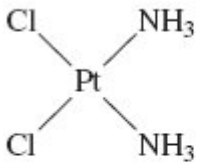
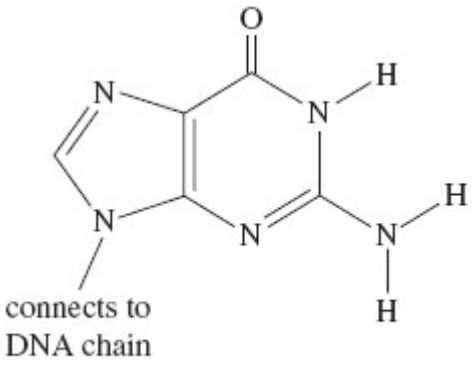
Q1. The complex cisplatin acts as an anticancer drug by changing the properties of DNA when it reacts with guanine, a component of DNA.



cisplatin



guanine

When cisplatin is absorbed into the human body, it undergoes a ligand substitution reaction and one chloride ligand is replaced by a water molecule forming a complex ion **Q**.

(a) Write an equation for this substitution reaction to form the complex ion **Q**.

.....

(2)

(b) The complex ion **Q** can bond to guanine in two different ways.

(i) The first way involves a hydrogen atom, from one of the ammonia ligands on **Q**, bonding to an atom in a guanine molecule. State the type of bond formed to guanine and identify an atom in guanine that could form a bond to this hydrogen atom.

Type of bond .....

Atom in guanine .....

(2)

(ii) The second way involves a ligand substitution reaction in which an atom in a guanine molecule bonds to platinum by displacing the water molecule from **Q**. State the type of bond formed between guanine and platinum when a water molecule is displaced and identify an atom in guanine that could bond to platinum in this way.

Type of bond .....

Atom in guanine .....

(2)

(c) State and explain **one** risk associated with the use of cisplatin as an anticancer drug.

Risk .....

Explanation .....

(2)
(Total 8 marks)

Q2. (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)

Q3. A 0.263 g sample of impure iron, containing an unreactive impurity, was reacted with an excess of hydrochloric acid. All of the iron in the sample reacted, evolving hydrogen gas and forming a solution of iron(II) chloride. The volume of hydrogen evolved was 102 cm^3, measured at 298 K and 110 kPa.

The percentage, by mass, of iron in the sample can be determined using either the volume of hydrogen produced or by titrating the solution of iron(II) chloride formed against a standard solution of potassium dichromate(VI).

(a) (i) Write an equation for the reaction between iron and hydrochloric acid.

.....

(ii) Calculate the number of moles of hydrogen produced in the reaction.

.....

.....

.....

.....

(iii) Use your answers to parts (a)(i) and (ii) to determine the number of moles of iron and the mass of iron in the original sample. (If you have been unable to complete part (a)(ii) you should assume the answer to be 4.25×10^{-3} mol. This is not the correct answer.)

Moles of iron .....

Mass of iron .....

(iv) Calculate the percentage of iron in the original sample.

.....

.....

(7)

(b) (i) Write half-equations for the oxidation of Fe^{2+} and for the reduction of $Cr_2O_7^{2-}$ in acidic solution, and use these to construct an overall equation for the reaction between these two ions.

Half-equation for the oxidation of Fe^{2+}

.....

Half-equation for the reduction of $Cr_2O_7^{2-}$

.....

Overall equation

.....

(ii) The number of moles of iron in the sample was determined in part (a)(iii). Use this answer to calculate the volume of a 0.0200 mol dm^{-3} solution of potassium dichromate(VI) which would react exactly with the solution of iron(II) chloride formed in the reaction.

(If you have been unable to complete part (a)(iii) you should assume the answer to be 3.63×10^{-3} mol. This is not the correct answer.)

.....

.....

.....

.....

.....

(iii) Explain why an incorrect value for the number of moles of iron(II) chloride formed would have been obtained if the original solution had been titrated with potassium manganate(VII).

.....

.....

(7)

(Total 14 marks)

Q4. (a) State the origin of the colour of transition-metal complexes.

.....

.....

(2)

(b) Give **three** changes to a transition-metal complex which result in a change in colour.

Change 1 .....

Change 2 .....

Change 3 .....

.....

(3)

(c) You are provided with a 1.00 mol dm^{-3} solution of iron(III) ions and a visible-light spectrophotometer (colorimeter). Outline a plan for experiments using this solution and this apparatus which would enable you to determine the concentration of iron(III) ions in a solution of unknown concentration.

.....

.....

.....

.....

.....

.....

.....

.....

(5)
(Total 10 marks)

Q5. (a) State what is meant by each of the following terms.

(i) *Ligand* .....

.....

(ii) *Complex ion* .....

.....

(iii) *Co-ordination number* .....

.....

(3)

(b) Using complex ions formed by Co^{2+} with ligands selected from H_2O, NH_3, Cl^-, $C_2O_4^{2-}$ and $EDTA^{4-}$, give an equation for each of the following.

(i) A ligand substitution reaction which occurs with no change in either the co-ordination number or in the charge on the complex ion.

.....

(ii) A ligand substitution reaction which occurs with both a change in the co-ordination number and in the charge on the complex ion.

.....

(iii) A ligand substitution reaction which occurs with no change in the co-ordination number but a change in the charge on the complex ion.

.....

(iv) A ligand substitution reaction in which there is a large change in entropy.

.....

(8)

(c) An aqueous solution of iron(II) sulphate is a pale-green colour. When aqueous sodium hydroxide is added to this solution a green precipitate is formed. On standing in air, the green precipitate slowly turns brown.

(i) Give the formula of the complex ion responsible for the pale-green colour.

.....

(ii) Give the formula of the green precipitate.

.....

(iii) Suggest an explanation for the change in the colour of the precipitate.

.....

.....

(4)
(Total 15 marks)

Q6. Which one of the following could **not** act as a ligand?

A F^-

B CH_3CH_3

C NH_2NH_2

D CH_3OCH_3

(Total 1 mark)