Surname	Other	Names			
Centre Number		Candida	ate Number		
Candidate Signature					

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General Certificate of Education January 2007 Advanced Subsidiary Examination ASSESSMENT and QUALIFICATIONS
ALLIANCE

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

Thursday 11 January 2007 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 on pages 3 and 4. Detach this perforated sheet at the start of the examination.

### **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 questions 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**.

F	or Exam	iner's Us	е			
Question	Mark	Question	Mark			
1						
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3						
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Total (Co	$\rightarrow$					
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TOTAL						
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## SECTION A

Answer all questions in the spaces provided.

1		_	es in the production of poly(propene) from petroleum are fractional distillation, acking and polymerisation.
	(a)		actional distillation, the petroleum is evaporated and different fractions condense ferent levels in a fractionating column.
		(i)	State in which part of the column the temperature is highest.
		(ii)	State in which part of the column hydrocarbons with lower molecular masses condense.
			(2 marks)
	(b)	Ther	mal cracking of alkanes at a high temperature gives a high percentage of alkenes.
		(i)	State why a high temperature is needed for the thermal cracking of alkanes.
		(ii)	Give the general formula for alkenes.
		(iii)	Write an equation for the thermal cracking of one molecule of $C_{13}H_{28}$ to give ethene and propene, in the ratio of 2:1, and an alkane.
		(iv)	Propene can be polymerised. Draw the structure of the repeating unit of poly(propene).

(5 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.

_	=											=	≥	>	>	<b>=</b>	0
1.0 <b>H</b> Hydrogen		_	Key														4.0 <b>He</b> Helium 2
6.9 <b>Li</b> Lithium	9.0 <b>Be</b> Beryllium 4		relative atomic	relative atomic mass		6.9 <b>Li</b> Lithium						10.8 <b>B</b> Boron	12.0 <b>C</b> Carbon	14.0 <b>N</b> Nitrogen	16.0 <b>O</b> Oxygen	19.0 <b>F</b> Fluorine	20.2 <b>Ne</b> Neon
23.0 23 2 23.0 23 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	H.3 Mg agnesium											_	.8.1 <b>Si</b> Silicon	31.0 <b>P</b> Phosphorus 15	32.1 <b>S</b> Sulphur 16		39.9 <b>Ar</b> Argon
	_	Scandium 21	_ ا	_	_	ı w	<b>Fe</b> 155.8 150 150 150 150 150 150 150 150 150 150	58.9 <b>Co</b> Cobalt 27	58.7 <b>Nickel</b> 28	63.5 <b>Cu</b> Copper 29	65.4 <b>Zn</b> Zinc 30	69.7 <b>Ga</b> Gallium 31	.2.6 <b>Ge</b> Sermanium	74.9 <b>As</b> Arsenic 33	79.0 <b>Se</b> Selenium 34		83.8 <b>Kr</b> Krypton 36
85.5 <b>Rb</b> Rubidium 37	87.6 Srontium 38	88.9 <b>Y</b> Yttrium 39	91.2 <b>Zr</b> Zirconium 40	92.9 <b>Nb</b> Niobium 41	95.9         98.9         101.1         102.9           Mo         Tc         Ru         Rh           Molybdenum         Technetium         Ruthenium         Rhodium           42         43         44         45	98.9 <b>Tc</b> Technetium	101.1 <b>Ru</b> Ruthenium 44		_	107.9 <b>Ag</b> Silver 47		114.8 <b>In</b> Indium 49		≥	127.6 <b>Te</b> Te Tellurium 52		131.3 <b>Xe</b> Xenon 54
	137.3 <b>Ba</b> Barium 56	138.9 <b>La</b> La Lanthanum 57 *	178.5 <b>Hf</b> Hafnium 72	180.9 <b>Ta</b> Tantalum 73	183.9 W Tungsten 74	186.2 <b>Re</b> Rhenium 75	190.2 <b>Os</b> Osmium 76	192.2 <b>    r</b>   <b>  r</b>   Iridium	195.1 <b>Pt</b> Platinum 78	197.0 <b>Au</b> Gold 79	200.6 <b>Hg</b> Mercury 80		207.2 <b>Pb</b> Lead 82	209.0 <b>Bi</b> Bismuth 83	210.0 <b>Po</b> Polonium 84	210.0 <b>At</b> Astatine 85	222.0 <b>Rn</b> Radon 86
223.0	226.0 <b>Ra</b> Radium 88	227 <b>Ac</b> Actinium 89 †															
thealthanides ada ada ada ada ada ada ada ada ada ad	Lantha	nides		_	140.9 <b>Pr</b> Praseodymium 1	Neodymium   60 (	144.9 Pm Promethium 631 (	150.4 <b>Sm</b> Samarium 62	152.0 <b>Eu</b> Europium (63	157.3 <b>Gd</b> Gadolinium 64	158.9 <b>Tb</b> Terbium	162.5 164.9 <b>Dy Ho</b> Dysprosium Holmium  66  67	164.9 <b>Ho</b> Holmium 67	167.3 <b>Er</b> bit 58	168.9 <b>Tm</b> Thulium 69	173.0 <b>Yb</b> Ytterbium 70	. Tm Yterbium Lutetium 69 70 70 70 70 70 70 70 70 70 70 70 70 70
rs.eom	3 Actini	səp		<b>Th</b> Thorium 90	Protactinium 91	.236.0 <b>U</b> Uranium 92	Np	Pu Pu Plutonium 94	Americium	Curium 96	Bk Bk Berkelium	247.1   252.1   (252)   (252	Einsteinium 99	(257) Fermi 100	Md Mendelevium 101	Nobelium	Lawrencium

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 <sub>3</sub>	0.7–1.2
$R_2CH_2$	1.2–1.4
$R_3$ CH	1.4–1.6
$RCOCH_3$	2.1–2.6
$ROCH_3$	3.1–3.9
RCOOCH <sub>3</sub>	3.7–4.1
ROH	0.5-5.0

**Table 2** Infra-red absorption data

Bond	Wavenumber/cm <sup>-1</sup>
С—Н	2850–3300
С—С	750–1100
C=C	1620–1680
C=O	1680–1750
С—О	1000-1300
O—H (alcohols)	3230–3550
O—H (acids)	2500–3000

2	(a)	petro	bleum. In car engines, fuels undergo combustion reactions, which can lead to the ation of pollutants.
		(i)	Write an equation for the complete combustion of pentane, $C_5H_{12}$
		(ii)	Identify a <b>solid</b> pollutant formed when pentane undergoes incomplete combustion.
		(iii)	Give one reason why sulphur dioxide gas may be found in the exhaust gases of cars.
		(iv)	Give one reason why sulphur dioxide is considered to be a pollutant.
			(4 marks)
	(b)		nol is an alternative fuel for car engines. Ethanol can be made either by the ation of ethene or by the fermentation of glucose.
		(i)	State what is meant by the term <i>hydration</i> .
		(ii)	Write an equation for the hydration of ethene.
		(iii)	Write an equation for the formation of ethanol from glucose, $C_6H_{12}O_6$
		(iv)	Write an equation for the incomplete combustion of ethanol to produce carbon monoxide and water only.

(4 marks)

 $3\,$  The table below gives the structures of the four isomeric alkenes with molecular formula  $C_4H_8$ 

Isomer 1		Isomer 2
	$CH_3CH_2$ $H$ $C=C$ $H$	$H_3C$ $H$ $C=C$ $H$
Isomer 3		Isomer 4
	$C=C$ $H_3$ $H_3$ $H_3$ $H_3$	$H$ $C=C$ $H_3C$ $CH_3$

(a)	Nam	te Isomer 1 and Isomer 2.	
	Isom	er 1	
	Isom	ver 2	(2 marks)
(b)	(i)	State what is meant by the term <i>stereoisomers</i> .	
	(ii)	From the table, identify two isomers which are stereoisomers.	
		and	
			(3 marks)
(c)	Fron	n the table, identify the isomer which is a chain isomer of Isomer 1.	
			(1 mark)

(d) Isomer 2 reacts with concentrated sulphuric acid to form compound W as shown in the equation below. Name and outline a mechanism for this reaction.

$$H_3C - C = CH_2 + H_2SO_4 \longrightarrow H_3C - C - CH_3$$

$$CH_3 CH_3$$

$$CH_3$$
OSO<sub>2</sub>OH
$$CH_3$$

Isomer 2 W

Name of mechanism .....

Mechanism

(5 marks)

- (e) Compound W reacts with water to form an alcohol and sulphuric acid.
  - (i) Complete the equation for this reaction

$$\begin{array}{c} OSO_2OH \\ H_3C-C-CH_3 & + & H_2O \\ \hline CH_3 & \end{array}$$

 $\mathbf{W}$ 

(ii) Name the alcohol produced in this reaction.

(2 marks)

(f) State the overall role of the sulphuric acid in the conversion of Isomer 2 into the alcohol formed in part (e).

.....

- **4** The reaction of acidified potassium dichromate(VI) with ethane-1,2-diol produces ethanedioic acid.
  - (a) (i) Balance the following equation for this reaction

(ii) An intermediate formed in this reaction is a compound with only aldehyde functional groups and an empirical formula of CHO Draw the structure of this intermediate compound.

(2 marks)

(b) Ethane-1,2-diol can be made from ethene by the following routes.

Route 2

$$\begin{array}{c} \text{Reaction 3} \\ \text{H}_2\text{C} = \text{CH}_2 \xrightarrow{\text{O}_2} \begin{array}{c} \text{Compound X} \\ \text{Ag catalyst} \end{array} \xrightarrow{\text{Reaction 4}} \begin{array}{c} \text{CH}_2\text{OH} \\ \text{CH}_2\text{OH} \end{array}$$

(i) State the type of mechanism in Reaction 1 and that in Reaction 2.

Type of mechanism in Reaction 1 .....

Type of mechanism in Reaction 2

(ii)	Name compound $X$ and state the type of reaction in Reaction 4.
	Name of compound X
	Type of reaction in Reaction 4
(iii)	The compound $BrCH_2CH_2Br$ can react with an excess of ammonia to produce a compound with $M_r = 60.0$ Complete and balance the equation for this reaction.
	$BrCH_2CH_2Br + NH_3 \longrightarrow$

(6 marks)

Turn over for the next question

- 5 The refrigerant R410A, used in modern air conditioners, is a mixture of difluoromethane and pentafluoroethane. These compounds are made by fluorination reactions.
  - (a) The mechanism for the reaction of fluorine with either an alkane or a fluoroalkane is a free-radical substitution similar to the chlorination of methane.

(1)	fluoromethane, CH <sub>3</sub> F, to form difluoromethane, CH <sub>2</sub> F <sub>2</sub>
	Initiation step
	First propagation step
	Second propagation step
(ii)	Write the overall equation for the reaction of fluorine with ethane to form pentafluoroethane, CF <sub>3</sub> CHF <sub>2</sub>
	(4 marks)
their	other refrigerants, R12 and R13, are no longer used because of concerns about possible effects on the ozone layer. refrigerant R12 is the compound dichlorodifluoromethane.
(i)	Write the formula for dichlorodifluoromethane.
(ii)	The compound R13 contains $11.5\%$ carbon and $34.0\%$ chlorine by mass. The remainder of the compound is fluorine. Calculate the empirical formula of R13.

(b)

 $(4 \ marks)$ 

### **SECTION B**

Answer both the questions below in the space provided on pages 11 to 16 of this booklet.

6 The compound prop-2-en-l-ol is an unsaturated alcohol with the structure

(a) Prop-2-en-l-ol can form a saturated alcohol by reaction with hydrogen in the presence of a nickel catalyst.

State what is meant by the term *saturated* as applied to a saturated alcohol. Write an equation for the reaction of prop-2-en-l-ol with hydrogen and name the product of this reaction.

(3 marks)

(b) Draw the structures of the two functional group isomers of prop-2-en-l-ol, each of which contains the C=O group. For each isomer, name the class of compounds to which it belongs.

(4 marks)

7 The haloalkane 2-bromo-2-methylbutane has the structure shown below.

This haloalkane can undergo elimination reactions to form two different alkenes. Identify a reagent and conditions for these elimination reactions.

Draw the structures of the two alkenes formed. Name one of these alkenes and outline a mechanism for its formation.

**END OF QUESTIONS** 

(8 marks)

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