Oxford Cambridge and RSA

Tuesday 13 October 2020 – Morning

A Level Chemistry B (Salters)

H433/02 Scientific literacy in chemistry

Time allowed: 2 hours 15 minutes

You must have:
- a clean copy of the Advance Notice Article (inside this document)
- the Data Sheet for Chemistry B

You can use:
- a scientific or graphical calculator
- an HB pencil

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **24** pages.

ADVICE
- Read each question carefully before you start your answer.

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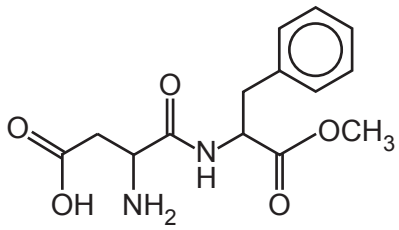
Answer **all** the questions.

1 Aspartame is a dipeptide that is used as an artificial sweetener. The structure of aspartame is shown in **Fig. 1.1**.

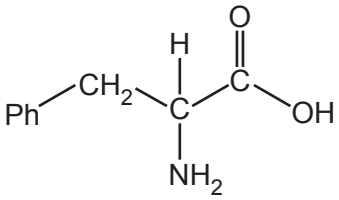


aspartame

Fig. 1.1

(a) Circle a secondary amide group on the structure of aspartame in **Fig. 1.1**. **[1]**

(b) Aspartame is hydrolysed by boiling with acid. One of the products is phenylalanine which is shown in **Fig. 1.2**. 'Ph' represents a benzene ring.



phenylalanine

Fig. 1.2

(i) Phenylalanine has a chiral centre. Draw the three dimensional formulae to show the enantiomers of phenylalanine.

mirror

[2]

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(ii) Phenylalanine in solution exists mainly as a zwitterion.
Complete the diagram in **Fig. 1.3** to show the structure of this zwitterion.

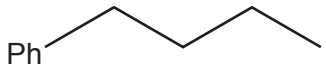

Fig. 1.3

[1]

(iii) A student says that acid hydrolysis of aspartame will only produce phenylalanine and one other amino acid.

Comment on the accuracy of this statement, giving the structures of any compounds you include in your answer.

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..... **[3]**

(c) Aspartame tastes sweet. One theory is that the sweetness is caused by hydrogen bonds forming between sweetener molecules and sweetness receptors in the body.

On the structure of aspartame in **Fig. 1.4** circle **all** the atoms that could hydrogen bond with a receptor.

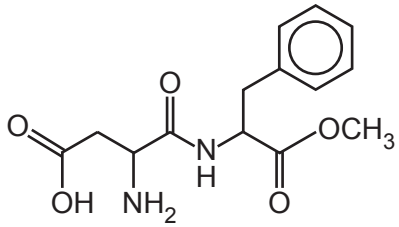

Fig. 1.4

[1]

(d) The enzyme pepsin catalyses the hydrolysis of protein chains. Some students read that pepsin breaks the peptide bonds adjacent to aromatic amino-acids, for example phenylalanine. This is because the active site is specific to benzene rings.

Suggest the type of bonds that form between a benzene ring and the active site.

..... **[1]**

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(e) The students mix excess aspartame and pepsin in aqueous solution at room temperature. After 30 minutes they place a spot of the mixture on some chromatography paper.

(i) Describe the rest of their method, including how they could tell whether hydrolysis has occurred.

You may include a diagram in your answer.

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..... **[4]**

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(ii) Other students boil the mixture of aspartame and pepsin to attempt to speed up the hydrolysis reaction.

State and explain whether or not this would work.

.....

..... **[1]**

(iii) Another student says that using a higher concentration of aspartame at room temperature will speed up the hydrolysis reaction.

Comment on this statement.

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..... **[2]**

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2 Some students use a method based on an electrochemical cell to measure the concentration of silver ions in solution.

They set up a cell as shown in **Fig. 2.1**.

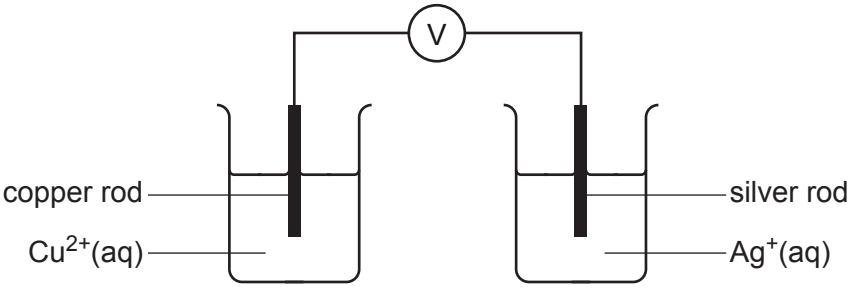

Fig. 2.1

(a) **(i)** There is something missing from the diagram.

State what it is and describe what it is made of.

.....

..... **[2]**

(ii) State **two** conditions necessary for the cell to measure electrode potentials under **standard** conditions.

1 .....

2 .....
[2]

(b) **Table 2.1** shows the electrode potential data for the cell in **Fig. 2.1**.

Half-equation	$E^{\ominus}$/V
$Cu^{2+}(aq) + 2e^{-} \rightleftharpoons Cu(s)$	+0.34
$Ag^{+}(aq) + e^{-} \rightleftharpoons Ag(s)$	+0.80

Table 2.1

Equation 2.1 shows the reaction that occurs when the standard cell delivers a current.

$2Ag^{+}(aq) + Cu(s) \longrightarrow Cu^{2+}(aq) + 2Ag(s)$ **Equation 2.1**

(i) Identify the oxidising agent in **equation 2.1**.

..... **[1]**

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(ii) State and explain which way electrons flow in the wire when the standard cell is delivering a current.

.....

..... **[1]**

(c) Silver bromide, AgBr, is usually described as 'insoluble' but a small amount can dissolve in water.

The students have a saturated solution of AgBr. This contains as much AgBr as will dissolve. They place this saturated solution in the right-hand beaker of the cell in **Fig. 2.1**.

They measure the cell potential against a standard copper electrode. Their result is 0.09 V (with the same electrode polarity as in the standard cell in **(b)**).

The students are told that the relationship between their measured cell potential, E_{cell}, and the concentration of silver ions is given by:

$$E_{cell} = E^{\ominus}_{cell} + 0.06 \log[Ag^+]$$

Calculate the silver ion concentration in the saturated solution of AgBr.

$[Ag^+]$ = ... mol dm^{-3} **[4]**

(d) Some other students make another cell, using two different half cells as shown in **Table 2.2**.

Half-reaction	$E^{\ominus}$**/V**
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	+0.34
$2IO_3^-(aq) + 12\,H^+(aq) + 10e^- \rightleftharpoons I_2(aq) + 6H_2O(l)$	+1.19

Table 2.2

(i) Write an equation for the reaction that occurs when the cell delivers a current.

[2]

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(ii) Draw a labelled diagram to show how the IO_3^-/I_2 electrode is made up.
You do **not** need to give concentrations.

[2]

(iii) The students are told that in a standard IO_3^-/I_2 electrode $[IO_3^-]^2 = [I_2]$.

They plan to prepare 40 cm^3 of the solution for the electrode by mixing 20 cm^3 of 0.08 mol dm^{-3} $I_2(aq)$ with 20 cm^3 of $IO_3^-(aq)$.

Calculate the concentration of IO_3^- needed so that $[IO_3^-]^2 = [I_2]$.

$[IO_3^-]$ = ... mol dm^{-3} **[3]**

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3 'Monopotassium phosphate', KH_2PO_4, is added to fertilisers.
KH_2PO_4 acts as a buffer and supplies phosphorus.

(a) The $H_2PO_4^-$ ion has two OH groups.

Draw a 'dot-and-cross' diagram for this ion.

[2]

(b) KH_2PO_4 when used in fertilisers is said to be equivalent to 52% P_2O_5 and 34% K_2O by mass.

Show that the mole ratio of potassium to phosphorus in 52% P_2O_5 and 34% K_2O is the same as in KH_2PO_4.

[2]

(c) In a solution of KH_2PO_4, the equilibrium in **equation 3.1** occurs:

$$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-} \qquad K_a = 6.2 \times 10^{-8}\,\text{mol dm}^{-3} \qquad \textbf{Equation 3.1}$$

(i) Identify the base in this reaction and explain your choice.

.....

..... **[1]**

(ii) Calculate the pK_a for the equilibrium in **equation 3.1**.

pK_a = ... **[1]**

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Equation 3.1 is repeated again.

$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-}$ $K_a = 6.2 \times 10^{-8}\,mol\,dm^{-3}$ **Equation 3.1**

(iii) Calculate the pH of a $1.0 \times 10^{-3}\,mol\,dm^{-3}$ solution of KH_2PO_4.

pH = ... **[2]**

(d) The acidity of KH_2PO_4 reduces the loss of ammonia from ammonium ions (NH_4^+) in a fertiliser.

Explain how this happens when the fertiliser is in solution.

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..... **[2]**

(e) A mixture of HPO_4^{2-} and $H_2PO_4^-$ ions in solution makes a 'phosphate buffer'.

Calculate the mass of KH_2PO_4 that must be added to $1.0\,dm^3$ of a $0.10\,mol\,dm^{-3}$ solution of HPO_4^{2-} to make a solution with a pH of 6.50.

The volume of the solution does not change when the solid is added.

mass of KH_2PO_4 = ... g **[4]**

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Equation 3.1 is repeated again.

$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-}$ $K_a = 6.2 \times 10^{-8}\,mol\,dm^{-3}$ **Equation 3.1**

(f) **(i)** A student says that a solution of HPO_4^{2-} alone will act as a buffer when acid is added. The student says that this is because the position of equilibrium in **equation 3.1** moves to the left to remove H^+ ions.

Discuss the student's statements.

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..... **[2]**

(ii) A student is doing calculations involving solutions of hydrochloric acid.

The student says that the concentration of hydrogen ions can be taken as the concentration of the acid.

Discuss this statement.

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..... **[1]**

(iii) Calculate the **change** in pH when 1 drop ($0.05\,cm^3$) of $0.01\,mol\,dm^{-3}$ HCl is added to $1.0\,dm^3$ of water at pH 7.0.

pH change = ... **[2]**

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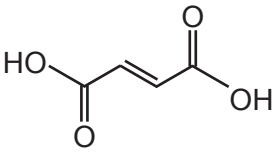
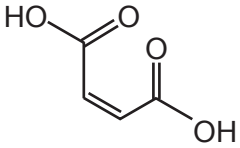
4 'Fumaric acid' is used as an acidity regulator in food. 'Maleic acid' is a stereoisomer of fumaric acid. The structure of the two acids are shown in **Fig. 4.1.**



fumaric acid



maleic acid

Fig. 4.1

(a) **(i)** Describe chemical tests that can be carried out in a laboratory to identify the two functional groups in both acids.

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..... **[2]**

(ii) A solution has 2.32 g dm^{-3} of maleic acid.

Calculate the volume (in cm^3) of 2.0 mol dm^{-3} NaOH(aq) that would completely neutralise 250 cm^3 of the solution.

volume = ... cm^3 **[3]**

(b) **(i)** Give the **empirical** formula of both acids.

..... **[1]**

(ii) Give the systematic name for **maleic acid**.

..... **[2]**

(c) Explain why maleic acid and fumaric acid are different compounds.

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..... **[2]**

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(d) The mass spectra of maleic and fumaric acid both have a peak at 71.
Suggest a reason for this.

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..... **[1]**

(e) Fumaric acid is made from maleic acid by an acid-catalysed isomerisation reaction.

A student suggests the mechanism shown in **Fig. 4.2** for the reaction.

(i) Draw 'curly arrows' on **Fig. 4.2** to complete the mechanism.

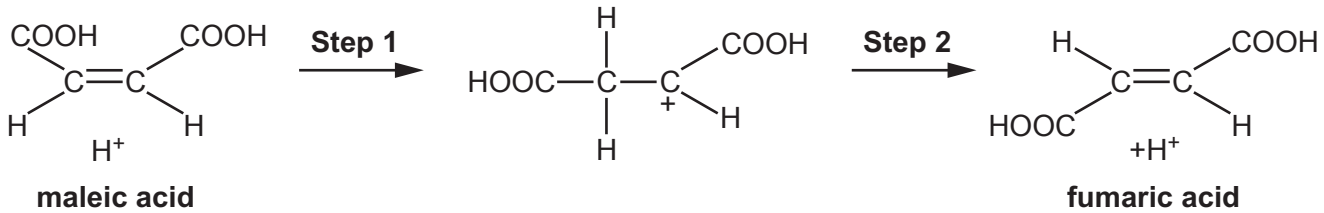

Fig. 4.2

[2]

(ii) Name the **type** of reaction that is occurring in **step 2**.

..... **[1]**

(iii) The student then reads that if $^{2}H^{+}$ ions are used for the isomerisation, then there isn't any ^{2}H found in the fumaric acid formed.

Does this support the student's mechanism in **Fig. 4.2**?

Explain your answer.

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..... **[2]**

(f) Maleic acid can be made from 'maleic anhydride', $C_4H_2O_3$.

Suggest a skeletal formula for maleic anhydride.

[1]

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(g) Maleic anhydride can be made industrially by oxidising butane or benzene.

$C_4H_{10} + 3.5O_2 \longrightarrow C_4H_2O_3 + 4H_2O$ **Reaction 1**

$C_6H_6 + 4.5O_2 \longrightarrow C_4H_2O_3 + 2H_2O + 2CO_2$ **Reaction 2**

(i) Use calculated atom economies to suggest, with a reason, which reaction is used more.

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..... **[2]**

(ii) Suggest another reason why the reaction selected in **(g)(i)** is preferred.

.....

..... **[1]**

(iii) Calculate the maximum mass of maleic anhydride, $C_4H_2O_3$, (in kg) that could be made from 15 m^3 of butane (measured at RTP).

Give your answer to an **appropriate** number of significant figures.

mass of maleic anhydride = ... kg **[2]**

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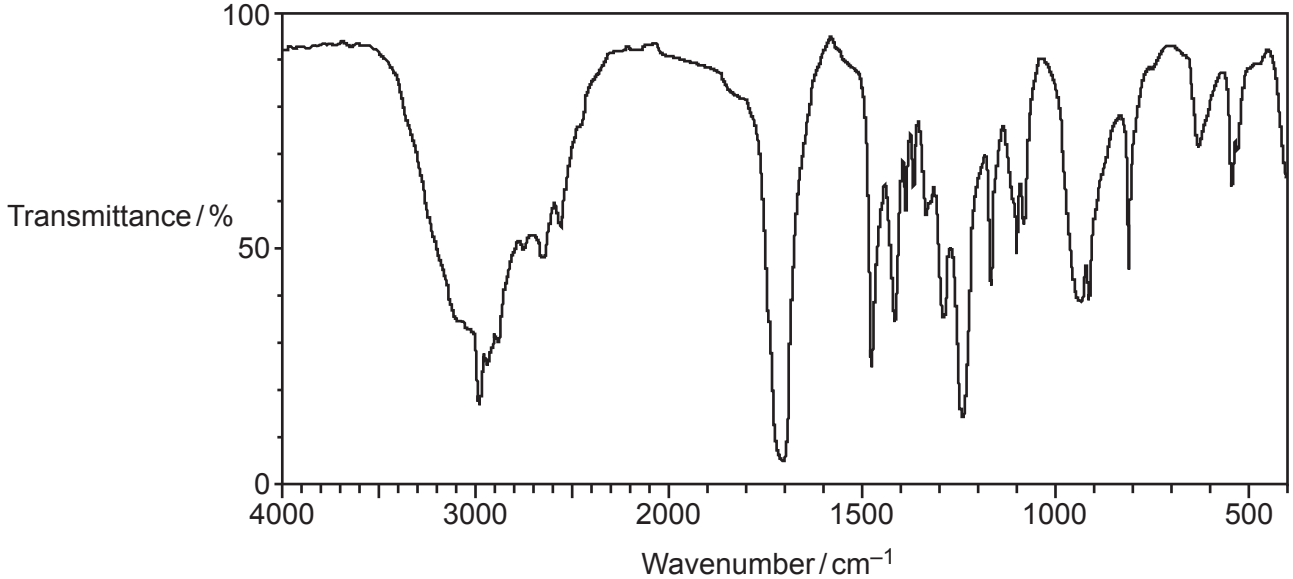
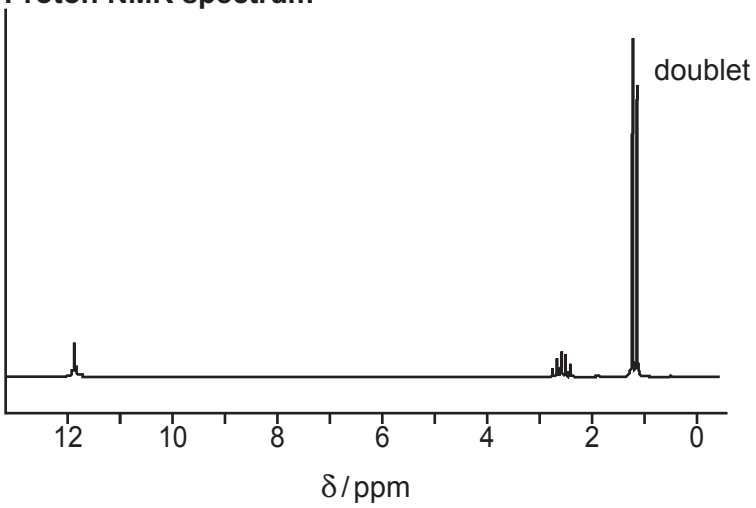
(h)* Compound **A** has spectra as shown below.

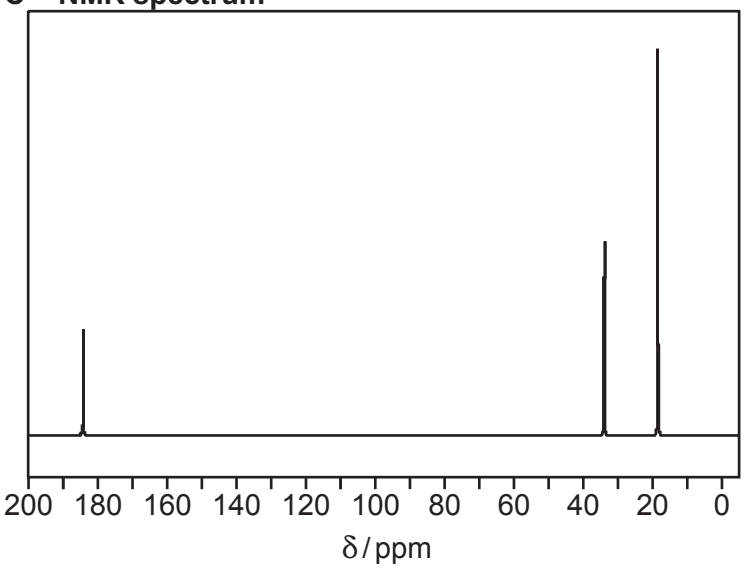
Infrared spectrum



Proton NMR spectrum



C^{13} NMR spectrum



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Compound **A** has four carbon atoms in its molecule.

Identify compound **A**, giving evidence from each spectrum. **[6]**

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5 This question refers to the Advance Notice Article 'Platinum metal complexes in medicine' that is included inside this document.

(a) Cisplatin is a neutral molecule.

(i) Explain why the oxidation state of the platinum in cisplatin is +2.

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..... **[1]**

(ii) Suggest the electronic configuration of the outermost sub-shell in a Pt^{2+} ion.

..... **[1]**

(iii) Is platinum a transition metal?

Give a reason.

.....

..... **[1]**

(b) Some ligands are described as bidentate.

Give the **full** structural formula of a bidentate ligand from a compound in the article.

[2]

(c) **Fig. 5.1** is a diagram from page 3 of the article. It shows a possible way in which a compound derived from cisplatin is thought to attach to a base in DNA. Two bonds have been labelled **B** and **C**.

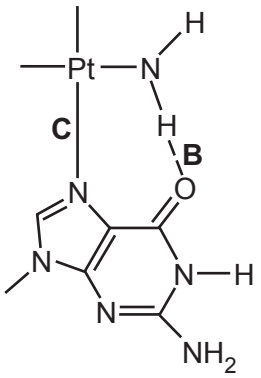

Fig. 5.1

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(i) What is the name of the base in **Fig. 5.1**? Use the Data Sheet to help you.

..... **[1]**

(ii) What is the name of the type of bond at **B** in **Fig. 5.1**?

..... **[1]**

(iii) Name the type of bond at **C** in **Fig. 5.1** and describe how it is formed.

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..... **[2]**

(d) Satraplatin was designed to be taken by mouth as it is soluble.

(i) Name the shape of a satraplatin molecule around the Pt atom.

..... **[1]**

(ii) Give the co-ordination number of Pt in satraplatin.

..... **[1]**

(iii) Suggest, in terms of intermolecular bonds, why satraplatin is soluble whereas cisplatin is not.

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(e)* Give the **disadvantages** of using cisplatin as an anti-cancer drug and give examples of how newer platinum-based drugs attempt to overcome these disadvantages. **[6]**

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Additional answer space if required

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END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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