| Surname | | Other Names | |
|---|---|---|---|
| Centre Number | | | Candidate Number | |
| Candidate Signature | | | |

For Examiner's Use

General Certificate of Education
June 2008
Advanced Subsidiary Examination

AQA
ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Wednesday 4 June 2008 9.00 am to 10.00 am

**For this paper you must have**
- a calculator.

Time allowed: 1 hour

**Instructions**
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Answers written in margins or blank pages will not be marked.
- Your answers to the parts of **Section B** should be on the pages indicated.
- 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 answer 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 | | | |
|---|---|---|---|
| Question | Mark | Question | Mark |
| 1 | | 4 | |
| 2 | | 5 | |
| 3 | | 6 | |
| Total (Column 1) → | | | |
| Total (Column 2) → | | | |
| TOTAL | | | |
| Examiner's Initials | | | |

## SECTION A

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

**1** Three atmospheric pollutants which can be formed when fossil fuels are burned are shown below.

| CO | NO | $SO_2$ |
|---|---|---|
| carbon monoxide | nitrogen monoxide | sulphur dioxide |

**1** (a) The combustion of hydrocarbons in a petrol-engined car can lead to the formation of CO and NO

**1** (a) (i) State what is meant by the term *hydrocarbon*.

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*(1 mark)*

**1** (a) (ii) Write an equation for the incomplete combustion of the hydrocarbon nonane ($C_9H_{20}$) to give CO and $H_2O$ as the only products.

.....

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*(1 mark)*

**1** (a) (iii) State **one** essential condition for the formation of NO from air in a petrol-engined car. Write an equation for the reaction in which NO is formed.

*Essential condition* .....

*Equation* .....

.....

*(2 marks)*

**1** (b) Most petrol-engined cars are fitted with a catalytic converter.

**1** (b) (i) Identify **one** of the metals used as a catalyst in a catalytic converter.

.....

.....

*(1 mark)*

**1** (b) (ii) Balance the following equation.

$$C_8H_{18} + \ldots\ldots NO \longrightarrow \ldots\ldots CO_2 + \ldots\ldots N_2 + \ldots\ldots H_2O$$

*(1 mark)*

**1** (c) Natural gas is mainly methane and is burned as a fuel. State what is meant by the term *fuel*.

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*(1 mark)*

**1** (d) Natural gas contains a small amount of hydrogen sulphide, $H_2S$
Write an equation for the combustion of $H_2S$ in air to give $SO_2$ and $H_2O$ as the only products.

.....

.....

*(1 mark)*

**8**

**Turn over for the next question**

**2** The table below gives some of the names and structures of three isomers.

| Name | Structure |
|---|---|
| | $H_3C-\overset{\overset{O}{\|\|}}{C}-CH_3$ |
| propanal | |
| prop-2-en-l-ol | $H_2C{=}CHCH_2OH$ |

**2** (a) Complete the table.

*(2 marks)*

**2** (b) Name the type of structural isomerism shown by these isomers.

.....

.....

*(1 mark)*

**2** (c) State what is meant by the term *molecular formula*.

.....

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*(1 mark)*

**2** (d) Give the molecular formula for these isomers.

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*(1 mark)*

**2** (e) Propanal reacts with acidified potassium dichromate(VI) to form a carboxylic acid.

**2** (e) (i) State the type of reaction.

.....

.....

*(1 mark)*

**2** (e) (ii) Draw the structure of the carboxylic acid formed from propanal in this reaction.

*(1 mark)*

**2** (e) (iii) Tollens' reagent or Fehling's solution can be used to show whether any propanal is present as an impurity in the carboxylic acid. Choose one of these reagents and state what will be observed if propanal is present.

*Chosen reagent* .....

*Observation if propanal is present* .....

*(1 mark)*

**2** (f) Prop-2-en-l-ol is an unsaturated alcohol.

**2** (f) (i) State what is meant by the term *unsaturated*.

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.....

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*(1 mark)*

**2** (f) (ii) Identify the class of alcohol to which prop-2-en-l-ol belongs.

.....

*(1 mark)*

**2** (f) (iii) Draw the structure of the product formed when prop-2-en-l-ol reacts with bromine.

*(1 mark)*

**11**

**3** (a) Tetrachloromethane, $CCl_4$, can be made by the reaction of chlorine with trichloromethane, $CHCl_3$
This reaction occurs in sunlight.

**3** (a) (i) Name the type of mechanism for this reaction.

.....

*(1 mark)*

**3** (a) (ii) Outline the following steps in the mechanism for the reaction of chlorine with $CHCl_3$ to form $CCl_4$

*Initiation step*

.....

*First propagation step*

.....

*Second propagation step*

.....

*A termination step*

.....

*(4 marks)*

**3** (b) The following reaction mechanism is suggested to show how the chlorofluorocarbon $CF_2Cl_2$ may damage the ozone layer ($O_3$) in the upper atmosphere.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Step **1*** | $CF_2Cl_2$ | | | $\xrightarrow{\text{sunlight}}$ | $\bullet CF_2Cl$ | + | $Cl\bullet$ |
| *Step **2*** | $O_3$ | + | $Cl\bullet$ | $\longrightarrow$ | $O_2$ | + | $ClO\bullet$ |
| *Step **3*** | $O_3$ | + | $ClO\bullet$ | $\longrightarrow$ | $2O_2$ | + | $Cl\bullet$ |

**3** (b) (i) Give the name of $CF_2Cl_2$

.....

*(1 mark)*

**3** (b) (ii) Name the type of reactive intermediate shown in each of these three steps.

.....

*(1 mark)*

**3** (b) (iii) Name the type of mechanistic step illustrated by Step **3** of this mechanism.

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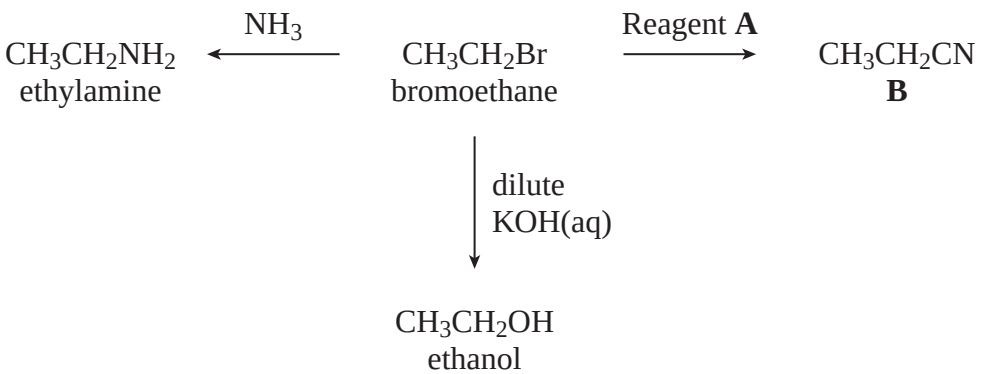
*(1 mark)*

**8**

**Turn over for the next question**

**4** Consider the following reactions of bromoethane.




**4** (a) Bromoethane reacts with ammonia to produce ethylamine.

**4** (a) (i) What feature of the bromoethane molecule makes it susceptible to attack by an ammonia molecule?

.....

*(1 mark)*

**4** (a) (ii) Outline a mechanism for this reaction.

*(4 marks)*

**4** (b) Bromoethane is converted into compound **B** by reaction with reagent **A**. Identify reagent **A** and give the name of compound **B**.

*Identity of reagent **A*** .....

*Name of compound **B*** .....

*(2 marks)*

**4** (c) The conversion of bromoethane into ethanol is a substitution reaction in which a nucleophile attacks the organic compound.

**4** (c) (i) State what is meant by the term *nucleophile*.

.....

*(1 mark)*

**4** (c) (ii) Identify the nucleophile in the reaction of potassium hydroxide with bromoethane.

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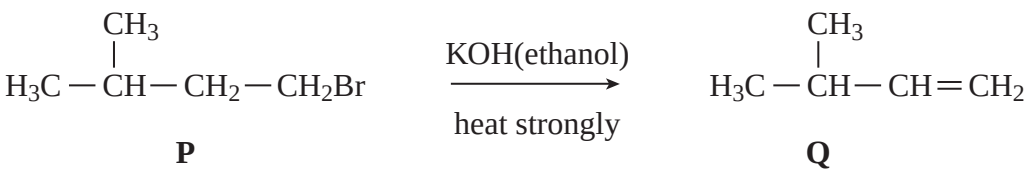
*(1 mark)*

**9**

**Turn over for the next question**

**5** Consider the following conversion of compound **P** into compound **Q**.




**P** **Q**

**5** (a) Give the name of compound **Q**.

.....

.....

*(1 mark)*

**5** (b) Name and outline a mechanism for the conversion of **P** into **Q**.

*Name of mechanism* .....

*Mechanism*

*(4 marks)*

**5** (c) Hydrogen bromide reacts with **Q** to form compound **R**, which is a position isomer of **P**.

**5** (c) (i) Identify compound **R**.

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*(1 mark)*

**5** (c) (ii) Name the type of mechanism for the conversion of **Q** into **R**.

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*(1 mark)*

**5** (d) Draw the structure of an alkene which is an isomer of **Q** and which shows stereoisomerism. State the type of stereoisomerism shown by this isomer.

*Structure of isomer*

*Type of stereoisomerism* .....

*(2 marks)*

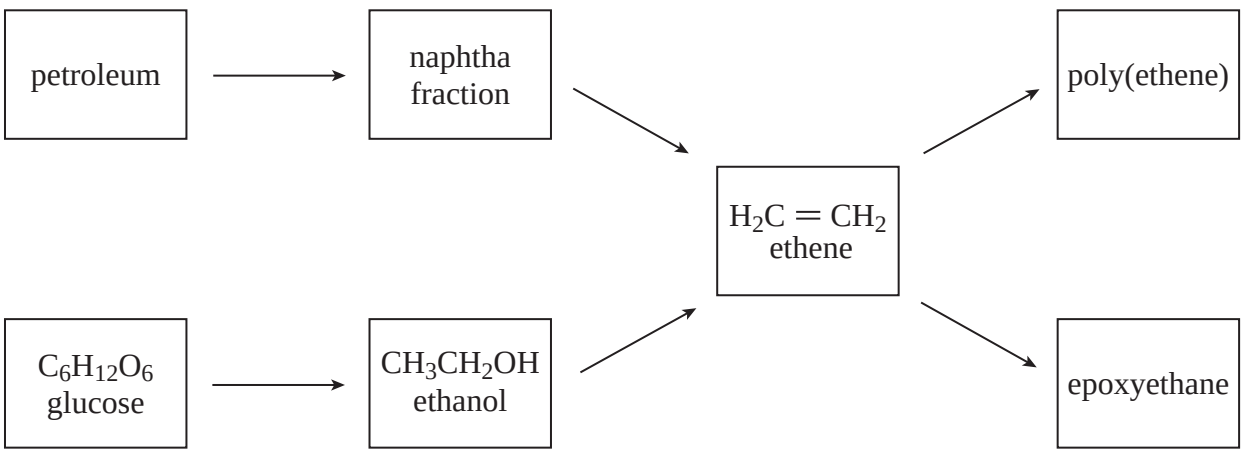
**9**

**Turn over for the next question**

## SECTION B

Answer the question below in the space provided on pages 13 to 17 of this booklet.
You should answer each part of the question on the separate page indicated.
Each part of the question is reprinted at the top of the page.

**6** Ethene can be produced either from petroleum or from glucose. These processes and the formation of some useful products from ethene are illustrated in the following scheme.




**6** (a) The naphtha fraction is separated from petroleum by the process of fractional distillation. State the essential features of this process and explain how separation is achieved.

*(4 marks)*

**6** (b) Give the name of the process by which ethene is produced from the naphtha fraction. Give **one** essential condition for this process and name the type of reactive intermediate involved.

*(3 marks)*

**6** (c) State what must be added to an aqueous solution of glucose to convert it into ethanol. Name the process and write an equation for this reaction.

*(3 marks)*

**6** (d) The reaction of aqueous glucose to form ethanol produces a dilute aqueous solution. Name the process used to separate ethanol from this dilute aqueous solution. Identify a catalyst for the conversion of ethanol into ethene and state the type of reaction.

*(3 marks)*

**6** (e) Draw the structure of the repeating unit of poly(ethene) and the structure of epoxyethane.

*(2 marks)*

**END OF QUESTIONS**

**6** (a) The naphtha fraction is separated from petroleum by the process of fractional distillation. State the essential features of this process and explain how separation is achieved.

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

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**6** (b) Give the name of the process by which ethene is produced from the naphtha fraction. Give **one** essential condition for this process and name the type of reactive intermediate involved.

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

**6** (c) State what must be added to an aqueous solution of glucose to convert it into ethanol. Name the process and write an equation for this reaction.

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

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**6** (d) The reaction of aqueous glucose to form ethanol produces a dilute aqueous solution. Name the process used to separate ethanol from this dilute aqueous solution. Identify a catalyst for the conversion of ethanol into ethene and state the type of reaction.

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

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**6** (e) Draw the structure of the repeating unit of poly(ethene) and the structure of epoxyethane.

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

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**DO NOT WRITE ON THIS PAGE**
**ANSWER IN THE SPACES PROVIDED**

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

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 |

# 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

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| * | 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