Surname			Other	Names			
Centre Number				Candida	ate Number		
Candidate Signa	ure						

For Examiner's Use

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	For Examiner's Use							
Question	Mark	Question	Mark					
1								
2								
3								
4								
5								
6								
7								
Total (Co	olumn 1)	<b>→</b>						
Total (Co	olumn 2) _	$\rightarrow$						
TOTAL								
Examine	r's Initials							

## 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 fferent 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.

				Ι		I				1		1
0	4.0 <b>He</b> Helium 2									222.0 <b>Rn</b>	Radon 86	
<b>=</b>		19.0 <b>म</b>	Fluorine 9	35.5 C	Chlorine 17	79.9 <b>Br</b>	Bromine 35	126.9 <b>–</b>	lodine 53	210.0 <b>At</b>	Astatine 85	
5		16.0 <b>O</b>	Oxygen 8	32.1 <b>S</b>	Sulphur 16	79.0 <b>Se</b>	Selenium 34	127.6 <b>Te</b>	Tellurium 52	210.0 <b>Po</b>	Polonium 84	
>		14.0 <b>Z</b>	Nitrogen Oxygen 9	31.0 <b>P</b>	Phosphorus 15	74.9 <b>As</b>	Arsenic 33	121.8 <b>Sb</b>	Antimony 51	209.0 <b>Bi</b>	Bismuth 83	
≥		12.0 C	Boron Carbon 7	28.1 <b>Si</b>	Silicon 14	72.6 <b>Ge</b>	Germanium 32	118.7 <b>Sn</b>	Tin 50	207.2 <b>Pb</b>	Lead 82	
≡		10.8 <b>B</b>	Boron 5	27.0 <b>Al</b>	Aluminium 13	59.7 <b>Ga</b>	Gallium 31	114.8 <b>"</b>	Indium 49	204.4 <b>T</b>	Thallium 81	
				1		55.4 <b>Zn</b>	Zinc 30	112.4 Cd	Cadmium 48	200.6 <b>Hg</b>	Mercury 30	
							Copper 29			197.0 <b>Au</b>		
							Nickel 28			195.1		
							Cobalt 27	. <b>Rh</b>	Rhodium 45	. 2.26	lridium 77	
						55.8 Fe	lron 26	01.1 <b>B</b>	Ruthenium 44	90.2 <b>Os</b>	Osmium 76	
		6.9 <b>Li</b>	Lithium 3			54.9 <b>Mn</b>	Manganese Iron Cobalt 25 27	98.9 <b>Tc</b>	Technetium 43	186.2 <b>Re</b>	Rhenium 75	
				I		52.0 <b>Ç</b>	Chromium 24	95.9 Mo	Molybdenum 42	183.9 W	Tungsten 74	
		tomic ma	ımber —			<b>5</b> 0.9		92.9 <b>N</b>		180.9 <b>Ta</b>	E	
	Key	relative atomic mass -	atomic number			47.9		91.2 <b>Zr</b>	Zirconium 40	178.5 <b>Hf</b>	Hafnium 72	
	_	_	.0			45.0 <b>Sc</b>		88.9 <b>&gt;</b>		138.9 <b>La</b>	_	227 <b>Ac</b> Actinium 89 †
=		9.0 <b>Be</b>	Beryllium 4	24.3 <b>Mg</b>		40.1 <b>Ca</b>		87.6 <b>S</b>	_	137.3 <b>Ba</b>	_	226.0 <b>Ra</b> Radium 88
-	1.0 <b>T</b> Hydrogen	6.9 Li	Lithium 2		Sodium 1	39.1 <b>K</b>		85.5 8	_	132.9 <b>CS</b>		223.0 <b>Fr</b> Francium 87
	. +-		(-)	1.4		100			(-)	1,-	4)	, ω

- V	140.1 <b>Ce</b>	140.1         140.9         144.2         144.9           Ce         Pr         Nd         Pm	144.2 <b>Nd</b>	144.9 <b>Pm</b>	150.4 152.0 <b>Sm Eu</b>		157.3 <b>Gd</b>			164.9 <b>Ho</b>	167.3 <b>Er</b>		173.0 <b>Yb</b>	175.0 <b>Lu</b>
<b>36 - 71</b> Laninanides	Cerium 58	Cerium Praseodymium Neodymium Promethium 58 60 61	Neodymium 60	Promethium 61	Samarium 62		Ε	Terbium 65	Dysprosium 66		Erbium 68	Thulium 69	Ytterbium 70	Lutetium 71
00 t	232.0 <b>Th</b>	232.0 231.0 238.0 237.0 <b>Th Pa U Np</b>	238.0 <b>U</b>		239.1 <b>Pu</b>	243.1 <b>Am</b>	E			(252) <b>Es</b>	(257) <b>Fm</b>	(258) <b>Md</b>	(259) <b>No</b>	(260) <b>Lr</b>
<b>90 - 103</b> Actimides	Thorium 90	Thorium Protactinium Uranium Neptunium 90 91	Uranium 92	Neptunium 93	Plutonium 94	Americium 95		Berkelium 97	_			Mendelevium 101	Nobelium 102	Lawrencium 103

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 <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	fuels used most frequently in car engines are mixtures of alkanes obtained from 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.
	(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.
		(:::)	White an advation for the formation of athenal from alvesta C.H. O
		(iii)	Write an equation for the formation of ethanol from glucose, C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>
		(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	
	$CH_3CH_2$ $H$ $C=C$ $H$		C = C $C = C$ $C = C$
Isomer 3		Isomer 4	
	$C=C$ $H_3$ $H_3$ $H_3$ $H_4$ $H_4$ $H_4$ $H_4$ $H_4$ $H_5$	Н	$H$ $C=C$ $CH_3$

(a)	Nam	e Isomer 1 and Isomer 2.	
	Isom	er 1	
	Isom	er 2	
			(2 marks)
(b)	(i)	State what is meant by the term stereoisomers.	
	(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.

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

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

 $\mathbf{W}$ 

(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).

(1 mark)

- 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 1

$$H_2C = CH_2 \xrightarrow{\text{Reaction 1}} BrCH_2CH_2Br \xrightarrow{\text{Reaction 2}} CH_2OH \xrightarrow{\text{NaOH(aq)}} CH_2OH$$

Route 2

$$\begin{array}{c} \text{H}_2\text{C} = \text{CH}_2 \xrightarrow{\text{Reaction 3}} & \text{Compound X} & \xrightarrow{\text{Reaction 4}} & \text{CH}_2\text{OH} \\ & O_2 & & | & | \\ & Ag \text{ catalyst} & & | & | \\ \end{array}$$

(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 <b>X</b> and state the type of reaction in Reaction <b>4</b> .
	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

- 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.

(i)	Outline the following steps in the mechanism for the reaction of fluorine with fluoromethane, $CH_3F$ , to form difluoromethane, $CH_2F_2$
	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.
	(4 marks)

(b)

### **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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