AQA

ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme January 2002

GCE

Chemistry

Unit CHM3

The Assessment and Qualifications Alliance (AQA) is a company limited by guarantee registered in England and Wales 3644723 and a registered charity number 1073334
Registered address: Addleshaw Booth & Co., Sovereign House, PO Box 8, Sovereign Street, Leeds LS1 1HQ
Kathleen Tattersall: *Director General*

LEAVE MARGIN BLANK

SECTION A

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

1 The equation below represents a reaction between methane and chlorine.

$$CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$$

(a) State an essential condition required for this reaction to occur. Explain why this condition is essential.

Condition uv light or sunlight or 450°C or high temp. (1)

Explanation uv light etc. provides energy to break (Cl-Cl) bond (1)

Do not accept ref. to E_A or wrong bond or 'to make Cl radicals

(2 marks)

(b) (i) State the type of mechanism involved in the above reaction.

(Free) radical substitution (1)

(ii) Name the three types of step involved in this mechanism.

Step 1 initiation (1) (Any order)

Step 2 propagation (1) (Don't be too harsh on spelling)

Step 3 termination (1)

(4 marks)

(c) In addition to CH_3Cl, compounds such as CH_2Cl_2 and CH_3CH_2Cl may also be formed. when chlorine reacts with methane.

(i) Write equations for the two steps in the mechanism by which CH_2Cl_2 is formed from CH_3Cl

mark eqn independently - any order

Equation 1 $CH_3Cl + Cl\cdot \rightarrow CH_2Cl\cdot + HCl$ (1)

Equation 2 $CH_2Cl\cdot + Cl_2 \rightarrow CH_2Cl_2 + Cl\cdot$ (1)

or $CH_2Cl\cdot + Cl\cdot \rightarrow CH_2Cl_2$

(ii) Write an equation to represent a step in the mechanism in which CH_3CH_2Cl is formed. $CH_2Cl\cdot + CH_3\cdot \rightarrow CH_3CH_2Cl$

or $CH_3CH_2\cdot + Cl_2 \rightarrow CH_3CH_2Cl + Cl\cdot$ (1)

or $CH_3CH_2\cdot + Cl\cdot \rightarrow CH_3CH_2Cl$

(3 marks)

(eq must have CH_3CH_2Cl as product)

(Accept C_2H_5Cl)

Penalise absence of · once only

9

LEAVE MARGIN BLANK

2 (a) In the manufacture of margarine, unsaturated vegetable oils such as sunflower oil are hardened.

(i) State the reagent and conditions used in this process.

M1=0 if M2 ✓ M3 ✗ max =M2=0 then =0

Reagent Hydrogen or H_2 (1)

Conditions Ni (catalyst) (1) Ignore (Pt)

M3 tied to M1. Only award M3 if M1 earned

100 - 200 °C or heat (1) Not 'high temp.' Not 'warm'

(ii) Soft and hard margarines are obtained from the same vegetable oil. How does the structure and the melting point of a soft margarine differ from that of a hard one?

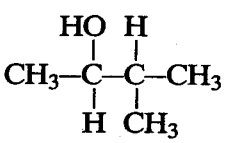
not be mparison

Difference in structure soft margarine less hydrogenated or has more C=C bonds or is more unsaturated than hard margarine (1)

Difference in melting point soft has lower melting point (1)

(5 marks)

(b) In the presence of reagent **X**, the alcohol shown below undergoes a reaction to form two isomeric alkenes.



(i) Name this alcohol.

3-methylbutan-2-ol (1) No alternatives

(ii) Give the name of the type of reaction involved in the formation of the two alkenes.

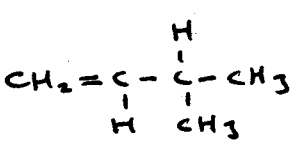
elimination or dehydration (1)

(iii) Suggest the identity of reagent **X**.

(c) H_2SO_4 or (c) H_3PO_4 - Name or correct formula (1)

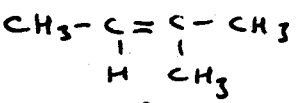
(iv) Give the structural formulae of the two isomeric alkenes.

Alkene 1



(1)

Alkene 2



(1)

(double bond must be shown)

(Accept any correct unambiguous structures)

(5 marks)

If but-1-ene and but-2-ene offered, allow M2

10

3 Propene reacts with bromine by a mechanism known as electrophilic addition.

(a) Explain what is meant by the term *electrophile* and by the term *addition*.

for 'species' accept atom, molecule, ion

Electrophile e⁻ pair / lone pair acceptor or e⁻ deficient species or e⁻ seeking species (1) Not '+' ion Not 'attracted to '−' charge

Addition reaction which increases number of substituents or converts double bond to single bond or where two molecules form one molecule (1) *(2 marks)*

(b) Explain why bromine, a non-polar molecule, is able to react with propene.

Not just 'C=C'

(high) e⁻ dense or e⁻ rich C=C or e⁻ rich π bond or 4e⁻ between the C's. (1)

causes induced dipole in Br_2 (1)

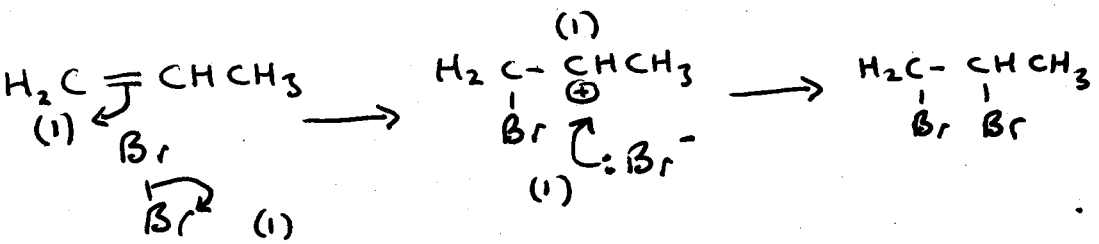
(2 marks)

Ignore refs. to 'temporary'
Can score M2 from δ+/δ− on Br_2 in (c) unless a contradicting error in (b)

(c) Outline the mechanism for the electrophilic addition of bromine to propene. Give the name of the product formed.

Mechanism If incorrect alkene, lose M3 (wrong cation)

If M1 curly arrow C⟶C allow



Mark M4 consequent on M3

Name of product 1,2-dibromopropane (1)

(5 marks)

(d) The polymerisation of propene to form poly(propene) is an important industrial process. Name the type of polymerisation involved.

addition (1)

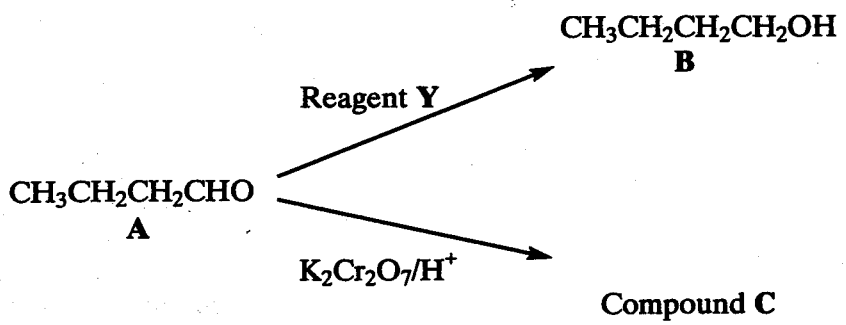
(1 mark)

Not 'additional'

10

LEAVE MARGIN BLANK

4 Two reactions of compound **A** are shown in the reaction scheme below.



(a) (i) State the type of reaction occurring in the conversion of compound **A** into compound **B**. Identify a suitable reagent **Y**.

Type of reaction reduction or (nucleophilic) addition or hydrogenation (1)

Reagent **Y** Sodium borohydride or $NaBH_4$ or H_2 (1)
(Not $NaBH_4$ for hydrogenation)

(ii) Write an equation for the conversion of compound **A** into compound **C**.
Use [O] to represent $K_2Cr_2O_7/H^+$

$CH_3CH_2CH_2CHO + [O] \rightarrow CH_3CH_2CH_2COOH$ (1)

accept [O] over arrow
accept $C_3H_7CHO + C_3H_7COOH$

(3 marks)

(b) Functional group isomerism is one type of structural isomerism.

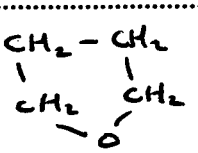
(i) Explain what is meant by the term *functional group isomerism*.

(compounds) with same molecular formula or number + type of atoms (1)
with atoms arranged in different functional groups (1)
or in different classes of compounds.

2 tied to 1

(ii) Give the name or structural formula of a functional group isomer of compound **A** which contains only one functional group.

butanone or $CH_3COCH_2CH_3$ (1)

or tetrahydrofuran or 

or other acceptable structure

(3 marks)

(c) (i) State what is meant by the terms *empirical formula* and *molecular formula*.

Empirical formula simplest ratio of atoms of each element in the compound or molecule (1)

Molecular formula (actual) number of atoms of each element present in a compound or molecule (1)

(ii) Deduce the empirical formula and the molecular formula of compound **D** (M_r = 116) which contains 62.07% carbon, 10.34% hydrogen and 27.59% oxygen by mass.

C: $62.07/12$ H: $10.34/1$ O: $27.59/16$ (1)

5.17 10.34 1.72

ratio C:H:O = 3:6:1 ∴ Emp. Form. = C_3H_6O (1)

Mol. Form $\left(= \frac{116}{58} \times C_3H_6O\right)$ = $C_6H_{12}O_2$ (1)

(if correct answer, working not essential) *(5 marks)*

11

TURN OVER FOR THE NEXT QUESTION

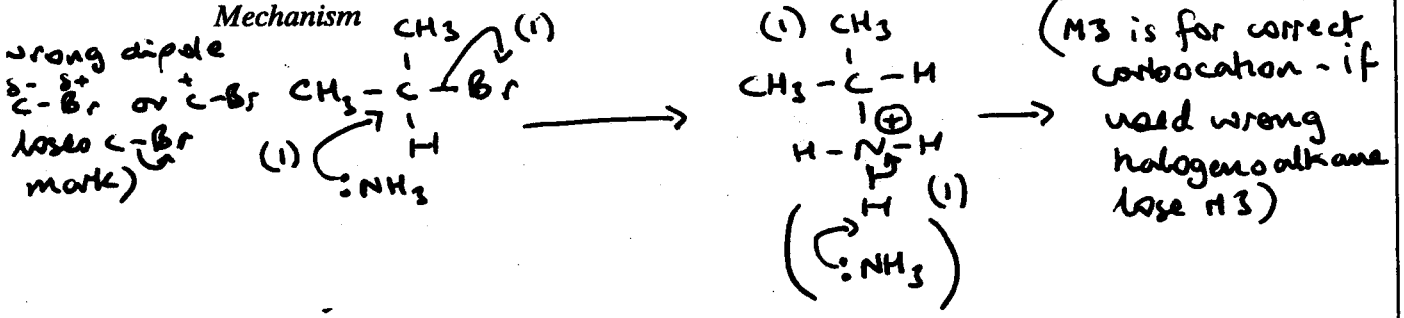
5 (a) The equation below shows the reaction of 2-bromopropane with an excess of ammonia.

$$CH_3CHBrCH_3 + 2NH_3 \rightarrow CH_3CH(NH_2)CH_3 + NH_4Br$$

Name and outline the mechanism involved.

Name of mechanism nucleophilic substitution (1)

Mechanism



mark S_N1 using same points

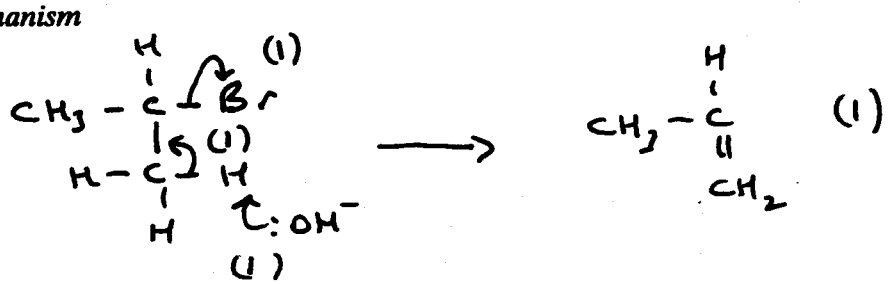
∴ M2 requires $CH_3-\overset{CH_3}{\overset{|}{C}}-Br$ (⊕ on C, :NH3)

(5 marks)

(b) When 2-bromopropane is heated with ethanolic potassium hydroxide, an elimination reaction occurs. State the role of potassium hydroxide and outline a mechanism for this reaction.

Role of potassium hydroxide Base (1)

Mechanism



mark E1 using same points

∴ M2/M3 $CH_3-\overset{\oplus}{C}H-CH_2$ (:OH⁻)

(5 marks)

10

LEAVE MARGIN BLANK

SECTION B

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

6 (a) Gas oil (diesel), kerosine (paraffin), mineral oil (lubricating oil) and petrol (gasoline) are four of the five fractions obtained by the fractional distillation of crude oil within the temperature range 40–400 °C.

Identify the missing fraction and state the order in which the five fractions are removed as the fractionating column is ascended. Give **two** reasons why the fractions collect at different levels in the fractionating column. *(4 marks)*

(b) Thermal cracking of large hydrocarbon molecules is used to produce alkenes. State the type of mechanism involved in this process. Write an equation for the thermal cracking of $C_{21}H_{44}$ in which ethene and propene are produced in a 3:2 molar ratio together with one other product. *(3 marks)*

(c) Write equations, where appropriate, to illustrate your answers to the questions below.

(i) Explain why it is desirable that none of the sulphur-containing impurities naturally found in crude oil are present in petroleum fractions.

(ii) The pollutant gas NO is found in the exhaust gases from petrol engines. Explain why NO is formed in petrol engines but is not readily formed when petrol burns in the open air.

(iii) The pollutant gas CO is also found in the exhaust gases from petrol engines. Explain how CO and NO are removed from the exhaust gases and why the removal of each of them is desirable. *(10 marks)*

7 Ethanol is produced commercially by fermentation of aqueous glucose, $C_6H_{12}O_6$
State **two** conditions, other than temperature, which are necessary for fermentation.
Explain why neither a low temperature nor a high temperature is suitable for this reaction.
Give **two** advantages of this method of production over that by the direct hydration of ethene.
Write an equation for the production of ethanol by fermentation and an equation for the complete combustion of ethanol. *(8 marks)*

END OF QUESTIONS

.....

.....

.....

SECTION B

Question 6

(a) Missing fraction = naphtha *(allow naphtha from list if not quoted separately)* (1)

Order = mineral oil (lubricating oil), gas oil (diesel), kerosine (paraffin), naphtha, petrol (gasoline) (1)
(mark order consequential on M1) (if no missing fraction given, M2=0)
(accept correct reversed order)

Negative temperature gradient on the column
or temperature of column decreases upwards (1)

Larger molecules **or** heavier fractions condense at higher temperatures **or** lower down the column **or** reference to different boiling points *(ignore mp)* (1) **4**

(b) Type of mechanism = (free) radical / homolytic fission - **used in complete sentence/phrase** (1)

$C_{21}H_{44} \rightarrow 3C_2H_4 + 2C_3H_6 + C_9H_{20}$ correct alkenes (1)
Accept CH_2CH_2 & CH_2CHCH_3 all correct (1) **3**

(c) (i) Sulphur (containing impurities) burn to form **or** forms SO_2 **or** oxides of sulphur *(if oxide identified, must be correct)* (1)
Or equation: e.g. $S + O_2 \rightarrow SO_2$ **or** $H_2S + 1\frac{1}{2} O_2 \rightarrow SO_2 + H_2O$

Leading to acid rain *(must have specified oxides of S or burning)* (1)
or toxic product **or** respiratory problems

(ii) NO formed by reaction between N_2 and O_2 from the air (1)
Or $N_2 + O_2 \rightarrow 2NO$
High combustion temperature **or** spark in engine (1)
provides E_A **or** sufficient heat/energy to break N≡N bond (1)

(iii) Need to remove NO as forms acid rain **or** toxic product **or** causes respiratory problems (1)
$2NO + O_2 \rightarrow 2NO_2$ (1)
$4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$ (1)

Need to remove CO as it is poisonous (1)

Catalytic converter (1)
uses Pt/Rh/Pd/Ir *(wrong answer cancels a correct one)* (1)
provides active sites / reduces E_A (1)
Forms $N_2 + CO_2$ (1)
$2NO + 2CO \rightarrow N_2 + 2CO_2$ *(correct equation worth last 2 marks)* (1) **Max 10**

Total 17

Question 7

Conditions = two from yeast *(anywhere in question)*
Air excluded **or** sterile/clean (2)
(Ignore references to pressure/temperature/aqueous/dark/high alcohol conc)

Temperature too low inactivates/deactivates enzymes **or** reaction too slow (1)
Temperature too high destroys **or denatures** yeast/enzymes (1)
(Not – kills enzymes; no t – deactivates here)

Advantage 1 = sugar/glucose/carbohydrate is renewable resource/source (1)
Advantage 2 = production uses low level technology/cheap equipment (1)
(Ignore references to energy. Do not allow contra-arguments about ethene)

$C_6H_{12}O_6 \rightarrow 2CH_3CH_2OH + 2CO_2$ balanced (1)

$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ balanced (1) **8**
(Allow C_2H_6O but penalise C_2H_5HO once)

Total 8