Surname		Other Names	
Centre Number			Candidate Number				
Candidate Signature									

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General Certificate of Education
June 2003
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

CHEMISTRY CHM3/W
Unit 3(a) Introduction to Organic Chemistry

Wednesday 4 June 2003 Morning Session

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

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 $R = 8.31$ J K^{-1} mol^{-1}
- Your answers to 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**.

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

SECTION A

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

1 (a) Butane, C_4H_{10}, is a hydrocarbon which is used as a fuel.

(i) Explain what is meant by the term *hydrocarbon*.

.....

.....

(ii) Explain what is meant by the term *fuel*.

.....

.....

(iii) Write an equation for the complete combustion of butane.

.....

(iv) Write an equation for the incomplete combustion of butane to produce carbon monoxide and water.

.....

(v) Under what conditions would you expect incomplete combustion to occur?

.....

(5 marks)

(b) Three different carbocations are formed by breaking C – C bonds in separate molecules of butane during catalytic cracking. One of these structures is shown below. Give the structures of the other two carbocations.

Structure 1 *Structure 2* *Structure 3*

$CH_3CH_2\overset{+}{C}H_2$

(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																	4.0 **He** Helium 2
6.9 **Li** Lithium 3	9.0 **Be** Beryllium 4											10.8 **B** Boron 5	12.0 **C** Carbon 6	14.0 **N** Nitrogen 7	16.0 **O** Oxygen 8	19.0 **F** Fluorine 9	20.2 **Ne** Neon 10
23.0 **Na** Sodium 11	24.3 **Mg** Magnesium 12											27.0 **Al** Aluminium 13	28.1 **Si** Silicon 14	31.0 **P** Phosphorus 15	32.1 **S** Sulphur 16	35.5 **Cl** Chlorine 17	39.9 **Ar** Argon 18
39.1 **K** Potassium 19	40.1 **Ca** Calcium 20	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
85.5 **Rb** Rubidium 37	87.6 **Sr** Strontium 38	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	127.6 **Te** Tellurium 52	126.9 **I** Iodine 53	131.3 **Xe** Xenon 54
132.9 **Cs** Caesium 55	137.3 **Ba** Barium 56	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	210.0 **At** Astatine 85	222.0 **Rn** Radon 86
223.0 **Fr** Francium 87	226.0 **Ra** Radium 88	227 **Ac** Actinium 89 †															

Key

relative atomic mass — 6.9 **Li** Lithium

atomic number — 3

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	158.9 **Tb** Terbium 65	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	247.1 **Bk** Berkelium 97	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) Ethane can be cracked in the presence of a catalyst to produce ethene and hydrogen.

(i) Write an equation for this reaction.

.....

(ii) Give a suitable catalyst for this reaction.

.....

(iii) State **one** reason why cracking is important.

.....

.....

(3 marks)

10

TURN OVER FOR THE NEXT QUESTION

2 When chlorine reacts with trichloromethane, tetrachloromethane, CCl_4, is formed.

(a) (i) Write the overall equation for this reaction.

.....

(ii) State **one** essential condition for this reaction.

.....

(2 marks)

(b) The mechanism for the chlorination of trichloromethane is free-radical substitution, which proceeds by a series of steps. Write equations for the steps named below in this chlorination.

Initiation step

.....

First propagation step

.....

Second propagation step

.....

A termination step

.....

(4 marks)

(c) (i) A chloroalkane, **W**, was shown to contain 37.2% carbon and 55.0% chlorine by mass. The remainder of the compound was hydrogen. Calculate the empirical formula of compound **W**.

.....

.....

.....

.....

(ii) What additional information would be needed to calculate the molecular formula of compound **W**?

.....

(4 marks)

3 (a) Compounds with double bonds between carbon atoms can exhibit geometrical isomerism.

(i) Draw structures for the two geometrical isomers of 1,2-dichloroethene.

Isomer 1 *Isomer 2*

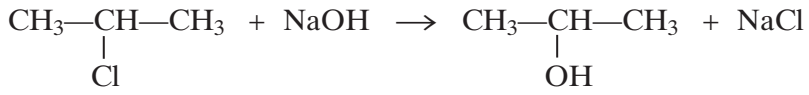
(ii) What feature of the double bond prevents isomer 1 from changing into isomer 2?

.....

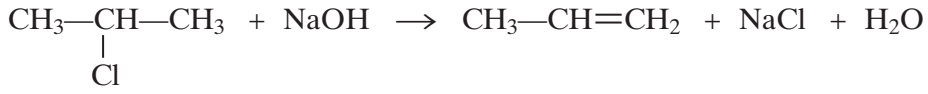
(3 marks)

(b) When 2-chloropropane reacts with sodium hydroxide, two different reactions occur. Each reaction produces a different organic product.

Reaction 1



Reaction 2



(i) Outline a mechanism for **Reaction 1** and state the role of the hydroxide ion in this reaction.

Mechanism

Role of the hydroxide ion .....

(ii) Outline a mechanism for **Reaction 2** and state the role of the hydroxide ion in this reaction.

Mechanism

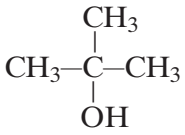
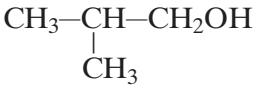
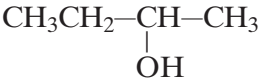
Role of the hydroxide ion .....

(7 marks)

10

TURN OVER FOR THE NEXT QUESTION

4 (a) Four isomers with the formula C_4H_9OH are given below.

Isomer	Name
$CH_3CH_2CH_2CH_2OH$	butan-1-ol
	2-methylpropan-2-ol
	
	

(i) Complete the naming of the isomers in the table above.

(ii) Name the type of isomerism shown by these four isomers.

.....

(3 marks)

(b) One of the isomers in part (a) is resistant to oxidation by acidified potassium dichromate(VI).

(i) Identify this isomer.

.....

(ii) This isomer can be dehydrated. Give a suitable dehydrating agent and write an equation for this dehydration reaction.

Dehydrating agent .....

Equation .....

(3 marks)

(c) (i) Identify the isomer in part (a) which can be oxidised to a ketone. Give the structure of the ketone formed.

Isomer .....

Structure of the ketone

(ii) Identify **one** of the isomers in part (a) which can be oxidised to an aldehyde. Give the structure of the aldehyde formed.

Isomer .....

Structure of the aldehyde

(iii) Give a reagent that can be used in a test to distinguish between a ketone and an aldehyde. State what you would observe in the test.

Reagent .....

Observation with ketone .....

.....

Observation with aldehyde .....

.....

(7 marks)

(d) Butan-1-ol can be oxidised to form a carboxylic acid. Using [O] to represent the oxidising agent, write an equation for this reaction and name the product.

Equation .....

Name of product .....

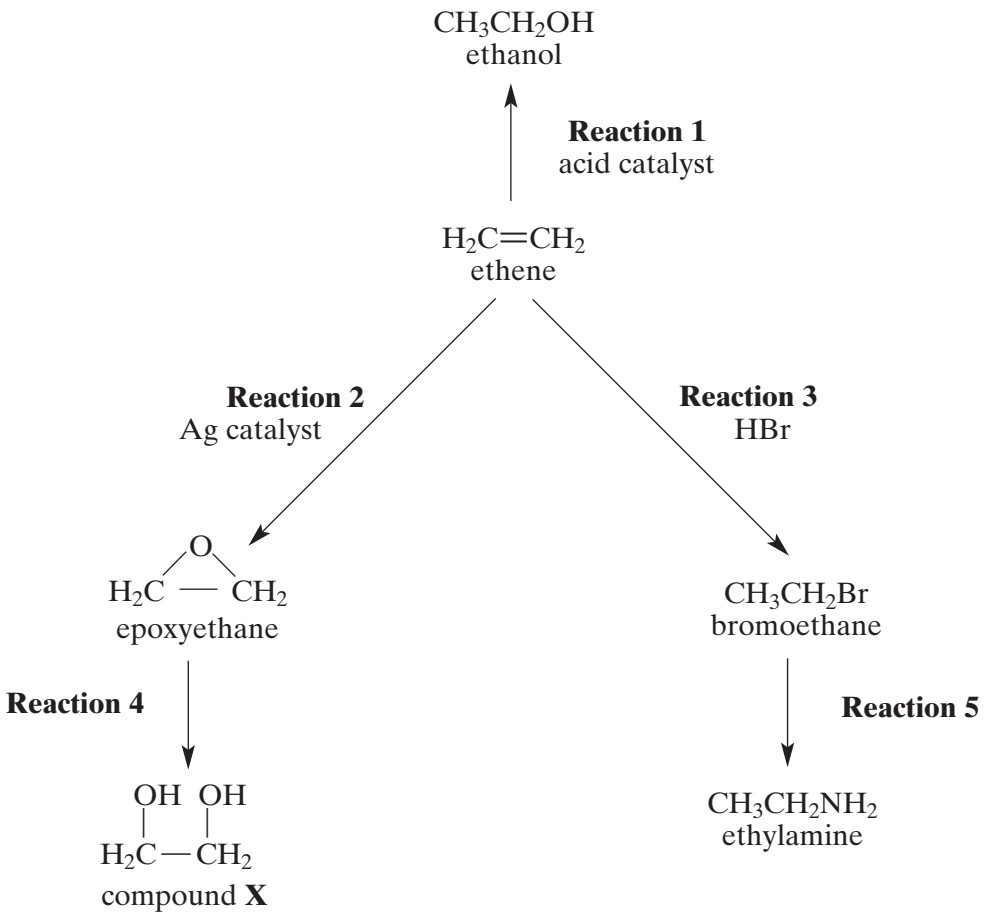
(2 marks)

15

SECTION B

Answer the question below in the space provided on pages 13 to 16 of this booklet.

5 Ethene can be converted into a variety of useful products as illustrated below.



(a) Name and give a use for compound **X**. *(2 marks)*

(b) Give a reagent for each of **Reactions 1**, **2**, **4** and **5**. *(4 marks)*

(c) Outline a mechanism for **Reaction 3**. *(4 marks)*

(d) Ethanol can be manufactured from ethene as shown in **Reaction 1** or by the fermentation of sugars. Outline the essential conditions and give an equation for the fermentation reaction. Compare the relative rates and the purity of the product obtained in each case by these two manufacturing processes. *(5 marks)*

END OF QUESTIONS