Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

For Examiner's Use

General Certificate of Education
January 2009
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Friday 9 January 2009 1.30 pm to 2.30 pm

For this paper you must have
- a calculator.

Time allowed: 1 hour

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer the questions in **Section A** and **Section B** in the spaces provided. **Answers written in margins or on blank pages will not be marked**.
- Your answers to the parts of **Section B** should be on the pages indicated.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- The Periodic Table/Data Sheet is provided as an insert.

Information

- The maximum mark for this paper is 60.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- Write your answer to the question in **Section B** in continuous prose, where appropriate. You will be assessed on your ability to use good English, to organise information clearly and to use specialist vocabulary where appropriate.

Advice

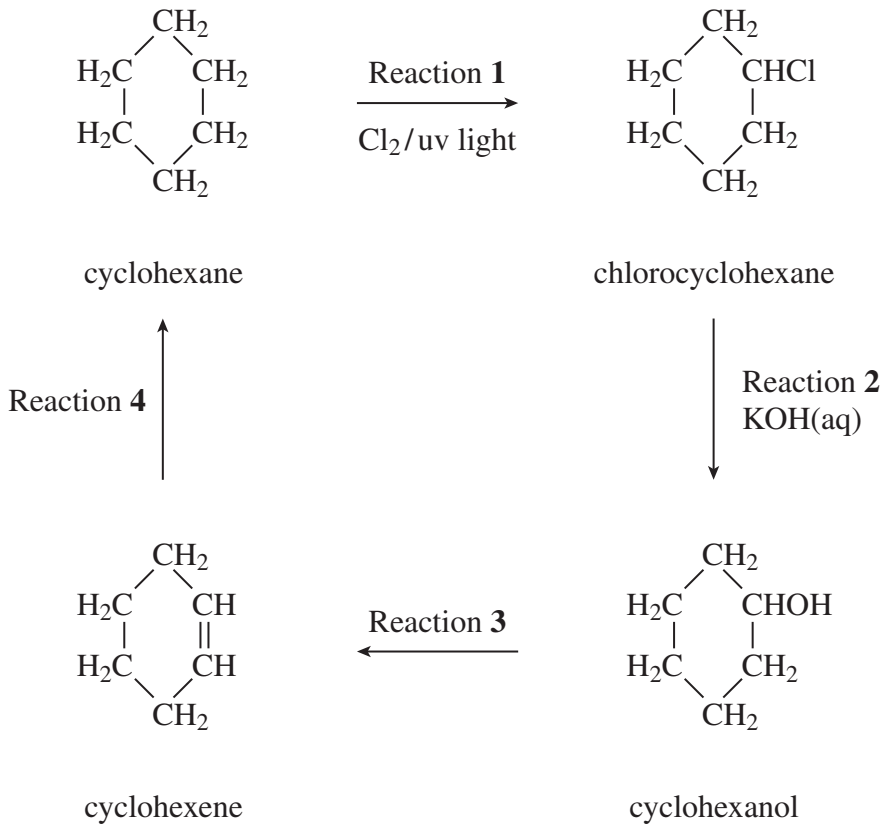
- You are advised to spend about 45 minutes on **Section A** and about 15 minutes on **Section B**.

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

SECTION A

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

1 Consider the following reaction scheme.



1 (a) The mechanism of Reaction **1** is similar to that of the reaction between chlorine and methane.
Name the type of mechanism in Reaction **1**.

.....

(1 mark)

1 (b) Name the type of mechanism in Reaction **2**.

.....

(1 mark)

1 (c) Identify a catalyst for Reaction **3**.

.....

(1 mark)

1 (d) Cyclohexanol can be oxidised by reaction with acidified potassium dichromate(VI).

1 (d) (i) State the class of alcohols to which cyclohexanol belongs.

.....

(1 mark)

1 (d) (ii) Identify the functional group formed when cyclohexanol is oxidised under these conditions.

.....

(1 mark)

1 (e) Cyclohexene is an unsaturated hydrocarbon.

1 (e) (i) State what is meant by the term *unsaturated* as applied to a hydrocarbon.

.....

.....

(1 mark)

1 (e) (ii) Identify a reagent and a catalyst which can be used for Reaction **4**.

Reagent .....

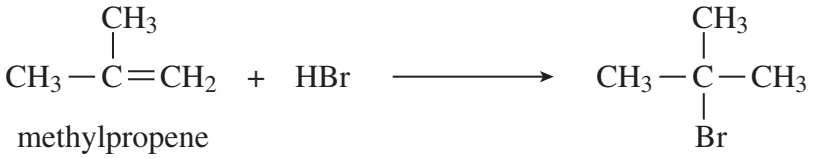
Catalyst .....

(2 marks)

8

Turn over for the next question

2 Consider the following reaction between methylpropene and hydrogen bromide.



2 (a) Name the product of this reaction.

.....

(1 mark)

2 (b) Name and outline a mechanism for this reaction between methylpropene and hydrogen bromide.

Name of mechanism .....

Mechanism

(5 marks)

2 (c) When methylpropene reacts with hydrogen bromide another organic compound is formed as a minor product.

2 (c) (i) Draw the structure of this minor product.

(1 mark)

2 (c) (ii) Use your knowledge of the mechanism to explain why only a relatively small amount of this minor product is formed.

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.....

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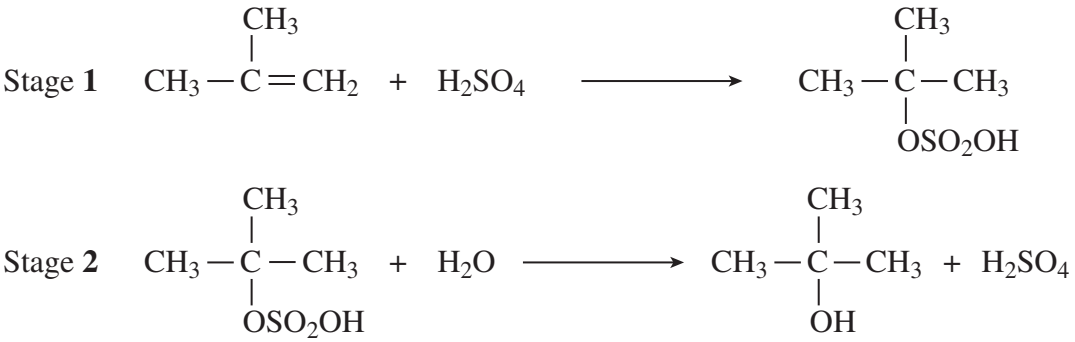
(2 marks)

2 (d) Methylpropene reacts to form a tertiary alcohol in a two-stage process.



2 (d) (i) State the overall role of the sulphuric acid in this two-stage process.

.....

(1 mark)

2 (d) (ii) Stage **2** of this process uses water as a reagent. Name the type of reaction in Stage **2**.

.....

(1 mark)

2 (d) (iii) Name the alcohol formed by this process.

.....

(1 mark)

2 (d) (iv) State why tertiary alcohols are resistant to oxidation by acidified potassium dichromate(VI).

.....

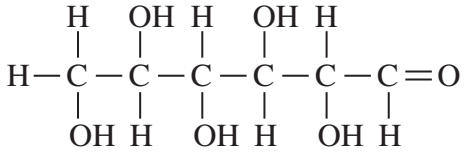
.....

(1 mark)

13

Turn over ▶

3 In aqueous solution, some glucose molecules ($C_6H_{12}O_6$) have the structure shown below.



3 (a) Give the empirical formula of glucose and name the **two** different types of functional group in this form of glucose.

Empirical formula of glucose .....

Name of functional group 1 .....

Name of functional group 2 .....

(3 marks)

3 (b) An aqueous solution of glucose can be converted into ethanol and carbon dioxide.

3 (b) (i) Name this process.

.....

(1 mark)

3 (b) (ii) Write an equation for this process.

.....

(1 mark)

3 (b) (iii) Give **two** disadvantages of this process when it is used to make ethanol on a large scale. Do **not** include the cost of the process in your answer.

Disadvantage 1 .....

.....

Disadvantage 2 .....

.....

(2 marks)

3 (b) (iv) Write an equation for the complete combustion of ethanol.

.....

(1 mark)

8

4 Ammonia reacts with 1–bromobutane according to the following equation.

$$CH_3CH_2CH_2CH_2Br + 2NH_3 \longrightarrow \underset{\mathbf{Q}}{CH_3CH_2CH_2CH_2NH_2} + NH_4Br$$

4 (a) Name and outline a mechanism for the reaction of ammonia with 1–bromobutane.

Name of mechanism .....

Mechanism

(5 marks)

4 (b) Name compound **Q** and draw the structure of a position isomer of **Q**.

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

*Structure of position isomer of **Q***

(2 marks)

7

5 But–2–ene is formed from 2–bromobutane. The equation for this reaction is shown below.

$$CH_3CH_2CHBrCH_3 + NaOH \longrightarrow CH_3CH{=}CHCH_3 + H_2O + NaBr$$

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

Name of mechanism .....

Mechanism

(4 marks)

5 (b) But–2–ene exists as two stereoisomers.

5 (b) (i) State what is meant by the term *stereoisomers*.

.....

.....

.....

(2 marks)

5 (b) (ii) Name the type of stereoisomerism shown by but–2–ene.

.....

(1 mark)

5 (b) (iii) Draw the structures of the **two** stereoisomers of but–2–ene. Name these stereoisomers.

Stereoisomer 1 *Stereoisomer 2*

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

(2 marks)

9

SECTION B

Answer the question below in the spaces provided on pages 10 to 12 of this booklet.
You should answer each part of the question on the separate pages as shown.
Each part of the question is reprinted at the top of the page.

6 Crude oil is a mixture of hydrocarbons from which several fractions, including gasoline and naphtha, can be separated.

Gasoline is used as a fuel in petrol-engined cars and this use can result in the formation of atmospheric pollutants.

Naphtha is thermally cracked to produce mainly alkenes.

6 (a) Give the name of the process used to separate the fractions gasoline and naphtha from crude oil. Outline the essential features of this process and explain why it leads to separation of the fractions.

(5 marks)

6 (b) The gaseous pollutants carbon monoxide and nitrogen monoxide are formed in small amounts during the combustion of nonane (C_9H_{20}) in a petrol-engined car.

Write equations for the reactions which produce these **two** pollutants.

Explain why these reactions occur in a petrol engine.

Write an equation for the reaction that occurs in a catalytic converter which removes **both** of these gaseous pollutants from the exhaust gases of a petrol-engined car.

(5 marks)

6 (c) Give **one** essential condition for the thermal cracking of naphtha and name the type of reactive intermediate involved.

Write an equation to show how one molecule of the alkane $C_{14}H_{30}$ can be converted into one molecule of ethene, two molecules of propene and one molecule of an alkane.

State **one** reason why the production of alkenes is such an important industrial process.

(5 marks)

END OF QUESTIONS

6 (a) Give the name of the process used to separate the fractions gasoline and naphtha from crude oil. Outline the essential features of this process and explain why it leads to separation of the fractions. *(5 marks)*

Write your answer to Question 6(a) on this page.

6 (b) The gaseous pollutants carbon monoxide and nitrogen monoxide are formed in small amounts during the combustion of nonane (C_9H_{20}) in a petrol-engined car.
Write the equations for the reactions which produce these **two** pollutants.

Explain why these reactions occur in a petrol engine.

Write an equation for the reaction that occurs in a catalytic converter which removes **both** of these gaseous pollutants from the exhaust gases of a petrol-engined car.

(5 marks)

Write your answer to Question 6(b) on this page.

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6 (c) Give **one** essential condition for the thermal cracking of naphtha and name the type of reactive intermediate involved.

Write an equation to show how one molecule of the alkane $C_{14}H_{30}$ can be converted into one molecule of ethene, two molecules of propene and one molecule of an alkane.

State **one** reason why the production of alkenes is such an important industrial process.

(5 marks)

Write your answer to Question 6(c) on this page.

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CHEMISTRY **CHM3/W**
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Gas constant $R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$

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

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