

2 This question is about copper chemistry.

(a) Aqueous copper(II) ions $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}(\text{aq})$ are blue.

(i) With reference to electrons, explain why aqueous copper(II) ions are blue.

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(3 marks)

(ii) By reference to aqueous copper(II) ions, state the meaning of each of the **three** terms in the equation $\Delta E = h\nu$.

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(3 marks)

(iii) Write an equation for the reaction, in aqueous solution, between $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ and an excess of chloride ions.
State the shape of the complex produced and explain why the shape differs from that of the $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ ion.

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(3 marks)

- (b) Draw the structure of the ethanedioate ion ($\text{C}_2\text{O}_4^{2-}$). Explain how this ion is able to act as a ligand.

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(2 marks)

- (c) When a dilute aqueous solution containing ethanedioate ions is added to a solution containing aqueous copper(II) ions, a substitution reaction occurs. In this reaction four water molecules are replaced and a new complex is formed.

- (i) Write an ionic equation for the reaction. Give the co-ordination number of the complex formed and name its shape.

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(4 marks)

- (ii) In the complex formed, the two water molecules are opposite each other. Draw a diagram to show how the ethanedioate ions are bonded to a copper ion and give a value for one of the $\text{O}-\text{Cu}-\text{O}$ bond angles. You are **not** required to show the water molecules.

(2 marks)

- 3** (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*.

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(3 marks)

- (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.

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(4 marks)

- (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.

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(4 marks)