

**Q1.** Aqueous metal ions can be identified by test-tube reactions.

For each of the following, describe what you would observe.

Write an equation or equations for any reactions that occur.

- (a) The addition of aqueous sodium carbonate to a solution containing  $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}(\text{aq})$  ions.

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**(4)**

- (b) The addition of aqueous sodium hydroxide, dropwise until in excess, to a solution containing  $[\text{Al}(\text{H}_2\text{O})_6]^{3+}(\text{aq})$  ions.

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**(4)**

- (c) The addition of dilute aqueous ammonia, dropwise until in excess, to a solution containing  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}(\text{aq})$  ions.

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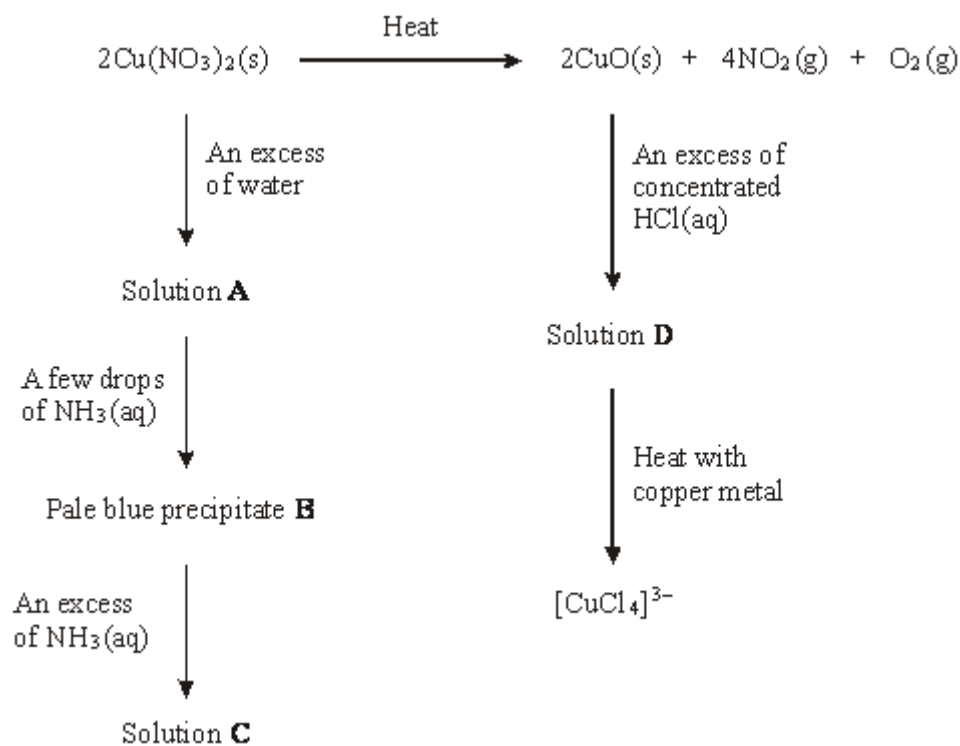
(4)

- (d) The addition of concentrated hydrochloric acid, dropwise until in excess, to a solution containing  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}(\text{aq})$  ions.

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(2)  
(Total 14 marks)

**Q2.** 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  $\text{NO}_2$  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  $\text{NO}_2$  .....

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) .....

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- (ii) In what way does the  $\text{NH}_3$  behave as a Brønsted–Lowry base?

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(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 .....

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- (ii) In what way does the  $\text{NH}_3$  behave as a Lewis base?

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(4)

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

*Identity* .....

*Colour* .....

*Shape* .....

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(3)

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

- (i) Give the electron arrangement of a  $\text{Cu}^+$  ion.

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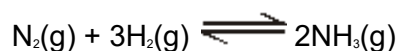
- (ii) Deduce the role of copper metal in the formation of  $[\text{CuCl}_4]^{3-}$  from the copper-containing species in solution **D**.

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(2)

(Total 17 marks)

- Q3.** (a) In the Haber Process for the manufacture of ammonia, the following equilibrium is established in the presence of a heterogeneous catalyst.



Identify the heterogeneous catalyst used in this process and state what is meant by the term *heterogeneous*.

A heterogeneous catalyst can become poisoned by impurities in the reactants. Give one substance which poisons the heterogeneous catalyst used in the Haber Process and explain how this substance poisons the catalyst.

(5)

(b) State what is observed when an excess of aqueous ammonia reacts with an aqueous iron(II) salt. Write an equation for this reaction.

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(Total 9 marks)