OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE **2812/01**

CHEMISTRY

Chains and Rings

THURSDAY 11 JANUARY 2007 Morning

Time: 1 hour

Additional materials: Scientific calculator
Data Sheet for Chemistry (Inserted)

Candidate Name

Centre Number | | | | | |

Candidate Number | | | | |

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- *Read each question carefully and make sure you know what you have to do before starting your answer.*
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. ANSWERS WRITTEN ELSEWHERE WILL NOT BE MARKED.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of *each question or part question.*
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry* is provided as an insert with this *question paper.*
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	12	
2	14	
3	12	
4	12	
5	10	
TOTAL	60	

This document consists of **14** printed pages, **2** blank pages and a *Data Sheet for Chemistry.*

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RECOGNISING ACHIEVEMENT

Data Sheet for Chemistry

GCE Advanced level and Advanced Subsidiary

Chemistry 3882, 7882

Chemistry units 2811 – 2816

These data are for the use of candidates following Chemistry 3882 or 7882.

Clean copies of this sheet must be issued to candidates in the examination room, and must be given up to the invigilator at the end of the examination.

Copies of this sheet may be used for teaching.

SP (SLM) T21424/2
CST243 (Pink)
2007

Characteristic infra-red absorptions in organic molecules

bond	location	wavenumber
C–O	alcohols, esters	1000 – 1300 cm^{-1}
C=O	aldehydes, ketones, carboxylic acids, esters	1680 – 1750 cm^{-1}
O–H	hydrogen bonded in carboxylic acids	2500 – 3300 cm^{-1} (broad)
N–H	primary amines	3100 – 3500 cm^{-1}
O–H	hydrogen bonded in alcohols, phenols	3230 – 3550 cm^{-1}
O–H	free	3580 – 3670 cm^{-1}

Chemical shifts for some types of protons in n.m.r. spectra

- Chemical shifts are for hydrogen relative to TMS (tetramethylsilane)
- Chemical shifts are typical values and can vary slightly depending on the solvent, concentration and substituents.

type of proton	chemical shift, δ
$R\text{–}CH_3$	0.7–1.6
$R\text{–}CH_2\text{–}R$	1.2–1.4
R_3CH	1.6–2.0
$R\text{–}C(=O)\text{–}CH_3$ $R\text{–}C(=O)\text{–}CH_2\text{–}R$	2.0–2.9
$C_6H_5\text{–}CH_3$ $C_6H_5\text{–}CH_2\text{–}R$	2.3–2.7
$\text{–O–}CH_3$ $\text{–O–}CH_2\text{–}R$	3.3–4.3
R–OH	3.5–5.5
$C_6H_5\text{–OH}$	6.5–7.0
$C_6H_5\text{–H}$	7.1–7.7
$R\text{–}C(=O)\text{–H}$ $C_6H_5\text{–}C(=O)\text{–H}$	9.5–10
$R\text{–}C(=O)\text{–OH}$	11.0–11.7

The Periodic Table of the Elements

Group 1	2											3	4	5	6	7	0
																	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	– Tc technetium 43	101 Ru ruthenium 44	103 Rh rhodium 45	106 Pd palladium 46	108 Ag silver 47	112 Cd cadmium 48	115 In indium 49	119 Sn tin 50	122 Sb antimony 51	128 Te tellurium 52	127 I iodine 53	131 Xe xenon 54
133 Cs caesium 55	137 Ba barium 56	139 La lanthanum 57 *	178 Hf hafnium 72	181 Ta tantalum 73	184 W tungsten 74	186 Re rhenium 75	190 Os osmium 76	192 Ir iridium 77	195 Pt platinum 78	197 Au gold 79	201 Hg mercury 80	204 Tl thallium 81	207 Pb lead 82	209 Bi bismuth 83	– Po polonium 84	– At astatine 85	– Rn radon 86
– Fr francium 87	– Ra radium 88	– Ac actinium 89 *	– Rf rutherfordium 104	– Db dubnium 105	– Sg seaborgium 106	– Bh bohrium 107	– Hs hassium 108	– Mt meitnerium 109	– Unn ununnilium 110	– Uuu unununium 111	– Uub ununbium 112		– Uuq ununquadium 114		– Uuh ununhexium 116		– Uuo ununoctium 118

Key

1.0 H hydrogen 1

relative atomic mass
atomic symbol
name
atomic number

lanthanides *	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	– Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
actinides *	– Th thorium 90	– Pa protactinium 91	– U uranium 92	– Np neptunium 93	– Pu plutonium 94	– Am americium 95	– Cm curium 96	– Bk berkelium 97	– Cf californium 98	– Es einsteinium 99	– Fm fermium 100	– Md mendelevium 101	– No nobelium 102	– Lw lawrencium 103

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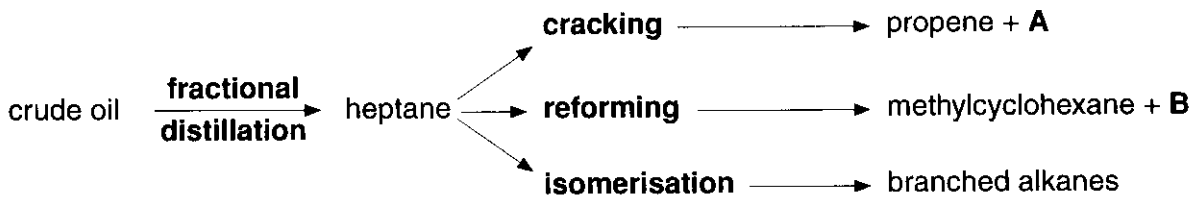
Answer **all** the questions.

1 Crude oil is first separated by fractional distillation. The fractions can then be refined further by cracking, reforming and isomerisation.

The reaction sequence below shows the production of heptane, C_7H_{16}, from fractional distillation of crude oil, followed by cracking, reforming and isomerisation.



(a) What is meant by the term *fractional distillation*?

.....

.....[1]

(b) The cracking of heptane produces propene and **A**.

Write a balanced equation for this cracking of heptane.

.....[1]

(c) The reforming of heptane produces methylcyclohexane and **B**.

(i) Show the structural formula of methylcyclohexane.

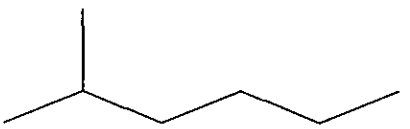
[1]

(ii) Write a balanced equation for this reforming.

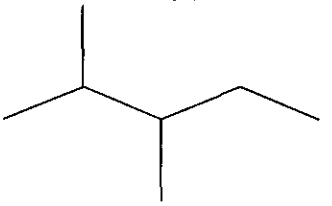
[1]

(d) The isomerisation of heptane produces **seven** branched alkanes, five of which are shown below.

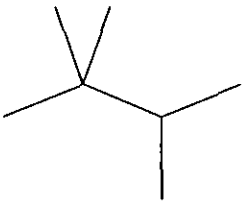
2-methylhexane



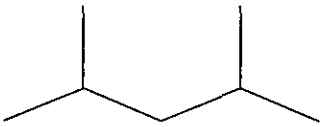
2,3-dimethylpentane



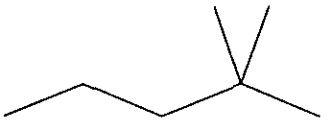
2,2,3-trimethylbutane



2,4-dimethylpentane



compound **C**



(i) Name compound **C**.

.....[1]

(ii) In the boxes above, draw skeletal formulae for the other **two** branched alkanes formed by isomerisation of heptane. [2]

(iii) Predict which of 2-methylhexane, 2,3-dimethylpentane and 2,2,3-trimethylbutane has the lowest boiling point.

.....[1]

(iv) Explain why 2-methylhexane, 2,3-dimethylpentane and 2,2,3-trimethylbutane have different boiling points.

.....

.....

.....[2]

(e) Crude oil and its fractions are described as non-renewable fossil fuels. To reduce the demand for fossil fuels, ethanol can be mixed with petrol. Ethanol is an example of a renewable biofuel.

(i) What is meant by a *biofuel*?

.....

.....[1]

(ii) Why are fossil fuels *non-renewable* but ethanol *renewable*?

.....

.....

.....[1]

[Total: 12]

2 This question is about two alcohols, ethanol and propan-2-ol, $CH_3CH(OH)CH_3$.

(a) Ethanol can be formed by fermentation of glucose, $C_6H_{12}O_6$.

(i) Write a balanced equation, including state symbols, for the formation of ethanol by fermentation.

.....[2]

(ii) Fermentation only occurs in the presence of yeast. State **two** other essential conditions.

.....

.....[2]

(iii) How would you know when fermentation of glucose is complete?

.....

.....[1]

(b) Propan-2-ol can be formed by the hydration of an alkene in the presence of a catalyst.

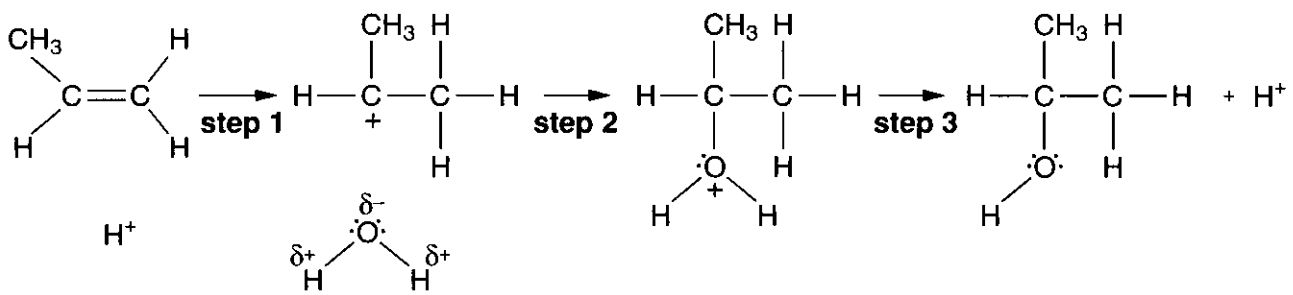
(i) Suggest a suitable catalyst for this reaction.

.....[1]

(ii) This is an electrophilic addition reaction. What is meant by the term *electrophile*?

.....[1]

(c) A mechanism for the reaction in **(b)** is shown below.



(i) Add 'curly arrows' to the mechanism to show the movement of electron pairs in steps **1**, **2** and **3**. [3]

(ii) Suggest, with a reason, the role of the H^+.

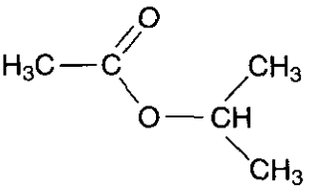
.....[1]

(d) Propan-2-ol is flammable and readily burns.

Write a balanced equation for the complete combustion of propan-2-ol.

.....[2]

(e) Compound **D**, shown below, can be used as a solvent for plastics and fats and is also used in perfumery.



compound **D**

Compound **D** can be prepared from propan-2-ol and another organic compound. Identify this other compound.

[1]

[Total: 14]

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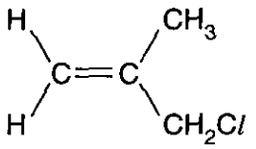
3 Methyl allyl chloride, MAC, is an important industrial chemical. It is used as an intermediate in the production of synthetic fibres, pharmaceuticals and epoxy resins. The structural formula of MAC is shown below.



MAC

(a) Give the **systematic** chemical name of MAC.

.....[1]

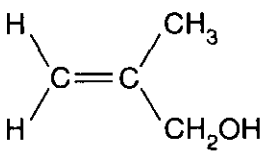
(b) MAC contains the alkene group and can undergo polymerisation. Draw a section of the polymer, poly(MAC), showing **two** repeat units.

[2]

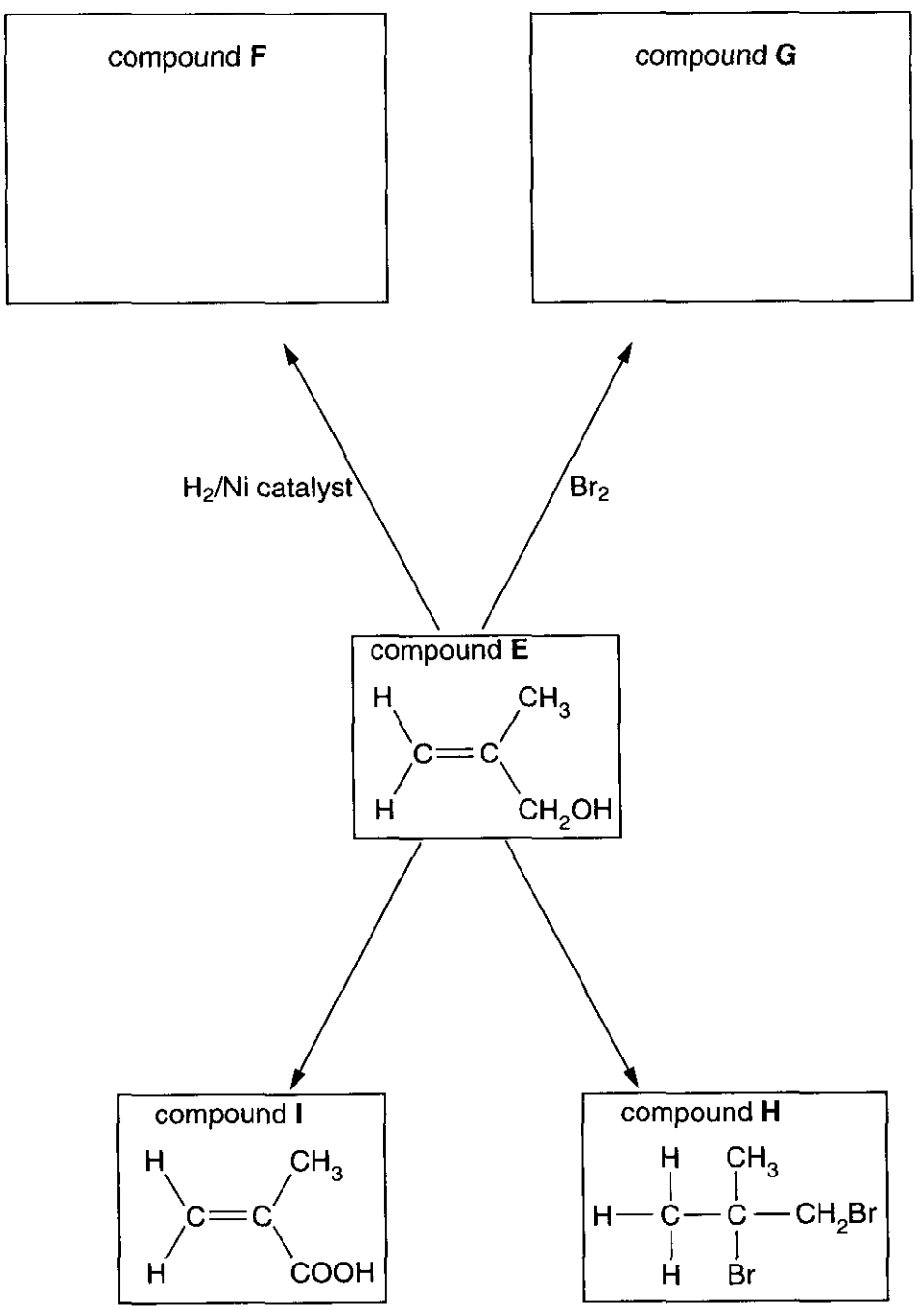
Part (c) continues on the next page

(c) MAC reacts with NaOH to produce compound **E**.

compound **E**



The reaction scheme below shows how compound **E** can be converted into a variety of other chemicals.



(i) Draw the structures of compounds **F** and **G** in the boxes. [2]

(ii) Complete the balanced equation for the formation of compound **H**.

compound **E** compound **H**

[2]

(iii) State the reagents and conditions for the formation of compound **I**.

.....

.....[2]

(iv) Suggest a possible organic intermediate that could be formed in the formation of compound **I**.

[1]

(d) Explain how infra-red spectroscopy could be used to distinguish between compound **E** and compound **I**.

.....

.....

.....

.....[2]

[Total: 12]

4 Butane, C_4H_{10}, under certain conditions, reacts with Cl_2 to form a mixture of chlorinated products. One possible product is C_4H_9Cl.

$$C_4H_{10} + Cl_2 \rightarrow C_4H_9Cl + HCl$$

(a) (i) State the conditions.

.....[1]

(ii) Write equations to show the mechanism of this reaction.

initiation .....

propagation .....

.....[3]

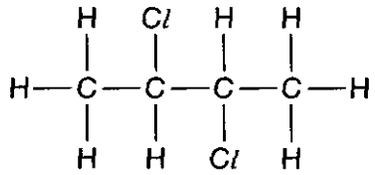
(iii) Write **one** equation for a reaction that would terminate this mechanism.

.....[1]

(iv) State the type of bond fission involved in the initiation step. .....[1]

(b) One other possible product of the reaction between butane and chlorine is compound **J**, $C_4H_8Cl_2$, shown below.

compound **J**



(i) Name compound **J**.

.....[1]

(ii) Draw the skeletal formula of compound **J**.

[1]

(iii) In addition to compound **J**, suggest **one** other possible structural isomer of $C_4H_8Cl_2$ that could have been formed in this reaction.

[1]

(c) 1-Chlorobutane can react with a solution of sodium hydroxide to produce but-1-ene, as shown in the equation below.

$$CH_3CH_2CH_2CH_2Cl + OH^- \rightarrow CH_3CH_2CH{=}CH_2 + H_2O + Cl^-$$

(i) State the solvent in which the sodium hydroxide is dissolved.

.....[1]

(ii) State the type of reaction.

.....[1]

(iii) Compound **J** also reacts with sodium hydroxide to produce a mixture of **structural** isomers, each with the formula C_4H_6.

Draw **one** of the structural isomers formed.

[1]

[Total: 12]

5 In this question, one mark is available for the quality of use and organisation of scientific terms.

- Describe, with the aid of a suitable diagram, the formation of the π-bond in propene.
- State the shape, and an approximate value for the bond angles, around each carbon atom in propene.
- Describe, with the aid of a suitable example, why some alkenes show *cis-trans* isomerism.

....[9]

Quality of Written Communication [1]

[Total: 10]

END OF QUESTION PAPER

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