Q1. The redox reaction, in aqueous solution, between acidified potassium manganate(VII) and sodium ethanedioate is autocatalysed.

(a)   Write an equation for this redox reaction.

Identify the species that acts as the catalyst.

Explain how the properties of the species enable it to act as a catalyst in this reaction.

....

....

....

....

....

....

....

....

....

....

(6)

(b)   Sketch a graph to show how the concentration of MnO_4^- ions varies with time in this reaction.
Explain the shape of the graph.
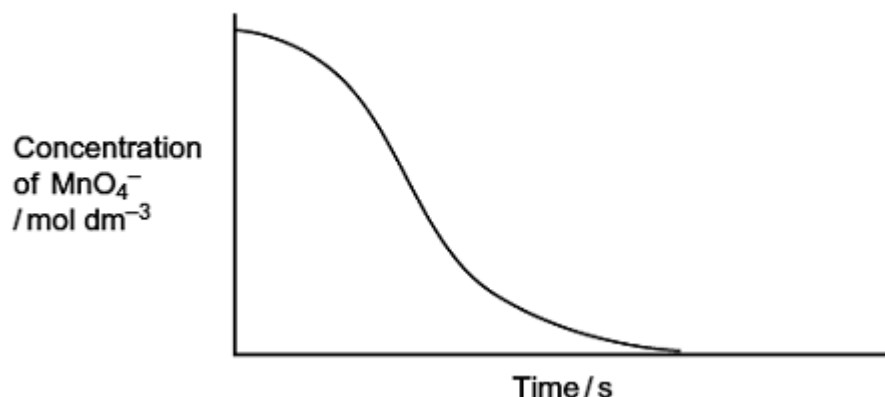
....

....

....

....

....

....

....

....

(4)
(Total 10 marks)

Q2. 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.

....

....

....

(Extra space) ....

....

(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.

....

....

....

....

(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* ....

....

Explanation ....

....

....

....

(3)

(d)   Identify the autocatalyst in this reaction.

....

(1)

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

Equation 1 ....

Equation 2 ....

(2)
(Total 10 marks)

Q3. When iodine molecules are dissolved in aqueous solutions containing iodide ions, they react to form triiodide ions (I_3^-).

$$I_2 \ + \ I^- \ \longrightarrow \ I_3^-$$

The reaction above between I^- ions and $S_2O_8^{2-}$ ions has a high activation energy and $S_2O_8^{2-}$ ions are only reduced slowly to SO_4^{2-} ions.
The reaction is catalysed by Fe^{2+} ions.

(a) Explain why the reaction between I^- ions and $S_2O_8^{2-}$ ions is slow.

....

....

....

(1)

(b) Other than having variable oxidation states, explain why Fe^{2+} ions are good catalysts for this reaction.

....

....

....

(1)

(c) Write a half-equation for the reduction of $S_2O_8^{2-}$ ions to SO_4^{2-} ions.

....

....

(1)

(d) Construct an overall equation for the reaction between $S_2O_8^{2-}$ ions and I^- ions.

....

....

....

....

(1)
(Total 4 marks)

Q4. Transition metal compounds have a range of applications as catalysts.

(a) State the general property of transition metals that allows the vanadium in vanadium(V) oxide to act as a catalyst in the Contact Process.

....

Page 5

(1)

(b)   Write **two** equations to show how vanadium(V) oxide acts as a catalyst in the Contact Process.

Equation 1

....

Equation 2

....

(2)

(c)   In the Contact Process, vanadium(V) oxide acts as a heterogeneous catalyst.

(i)   Give the meaning of the term *heterogeneous*.

....

....

....

(1)

(ii)   Give **one** reason why impurities in the reactants can cause problems in processes that use heterogeneous catalysts.

....

....

....

(1)

(d)   The oxidation of $C_2O_4^{2-}$ ions by MnO_4^- ions in acidic solution is an example of a reaction that is autocatalysed.

(i)   Give the meaning of the term *autocatalysed*.

....

PhysicsAndMathsTutor.com

....

.... **(1)**

(ii)   Identify the autocatalyst in this reaction.

.... **(1)**

(iii)   Write **two** equations to show how the autocatalyst is involved in this oxidation of $C_2O_4^{2-}$ ions.

Equation 1

....

Equation 2

....

(2)
(Total 9 marks)

Q5. This question explores some reactions and some uses of cobalt compounds.

(a)   Ethanal is oxidised to ethanoic acid by oxygen. The equation for this reaction is

$$2CH_3CHO + O_2 \longrightarrow 2CH_3COOH$$
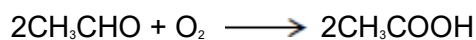
This redox reaction is slow at room temperature but speeds up in the presence of cobalt compounds.

Explain why a cobalt compound is able to act as a catalyst for this process.

Illustrate your explanation with **two** equations to suggest how, in the presence of water and hydrogen ions, Co^{3+} and then Co^{2+} ions could be involved in catalysing this reaction.

....

....

Page 7

....

....

....

....

....

....

(4)

(b)   In aqueous solution, the $[Co(H_2O)_6]^{2+}$ ion reacts with an excess of
ethane-1,2-diamine to form the complex ion **Y**.

(i)   Write an equation for this reaction.

Explain, in terms of the chelate effect, why the complex ion **Y** is formed in
preference to the $[Co(H_2O)_6]^{2+}$ complex ion.

....

....

....

....

....

....

....

(3)

(ii)   Draw a diagram that shows the shape of the complex ion **Y** and shows the
type of bond between the ethane-1,2-diamine molecules and the cobalt.

(3)

(c)   Compound **Z** is a complex that contains only cobalt, nitrogen, hydrogen and chlorine.

A solid sample of **Z** was prepared by reaction of 50 cm^3 of 0.203 mol dm^{-3} aqueous cobalt(II) chloride with ammonia and an oxidising agent followed by hydrochloric acid.

When this sample of **Z** was reacted with an excess of silver nitrate, 4.22 g of silver chloride were obtained.

Use this information to calculate the mole ratio of chloride ions to cobalt ions in **Z**.

Give the formula of the complex cobalt compound **Z** that you would expect to be formed in the preparation described above.

Suggest **one** reason why the mole ratio of chloride ions to cobalt ions that you have calculated is different from the expected value.

....

....

....

....

....

....

....

....

....

....

....

(5)
(Total 15 marks)

Q6. An equation for the decomposition of hydrogen peroxide is

$$2H_2O_2 \longrightarrow 2H_2O + O_2$$

(a)   The rate of reaction can be determined by collecting the oxygen formed and measuring its volume at regular intervals.

Draw a diagram to show the apparatus that you would use to collect and measure the volume of the oxygen formed.

(2)

(b)   Explain how you could use your results from the experiment in part (a) to determine the initial rate of this reaction.

....

....

....

....

....

(2)

(c)   The rate of decomposition of hydrogen peroxide is increased by the addition of cobalt(II) ions.

Outline the essential features of an additional experiment to show that the rate of decomposition is increased by the addition of cobalt(II) chloride. Use the same method and the same apparatus as in part (a).

....

....

....

....

....

(2)
(Total 6 marks)