reaction. Write an equation for one such reaction and state the colours of the complex ions involved.

- (ii) Bidentate ligands replace unidentate ligands in a metal complex by a ligand substitution reaction. Write an equation for such a reaction and explain why this reaction occurs.

(8)

- (c) The frequency, ν , of light absorbed by a transition metal complex ion can be determined using the relationship $\Delta E = h\nu$. State what is meant by the symbols ΔE and h . Give **three** factors which result in a change in the frequency of light absorbed as a result of the reaction of a complex ion.

(5)

(Total 16 marks)

Q3. (a) State what is meant by each of the following terms.

(i) *Ligand*

.....

(ii) *Complex ion*

.....

(iii) *Co-ordination number*

.....

(3)

(b) Using complex ions formed by Co^{2+} with ligands selected from H_2O , NH_3 , Cl^- , $\text{C}_2\text{O}_4^{2-}$ and EDTA^{4-} , give an equation for each of the following.

(i) A ligand substitution reaction which occurs with no change in either the co-ordination number or in the charge on the complex ion.

.....

(ii) A ligand substitution reaction which occurs with both a change in the co-ordination number and in the charge on the complex ion.

.....

(iii) A ligand substitution reaction which occurs with no change in the co-ordination number but a change in the charge on the complex ion.

.....

(iv) A ligand substitution reaction in which there is a large change in entropy.

.....

(8)

(c) An aqueous solution of iron(II) sulphate is a pale-green colour. When aqueous

sodium hydroxide is added to this solution a green precipitate is formed. On standing in air, the green precipitate slowly turns brown.

- (i) Give the formula of the complex ion responsible for the pale-green colour.

.....

- (ii) Give the formula of the green precipitate.

.....

- (iii) Suggest an explanation for the change in the colour of the precipitate.

.....

.....

(4)
(Total 15 marks)

- Q4.** (a) Give **one** example of a bidentate ligand.

.....

(1)

- (b) Give **one** example of a linear complex ion formed by a transition metal.

.....

(1)

- (c) Write an equation for a substitution reaction in which the complete replacement of ligands in a complex ion occurs with a change in **both** the co-ordination number and the overall charge of the complex ion.

.....

(2)

- (d) Write an equation for a substitution reaction in which the complete replacement of ligands in a complex ion occurs without a change in either the co-ordination number or the overall charge of the complex ion.

.....

(2)

- (e) When a solution containing $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ ions is treated with a solution containing EDTA^{4-} ions, a more stable complex is formed. Write an equation for this reaction and explain why the complex is more stable.

Equation

Explanation

.....

(3)

(Total 9 marks)