Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

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General Certificate of Education
January 2005
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Tuesday 11 January 2005 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 $R = 8.31\,\text{J}\,\text{K}^{-1}\,\text{mol}^{-1}$
- Your answers to the question 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			
6			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

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SECTION A

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

1 (a) (i) Name the process used to separate petroleum into fractions.

.....

(ii) Give the molecular formula for an alkane with nine carbon atoms.

.....

(iii) Write an equation for the complete combustion of the alkane $C_{11}H_{24}$

.....

(iv) Write an equation for the incomplete combustion of $C_{11}H_{24}$ to produce carbon and water only.

.....

(4 marks)

(b) Alkenes can be produced by cracking the naphtha fraction obtained from petroleum.

(i) Write an equation for the thermal cracking of one molecule of $C_{10}H_{22}$ to give one molecule of propene and one molecule of an alkane only.

.....

(ii) Draw the structure of the chain isomer of but-1-ene.

(2 marks)

(c) The alkanes and the alkenes are examples of homologous series of compounds. One feature of an homologous series is the gradual change in physical properties as the relative molecular mass increases. State **two** other general features of an homologous series of compounds.

Feature 1 .....

.....

Feature 2 .....

.....

(2 marks)

8

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

2 The mechanism for the reaction of methane with fluorine is a free-radical substitution similar to the chlorination of methane.

(a) Outline the following steps in the mechanism for the reaction of methane with fluorine to form fluoromethane, CH_3F

Initiation step

.....

First propagation step

.....

Second propagation step

.....

A termination step

.....

(4 marks)

(b) Write an overall equation for the reaction of fluorine with fluoromethane to form tetrafluoromethane.

.....

(1 mark)

5

TURN OVER FOR THE NEXT QUESTION

3 Consider the following reaction schemes involving two alcohols, **A** and **B**, which are position isomers of each other.

$CH_3CH_2CH_2CH_2OH \longrightarrow CH_3CH_2CH_2CHO \longrightarrow CH_3CH_2CH_2COOH$

A butanal butanoic acid

$CH_3CH_2CH(OH)CH_3 \longrightarrow CH_3CH_2COCH_3$

B **C**

(a) State what is meant by the term *position isomers*.

.....

.....

.....

(2 marks)

(b) Name compound **A** and compound **C**.

*Compound **A*** .....

*Compound **C*** .....

(2 marks)

(c) Each of the reactions shown in the schemes above is of the same type and uses the same combination of reagents.

(i) State the type of reaction.

.....

(ii) Identify a suitable combination of reagents.

.....

(iii) State how you would ensure that compound **A** is converted into butanoic acid rather than into butanal.

.....

.....

(iv) Draw the structure of an isomer of compound **A** which does not react with this combination of reagents.

(v) Draw the structure of the carboxylic acid formed by the reaction of methanol with this combination of reagents.

(6 marks)

(d) (i) State a reagent which could be used to distinguish between butanal and compound **C**.

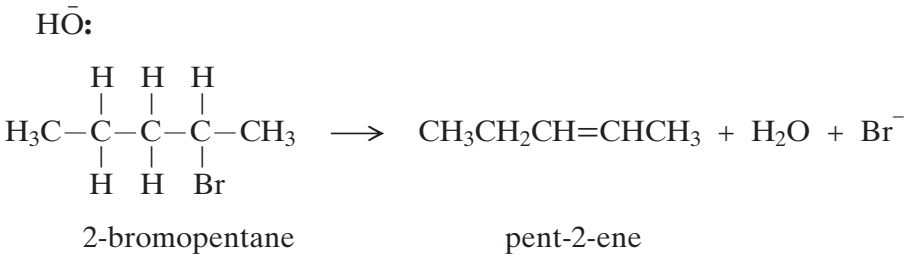
.....

(ii) Draw the structure of another aldehyde which is an isomer of butanal.

(2 marks)

12

4 (a) Complete the mechanism below by drawing appropriate curly arrows.



2-bromopentane pent-2-ene

(3 marks)

(b) Draw and name the geometrical isomers of pent-2-ene.

Isomer 1 *Isomer 2*

Name ..... *Name* .....

(2 marks)

(c) Pent-1-ene reacts with hydrogen bromide to produce 2-bromopentane as the major product.

(i) Outline the mechanism for this reaction.

(ii) Identify the minor product formed in this reaction.

.....

(iii) Explain why 2-bromopentane is the major product of this reaction.

.....

.....

.....

(7 marks)

12

TURN OVER FOR THE NEXT QUESTION

5 Glucose can be used as a source of ethanol. Ethanol can be burned as a fuel or can be converted into ethene.

$$\underset{\text{glucose}}{C_6H_{12}O_6} \longrightarrow \underset{\text{ethanol}}{CH_3CH_2OH} \longrightarrow \underset{\text{ethene}}{H_2C{=}CH_2}$$

(a) Name the types of reaction illustrated by the two reactions above.

Glucose to ethanol .....

Ethanol to ethene .....

(2 marks)

(b) (i) State what must be added to an aqueous solution of glucose so that ethanol is formed.

.....

(ii) Identify a suitable catalyst for the conversion of ethanol into ethene.

.....

(2 marks)

(c) (i) State the class of alcohols to which ethanol belongs.

.....

(ii) Give **one** advantage of using ethanol as a fuel compared with using a petroleum fraction.

.....

(2 marks)

(d) Most of the ethene used by industry is produced when ethane is heated to 900 °C in the absence of air. Write an equation for this reaction.

.....

(1 mark)

(e) Name the type of polymerisation which occurs when ethene is converted into poly(ethene).

.....

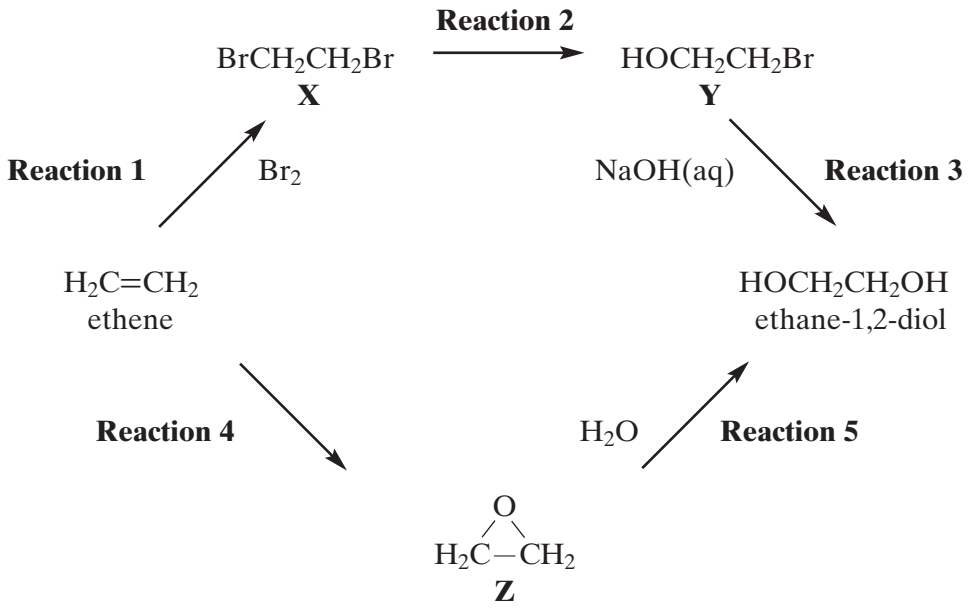
(1 mark)

8

SECTION B

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

6 Consider the following scheme of reactions for making ethane-1,2-diol from ethene by two different routes.



(a) Name compound **X** and name a mechanism for **Reaction 1**. Explain why ethene is able to react with bromine in this reaction, given that bromine molecules are non-polar. *(4 marks)*

(b) Name and outline a mechanism for **Reaction 3**. Explain why compound **Y** is susceptible to attack by hydroxide ions. *(4 marks)*

(c) Identify a reagent and a suitable catalyst for **Reaction 4**. Name compound **Z** and explain why compound **Z** reacts readily with water in **Reaction 5**. *(4 marks)*

(d) Give a use for ethane-1,2-diol. For **each** route from ethene to ethane-1,2-diol, identify **one** hazard. *(3 marks)*

END OF QUESTIONS

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