

GCE 2004

June Series



Mark Scheme

Chemistry

(Subject Code CHM3/W)

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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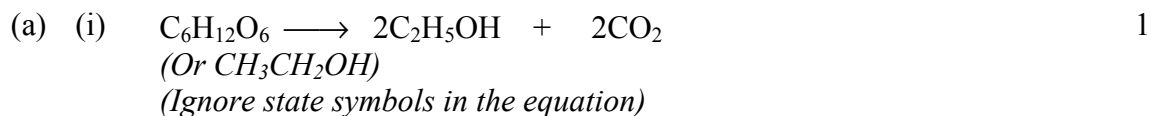
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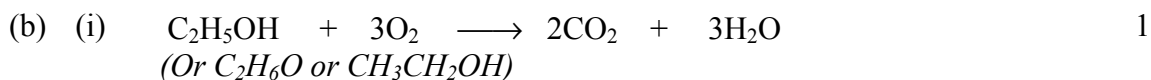
CHM3/W Introduction to Organic Chemistry

SECTION A

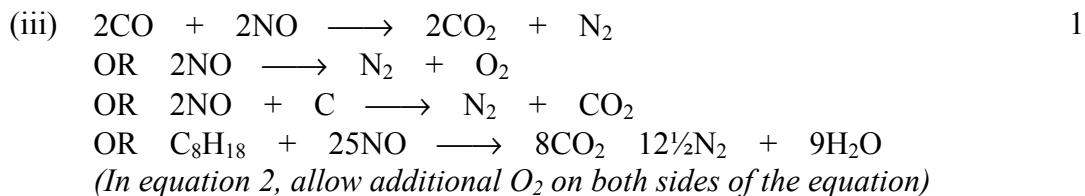
Question 1



(ii) Fermentation 1

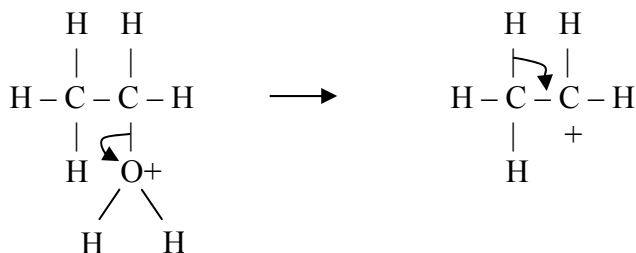


(ii) CO or carbon monoxide or C or carbon ONLY 1



(c) Elimination 1
 (Penalise additional words such as "electrophilic")

M1 structure of protonated alcohol (allow $CH_3CH_2OH_2^+$) 1



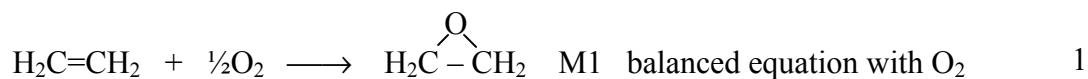
M2 arrow to show breakage of C – O bond on protonated alcohol 1

M3 structure of carbocation (allow $CH_3^+CH_2$) 1

M4 arrow from correct C – H bond on carbocation 1

(penalise 'sticks' once only for structures M1 and M3)
 (synchronous mechanism using correct structure required for M1, loses M3)

- (d) Silver OR silver-based 1
(NOT silver oxide)



M2 correct structure for epoxyethane 1

(Allow $\text{CH}_2=\text{CH}_2$ or C_2H_4 in the equation)

(Credit the structure of epoxyethane independently)

(Credit M1 provided O_2 has been used and the atoms balance, but the structure is poor e.g. $\text{C}_2\text{H}_4\text{O}$ or CH_2OCH_2 but NOT CH_3CHO)

Total 13

Question 2

- (a) (i) Electrophilic addition 1
(Both words required)

- (ii) M1 the reaction to form 1-bromopropane goes via the primary carbocation OR 1° carbocation 1

OR via $\text{CH}_3\text{CH}_2\overset{+}{\text{C}}\text{H}_2$

M2 primary carbocations are less stable than secondary carbocations. 1

(Credit converse arguments for M1 and M2 i.e. the reaction to form 2-bromopropane goes via the secondary carbocation, M1, and secondary carbocations are more stable than primary carbocations. M2)

(Accept the use of “carbonium ions” as an alternative to carbocation)

- (b) M1 NaOH OR KOH OR correct name 1
M2 aqueous or solution in water (ignore heat, reflux etc.) 1

(Penalise M1 for hydroxide ion alone, but mark on and credit M2)
(Credit M2 ONLY for H_2O as reagent and heat / warm / $T=50$ to 100°C)

(NaOH(aq) scores M1 and M2 provided it is not contradicted)

(Penalise M2 if NaOH(aq) followed by concentrated or ethanol)

(Penalise M1 and M2 if followed by acid)

- (c) Ethanolic OR alcoholic OR $\text{CH}_3\text{CH}_2\text{OH}$ / CH_3OH solvent OR 1
aqueous ethanol/alcohol

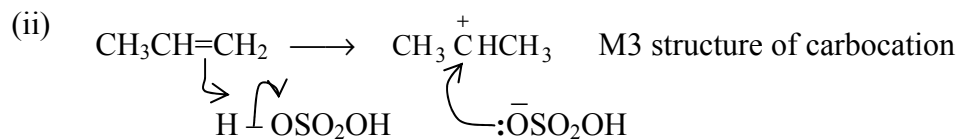
OR higher temperature (must be comparative)

(Ignore heat or heat under reflux)

(Credit part (c) independently from part (b))

(Penalise “ethanoic”)

(d) (i) Secondary OR 2° 1



M1 arrow from double bond to H of H – O bond

M2 arrow from bond to oxygen atom to show H – O bond breakage

M4 arrow from lone pair of electrons to carbon atom of carbocation

(Penalise M1 if arrow goes to H₂SO₄ or to formal positive charge on H, but ignore partial charges on sulphuric acid unless wrong)

(Credit M2 for H⁺ ion)

(For M4, accept negative charge anywhere on the ion)

(iii) Catalyst ONLY 1
(Ignore homogeneous, heterogeneous)

Total 12

Question 3

- (a) (i) Potassium (OR sodium) dichromate(VI) OR correct formula 1
 OR potassium manganate(VII)
(Oxidation state not needed, but must be correct if included)
(Penalise errors in the formula or oxidation state, but mark conditions)
 Acidified OR H₂SO₄ / HCl (*NOT with KMnO₄*) / H₃PO₄ / HNO₃ 1
(Ignore heat or reflux)
(Credit “acidified” as part of reagent)
 Oxidation or redox 1
- (ii) NaBH₄ OR LiAlH₄ OR H₂/Ni 1
- CH₃COCH₃ + 2[H] → CH₃CH(OH)CH₃ 1
(Credit H₂ in the equation if H₂ has been chosen as reagent)
- (b) (i) CH₃CH₂C = O 1
 |
 H
(Structure must show aldehyde structure)
(Credit C₂H₅ as alternative to CH₃CH₂)
- (ii) M1 Tollens’ reagent OR ammoniacal silver nitrate OR AgNO₃ + NH₃ OR Fehling’s solution OR acidified potassium dichromate 1
- M2 stays colourless stays blue stays orange 1
(Provided reagent is correct, credit “no reaction”, “no change”, “nothing”, “no observation” for M2)
- M3 silver mirror / deposit OR black / grey OR red / brown / orange precipitate / solid goes green 1
(Credit other correct reagents and observation)
(For M1, penalise AgNO₃ alone, penalise Ag(NH₃)₂⁺, penalise “potassium dichromate”, etc., but, in each case, mark on and credit correct M2 and M3)
(If totally wrong reagent or no reagent, CE = no marks for M1, M2 or M3)

Total 9

Question 4

- (a) (i) (Free) radical substitution 1
(Both words needed)
- (ii) M1 initiation ONLY 1
M2 ultra-violet light OR sunlight OR $1000^{\circ}\text{C} \geq T \geq 450^{\circ}\text{C}$ 1
(Ignore reference to temperature if included with uv light)
(Penalise “high temperature” for M2)
- (iii) • 1
 $2\text{CH}_3 \longrightarrow \text{C}_2\text{H}_6$
(OR CH_3CH_3 as alternative to C_2H_6)
- (iv) $\text{CH}_3\text{Br} + \text{Br}_2 \longrightarrow \text{CH}_2\text{Br}_2 + \text{HBr}$ 1
- (b) (i) Electron pair donor 1
OR species with an electron pair able to form a covalent bond.
- (ii) Methylamine 1
(Credit “aminomethane”)
- (iii)
-
- M1 arrow to show breakage of C – Br bond 1
M2 arrow from lone pair on N of NH_3 to form bond with C 1
M4 arrow from bond of N – H to N atom of CH_3NH_3^+ 1
- (Ignore partial charges on haloalkane but penalise if incorrect)
- (Accept CH_3NH_3^+ for M3)
(Full credit for carbocation mechanism; M1 for C – Br bond breakage and M2 for lone pair attack on carbocation)
(Second mole of ammonia not essential to mechanism for full credit)

Total 11

SECTION B**Question 5**

- (a) M1 separation depends on boiling point QoL 1
 M2 boiling point depends on size of molecules / M_r / chain length / intermolecular forces. 1
 M3 specified temperature gradient or difference (stated or explained) on column / tower 1
 M4 lower M_r / lower b.p. / more volatile / shorter chains / smaller fractions or molecules / lighter fractions or molecules at the top of the column. QoL 1
(or converse at the bottom of the column)
(Penalise M1 if bonds are broken or cracking is mentioned / discussed.)
(Penalise M4 if the candidate refers to polymers)
- (b) M1 process 1 is thermal cracking 1
(ONLY award M1 if linked to Process 1 or clearly included in part b)
- M2 any temperature (or range) in the range 400 – 900 °C OR high T 1
(ignore pressure)
- M3 (free) radical intermediates / molecules / mechanism. 1
(Credit reference to homolysis)
(Penalise radical substitution)
- (ONLY award M2 and M3 if linked to Process 1 or clearly included in part b)*
- $C_{13}H_{28} \longrightarrow C_6H_{14} + C_3H_6 + 2C_2H_4$
- M4 correct formula for both alkenes 1
 M5 correct balanced equation 1
(Credit M4 and M5 independently wherever the equation occurs in either part (b) or part (c) recording the marks in part b)

(c) M1 process 2 is catalytic cracking 1
(ONLY award M1 if linked to Process 2 or clearly included in part (c))

M2 carbocation or carbonium ion intermediates 1

(ONLY award M2 if linked to Process 2 or clearly included in part (c))
(Award one mark if both Process 1 and Process 2 are referred to as cracking reactions OR the two process names are the wrong way)

M3 C₅H₁₂ could be (CH₃)₂CHCH₂CH₃ OR (CH₃)₃CCH₃ 1

M4 correct name i.e. 2-methylbutane or 2,2-dimethylpropane 1

(Numbers are not essential in the names, but if used they must be correct)

M5 C₆H₁₂ could be one structure of cyclohexane OR methylcyclopentane etc. correct structure drawn 1

(Credit M3, M4 and M5 independently wherever they occur in part (b) or part (c) recording the marks in part (c))

(d) Equation $n \text{H}_2\text{C}=\text{CHCH}_3 \longrightarrow \text{-(}\overset{\text{CH}_3}{\underset{|}{\text{CH}}}\text{-CH}_2\text{)}_n$ 1

(Equation must show *n* and be balanced with a clear structure for the polymer showing the single bond between each C atom in the chain and extending through the brackets)

(Credit $n\text{CH}_2=\text{CHCH}_3$ OR $n\text{C}_3\text{H}_6$ in the equation)

Total 15

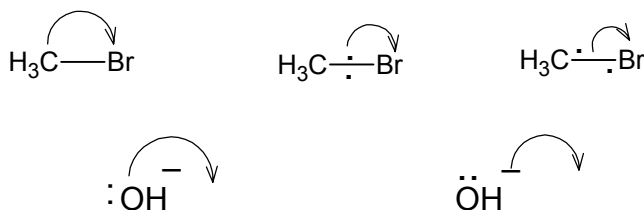
Some general principles applied to the marking of CHM3/W papers**Errors which should be penalised**

Each of the following illustrates an error which should be **penalised once only** per script.

On the second occasion that the **same error** is repeated, the mark should be awarded and the tick annotated **RE** (repeat error).

Mechanisms

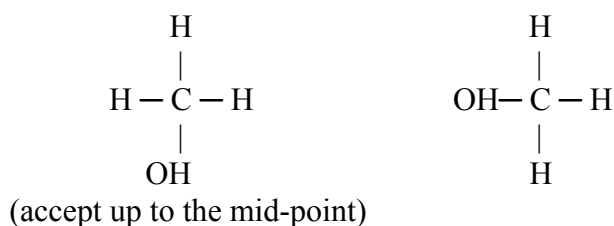
- Curly arrows should originate either from a lone pair of electrons or from a bond. Each of the following representations should be **penalised once only** per script.



- The absence of a radical dot in a free radical substitution should be **penalised once only** per script.

Structures

- Bonds should be drawn clearly between the relevant atoms. By way of illustration, each of the following representations should be **penalised once only** per script.



- Formulae for specific compounds which should be **penalised**.

CH ₃ COH	for	ethanal
CH ₂ OCH ₂ or CH ₂ CH ₂ O	for	epoxyethane
CH ₃ CH ₂ HO or OHCH ₂ CH ₃	for	ethanol

(N.B. specific exceptions may be made in the context of balancing equations)

3. The use of ‘sticks’ in structures should be **penalised once only** per script.

Names

As a general principle, non-IUPAC names or incorrect spelling or incomplete names should be **penalised once only** per script. Some illustrations are given here. (*N.B. specific exceptions may be made at individual standardising meetings*)

but-2-ol	
2-hydroxybutane	all should be butan-2-ol
butane-2-ol	
2-butanol	
2-methpropan-2-ol	should be 2-methylpropan-2-ol
2-methylbutan-3-ol	should be 3-methylbutan-2-ol
3-methylpentan	both should be 3-methylpentane
3-mythylpentane	

Some general guidance on organic structures

Each of the following **should be given credit** as alternatives to correct structures.

$\text{CH}_2 = \text{CH}_2$	for	ethene
$\text{CH}_3\text{CHOHCH}_3$	for	propan-2-ol
$\text{CH}_2\text{OHCH}_2\text{OH}$	for	ethane-1,2-diol
$\begin{array}{c} \text{H} \\ \\ \text{CH}_3 - \text{C} = \text{C} - \text{CH}_3 \\ \\ \text{H} \end{array}$	for	<i>trans</i> but-2-ene