

# GCE 2005

## *January Series*



# Mark Scheme

## Chemistry

### CHM3 Introduction to Organic Chemistry

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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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*Dr Michael Cresswell Director General*

### Guidance on the award of the mark for Quality of Written Communication

Quality of Written Communication assessment requires candidates to:

- select and use a form and style of writing appropriate to purpose and complex subject matter;
- organise relevant information clearly and coherently, using specialist vocabulary when appropriate; and
- ensure text is legible, and spelling, grammar and punctuation are accurate, so that meaning is clear.

For a candidate to be awarded 1 mark for quality of written communication on the question identified as assessing QWC in a unit test, the minimum acceptable standard of performance should be:

- the longer parts (worth 4 marks or more) should be structured in a reasonably logical way, appropriate and relevant to the question asked;
- ideas and concepts should be explained sufficiently clearly to be readily understood. Continuous prose should be used and sentences should be generally be complete and constructed grammatically. However, minor errors of punctuation or style should not disqualify;
- appropriate AS/A level terminology should be used. Candidates should not use such phrases as ‘fighting disease’, ‘messages passing along nerves’, ‘enzymes being killed’ etc, but a single lapse would not necessarily disqualify. Technical terms should be spelled correctly, especially where confusion might occur, e.g. mitosis/meiosis, glycogen/glucagon.

The Quality of Written Communication mark is intended as a recognition of competence in written English. Award of the mark should be based on overall impression of performance on the question identified on the paper as assessing QWC. Perfection is not required, and typical slips resulting from exam pressure such as ‘of’ for ‘off’ should not be penalised. Good performance in one area may outweigh poorer performance in another. Care should be taken not to disqualify candidates whose lack of knowledge relating to certain parts of a question hampers their ability to write a clear and coherent answer; in such cases positive achievement on other questions might still be creditworthy. No allowance should be made in the award of this mark for candidates who appear to suffer from dyslexia or for whom English is a second language. Other procedures will be used by the Board for such candidates.

Examiners should record 1 or 0 at the end of the paper in the Quality of Written Communication lozenge. This mark should then be transferred to the designated box on the cover of the script.

**CHM3/W Introduction to Organic Chemistry****SECTION A****Question 1**

- (a) (i) fractional distillation or fractionation 1
- (ii)  $C_9H_{20}$  only 1
- (iii)  $C_{11}H_{24} + 17O_2 \longrightarrow 11CO_2 + 12H_2O$  1
- (iv)  $C_{11}H_{24} + 6O_2 \longrightarrow 11C + 12H_2O$  1
- (b) (i)  $C_{10}H_{22} \longrightarrow C_3H_6 + C_7H_{16}$  1
- (ii) correctly drawn structure of methylpropene 1  
(insist on clearly drawn C-C and C=C bonds)
- (c) Any two from 2
- chemically similar or chemically the same or react in the same way
  - same functional group
  - same general formula
  - differ by  $CH_2$
- (penalise same molecular formula or same empirical formula)

Total 8

**Question 2**

- (a)  $F_2 \longrightarrow 2F\cdot$  1
- $CH_4 + F\cdot \longrightarrow \cdot CH_3 + HF$  1
- $\cdot CH_3 + F_2 \longrightarrow CH_3F + F\cdot$  1
- $\cdot CH_3 + F\cdot \longrightarrow CH_3F$  1
- OR  $2\cdot CH_3 \longrightarrow C_2H_6$
- (allow credit on this occasion for  $2F\cdot \longrightarrow F_2$ )  
(penalise incorrect symbol *Fl*, once only)  
(penalise absence of radical dot once only)
- (b)  $CH_3F + 3F_2 \longrightarrow CF_4 + 3HF$  1

Total 5

**Question 3**

- (a) Compounds with the same molecular formula 1  
but different structures due to different positions of the same functional group on 1  
the same carbon skeleton/chain
- (b) Compound A is butan-1-ol only 1  
Compound C is butanone or butan-2-one 1  
*(penalise but-1-ol, but allow repeat error for but-2-one)*  
*(credit butane-1-ol)*
- (c) (i) oxidation or redox 1
- (ii)  $K_2Cr_2O_7$  or potassium dichromate(VI) 1  
*(penalise the dichromate ion or incorrect oxidation state, but mark on)*  
acidified or  $H_2SO_4$  (or other identified strong acid) 1  
*(penalise  $H^+$ )*  
*(do not credit the acid unless M1 has been correctly attempted)*
- (iii) (heat under) reflux 1  
OR use excess oxidising agent
- (iv) correctly drawn structure of 2-methylpropan-2-ol 1  
*(insist on clearly drawn C-C and C-O bonds)*
- (v) correctly drawn structure of methanoic acid 1  
*(insist on C-O and C=O displayed in the formula)*
- (d) (i) Tollens' reagent or this whole reagent specified (ammoniacal silver 1  
nitrate)  
OR Fehling's solution  
OR acidified potassium dichromate(VI)
- (ii) correctly drawn structure of methylpropanal 1  
*(insist on C-H and C=O of aldehyde displayed in the formula)*

Total 12

**Question 4**

- (a) M1 curly arrow from lone pair on oxygen of hydroxide ion to H atom on C-H adjacent to C-Br 1  
 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)*
- (b) M1 credit a correct structure for either geometrical isomer and its designation as either *cis* or *trans*. 1  
 OR credit two correct geometrical isomer structures (ignore the names)  
 OR credit two correct names for *cis* pent-2-ene and *trans* pent-2-ene (ignore the structures)  
 M2 credit a second mark if all four parts of the required structures and names are correct. 1  
*(credit “linear” structures)*  
*(insist on the alkyl groups being attached clearly by C-C bonds)*
- (c) (i) M1 curly arrow from middle of C=C bond to H atom on H-Br 1  
*(penalise M1 if partial negative charge or formal positive charge on H)*  
*(penalise M1 if pent-2-ene is used)*  
 M2 curly arrow from H-Br bond to side of Br atom 1  
 M3 correct structure for correct secondary carbocation 1  
 M4 curly arrow from lone pair on bromide ion to the positive carbon of carbocation, ensuring that bromide ion has a negative charge. 1  
*(with the exception of pent-2-ene, if the wrong alkene is used, only penalise the structure M3)*  
*(penalise the use of two dots in addition to a covalent bond, once only)*
- (ii) 1-bromopentane 1
- (iii) M1 2-bromopentane is formed *via* the secondary (or 2°) carbocation 1  
 OR 1-bromopentane is formed *via* the primary (or 1°) carbocation  
 M2 a secondary carbocation is more stable than a primary carbocation – 1  
 award this mark only if the quality of language justifies the award.  
*(the argument must involve clear statements about carbocations)*

Total 12

**Question 5**

- (a) M1 fermentation 1  
M2 dehydration or elimination 1
- (b) (i) yeast OR zymase OR an enzyme 1  
(ii) concentrated sulphuric or phosphoric acid 1  
(penalise aqueous or dilute as a contradiction)
- (c) (i) primary or 1° 1  
(ii) sugar or glucose or ethanol is renewable 1  
OR ethanol does not contain sulphur-containing impurities  
OR ethanol produces less pollution or is less smoky or less CO/C  
(the objective is a positive statement about ethanol)  
(penalise the idea that ethanol is an infinite source or vague statements that ethanol has less impurities)  
(penalise the idea that ethanol produces no pollution)
- (d)  $C_2H_6 \longrightarrow C_2H_4 + H_2$  1
- (e) Addition 1  
(ignore self or chain as a preface to "addition")  
(penalise additional)

Total 8

**SECTION B****Question 6**

- (a) M1 X is 1,2-dibromoethane only 1  
M2 electrophilic addition 1  
(both words needed)  
M3 the double bond is a centre of electron density 1  
OR electron-rich  
OR nucleophilic  
OR a source of an electron pair  
OR a pi cloud/bond of electrons  
M4 a dipole or polarity is induced/created/formed in the Br-Br bond/molecule - 1  
award this mark only if the quality of language justifies the award.
- (b) nucleophilic substitution 1  
(both words needed)  
Mechanism M1 curly arrow from lone pair on oxygen of hydroxide ion to C atom of C-Br 1  
Mechanism M2 curly arrow from C-Br bond to side of Br atom 1  
(a possible repeat error here from Question 4a)  
(award a maximum of one mark for the wrong haloalkane)  
(credit an SN1 mechanism in which M1 will be a curly arrow from the lone pair on oxygen of the hydroxide ion to the correct positive carbon atom)  
Y is susceptible to attack by hydroxide ions for one of the following reasons 1

- the C-Br bond is polar
  - the carbon atom is partially positive (or shown as such)
  - the carbon atom is electron deficient
- (c) M1 oxygen 1  
*(ignore “air”)*  
 M2 silver or silver-based 1  
*(penalise silver nitrate)*  
 M3 Z is epoxyethane 1  
 M4 epoxyethane 1
- has a strained ring structure
  - has a bond angle of 60°
  - has a bond angle significantly less than tetrahedral
- (ignore “unstable”, “has strained bonds”, “is stressed”)*
- (d) Ethane-1,2-diol is used in antifreeze 1  
 OR in the manufacture of PET/Terylene/polyester  
*(penalise “solvent” or “plasticiser”)*  
 Hazard in Route *via* X/Y 1
- bromine is toxic or corrosive
  - sodium hydroxide is corrosive or caustic
- Hazard in Route *via* epoxyethane 1
- risk of explosion in reaction 4
  - epoxyethane is toxic
  - epoxyethane is a respiratory irritant
  - epoxyethane causes neurological damage

Total 15

### *Some general principles applied to the marking of CHM3/W papers*

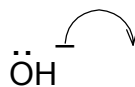
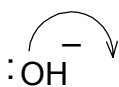
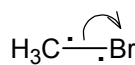
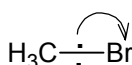
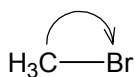
#### **Errors which should be penalised**

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.

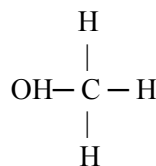
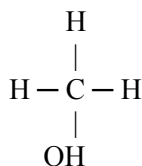


- The absence of a radical dot in a free radical substitution should be **penalised once only** per script.



### Structures

1. 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.



(accept up to the mid-point)

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

CH <sub>3</sub> COH	for	ethanal
CH <sub>2</sub> OCH <sub>2</sub> or CH <sub>2</sub> CH <sub>2</sub> O	for	epoxyethane
CH <sub>3</sub> CH <sub>2</sub> HO or OHCH <sub>2</sub> CH <sub>3</sub>	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	all should be <b>butan-2-ol</b>
2-hydroxybutane	
butane-2-ol	
2-butanol	
2-methpropan-2-ol	should be <b>2-methylpropan-2-ol</b>
2-methylbutan-3-ol	should be <b>3-methylbutan-2-ol</b>
3-methylpentan	both should be <b>3-methylpentane</b>
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 *trans* but-2-ene