Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

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General Certificate of Education
January 2004
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Friday 9 January 2004 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 30 per cent of the total marks for AS. For Advanced Level this paper carries 15 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 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			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

SECTION A

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

1 (a) Crude oil is composed mainly of alkanes, which are saturated hydrocarbons.

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

.....

(ii) State what is meant by the term *saturated*, as applied to a hydrocarbon.

.....

(2 marks)

(b) Crude oil can be separated into the fractions listed in the table below.

Name of fraction	Number of carbon atoms
LPG (liquefied petroleum gas)	1 – 4
Petrol (gasoline)	4 – 12
Naphtha	7 – 14
	11 – 15
Gas oil (diesel)	15 – 19
Mineral oil (lubricating oil)	20 – 30
Fuel oil	30 – 40

(i) Name the process used to obtain these fractions from crude oil.

.....

(ii) Complete the table by naming the missing fraction.

(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) Some of the naphtha fraction is thermally cracked to produce more useful products.

(i) Give the molecular formula of an alkane with ten carbon atoms.

.....

(ii) Write an equation to illustrate the thermal cracking of one molecule of tetradecane, $C_{14}H_{30}$, in which the products are ethene and propene, in the ratio of 2:1, and one other product.

.....

(iii) Name the mechanism involved in thermal cracking.

.....

(4 marks)

(d) Ethene can react with oxygen to produce epoxyethane. If the reaction is not controlled carefully, the ethene can undergo complete combustion.

(i) Write an equation for the partial oxidation of ethene to form epoxyethane.

.....

(ii) Write an equation for the complete combustion of ethene in oxygen.

.....

(2 marks)

10

TURN OVER FOR THE NEXT QUESTION

2 The burning of fossil fuels can produce atmospheric pollutants.

(a) The combustion of petrol in an internal combustion engine can lead to the formation of carbon monoxide, CO, and nitrogen monoxide, NO.

(i) Write an equation for the incomplete combustion of octane, C_8H_{18}, to produce CO and water only.

.....

(ii) State **one** essential condition for the formation of NO in an engine. Write an equation for the reaction in which NO is formed.

Condition .....

Equation .....

(3 marks)

(b) All new petrol-engined cars must be fitted with a catalytic converter.

(i) Name **one** of the metals used as a catalyst in a catalytic converter.

.....

(ii) Write an equation to show how CO and NO react with each other in a catalytic converter.

.....

(2 marks)

(c) State why sulphur dioxide gas is sometimes found in the exhaust gases of petrol-engined cars. Give **one** adverse effect of sulphur dioxide on the environment.

Reason for SO_2 in exhaust gases .....

.....

Environmental effect of SO_2 .....

.....

(2 marks)

7

3 The table below gives the names and structures of three isomeric alkenes.

Name	Structure
but-1-ene	$CH_3CH_2CH=CH_2$
but-2-ene	$CH_3CH=CHCH_3$
methylpropene	$H_3C-\overset{\displaystyle CH_3}{\overset{\vert}{C}}=CH_2$

(a) Give the molecular formula and the empirical formula of but-2-ene.

Molecular formula .....

Empirical formula .....

(2 marks)

(b) Methylpropene reacts with hydrogen bromide to produce 2-bromo-2-methylpropane as the major product.

(i) Name and outline the mechanism for this reaction.

Name of mechanism .....

Mechanism

(ii) Draw the structure of another product of this reaction and explain why it is formed in smaller amounts.

Structure

Explanation .....

.....

.....

(8 marks)

(c) Draw the structures and give the names of the two geometrical isomers of but-2-ene.

Isomer 1 *Isomer 2*

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

(2 marks)

(d) One of the isomers shown in the table can be hydrated to form a tertiary alcohol.

(i) Draw the structure and give the name of this tertiary alcohol.

Structure

Name .....

(ii) Suggest a reason why tertiary alcohols are resistant to oxidation.

.....

.....

(3 marks)

15

Turn over ▶

4 (a) Chloromethane can be made by the reaction of chlorine with methane.

(i) Give **one** essential condition for this reaction.

.....

(ii) Name the mechanism for this reaction.

.....

(iii) Further substitution can occur during this reaction. Identify the main organic product when a large excess of chlorine is used in this reaction.

.....

(3 marks)

(b) Ethanenitrile can be made by reacting chloromethane with potassium cyanide.

(i) Write an equation for this reaction.

.....

(ii) Name the mechanism for this reaction.

.....

(iii) Explain, in terms of bond enthalpies, why bromomethane reacts faster than chloromethane with potassium cyanide.

.....

.....

.....

(3 marks)

(c) Ethanenitrile can be hydrolysed to a carboxylic acid by heating it under reflux with a dilute acid. Identify the carboxylic acid formed in this reaction.

.....

(1 mark)

(d) Chloromethane can react with ammonia to produce a primary amine.

(i) What feature of the chloromethane molecule makes it susceptible to attack by an ammonia molecule?

.....

(ii) Name the amine produced in this reaction.

.....

(iii) Outline a mechanism for this reaction.

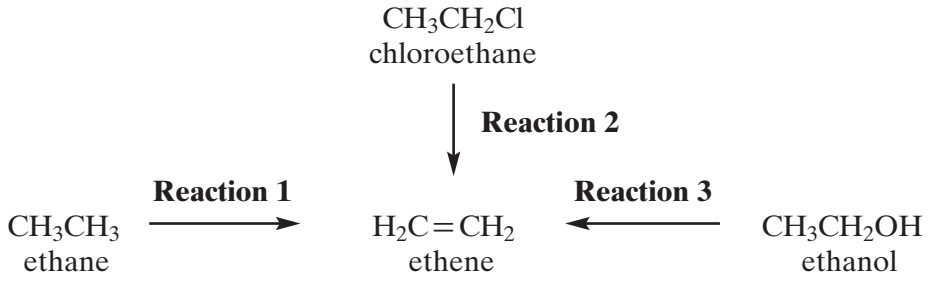
(6 marks)

13

SECTION B

Answer the question below in the space provided on pages 12 to 14 of this booklet.

5 Ethene is an important starting point for the manufacture of plastics and pharmaceutical chemicals. Most of the ethene used by industry is produced by the thermal cracking of ethane obtained from North Sea gas (**Reaction 1**). It is also possible to make ethene either from chloroethane (**Reaction 2**) or from ethanol (**Reaction 3**).



(a) Give essential conditions and reagents for each of **Reactions 2** and **3**. *(4 marks)*

(b) Name and outline a mechanism for **Reaction 2**. Suggest a reason why chloroethane is **not** chosen by industry as a starting material to make ethene commercially. *(5 marks)*

(c) Name and outline a mechanism for **Reaction 3**. Suggest why this route to ethene may become used more commonly in the future as supplies of North Sea gas begin to run out. *(6 marks)*

END OF QUESTIONS

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