Q1. (a) The ion $C_2O_4^{2-}$ can act as a bidentate ligand.

(i) Explain the meaning of the term *bidentate ligand*.

.....

.....

(ii) Sketch the structure of the octahedral complex ion formed by Fe^{3+} ions which contains $C_2O_4^{2-}$ as the only ligand. Include the overall charge on the complex ion.

(5)

(b) Explain the meaning of the term *chelate effect*.

.....

.....

(2)

(c) The chloride ion can act as a monodentate ligand.

(i) Deduce the formula of the linear complex formed when an excess of concentrated hydrochloric acid is added to silver chloride.

.....

(ii) Explain why metal(II) ions do not usually form octahedral complexes when chloride ions are the only ligands.

.....

(2)

(d) The concentration of $C_2O_4^{2-}$ ions can be determined by titration in acidic solution using a standard solution of potassium manganate(VII). At room temperature, the reaction proceeds very slowly at first but becomes faster after some of the manganate(VII) ions have reacted.

(i) Suggest why this reaction is very slow at first.

.....

(ii) This is an example of an autocatalytic reaction. State the meaning of the term *autocatalytic* and identify the catalyst.

Meaning of the term autocatalytic .....

Catalyst .....

(iii) Suggest how this catalyst might be involved in the reaction.

.....

.....

.....

(5)
(Total 14 marks)

Q2. In the table below, which one of the following complex ions has a correct shape, co-ordination number and oxidation state?

	Complex	**Shape**	**Co-ordination number**	**Oxidation state of central cation**
A	$[Ag(CN)_2]^-$	Linear	2	–1

B	$[CuCl_4]^{2-}$	Tetrahedral	4	–2
C	$[Cr(C_2O_4)_3]^{3-}$	Octahedral	3	+3
D	$[Cu(NH_3)_4(H_2O)_2]^{2+}$	Octahedral	6	+2

(Total 1 mark)

Q3. (a) Give **one** example of a bidentate ligand.

.....

(1)

(b) Give **one** example of a linear complex ion formed by a transition metal.

.....

(1)

(c) Write an equation for a substitution reaction in which the complete replacement of ligands in a complex ion occurs with a change in **both** the co-ordination number and the overall charge of the complex ion.

.....

(2)

(d) Write an equation for a substitution reaction in which the complete replacement of ligands in a complex ion occurs without a change in either the co-ordination number or the overall charge of the complex ion.

.....

(2)

(e) When a solution containing $[Co(H_2O)_6]^{2+}$ ions is treated with a solution containing $EDTA^{4-}$ ions, a more stable complex is formed. Write an equation for this reaction and explain why the complex is more stable.

Equation .....

Explanation .....

.....

(3)
(Total 9 marks)

Q4. (a) State what is meant by the term *co-ordinate bond*.

.....

.....

(2)

(b) Define the terms *Brønsted–Lowry acid* and *Lewis acid*.

Brønsted–Lowry acid .....

Lewis acid .....

(2)

(c) State what is meant by the term *bidentate ligand*.

.....

.....

(2)

(d) State how the co-ordination number of cobalt(II) ions in aqueous solution changes when an excess of chloride ions is added. Give a reason for the change.

Change in co-ordination number .....

Reason for change .....

.....

(2)

(e) Suggest why the enthalpy change for the following reaction is close to zero.

$[Co(NH_3)_6]^{2+} + 3NH_2CH_2CH_2NH_2 \rightarrow Co(NH_2CH_2CH_2NH_2)_3]^{2+} + 6NH_3$

.....

.....

(2)

(f) Deduce the formula of the compound formed when ethane-1,2-diamine is treated with an excess of hydrochloric acid.

.....

(1)

(Total 11 marks)