



ASSESSMENT and
QUALIFICATIONS
ALLIANCE

Mark scheme January 2003

GCE

Chemistry

Unit CHM3/W

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SECTION A

Answer all questions in the spaces provided.

1 The alkanes form an homologous series of hydrocarbons. The first four straight-chain alkanes are shown below.

methane	CH ₄
ethane	CH ₃ CH ₃
propane	CH ₃ CH ₂ CH ₃
butane	CH ₃ CH ₂ CH ₂ CH ₃

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

molecule
compound
consists
composed
made up } of hydrogen and carbon only ①

(ii) Give the general formula for the alkanes.

C_nH_{2n+2} ①

(iii) Give the molecular formula for hexane, the sixth member of the series.

C₆H₁₄ only ① (3 marks)

Do not credit structures alone or in addition

(b) Each homologous series has its own general formula. State two other characteristics of an homologous series.

any 2
① + ①
[chemically similar / react in same way / same chemistry...
differ by CH₂
graduation in physical properties or specified trend e.g. b.p.
same functional group (2 marks)

(c) Branched-chain structural isomers are possible for alkanes which have more than three carbon atoms.

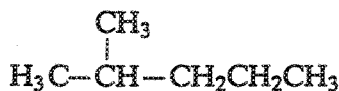
(i) State what is meant by the term *structural isomers*.

M1 same molecular formula ① NOT same Mr
M2 different structural formula ①
structures
atoms arranged in different ways NOT different spatial arrangements

Only credit M2 if M1 is correct

(ii) Name the two isomers of hexane shown below.

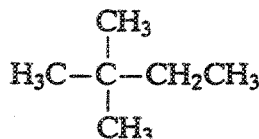
Isomer 1



Penalise "meth" etc.
on first occasion

Name 2-methylpentane ①

Isomer 2



Ignore comma
and dashes in names

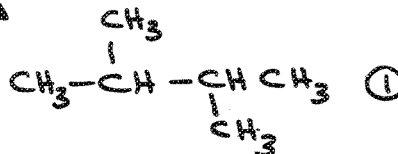
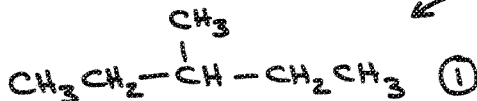
Name 2,2-dimethylbutane ①

(iii) Give the structures of two other branched-chain isomers of hexane.

Isomer 3

either order

Isomer 4



Penalise "sticks" once
Penalise absence of vertical
bonds once
Penalise badly drawn bonds
once (vertical between atoms)

OR correct [condensed formula
structural formula
(6 marks)]

(d) A hydrocarbon, W, contains 92.3% carbon by mass. The relative molecular mass of W is 78.0

(i) Calculate the empirical formula of W.

Credit variations
for M2 e.g.

$$\left(\begin{array}{l} \frac{78 \times 77}{100} = 6 \\ \text{and} \\ \frac{78 \times 92.3}{100} = 6 \end{array} \right)$$

M1 % by mass of H = 7.70% ①

M2 and mol H = $\frac{7.70}{1} = 7.70$
mol C = $\frac{92.3}{12} = 7.69$ ① Use of A_r

M3 (Ratio 1:1 ∴) CH ① answer

(ii) Calculate the molecular formula of W.

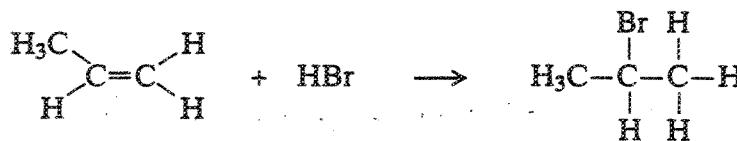
Correct answer = 3 marks

(CH has empirical mass of 13

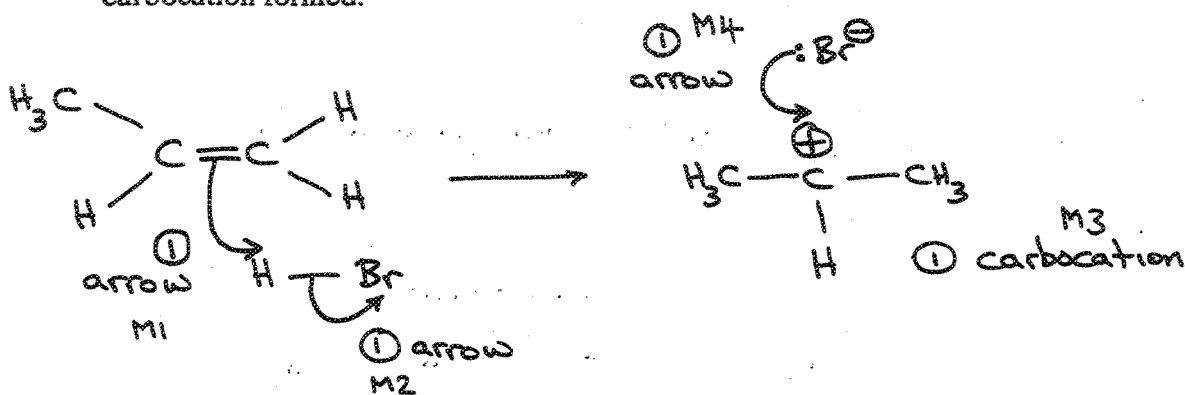
$\frac{78}{13} = 6$ ∴) C₆H₆ ①

correct answer = 1 mark (4 marks)

- 2 (a) Propene reacts with hydrogen bromide by an electrophilic addition mechanism forming 2-bromopropane as the major product. The equation for this reaction is shown below.



- (i) Outline the mechanism for this reaction, showing the structure of the intermediate carbocation formed.



if wrong carbocation, lose structure mark } can still score 3/4
 if wrong alkene, lose structure mark } i.e. penalise M3

Penalise M2 [if polarity is included incorrectly
 if no bond between H and Br
 if bond is shown as $\overset{\cdot}{\text{H}}-\text{Br}$ or $\text{H}-\overset{\cdot}{\text{Br}}$

- (ii) Give the structure of the alternative carbocation which could be formed in the reaction between propene and hydrogen bromide.



Credit secondary carbocation here if primary carbocation has been used in (i)

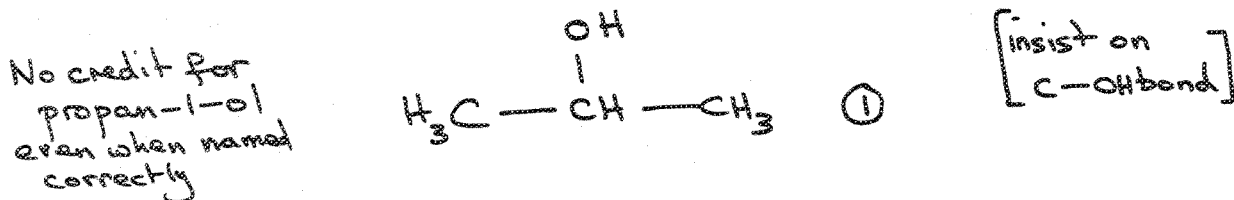
(5 marks)

Ignore attack on this carbocation by Br^-

(b) A substitution reaction occurs when 2-bromopropane reacts with aqueous sodium hydroxide.

(i) Draw the structure of the organic product of this reaction and give its name.

Structure



Credit propan-2-ol

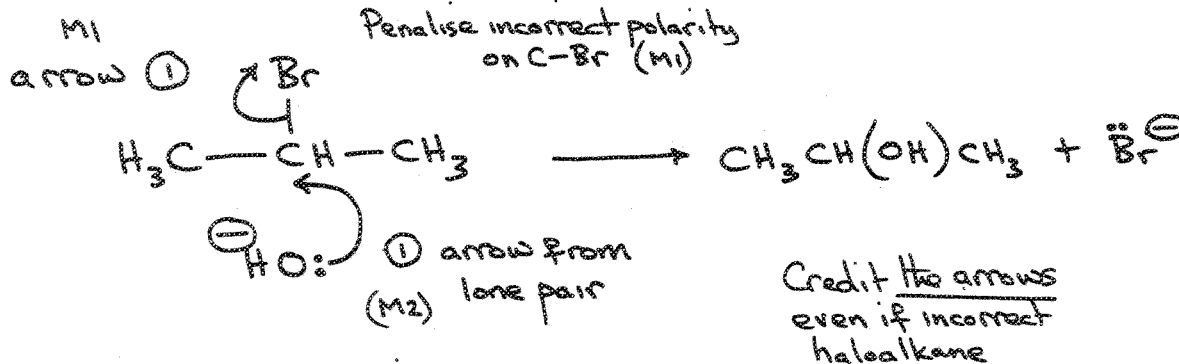
Name propan-2-ol $\textcircled{1}$
NOT 2-hydroxypropane

(ii) Name and outline the mechanism for this reaction.

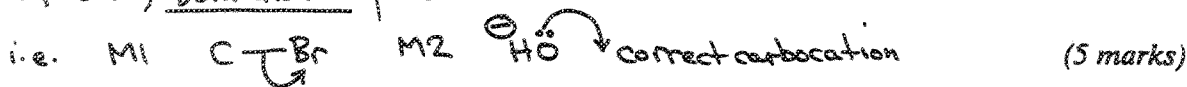
Name of mechanism nucleophilic substitution $\textcircled{1}$ (both words)

Mechanism

NOT S_N2 (or S_N1)



If Sw1, both marks possible



(c) Under different conditions, 2-bromopropane reacts with sodium hydroxide to produce propene.

(i) Name the mechanism for this reaction.

ignore nucleophilic elimination
penalise electrophilic elimination

..... elimination $\textcircled{1}$

(ii) State the role of sodium hydroxide in this reaction.

NOT nucleophile (base)

..... base $\textcircled{1}$

OR proton acceptor (2 marks)

3 (a) Ethanol can be manufactured by the direct hydration of ethene and by the fermentation of sugars.

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

ignore "to the reaction"

..... addition of [water ①
..... steam

(ii) Give one advantage and one disadvantage of manufacturing ethanol by fermentation rather than by hydration.

Do not include energy consumption or cost.

NOT "infinite" resource
"non-finite"
Do not credit negative statements

Advantage

[low technology renewable feedstock/resource ① any one
allowed for use in drinks, perfumes
(considered to be) green

Disadvantage

[slow ① any one
low yield
significant land use
has to be distilled
labour intensive

Ignore yeast

NOT (unqualified) batch process

NOT impure product

(3 marks)

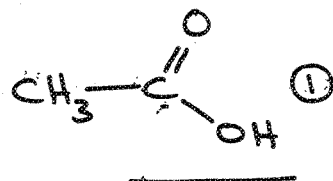
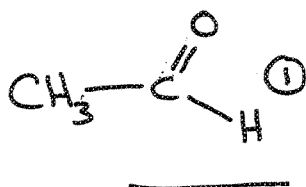
(b) Ethanol can be oxidised to an aldehyde and to a carboxylic acid.

(i) Draw the structure of this aldehyde and of this carboxylic acid.

Structure of aldehyde

Structure of carboxylic acid

Penalise incorrect R group once



NOT CH_3CHO

NOT CH_3COOH

(ii) Give a suitable reagent and reaction conditions for the oxidation of ethanol to form the carboxylic acid as the major product.

Reagent ^{or here} Sodium potassium dichromate (VI) ① M1

(not essential)

Conditions acidified or sulphuric acid ① M2

..... (heat under) reflux ① M3

(5 marks)

OR
correct formulae
for M1/M2

M2 depends on M1 (but mark M2 correct from $\text{Cr}_2\text{O}_7^{2-}$, $\text{K}_2\text{Cr}_2\text{O}_7$ etc)

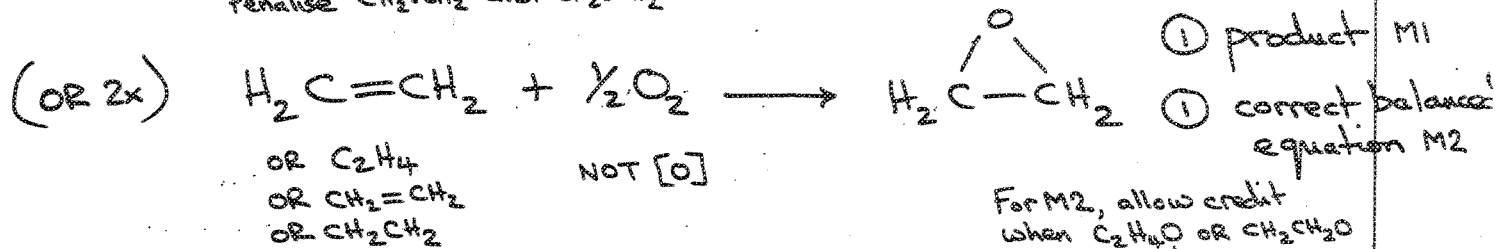
M3 mark is independent

Credit KMnO_4 for M1

Ignore T and P for M2

4 (a) (i) Write an equation for the formation of epoxyethane from ethene, showing the structure of the product.

Penalise $\text{CH}_2 \cdot \text{CH}_2$ and $\text{CH}_2 : \text{CH}_2$

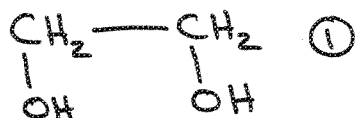


(ii) Explain why the epoxyethane molecule is highly reactive.

..... strained (ring) ① NOT weak bonds
Credit "stressed" NOT unstable

(iii) Give the structure of the product formed by the reaction of one molecule of epoxyethane with one molecule of water. Give one use for this product.

Structure



NOT plasticiser
NOT solvent
NOT de-icer
NOT alcohol

C-OH
[possible repeat error]
2b(i), 3c(i), 3e(ii)

Use

..... antifreeze ①

OR production of Terylene (5-marks)
OR feedstock for polyester or PET

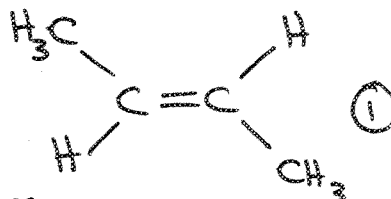
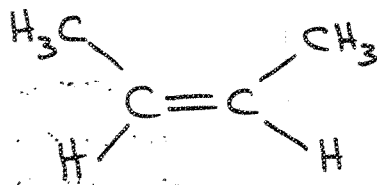
(b) But-2-ene can exist in two isomeric forms. Give the structures of these two isomers and name the type of isomerism.

Credit 1 mark for a correct formula for but-2-ene

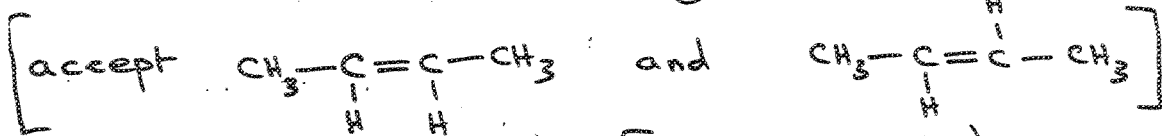
Structure 1

Credit 1 mark for any pair of cis/trans isomers

Structure 2



ignore names



Type of isomerism

NOT stereoisomerism

..... geometric (all) ①
cis-trans
diastereoisomerism (3 marks)

Section B

Question 5



Penalise equations for other alkanes or incorrect formulae (e.g. CH_3)

Ignore equations with S

Two pollutants (1) + (1) and Two linked effects (1) + (1)

e.g. SO_2 only toxic or acid rain (or its effect)

Penalise incorrect answers e.g. sulphur oxides, sulphur monoxide (or SO), but mark on and credit correct effect for SO_2

Penalise SO_3 , H_2SO_4 etc. if given as alternative answers or as additional answers unless in an obvious sequence from SO_2 , but mark on.

OR CO toxic
or explanation of effect on oxygen transport
(ignore greenhouse effect)

OR C asthma or bronchial problems

OR Hydrocarbon greenhouse gas

NOT CO_2 (ignore) No credit for "harmful" or "dangerous" as effect

NOT NO_x (ignore)

Ignore references to the ozone layer

(7 marks)

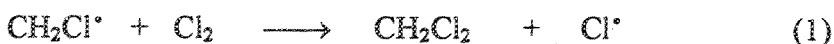
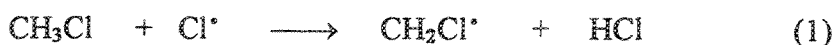
5(b) Initiation (1)

uv or $T \geq 500^\circ\text{C}$ or high temperature (1)

(ignore subsequent reference to temperature after uv)



Propagation (1)



Penalise incorrect use of arrows (credit correct half arrows)

Ignore preliminary mechanism/reaction of CH_4 to CH_3Cl

Ignore subsequent mechanism/reaction of CH_2Cl_2 to CHCl_3 etc.



(or $\text{C}_2\text{H}_4\text{Cl}_2$)

Penalise absence of radical dot once only

Ignore other termination steps

(7 marks)

Total 14 marks

Question 6

Fractional distillation

The separation depends on boiling point or a similar phrase (1) (QoL)

Boiling point depends on M_r / size of molecules / chain length (1)

Specified temperature gradient or difference (stated) on column / tower
OR explained e.g. hotter at the bottom of column (or cooler at the top) (1)

Lower M_r / lower b.p. / shorter chains / smaller fractions / more volatile at the top
(or higher etc. at bottom) (1)

(4 marks)

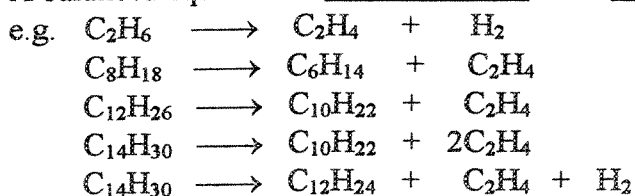
Thermal cracking

Any T (or range) in range 400 – 900 °C or high T (ignore pressure) (1)

C – C bond or the carbon chain splits/breaks or homolytic or (free) radical (1)

Uses the naphtha fraction or uses any C_7 to C_{14} alkane (stated or in an equation) (1)

A balanced equation to make an alkene from any alkane (1)



Credit a correct sequence of mechanistic steps which give a balanced equation

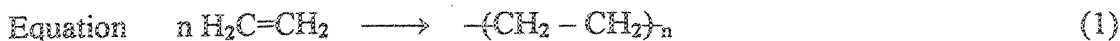
Larger molecules / hydrocarbons \longrightarrow smaller molecules / hydrocarbons
OR higher M_r alkanes \longrightarrow lower M_r alkanes + alkenes (+ H_2) (1)
(5 marks)

Polymerisation

Short-chain(ed molecule)s/monomers join/combine to make long-chain(ed molecule)s

OR

small molecules join/combine to make long/long chained/big molecules (1) (QoL)



Equation must show n correctly and be balanced with a clear structure for the polymer showing the bonds between each CH_2 and extending through the brackets.

Credit nC_2H_4 or $nCH_2=CH_2$ in the equation

(2 marks)

Total 11 marks