Version 1.0

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Chemistry 5421

CHM3/W Introduction to Organic Chemistry

Mark Scheme

2005 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.

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.

Question 1

(a) (i) compounds/mixtures/alkanes/hydrocarbons/molecules with a boiling point <u>range</u>/<u>similar</u> boiling point/<u>similar</u> number of carbon atoms/<u>similar</u> chain length; 1

(insist on "similar" rather than "same")

(ignore references to size or M_r)

(penalise references to bond breaking/cracking as contradictions)

(ii) molecules have <u>different</u> boiling points/intermolecular forces/sizes/chain lengths/M_r; 1

(ignore references to melting points)

(credit the idea that molecules condense at <u>different</u> temperatures)

(iii) the column has a high<u>er</u> temperature at the base

OR

the column has a low<u>er</u> temperature at the top; 1

(the statement needs to be expressed in good English and show a clear understanding of the correct temperature <u>difference</u>)

(penalise "negative OR positive temperature gradient" without qualification to what the candidate means, otherwise ignore)

(ignore references to the boiling points of the molecules)

(credit correct statements which use specific temperatures with a maximum temperature of 500 ^oC at the base)

(b) (i) $C_8H_{18} + 8½O_2 \longrightarrow 8CO + 9H_2O$; 1

(or double this equation)

(ii) correctly drawn structure of 2,2,3-trimethylpentane 1

(penalise the use of 'sticks' once on the paper, including the structures in the 2(a)(ii) and 2(c)(iii)mechanisms)

(credit correctly condensed structures)

(c) cracking <u>produces/makes</u> ethene/propene/alkenes/motor fuels/petrol

OR

cracking makes more useful products/high(er) value products

OR

cracking satisfies the high demand for small(er) products; 1

(ignore the idea that cracking makes or leads to plastics or polyethene)

(high demand needs to be qualified)

(d) (i) carbocation

OR

carbonium ion; 1

(do not credit examples or formulae, but otherwise ignore)

(credit "carbon cation")

(ii) zeolite

OR

aluminosilicate OR Al_2O_3l; 1

(e) (i) M1: (free) radical; 1

(credit alkyl radical)

(do not credit examples or formulae, but otherwise ignore)

(penalise "radical substitution" OR "hydrocarbon radical" as contradictions)

M2: homolysis

OR

homolytic fission/splitting/cleavage

OR

C-C / C-H bonds break; 1

(ii) alkene(s); 1

(credit "small or short chain alkenes")

(penalise "cycloalkenes"

(penalise additional types of compounds (e.g. branched alkanes) as a contradiction)

(do not credit examples or formulae, but ignore if these are correct and in addition to the word "alkene")

Total 11

Question 2

(a) (i) Electron pair/ lone pair acceptor OR seeking/bonds with an electron pair 1

(insist on reference to a pair of electrons)

(ii) M1 curly arrow from middle of C=C bond of the alkene towards/alongside the H atom of the H-Br; 1

(penalise arrows which go towards one of the carbon atoms)

(ignore a partial negative charge on the C=C)

M2 curly arrow from H-Br bond to side of Br atom; 1

(penalise M2 if there are formal charges on HBr or if there are partial charges which are the wrong

(penalise M2 if the single bond has two dots in addition to the line)

M3 correct structure for carbocation; 1

(penalise M3 if the positive charge is placed on the end of a bond)

(penalise M3 if any alkene other than ethene is used- all other marks can score)

M4 curly arrow from lone pair on bromide ion to the positive carbon of carbocation, ensuring that bromide ion has a negative charge; 1

(b) (i) M1 Oxygen *OR* O_2; 1

(do not credit "air" alone, but otherwise ignore)

M2 silver *OR* Ag OR silver-based 1

(penalise silver nitrate)

(ii) correct structure for epoxyethane; 1

(penalise poorly presented C-O bonds)

(iii) water 1

OR

H_2O;

(credit steam OR H_2SO_4 (aqueous OR dilute) OR NaOH(aq) OR HCl(aq), OR H_3PO_4(aq), but insist that (aq) is included)

(do not credit HCl or H_2SO_4 (concentrated or without water present)

(c) (i) M1: potassium cyanide OR KCN OR sodium Cyanide OR NaCN; 1

(ignore conditions – dissolved in (aq) or (alc) or KOH(aq) all work)

(penalise HCN)

M2: propanenitrile; 1

(credit propan-1-nitrile OR propan nitrile, but not propanitrile)

(ii) M1: ammonia OR NH_3; 1

(If formula is written, insist that it is correct)

(ignore conditions, but penalise acidic)

M2: ethylamine; 1

(credit aminoethane)

(iii) M1: curly arrow <u>from lone pair</u> on nitrogen of (correct formula for) ammonia towards/alongside C atom of C-Br; 1

(penalise M1 if formula of ammonia is wrong or has a negative charge or has no lone pair or arrow is from negative charge)

M2: curly arrow <u>from C-Br bond</u> towards/alongside side Br atom; 1

(credit M2 independently)

(penalise M2 if formal positive charge on C atom of C-Br)

M3: correct structure of the ethylammonium ion; 1

(credit the structure drawn out with all four bonds around the nitrogen atom OR written as $C_2H_5NH_3^+$ OR $CH_3CH_2NH_3^+$)

M4: curly arrow <u>from the middle of one of the H-N bonds</u> towards the positive <u>N atom;</u> 1

(possible to credit M4 on an incorrect ethylammonium ion with no positive charge)

(ignore use of ammonia or bromide ion etc. to remove proton from ethylammonium ion)

(If the wrong haloalkane is used, award MAX. 3 marks for the mechanism)

(If S_N1 mechanism is used, give full credit in which M1 is for a curly arrow from the lone pair of the N atom of (correct formula for) ammonia towards/alongside the positive carbon atom of $CH_3CH_2^+$)

Total 17

Question 3

(a) 2-bromobutane; 1

(b) Elimination; 1

(penalise "nucleophilic" OR "electrophilic" before the word "elimination")

M1: curly arrow from lone pair on oxygen of hydroxide ion to H atom on correct C-H adjacent to C-Br; 1

(penalise M1 if KOH shown as covalent with an arrow breaking the bond)

M2: curly arrow from single bond of adjacent C-H to adjacent single bond C-C; 1

(only credit M2 if M1 is being attempted to correct H atom)

M3: curly arrow from C-Br bond to side of Br atom; 1

(credit M3 independently unless arrows contradict)

(Credit possible repeat error from 2(c)(iii) for M3)

(If the wrong haloalkane is used OR but-1-ene is produced, award MAX. 2 marks for the mechanism)

(If E1 mechanism is used, give full credit in which M1 and M2 are for correct curly arrows on the correct carbocation)

(c) (i) (structural) isomers/hydrocarbons/compounds/they have the same molecular formula, but different structural formulas/different structures; 1

(penalise statements which are not expressed in good English and which do not refer clearly to structural isomers i.e. plural)

(penalise statements which refer to "different (spatial) arrangements")

(credit " different displayed formulas")

(ii) Correct structure for but-1-ene; 1

Total 7

Question 4

(a) (i) $C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$; 1

(penalise C_2H_6O once only in this question)

(ii) Concentrated H_2SO_4 OR concentrated H_3PO_4 OR Al_2O_3; 1

(penalise aqueous or dilute as a contradiction)

$C_2H_5OH \longrightarrow C_2H_4 + H_2O$ OR $C_2H_5OH \longrightarrow H_2C{=}CH_2 + H_2O$; 1

(penalise CH_2CH_2 and $CH_2{\cdot}CH_2$ and $CH_2{:}CH_2$ for ethene)

(b) Nickel OR Ni OR platinum OR Pt OR palladium OR Pd; 1

Hydrogen OR H_2; 1

(c) (i) $C_{18}H_{34}O_2$ Only; 1

$C_9H_{17}O$ Only; 1

(empirical formula is not consequential on molecular formula)

(ii) (An unsaturated compound) contains (at least) one double bond 1

OR

contains C=C;

(must be a positive statement)

(iii) M1: Bromine water

OR

$Br_2(aq)$

OR

bromine

OR

Br_2; 1

(penalise "bromide water", but mark on)

M2: decolourised or goes colourless

OR

from brown/red/orange/yellow to colourless; 1

(Must be "colourless" not "clear" for M2)

(chemical error if no reagent or wrong reagent, loses both marks)

(credit $KMnO_4$ for M1, (purple) to colourless for M2(if acidified) OR (purple) to brown/brown precipitate(if alkaline or unspecified)

(No credit for hydrogen or iodine as reagents)

Total 10

Question 5

(a) M1: uv light/sunlight

OR

T = 450°C to 1000°C; 1

(do not credit "high temperature")
(ignore references to pressure or catalyst)
(penalise M1 if aqueous chlorine OR chlorine water)
(credit M1 if the condition appears over the arrow of the initiation step)

M2: $Cl_2 \longrightarrow 2Cl\cdot$; 1

(credit correct half arrows, but penalise (once in the question) the use of double headed arrows)

M3: $C_2H_6 + Cl\cdot \longrightarrow CH_3CH_2\cdot + HCl$; 1

(credit CH_3CH_3 for ethane and $C_2H_5\cdot$ for the ethyl radical)

M4: $CH_3CH_2\cdot + Cl_2 \longrightarrow C_2H_5Cl + Cl\cdot$; 1

M5: $CH_3CH_2\cdot + CH_3CH_2\cdot \longrightarrow C_4H_{10}$; 1

(penalise the absence of dots once only in this question)
(penalise subsequent ionic reactions as contradictions for each reaction contradicted)
(if <u>neither</u> M3 nor M4 scored, allow $CH_3CH_2\cdot + Cl\cdot \longrightarrow C_2H_5Cl$ for one mark)

Total 5

Question 6

(a) M1: $CH_3CH_2CH_2CH_2OH$; 1

M2: $CH_3CH(OH)CH_2CH_3$; 1

(penalise incorrect alcohols in part (a), but mark consequentially in part (b) and in part (c), if relevant)
(if three alcohols drawn, award MAX. 1 mark)

(b) M1, M2 and M3: Correct structures for butanal, butanone and butanoic acid; 3

(award these structure marks wherever the structures appear, but insist that the C=O is shown in each structure and additionally, the C-O in the carboxylic acid

M4: balanced equation for the reaction of butan-1-ol with [O] to produce butanal and water; 1

M5: balanced equation for the reaction of butan-1-ol with [O] to produce butanoic acid and water

OR

balanced equation for the reaction of butanal with [O] to produce butanoic acid; 1

M6: balanced equation for the reaction of butan-2-ol with [O] to produce butanone and water; 1

(Credit condensed structures or molecular formulas in each equation, provided it is obvious to which reaction the equation refers)
(Insist that whatever formula is used in each equation that it is a conventional representation of the compound; for example penalise $CH_3CH_2CH_2COH$ for butanal)

(c) M1: Correct structure for 2-methylpropan-2-ol; 1

M2: 2-methylpropan-2-ol

OR

methylpropan-2-ol; 1
(penalise on every occasion in parts (a) and (c), structures for the alcohols that are presented with the alcohol functional group as C-H-O)

Total 10

General principles applied to marking CHM3/W papers

(updated June 2005)

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.

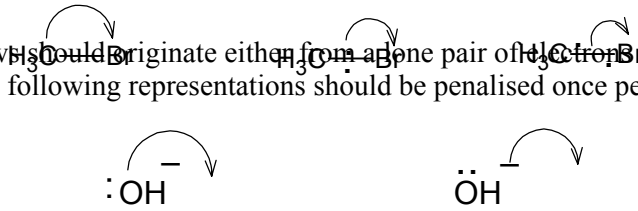
Errors which should be penalised

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

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

A: Mechanisms

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

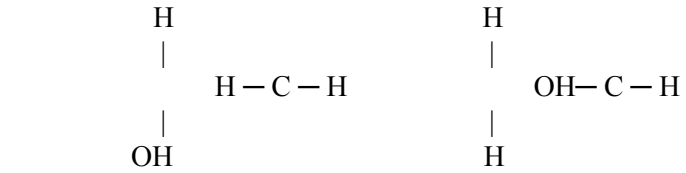


2. The absence of a radical dot in a free radical substitution should be penalised once per script.

3. The use of double-headed arrows or the incorrect use of half-headed arrows in a free-radical mechanisms will be penalised once only per script. In general, there is no expectation for candidates to use half –headed arrows.

B: Structures

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



(accept up to the mid-point)

If candidates show the alcohol functional group as C-H-O, they may be penalised on every occasion.

Some latitude may 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.

2. Formulae for specific compounds which should be penalised.

CH_3COH	for	ethanal
CH_2OCH_2 or CH_2CH_2O	for	epoxyethane
CH_3CH_2HO $OHCH_2CH_3$ C_2H_6O	for	ethanol
CH_2CH_2 $CH_2.CH_2$ $CH_2:CH_2$	for	ethene

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

3. The use of 'sticks' in structures should be penalised once per script. This will also apply to structures in mechanisms.

C: Names

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

but-2-ol 2-hydroxybutane butane-2-ol 2-butanol	all should be butan-2-ol
2-methpropan-2-ol	should be 2-methylpropan-2-ol
2-methylbutan-3-ol	should be 3-methylbutan-2-ol
3-methylpentan 3-mythylpentane	both should be 3-methylpentane
propanitrile	should be propanenitrile
aminethane	should be ethylamine (although aminoethane may gain credit)

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

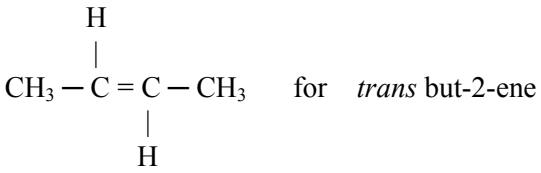
Some general guidance on organic structures

Each of the following should be given 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



for *trans* but-2-ene