Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

For Examiner's Use

General Certificate of Education
January 2008
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Thursday 10 January 2008 9.00 am to 10.00 am

For this paper you must have
- 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.
- Answer the 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 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 answers to the question in **Section B** 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**.
- The parts of Section B should be answered on separate pages as indicated.

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 Petroleum and natural gas are mixtures of alkanes with sulphur-containing impurities. Alkanes are saturated hydrocarbons.

(a) (i) Name the process that is used to separate petroleum into useful fractions.

.....

(1 mark)

(ii) State what is meant by the term petroleum *fraction*.

.....

.....

(1 mark)

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

.....

.....

(1 mark)

(c) Pollutants are formed when hydrocarbon fractions are burned in a limited supply of air.

(i) Write an equation for the incomplete combustion of decane ($C_{10}H_{22}$) to give carbon monoxide and water only.

.....

(1 mark)

(ii) Identify a **solid** pollutant which could form during the incomplete combustion of decane.

.....

(1 mark)

(iii) Identify the pollutant which would be formed from the sulphur-containing impurities in petroleum if they were burned.

.....

(1 mark)

(d) When they are burned in air, the alcohols methanol and ethanol produce smaller amounts of pollutants than petroleum fractions.

(i) Write an equation for the complete combustion of methanol, CH_3OH

.....

(1 mark)

(ii) It may be desirable to increase the use of ethanol as a fuel in the future. Give **one** reason for this, other than the production of smaller amounts of pollutants.

.....

.....

(1 mark)

8

Turn over for the next question

2 The first four members of the homologous series of alkenes are shown below.

ethene	$H_2C{=}CH_2$
propene	$H_2C{=}CHCH_3$
but-1-ene	$H_2C{=}CHCH_2CH_3$
pent-1-ene	$H_2C{=}CHCH_2CH_2CH_3$

(a) One characteristic of an homologous series is that it can be represented by a general formula.

(i) Give the general formula for these alkenes.

.....

(1 mark)

(ii) State **two** other characteristics of an homologous series.

Characteristic 1 .....

.....

Characteristic 2 .....

.....

(2 marks)

(b) Give the molecular formula for the next member of this homologous series.

.....

(1 mark)

(c) Draw the structure of the position isomer of pent-1-ene.

(1 mark)

(d) Buta-l,3-diene has the formula

$$H_2C{=}CH{-}CH{=}CH_2$$

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

.....

.....

(1 mark)

(ii) Give the empirical formula of buta-l,3-diene.

.....

(1 mark)

(e) Alkenes are able to react with bromine even though bromine is a non-polar molecule.

(i) Explain why non-polar bromine molecules are able to react with the double bonds in alkenes.

.....

.....

.....

.....

(2 marks)

(ii) Name the type of mechanism involved in this reaction.

.....

(1 mark)

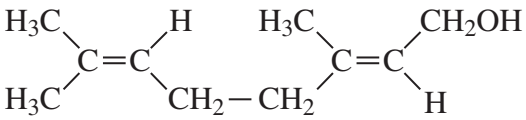
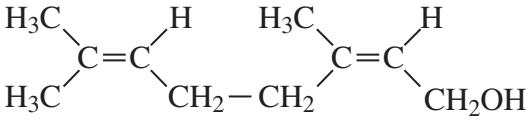
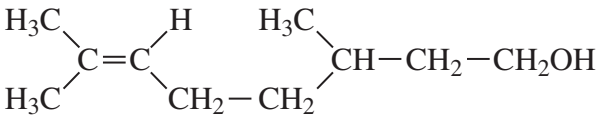
(iii) Draw the structure of the compound with M_r = 373.6, formed when buta-1,3-diene reacts with an excess of bromine.

(1 mark)

11

Turn over for the next question

3 The naturally-occurring fragrances in rose oil contain unsaturated alcohols. Three of these alcohols are shown in the following table.

Geraniol	
Nerol	
Citronellol	

(a) Geraniol and nerol are stereoisomers of each other.

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

.....

.....

.....

(2 marks)

(ii) State the type of stereoisomerism shown by geraniol and nerol.

.....

(1 mark)

(b) Citronellol can be formed from either geraniol or nerol by the same type of chemical reaction.

(i) State the type of reaction.

.....

(1 mark)

(ii) Give a reagent and a catalyst for this reaction.

Reagent .....

Catalyst .....

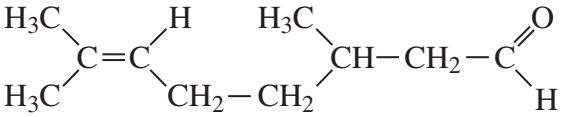
(2 marks)

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

.....

(1 mark)

(d) Citronellol can be converted into the aldehyde citronellal, which has the following structure.



State the type of reaction and a reagent or combination of reagents which could be used to convert citronellol into citronellal.

Type of reaction .....

Reagent or combination of reagents

.....

(2 marks)

9

Turn over for the next question

4 Catalysts are used extensively in reactions.

(a) Write an equation for the reaction between nitrogen monoxide and carbon monoxide in a catalytic converter of a petrol-engined car. Identify a catalyst used in a catalytic converter.

Equation

Catalyst .....

(2 marks)

(b) Epoxyethane is manufactured from ethene and oxygen. Draw the structure of epoxyethane and identify the catalyst used in this reaction.

Structure

Catalyst .....

(2 marks)

(c) Write an equation for the catalytic cracking of dodecane ($C_{12}H_{26}$) to form cyclohexane and one other alkane. Identify the catalyst used in this reaction.

Equation

Catalyst .....

(2 marks)

(d) Write an equation for the fermentation of glucose ($C_6H_{12}O_6$) and identify a catalyst for this process.

Equation

Catalyst .....

(2 marks)

(e) Write an equation for the elimination of water from butan-1-ol showing the structures of the organic compounds. Identify a catalyst used in this reaction.

Equation

Catalyst .....

(2 marks)

10

5 Bromomethane (CH_3Br) reacts with bromine by a free-radical substitution mechanism to form dibromomethane, CH_2Br_2
The reaction mechanism is similar to that for the reaction of chlorine with methane.

(a) Write equations for the following steps in the mechanism for the reaction of bromine with CH_3Br to form CH_2Br_2

Initiation step

.....

First propagation step

.....

Second propagation step

.....

(3 marks)

(b) The bromination of bromomethane will produce a mixture of products including dibromomethane, tribromomethane and tetrabromomethane.

(i) Write an overall equation for the conversion of bromomethane into tetrabromomethane, CBr_4

.....

(1 mark)

(ii) State how the reaction conditions would have to be adjusted to produce the highest possible yield of tetrabromomethane.

.....

.....

(1 mark)

(c) Complete and balance the following equation for the reaction of ammonia with bromomethane. Give the name of the organic product of this reaction.

CH_3Br + …… ⟶ …… + NH_4Br

Name of product .....

(2 marks)

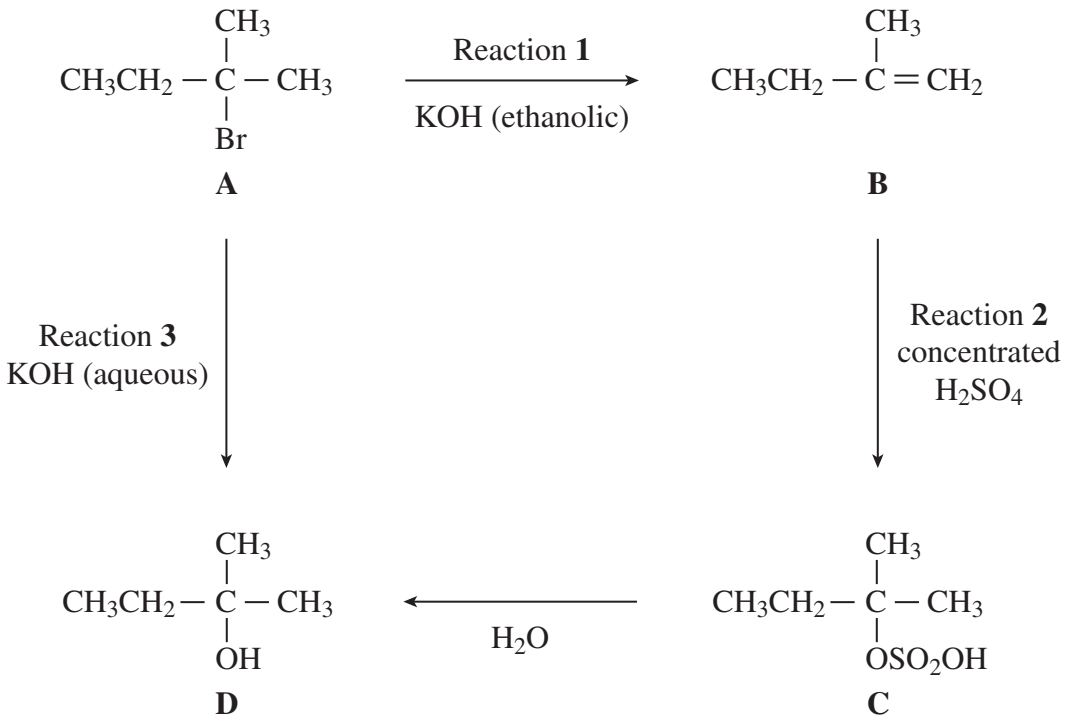
7

Turn over ▶

SECTION B

Answer the question below in the spaces provided on pages 11 to 16 of this booklet. You should answer part (a) on page 11, part (b) on page 12, part (c) on page 13 and part (d) on page 14.

6 Consider the following scheme of reactions.



(a) Name compounds **A**, **B** and **D**.

(3 marks)

(b) Name and outline a mechanism for the conversion of **A** into **B** (Reaction **1**).

(4 marks)

(c) Name and outline a mechanism for the conversion of **B** into **C** (Reaction **2**).

(5 marks)

(d) Name and outline a mechanism for the conversion of **A** into **D** (Reaction **3**).

(3 marks)

END OF QUESTIONS

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

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

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

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

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