AQA

AS
CHEMISTRY
7404/2

Paper 2 Organic and Physical Chemistry

Mark scheme

June 2022

Version: 1.0 Final

226A7404/2/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.

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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 not 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 (e.g. 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.

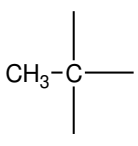
3.12 Organic structures

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.

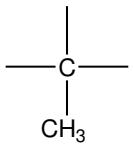
In general

- 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, eg 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.

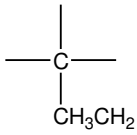
By way of illustration, the following would apply.



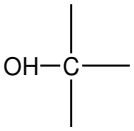
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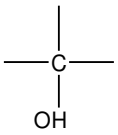
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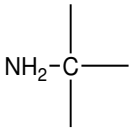
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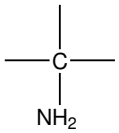
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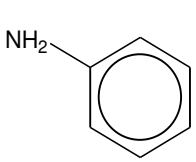
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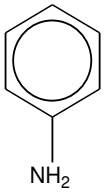
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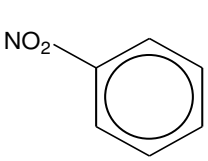
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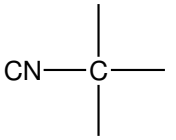
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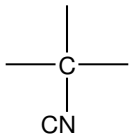
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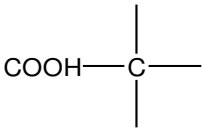
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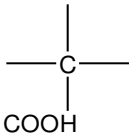
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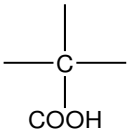
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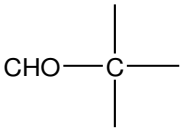
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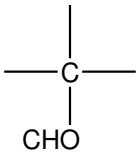
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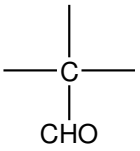
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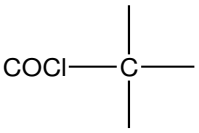
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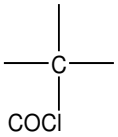
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- Representation of CH_2 by $C–H_2$ will be penalised
- Some examples are given here of **structures** for specific compounds that should **not** gain credit (but, exceptions <u>may</u> be made in the context of balancing equations)

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 (e.g. 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.

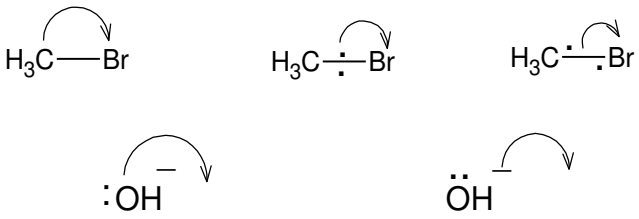
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

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**

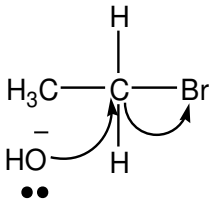
3.14 Organic reaction mechanisms

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:

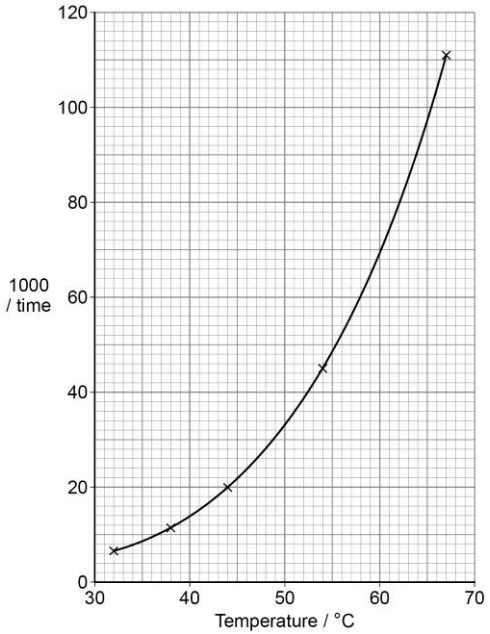
Where a mark scheme includes linkage words (such as 'therefore', 'so', 'because' etc), these are optional. However, a student's marks for the question may be limited if they do not demonstrate the ability to construct and develop a sustained line of reasoning which is coherent, relevant, substantiated 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	111(.1)	Allow an answer to a finite number of sig figs (that is correctly rounded) Allow 110 Do not allow answers with recurring dot above number (ignore dots after the final number)	1 (AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
01.2	temperature		1 (AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
01.3	Measure the temperature at the start and end of the reaction <u>and</u> find the mean/average	Measure the temperature at regular intervals during the reaction <u>and</u> find the mean/average Allow idea of doing the reaction in a water bath	1 (AO3)

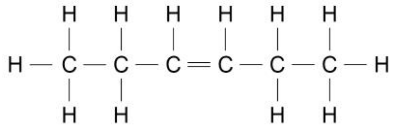
Question	Marking guidance	Additional Comments/Guidelines	Mark
01.4	**M1** suitable vertical scale **M2** points plotted correctly (± ½ small square per point) **M3** best fit line drawn (within one small square of each point and should be a smooth curve)  	**M1** should use more than half the axis to cover the four points given and the point for 67°C (if plotted) **M2** allow ECF for plotting of point found in 1.1 (if no value found in 1.1 allow graph that omits this) **M3** allow ECF for a line based on their plotted points, but only where the line continues to rise throughout the temperature range	1 1 1 (2 x AO1, 1 x AO2)

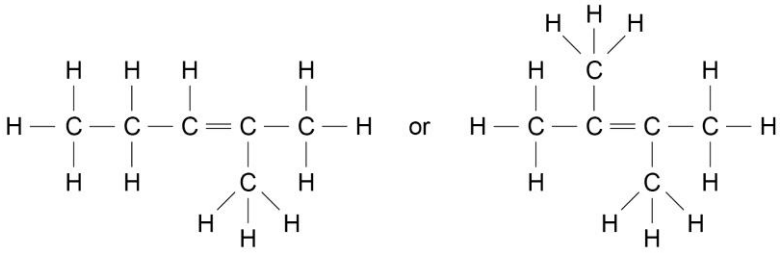
Question	Marking guidance	Additional Comments/Guidelines	Mark
01.5	Time = $\frac{1000}{\text{value from graph at 60°C}}$	Answers should be at least 2 sf Working needs to be shown that includes a value from the graph at 60 °C and/or construction line(s) showing 1000/*t* at 60 °C on the graph Use the value for their line at 60 °C (±½ small square)	1 (AO3)

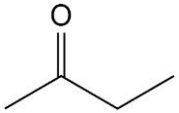
Question	Marking guidance	Additional Comments/Guidelines	Mark
01.6	**M1** many more particles/ions have (energy ≥) activation energy **M2** more successful collisions per unit time / greater frequency of successful collisions	**M1** need the idea that it is many / much more particles; allow reference to atoms / molecules instead of particles / ions **M2** allow higher proportion of the collisions are successful	1 1 (2 x AO1)

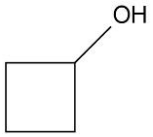
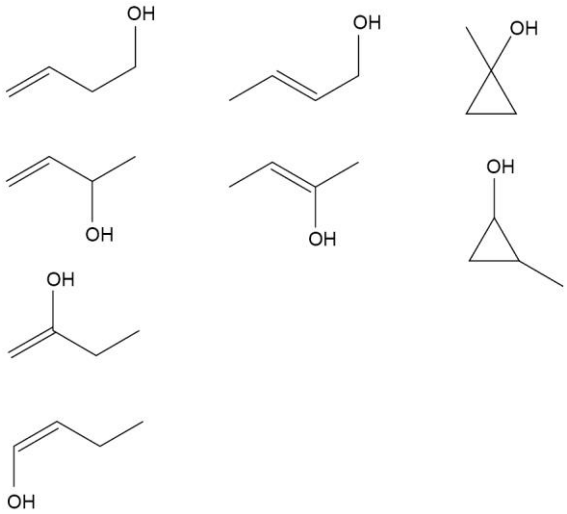
<table>
<tr><th>Question</th><th colspan="2">Marking Guidance</th><th>Additional Comments/Guidelines</th><th>Mark</th></tr>
<tr><td rowspan="5">02</td><td colspan="2">This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.</td><td rowspan="5">Stage 1
Identifying aldehyde / 2-methylpropanal
1a Tollens' or Fehling's
1b silver mirror or orange-red precipitate
Stage 2
Identifying alcohol / 2-methylpropan-1-ol
2a acidified potassium dichromate
2b (orange to) green
2c tests done in suitable sequence to distinguish aldehyde from alcohol, or to state that aldehyde would give same result if this test is done first
If aldehyde is identified, alcohol may be identified by elimination of the other two as acids using Na_2CO_3/$NaHCO_3$/Mg/indicator (2a = appropriate reagent, 2b = correct observations, 2c = in a suitable sequence)
Stage 3
Distinguishing the acids
3a using IR spectroscopy to distinguish the two acids (or other suitable technique)
3b use finger-print region of IR spectrum (feature of spectrum to use)
3c look for exact match to spectra of known compounds (what the difference is)</td><td rowspan="5">6

(4 x AO1, 2 x AO3)</td></tr>
<tr><td>Level 3
(5-6 marks)</td><td>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></tr>
<tr><td>Level 2
(3-4 marks)</td><td>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></tr>
<tr><td>Level 1
(1-2 marks)</td><td>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></tr>
<tr><td>0 marks</td><td>Insufficient correct chemistry to gain a mark.</td></tr>
</table>

Question	Marking guidance	Additional Comments/Guidelines	Mark
03.1		**Displayed** formula of hex-3-ene (*E* or *Z* isomer) Award 1 mark if correct compounds given in 3.1 and 3.2 but they are not displayed formulas	1 (AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
03.2		**Displayed** formula of 2-methylpent-2-ene or 3,4-dimethylbut-2-ene Allow molecules that are both chain and position isomers, e.g. 2-methylpent-1-ene, 3-methylpent-1-ene, 4-methylpent-1-ene, 3,3-dimethylbut-1-ene, 2,3-dimethylbut-1-ene, 2-ethylbut-1-ene Award 1 mark if correct compounds given in 3.1 and 3.2 but they are not displayed formulas	1 (AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
03.3		**Skeletal** formula Award 1 mark if correct compounds given in 3.3 and 3.4 but they are not skeletal formulas	1 (AO2)

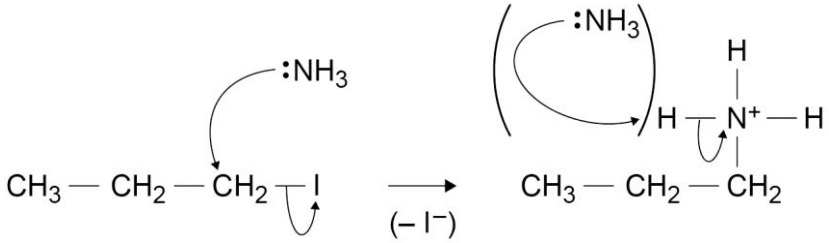
Question	Marking guidance	Additional Comments/Guidelines	Mark
03.4		**Skeletal** formula Alternative answers:  Award 1 mark if correct compounds given in 3.3 and 3.4 but they are not skeletal formulas	1 (AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
03.5	**M1** divide %s by relative atomic masses: C $\frac{17.8}{12.0} = 1.48$ H $\frac{3.0}{1.0} = 3.00$ Br $\frac{79.2}{79.9} = 0.99$ **M2** **(**1.48 : 3.00 : 0.99 = 3 : 6 : 2) empirical formula = $C_3H_6Br_2$ **M3, 4** any 2 of: 1,1-dibromopropane 1,2-dibromopropane 1,3-dibromopropane 2,2-dibromopropane	Allow ECF from **M1** to **M2** for a correct empirical formula for their working in **M1** Allow ECF from **M2** to **M3**/**4** for compounds that are saturated halogenoalkanes	1 1 2 (2 x AO2, 2 x AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
04.1	**M1** amount of TNT = $\frac{1000}{227.0}$ (= 4.41 mol) **M2** amount of gases formed = 10 x **M1** (= 44.1 mol) **M3** $V = \frac{nRT}{P}$ **M4** converting T to 1523 (K) (or 273 + 1250) **M5** $V = \frac{\textbf{M2} \times 8.31 \times 1523}{101000}$ = 5.52 (m^3) range 5.5(1) to 5.53 (m^3)	Final answer should be at least 2sf Correct final answer scores 5 marks Allow ECF from **M1** to **M2**, **M2** to **M5**, **M4** to **M5** and **M3** to **M5** 0.552 (m^3) for using 4.41 mol in **M5** scores 4 marks (loses **M2**) 4.54 (m^3) for using 1250 K scores 4 marks (loses **M4**); 3.54 (m^3) for using (1250 – 273) K scores 4 marks (loses **M4**); 0.18 (m^3) for inverted expression scores 4 marks (loses **M3** or **M5**) **M3** can score from a substituted expression	1 1 1 1 1 (1 x AO1, 4 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
04.2	1200 (cm^3)	200 x $\frac{3n}{2}$ where n = 4 200 x $\frac{12}{2}$	1 (AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
04.3	$\frac{3n+1}{2}$	1.5n + 0.5 allow other correct expressions (e.g. $n + \frac{(n+1)}{2}$)	1 (AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
05.1	**M1** nucleophilic substitution  **M2** attack by NH_3: arrow from lone pair on N of NH_3 towards C of C-I bond **M3** breaking of C-I bond: arrow from C-I bond to I **M4** structure of intermediate **M5** loss of H^+: arrow from N-H bond to N	Penalise **M3** for formal charge on C and / or I of C-I or incorrect partial charges on C-I; ignore other partial charges on uncharged atoms **M4** is independent For **M5** 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 and has been penalised in **M2** (or **M3** for SN1), then do not penalise the same error again in **M5**); penalise removal of H^+ by attack with I^- For SN2: penalise **M2** for any additional arrow or charge on NH_3; penalise **M3** for any additional arrow(s) to / from the I to / from anything else If SN1 mechanism given (loss of I first followed by attack by NH_3): **M2** curly arrow from C-I bond to the I **M3** curly arrow from lone pair on N of NH_3 to positive C atom of correct carbocation penalise **M2** for any additional arrow(s) to / from the I to / from anything else penalise **M3** for any additional arrow or charge on NH_3	1 1 1 1 (5 x AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
05.2	**M1** amount of 1-iodopropane = $\frac{5.0 \times 1.75}{169.9}$ (= 0.0515 mol) **M2** number of molecules = **M1** x 6.022×10^{23} = 3.1(0)-3.13(144) x 10^{22}	Allow ECF from **M1** to **M2** based on an attempt to find the amount of 1-iodopropane in moles using the M_r **M2** Answer must be standard form (and be at least 2sf)	1 1 (2 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
05.3	**M1** amount of propylamine = $\frac{2.3}{59.0}$ (= 0.0390 mol) **AND** amount of 1-iodopropane = $\frac{10.3}{169.9}$ (= 0.0606 mol) **M2** % yield = ($\frac{0.0390}{0.0606} x\ 100$) = 63.9 to 64(.4 %)	Correct answer scores 2 marks Allow ECF from **M1** to **M2** Alternative method **M1** mass of 1-iodopropane = $\frac{10.3 \times 59.0}{169.9}$ (= 3.58 g) **M2** % yield = ($\frac{2.3}{M1} x\ 100$) = 63.9 to 64(.4 %)	1 1 (2 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.1	**M1** $\frac{137.5}{492.6}$ or $\frac{12.0 + 3(35.5) + 19.0}{121.8 + 3(19.0) + 2(79.9) + 12.0 + 4(35.5)}$ or $\frac{137.5}{338.6 + 154.0}$ $\frac{12.0 + 3(35.5) + 19.0}{12.0 + 3(35.5) + 19.0 + 121.8 + 2(19.0) + 2(79.9) + 35.5}$ or $\frac{137.5}{355.1 + 137.5}$ **M2** (x 100) = 27.9 (%)	**M2** must be 3 sig figs Correct answer scores 2 marks Can score 1 mark for 137.5 (or working that gives this) or 492.6 (or working that gives this) in working if no other marks scored	1 1 (2 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.2	**M1** $CHCl_2F + \bullet Cl \rightarrow \bullet CCl_2F + HCl$ **M2** $\bullet CCl_2F + Cl_2 \rightarrow CCl_3F + \bullet Cl$	Allow equations in either order Allow dot anywhere on the correct radical Ignore extra initiation and termination steps Penalise absence of dots once only	1 1 (2 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.3	$2\ \bullet CCl_2F \rightarrow CCl_2FCCl_2F$	Allow dot anywhere on the radical Structural formula of product must be shown in answer (ignore additional correct molecular formula)	1 (AO3)

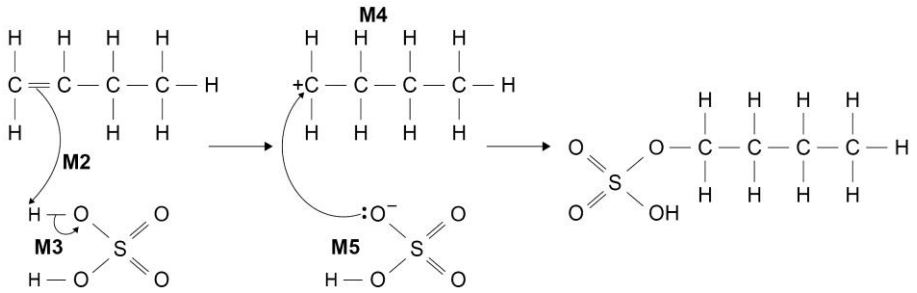
Question	Marking guidance	Additional Comments/Guidelines	Mark
07.1	**M1** $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$ **M2** $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ **M3** $2C_2H_5OH + 6O_2 \rightarrow 4CO_2 + 6H_2O$ **M4** explains with reference to relevant equations that formation of $C_6H_{12}O_6$ takes in $6CO_2$ and fermentation and combustion of ethanol gives out $6CO_2$	**M1/2/3** allow multiples Allow C_2H_6O for ethanol formula **M3** $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ **M4** depends on having appropriate equations in **M1/2/3** showing 6 CO_2 in and out	1 1 1 1 (3 x AO1, 1 x AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.2	transport (from South America to Europe) produces CO_2 / has C emissions / has larger C footprint	Process to separate ethanol from propanone and butan-1-ol produces CO_2 / has C emissions / has larger C footprint	1 (AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.3	**M1** 685.5 (686), 668(.25), 595(.33…) in third column of table **M2** depends on their answer to **M1** – must be the compound giving most energy per mole of CO_2 released (correct **M1** would give ethanol)	**M1** ignore any minus sign on values **M2** need evidence of attempt to calculate energy released per C atom (i.e. per mole of CO_2 formed)	1 1 (2 x AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.4	**M1** amount propanone $= \frac{1.18}{58.0}$ (= 0.0203 mol) **M2** q = **M1** x 1786 (= 36.3 kJ = 36300 J) **M3** $\Delta T \left(= \frac{q}{mc} = \frac{\textbf{M2 (in J)}}{260 \times 4.18}\right)$ = 33.4 (°C) (allow 32.8-33.4) **M4** final temperature = (22.3 + **M3**) = 55.7 (°C) (allow 55-56)	Correct answer scores 4 marks Allow ECF at each stage **M3** ignore sign **M4** must show a temperature rise	1 1 1 1 (4 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.5	**M1** correctly showing how many of which types of bonds are broken and made (broken) 3(C-C) + 9(C-H) + (C-O) + (O-H) + 6(O=O) (made) 8(C=O) + 10(O-H) **M2** (bonds broken) – (bonds made) = –2504 7507 + 3(C-C) – 11070 = –2504 3(C–C) = 1059 **M3** (C–C) = $\frac{\text{M2}}{3}$ = 353 (kJ mol^{-1})	Correct answer scores 3 marks; 265 scores 2 marks if from 4(C-C) bonds 1188 scores 2 marks (not included –2504) 2022 scores 2 marks (using (made – broken)) –353 scores 2 marks ±834 scores 2 marks (use of C-O in CO_2) ±836 scores 1 marks (use of C-O in CO_2 and using (made – broken)) **M1** could show broken as: 3(C-C) + 9(412) + (360) + (463) + 6(496) or 7507 + 3(C-C) and, could show made as 8(805) + 10(463) or 11070 **M2** Allow ECF from **M1** to **M2** Ignore incorrect number of C-C bonds in **M1**/**2**, but should be 3 for **M3** **M3** Allow ECF from **M2** to **M3** (if **M2** is negative value, then ignore sign for **M3**)	1 1 1 (3 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.6	**M1** electrophilic addition  **M2** must show an arrow from the double bond towards the H atom of the H_2SO_4 molecule **M3** must show the breaking of the H-O bond in H_2SO_4 **M4** is for the structure of the correct carbocation **M5** must show an arrow from the lone pair of electrons on the correct oxygen of HSO_4^- towards the positively charged atom of <u>their</u> carbocation drawn	All arrows are double-headed. Penalise one mark from the total for **2-5** if half headed arrows are used Do not penalise the "correct" use of "sticks" Penalise only once in any part of the mechanism for a line and two dots to show a bond For **M2** / **3**, the full structure of H_2SO_4 does not need to be shown, but the key features for the mechanism should be shown and the formula must be correct. Penalise only once in **M2** / **3** an incorrect but genuine attempt at the structure of sulfuric acid **M2** ignore partial negative charges on the double bond **M3** penalise incorrect partial charges on the H–O bond and penalise formal charges Penalise **M4** if there is a bond drawn to the positive charge **Max 3 of 4 marks (M2-5)** for wrong organic reactant or wrong carbocation (ignore structure of product) If attack is shown from C=C to H^+ rather than H_2SO_4, then allow **M2** but not **M3** For **M5**, credit attack on a partially positively charged carbocation structure, but penalise **M4** for the structure of the carbocation For **M5**, the full structure of HSO_4^- is not essential, but attack must come from a lone pair on an individual oxygen on HSO_4^-, but the – sign could by anywhere on the ion (eg $:OSO_3H^-$)	1 1 1 1 1 (1 x AO1, 4 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.7	**M1** formed from/on/via less stable carbocation **M2** (formed from) primary rather than secondary carbocation	**M1** must be clear that it is the stability of the carbocation that matters rather than the stability of the alcohol **M2** allow 1 mark for primary carbocation is less stable than secondary carbocation even if not clear that product is formed from a carbocation (but must be clear that the alcohols are not the carbocations)	1 1 (1 x AO1, 1 x AO3)

Question	Marking Guidance	AO	Mark	Comments
8	C	AO2	1	$C_{16}H_{34} \rightarrow C_8H_{18} + 2C_2H_4 + C_4H_8$
9	D	AO1	1	Kerosene is a mixture of compounds
10	C	AO1	1	It has a higher melting point than ethene
11	A	AO3	1	The monomer is propanenitrile
12	D	AO3	1	pentan-2-ol
13	B	AO2	1	$CH_3CH_2CH_2CH_2OH$
14	B	AO1	1	At a fixed temperature their average kinetic energy is constant
15	D	AO1	1	3-methylbutan-2-ol
16	A	AO2	1	chloromethane with aqueous sodium hydroxide
17	C	AO1	1	propane
18	B	AO2	1	$K_c = \frac{[CH_3OH]}{[CO]\,[H_2]^2}$
19	B	AO2	1	3.8
20	D	AO3	1	Increase the temperature
21	A	AO2	1	butan-1-ol
22	A	AO1	1	base