

**ADVANCED GCE
CHEMISTRY**

Chains, Rings and Spectroscopy

THURSDAY 12 JUNE 2008

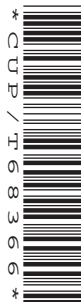
2814/01

Afternoon
Time: 1 hour 30 minutes

Candidates answer on the question paper

Additional materials (enclosed): *Data Sheet for Chemistry*

Additional materials (required):
Scientific calculator



Candidate
Forename

Candidate
Surname

Centre
Number

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Candidate
Number

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INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [] at the end of each question or part question.
- The total number of marks for this paper is **90**.
- You may be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE

Qu.	Max.	Mark
1	12	
2	17	
3	12	
4	14	
5	12	
6	9	
7	14	
TOTAL	90	

This document consists of **16** printed pages.

Answer **all** the questions.

1 An unknown aldehyde **A**, $C_5H_{10}O$, was analysed using different techniques.

(a) (i) Describe a chemical test that could be used to confirm that compound **A** is an aldehyde.

.....

[2]

(ii) Identify the functional group formed in this chemical test.

.....[1]

(b) Describe a chemical method that could be used to confirm the presence of the carbonyl group in compound **A**.

Explain how you would use the product of this test to identify compound **A**.

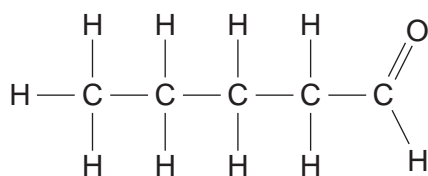
.....

[3]

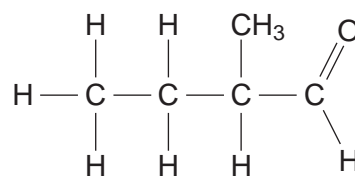
(c) In a mass spectrum of compound **A**, determine the m/e value of the molecular ion peak.

.....[1]

(d) There are the four possible structural isomers for the aldehyde **A**, $C_5H_{10}O$. Two structures are shown below.



isomer 1

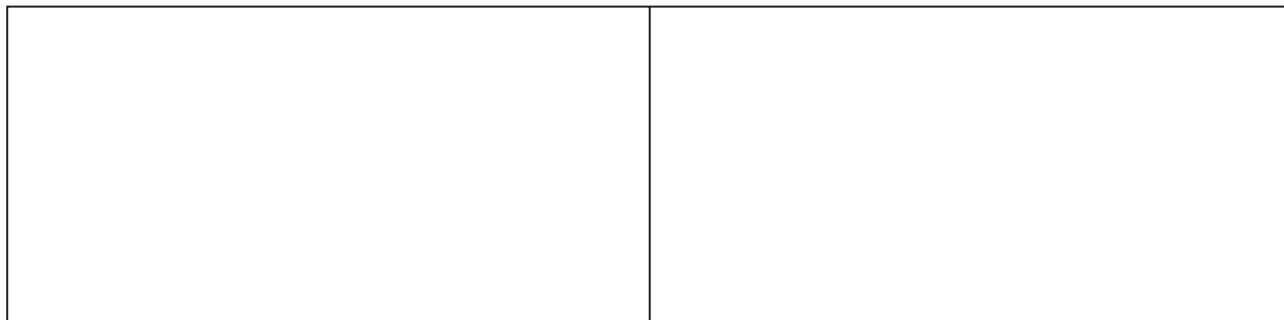


isomer 2

(i) Draw the skeletal formula for structural isomer **2**.

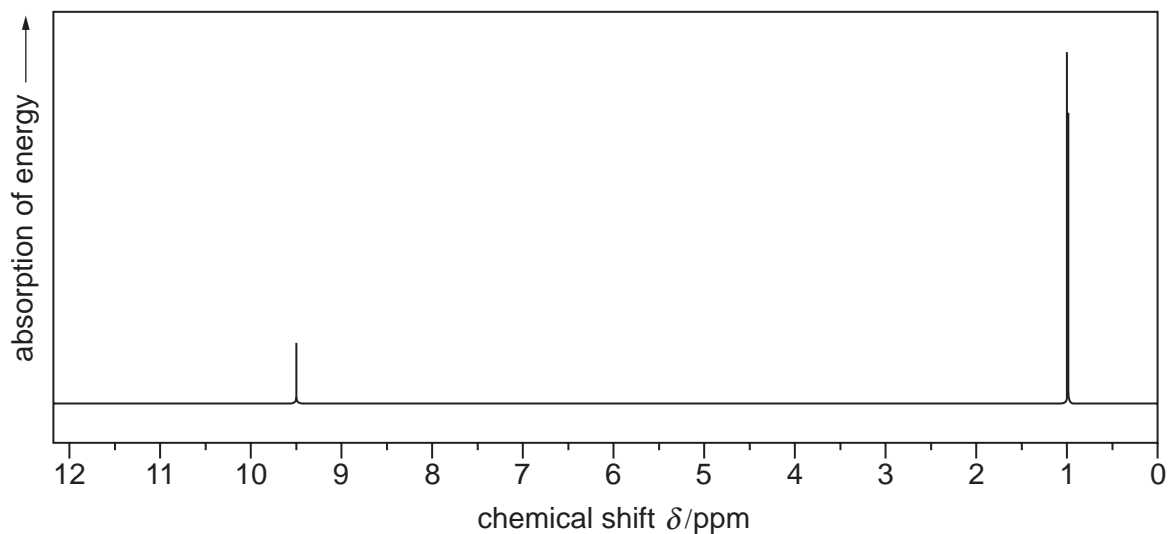
[1]

(ii) Draw the two other possible structural isomers of the aldehyde **A**, $\text{C}_5\text{H}_{10}\text{O}$.



[2]

(e) The n.m.r. spectrum of aldehyde **A** is shown below.



Identify aldehyde **A**. Explain your reasoning.

.....

[2]

[Total: 12]

[Turn over]

2 Nitration of benzene using concentrated nitric acid is an important industrial process.

(a) (i) Write an overall equation for the reaction of benzene with nitric acid to form nitrobenzene.

[1]

(ii) State a suitable catalyst for this reaction.

.....[1]

(b) Outline the mechanism for the nitration of benzene, starting from nitric acid, to form nitrobenzene.

Include relevant 'curly arrows' in the steps involving the benzene ring and write equations to show how the catalyst is involved.

[6]

(c) This preparation of nitrobenzene is generally carried out at 55–60 °C. If the temperature rises above 100 °C, a compound forms with the formula $C_6H_4N_2O_4$.

Suggest the structure of this compound.

[1]

In your answer, include details of reagents, essential conditions and balanced equations.

.....[8

- 3 Alanine, $\text{CH}_3\text{CH}(\text{NH}_2)\text{COOH}$, and valine, $(\text{CH}_3)_2\text{CH}(\text{NH}_2)\text{CHCOOH}$, are both α -amino acids that occur naturally.

(a) Draw the zwitterion structure of alanine.

[1]

(b) Draw the structures of two different dipeptides that could be formed from the reaction of one molecule of alanine with one molecule of valine.

[3]

(c) Aqueous sodium hydroxide was added to valine.

Draw the structure of the ion formed.

[1]

- (d) Hydrochloric acid was added to alanine. The resulting solution was concentrated and crystals of a compound **B** were separated.
Draw the displayed formula of compound **B**.

[2]

- (e) Phosphorus pentachloride, PCl_5 was added to alanine forming an acyl chloride.
The acyl chloride was then reacted separately with methanol and with ammonia.

Draw the structure of the acyl chloride and the organic compounds formed from the acyl chloride.

acyl chloride	product with methanol	product with ammonia

[3]

- (f) Compounds **C** and **D** are also α -amino acids.
Compound **C** has the molecular formula $\text{C}_4\text{H}_9\text{NO}_3$.
Compound **D** has the molecular formula $\text{C}_6\text{H}_{14}\text{N}_2\text{O}_2$.

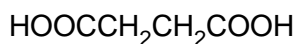
Suggest structures for amino acids **C** and **D**.

C	D

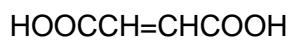
[2]

[Total: 12]

- 4 The three dicarboxylic acids shown below are all found in living cells.



succinic acid



fumaric acid



malic acid

- (a) Which of these dicarboxylic acids have stereoisomers? Explain your answer(s).

.....

.....

.....

.....

.....[2]

- (b) These dicarboxylic acids have dicarboxylate salts, for example, disodium succinate.

Write an equation to show how disodium succinate can be produced from succinic acid in the laboratory.

[2]

- (c) Succinic acid can also be **dehydrated** to give a cyclic compound with formula, $\text{C}_4\text{H}_4\text{O}_3$.

Suggest a possible structure for this compound.

[1]

(i) Predict the expected features of this n.m.r. spectrum.

- the number of peaks and their relative peak areas
- the splitting patterns of the peaks
- the difference in the n.m.r. spectrum if it were run in a solution **without** D_2O .

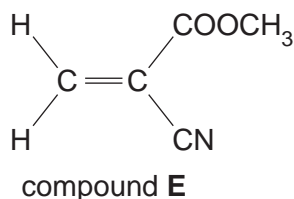
[6]

(ii) The n.m.r. spectrum for succinic acid **without** D_2O consists of two peaks, both singlets.

.....[2]

[Turn over

- 5 Compound **E** is used by forensic scientists to investigate fingerprints.



- (a) Compound **E** forms a polymer when its vapour comes into contact with the fingerprint.

Draw a short section of this polymer showing **two** repeat units.

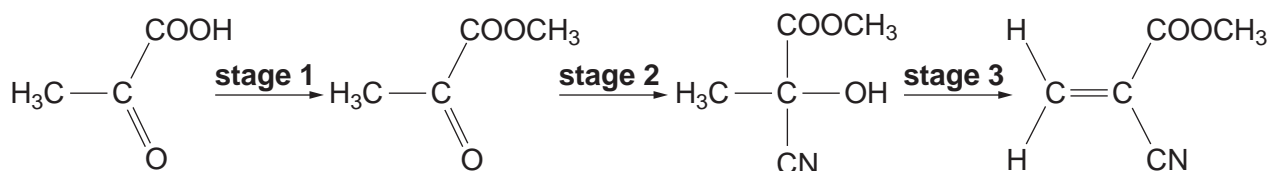
[1]

- (b) Compound **E** reacts with hot aqueous hydrochloric acid to form an unsaturated organic compound.

Suggest the structure of this compound.

[2]

- (c) Compound **E** can be manufactured from 2-oxopropanoic acid in three stages as shown below.



2-oxopropanoic acid

- (i) Identify the reagents and conditions required for **stage 1**.

.....
[2]

(ii) Identify the reagents required for **stage 2**.

.....[1]

(iii) State the name of the mechanism in **stage 2**.

.....[1]

(iv) Deduce the other product formed in **stage 3**.

.....[1]

(d) A typical yield of compound **E** from 2-oxopropanoic acid is 30%.

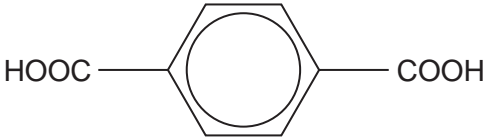
Calculate the mass of compound **E** you would expect to produce from 10 kg of 2-oxopropanoic acid. Give your answer to two significant figures.

Show your working.

mass of compound **E** = kg [4]

[Total: 12]

- 6 Ecoflex[®] is a biodegradable plastic made by combining the monomers below in the following approximate molar proportions.

monomer F	monomer G	monomer H
	$\text{HOOC}(\text{CH}_2)_4\text{COOH}$	$\text{HO}(\text{CH}_2)_4\text{OH}$
proportion: 25%	25%	50%

- (a) Draw the repeat unit of a polyester that could be made by combining **two** of the monomers shown above.

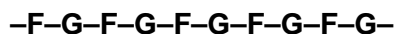
[2]

- (b) State the type of polymerisation reaction used to make Ecoflex[®].

.....[1]

- (c) A sequence of letters can be used to represent the order of the monomers in a polymer.

For example, a short length of polymer made from monomers **F** and **G** alternating can be shown as:



Suggest a possible sequence for the monomers **F**, **G** and **H** in a similar length of Ecoflex[®].

.....[1]

(d) Monomer **H** can be made in the laboratory by reducing compound **J** containing two aldehyde groups.

(i) State a suitable reagent for this reduction.

.....[1]

(ii) Identify compound **J**.

[1]

(iii) Write a balanced equation for the reduction of compound **J**.

[1]

(iv) How could the infra-red spectra of compound **J** and the organic product **H** be used to confirm that a reaction had taken place?

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

[Total: 9]

7 In this question, one mark is available for the quality of spelling, punctuation and grammar.

- (a)** Cyclohexene reacts with bromine at room temperature. Benzene reacts with bromine only in the presence of a halogen carrier. Phenol rapidly decolourises bromine at room temperature.

Explain the different reactivities of bromine with cyclohexene, with benzene and with phenol. In your answer, include balanced equations and state the reaction type in each case.

This image shows a full page of a worksheet designed for handwriting practice. It features approximately 20 horizontal rows. Each row is defined by two parallel dashed lines, creating a series of uniform gaps for letter height. The entire page is otherwise blank, with no text or other markings.

(b) Compound **K** is an aromatic hydrocarbon with the molecular formula C_8H_{10} . When compound **K** reacts with bromine in the presence of a halogen carrier, only one organic product, **L**, is formed.

Identify compounds **K** and **L** by drawing their structures below.

[2]

[Total: 14]

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE

Copyright Acknowledgements:

The n.m.r. spectrum in Q.1 was adapted from a spectrum provided by SDBSWeb: <http://www.aist.go.jp/RIODB/SDBS/> (National Institute of Advanced Industrial Science and Technology, 30/10/06).

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