Q1. An experiment was carried out to determine the original concentration of iron(II) ions in a solution that had been stored in air. An excess of zinc and acid was added to this solution. The mixture was then filtered to remove the excess zinc before titration.

(a) Suggest why the zinc and acid were added.

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(1)

(b) Explain why it was necessary to remove the excess zinc.

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(1)
(Total 2 marks)

Q2. (a) The iron(II) ions in well-water can be removed by oxidation using potassium manganate(VII) in **alkaline** solution. A mixture containing solid iron(III) hydroxide and solid manganese(IV) oxide is formed. These solid products can be removed by filtration under reduced pressure.

(i) Draw a diagram of the apparatus used for this filtration. Do **not** include the apparatus used to reduce the pressure.

(2)

(ii) An equation representing the oxidation reaction is given below.

$$3Fe^{2+}(aq) + KMnO_4(aq) + 5OH^-(aq) + 2H_2O(l) \longrightarrow 3Fe(OH)_3(s) + MnO_2(s) + K^+(aq)$$

Calculate the mass, in grams, of $KMnO_4$ required to react with the iron(II) ions in 1.00 dm^3 of well-water that has an iron(II) concentration of 0.225 mol dm^{-3}.
Give your answer to the appropriate precision.
Show your working.

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(3)

(iii) In practice, a slight excess of potassium manganate(VII) is used to treat the well-water.
Although this treated water is safe to drink, this excess of potassium manganate(VII) is undesirable. Suggest **one** reason, other than colour, why the excess is undesirable.

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(1)

(b) Suggest **one** reason why the colour of potassium manganate(VII) solution can be a source of error when using a volumetric (graduated) flask to prepare a standard solution.

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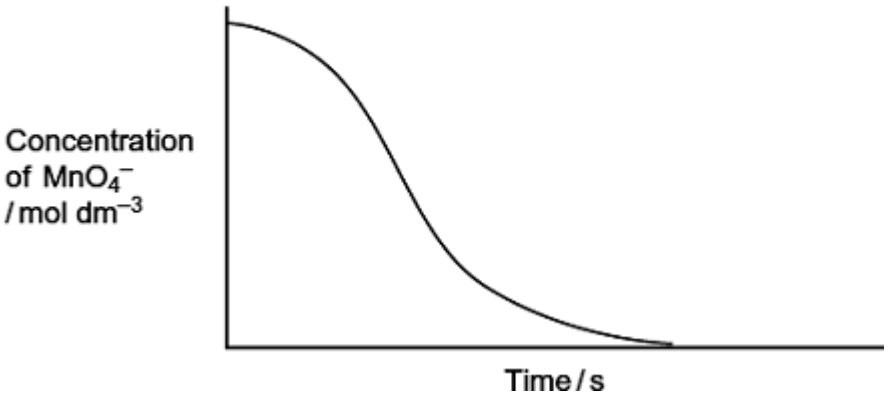
(1)
(Total 7 marks)

Q3. An acidified solution of potassium manganate(VII) was reacted with a sample of sodium ethanedioate at a constant temperature of 60 °C. The concentration of the manganate(VII) ions in the reaction mixture was determined at different times using a spectrometer to measure the light absorbed.

The following results were obtained.



(a) Write an equation for the reaction between manganate(VII) ions and ethanedioate ions in acidic solution.

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(Extra space) .....

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(2)

(b) By considering the properties of the reactants and products, state why it is possible to use a spectrometer to measure the concentration of the manganate(VII) ions in this reaction mixture.

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(2)

(c) This reaction is autocatalysed. Give the meaning of the term *autocatalyst*. Explain how the above curve indicates clearly that the reaction is autocatalysed.

Meaning of *autocatalyst* .....

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Explanation .....

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(3)

(d) Identify the autocatalyst in this reaction.

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(1)

(e) Write **two** equations to show how the autocatalyst is involved in this reaction.

Equation 1 .....

Equation 2 .....

(2)

(Total 10 marks)

Q4. When using potassium manganate(VII) in redox titrations with iron(II) ions it is essential that the reaction mixture is acidified. Normally, dilute sulfuric acid is used.

(a) State why an excess of hydrogen ions is added to the reaction mixture.

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(1)

(b) State why the acid used must **not** be ethanoic acid.

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(1)

(c) Explain why an indicator is **not** needed in this redox titration.

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(1)
(Total 3 marks)

Q5.(a) Use data from the table below to explain why dilute hydrochloric acid cannot be used to acidify potassium manganate(VII) in a titration.

	$E^{\ominus}$ / V
$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$	+1.51
$Cl_2(aq) + 2e^- \rightarrow 2Cl^-(aq)$	+1.36
$2H^+(aq) + 2e^- \rightarrow H_2(aq)$	0.00

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(2)

(b) Use information from the table in part (a) to determine the minimum volume, in cm^3, of 0.500 mol dm^{-3} sulfuric acid that is required for a titre of 25.0 cm^3 of 0.0200 mol dm^{-3} potassium manganate(VII) solution.
Show your working.

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(3)

(c) In each titration using potassium manganate(VII), a large excess of dilute sulfuric acid is used to avoid any possibility of the brown solid MnO_2 forming.

(i) Deduce a half-equation for the reduction of MnO_4^- ions in acidic solution to form MnO_2.

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(1)

(ii) Give **two** reasons why it is essential to avoid this reaction in a titration between potassium manganate(VII) and iron(II) ions.

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(2)

(d) Potassium manganate(VII) is an oxidising agent.
Suggest **one** reason why a 0.0200 mol dm^{-3} solution of potassium manganate(VII) does **not** need to be kept away from flammable material.

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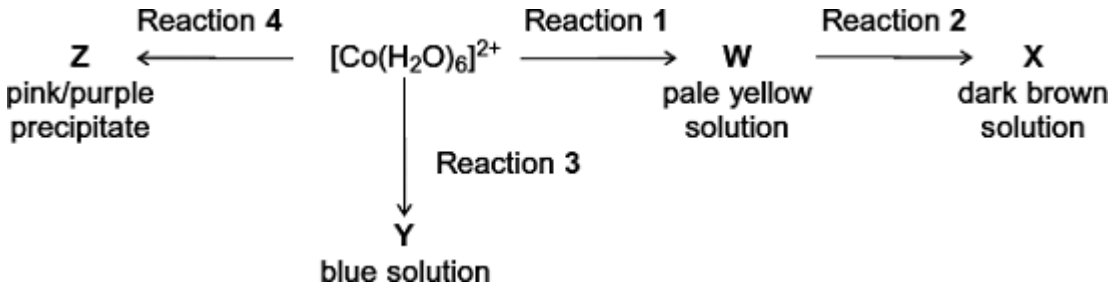
(1)
(Total 9 marks)

Q6. This question is about cobalt chemistry.

(a) Consider the following reaction scheme that starts from $[Co(H_2O)_6]^{2+}$ ions.
W, **X** and **Y** are ions and **Z** is a compound.



For each of the reactions **1** to **4**, identify a suitable reagent.

Identify **W**, **X**, **Y** and **Z** and write an equation for each of reactions **1** to **4**.

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(Extra space) .....

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(12)

(b) A flue-gas desulfurisation process involves the oxidation, by oxygen, of aqueous sulfate(IV) ions (SO_3^{2-}) into aqueous sulfate(VI) ions (SO_4^{2-}). This reaction is

catalysed by Co^{2+} ions in an acidic aqueous solution.

Write an equation for the overall reaction of sulfate(IV) ions with oxygen to form sulfate(VI) ions.

Suggest why this overall reaction is faster in the presence of Co^{2+} ions.

Suggest a mechanism for the catalysed reaction by writing **two** equations involving Co^{2+} and Co^{3+} ions. You will need to use H^+ ions and H_2O to balance these two equations.

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(4)
(Total 16 marks)