UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **9701/04**

Paper 4 Structured Questions **October/November 2008**

1 hour 45 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

Section B
Answer **all** questions.

You may lose marks if you do not show your working or if you do not use appropriate units.
A Data Booklet is provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
Total	

This document consists of **18** printed pages and **2** blank pages.

UNIVERSITY of CAMBRIDGE International Examinations

For Examiner's Use

Section A

Answer **all** questions in the spaces provided.

1 **(a)** Natural bromine consists of the two isotopes ^{79}Br and ^{81}Br in roughly equal proportions.

The mass spectrum of bromine consists of 5 peaks.

(i) Suggest the mass numbers for the 5 peaks and the identities of the species responsible for them.

.....

.....

.....

(ii) Suggest the ratios of the relative abundances of

- the three lines with the highest mass numbers,

.....

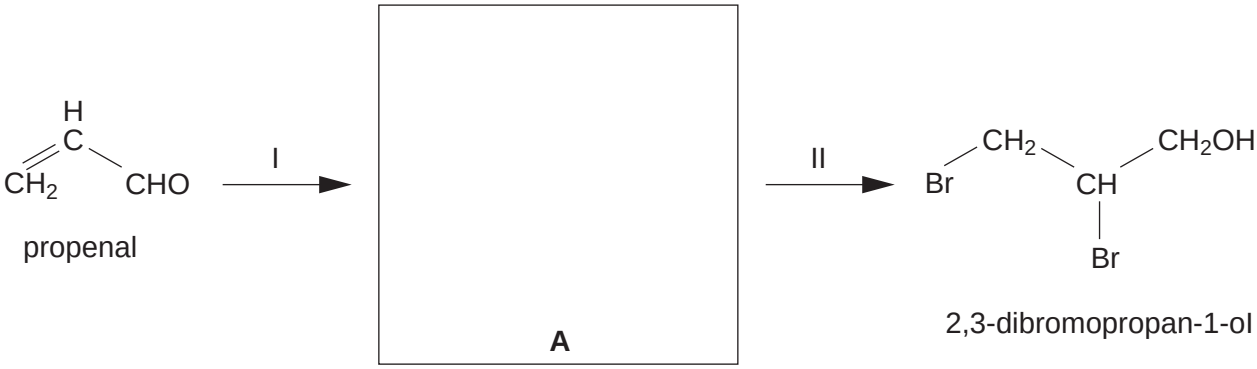
- the two lines with the lowest mass numbers.

.....

[4]

Esters of 2,3-dibromopropan-1-ol with phosphoric acid are useful flame retardants used in plastics and fibres.

2,3-dibromopropan-1-ol can be made from propenal by the following two-stage process.



For Examiner's Use

(b) (i) Draw the structure of the intermediate **A** in the box opposite.

(ii) Suggest reagents and conditions for

- reaction I,

.....

- reaction II.

.....

[3]

(c) The mass spectrum of 2,3-dibromopropan-1-ol includes the following peaks.

mass number	relative abundance
31	100
106	44
108	45
185	0.3
187	0.6
189	0.3

(i) At what mass number would you expect the molecular ion to occur?

.....

(ii) Identify the molecular formula (including isotopic composition where relevant) of these 6 peaks.

mass number	molecular formula
31	
106	
108	
185	
187	
189	

[5]

[Total: 12]

For Examiner's Use

2 In the late 19th century the two pioneers of the study of reaction kinetics, Vernon Harcourt and William Esson, studied the rate of the reaction between hydrogen peroxide and iodide ions in acidic solution.

$$H_2O_2 + 2I^- + 2H^+ \rightarrow 2H_2O + I_2$$

This reaction is considered to go by the following steps.

step **1** $H_2O_2 + I^- \rightarrow IO^- + H_2O$

step **2** $IO^- + H^+ \rightarrow HOI$

step **3** $HOI + H^+ + I^- \rightarrow I_2 + H_2O$

The general form of the rate equation is as follows.

$$\text{rate} = k[H_2O_2]^a[I^-]^b[H^+]^c$$

(a) Suggest how the appearance of the solution might change as the reaction takes place.

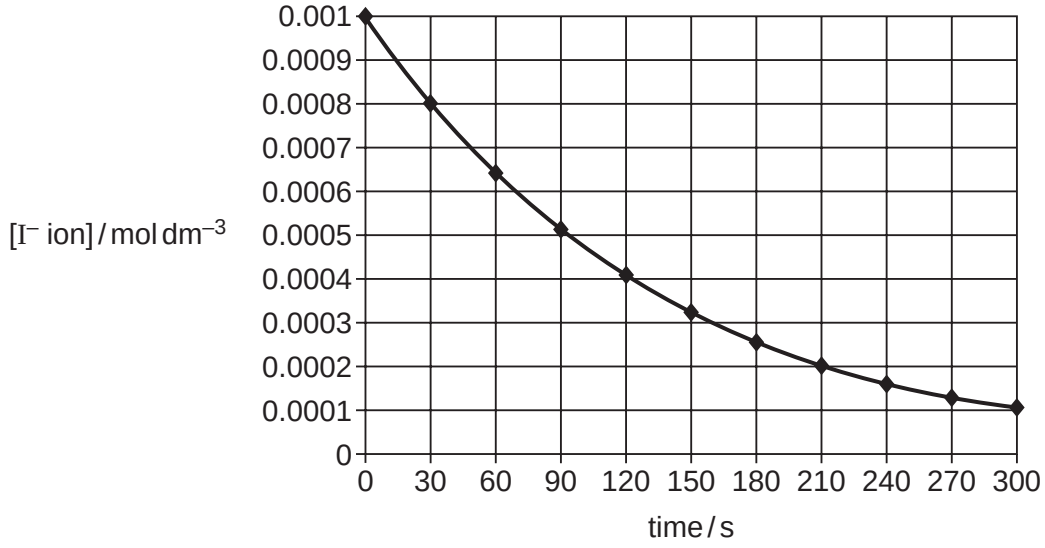
..... [1]

(b) Suggest values for the orders *a*, *b* and *c* in the rate equation for each of the following cases.

case	numerical value		
	a	*b*	*c*
step **1** is the slowest overall			
step **2** is the slowest overall			
step **3** is the slowest overall			

[3]

A study was carried out in which both $[H_2O_2]$ and $[H^+]$ were kept constant at 0.05 mol dm^{-3}, and $[I^-]$ was plotted against time. The following curve was obtained.



To gain full marks for the following answers you will need to draw relevant construction lines on the graph opposite to show your working. Draw them using a pencil and ruler.

(c) Calculate the initial rate of this reaction and state its units.

rate = ... units ..... [2]

(d) Use half-life data calculated from the graph to show that the reaction is first order with respect to $[I^-]$.

..... [2]

(e) Use the following data to deduce the orders with respect to $[H_2O_2]$ and $[H^+]$, explaining your reasoning.

$[H_2O_2]$ / mol dm^{-3}	$[H^+]$ / mol dm^{-3}	relative rate
0.05	0.05	1.0
0.07	0.05	1.4
0.09	0.07	1.8

.....

.....

order with respect to $[H_2O_2]$ = ...

order with respect to $[H^+]$ = ...

[2]

(f) From your results, deduce which of the three steps is the slowest (rate determining) step.

..... [1]

[Total: 11]

For Examiner's Use

3 **(a)** **(i)** Describe and explain the trend observed in the thermal stability of the carbonates of the Group II elements.

.....

.....

.....

.....

.....

(ii) By quoting suitable data from the *Data Booklet* suggest how the thermal stabilities of

- zinc carbonate and
- lead carbonate

might compare to that of calcium carbonate.

.....

.....

.....

.....

.....

[6]

(b) Malachite is an ore of copper. It contains the following percentages by mass.

copper	57.7%
oxygen	36.2%
carbon	5.4%
hydrogen	0.9%

Malachite reacts with dilute H_2SO_4 producing a gas **B** that turns limewater milky and leaving a blue solution **C**.

When heated in the absence of air, malachite produces gas **B** and steam, and leaves a black solid **D**. **D** reacts with dilute H_2SO_4 to produce the same blue solution **C**.

Adding iron filings to **C** produces a pink solid **E** and a pale green solution **F**.

(i) Calculate the empirical formula of malachite.

.....

For Examiner's Use

(ii) Suggest the formula of the ion responsible for the blue colour of solution **C**.

.....

(iii) Identify the black solid **D** and calculate the mass of **D** that could be obtained by heating 10 g of malachite.

.....

.....

.....

.....

(iv) Use data from the *Data Booklet* to identify the pink solid **E** and the solution **F**, and suggest an equation for the reaction producing them.

.....

.....

.....

(v) What type of reaction is the reaction that produces **E** and **F**?

.....

(vi) Describe and explain what you would see happen when dilute NH_3(aq) is added slowly to the solution **C** until it is in an excess.

.....

.....

.....

.....

.....

[13]

[Total: 19]

For Examiner's Use

4 **(a)** The viscosity of engine oil can be improved by the addition of certain medium chain-length polymers.

A portion of the chain of one such polymer is shown below.

$$-CH_2CH(CH_2CH_2CH_3)CH_2CH(CH_2CH_2CH_3)CH_2-$$

On average, the molecules of the medium-chain polymer contain 40 carbon atoms.

(i) Suggest the structure of the monomer.

.....

(ii) How many monomer units are incorporated into the average molecule of the polymer?

.....

[2]

(b) Used car engine oil can be recycled for use as a fuel by the processes of distillation and cracking.

(i) Assuming a typical molecule of engine oil has the formula $C_{40}H_{82}$, suggest an equation for a cracking reaction that could produce diesel fuel with the formula $C_{16}H_{34}$ and other hydrocarbons only.

.....

(ii) What conditions are needed for this cracking reaction?

.....

(iii) Considering only the bonds broken and the bonds formed during the reaction, use the *Data Booklet* to calculate the enthalpy change for the reaction you wrote in **(b)(i)**.

.....

.....

.....

(iv) Comment on how the conditions you described in **(b)(ii)** relate to the enthalpy change you calculated in **(b)(iii)**.

.....

.....

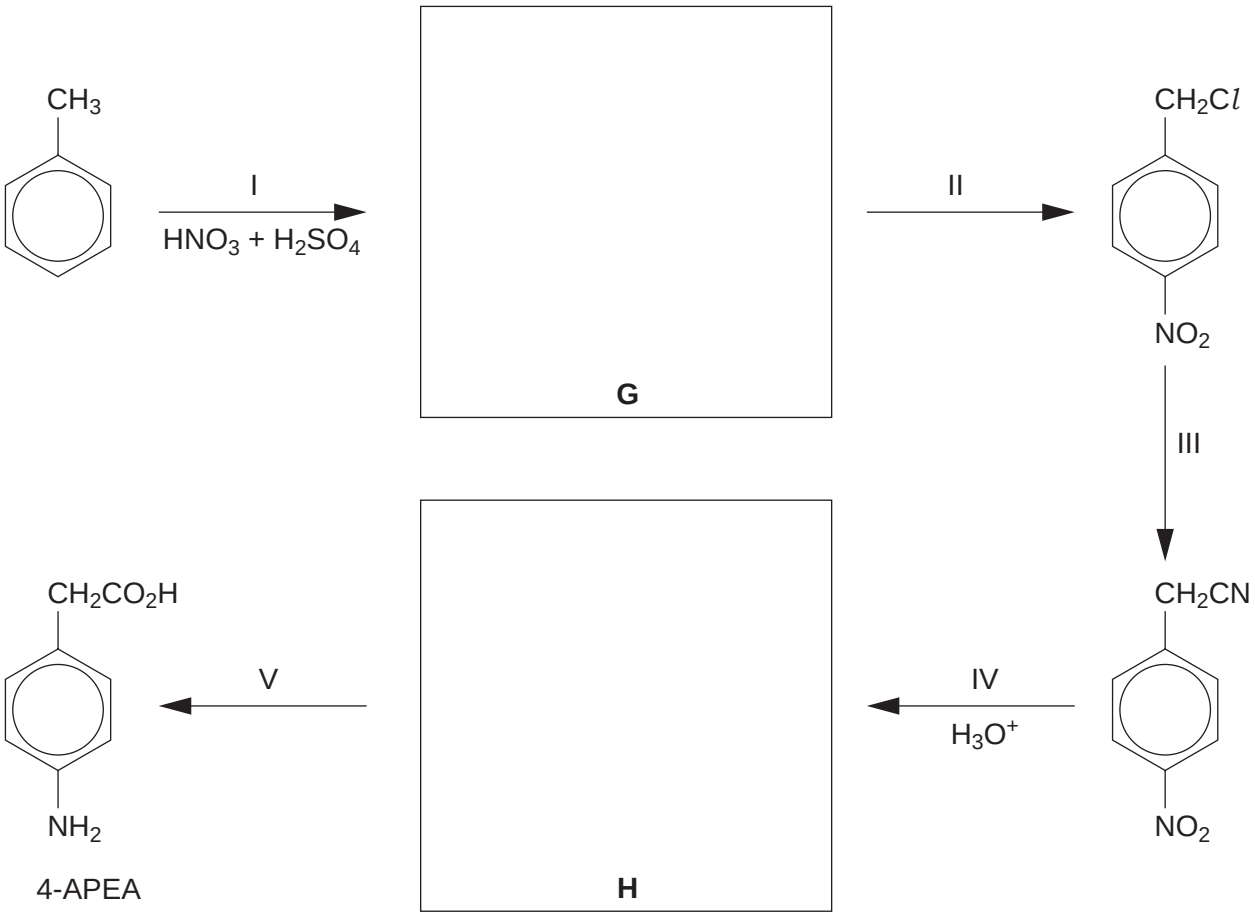
[4]

[Total: 6]

For Examiner's Use

5 (4-aminophenyl)ethanoic acid (4-APEA) and its derivatives are being investigated as possible drugs to treat chronic inflammation of the intestines.

The synthesis of 4-APEA from methylbenzene is shown in the following scheme.



(a) Draw the structures of the compounds **G** and **H** in the boxes above. [2]

(b) Suggest reagents and conditions for the following steps.

- step II

.....

- step III

.....

- step V

.....

[3]

[Total: 5]

For Examiner's Use

6 Suggest a test or simple reaction you could carry out on each of the following pairs of compounds to enable them to be distinguished.

(a) $CH_3COCH_2CH_2CH_3$ **J** $CH_3CH_2COCH_2CH_3$ **K**

(i) description of test or reaction

.....

.....

(ii) observation with compound **J**

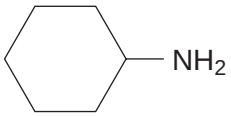
.....

(iii) observation with compound **K**

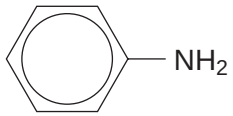
.....

[2]

(b)



L



M

(i) description of test or reaction

.....

.....

(ii) observation with compound **L**

.....

(iii) observation with compound **M**

.....

[2]

For Examiner's Use

(c) CH_3CH_2COCl $CH_3CH_2CH_2Cl$

N **P**

(i) description of test or reaction

.....

.....

(ii) observation with compound **N**

.....

(iii) observation with compound **P**

.....

[2]

(d) $CH_3CH_2CONH_2$ $CH_3CH_2CH_2NH_2$

Q **R**

(i) description of test or reaction

.....

.....

(ii) observation with compound **Q**

.....

(iii) observation with compound **R**

.....

[2]

[Total: 8]

For Examiner's Use

7 **(a)** Explain briefly what is meant by the word *protein*.

.....

..... [1]

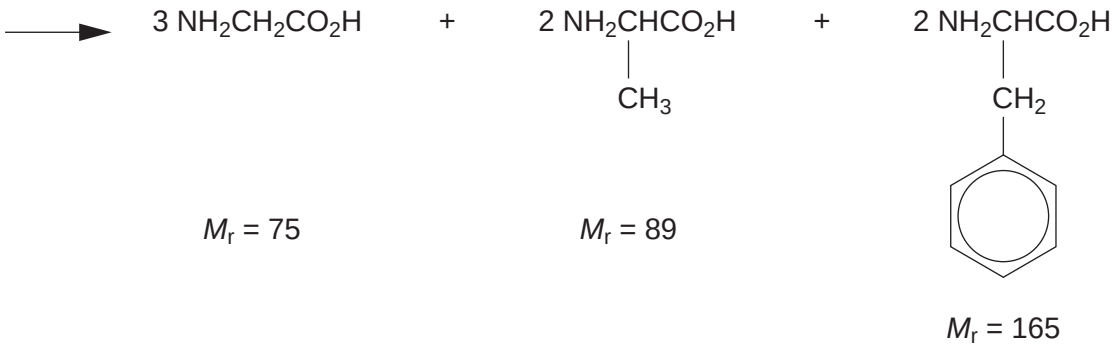
(b) Describe how peptide bonds are formed between amino acids during the formation of a tripeptide. Include diagrams and displayed formulae in your answer.

..... [3]

(c) Describe how proteins can be broken down into amino acids in the laboratory **without** the aid of enzymes.

..... [2]

(d) When a small polypeptide **S** was broken down in this way, three different amino acids were produced according to the following reaction.



(i) How many peptide bonds were broken during this reaction?

.....

(ii) Calculate the M_r of the polypeptide **S**.

M_r = ...
[3]

[Total: 9]

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[Turn over

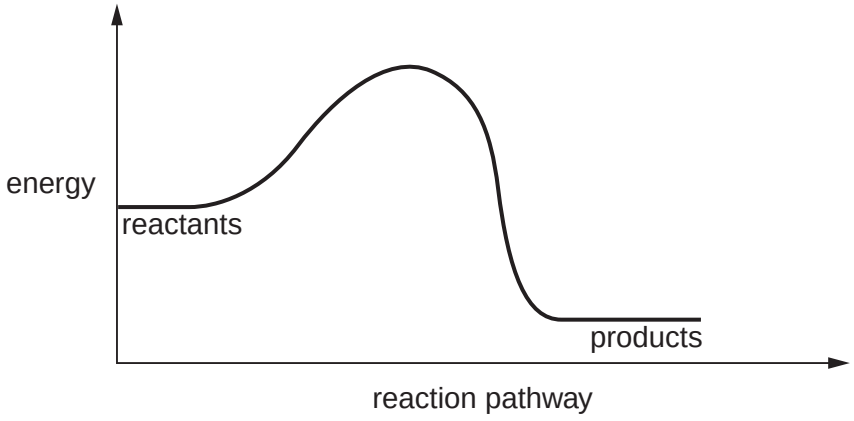
For Examiner's Use

Section B – Applications of Chemistry

Answer **all** questions in the spaces provided.

8 **(a)** Enzymes play a vital role in all living organisms, helping chemical reactions to take place at body temperature.

(i) The diagram below shows the reaction pathway of an enzyme-catalysed reaction without an enzyme present. On the diagram sketch the pathway if the enzyme was present.



(ii) What type of molecule are most enzymes?

.....

(iii) Why do many enzymes lose their catalytic effectiveness above 40 °C?

.....

[3]

(b) **(i)** Explain the difference between competitive and non-competitive inhibition of an enzyme.

.....

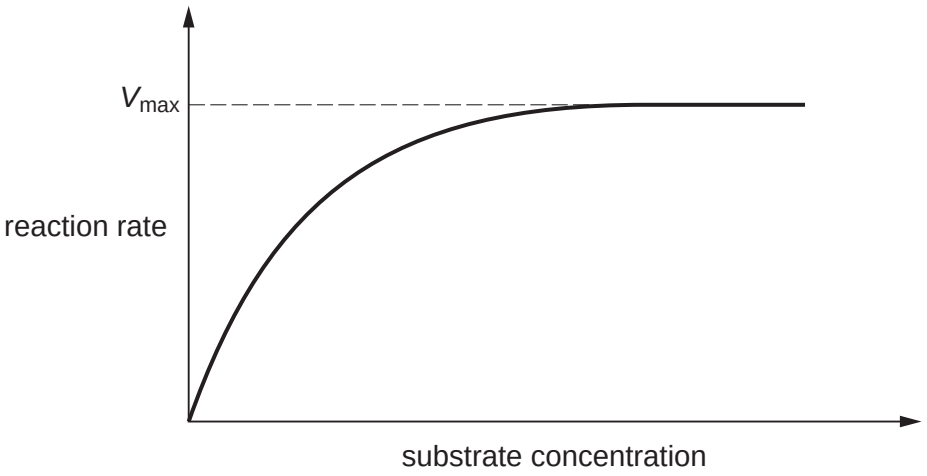
.....

.....

For Examiner's Use

(ii) The graph below shows how the rate of an enzyme-catalysed reaction varies with substrate concentration in the absence of an inhibitor.

For a given amount of enzyme, V_{max} represents the rate when all of the active sites on the enzyme are being used.



Sketch on the diagram curves to show the effect on the rate of reaction of:

I a competitive inhibitor;

II a non-competitive inhibitor.

Clearly label your curves.

[4]

(c) Heavy metal ions like Hg^{2+} can bind irreversibly to enzymes and this can result in poisoning.

(i) Suggest to what atom or group Hg^{2+} ions bind.

.....

(ii) Explain how this affects enzyme activity.

.....

.....

.....

[3]

[Total: 10]

For Examiner's Use

9 The technology of DNA fingerprinting has enormously advanced scientific identification techniques in medicine, crime detection and archaeology in recent years.

(a) (i) In order to prepare a DNA sample for analysis, the DNA is treated with restriction enzymes. What do restriction enzymes do?

.....

.....

(ii) What is the next stage in DNA analysis, after the treatment with restriction enzymes?

.....

(iii) How are the DNA fragments made visible?

.....

[3]

(b) NMR and X-ray crystallography have made significant contributions to our knowledge of the structure of proteins and, in the pharmaceutical industry, how drugs react with target proteins.

(i) Suggest an advantage of **each** technique in helping to determine protein structure.

.....

.....

.....

(ii) MRI scanning is a medical technique based on NMR spectroscopy. It is particularly useful for looking for tumours in healthy tissue.

Suggest how this technique can distinguish tumour tissue from healthy tissue.

.....

.....

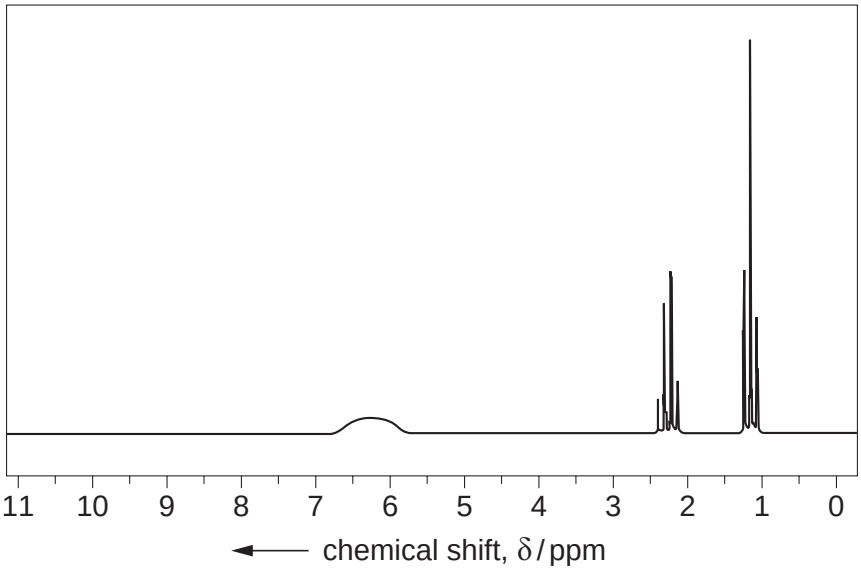
[3]

For Examiner's Use

(c) A saturated molecule of formula C_xH_yNO was subjected to analysis by mass spectrometry and NMR spectroscopy. In the mass spectrum of the compound, the M peak was at *m/e* 73 and the ratio of the heights of the M:M+1 peak was 48 : 1.7.

(i) Using the data from the mass spectrum, determine the values of *x* and *y* in the formula of the compound.

(ii) Use the data from **(i)** together with the NMR spectrum below to deduce a structure for the compound, explaining how you arrive at your answer.

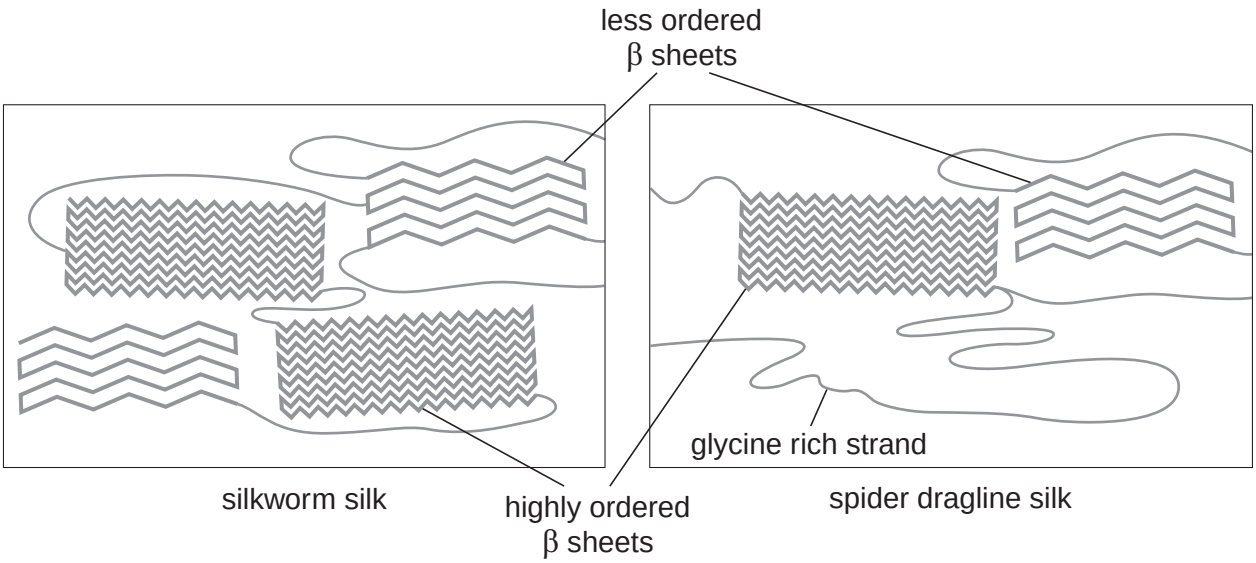


[4]

[Total: 10]

For Examiner's Use

10 **(a)** Silk from silkworms, used as a fabric shows a different secondary structure to that produced by spiders.



(i) What sort of bonding would you expect to occur between adjacent parts of the protein chains in each form of silk?

silkworm .....

spider .....

(ii) Suggest **two** differences in properties that these forms of silk could have. Explain your answer.

.....

.....

.....

.....

(iii) Spider dragline silk contains large amounts of the amino acid glycine. How does this affect the properties of the silk?

.....

.....

[5]

For Examiner's Use

(b) Both forms of silk are condensation polymers.

(i) Explain what is meant by a condensation polymer.

.....

.....

(ii) Another type of polymer is called an addition polymer. Name an example of an addition polymer.

.....

(iii) Suggest why condensation polymers such as proteins show a wider range of properties than addition polymers.

.....

.....

.....

.....

.....

[5]

[Total: 10]

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