OXFORD CAMBRIDGE AND RSA EXAMINATIONS

A2 GCE

F334/01

CHEMISTRY B (SALTERS)

Chemistry of Materials

MONDAY 14 JANUARY 2013: Afternoon

DURATION: 1 hour 30 minutes plus your additional time allowance

MODIFIED ENLARGED 24pt

Candidate forename		Candidate surname	

Centre number						Candidate number				

Candidates answer on the Question Paper.

OCR SUPPLIED MATERIALS:

Data Sheet for Chemistry B (Salters) **(inserted)**

OTHER MATERIALS REQUIRED:

Scientific calculator

READ INSTRUCTIONS OVERLEAF

DC (NH/SW) 1486997990 70935/2

INSTRUCTIONS TO CANDIDATES

- **The Insert will be found in the centre of this document.**
- **Write your name, centre number and candidate number in the boxes on the first page. Please write clearly and in capital letters.**
- **Use black ink. HB pencil may be used for graphs and diagrams only.**
- **Answer ALL the questions.**
- **Read each question carefully. Make sure you know what you have to do before starting your answer.**
- **Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.**

INFORMATION FOR CANDIDATES

- **The number of marks is given in brackets [ ] at the end of each question or part question.**
-  **Where you see this icon you will be awarded marks for the quality of written communication in your answer.**

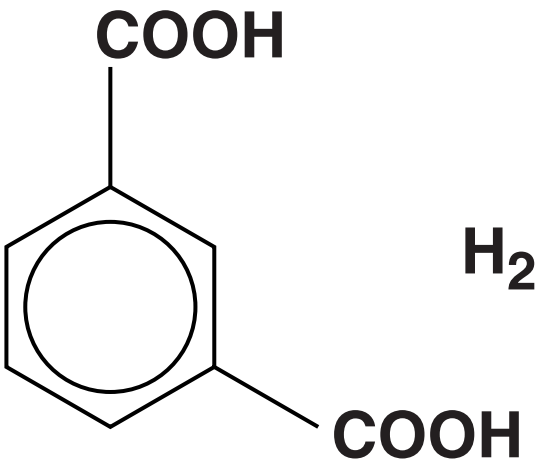
  This means for example you should:

  - **ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;**
  - **organise information clearly and coherently, using specialist vocabulary when appropriate.**
- **You may use a scientific calculator.**
- **A copy of the *Data Sheet for Chemistry B (Salters)* is provided as an insert with this question paper.**
- **You are advised to show all the steps in any calculations.**
- **The total number of marks for this paper is 90.**

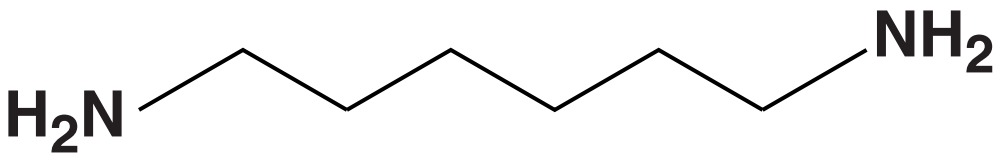
Answer ALL the questions.

1 To combat the security problems of metal cutlery on aircraft, chemists have developed a polymer known as PPA. This polymer, a polyamide, is strong enough to replace stainless steel cutlery for in-flight use.

The following monomers, A and B, can be reacted to make PPA polymer.



A



B

(a) (i) Use the formulae on page 4 to draw the structural formula of the repeating unit for PPA.

[2]

(ii) On your diagram circle a secondary amide group. [1]

(iii) Name monomer B.

_____ **[2]**

(b) Nylon-6 is also a polyamide.

Nylon-6 has six carbon atoms in its repeating unit and can be made from a single monomer having a straight carbon chain.

(i) Suggest a structural formula for this single monomer of nylon-6.

[1]

(ii) Name and explain the TYPE of polymerisation reaction this monomer undergoes to form nylon-6.

_____

_____

_____ **[1]**

(c) Polyamides have a high proportion of crystalline areas.

(i) Explain what is meant by crystalline.

_____

_____ **[1]**

(ii) PPA has more crystalline areas than nylon-6. This gives PPA a greater T_m than nylon-6.

Explain this greater T_m in terms of the intermolecular bonding involved.

_____

_____

_____

_____

_____

_____ [3]

(iii) Name a process by which a nylon-6 fibre could be made more crystalline.

_____ [1]

(d) In the manufacture of PPA, monomer B can be made from butane by the 3-step process shown on page 11.

(i) For each step, name the type of reaction taking place by selecting a suitable word from the list below.

ADDITION CONDENSATION

ELIMINATION REARRANGEMENT

SUBSTITUTION

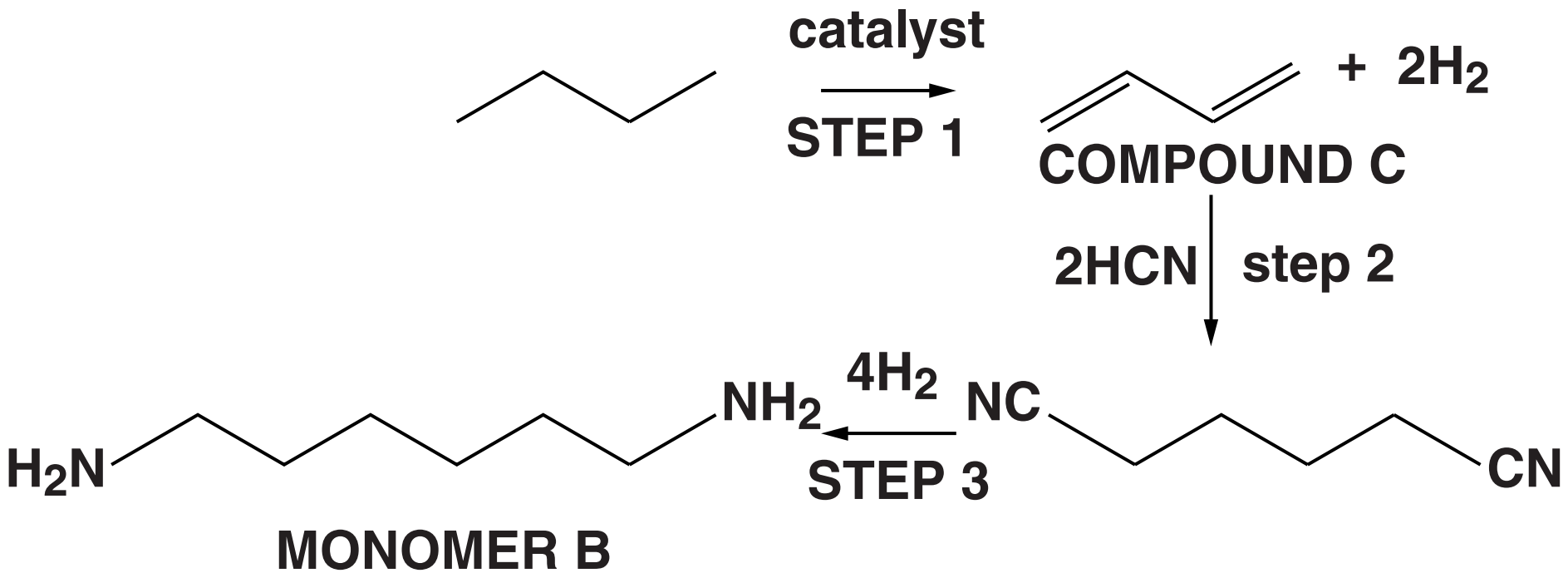
STEP 1 _____

STEP 2 _____

STEP 3 _____

[3]

11


catalyst
STEP 1
+ 2H2
COMPOUND C
2HCN
step 2
4H2
NC
NH2
STEP 3
H2N
CN
MONOMER B

(ii) How does the hydrogen produced by STEP 1 help to reduce the cost of the overall process?

_____

_____ [1]

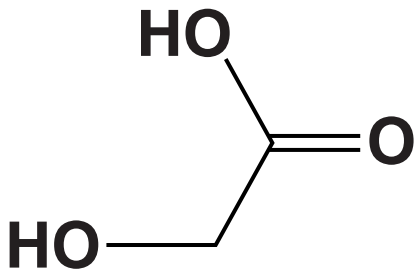
(e) In some countries, compound C is synthesised by first converting ethanol into CH_3CHO.

Give the reagents used in a laboratory to convert ethanol into CH_3CHO.

_____ [1]

[TOTAL: 17]

2 Glycolic acid is widely used in cosmetic skin-care products. It is an odourless and crystalline solid that is very soluble in water.



GLYCOLIC ACID

(a) Describe and explain how part of the glycolic acid structure acts as an acid.

_____

_____

_____ **[2]**

(b) The concentration of glycolic acid in a skin-care product is important. Any product containing over 10.0 g of glycolic acid in 100 cm^3 solution is classed as a hazardous material.

'Acnegone' is a solution of glycolic acid.

A student carries out an acid–base titration using a standard solution of NaOH to find out how much glycolic acid is in the Acnegone solution.

The student dilutes 14.0 cm^3 of Acnegone with water to form 250 cm^3 of solution.

25.0 cm^3 of this solution reacts exactly with 16.0 cm^3 of 0.250 mol dm^{-3} aqueous NaOH.

(i) Complete the equation for the reaction of glycolic acid with sodium hydroxide. [1]

$CH_2OHCOOH$ + →

(ii) Calculate the mass of glycolic acid in 100 cm^3 of Acnegone and state whether Acnegone should be classed as a hazardous product. Give your answer to an APPROPRIATE number of significant figures.

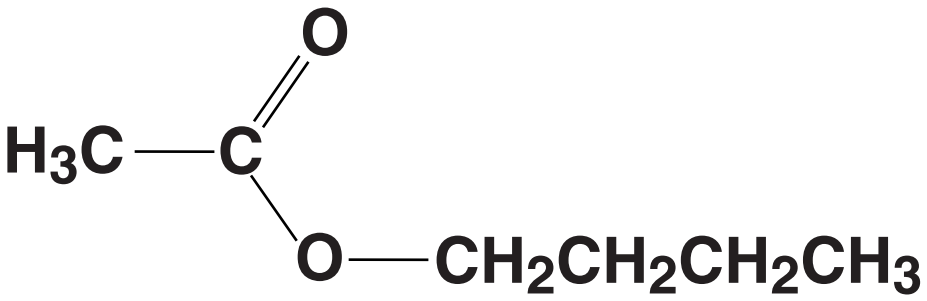
mass of glycolic acid

= _____ g in 100 cm^3

is it classed as hazardous?

_____ [6]

(c) **Carboxylic acids can be converted to esters. Esters, such as compound D, are often used in varnishes.**



COMPOUND D

(i) **Name compound D and circle the ester group.**

_____ **[2]**

(ii) **NAME the compounds you would heat under reflux with ethanoic acid to form compound D.**

_____

_____ **[2]**

(iii) Name the types of intermolecular bonds present in ethanoic acid and compound D.

ethanoic acid _____

_____

compound D _____

_____

[3]

(d) A student attempts to synthesise compound D from ethanoic acid. The student distils off the product and runs an infrared spectrum and a mass spectrum on it.

The infrared spectrum is shown on the opposite page.

(i) Use the IR spectrum and your Data sheet to give TWO pieces of evidence to show that the product does not contain any starting materials.

_____

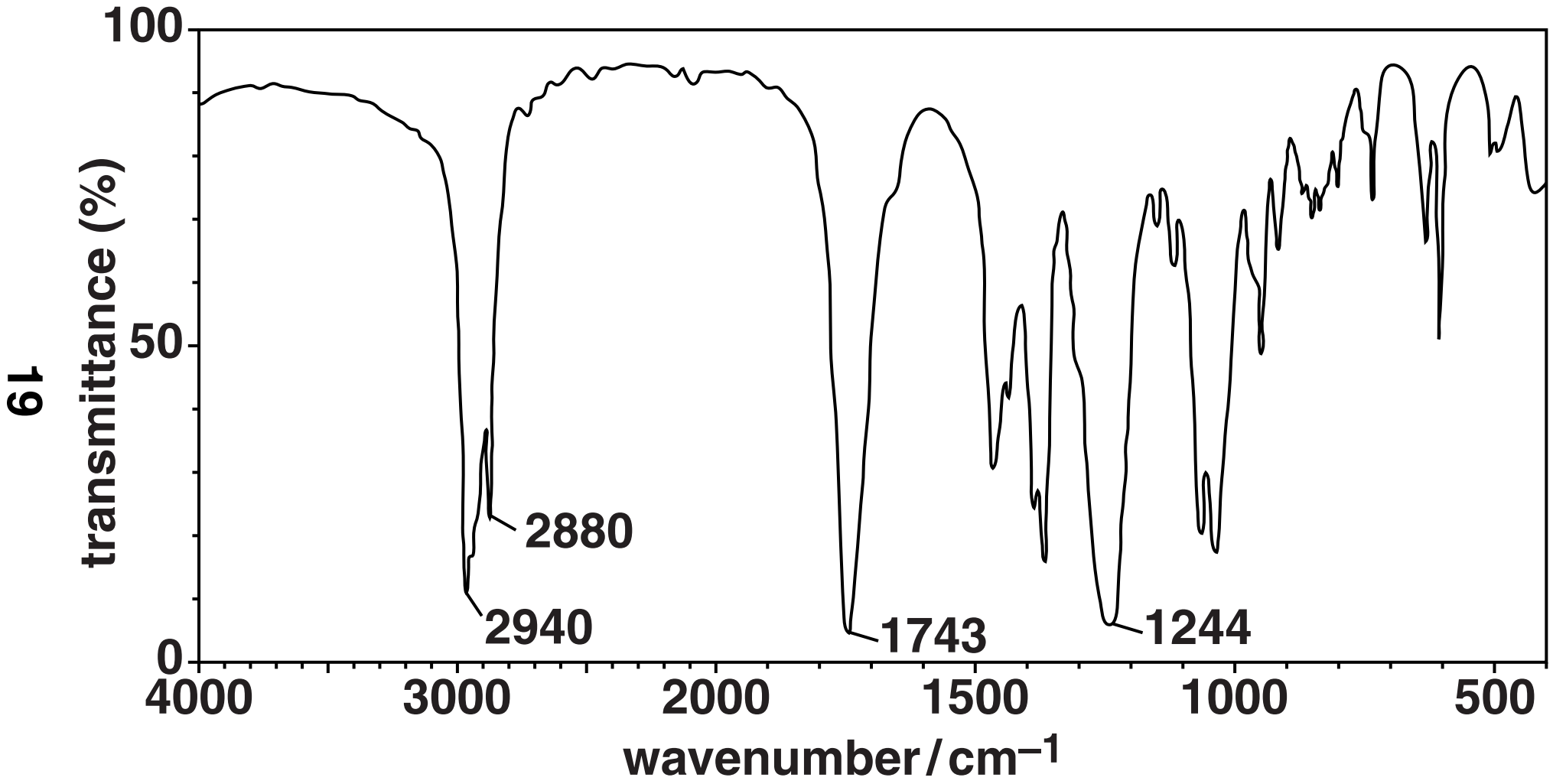
_____

_____

_____

_____

_____ **[2]**


100
50
0
transmittance (%)
2880
2940
1743
1244
4000
3000
2000
1500
1000
500
wavenumber / cm−1

19

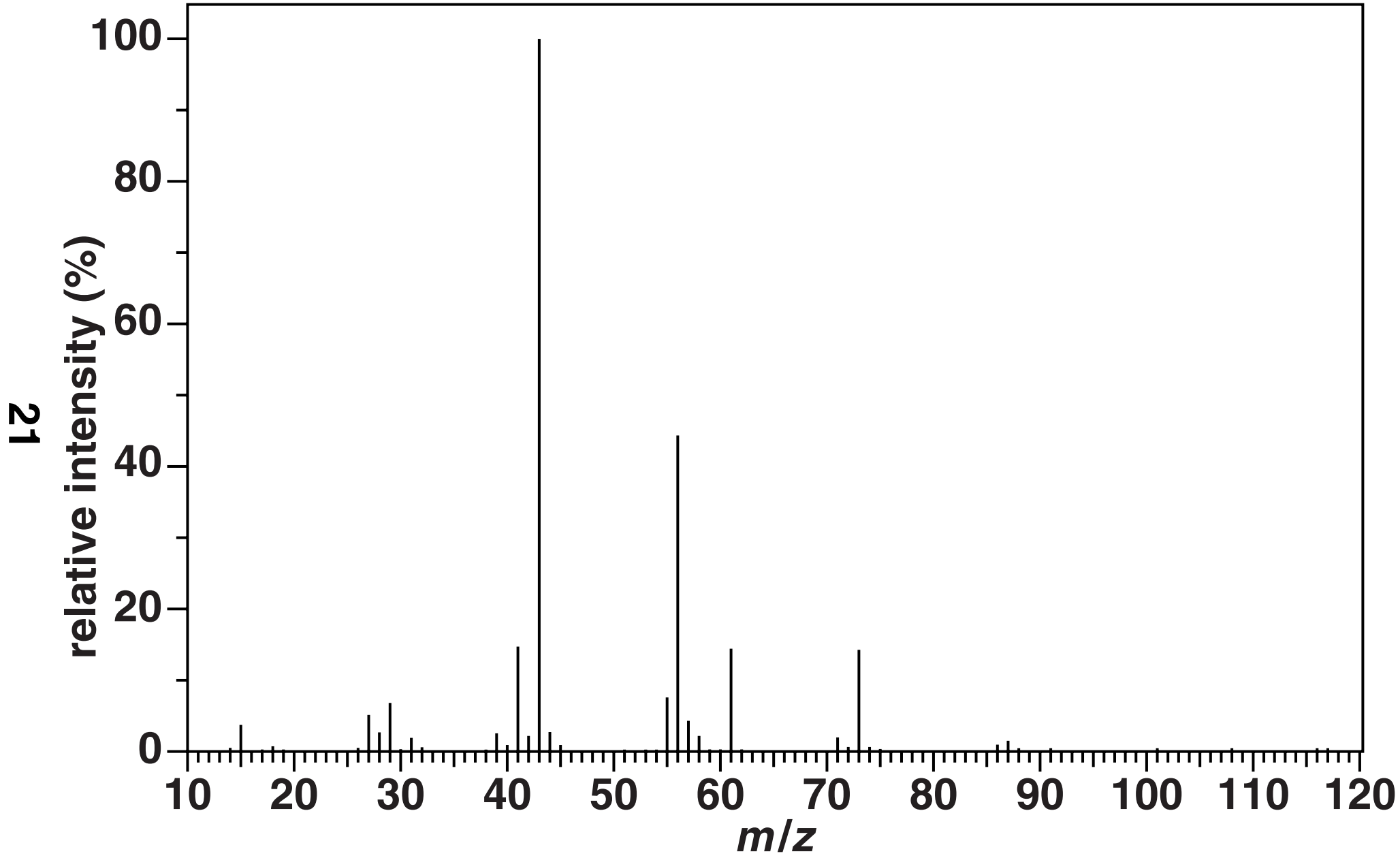
The mass spectrum of the ester is shown opposite.

(ii) Suggest formulae for the following:

the chemical species responsible for the peak at *m/z* 73,

the species LOST from the molecular ion to form this chemical species.

Write your answers in the table on page 22.


21
relative intensity (%)
100
80
60
40
20
0
10
20
30
40
50
60
70
80
90
100
110
120
m/z

	FORMULA
SPECIES WHICH GIVES THE PEAK AT *m/z* 73	
SPECIES LOST FROM THE MOLECULAR ION	

[3]

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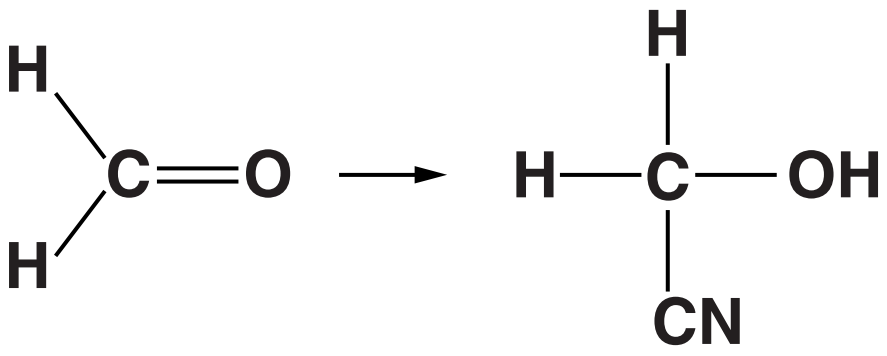
(e) Glycolic acid can be made from methanal. Methanal is first reacted with cyanide ions in aqueous solution to form a cyanohydrin.



(i) Underline TWO of the following words which describe the mechanism of the reaction described above. [2]

ADDITION CONDENSATION

ELECTROPHILIC ELIMINATION

NUCLEOPHILIC RADICAL

SUBSTITUTION

(ii) **Describe the mechanism of the reaction using 'curly' arrows, bond polarities and relevant lone pairs of electrons.**

[5]

[TOTAL: 28]

3 DNA and proteins are polymers made up of long chains of monomer units. At one time proteins were considered more likely than DNA to transmit genetic data.

(a) (i) Name the monomer units in DNA and the components of which they are made.

_____

_____ [2]

(ii) Name the monomer units in proteins.

_____ [1]

(iii) Suggest why scientists once thought that proteins were more likely to transmit genetic data.

_____

_____

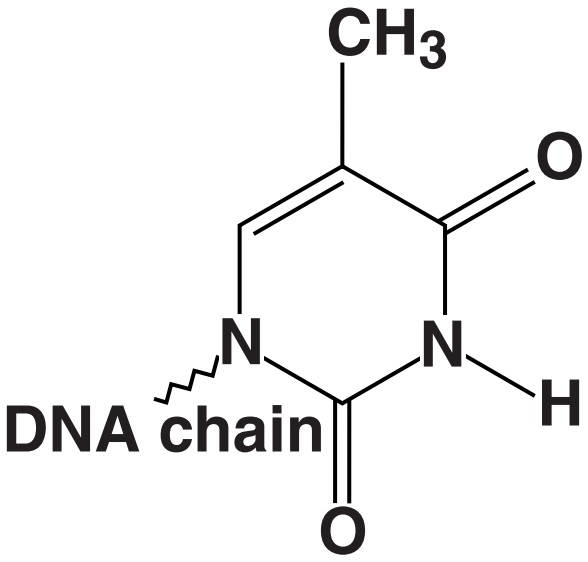
_____

_____ [2]

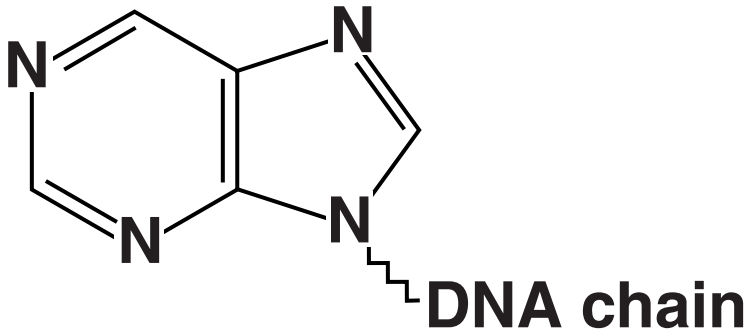
(b) **Hydrogen bonding is important in base pairing in DNA.**

Complete the structure of adenine in the diagram below using your Data Sheet. Show how adenine hydrogen bonds with thymine.

Show any relevant lone pairs of electrons and partial charges.



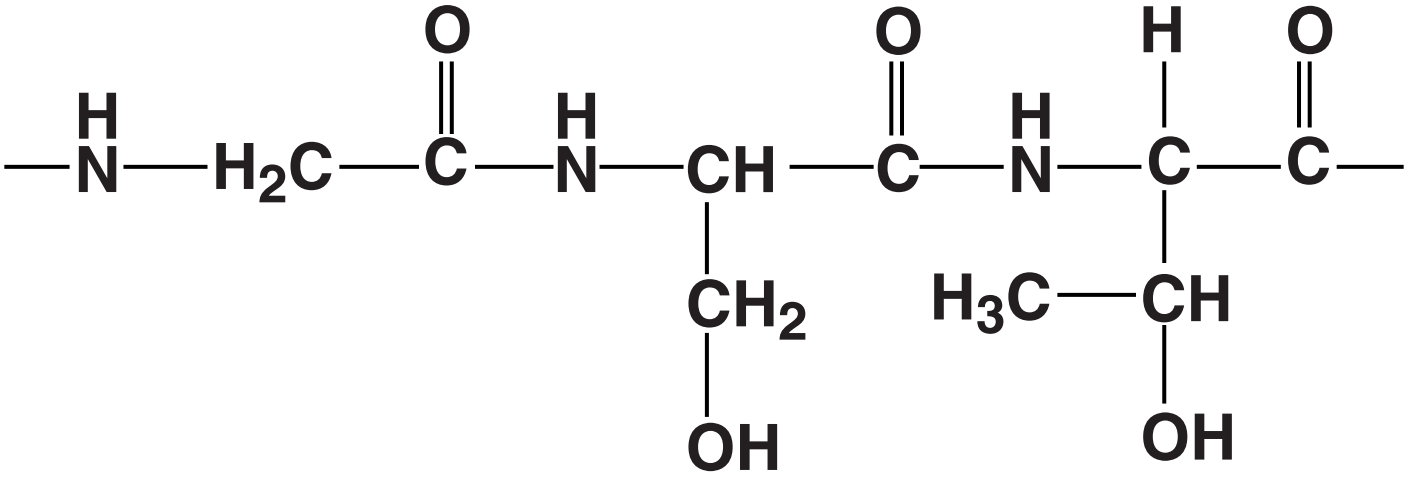
THYMINE



ADENINE

[3]

(c) The diagram below shows part of the primary structure of an enzyme.



(i) On the diagram circle TWO chiral carbon atoms. [1]

(ii) Proteins are hydrolysed by refluxing with aqueous NaOH.

On the diagram above draw arrows pointing to the bonds that will break in the two FULL peptide links in the structure. [1]

(iii) Draw the structural formula of the complete ion formed by breaking THESE peptide links in ALKALINE solution.

[2]

(iv) As well as having a primary structure, enzymes also have secondary and tertiary structures.

What is meant by the secondary structure and the tertiary structure of an enzyme?

secondary _____

_____

tertiary _____

_____ [2]

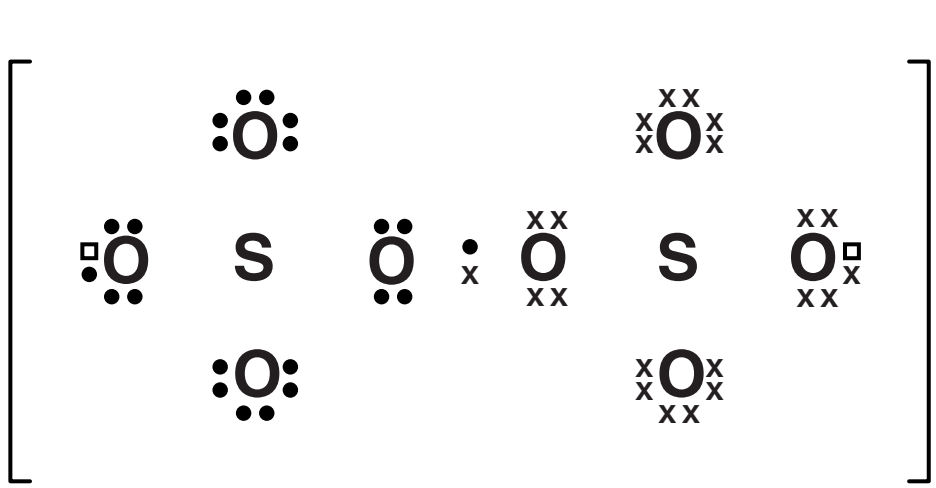
[TOTAL: 14]

4 **A common way of cleaning laboratory glassware is by dipping it in a bath containing acidified potassium dichromate(VI), often called chromic acid, which is a powerful oxidising agent. However, such use of compounds containing heavy metal ions is considered hazardous.**

'Nochromix®' is a metal-free alternative to chromic acid. It consists of ammonium peroxodisulfate crystals. These are white crystals that are very soluble in water, forming a solution which can also act as a strong oxidising agent.

(a) The diagram shows the arrangement of atoms in a peroxodisulfate ion, $S_2O_8^{2-}$.

(i) Complete the diagram to show a 'dot-and-cross' representation of the peroxodisulfate ion.



▫ represents the extra electrons required to form the ion

[2]

(ii) Give the formula of ammonium peroxodisulfate.

_____ [1]

(b) Use the data in the table below to decide which of the two oxidising agents, $Cr_2O_7^{2-}/H^+$ and $S_2O_8^{2-}$, is the stronger under standard conditions.

Give your reasoning.

HALF-REACTION	$E^{\ominus}$/V
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$	+1.33
$S_2O_8^{2-} + 2e^- \rightarrow 2SO_4^{2-}$	+2.01

_____

_____

_____ [2]

(c) Peroxodisulfate ions will oxidise iodide ions to iodine in an aqueous solution. The half-equations are shown below.

$S_2O_8^{2-} + 2e^- \rightarrow 2SO_4^{2-}$

$2I^- \rightarrow I_2 + 2e^-$

(i) Write an ionic equation for the reaction between peroxodisulfate and iodide ions.

State symbols are not required.

→

[1]

(ii) A student investigates the rate of this reaction at room temperature by using a colorimeter.

The student performs one experiment only in which a large excess of peroxodisulfate ions to iodide ions is used.

The student has a flask in which the reagents are mixed.

Describe how the student could use a colorimeter to measure the concentrations of iodine in the flask as the reaction proceeds.

In your answer:

Describe the procedures the student would carry out. Assume that samples of required solutions are available.

State the measurements that would be recorded and indicate how these can be converted into concentrations of iodine.

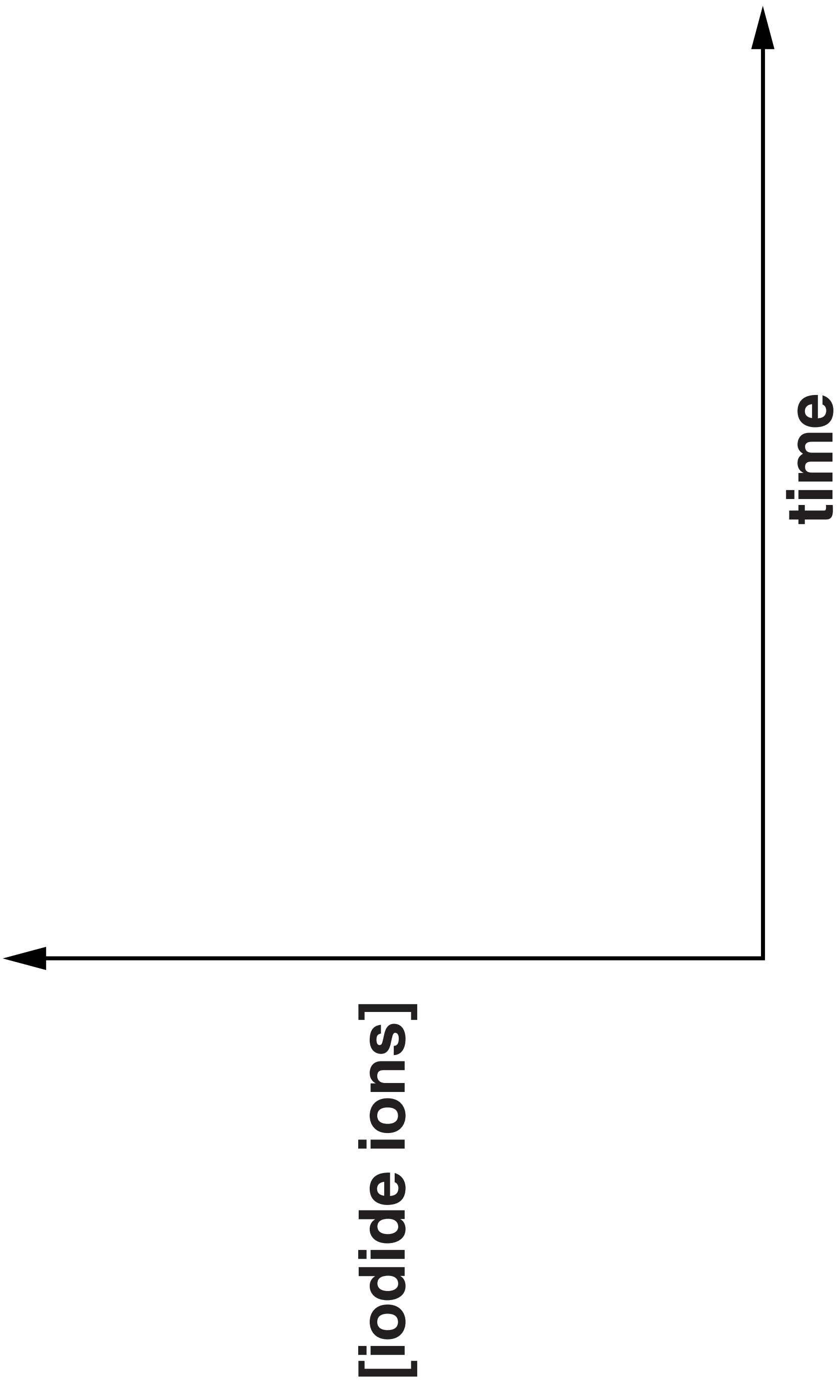
In your answer you should use technical terms spelled correctly.

[6]

(iii) The student converts the concentrations of iodine into concentrations of iodide remaining.

The student then uses a time–concentration graph to show that the reaction is first-order with respect to iodide ions.

Sketch a curve and indicate on the graph opposite how the reaction can be shown to be first-order. [3]


time
[iodide ions]

(d) The student investigates whether transition metal ions would catalyse the reaction between $S_2O_8^{2-}$ and I^- ions. The student uses the data in the table below to decide if the use of Fe^{3+} ions might speed the reaction up.

HALF-REACTION	$E^{\ominus}$/V
$I_2 + 2e^- \rightarrow 2I^-$	+0.54
$Fe^{3+} + e^- \rightarrow Fe^{2+}$	+0.77
$S_2O_8^{2-} + 2e^- \rightarrow 2SO_4^{2-}$	+2.01

(i) Name the TYPE of catalysis the student is investigating.

Give a reason for your answer.

_____

_____ [1]

(ii) Complete the electron structures for Fe^{2+} and Fe^{3+}.

Fe^{2+} $1s^2 2s^2 2p^6$ _____

Fe^{3+} $1s^2 2s^2 2p^6$ _____ [2]

(iii) Use the table of data to explain why adding Fe^{3+} ions to the mixture of I^- and $S_2O_8^{2-}$ ions provides an alternative route for this reaction.

Include ionic equations for any reactions you describe.

In your answer you should explain how the data from the table are linked to the reactions you describe.

_____

_____

_____

_____

[6]

BLANK PAGE

(e) The student's results for the uncatalysed reaction are given opposite.

(i) Complete the rate equation for the reaction. [2]

Rate = k ×

(ii) Calculate the rate constant, k, for the reaction and give its units.

k = _____

units _____ [3]

45

EXPERIMENT	$[S_2O_8^{2-}]$ /mol dm^{-3}	$[I^-]$ /mol dm^{-3}	RATE OF FORMATION OF IODINE, I_2 /mol dm^{-3} s^{-1}
1	0.075	0.040	2.0×10^{-5}
2	0.150	0.040	4.0×10^{-5}
3	0.075	0.020	1.0×10^{-5}

(iii) What would be the rate of DISAPPEARANCE OF I^- in experiment 3?

_____ [2]

[TOTAL: 31]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

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

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