AQA

ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme June 2002

GCE

Chemistry

Unit CHM3/W

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SECTION A

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

1 (a) Crude oil is separated into fractions by fractional distillation. Outline how different fractions are obtained by this process.

Crude oil heated to be vaporised / it / oil is vaporised (1)

(vapour passed into)(fractionating) tower/column (1)

Top of tower cooler than bottom
or negative temperature gradient } (1)

fractions separated by b.p. } (1)
or condensed at different temperatures or levels
or low boiling fractions at the top.

max. (3 marks)

(b) The table below gives details of the supply of, and demand for, some crude oil fractions.

Fractions	Approximate %	
	Typical supply from crude oil	Global demand
Gases	2	4
Petrol and naphtha	16	27
Kerosine	13	8
Gas oil	19	23
Fuel oil and bitumen	50	38

(i) Use the data given above to explain why catalytic cracking of crude oil fractions is commercially important.

identifies shortfall in supply - e.g. petrol, small molecules (1)

higher value products or more useful products (1)

or cracking produces more of material (problem solving)

(ii) Give the two main types of product obtained by catalytic cracking.

Type 1 Motor fuels (1)

Type 2 Aromatic (hydrocarbons) (1)
branched alkanes/ hydrocarbons
cycloalkanes.

any 2

(4 marks)

Ignore specific fractions, alkanes, shorter chains

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(c) Name a catalyst used in catalytic cracking. State the type of mechanism involved and outline the industrial conditions used in the process.

Catalyst Zeolite / aluminosilicate (1)

Type of mechanism carbocation / heterolytic fission (1)

Conditions NOT heat/warm
High temp. or around 450°C [300-600°C] (1)
slight pressure [>1 atm ≤ 10 atm [1 mega Pa. 1000 kPa.]] (1)
(NOT high pressure)

(4 marks)

11

Penalise missing • once only

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2 (a) In the presence of ultraviolet light, methane and chlorine react to form a number of chlorine-containing products, including CH_2Cl_2 and $CHCl_3$

(i) Write an equation for the initiation step in the mechanism for this reaction.

$Cl_2 \longrightarrow 2Cl\cdot$ (1)

(ii) Write the overall equation for the formation of $CHCl_3$ from CH_2Cl_2 and Cl_2

$CH_2Cl_2 + Cl_2 \longrightarrow CHCl_3 + HCl$ (1)

(iii) Write equations for the two propagation steps by which CH_2Cl_2 is converted into $CHCl_3$

Can reverse order

Equation 1 $CH_2Cl_2 + Cl\cdot \longrightarrow CHCl_2\cdot + HCl$ (1)

Equation 2 $CHCl_2\cdot + Cl_2 \longrightarrow CHCl_3 + Cl\cdot$ (1)

(iv) Suggest what effect increasing the intensity of the ultraviolet light would have on the rate of the reaction between methane and chlorine. Explain your answer.

If decrease given C.E. zero marks

Effect on rate Increases (1)

Explanation more $Cl\cdot$ radicals formed (1)

more Cl atoms, more Cl–Cl or Cl_2 bonds broken

more Cl_2 have E_A, increased rate of $Cl\cdot$ produced (6 marks)

(b) Many hydrocarbon compounds burn readily in air.

(i) Write an equation to show the complete combustion of $C_{15}H_{32}$

If wrong reactant C.E

$C_{15}H_{32} + 23O_2 \longrightarrow 15CO_2 + 16H_2O$ products (1)

balance (1)

(ii) One of the gaseous products of the incomplete combustion of methane in gas fires is known to be poisonous. Identify this product and write an equation for the reaction in which it is formed from methane.

Identity of product CO or carbon monoxide (1)

Equation $CH_4 + \frac{3}{2}O_2 \longrightarrow CO + 2H_2O$ (1)

(4 marks)

Any balanced equation using CH_4, producing CO [could make C + CO_2 also]

10

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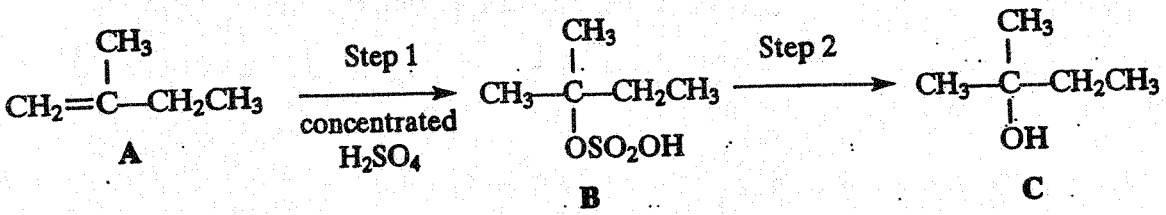
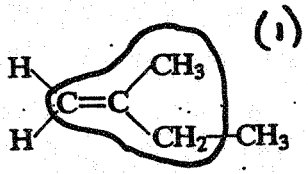
3 The reaction scheme below shows the conversion of compound **A**, 2-methylbut-1-ene, into compound **B** and then into compound **C**.



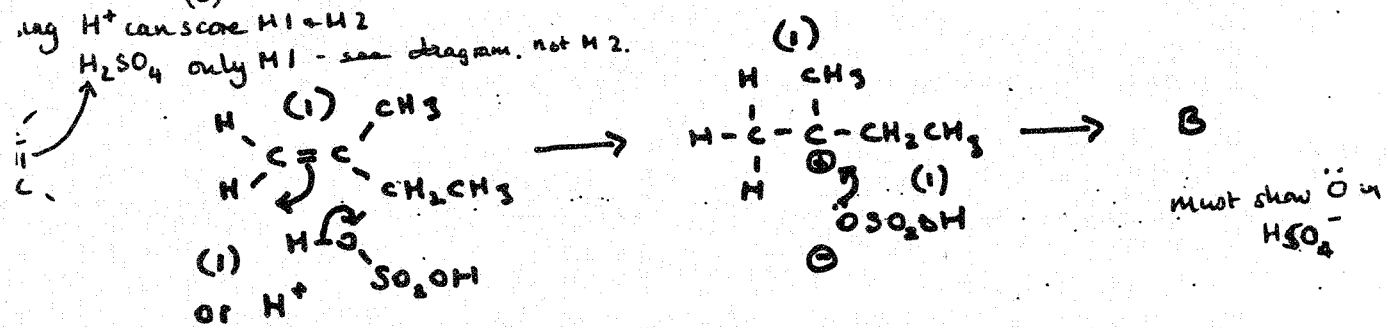
(a) The structure of **A** is shown below. Circle those carbon atoms which must lie in the same plane.



(1) may circle 4 Cs separately

(1 mark)

(b) Outline a mechanism for the reaction in Step 1.



ignore δ+, δ− unless wrong

(4 marks)

(c) State the reagent and condition used in Step 2. Name compound **C**.

Reagent H2O or water or steam or dilute sulphuric acid (1)

Condition (red to reagent) Heat or warm or boil or reflux [50 - 100°C] (1)

Name of compound C 2-methylbutan-2-ol allow 2methyl butane-2-ol (1)

(3 marks)

ignore + to phrase otherwise wrong can cancels correct one

analise hydroxy 2methyl butane → 2 methyl but-2-ol

mec only 1 paper

(d) When compound **A** is converted into compound **C**, a second alcohol, **D**, is also formed. Alcohol **D** is isomeric with **C** but is formed as a minor product. Identify alcohol **D** and explain why it is formed as the minor product.

Identity of alcohol D 2-methylbutan-1-ol - or its structure. (1)

could describe structures.

Explanation C formed via t-carbocation; D via p-carbocation (1)

tertiary more stable than primary (1)

(3 marks)

If have wrong carbocations but can score stability

MARGIN BLANK

4 (a) An alcohol containing carbon, hydrogen and oxygen only has 64.9% carbon and 13.5% hydrogen by mass. Using these data, show that the empirical formula of the alcohol is $C_4H_{10}O$

% O = 21.6 % (1)

If no %age O calculated only M2 available

C 64.9/12 H 13.5/1 O 21.6/16 (1)

If arithmetic error in any result - lose M3

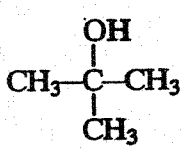
= 5.41 = 13.5 = 1.35

Ratio 4 : 10 : 1 (∴ $C_4H_{10}O$) (1)

If percentage composition calculation done - zero

(3 marks)

(b) The structural formulae of two of the four possible alcohols of molecular formula $C_4H_{10}O$ are shown below.



Isomer 1

$CH_3CH_2CH_2CH_2OH$

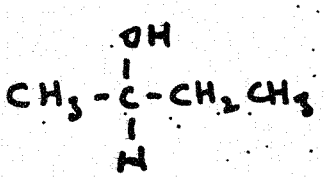
Isomer 2

(i) What type of alcohol is Isomer 1? Suggest a reason why this type of alcohol is not easily oxidised.

Type of alcohol Tertiary (1)

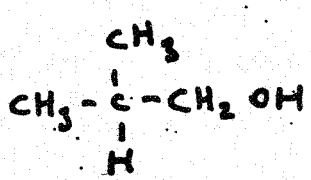
Reason No hydrogen atom on central carbon (1)

(ii) Draw the structural formulae of the two remaining alcohols of molecular formula $C_4H_{10}O$



(1)

Isomer 3



(1)

Isomer 4

(4 marks)

Penalise missing bonds / incorrect bonds once per paper.

(c) Isomer 2 was oxidised by adding it dropwise to acidified potassium dichromate(VI) solution and immediately distilling off the product. When this product was treated with Fehling's solution, a red precipitate was formed.

(i) State the type of product distilled off during the oxidation by acidified potassium dichromate(VI) solution.

Aldehyde (1)

ignore named aldehydes or their structures
penalise wrong named compound

(ii) Write an equation for the oxidation by potassium dichromate(VI), showing clearly the structure of the organic product. Use [O] to represent the oxidising agent.

if use C_3 or C_5 compds no marks in (ii) C.E. if wrong alcohol

$CH_3CH_2CH_2CH_2OH + [O] \rightarrow CH_3CH_2CH_2CHO + H_2O$

$C_4H_{10}O$ is OK as reactant

[O] can be over arrow

(1) not C_3H_7CHO but $C_2H_5CH_2CHO$ is OK.

balanced (1)

(iii) Name and draw a structure for the organic product formed by the reaction with Fehling's solution.

mark correct or as stated.

Name Butanoic acid (1)

Structure $CH_3CH_2CH_2COOH$ (1)

(5 marks)

(d) State **one** advantage and **one** disadvantage of the production of ethanol by the hydration of ethene compared to the fermentation of glucose.

high yield, 100% alcohol

Advantage Fast reaction or pure product or continuous process or cheap on manpower (1)

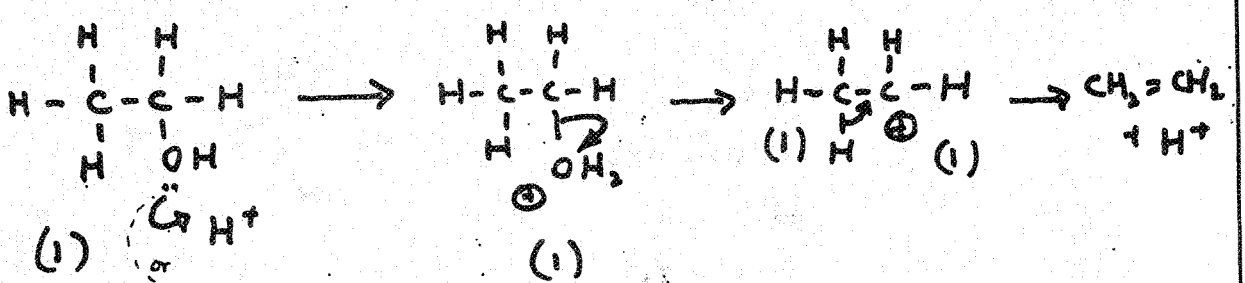
NOT answers based on fermentation

Disadvantage High technology or ethene from non-renewable source. (1)

expensive equipment not just costly.

(2 marks)

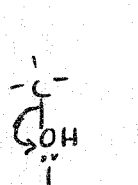
(e) Outline a mechanism for the dehydration of ethanol to form ethene in the presence of an acid catalyst.



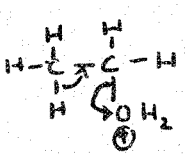
(1) (1) (1)

Can use H_2SO_4

(4 marks)



Scores M1 only



scores M2 & M4 but not carbocation mark, M3.

SECTION B

Answer **both** the questions below in the space provided on pages 9 to 12 of this booklet.

5 Epoxyethane is produced commercially by the oxidation of ethene.

State the reagent and the catalyst required for this process and identify two different types of hazard associated with the production of epoxyethane. Write an equation for the reaction of epoxyethane with water in a 1:1 mole ratio and give a use for the product obtained. Write an equation for the reaction of an excess of epoxyethane with ethanol and give a use for the product obtained. *(8 marks)*

6 Reaction of 2-bromobutane with potassium hydroxide can produce two types of product depending on the solvent used. In aqueous solution, the formation of an alcohol, **E**, is more likely but in ethanolic solution the formation of alkenes is more likely.

(a) For each type of product, name the type of reaction occurring and state the role of the potassium hydroxide. *(4 marks)*

(b) Name alcohol **E** and draw its structural formula. By reference to the structure of the halogenoalkane, explain why the initial step in the mechanism of the reaction producing the alcohol occurs. *(5 marks)*

(c) When 2-bromobutane reacts with ethanolic potassium hydroxide, two structurally isomeric alkenes are produced, one of which shows stereoisomerism.

Outline the mechanism for the formation of one of the structurally isomeric alkenes. Explain why two structurally isomeric alkenes are formed and draw the structure of the second structural isomer. Draw the structural formulae of the two stereoisomers. *(8 marks)*

END OF QUESTIONS

SECTION B

Question 5

Oxygen or air - can score from equation (1)
Silver catalyst (1)

Linked to process: e.g. Consequence of leaks etc.
Hazard 1 = flammable or explosive (1)
Hazard 2 = toxic or causes respiratory failure or neurological effects (1)

$(CH_2CH_2)O + H_2O \rightarrow HOCH_2CH_2OH$ (1)
Uses include antifreeze or polyester formation / terylene (1)
NOT plastics, polymers, dacron, surfactants

$n(CH_2CH_2)O + CH_3CH_2OH \rightarrow CH_3CH_2O(CH_2CH_2O)_nH$ (1)
Uses include brake fluids or plasticisers or surfactant or detergent. (1)

wrong penalise once only

Total 8

$CH_3CH_2(OCH_2CH_2)_nOH$
$H(CH_2CH_2O)_{n+1}OH$
} ok. in last eqn.

If no indication of order in (a) assume as in question.
If order is wrong can still score 'role' mark.

Question 6

(a)

Alkohol: Reaction = substitution / hydrolysis — ignore ref. to nucleophilic but electrophilic subst → 0. (1)
Alcohol: Role = nucleophile / lone pair donor (1)
Alkene: Reaction = elimination - ignore ref. to nucleophilic or electrophilic (1)
Alkene: Role = base / proton acceptor (1) 4

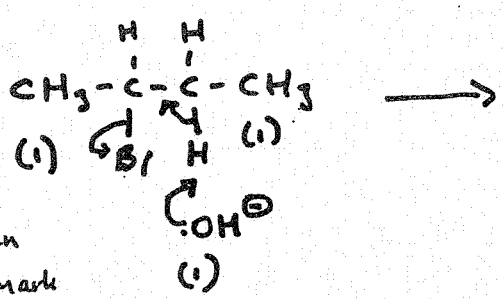
(b)

Alcohol = butan-2-ol - not 2 hydroxybutane not but-2-ol (1) * Penalise once per paper
Appropriate structure for $CH_3CH(OH)CH_2CH_3$ brackets not essential (1)

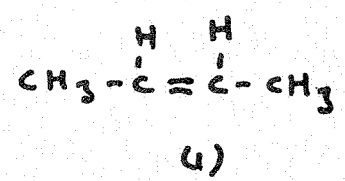
(c)

1. can be scored from a diagram
2 or 3 from written explanation only

S_N2 version		S_N1 version	
$\delta+$ $\delta-$ C–Br bond is polar		C–Br bond is polar	(1)
Lone pair on OH^-		C–Br bond breaks	(1)
Attacks the $C^{\delta+}$		forming carbocation / carbonium ion	(1) 5



$\ddot{O}H^-$ attacks wrong H, i.e. not on C_1 or C_3) can only score C–Br mark



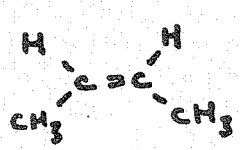
if but-2-ene not given here it may be obtained from cis/trans isomer

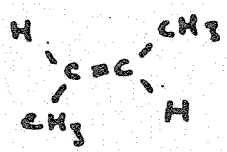
$CH_2 = CH - CH_2CH_3$ (1)

different
H lost from ~~adjacent~~ carbon atoms (1)
H removes from C^1 and C^3 to give two isomers (1)

Can score these marks from a diagram

Draws clear Cis and trans isomers for but-2-ene (1) 8





Total 17