AS
CHEMISTRY
7404/2

Paper 2 Organic and Physical Chemistry

Mark scheme

June 2025

Version: 1.0 Final

256A7404/2/MS

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' 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.

No student should be disadvantaged on the basis of their gender identity and/or how they refer to the gender identity of others in their exam responses.

A consistent use of 'they/them' as a singular and pronouns beyond 'she/her' or 'he/him' will be credited in exam responses in line with existing mark scheme criteria.

Further copies of this mark scheme are available from aqa.org.uk

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AS and A-Level Chemistry
Mark Scheme Instructions for Examiners

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the examiner make his or her judgement and help to delineate what is acceptable or not worthy of credit or, in discursive answers, to give an overview of the area in which a mark or marks may be awarded.

The extra information in the 'Comments' column is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.

You should mark according to the contents of the mark scheme. If you are in any doubt about applying the mark scheme to a particular response, consult your Team Leader.

At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.

In general the right-hand side of the mark scheme is there to provide those extra details which might confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent.

The use of M1, M2, M3 etc in the right-hand column refers to the marking points in the order in which they appear in the mark scheme. So, M1 refers to the first marking point, M2 the second marking point etc.

2. Emboldening

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following bullet points is a potential mark.

2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.

2.3 Alternative answers acceptable for a mark are indicated by the use of **OR**. Different terms in the mark scheme are shown by a / ; eg allow smooth / free movement.

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which students have provided extra responses. The general 'List' principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error / contradiction negates each correct response. So, if the number of error / contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (often prefaced by 'Ignore' in the mark scheme) are not penalised.

For example, in a question requiring 2 answers for 2 marks:

Correct answers	Incorrect answers (ie incorrect rather than neutral)	Mark (2)	Comment
1	0	1	
1	1	1	They have not exceeded the maximum number of responses so there is no penalty.
1	2	0	They have exceeded the maximum number of responses so the extra incorrect response cancels the correct one.
2	0	2	
2	1	1	
2	2	0	
3	0	2	The maximum mark is 2
3	1	1	The incorrect response cancels out one of the two correct responses that gained credit.
3	2	0	Two incorrect responses cancel out the two marks gained.
3	3	0	

3.2 Marking procedure for calculations

Full marks should be awarded for a correct numerical answer, without any working shown, unless the question states 'Show your working' or 'justify your answer'. In this case, the mark scheme will clearly indicate what is required to gain full credit.

If an answer to a calculation is incorrect and working is shown, process mark(s) can usually be gained by correct substitution / working and this is shown in the 'Comments' column or by each stage of a longer calculation.

3.3 Errors carried forward, consequential marking and arithmetic errors

Allowances for errors carried forward are most likely to be restricted to calculation questions and should be shown by the abbreviation ECF or consequential in the marking scheme.

An arithmetic error should be penalised for one mark only unless otherwise amplified in the marking scheme. Arithmetic errors may arise from a slip in a calculation or from an incorrect transfer of a numerical value from data given in a question.

3.4 Equations

In questions requiring students to write equations, state symbols are generally ignored unless otherwise stated in the 'Comments' column.

Examiners should also credit correct equations using multiples and fractions unless otherwise stated in the 'Comments' column.

3.5 Oxidation states

In general, the sign for an oxidation state will be assumed to be positive unless specifically shown to be negative.

3.6 Interpretation of 'it'

Answers using the word 'it' should be given credit only if it is clear that the 'it' refers to the correct subject.

3.7 Phonetic spelling

The phonetic spelling of correct scientific terminology should be credited **unless** there is a possible confusion with another technical term or if the question requires correct IUPAC nomenclature.

3.8 Brackets

(…..) are used to indicate information which is not essential for the mark to be awarded but is included to help the examiner identify the sense of the answer required.

3.9 Ignore / Insufficient / Do <u>not</u> allow

Ignore or insufficient is used when the information given is irrelevant to the question or not enough to gain the marking point. Any further correct amplification could gain the marking point.

Do **not** allow means that this is a wrong answer which, even if the correct answer is given, will still mean that the mark is not awarded.

3.10 Marking crossed out work

Crossed out work that **has not been** replaced should be marked as if it were not crossed out, if possible. Where crossed out work **has been** replaced, the replacement work and not the crossed out work should be marked.

3.11 Reagents

The command word 'Identify', allows the student to choose to use **either** the name **or** the formula of a reagent in their answer. In some circumstances, the list principle may apply when both the name and the formula are used. Specific details will be given in mark schemes.

The guiding principle is that a reagent is a chemical which can be taken out of a bottle or container. Failure to identify complete reagents **will be penalised**, but follow-on marks (eg for a subsequent equation or observation) can be scored from an incorrect attempt (possibly an incomplete reagent) at the correct reagent. Specific details will be given in mark schemes.

For example, **no credit** would be given for:

- the cyanide ion or CN^- when the reagent should be potassium cyanide or KCN;
- the hydroxide ion or OH^- when the reagent should be sodium hydroxide or NaOH;
- the $Ag(NH_3)_2^+$ ion when the reagent should be Tollens' reagent (or ammoniacal silver nitrate). In this example, no credit is given for the ion, but credit could be given for a correct observation following on from the use of the ion. Specific details will be given in mark schemes.

In the event that a student provides, for example, **both** KCN and cyanide ion, it would be usual to ignore the reference to the cyanide ion (because this is not contradictory) and credit the KCN. Specific details will be given in mark schemes.

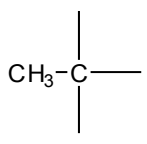
3.12 Organic structures

Where students are asked to draw organic structures, unless a specific type is required in the question and stated in the mark scheme, these may be given as displayed, structural or skeletal formulas or a combination of all three as long as the result is unambiguous.

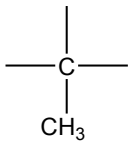
In general

- Displayed formulae must show all of the bonds and all of the atoms in the molecule, but need not show correct bond angles.
- Skeletal formulae must show carbon atoms by an angle or suitable intersection in the skeleton chain. Functional groups must be shown and it is essential that all atoms other than C atoms are shown in these (except H atoms in the functional groups of aldehydes, secondary amines and N-substituted amides which do not need to be shown).
- Structures must not be ambiguous, e.g. 1-bromopropane should be shown as $CH_3CH_2CH_2Br$ and not as the molecular formula C_3H_7Br which could also represent the isomeric 2-bromopropane.
- Bonds should be drawn correctly between the relevant atoms. This principle applies in all cases where the attached functional group contains a carbon atom, eg nitrile, carboxylic acid, aldehyde and acid chloride. The carbon-carbon bond should be clearly shown. Wrongly bonded atoms will be penalised **on every occasion**. (see the examples below)
- The same principle should also be applied to the structure of alcohols. For example, if students show the alcohol functional group as C ─ HO, they should be penalised **on every occasion**.
- Latitude should be given to the representation of C ─ C bonds in alkyl groups, given that CH_3─ is considered to be interchangeable with H_3C─ even though the latter would be preferred.
- Similar latitude should be given to the representation of amines where NH_2─ C will be allowed, although H_2N─ C would be preferred.
- Poor presentation of vertical C ─ CH_3 bonds or vertical C ─ NH_2 bonds should **not** be penalised. For other functional groups, such as ─ OH and ─ CN, the limit of tolerance is the half-way position between the vertical bond and the relevant atoms in the attached group.

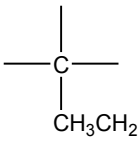
By way of illustration, the following would apply.



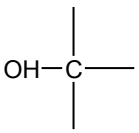
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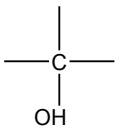
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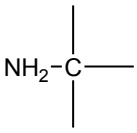
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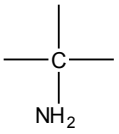
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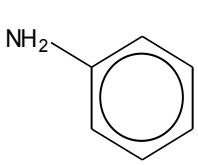
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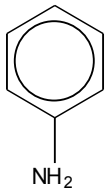
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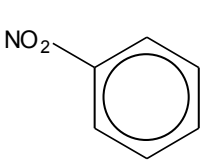
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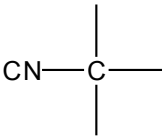
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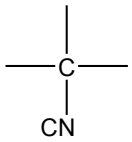
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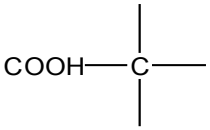
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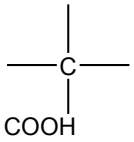
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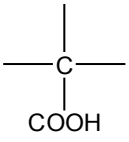
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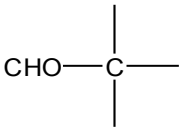
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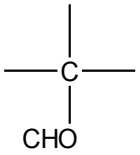
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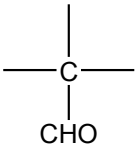
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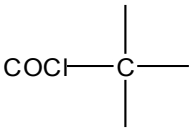
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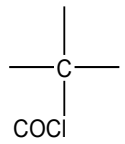
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- Representation of CH_2 by $C{-}H_2$ will be penalised
- Some examples are given here of **structures** for specific compounds that should **not** gain credit (but, exceptions **may** be made in the context of balancing equations)

CH_3COH	for	ethanal
CH_3CH_2HO	for	ethanol
$OHCH_2CH_3$	for	ethanol
C_2H_6O	for	ethanol
CH_2CH_2	for	ethene
$CH_2.CH_2$	for	ethene
$CH_2{:}CH_2$	for	ethene

- 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, $CH_3CH(OH)CH_3$

- In most cases, the use of 'sticks' to represent C ─ H bonds in a structure should **not** be penalised. The exceptions to this when "sticks" will be penalised include
  - structures in mechanisms where the C ─ H bond is essential (eg elimination reactions in halogenoalkanes and alcohols)
  - when a displayed formula is required
  - when a skeletal structure is required or has been drawn by the candidate.

3.13 Organic names

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

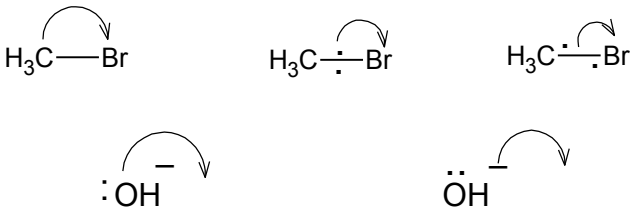
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

but-2-ol	should be **butan-2-ol**
2-hydroxybutane	should be **butan-2-ol**
butane-2-ol	should be **butan-2-ol**
2-butanol	should be **butan-2-ol**
ethan-1,2-diol	should be **ethane-1,2-diol**
2-methpropan-2-ol	should be **2-methylpropan-2-ol**
2-methylbutan-3-ol	should be **3-methylbutan-2-ol**
3-methylpentan	should be **3-methylpentane**
3-mythylpentane	should be **3-methylpentane**
3-methypentane	should be **3-methylpentane**
propanitrile	should be **propanenitrile**
aminethane	should be **ethylamine** (although aminoethane can gain credit)
2-methyl-3-bromobutane	should be **2-bromo-3-methylbutane**
3-bromo-2-methylbutane	should be **2-bromo-3-methylbutane**
3-methyl-2-bromobutane	should be **2-bromo-3-methylbutane**
2-methylbut-3-ene	should be **3-methylbut-1-ene**
difluorodichloromethane	should be **dichlorodifluoromethane**

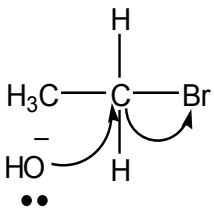
3.14 Organic reaction mechanisms

Curly arrows should originate either from a lone pair of electrons or from a bond.

The following representations should not gain credit **and will be penalised each time** within a clip.



For example, the following would score zero marks



When the curly arrow is showing the formation of a bond to an atom, the arrow can go directly to the relevant atom, alongside the relevant atom or **more than half-way** towards the relevant atom.

In free-radical substitution:

- the absence of a radical dot should be penalised **once only** within a clip.
- the use of half-headed arrows is not required, but 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.

The correct use of skeletal formulae in mechanisms is acceptable, but where a C-H bond breaks, both the bond and the H must be drawn to gain credit.

3.15 Extended responses

For questions marked using a 'Levels of Response' mark scheme:

Level of response mark schemes are broken down into three levels, each of which has a descriptor. Each descriptor contains two statements. The first statement is the Chemistry content statement and the second statement is the communication statement.

Determining a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the Chemistry content descriptor for that level. The descriptor for the level indicates the qualities that might be seen in the student's answer for that level. If it meets the lowest level, then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level.

Once the level has been decided, the mark within the level is determined by the communication statement:

• If the answer completely matches the communication descriptor, award the higher mark within the level.

• If the answer does not completely match the communication descriptor, award the lower mark within the level.

The exemplar materials used during standardisation will help you to determine the appropriate level. There will be an exemplar in the standardising materials which will correspond with each level of the mark scheme and for each mark within each level. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the exemplar to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the exemplar.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other chemically valid points. Students may not have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme. The mark scheme will state how much chemical content is required for the highest level.

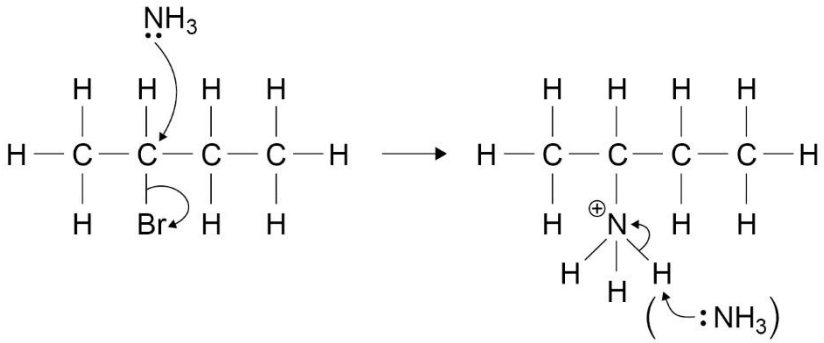
An answer which contains nothing of relevance to the question must be awarded no marks.

For other extended response answers:

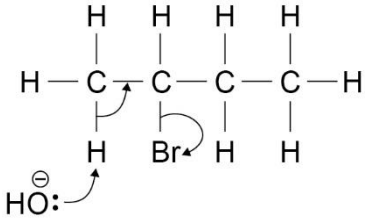
Where a mark scheme includes linkage words (such as 'therefore', 'so', 'because' etc), these are optional. However, a student's marks for the question may be limited if they do not demonstrate the ability to construct and develop a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. In particular answers in the form of bullet pointed lists may not be awarded full marks if there is no indication of logical flow between each point or if points are in an illogical order.

The mark schemes for some questions state that the maximum mark available for an extended response answer is limited if the answer is not coherent, relevant, substantiated and logically structured. During the standardisation process, the Lead Examiner will provide marked exemplar material to demonstrate answers which have not met these criteria. You should use these exemplars as a comparison when marking student answers.

Question	Marking guidance	Additional Comments/Guidelines	Mark
01.1	**M1** C of C-halogen is δ+ **M2** lone pair on nucleophile attacks/attracted to C of C-halogen	Ignore drawn mechanism (but could score **M1** for δ+ on mechanism) Alternative based on SN1 **M1** carbocation formed **M2** lone pair on nucleophile attacks/attracted to positive C	2 (2 x AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
01.2	**M1** Attack by NH_3 with curly arrow from lone pair on N to the correct C **M2** Structure of intermediate **M3** Loss of H^+ with curly arrow from N–H bond to N  	Ignore use of sticks Penalise **M1** for formal charge on C and / or Br of C–Br or incorrect partial charges on C–Br; ignore other partial charges on uncharged atoms Penalise **M1** for any additional arrow or charge on NH_3 or missing lone pair Penalise **M1** for any additional arrow(s) to / from the Br to / from anything else For **M2**, the $^+$ should be on the N For **M3** there is no need to show attack by a second NH_3 molecule, but if it is shown, it must be correct (but, if the NH_3 is charged or the lone pair is missing and this has been penalised in **M1** then do not penalise the same error again in **M3**) For **M3**, NOT removal of H by attack with Br ***For SN1:*** **M1** structure of correct carbocation **M2** attack by NH_3 with curly arrow from lone pair on N to the +C of their carbocation	3 (1 x AO1, 2 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
01.3	water / aqueous	Allow aqueous KOH/NaOH NOT ethanol / alcohol Ignore temperature	1 (1 x AO1)

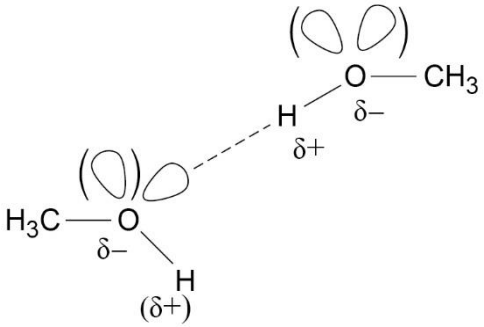
Question	Marking guidance	Additional Comments/Guidelines	Mark
01.4	**M1** (basic) elimination **M2** curly arrow from lone pair of OH^- to an H on C1 **M3** curly arrow from C–H bond on C1 to bond between C1 and C2  **M4** *E*-but-2-ene (name or structure) **M5** *Z*-but-2-ene (name or structure)	Ignore use of sticks but H must be shown for H that is lost by C–H breaking Penalise **M2** for any additional arrow or charge on OH^- Penalise **M3** for formal charge on C and / or Br of C–Br or incorrect partial charges on C–Br; ignore other partial charges on uncharged atoms Penalise **M3** for any additional arrow(s) to / from the Br to / from anything else If H on C3 attacked, NOT **M2**: but allow **M3** for correct arrows only for curly arrow from C–H bond on C3 to bond between C3 and C2 Cannot score **M2/3** if attacking H on C2 or C4 ***For E1:*** **M2** curly arrow from lone pair of OH^- to an H on C1 of correct carbocation **M3** curly arrow from C–H bond on C1 to bond between C1 and C2 (allow ECF for making but-2-ene) **M4** and **M5** in either order; allow 1 mark for **M4/5** for but-2-ene (even if there is a second incorrect product named)	5 (1 x AO1, 2 x AO2, 2 x AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
01.5	120(°)		1 (1 x AO3)

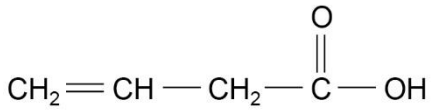
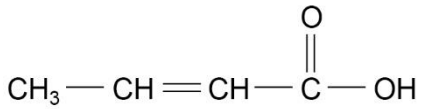
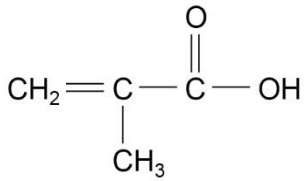
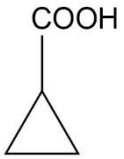
Question	Marking guidance	Additional Comments/Guidelines	Mark
01.6	**M1** (idea of covalent bond where or shared electrons where) both electrons come from the same species **M2** lone pair donated from C of CN^- to C^+ or central C (of carbocation)	Allow structure showing (:)→ from $CN(^-)$ to $C(^+)$, but with a straight arrow Allow curly arrow mechanism but need charges and lone pair **M2** also scores **M1**	2 (1 x AO1, 1 x AO2)

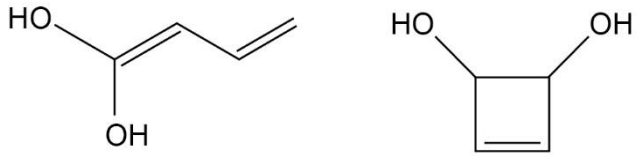
Question	Marking guidance	Additional Comments/Guidelines	Mark
02.1	**M1** provides alternative route/mechanism/pathway **M2** with lower activation energy		2 (2 x AO1)

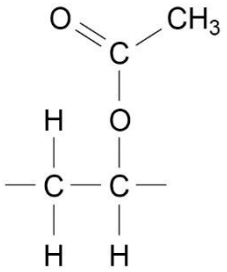
Question	Marking guidance	Additional Comments/Guidelines	Mark
02.2	**M1** particles/molecules/reactants move faster / have greater (kinetic) energy **M2** more particles/molecules have (energy greater than/equal to) the activation energy **M3** successful collisions are more frequent	Ignore atoms Ignore vibrations Allow per unit time for frequency	3 (3 x AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
02.3	**M1** lone pairs and partial charges (O δ−, H δ+, :O δ−) on atoms involved in the hydrogen bond of one methanol molecule to a second methanol molecule **M2** dotted line between lone pair on O to correct H **M3** linear O–H·····O 	Accept two dots or two crosses for lone pair Ignore partial charges on atoms in CH_3 group For incorrect compounds that do have hydrogen bonding (e.g. ethanol, water), **M2/3** could score for a correct hydrogen bond	3 (3 x AO2)

<table>
<tr><th>Question</th><th>Marking guidance</th><th>Additional Comments/Guidelines</th><th>Mark</th></tr>
<tr>
<td>03</td>
<td>This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.
<table>
<tr><td>Level 3:
All stages are covered and each stage is generally correct and virtually complete.
(6 v 5) Answer is well structured, with no repetition or irrelevant points, and covers all aspects of the question. Accurate and clear expression of ideas with no errors in use of technical terms.</td><td>5-6</td></tr>
<tr><td>Level 2:
All stages are covered but stage(s) may be incomplete or may contain inaccuracies OR
two stages are covered and are generally correct and virtually complete.
(4 v 3) Answer has some structure and covers most aspects of the question. Ideas are expressed with reasonable clarity with, perhaps, some repetition or some irrelevant points. If any, only minor errors in use of technical terms.</td><td>3-4</td></tr>
<tr><td>Level 1:
Two stages are covered but stage(s) may be incomplete or may contain inaccuracies OR
only one stage is covered but is generally correct and virtually complete.
(2 v 1) Answer includes statements which are presented in a logical order and / or linked.</td><td>1-2</td></tr>
<tr><td>Level 0
Insufficient correct chemistry to gain a mark.</td><td>0</td></tr>
</table>
</td>
<td>Stage 1 - Shape
1a 4 bonding pairs (& no lone pairs) (allow bonds but not atoms for bonding pairs)
1b repel as far as possible / repel equally / to minimise repulsion
(covered = 1, virtually complete = 1 or 2)
Stage 2 - Polarity
2a C–Cl bonds polar
2b CCl_4 not polar
2c CCl_4 dipoles cancel due to symmetry
2d $CHCl_3$ polar
2e $CHCl_3$ dipoles do not cancel out
(covered = 2, virtually complete = 3/4/5)
Stage 3 - Boiling points (no credit for reference to breaking of covalent bonds)
3a CCl_4 has van der Waals' forces
3b $CHCl_3$ has dipole-dipole forces and van der Waals'
3c van der Waals'/intermolecular forces in CCl_4 stronger than (combined) van der Waals' (and dipole-dipole)/ intermolecular forces in $CHCl_3$
3d as CCl_4 has more electrons (or higher M_r or bigger molecule) than $CHCl_3$
Allow dispersion / London forces for van der Waals'
(covered = 1, virtually complete = 3 or 4)</td>
<td>6
(1 x AO1,
3 x AO2,
2 x AO3)</td>
</tr>
</table>

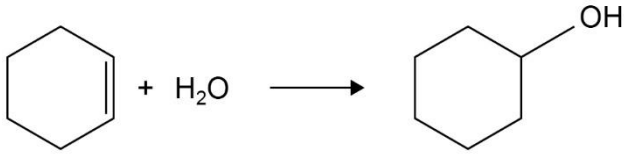
Question	Marking guidance	Additional Comments/Guidelines	Mark
04.1	**A** one of these compounds    **B** 	Allow any correct representation of correct answers.	2 (2 x AO3)

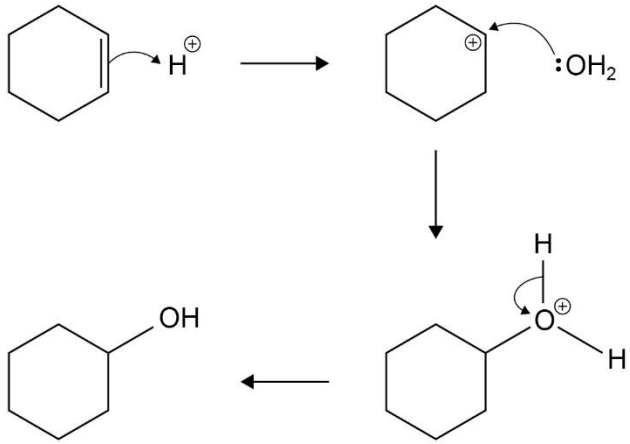
Question	Marking guidance	Additional Comments/Guidelines	Mark
04.2	Any molecule with formula $C_4H_6O_2$ containing either: • chain with 2 C=C groups and 2 OH groups OR • cyclic compound with 1 C=C group and 2 OH groups e.g. 	Allow cyclic ethers with one OH and one C=C Any correct structural representation	1 (1 x AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
04.3	 Ignore any n or brackets	Any correct structural representation	1 (1 x AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
05.1	**M1** butane (and propanone) have different M_r to several/more decimal places **M2** prop-2-en-1-ol (and propanone) have the same molecular formula or are isomers	**M1** ignore reference to fragmentation and/or same molecular formula	2 (2 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
05.2	**M1** $n = \frac{PV}{RT}$ **M2** converting V to 272 $\times 10^{-6}$ and T to 373 **M3** $n = \frac{102000 \times 272 \times 10^{-6}}{8.31 \times 373}$ (= 0.00895) **M4** mass of **X** = 106.633 – 105.872 (=0.761 (g)) **M5** $M_r = \frac{\mathbf{M4}}{\mathbf{M3}}$ = 85.0 (at least 2 sf)	If expression not written out, **M1** could score from a substituted correct expression later on (even if any unit conversions are incorrect) Allow ECF from **M1** to **M3**, **M2** to **M3**; **M3** and/or **M4** to **M5** If 373.15 used as T, then M_r = 85.055 (scores 5) If 100 used as T, then M_r = 22.79…. (scores 4) Alternative method **M3** $M_r = \frac{mRT}{PV}$ **M5** $M_r = \left(\frac{0.761 \times 8.31 \times 373}{102000 \times 272 \times 10^{-6}}\right)$ = 85.0 (at least 2 sf)	5 (1 x AO1, 4 x AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.1		Do not allow equations with H_3PO_4 or H^+ on both sides Ignore any acids (or attempt at formula of an acid) on the arrow.	1 (1 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.2	**M1** curly arrow from C=C to H^+ **M2** curly arrow from lone pair on O to positive C atom **M3** curly arrow from an O–H bond to O 	Mark each of the three stages independently. Any extra curly arrows within each of the three steps of the mechanism would contradict the correct arrow within that step.	3 (3 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.3	**M1** Mass of concentrated phosphoric acid = 6.0 × 1.69 (= 10.14 g) **M2** Amount of H_3PO_4 = $\frac{\textbf{M1} \times 0.85}{98.0}$ = 0.0879 mol (at least 2sf)	0.10(3) scores 1 mark (at least 2 sf) for not using 85% Allow 1 mark for = 6.0 x 1.69 x 0.85 (= 8.619 g) Allow 1 mark for = $\frac{6.0 \times 1.69 \text{ x } 0.85}{\text{incorrect } M_r}$ = $\frac{8.619}{\text{incorrect } M_r}$	2 (2 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.4	**M1** idea of ensuring the condenser fills with water **M2** idea that condenser is cool(er) or ensuring (more) vapour condenses	**M1** allow idea of no air bubbles **M2** not water vapour; ignore cyclohexene	2 (2 x AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.5	to produce smaller bubbles / prevent the formation of large bubbles		1 (1 x AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.6	as the mixture / cyclohexanol is flammable	Igno0re to control temperature	1 (1 x AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.7	**M1** System is closed / sealed **M2** idea of vent or opening on or near the collection flask	**M1** allow build-up of pressure	2 (2 x AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.8	elimination	Allow acid catalysed elimination Ignore dehydration Not acid-based elimination	1 (1 x AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.9	$C_6H_{11}OH + 8\frac{1}{2} O_2 \longrightarrow 6\,CO_2 + 6\,H_2O$	Allow multiples / fractions Allow $C_6H_{12}O$ Ignore state symbols	1 (1 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.10	**M1** (A carbon-neutral fuel results in) no net emissions of <u>carbon dioxide</u> to the <u>atmosphere</u>/<u>air</u> **M2** (Extra CO_2 will be emitted) because of use of fossil fuels in processing / transport OR contains diesel which is non-renewable/fossil fuel/not biofuel		2 (1 x AO1, 1 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.1	heat (energy) change at constant pressure	change in heat content at constant pressure ignore reference to standard states	1 (1 x AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.2	**M1** q (= $mc\Delta T$) = 55 × 4.18 × 46.2 **M2** = 10621 J or 10.621 kJ **M3** amount of ethanol = $(-)\frac{q}{\Delta H}$ **M4** = $\frac{\textbf{M2 in kJ}}{1371}$ (= 0.007747) **M5** mass ethanol = **M4** × 46.0 = 0.356 (g) (min 2sf)	Ignore minus sign in **M1/2** Allow ECF from **M1** to **M2** Allow ECF from **M2** to **M4** Allow ECF from **M3** to **M4** Allow ECF from **M4** to **M5** 356 g scores 4 marks Use of ΔT as (46.2+273) gives 73.4 kJ and 2.46 g – scores 4 marks	5 (1 x AO1, 4 x AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.3	$2n(805) + 2(n+1)463$ OR $2n(805) + (2n+2)463$ OR $1610n + 926n + 926$ $(= 2536n + 926)$	Required brackets must be used correctly Accept 2 *x* n *x* 805 + 2 *x* (n+1) *x* 463	1 (1 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.4	**M1** Energy change = (1916*n* + 724) – (2536*n* + 926) or –3302 = (1916*n* + 724) – (2536*n* + 926) or 620*n* = 3100 **M2** *n* = 5 (must be an integer) **M3** C_5H_{12}	No ECF from **M1** to **M2** Could allow **M1, M2** and/or **M3** for correct answers with no working Allow ECF from **M2** to **M3** using nearest integer (but must be a positive integer) Answer for **M3** is dependent on their value for **M2**	3 (3 x AO3)

Question	Marking Guidance	Mark	Comments
08	**B**	1 (AO2)	3-methylbutanal
09	**A**	1 (AO1)	Exhaust gases can contain a mixture of unburned hydrocarbon molecules.
10	**C**	1 (AO1)	C–C bonds are broken.
11	**D**	1 (AO3)	3-methylbutan-2-ol
12	**D**	1 (AO3)	*Z*–3-fluoro-4-methylpent-2-ene
13	**C**	1 (AO3)	$C_6H_{10}O_4$
14	**D**	1 (AO1)	Sulfur dioxide molecules contain polar bonds.
15	**A**	1 (AO1)	$Cl\bullet + O_3 \rightarrow O_2 + ClO\bullet$
16	**C**	1 (AO1)	They are more volatile.
17	**D**	1 (AO1)	N_2
18	**A**	1 (AO2)	+51

19	**B**	1 (AO1)	
20	**C**	1 (AO3)	0.96 g of magnesium reacting with 200 cm^3 of 1.0 mol dm^{-3} hydrochloric acid
21	**B**	1 (AO2)	$C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl$
22	**B**	1 (AO2)	$\frac{1}{2}I_2(s) + 2C(s) + \frac{5}{2}H_2(g) \rightarrow C_2H_5I(l)$