OCR
RECOGNISING ACHIEVEMENT

Monday 14 January 2013 – Afternoon

A2 GCE CHEMISTRY A

F324/01 Rings, Polymers and Analysis

F3144601 13

Candidates answer on the Question Paper.

OCR supplied materials:
- *Data Sheet for Chemistry A* (inserted)

Other materials required:
- Scientific calculator

Duration: 1 hour 15 minutes

F 3 2 4 0 1

Candidate forename		Candidate surname	

Centre number						Candidate number				

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 above. 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.
- Do **not** write in the bar codes.

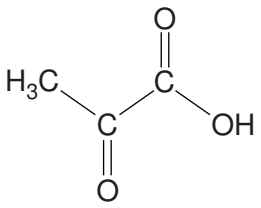
INFORMATION FOR CANDIDATES

- 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 A* 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 **60**.
- This document consists of **20** pages. Any blank pages are indicated.

© OCR 2013 [M/500/7836]
OCR is an exempt Charity

Answer **all** the questions.

1 Pyruvic acid, shown below, is an organic compound that has a smell similar to ethanoic acid. It is extremely soluble in water.



pyruvic acid

(a) Explain why pyruvic acid is soluble in water.

Use a labelled diagram to support your answer.

.....

.....

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

(b) Pyruvic acid can be prepared in the laboratory by reacting propane-1,2-diol with excess acidified potassium dichromate(VI). The reaction mixture is heated under reflux.

Write an equation for this oxidation.

Use **[O]** to represent the oxidising agent and show structural formulae for organic compounds.

[2]

© OCR 2013

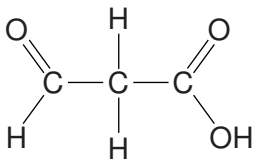
(c) Pyruvic acid can also be reduced by $NaBH_4$ to form $CH_3CH(OH)COOH$.

Outline the mechanism for this reduction.

Use curly arrows and show relevant dipoles.

[4]

(d) Compound **A**, shown below, is a structural isomer of pyruvic acid.



compound A

Describe a chemical test that could be carried out in a laboratory to distinguish between samples of pyruvic acid and compound **A**.

Your answer should include reagents, observations, the type of reaction and the organic product formed.

In your answer, you should use appropriate technical terms, spelled correctly.

.....

.....

.....

.....

.....

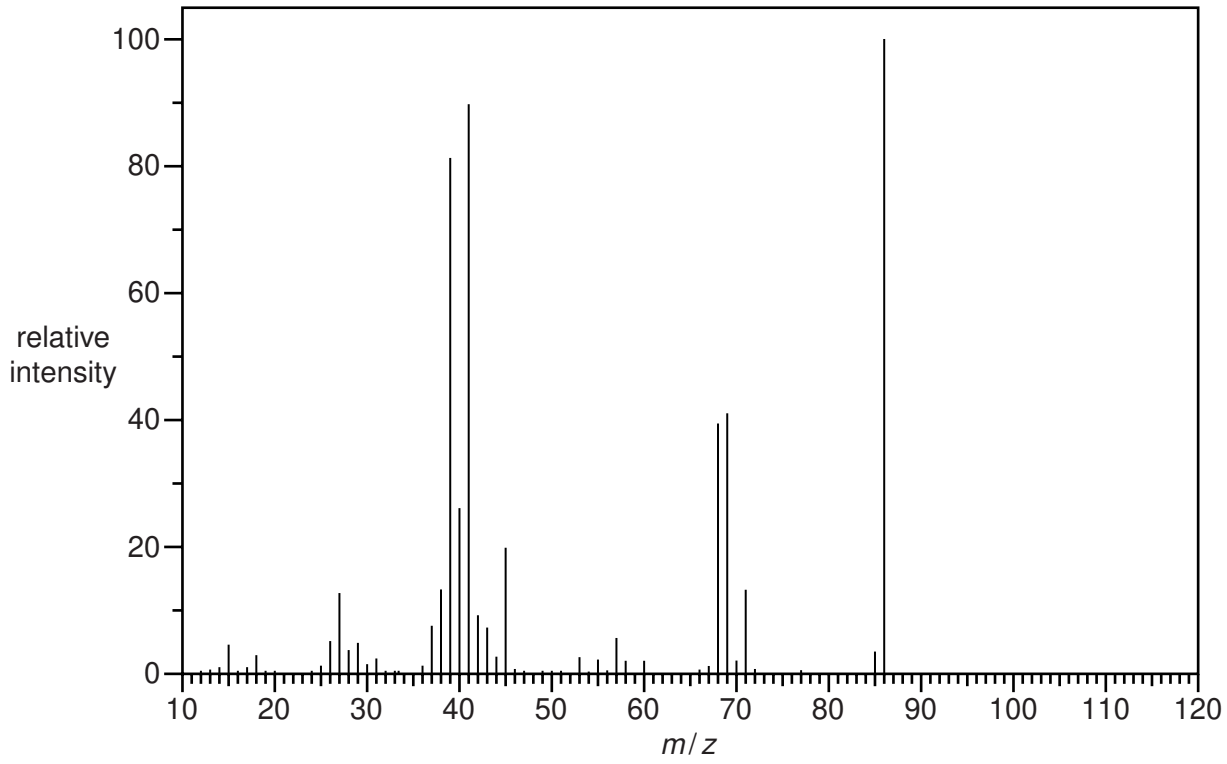
..... **[3]**

© OCR 2013

(e) Compound **B** is an organic compound used to make some cosmetics.

Compound **B** contains C, H and O only. Elemental analysis shows that **B** has the percentage composition by mass: C, 55.81%; H, 7.02%; O, 37.17%.

The mass spectrum of compound **B** is shown below.



(i) Determine the **molecular** formula of compound **B**.

Show all of your working.

molecular formula of compound **B** = ... **[2]**

© OCR 2013

(ii) Compound **B** is an *E*-stereoisomer.

Compound **B** effervesces with aqueous Na_2CO_3 to form organic compound **C**.

Compound **B** decolourises Br_2 to form compound **D**.

Compound **B** polymerises to form polymer **E**.

In the boxes below:

- draw structures for compounds **B**, **C** and **D**.
- draw **one** repeat unit for polymer **E**.

compound B

compound C

compound D

one repeat unit of polymer E

[4]

[Total: 17]

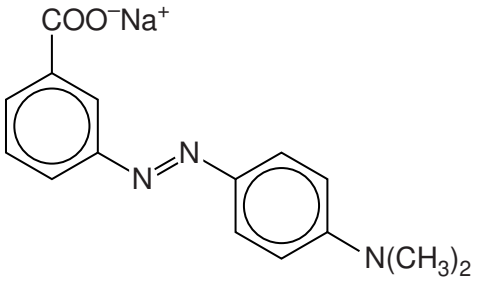
© OCR 2013

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

© OCR 2013

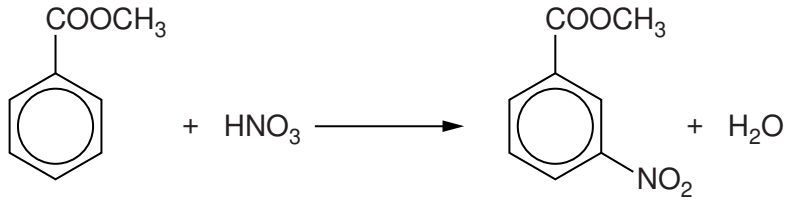
2 A chemist is developing a new azo dye. The structure of this dye is shown below.



azo dye

(a) In the first stage of the synthesis of this dye, methyl 3-nitrobenzoate is formed.

In this stage, methyl benzoate is nitrated by concentrated nitric acid, in the presence of concentrated sulfuric acid as a catalyst.



methyl benzoate **methyl 3-nitrobenzoate**

(i) Outline the mechanism for this nitration of methyl benzoate.

Show how H_2SO_4 behaves as a catalyst.

[5]

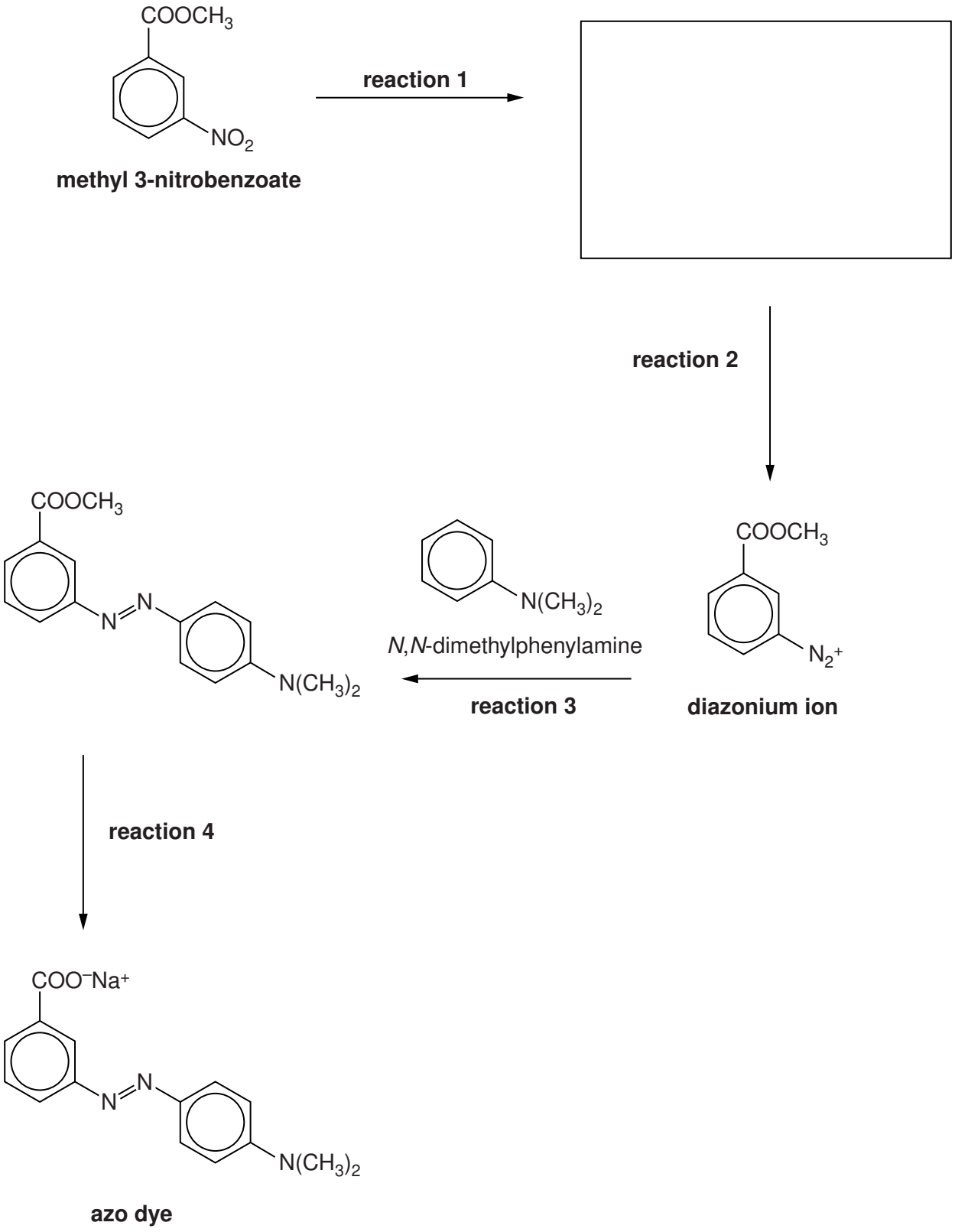
(ii) State the name for this type of mechanism.

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

© OCR 2013

(b) Methyl 3-nitrobenzoate can be converted into the azo dye in a multi-step synthesis.

The multi-step synthesis is shown in the flowchart below.



© OCR 2013

(i) In the flowchart on page 8, draw the structure of the organic product of **reaction 1**. **[1]**

(ii) Suggest the reagents for **reaction 1**, and the reagents and conditions for **reactions 2** and **4**.

reaction 1 .....

.....

reaction 2 .....

.....

.....

reaction 4 .....

.....

[4]

(iii) The reactions of aromatic amines with bromine and with diazonium ions are similar to those of phenol with bromine and with diazonium ions.

In **reaction 3**, suggest why *N,N*-dimethylphenylamine reacts with the diazonium ion, but benzene would **not** react.

Explain your answer.

In your answer, you should use appropriate technical terms, spelled correctly.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

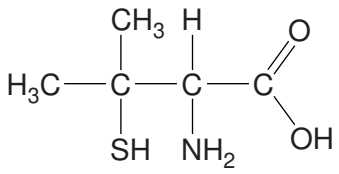
[3]

[Total: 14]

© OCR 2013

3 Penicillamine is an α-amino acid that is used as a drug to treat rheumatoid arthritis.

The structure of penicillamine is shown below.



penicillamine

(a) Explain why penicillamine is described as an *α-amino acid.*

.....

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

(b) Penicillamine exists as a zwitterion in aqueous solution.

(i) Draw the structure of this zwitterion.

[1]

(ii) Dilute aqueous acid is added to an aqueous solution of penicillamine.

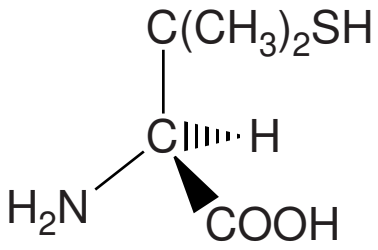
Draw the structure of the ion that forms.

[1]

© OCR 2013

(c) Penicillamine exists as optical isomers. Only one isomer is pharmacologically active. Its 3-D structure is shown below.

In the box below, draw a 3-D diagram to show the structure of the other optical isomer of penicillamine.



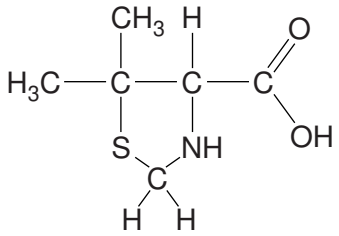
pharmacologically active isomer of penicillamine

[1]

(d) The –SH (thiol) group shows similar chemical properties to –OH.

(i) The –SH and $–NH_2$ groups in penicillamine react with halogenoalkanes by nucleophilic substitution.

Penicillamine reacts with a dihalogenoalkane to form the compound shown below.



Suggest the formula of a dihalogenoalkane that will react with penicillamine to form this compound.

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

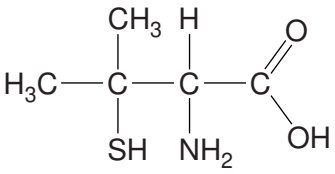
© OCR 2013

(ii) Penicillamine is able to undergo condensation polymerisation to form polypeptide chains.

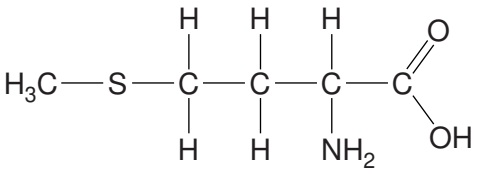
Draw **two** repeat units of a polypeptide chain of penicillamine.

[2]

(e) Penicillamine is a structural isomer of methionine, which is also an α-amino acid.



penicillamine



methionine

NMR spectroscopy can be used to distinguish samples of the two isomers.

(i) Predict the number of peaks in the ^{13}C NMR spectrum of **each** of these α-amino acids.

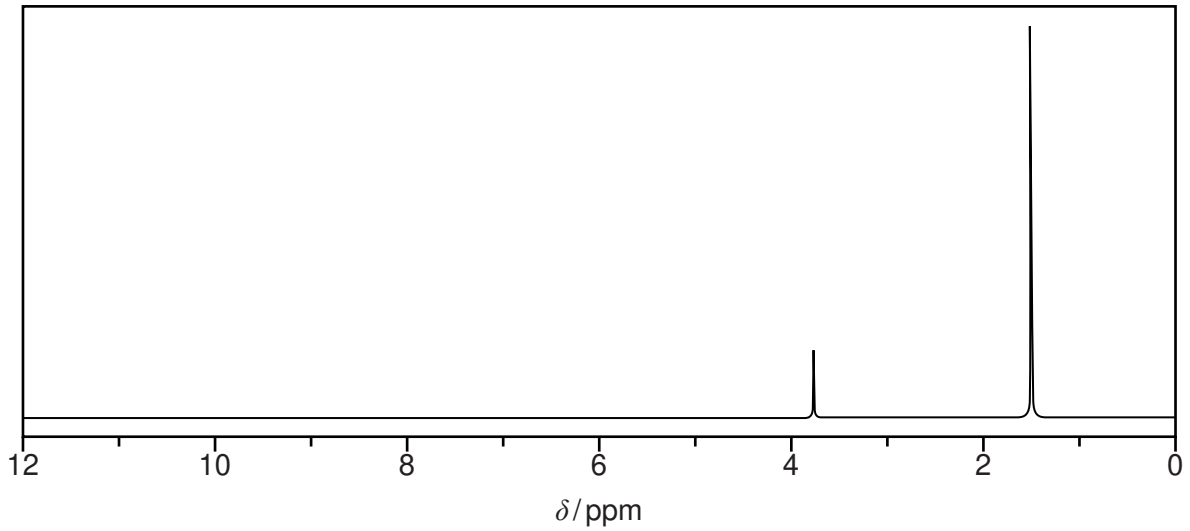
penicillamine .....

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

© OCR 2013

(ii) A ^{1}H NMR spectrum of **penicillamine** showed five peaks.

A solution of penicillamine was shaken with a few drops of D_2O and a second ^{1}H NMR spectrum was run. The second ^{1}H NMR spectrum is shown below.



- Identify the **three** types of protons in penicillamine responsible for the peaks that disappeared in the second ^{1}H NMR spectrum.

- Explain why these peaks were **not** seen in the second spectrum.

.....

.....

.....

.....

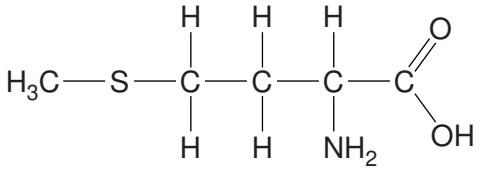
.....

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

© OCR 2013

(iii) ^{1}H NMR spectroscopy can be used to distinguish between penicillamine and methionine.

Complete the table below to predict the ^{1}H NMR spectrum of **methionine**, which is shown below. The actual chemical shifts for three types of proton in methionine have been added for you.



methionine

^{1}H NMR spectrum for methionine			
Type of proton(s)	**Chemical shift, δ /ppm**	**Splitting pattern**	**Relative peak area**
$N\mathbf{H}_2$	4.5	Singlet	2
$\mathbf{H}_3C$—S—	2.1		
—S—$C\mathbf{H}_2$—	2.4		

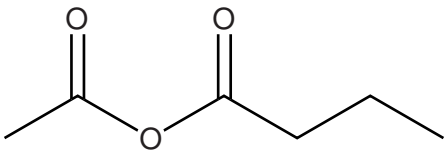
[5]

[Total: 16]

© OCR 2013

4 Acid anhydrides are organic compounds that can be reacted with alcohols to form esters and carboxylic acids.

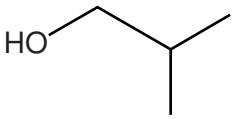
Compound **F**, shown below, is an acid anhydride used in the perfume industry as a starting material in the production of esters.



compound F

Compound **F** is a 'mixed' acid anhydride, formed from two different carboxylic acids.

(a) A chemist reacts compound **F** with an alcohol, **G**.



alcohol G

(i) Name alcohol **G**.

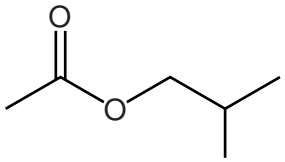
..... **[1]**

(ii) The reaction between **F** and **G** forms a mixture of four organic compounds.

Two of the compounds are esters, and two are carboxylic acids.

One of the esters is shown below.

Draw the structures of the other three organic compounds formed.



[3]

© OCR 2013

(b) After the reaction in part **(a)**, the chemist wished to analyse the mixture by separating the compounds using gas chromatography (GC), and measuring their retention times.

(i) State what is meant by *retention time*.

.....

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

(ii) What are the possible limitations of this analysis by GC?

.....

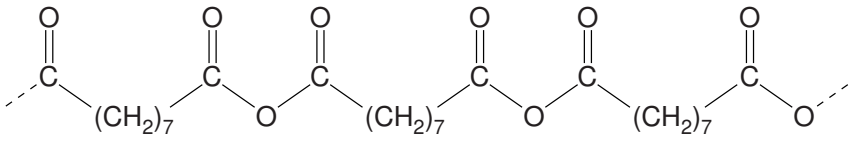
.....

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

(c) Polyanhydrides are condensation polymers that have been recently developed for use in the pharmaceutical industry.

The polyanhydride, **PAPA**, is used to form a protective coating around some anti-cancer drugs.

A section of the polymer chain of **PAPA** is shown below.



(i) **In the diagram above**, draw a box around a repeat unit of **PAPA**. **[1]**

© OCR 2013

(ii) The **PAPA** coating is degradable and breaks down to form the dicarboxylic acid $HOOC(CH_2)_7COOH$.

Name the type of reaction that occurs when **PAPA** degrades.

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

(iii) **PAPA**-coated tablets can be stored for a long time in blister packets. Scientists can detect whether **PAPA** has degraded using infrared (IR) spectroscopy.

Outline how IR spectroscopy could be used to determine if **PAPA** has degraded.

Include in your answer the wavenumber range of any characteristic absorptions that would be seen.

.....

.....

.....

.....

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

(iv) The dicarboxylic acid, $HOOC(CH_2)_7COOH$, can react with benzene-1,3-diol to form a condensation polymer.

Draw **one** repeat unit of this condensation polymer.

[3]

[Total: 13]

END OF QUESTION PAPER

© OCR 2013

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 margins.

© OCR 2013

© OCR 2013

OCR
RECOGNISING ACHIEVEMENT

Copyright Information

OCR is committed to seeking permission to reproduce all third-party content that it uses in its assessment materials. OCR has attempted to identify and contact all copyright holders whose work is used in this paper. To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced in the OCR Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download from our public website (www.ocr.org.uk) after the live examination series.

If OCR has unwittingly failed to correctly acknowledge or clear any third-party content in this assessment material, OCR will be happy to correct its mistake at the earliest possible opportunity.

For queries or further information please contact the Copyright Team, First Floor, 9 Hills Road, Cambridge CB2 1GE.

OCR is part of the Cambridge Assessment Group; Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

© OCR 2013