AS
CHEMISTRY
7404/2

Paper 2 Organic and Physical Chemistry

Mark scheme

June 2024

Version: 1.0 Final

246A7404/2/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

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 (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.

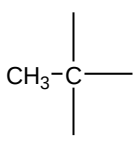
3.12 Organic structures

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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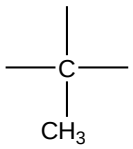

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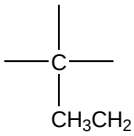

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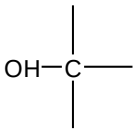

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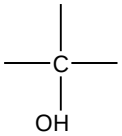

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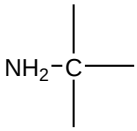

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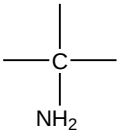

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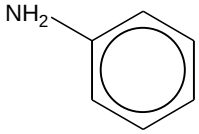

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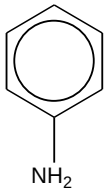

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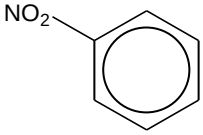

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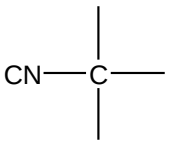

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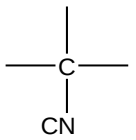

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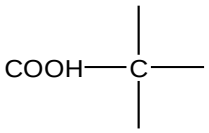

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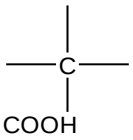

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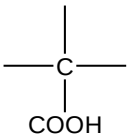

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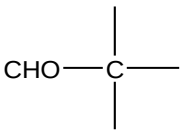

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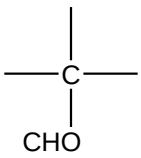

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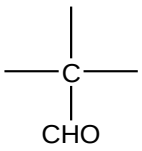

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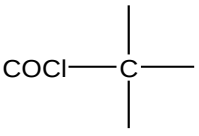

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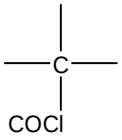

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- Representation of CH_2 by $C–H_2$ will be penalised
- Some examples are given here of **structures** for specific compounds that should **not** gain credit (but, exceptions <u>may</u> be made in the context of balancing equations)

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.

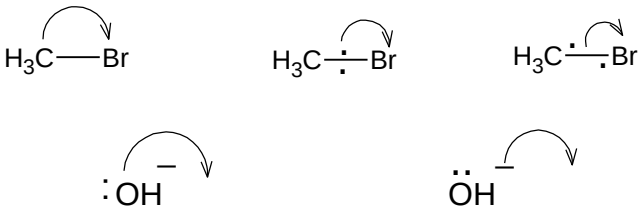
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

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**

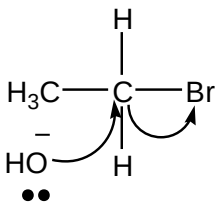
3.14 Organic reaction mechanisms

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.

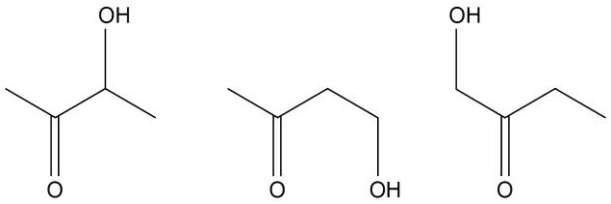
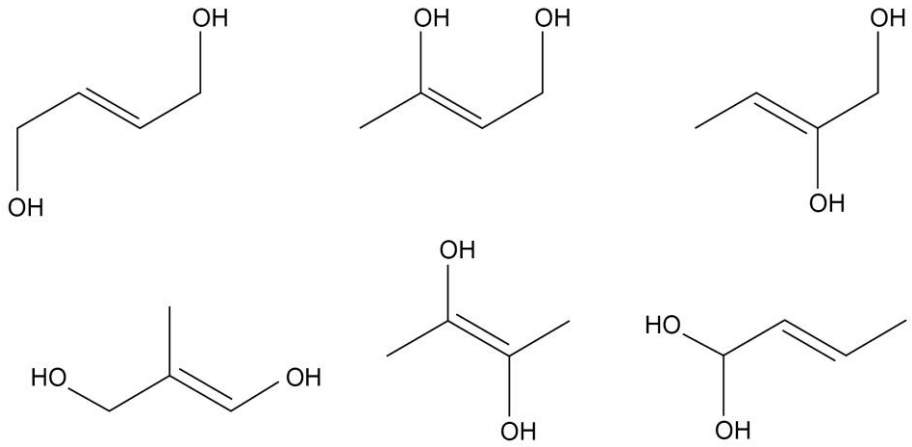
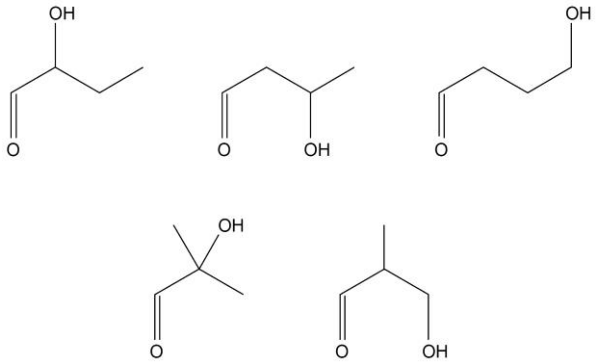
For other extended response answers:

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	Row 1 = no (visible) change/reaction / stays orange/yellow Row 2 = name or formula of a (hydrogen)carbonate (e.g. Na_2CO_3, $NaHCO_3$, $CaCO_3$) OR name or formula of reactive metal (e.g. Mg, Na) Row 3 = no (visible) change/reaction / stays blue	Row 1 – allow stays brown (ignore red) Row 2 – name or formula, but formula must be correct if given (even if correct name also given); allow bicarbonate for hydrogencarbonate; ignore reference to limewater for a (hydrogen)carbonate Do not allow nothing / no observation for Row 1/3	3 (3 x AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
01.2	**M1** mass of H = 0.50 – 0.45 (= 0.05(0)) (g) **M2** C $\frac{0.45}{12(.0)}$ = 0.0375, H = $\frac{0.05}{1(.0)}$ = 0.05 **M3** C_3H_4	Correct answer scores 3 marks allow ECF from **M1** to **M2** allow ECF from **M2** (if an attempt at moles) to **M3** Alternative **M1/2** **M1** 10% H, 90% C **M2** C $\frac{90}{12(.0)}$ = 7.5, H = $\frac{10}{1(.0)}$ = 10	3 (3 x AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
02.1	Compound **A** - structural formula of any compound with formula $C_4H_8O_2$ containing C=O and alcohol O-H group, e.g.  Compound **B** - structural formula of any compound with formula $C_4H_8O_2$ containing C=C and two alcohol O-H groups, e.g.  	Answers may be given by the spectra. Ignore (in)correct name. Compound **A**: • do NOT allow carboxylic acids • allow compounds with aldehyde and alcohol OH groups  Compound **B**: • the C=C must be shown in the structure • allow compounds with one C=C, one alcohol OH and an ether group	2 (2 x AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
02.2	**M1** use fingerprint region **M2** look for (exact) match to known spectrum	**M1** Allow region below 1500 cm^{-1} for fingerprint region **M1** if values are quoted the top number must be 1500 cm^{-1}	2 (2 x AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
02.3	Methane/it absorbs IR (radiation/light) or Methane/it absorbs (radiation/light) around 3000 and/or 1200 (cm^{-1})	Answer must have idea of absorbing / taking in IR (or wavenumbers that correspond to IR) Allow (C-H) bonds absorbing IR radiation (penalise reference to bonds other than C-H) Ignore re-emission of (IR) radiation by methane	1 (1 x AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
03.1	trichlorofluoromethane	No other names	1 (1 x AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
03.2	$CHFCl_2 + {}^{\bullet}Cl \rightarrow {}^{\bullet}CFCl_2 + HCl$ ${}^{\bullet}CFCl_2 + Cl_2 \rightarrow CFCl_3 + {}^{\bullet}Cl$	Equations in either order Allow dot anywhere on each radical species Allow 1 mark for two equations with missing dots that are otherwise correct Ignore any arrows for electron movement	2 (2 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
03.3	$CFCl_3 \rightarrow {}^{\bullet}CFCl_2 + {}^{\bullet}Cl$	Allow dot anywhere on each radical species Ignore any arrows for electron movement	1 (1 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
03.4	$O_3 + {\bullet}Cl \rightarrow {\bullet}OCl + O_2$ ${\bullet}OCl + O_3 \rightarrow 2O_2 + {\bullet}Cl$	Equations in either order Allow dot anywhere on each radical species Allow 1 mark for two equations with missing dots that are otherwise correct (Accept alternative pair of equations for **M2** (both needed for **M2**) $O_3 \longrightarrow O + O_2$ $ClO{\bullet} + O \longrightarrow Cl{\bullet} + O_2$)	2 (2 x AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
03.5	Absorbs/removes ultraviolet/UV radiation that is harmful/causes (skin) cancer/causes (cell) mutations	Answer must refer to removal of UV <u>and</u> idea of it being harmful / the harm it causes Ignore stopping UV / blocking UV / preventing UV / protecting from UV ignore reference to greenhouse effect/gases / absorption of IR / global warming	1 (1 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">04.1</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 - What stereoisomers are (1 'covered' or 'virtually complete')
1a same structure / structural formula
1b different arrangement of atoms/bonds in space

Stage 2 - E-Z isomerism occurs (1 'covered ', 2 'virtually complete')
2a lack of rotation around C=C
2b each C atom of C=C has (two) different groups attached
2c this is E

Stage 3 – Justify E/Z (2 'covered”, 3 'virtually complete')
3a indicates in some way that CH_3CH_2 is higher priority than H on RHS C
3b as atomic number of C is higher than H or C = 6 v H = 1
3c indicates in some way that $(CH_3)_2CH$ is higher priority than CH_3CH_2 on LHS C
3d as atomic numbers of atoms joined to C (joined to C=C) are higher for $(CH_3)_2CH$ than CH_3CH_2 or 6,6,1 v 6,1,1
3e highest priority groups on opposite sides (of C=C)</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.

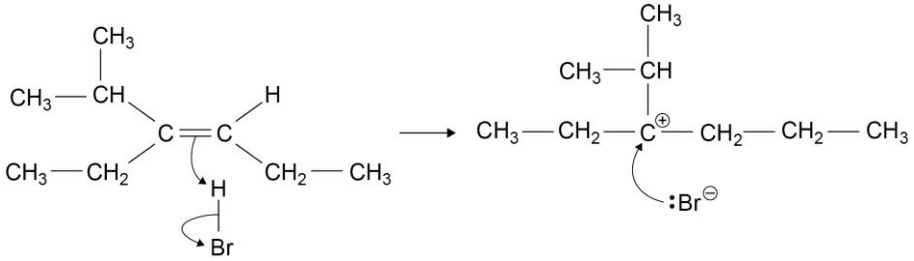
(6 v 5) Answer is well structured, with no repetition or irrelevant points, and covers all aspects of the question. Accurate and clear expression of ideas with no errors in use of technical terms.</td></tr>
<tr><td>Level 2
(3-4 marks)</td><td>All stages are covered but stage(s) may be incomplete or may 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>

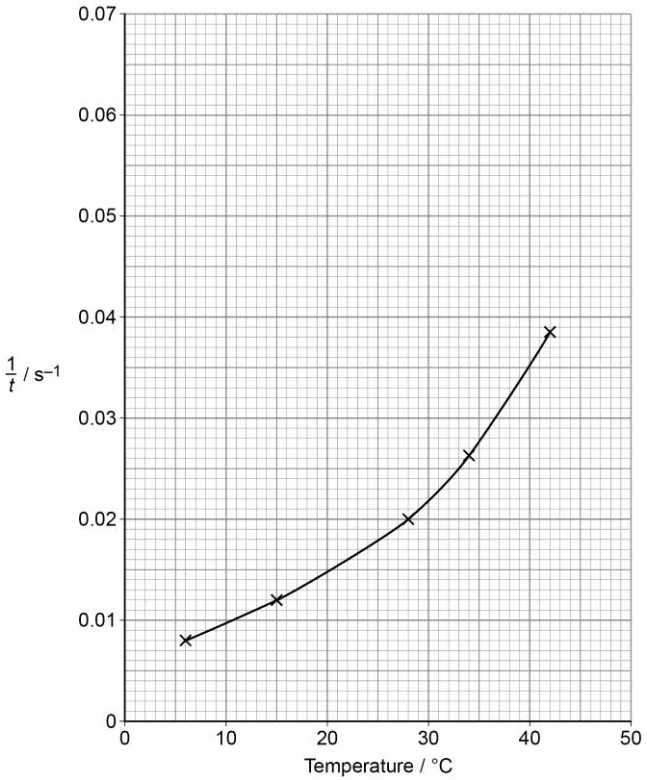
Question	Marking guidance	Additional Comments/Guidelines	Mark
04.2	**M1** electrophilic addition **M2-5**  **M2** arrow from C=C bond towards H of HBr **M3** breaking of H-Br bond **M4** correct carbocation **M5** arrow from lone pair of Br^- to positively charged C of their carbocation	All arrows are 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 **M2** ignore partial negative charges on the double bond **M3** penalise incorrect partial charges on the H–Br 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); for example, correct mechanism for compound **L** would score 3/4 for **M2-5**) For **M5**, credit attack on a partially positively charged carbocation structure, but penalise **M4** for the structure of the carbocation	5 (1 x AO1, 4 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
04.3	**M1** idea that **K** is formed <u>from/via/has/by</u> the <u>more stable carbocation</u> (intermediate) **M2** idea that major product from tertiary carbocation rather than secondary carbocation **M3** idea of stability from <u>greater</u> (positive) inductive effect (from more alkyl/C groups) or <u>more</u> electron-releasing alkyl/C groups	**M1** and **M2** must refer to stability of carbocations (ignore reference to stability of products). **M1** and **M2** are penalised if answer suggests that the products are carbocation. **M2** allow descriptions in terms of number of alkyl groups attached to positive C atom **M3** must be a comparison; could refer to 3 v 2 electron-releasing alkyl/R/C groups (but allow ECF from **M2** for number of alkyl groups)	3 (3 x AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
05.1	**M1** amount of Mg = $\frac{0.400}{24.3}$ = 0.016(5) (mol) **M2** amount of HCl = 1.50 × $\frac{20.0}{1000}$ = 0.03(00) (mol) **M3** justification that HCl is the limiting reagent (e.g. 0.0165 mol of Mg requires 0.0330 mol of HCl or only 0.0150 mol of Mg reacts with 0.030 mol of HCl or mols of HCl is less than double the moles of Mg or mols of Mg is more than half the moles of HCl) **M4** amount of H_2 formed = 0.0150 (or $\frac{\textbf{M2}}{2}$) **M5** converting T to 288, P to 101000 **M6** V = $\frac{\textbf{M4} \times 8.31 \times 288}{101000}$ **M7** V = 3.55×10^{-4} (m^3)	**M7** to at least 2 sf ($3.554376\ldots \times 10^{-4}$) 3.6×10^{-4} to 2sf **M2** penalise 0.015 mol shown as amount of HCl but ignore 0.015 in working out of limiting reagent Allow ECF at each stage, but note: • **M3** should be based on their values for **M1/2** • **M4** should be based on their values of **M1/2** independent of **M3** • Note that answer based on 0.0165 mol Mg as limiting reagent gives $3.79–3.91 \times 10^{-4}$ m^3 which scores **M5,6,7** and possibly **M3,4** If candidates use 1 mol has volume of 24 dm^3 rather than use ideal gas equation - cannot score **M5/6/7**	7 (2 x AO1, 5 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
05.2	**M1** $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$ **M2** 250 (cm^3)	**M1** allow multiples/fractions ECF from **M1** to **M2** (i.e. 50 x mol O_2 in equation)	2 (2 x AO2)

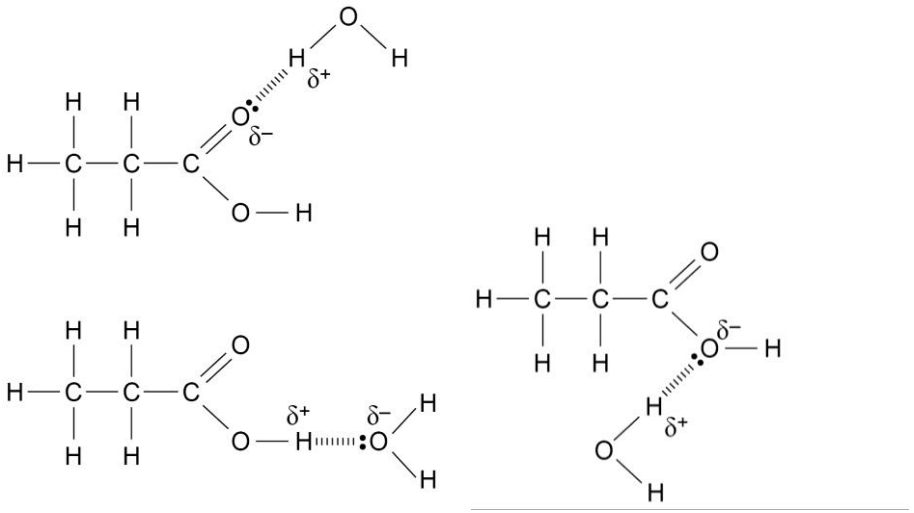
Question	Marking guidance	Additional Comments/Guidelines	Mark
06.1	Silver iodide or AgI	If name and formula given, both must be correct	1 (1 x AO2)

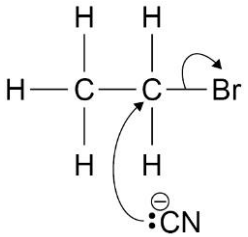
Question	Marking guidance	Additional Comments/Guidelines	Mark
06.2	 **M1** All points plotted (within half a square) **M2** Best fit line - slight curve (for at least 6 to 42°C) **M3** Use $\frac{1}{\text{reading}}$ from <u>extrapolated line</u> (reading within half square)	**M2** best-fit line should be no more than one square away from each point (but allowance made for incorrectly plotted points that mean the line may be further away from some points) **M3** typical answer = $\frac{1}{0.054}$ = 18.5 s	3 (3 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.3	**M1** rate of reaction would be slower **M2** C-Br bond is stronger than C-I bond **M3** line for 1-bromobutane will be below that for 1-iodobutane	Mark **M1** and **M2** independently (no ECF from **M1** to **M2**) **M2** ignore reference to bond polarity / electronegativities / bond length; allow C-Br bond has greater bond enthalpy/energy than C-I bond **M3** ignore references to gradient, shallowness or distance between lines **M3** allow ECF from faster in **M1** to **M3** with the line is above the original	3 (3 x AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.1	from orange to green		1 (1 x AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.2	propanal (allow name or structure)	If name and structure shown, both must be correct Ignore aldehyde	1 (1 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.3	**M1** dashed line from H in water to lone pair on an O in propanoic acid, or dashed line from lone pair on O in water to the H (of OH) in propanoic acid **M2** for the H and O atoms in their H-bond: δ- <u>and</u> lone pair on O on one molecule, δ+ on H (of OH) on the other molecule **M3** linear O ····· H–O 3 examples of correct answers are shown in in the diagram 	Accept a pair of dots/crosses or a shaped orbital (without or without two electrons) for lone pair Ignore any partial charges on other atoms For linear in **M3**, accept a deviation up to 10° If two H-bonds formed between an acid molecule and a water molecule, could score maximum of 1 mark for **M1** or **M2** Lose **M1** if structure of water incorrect or the H-bonding is to another propanoic acid molecule (instead of water)	3 (3 x AO1)

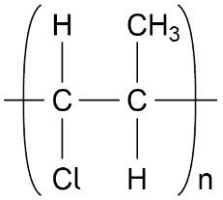
Question	Marking guidance	Additional Comments/Guidelines	Mark
07.4	**M1** Nucleophilic Substitution  **M2** arrow from lone pair on C of CN^- to the C of the CH_2Br group **M3** arrow from the C–Br bond to the Br	All arrows are double-headed. Penalise one mark from the total if half headed arrows are used. Do not penalise the "correct" use of "sticks". Penalise only once in mechanism for a line and two dots to show a bond **M2** allow the minus sign to be anywhere on the CN^- ion **M2** penalise any extra arrows involving CN^- or covalent bond in NaCN **M3** penalise formal charges or incorrect partial charges on C–Br bond **M3** penalise any extra arrows involving Br Ignore wrong organic product (if shown) SN1: allow SN1 mechanism with **M2** for breakage of C–Br bond and **M3** for attack by CN^- on correct carbocation	3 (1 x AO1, 2 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.5	Any one from: • an alcohol / ethanol would be formed • water/it/hydroxide ions would act as the nucleophile/be involved with nucleophilic substitution • bromoethane is insoluble (in water)	Do not allow it/NaCN is insoluble (in water)	1 (1 x AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.6	$K_c = \frac{[CH_3CH_2COOH]}{[C_2H_4][CO][H_2O]}$	• Must be square brackets • Ignore state symbols • Ignore units	1 (1 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.7	**M1** divides moles by volume (1.2 or 1200/1000) **M2** $K_c = \frac{\left(\frac{0.420}{1.2}\right)}{\left(\frac{0.078}{1.2}\right)\left(\frac{0.062}{1.2}\right)\left(\frac{0.062}{1.2}\right)}$ *or* $\frac{(0.350)}{(0.065)(0.052)(0.052)}$ **M3** 2017 (allow 1990 to 2020) **M4** $mol^{-2}\,dm^6$	For **M1-3** • ~~M3 to at least 2sf~~ • Correct answer scores **M1-3** • Allow ECF from **M1** to **M2** for incorrect or no attempt to determine concentration in **M1 (**1401 scores **M2+3** if moles not concentration used) • Allow ECF from **M2** to **M3** • Incorrect K_c expression: allow ECF from **7.6** to **7.7** **M4** units must be consistent with expression used in **7.7** (or **7.6** if calculation not attempted in **7.7**)	4 (4 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.8	**M1** yield will decrease **M2** the equilibrium shifts (left) in the endothermic direction **M3** to oppose the temperature increase/change / to decrease the temperature	Mark each point independently **M2** allow equilibrium shifts left as the forward reaction is exothermic; **M2** allow the equilibrium shifts (left) to the endothermic side **M2** ignore reference to reaction being favoured	3 (3 x AO2)

Question	Marking Guidance	Mark	Comments
8	**A**	1 (AO2)	$\frac{0.15}{0.20} \times 100$
9	**B**	1 (AO1)	96.0
10	**C**	1 (AO1)	The proportion of successful collisions increases because there is a decrease in the activation energy.
11	**D**	1 (AO3)	D
12	**C**	1 (AO3)	3-bromo-3-methylhexane
13	**B**	1 (AO1)	B
14	**B**	1 (AO1)	**Y** + $4Cl_2$ → **Z** + $4HCl$
15	**A**	1 (AO2)	
16	**B**	1 (AO2)	$C_{18}H_{38} \longrightarrow C_8H_{16} + C_4H_{10} + 2C_3H_6$
17	**A**	1 (AO3)	decane
18	**D**	1 (AO)	prop-2-enoic acid
19	**C**	1 (AO2)	–2220

20	**A**	1 (AO2)	+21.2
21	**D**	1 (AO2)	25.2%
22	**A**	1 (AO1)	70.0g