

Surname						Other Names					
Centre Number						Candidate Number					
Candidate Signature											

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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 $12\frac{1}{2}$ 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.

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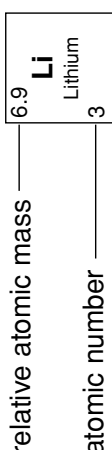
(ii) One isomer of C_8H_{18} is 2,2,3-trimethylpentane. Draw the structure of this isomer.

(2 marks)

The Periodic Table of the Elements

- The atomic numbers and approximate relative atomic masses shown in the table are for use in the examination unless stated otherwise in an individual question.

		I		II		III		IV		V		VI		VII		0																			
1.0	H Hydrogen 1	9.0	Be Beryllium 4	45.0	Sc Scandium 21	47.9	Ti Titanium 22	50.9	V Vanadium 23	52.0	Cr Chromium 24	54.9	Mn Manganese 25	55.8	Fe Iron 26	58.9	Co Cobalt 27	58.7	Ni Nickel 28	63.5	Cu Copper 29	65.4	Zn Zinc 30	69.7	Ga Gallium 31	72.6	Ge Germanium 32	74.9	As Arsenic 33	79.0	Se Selenium 34	79.9	Br Bromine 35	83.8	Kr Krypton 36
6.9	Li Lithium 3	24.3	Mg Magnesium 12	88.9	Y Yttrium 39	91.2	Zr Zirconium 40	92.9	Nb Niobium 41	95.9	Mo Molybdenum 42	98.9	Tc Technetium 43	101.1	Ru Ruthenium 44	102.9	Rh Rhodium 45	106.4	Pd Palladium 46	107.9	Ag Silver 47	112.4	Cd Cadmium 48	114.8	In Indium 49	118.7	Sn Tin 50	121.8	Sb Antimony 51	126.9	I Iodine 53	131.3	Xe Xenon 54		
23.0	Na Sodium 11	40.1	Ca Calcium 20	138.9	La Lanthanum 57	178.5	Hf Hafnium 72	180.9	Ta Tantalum 73	183.9	W Tungsten 74	186.2	Re Rhenium 75	190.2	Os Osmium 76	192.2	Ir Iridium 77	195.1	Pt Platinum 78	197.0	Au Gold 79	200.6	Hg Mercury 80	204.4	Tl Thallium 81	207.2	Pb Lead 82	209.0	Bi Bismuth 83	210.0	Po Polonium 84	222.0	Rn Radon 86		
39.1	K Potassium 19	87.6	Sr Strontium 38	227	Ac Actinium 89																														
85.5	Rb Rubidium 37	137.3	Ba Barium 56																																
132.9	Cs Caesium 55	226.0	Ra Radium 88																																
223.0	Fr Francium 87																																		



140.1	Ce Cerium 58	140.9	Pr Praseodymium 59	144.2	Nd Neodymium 60	144.9	Pm Promethium 61	150.4	Sm Samarium 62	152.0	Eu Europium 63	157.3	Gd Gadolinium 64	162.5	Dy Dysprosium 66	164.9	Ho Holmium 67	167.3	Er Erbium 68	168.9	Tm Thulium 69	173.0	Yb Ytterbium 70	175.0	Lu Lutetium 71
232.0	Th Thorium 90	231.0	Pa Protactinium 91	238.0	U Uranium 92	237.0	Np Neptunium 93	239.1	Pu Plutonium 94	243.1	Am Americium 95	247.1	Cm Curium 96	252.1	Cf Californium 98	(252)	Es Einsteinium 99	(257)	Fm Fermium 100	(258)	Md Mendelevium 101	(259)	No Nobelium 102	(260)	Lr Lawrencium 103

* 58 – 71 Lanthanides

† 90 – 103 Actinides

Table 1
Proton n.m.r chemical shift data

Type of proton	δ/ppm
RCH_3	0.7–1.2
R_2CH_2	1.2–1.4
R_3CH	1.4–1.6
RCOCH_3	2.1–2.6
ROCH_3	3.1–3.9
RCOOCH_3	3.7–4.1
ROH	0.5–5.0

Table 2
Infra-red absorption data

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

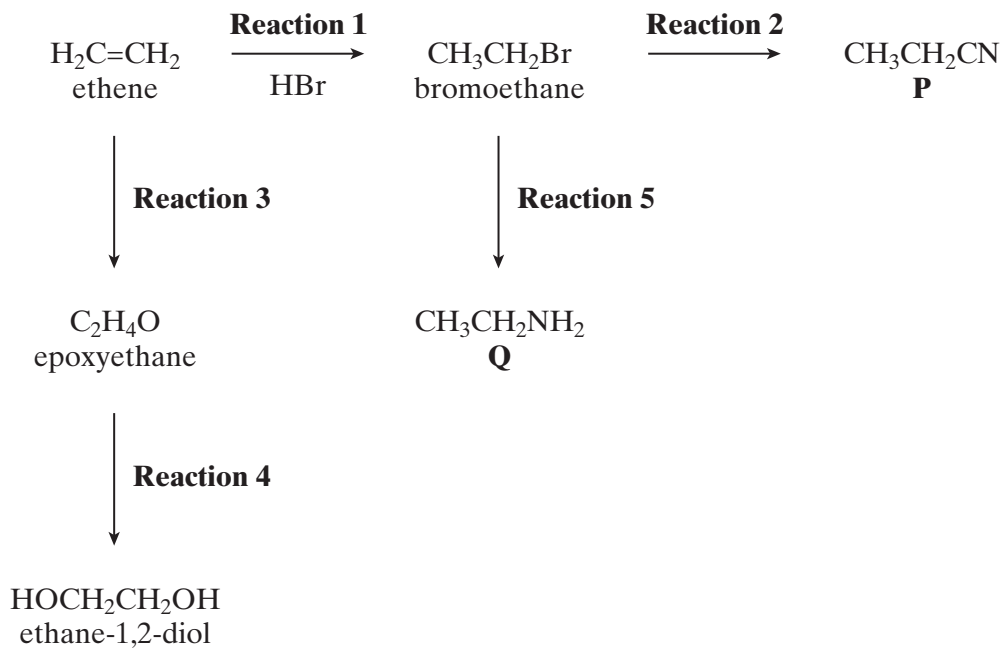
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(3 marks)

11

TURN OVER FOR THE NEXT QUESTION

Turn over ►

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

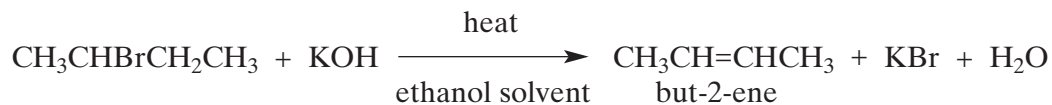
(iii) Outline a mechanism for **Reaction 5**.

(8 marks)

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NO QUESTIONS APPEAR ON THIS PAGE

- 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)

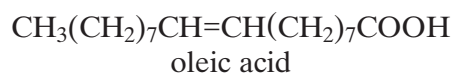
(b) Vegetable oils, which contain unsaturated compounds, are used to make margarine.
Identify a catalyst and a reagent for converting a vegetable oil into margarine.

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

.....

(5 marks)

10

TURN OVER FOR THE NEXT QUESTION

Turn over ►

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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