Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

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General Certificate of Education
June 2006
Advanced Subsidiary Examination

AQA
ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Wednesday 7 June 2006 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 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 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 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**.

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

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SECTION A

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

1 (a) In industry, ethanol is made from ethene in an acid-catalysed reaction. Name the type of reaction. Write an equation and identify a suitable catalyst for this reaction.

Type of reaction .....

Equation

.....

Catalyst .....

(3 marks)

(b) Ethanol burns completely in a plentiful supply of air, but incomplete combustion occurs if the air supply is limited.

(i) Identify a **solid** pollutant produced by burning ethanol in a limited supply of air.

.....

(ii) Write an equation for the incomplete combustion of ethanol to produce the solid pollutant that you have identified in part (b)(i).

.....

(2 marks)

5

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

atomic number — 3

Li Lithium

*	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

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) Write an equation for the thermal decomposition of ethane to form ethene and one other product.

.....

(1 mark)

(b) Bromoethane, CH_3CH_2Br, reacts with sodium hydroxide in an elimination reaction to form ethene.

(i) Outline a mechanism for this elimination reaction.

(ii) Suggest **one** reason why this method for making ethene is not used in industry.

.....

.....

(4 marks)

(c) Ethene is used to make epoxyethane.

(i) State why epoxyethane is very reactive.

.....

.....

(ii) Identify the product formed when one molecule of epoxyethane reacts with one molecule of water. Give a use for this product.

Product .....

Use .....

(3 marks)

8

3 The reaction of bromine with ethane is similar to that of chlorine with ethane. Three steps in the bromination of ethane are shown below.

Step **1** $Br_2 \longrightarrow 2Br^{\bullet}$

Step **2** $Br^{\bullet} + CH_3CH_3 \longrightarrow CH_3CH_2^{\bullet} + HBr$

Step **3** $CH_3CH_2^{\bullet} + Br_2 \longrightarrow CH_3CH_2Br + Br^{\bullet}$

(a) (i) Name this type of mechanism.

.....

(ii) Suggest an essential condition for this reaction.

.....

(iii) Steps **2** and **3** are of the same type. Name this type of step.

.....

(iv) In this mechanism, another type of step occurs in which free-radicals combine. Name this type of step. Write an equation to illustrate this step.

Type of step .....

Equation

.....

(5 marks)

(b) Further substitution in the reaction of bromine with ethane produces a mixture of liquid organic compounds.

(i) Name a technique which could be used to separate the different compounds in this mixture.

.....

(ii) Write an equation for the reaction between bromine and ethane which produces hexabromoethane, C_2Br_6, by this substitution reaction.

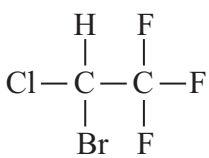
.....

(2 marks)

(c) The compound 1,2-dibromo-1,1,2,2-tetrafluoroethane is used in some fire extinguishers. Draw the structure of this compound.

(1 mark)

(d) Halothane is used as an anaesthetic and has the following structure.



(i) Give the systematic name of *halothane*.

.....

(ii) Calculate the M_r of halothane.

.....

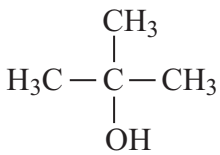
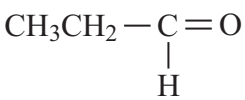
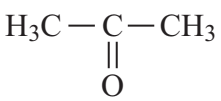
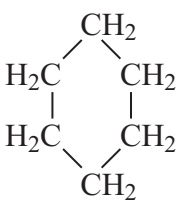
(iii) Calculate the percentage by mass of fluorine in halothane.

.....

(3 marks)

11

4 Consider the following pairs of structural isomers.

Molecular formula	Structure	Structure
$C_4H_{10}O$	Isomer **A** 	Isomer **B** $CH_3CH_2CH_2CH_2OH$
	Isomer **C** 	Isomer **D** 
C_6H_{12}	Isomer **E** 	Isomer **F** $CH_3CH_2CH=CHCH_2CH_3$

(a) (i) Explain what is meant by the term *structural isomers*.

.....

.....

(ii) Complete the table to show the molecular formula of isomers **C** and **D**.

(iii) Give the empirical formula of isomers **E** and **F**.

.....

(4 marks)

(b) A simple chemical test can be used to distinguish between separate samples of isomer **A** and isomer **B**. Suggest a suitable test reagent and state what you would observe in each case.

Test reagent .....

*Observation with isomer **A*** .....

*Observation with isomer **B*** .....

(3 marks)

(c) A simple chemical test can be used to distinguish between separate samples of isomer **C** and isomer **D**. Suggest a suitable test reagent and state what you would observe in each case.

Test reagent .....

*Observation with isomer **C*** .....

*Observation with isomer **D*** .....

(3 marks)

(d) A simple chemical test can be used to distinguish between separate samples of isomer **E** and isomer **F**. Suggest a suitable test reagent and state what you would observe in each case.

Test reagent .....

*Observation with isomer **E*** .....

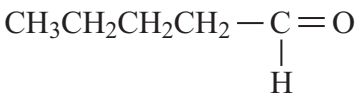
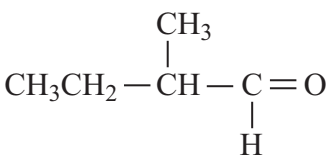
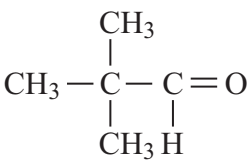
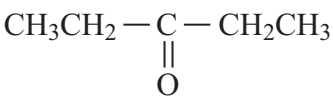
*Observation with isomer **F*** .....

(3 marks)

13

Turn over for the next question

5 There are **seven** isomeric carbonyl compounds with the molecular formula $C_5H_{10}O$
The structures and names of some of these isomers are given below.

Structure	Name
	pentanal
	2-methylbutanal
	2,2-dimethylpropanal
	
	pentan-2-one

(a) (i) Complete the table.

(ii) **Two** other isomeric carbonyl compounds with the molecular formula $C_5H_{10}O$ are not shown in the table. One is an aldehyde and one is a ketone.
Draw the structure of each.

isomeric aldehyde *isomeric ketone*

(4 marks)

(b) Pentanal, $CH_3CH_2CH_2CH_2CHO$, can be oxidised to a carboxylic acid.

(i) Write an equation for this reaction. Use [O] to represent the oxidising agent.

.....

(ii) Name the carboxylic acid formed in this reaction.

.....

(2 marks)

(c) Pentanal can be formed by the oxidation of an alcohol.

(i) Identify this alcohol.

.....

(ii) State the class to which this alcohol belongs.

.....

(2 marks)

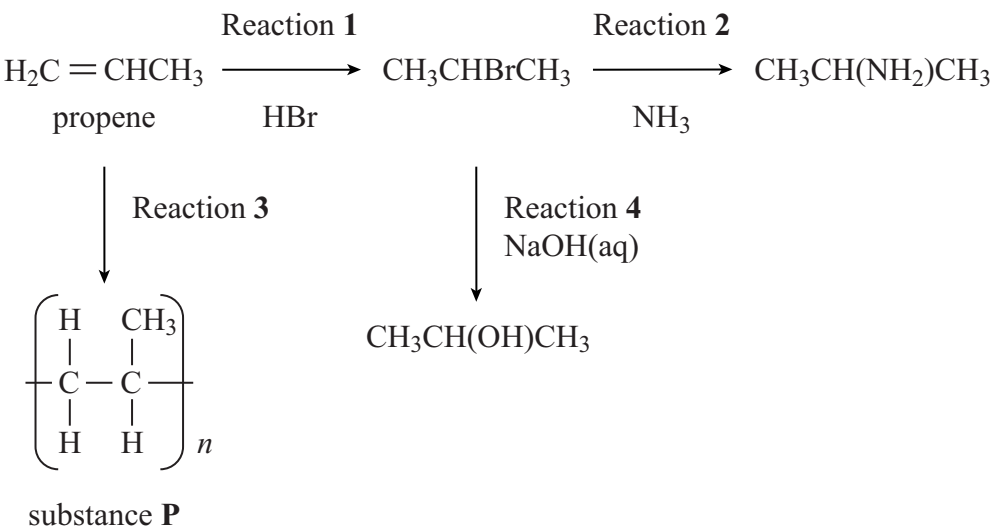
8

Turn over for the next question

SECTION B

Answer the question in the space provided.

6 One of the fractions obtained from petroleum can be thermally cracked to produce propene. Some of the reactions of propene are shown below.



substance **P**

(a) Identify the type of reactive intermediates formed during thermal cracking and explain how they are produced.

(2 marks)

(b) Outline a mechanism for Reaction **1**.

(4 marks)

(c) Outline a mechanism for Reaction **2**.

(4 marks)

(d) Name substance **P**, which is formed in Reaction **3**. Explain why substance **P** is a solid at room temperature.

(3 marks)

(e) Reaction **4** is a nucleophilic substitution reaction. Explain what is meant by the term *nucleophile* and identify the nucleophile in this reaction.

(2 marks)

END OF QUESTIONS

.....

.....

.....

.....

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