Version 1.0

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Chemistry 5421

CHM3/W Introduction to Organic Chemistry

Mark Scheme

2008 examination - June series

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.

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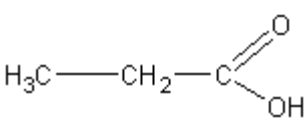
Dr Michael Cresswell Director General

CHM3/W

Question 1

(a)	(i)	A compound OR molecule containing OR consisting of hydrogen and carbon <u>only</u>	1	
(a)	(ii)	$C_9H_{20} + 9\frac{1}{2}O_2 \longrightarrow 9CO + 10H_2O$	1	*Or multiple*
(a)	(iii)	**M1** <u>High</u> temperature OR spark OR 2500°C ≤ T ≤ 4000°C **M2** $\frac{1}{2}N_2 + \frac{1}{2}O_2 \longrightarrow NO$	2	*Ignore "very" when referring to high temperature* *Or multiple*
(b)	(i)	Platinum OR Pt OR Palladium OR Pd OR Rhodium OR Rh	1	*Credit phonetic spelling*
(b)	(ii)	**25** NO **8** CO_2 **12½** N_2 **9** H_2O	1	*Credit whole equation doubled*
(c)		Releases OR is a source of OR provides a useable form of <u>heat OR energy</u> (when burned)	1	*Ignore "enthalpy"* *Ignore "exothermic"*
(d)		$H_2S + 1\frac{1}{2}O_2 \longrightarrow SO_2 + H_2O$	1	*Or multiple*

Question 2

(a)		**M1** propanone **M2** CH_3CH_2CHO OR correct aldehyde with functional group drawn out.	2	*Credit propan-2-one as the only other acceptable response.* *Penalise CH=O for the aldehyde group*
(b)		Functional group (isomerism) ONLY	1	*Both words needed*
(c)		The formula which shows the (actual) number of each type of atom OR atoms of each element in the molecule / compound.	1	*Penalise reference to ratio of atoms*
(d)		C_3H_6O ONLY	1	*Elements in any order*
(e)	(i)	Redox OR Oxidation	1	*Either word ONLY*
(e)	(ii)	The mark is for the structure of propanoic acid  	1	*Carboxylic acid group must show both the double and the single bonds to oxygen.* *Formula could show C_2H_5 OR CH_3CH_2*

(e)	(iii)	*If Tollens' is chosen, then*
		silver mirror / coating
		OR black precipitate / solid
		If Fehling's is chosen, then
		red precipitate / solid
			1	*No mark for choice of reagent, but do not award the mark if no reagent given.*
				Insist on Tollens' OR Fehling's as the ONLY reagents

(f)	(i)	Contains a C=C OR double bond	1	
(f)	(ii)	1^{o} OR Primary (alcohol)	1	
(f)	(iii)	<u>Structure</u> for $CH_2BrCHBrCH_2OH$ as shown or drawn out	1	*Structure must be clear* *Accept the alternatives* $CH_2BrCHBrCHO$ *and* $CH_2BrCHBrCOOH$

Question 3

(a) (i) (free-) radical substitution — 1 — *Both words needed*

(a) (ii) *Initiation*: $Cl_2 \longrightarrow 2Cl\bullet$ — 4 — *Ignore reference to uv/sunlight/heat.*

First propagation:

$Cl\bullet + CHCl_3 \longrightarrow \bullet CCl_3 + HCl$

The dot can be anywhere on the CCl_3

Second propagation:

$Cl_2 + \bullet CCl_3 \longrightarrow CCl_4 + Cl\bullet$

Penalise the absence of a dot once only

If half-arrows used, they must be correct.

Termination:

One from

$2\bullet CCl_3 \longrightarrow C_2Cl_6$

$\bullet CCl_3 + Cl\bullet \longrightarrow CCl_4$

$2\ Cl\bullet \longrightarrow Cl_2$

(b) (i) dichlorodifluoromethane — 1 — *ONLY these*

OR

1,1-dichloro-1,1-difluoromethane

QoL

Penalise "cloro" and penalise "flouro"

(b) (ii) (free- OR chlorine-) radical — 1 — *Penalise reference to "substitution"*

OR chlorine atoms

Ignore "alkyl"

(b) (iii) propagation (step) — 1 — *Ignore "first" or "second"*

Question 4

(a) (i) Polar C-Br (bond)

OR

δ+ (δ-)

C Br

OR

partially positive carbon atom on C-Br (bond)

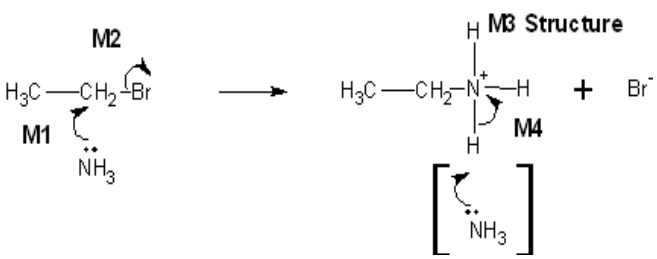
1

The C-Br bond needs to be drawn out or stated

(a) (ii)

4

Penalise M1 if negative charge on ammonia



Penalise M2 for formal charge on C of C-Br or incorrect partial charges

M1 must show an arrow from the lone pair of electrons on the nitrogen atom of the ammonia to the C atom of the C-Br bond.

Penalise once only for a line and two dots to show a bond.

M2 must show the movement of a pair of electrons from the C-Br bond to the Br atom.

Mark M2 independently.

Max 3 marks for wrong reactant or "sticks"

M3 is for the structure of the alkylammonium ion and could be obtained from $CH_3CH_2NH_3^+$

M4 is for an arrow from the N-H bond to the N atom.

The second mole of ammonia is not essential for full credit, therefore ignore this part even if other species are used.

Award full marks for an S_N1 mechanism in which M1 is the attack of the ammonia on the intermediate carbocation.

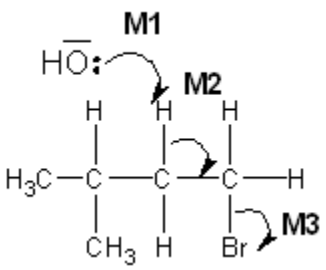
(b)		*Reagent:* KCN OR potassium cyanide OR NaCN OR sodium cyanide	1	*Penalise "acidic" as a condition but ignore other conditions.*
		Name: propan(e)nitrile OR propan(e)-1-nitrile	1	*ONLY these names*
(c)	(i)	Electron pair donor OR Forms a coordinate / covalent bond by the reaction of OR attack by an electron pair / pair of electrons.	1	*Insist on both "electron pair" and an action by the electron pair.* *Accept "lone pair"*
(c)	(ii)	Hydroxide ion OR OH^- ONLY	1	*The minus sign can be anywhere on the OH* *The electron pair (if drawn) MUST be on the oxygen atom*

Question 5

(a) **3**-methylbut-**1**-ene — 1 — *ONLY*

(b) Elimination — 1 — *Credit "base elimination" but NOT "nucleophilic elimination"*

No other prefix.



3

Penalise M1 if covalent KOH

Penalise M3 for formal charge on C or incorrect partial charges or extra arrow from Br to e.g. K+

M1 must show an arrow from the lone pair on oxygen of a negatively charged hydroxide ion to the correct H atom.

Penalise once only for a line and two dots to show a bond.

M2 must show an arrow from the correct C-H bond to the correct C-C bond and should only be awarded if an attempt has been made at M1

Max 2 marks for the mechanism for wrong reactant or "sticks"

M3 is independent.

Ignore incorrect organic product

Award full marks for an E1 mechanism in which M2 is on the correct carbocation.

(c) (i) *Structure OR name* — 1 — *If name is given it must be correct with "bromo" before "methyl"*

2-bromo-**3**-methylbutane

OR

$(CH_3)_2CHCHBrCH_3$

Apply list principle if both structure and name given

(c) (ii) Electrophilic addition ONLY — 1 — *Both words*

(d) **M1** *<u>Structure</u> of pent-2-ene ONLY*: 2 *M1 and M2 should be marked independently*

$CH_3CH_2CH=CHCH_3$

Credit M1 with a structure which is either linear or cis or trans (or both)

Structure MUST show a double bond

M2 *Type*: Geometric(al) OR <u>cis-trans</u>

(OR E/Z)

Question 6

(a)

M1 (Separation based on boiling point)

Separation depends on <u>boiling point.</u> (Ignore reference to melting point or density)

M2 (Link between boiling point and size/forces)

<u>Boiling point</u> depends on M_r OR molecular size OR chain length OR intermolecular / Van der Waals forces OR candidate links <u>boiling point</u> with heavier/lighter fractions.

M3 (Specified temperature gradient)

<u>Specified</u> temperature gradient OR difference stated on column/tower OR explained e.g. hot<u>ter</u> at bottom.

(If numbers used, accept up to 400^{o}C at the base and down to 25^{o}C at top)

M4 (Position of molecules/fractions on column)

Lower M_r OR lower boiling point OR shorter chains OR smaller molecules OR more volatile/gaseous molecules OR lighter fractions (condense) at top

(OR converse at bottom)

4

***Maximum 2 marks** if candidate refers to bond breaking or cracking or using a Blast furnace or adding oxygen/air.*

Ignore references to smaller/larger fractions.

QoL for M2

(b)

M1

<u>Thermal cracking</u>

M2

Any T (or range) in the range 400^{o}C to 900^{o}C OR

<u>High</u> temperature.

M3

(Free- OR alkyl-) <u>radical</u>

Mark M1, M2 and M3 independently

3

NOT just "hot" for M2

<u>Penalise M2</u> for any reference to catalyst.

Penalise M3 for reference to "substitution"

(c) **M1**

Yeast or suitable enzyme (zymase)

M2

Fermentation

M3

$C_6H_{12}O_6 \longrightarrow 2CH_3CH_2OH + 2CO_2$

(or $2C_2H_5OH$)

If O_2 is in the equation, penalise the equation (M3) but NOT M1

Mark M1, M2 and M3 independently

3

Penalise M1 if oxygen/air added to process .

Ignore reference to temperature and water.

Penalise C_2H_6O

(d) **M1**

(fractional) distillation OR fractionation

M2

c(oncentrated) H_3PO_4 OR c(oncentrated) H_2SO_4 OR Al_2O_3 OR alumina OR porous pot OR pumice

M3

(acid-catalysed) dehydration OR elimination

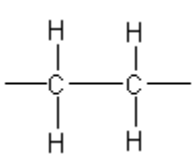
Mark M1, M2 and M3 independently

3

There are two processes and therefore assume that the order of answers is the order of marking unless annotated by the candidate

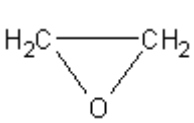
Penalise M3 for any other prefix such as "base"

(e) **M1**



OR —CH_2—CH_2—

M2



2

Accept structures in either order

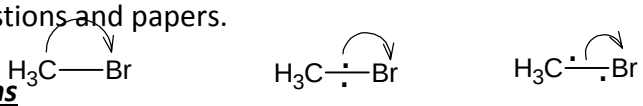
For M1, insist on bonds either side of CH_2 groups

For M1 ignore "n" and brackets

Insist on C-O bonds in M2 structure.

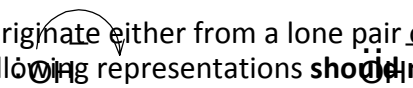
General principles applied to marking CHM3/W papers

It is important to note that the guidance given here is generic and specific variations may be made at individual standardising meetings in the context of particular questions and papers.



A. Mechanisms

Curly arrows should originate either from a lone pair of electrons or from a bond. Each of the following representations **should not gain credit**.



1. The absence of a radical dot in a free radical substitution should be penalised **once only** within a clip.
2. The use of double-headed arrows or the incorrect use of half-headed arrows in free-radical mechanisms should be penalised **once only** within a clip.

B. Structures

1. Bonds should be drawn correctly between the relevant atoms.
   For example, if candidates show the alcohol functional group as C-H-O, they should be penalised **on every occasion**.
2. Some latitude should be given to the representation of C-C bonds in structures, given that CH_3— is considered to be interchangeable with H_3C— even though the latter would be preferred.
3. Poor presentation of vertical C — C bonds should **not** gain credit.
4. The use of 'sticks' in structures should **not** gain credit. The occasions that this applies will be indicated in the mark scheme.
5. Some examples of formulae for specific compounds which should **not** gain credit are given here

CH_3COH	for	ethanal
CH_2OCH_2 or CH_2CH_2O	for	epoxyethane
CH_3CH_2HO $OHCH_2CH_3$ C_2H_6O (except when specifically indicated in the mark scheme)	for	ethanol
CH_2CH_2 $CH_2.CH_2$ $CH_2:CH_2$	for	ethene

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

C. Names

As a general principle, non-IUPAC names or incorrect spelling or incomplete names should **not** gain credit. Some illustrations are given here.

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 — all should be **3-methylpentane**
3-mythylpentane
3-methypentane

propanitrile — should be **propanenitrile**

aminethane — should be **ethylamine** (although aminoethane can gain credit)

2-methyl-3-bromobutane — all should be **2-bromo-3-methylbutane**
3-bromo-2-methylbutane
3-methyl-2-bromobutane

2-methylbut-3-ene — should be **3-methylbut-1-ene**

difluorodichloromethane — should be **dichlorodifluoromethane**

D. Reagents

The guiding principle is that a reagent is a chemical which can be taken out of a bottle or container. Failure to identify whole reagents **will be penalised**.

cyanide (ion) — should be e.g. potassium cyanide
hydroxide (ion) — should be e.g. sodium hydroxide

E. Some general guidance on organic structures

Each of the following **should gain credit** as alternatives to correct representations of the structures.

$CH_2 = CH_2$ for ethene, $H_2C=CH_2$

$CH_3CHOHCH_3$ for propan-2-ol, $CH_3CH(OH)CH_3$

CH_2OHCH_2OH for ethane-1,2-diol

F. Incorrect case for element symbol

The use of an incorrect case for the symbol of an element should be penalised **once only** within a clip.
For example, penalise the use of “h” for hydrogen, “CL” for chlorine or “br” for bromine.

G. The “List principle”

If a question requires one answer and a candidate gives two answers, no mark is scored if one answer is correct and one answer is incorrect.
There is no penalty, however, if both answers are correct.

N.B. Certain answers are designated in the mark scheme as those which the examiner should “Ignore” and these answers are not counted as part of the list.