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General Certificate of Education  
June 2005  
Advanced Subsidiary Examination



**CHEMISTRY**  
**Unit 3(a) Introduction to Organic Chemistry**

**CHM3/W**

Wednesday 8 June 2005 Morning Session

**In addition to this paper you will require:**  
a calculator.

For Examiner's Use			
Number	Mark	Number	Mark
1			
2			
3			
4			
5			
6			
Total (Column 1)	→		
Total (Column 2)	→		
TOTAL			
Examiner's Initials			

Time allowed: 1 hour

**Instructions**

- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in **Section A** and **Section B** in the spaces provided. All working must be shown.
- Do all rough work in this book. Cross through any work you do not want marked.
- The Periodic Table/Data Sheet is provided on pages 3 and 4. Detach this perforated sheet at the start of the examination.

**Information**

- The maximum mark for this paper is 60.
- Mark allocations are shown in brackets.
- This paper carries 25 per cent of the total marks for AS. For Advanced Level this paper carries 12½ per cent of the total marks.
- You are expected to use a calculator where appropriate.
- The following data may be required.  
Gas constant  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
- Your answers to the questions in **Section B** should be written in continuous prose, where appropriate. You will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary, where appropriate.

**Advice**

- You are advised to spend about 45 minutes on **Section A** and about 15 minutes on **Section B**.

**SECTION A**

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

1 Petroleum is separated into fractions by fractional distillation. The petrol fraction ( $C_4$  to  $C_{12}$ ) is burned in internal combustion engines and the naphtha fraction ( $C_7$  to  $C_{14}$ ) is cracked.

(a) Petroleum is separated into fractions when it is heated and the vapour mixture is passed into a fractionating column.

(i) Explain what is meant by the term *fraction* as applied to fractional distillation.

.....  
.....

(ii) State a property of the molecules in petroleum which allows the mixture to be separated into fractions.

.....  
.....

(iii) Describe the temperature gradient in the column.

.....  
.....

(3 marks)

(b) The fractions from petroleum contain alkane hydrocarbons.

(i) Write an equation for the incomplete combustion of the alkane  $C_8H_{18}$  to produce carbon monoxide and water only.

.....

(ii) One isomer of  $C_8H_{18}$  is 2,2,3-trimethylpentane. Draw the structure of this isomer.

(2 marks)



**Table 1**  
Proton n.m.r chemical shift data

Type of proton	$\delta/\text{ppm}$
$\text{RCH}_3$	0.7–1.2
$\text{R}_2\text{CH}_2$	1.2–1.4
$\text{R}_3\text{CH}$	1.4–1.6
$\text{RCOCH}_3$	2.1–2.6
$\text{ROCH}_3$	3.1–3.9
$\text{RCOOCH}_3$	3.7–4.1
$\text{ROH}$	0.5–5.0

**Table 2**  
Infra-red absorption data

Bond	Wavenumber/ $\text{cm}^{-1}$
$\text{C—H}$	2850–3300
$\text{C—C}$	750–1100
$\text{C=C}$	1620–1680
$\text{C=O}$	1680–1750
$\text{C—O}$	1000–1300
$\text{O—H}$ (alcohols)	3230–3550
$\text{O—H}$ (acids)	2500–3000

- (c) State **one** economic reason for the cracking of petroleum fractions.

.....  
(1 mark)

- (d) (i) Give the type of reactive intermediate formed during catalytic cracking.

.....

- (ii) Identify a catalyst used in catalytic cracking.

.....  
(2 marks)

- (e) (i) Give the type of reactive intermediate formed during thermal cracking.  
State how this reactive intermediate is formed.

*Reactive intermediate* .....

*How intermediate is formed* .....

.....

- (ii) Identify the different type of hydrocarbon produced in a high percentage by the thermal cracking of alkanes.

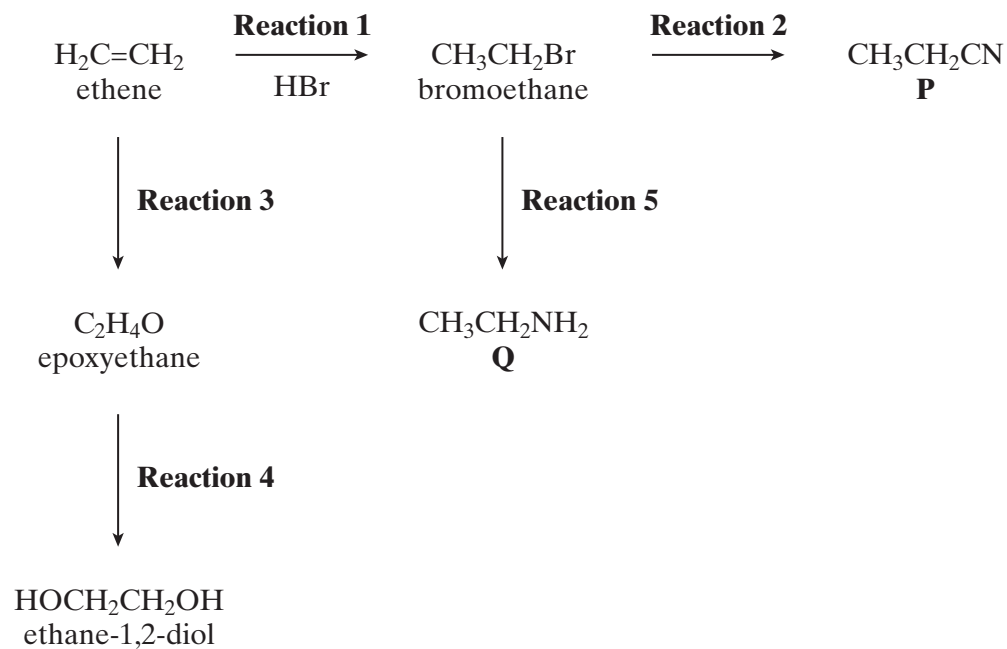
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(3 marks)

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2 Consider the following scheme of reactions.



(a) In **Reaction 1**, ethene undergoes electrophilic addition with hydrogen bromide.

(i) State what is meant by the term *electrophile*.

.....  
.....

(ii) Outline a mechanism for this reaction.

(5 marks)

(b) Epoxyethane is formed from ethene in **Reaction 3**.

(i) Identify a reagent and a catalyst for this reaction.

Reagent .....

Catalyst .....

(ii) Draw the structure of epoxyethane.

(iii) Identify a reagent which will react with epoxyethane to form ethane-1,2-diol in **Reaction 4**.

.....  
(4 marks)

(c) In **Reactions 2** and **5**, bromoethane undergoes nucleophilic substitution.

(i) Identify a reagent for **Reaction 2**. Name the organic product, **P**.

Reagent for **Reaction 2** .....

Name of product **P** .....

(ii) Identify a reagent for **Reaction 5**. Name the organic product, **Q**.

Reagent for **Reaction 5** .....

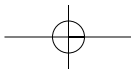
Name of product **Q** .....

(iii) Outline a mechanism for **Reaction 5**.

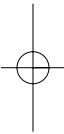
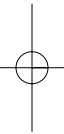
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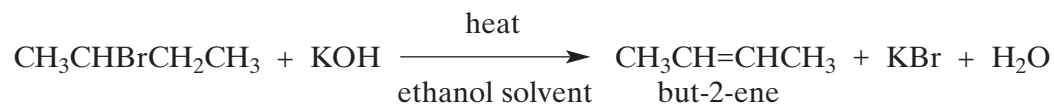


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3 Consider the following reaction in which an alkene is formed from a haloalkane.



(a) Name the haloalkane used in this reaction.

.....  
(1 mark)

(b) Name and outline a mechanism for this reaction.

Name of mechanism .....

Mechanism

(4 marks)

(c) Another alkene, which is a structural isomer of but-2-ene, is also formed during this reaction.

(i) State what is meant by the term *structural isomers*.

.....  
.....

(ii) Draw the structure of this other alkene.

(2 marks)

Turn over ▶

7

4 Many naturally-occurring organic compounds can be converted into other useful products.

(a) Glucose,  $C_6H_{12}O_6$ , can be fermented to make ethanol, which can then be dehydrated to make the unsaturated compound, ethene.

(i) Write an equation for the fermentation of glucose to form ethanol.

.....

(ii) Identify a catalyst for the dehydration of ethanol to form ethene.  
Write an equation for this reaction.

*Catalyst* .....

*Equation* .....

(3 marks)

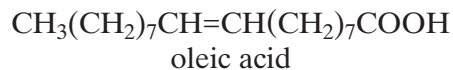
(b) Vegetable oils, which contain unsaturated compounds, are used to make margarine.  
Identify a catalyst and a reagent for converting a vegetable oil into margarine.

*Catalyst* .....

*Reagent* .....

(2 marks)

- (c) Oleic acid can be obtained from vegetable oils. Oleic acid is an example of an unsaturated compound.



- (i) Deduce the molecular formula and the empirical formula of oleic acid.

*Molecular formula* .....

*Empirical formula* .....

- (ii) State what is meant by the term *unsaturated*.

.....

- (iii) Identify a reagent for a simple chemical test to show that oleic acid is unsaturated. State what you would observe when oleic acid reacts with this reagent.

*Reagent* .....

*Observation with oleic acid* .....

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(5 marks)

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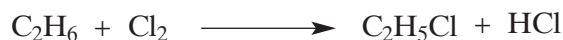
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**SECTION B**

Answer the questions below in the space provided on pages 12 to 16 of this booklet.

- 5 Chlorination of ethane follows a free-radical substitution mechanism. This mechanism is similar to that which occurs when methane is chlorinated. The overall equation for the reaction of ethane to form chloroethane is given below.



State the conditions and outline a mechanism for this reaction. Show how butane can be formed in this reaction. (5 marks)

- 6 Some alcohols can be oxidised to form aldehydes, which can then be oxidised further to form carboxylic acids.  
Some alcohols can be oxidised to form ketones, which resist further oxidation.  
Other alcohols are resistant to oxidation.

- (a) Draw the structures of the **two** straight-chain isomeric alcohols with molecular formula,  $\text{C}_4\text{H}_{10}\text{O}$  (2 marks)
- (b) Draw the structures of the oxidation products obtained when the two alcohols from part (a) are oxidised separately by acidified potassium dichromate(VI).  
Write equations for any reactions which occur, using [O] to represent the oxidising agent. (6 marks)
- (c) Draw the structure and give the name of the alcohol with molecular formula  $\text{C}_4\text{H}_{10}\text{O}$  which is resistant to oxidation by acidified potassium dichromate(VI). (2 marks)

**END OF QUESTIONS**

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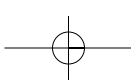
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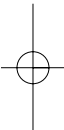
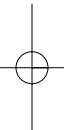
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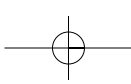


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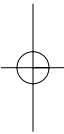
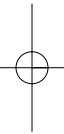


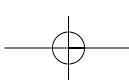
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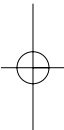
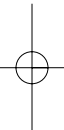
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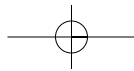


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