

Surname						Other Names					
Centre Number						Candidate Number					
Candidate Signature											

For Examiner's Use

General Certificate of Education
January 2007
Advanced Subsidiary Examination



CHEMISTRY
Unit 3(a) Introduction to Organic Chemistry

CHM3/W

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**.

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

SECTION A

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

1 Three stages in the production of poly(propene) from petroleum are fractional distillation, thermal cracking and polymerisation.

(a) In fractional distillation, the petroleum is evaporated and different fractions condense at different 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) Thermal 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)

7

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

2 (a) The fuels used most frequently in car engines are mixtures of alkanes obtained from petroleum. In car engines, fuels undergo combustion reactions, which can lead to the formation of pollutants.

(i) Write an equation for the complete combustion of pentane, C_5H_{12}

.....

(ii) Identify a **solid** 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) Ethanol is an alternative fuel for car engines. Ethanol can be made either by the hydration of ethene or by the fermentation of glucose.

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

.....

.....

(ii) Write an equation for the hydration of ethene.

.....

(iii) Write an equation for the formation of ethanol from glucose, $C_6H_{12}O_6$

.....

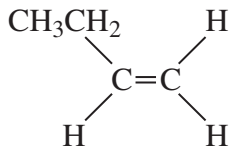
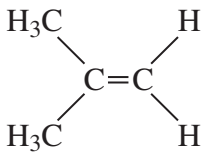
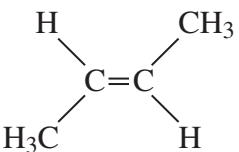
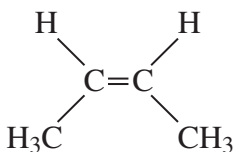
(iv) Write an equation for the incomplete combustion of ethanol to produce carbon monoxide and water only.

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(4 marks)

Turn over ►

- 3 The table below gives the structures of the four isomeric alkenes with molecular formula C_4H_8

<p>Isomer 1</p> 	<p>Isomer 2</p> 
<p>Isomer 3</p> 	<p>Isomer 4</p> 

- (a) Name Isomer 1 and Isomer 2.

Isomer 1

Isomer 2

(2 marks)

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

.....

- (ii) From the table, identify two isomers which are stereoisomers.

..... and

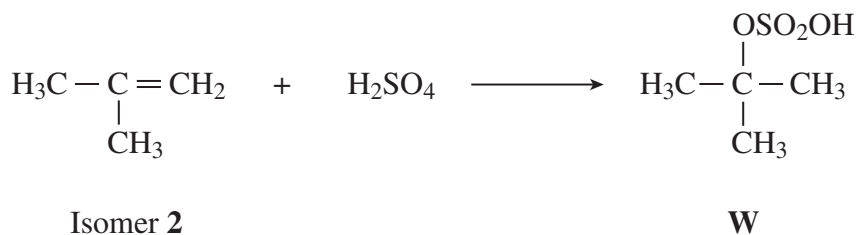
(3 marks)

- (c) From 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.



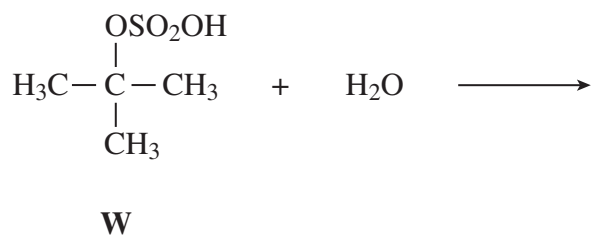
Name of mechanism

Mechanism

(5 marks)

- (e) Compound **W** reacts with water to form an alcohol and sulphuric acid.

- (i) Complete the equation for this reaction



- (ii) Name the alcohol produced in this reaction.

.....
(2 marks)

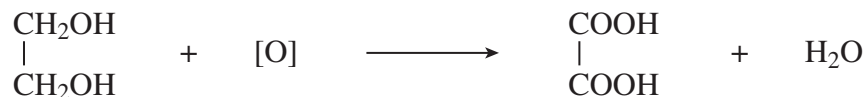
- (f) State the overall role of the sulphuric acid in the conversion of Isomer **2** into the alcohol formed in part (e).

.....
(1 mark)

Turn over ►

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

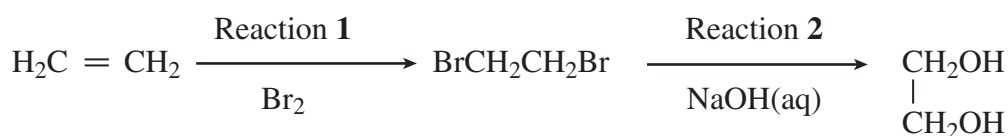


(ii) An intermediate formed in this reaction is a compound with only aldehyde functional groups and an empirical formula of CHO. Draw the structure of this intermediate compound.

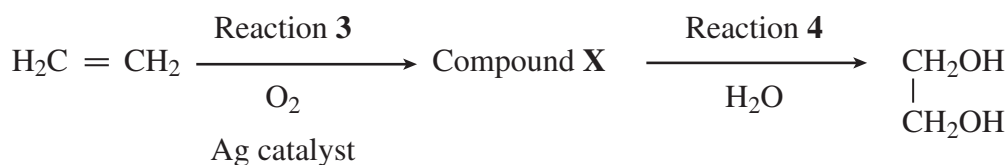
(2 marks)

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

Route 1



Route 2



(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 $\text{BrCH}_2\text{CH}_2\text{Br}$ can react with an excess of ammonia to produce a compound with $M_r = 60.0$
Complete and balance the equation for this reaction.



(6 marks)

8

Turn over for the next question

Turn over ►

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.

(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_3CHF_2

.....

(4 marks)

(b) Two other refrigerants, R12 and R13, are no longer used because of concerns about their possible effects on the ozone layer.
The 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.

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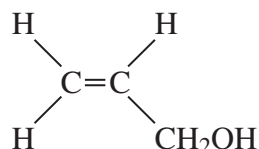
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(4 marks)

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-1-ol is an unsaturated alcohol with the structure



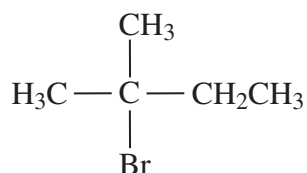
- (a) Prop-2-en-1-ol can form a saturated alcohol by reaction with hydrogen in the presence of a nickel catalyst.
State what is meant by the term *saturated* as applied to a saturated alcohol.
Write an equation for the reaction of prop-2-en-1-ol with hydrogen and name the product of this reaction.

(3 marks)

- (b) Draw the structures of the two functional group isomers of prop-2-en-1-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.

(8 marks)

END OF QUESTIONS

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Turn over ►

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Dotted lines for writing.

Turn over ►

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