Q1. Which one of the following electronic configurations is that of a transition element?

A [Ar] $4s^2 3d^{10}$

B [Ar] $4s^2 3d^9$

C [A] $4s^2 3d^0$

D [Ar] $4s^2 3d^{10} 4p^1$

(Total 1 mark)

Q2. Which of the species given below can behave as ligands?

NH_2^- NH_3 NH_4^+

A all three

B only NH_3

C NH_3 and NH_4^+

D NH_2^- and NH_3

(Total 1 mark)

Q3.(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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(2)

(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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(4)

(c) When the complex ion $[Cu(NH_3)_4(H_2O)_2]^{2+}$ 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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(1)

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

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(2)

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

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(2)
(Total 11 marks)

Q4.

Summarised directions for recording responses to multiple completion questions			
A (i), (ii) and (iii) only	**B** (i) and (iii) only	**C** (ii) and (iv) only	**D** (iv) alone

In which of the following conversions is the copper reduced?

(i) $[Cu(H_2O)_6]^{2+} \rightarrow [CuCl_4]^{2-}$

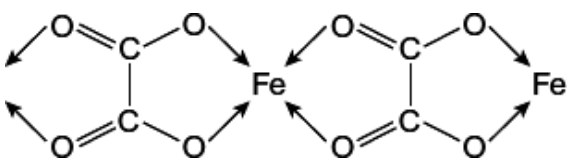
(ii) $[Cu(H_2O)_6]^{2+} \rightarrow Cu(H_2O)_4(OH)_2$

(iii) $Cu \rightarrow CuCl_2$

(iv) $[Cu(H_2O)_6]^{2+} \rightarrow CuCl$

(Total 1 mark)

Q5. Solid iron(II) ethanedioate dihydrate ($FeC_2O_4.2H_2O$) has a polymeric structure.
Two repeating units in the polymer chain are shown.



Each iron ion is also bonded to two water molecules. These are **not** shown in the diagram.

(a) Name the type of bond that is represented by the arrows.

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(1)

(b) In terms of electrons explain how the water molecules, **not** shown in the diagram, form bonds to the iron.

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(2)

(c) Predict the value of the bond angle between the two bonds to iron that are formed by these two water molecules.

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(1)

(d) Iron(II) ethanedioate dihydrate can be analysed by titration using potassium manganate(VII) in acidic solution. In this reaction, manganate(VII) ions oxidise iron(II) ions and ethanedioate ions.

A 1.381 g sample of impure $FeC_2O_4.2H_2O$ was dissolved in an excess of dilute sulfuric acid and made up to 250 cm^3 of solution.
25.0 cm^3 of this solution decolourised 22.35 cm^3 of a 0.0193 mol dm^{-3} solution of potassium manganate(VII).

(i) Use the half-equations given below to calculate the reacting ratio of moles of manganate(VII) ions to moles of iron(II) ethanedioate.

$$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$$

$$Fe^{2+} \longrightarrow Fe^{3+} + e^-$$

$$C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^-$$

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(1)

(ii) Calculate the percentage by mass of $FeC_2O_4.2H_2O$ in the original sample.

(If you have been unable to answer part (d)(i) you may assume that three moles of manganate(VII) ions react with seven moles of iron(II) ethanedioate. This is **not** the correct ratio.)

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(5)
(Total 10 marks)

Q6. Transition metal ions can act as homogeneous catalysts in redox reactions. For example, iron(II) ions catalyse the reaction between peroxodisulfate ($S_2O_8^{2-}$) ions and iodide ions.

(a) State the meaning of the term *homogeneous*.

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(1)

(b) Suggest why ions from s block elements do **not** usually act as catalysts.

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(1)

(c) Write an equation for the overall reaction that occurs, in aqueous solution, between $S_2O_8^{2-}$ ions and I^- ions.

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(1)

(d) Give **one** reason why, in the absence of a catalyst, the activation energy for the reaction between $S_2O_8^{2-}$ ions and I^- ions is high.

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(1)

(e) Write two equations to show how Fe^{2+} ions can catalyse the reaction between $S_2O_8^{2-}$ ions and I^- ions. Suggest **one** reason why the activation energy for each of these reactions is low.

Equation 1 .....

Equation 2 .....

Reason .....

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(3)

(f) Explain why Fe^{3+} ions are as effective as Fe^{2+} ions in catalysing this reaction.

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(1)
(Total 8 marks)

Q7. Due to their electron arrangements, transition metals have characteristic properties including catalytic action and the formation of complexes with different shapes.

(a) Give **two other** characteristic properties of transition metals. For each property,illustrate your answer with a transition metal of your choice.

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(4)

(b) Other than octahedral, there are several different shapes shown by transition metal complexes. Name **three** of these shapes and for each one give the formula of a complex with that shape.

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(6)

(c) It is possible for Group 2 metal ions to form complexes. For example, the $[Ca(H_2O)_6]^{2+}$ ion in hard water reacts with $EDTA^{4-}$ ions to form a complex ion in a similar manner to hydrated transition metal ions. This reaction can be used in a titration to measure the concentration of calcium ions in hard water.

(i) Write an equation for the equilibrium that is established when hydrated calcium ions react with $EDTA^{4-}$ ions.

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(1)

(ii) Explain why the equilibrium in part (c)(i) is displaced almost completely to the right to form the EDTA complex.

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(3)

(iii) In a titration, 6.25 cm^3 of a 0.0532 mol dm^{-3} solution of EDTA reacted completely with the calcium ions in a 150 cm^3 sample of a saturated solution of calcium hydroxide.
Calculate the mass of calcium hydroxide that was dissolved in 1.00 dm^3 of the calcium hydroxide solution.

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(Extra space) .....

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(3)
(Total 17 marks)

Q8. Transition metals and their complexes have characteristic properties.

(a) Give the electron configuration of the Zn^{2+} ion.

Use your answer to explain why the Zn^{2+} ion is **not** classified as a transition metal ion.

Electron configuration .....

Explanation .....

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(2)

(b) In terms of bonding, explain the meaning of the term *complex*.

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(2)

(c) Identify **one** species from the following list that does **not** act as a ligand. Explain your answer.

H_2 O^{2-} O_2 CO

Not a ligand.....

Explanation .....

(2)

(d) The element palladium is in the d block of the Periodic Table. Consider the following palladium compound which contains the sulfate ion.

$[Pd(NH_3)_4]SO_4$

(i) Give the oxidation state of palladium in this compound.

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(1)

(ii) Give the names of two possible shapes for the complex palladium ion in this compound.

Shape 1 .....

Shape 2 .....

(2)
(Total 9 marks)