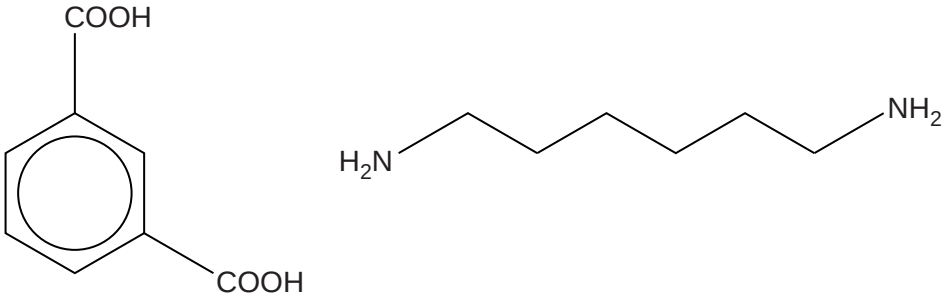
Answer **all** the questions.

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 above 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.

.....

.....

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.....

.....

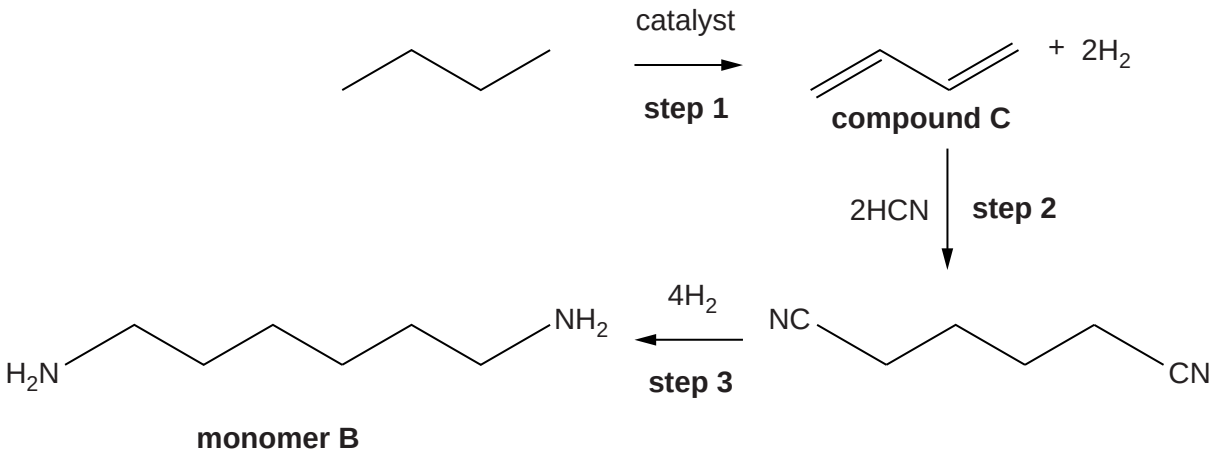
..... **[3]**

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

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

Turn over

(d) In the manufacture of PPA, monomer **B** can be made from butane by the following 3-step process.



monomer B

(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]

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

.....

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

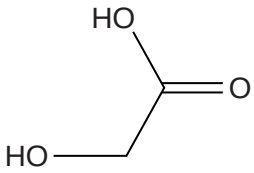
(e) In some countries, compound **C** is synthesised by first converting ethanol into CH_3CHO.

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.

$CH_2OHCOOH$ + →

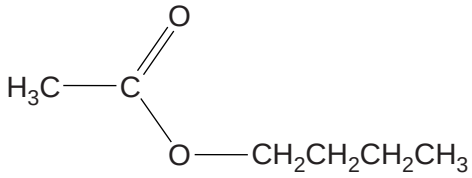
[1]

(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**.

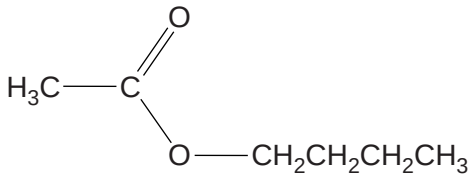
ethanoic acid .....

.....

compound **D** .....

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

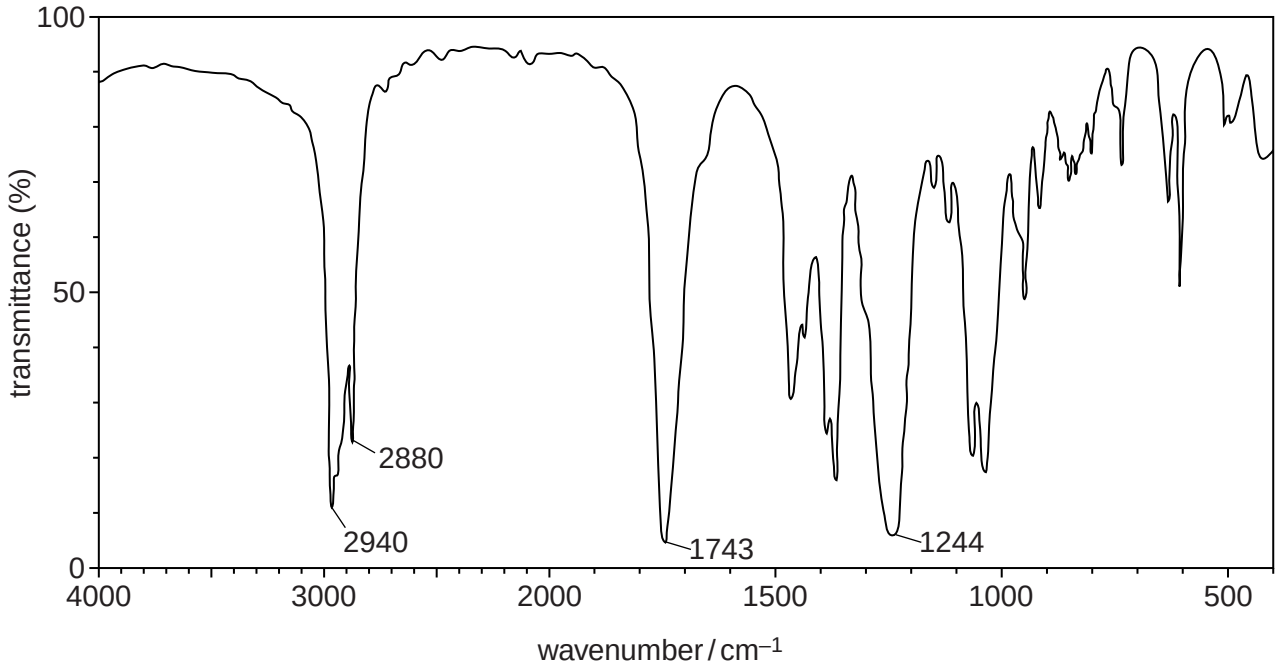
Turn over



compound D

(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 below.



(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.

.....

.....

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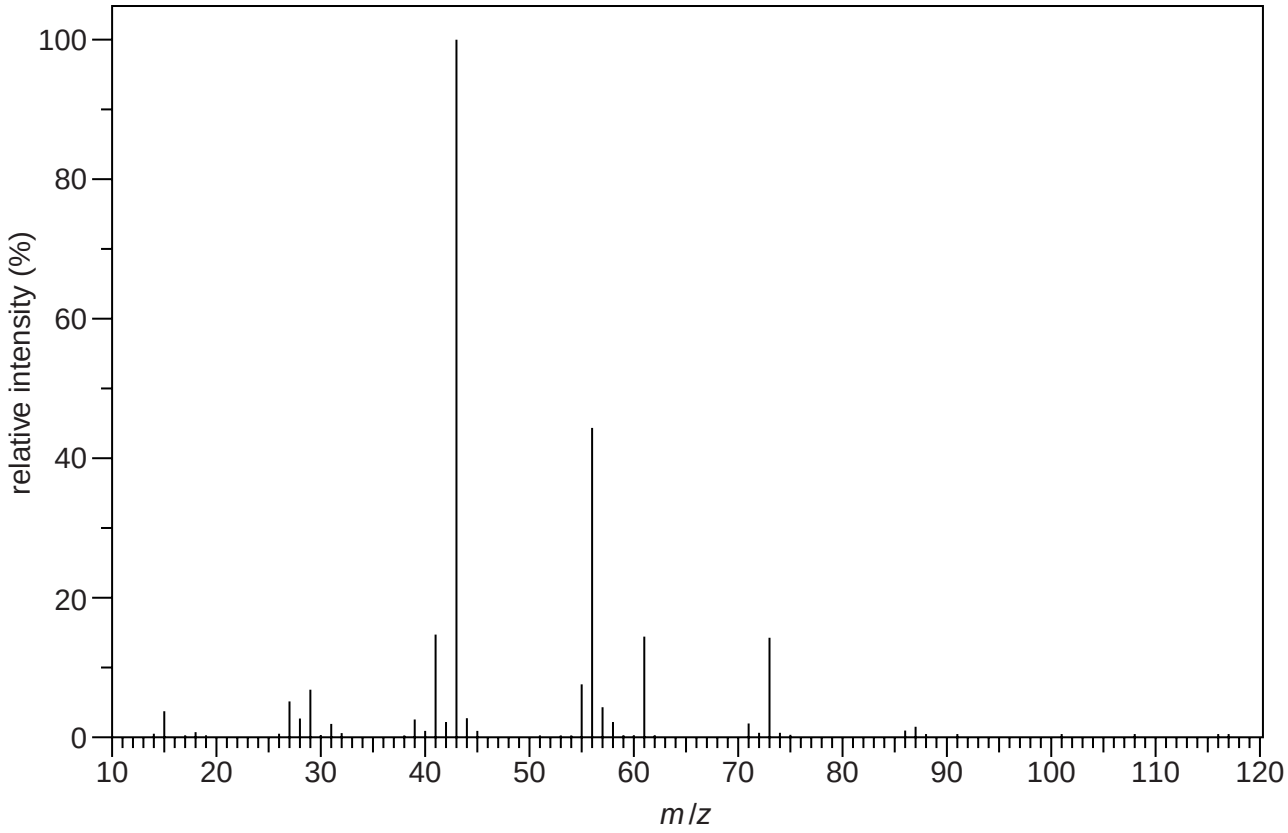
.....

.....

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

The mass spectrum of the ester is shown below.



(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.

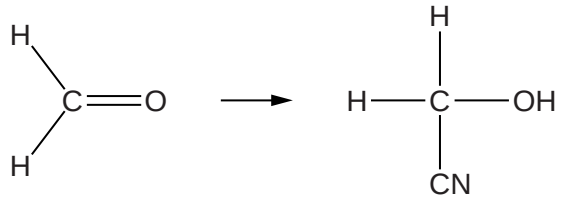
Write your answers in the table below the working space.

	Formula
Species which gives the peak at *m/z* 73	
Species lost from the molecular ion	

[3]

Turn over

(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.

addition **condensation** **electrophilic** **elimination**

nucleophilic **radical** **substitution**

[2]

(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.

.....

.....

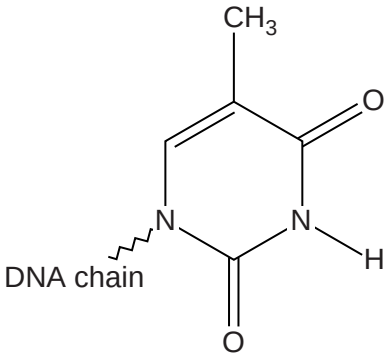
.....

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

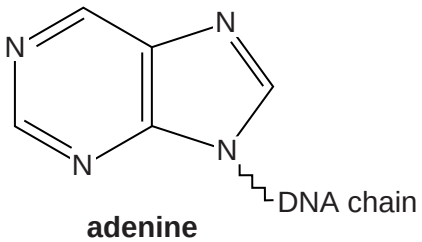
(b) Hydrogen bonding is important in base pairing in DNA.

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.



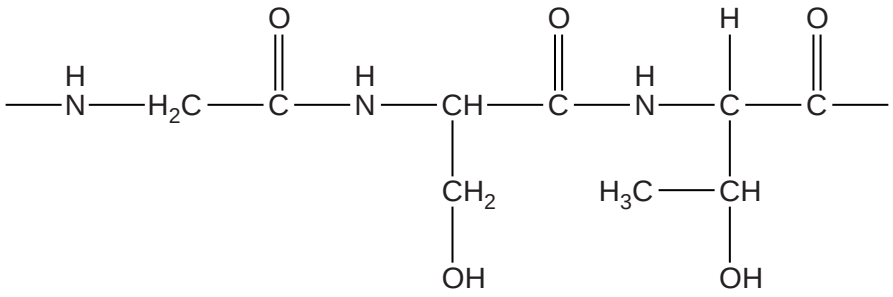
thymine



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]**

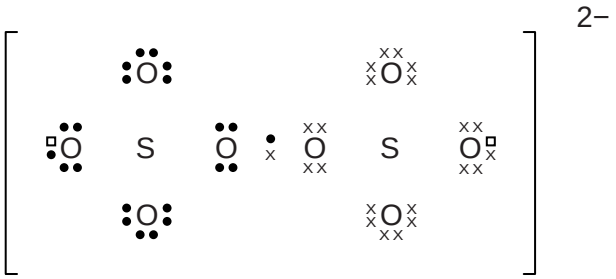
[Total: 14]

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]**

Turn over

(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.

$\rightarrow$

[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.

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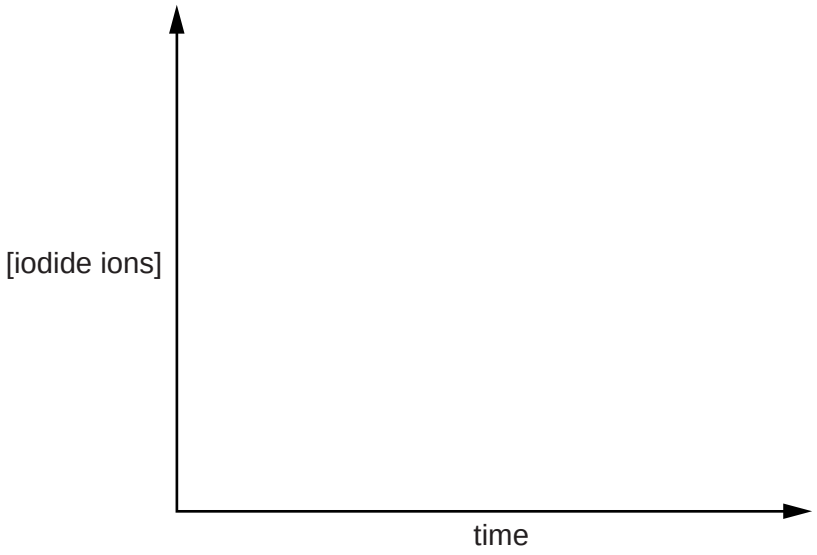
..... **[6]**

(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 how the reaction can be shown to be first-order.



[3]

Question 4 continues on page 16

(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
$I_2 + 2e^- \longrightarrow 2I^-$	+0.54
$Fe^{3+} + e^- \longrightarrow Fe^{2+}$	+0.77
$S_2O_8^{2-} + 2e^- \longrightarrow 2SO_4^{2-}$	+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.

.....

.....

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.....

..... **[6]**

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

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}

(i) Complete the rate equation for the reaction.

Rate = k × **[2]**

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

k = ... units ..... **[3]**

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

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

[Total: 31]

END OF QUESTION PAPER