Q1. 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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(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)

Q2. Iron is an important element in living systems. It is involved in redox and in acid–base reactions.

(a) Explain how and why iron ions catalyse the reaction between iodide ions and $S_2O_8^{2-}$ ions. Write equations for the reactions that occur.

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(Extra space) .....

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(5)

(b) Iron(II) compounds are used as moss killers because iron(II) ions are oxidised in air to form iron(III) ions that lower the pH of soil.

(i) Explain, with the aid of an equation, why iron(III) ions are more acidic than iron(II) ions in aqueous solution.

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(3)

(ii) In a titration, 0.321 g of a moss killer reacted with 23.60 cm^3 of acidified 0.0218 mol dm^{-3} $K_2Cr_2O_7$ solution.

Calculate the percentage by mass of iron in the moss killer. Assume that all of the iron in the moss killer is in the form of iron(II).

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(c) Some sodium carbonate solution was added to a solution containing iron(III) ions. Describe what you would observe and write an equation for the reaction that occurs.

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(Total 16 marks)

Q3. The table below shows some standard electrode potentials.

			$E^{\ominus}$ / V
$MnO_4^- + 8H^+ + 5e^-$	⟶	$Mn^{2+} + 4H_2O$	+1.51
$Cl_2(g) + 2e^-$	⟶	$2Cl^-(aq)$	+1.36
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⟶	$2Cr^{3+} + 7H_2O$	+1.33

A student determined the concentration of iron(II) ions in a solution of iron(II) chloride by titration with acidified potassium dichromate(VI) solution. A second student titrated the same solution of iron(II) chloride with acidified potassium manganate(VII) solution.
By reference to the table, explain why the second student obtained a greater value for the concentration of iron(II) ions.

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(Total 2 marks)

Q4.(a) When a solution containing iron(II) ions is treated with a slight excess of a solution containing ethanedioate ions a bright yellow precipitate of hydrated iron(II) ethanedioate, $FeC_2O_4.2H_2O$, is formed. The precipitate is filtered off, washed with propanone and then allowed to dry. A typical yield of the solid is 95%.

(i) Propanone boils at 56 °C and is miscible with water in all proportions. Suggest **two** reasons why washing with propanone is an effective method for producing a pure, dry precipitate.

Reason 1 .....

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Reason 2 .....

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(2)

(ii) By suggesting a simple test tube reaction, state how the filtrate could be tested to show that all of the iron(II) ions have been removed from the solution. State what you would observe.

Test .....

Observation .....

(2)

(iii) Suggest **one** reason why the typical yield of iron(II) ethanedioate is less than 100%.

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(1)

(iv) Calculate the mass of hydrated iron(II) ethanedioate, $FeC_2O_4.2H_2O$ that can be formed from 50.0 cm^3 of a 0.50 mol dm^{-3} solution of iron(II) sulfate when the yield of the reaction is 95%. Show your working.

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(v) The identity of the precipitate can be confirmed by dissolving it in sulfuric acid and titrating the mixture with potassium manganate(VII).

Deduce the number of moles of iron(II) ethanedioate that would react with one mole of potassium manganate(VII) in acidic solution.

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(b) Ethanedioate ions can be used to remove calcium ions from blood plasma. A precipitate of calcium ethanedioate is formed. Write an ionic equation for the reaction of ethanedioate ions with calcium ions.

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(1)

(c) Ethanedioic acid is used to clean marble, a form of calcium carbonate. Suggest **one** reason why the reaction between ethanedioic acid and marble stops after a short time.

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(1)

(d) Tea leaves contain ethanedioic acid. Suggest **one** reason why tea drinkers do **not** suffer from ethanedioic acid poisoning.

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(1)

(e) Ethanedioic acid is produced by the oxidation of carbon monoxide in a multi-step process. The equation which summarises the reactions taking place is shown below.

$$4CO + 4NaOH + O_2 + 4HCl \rightarrow 2H_2C_2O_4 + 4NaCl + 2H_2O$$

Calculate the percentage atom economy for the formation of ethanedioic acid in this reaction. Show your working.

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(Total 14 marks)