# A-level
# CHEMISTRY
# 7405/2

Paper 2 Organic and Physical Chemistry

**Mark scheme**

June 2022

Version: 1.0 Final

*226A74052/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 (i.e. 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.

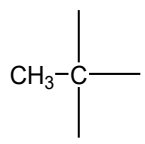
### 3.12 Organic structures

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.

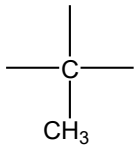
In general

- 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, 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, e.g 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.

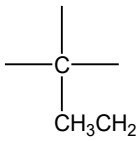
By way of illustration, the following would apply.



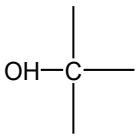
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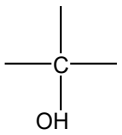
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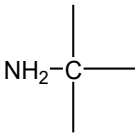
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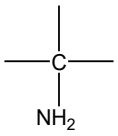
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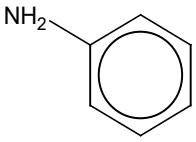
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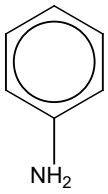
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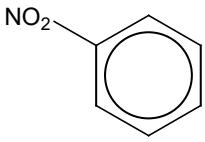
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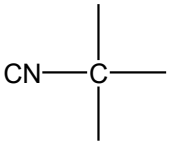
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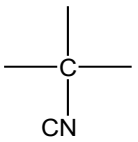
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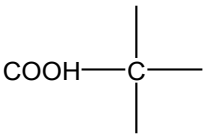
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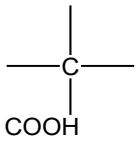
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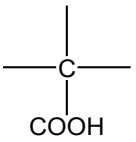
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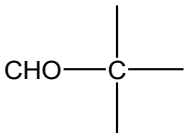
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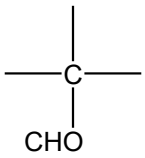
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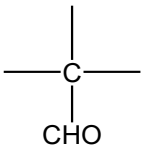
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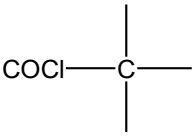
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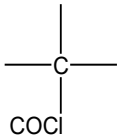
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- Representation of $CH_2$ by $C–H_2$ will be penalised
- Some examples are given here of **structures** for specific compounds that should **not** gain credit (but, exceptions may be made in the context of balancing equations)

| | | |
|---|---|---|
| $CH_3COH$ | 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 (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.

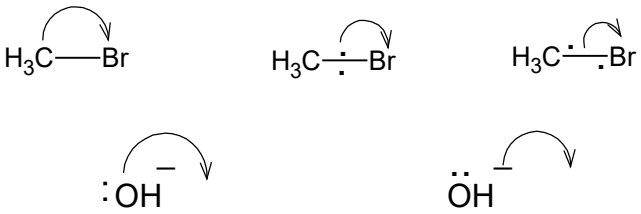
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

| | |
|---|---|
| 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** |

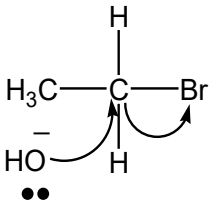
### 3.14 Organic reaction mechanisms

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.

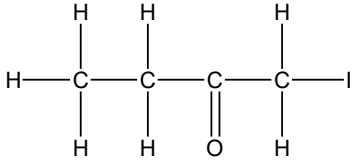
Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other chemically valid points. Students may not have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme. The mark 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 | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 01.1 | <br>1-iodobutan(-2-)one | Apply list principle for more than one structure given<br><br>Allow 1-iodo-2-butanone | M1<br><br>M2<br>(2 x AO1) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 01.2 | $\frac{\text{Rate}}{[CH_3CH_2COCH_3]\,[H^+]} = k$<br><br>$k = 4.(04) \times 10^{-5}$ or 0.00004(04)<br><br>$mol^{-1}\ dm^3\ s^{-1}$ | Rearranged expression Or with numbers<br><br>If upside down = 24752 mol $dm^{-3}$ s<br>If multiply = 5.20 x $10^{-4}$ $mol^3$ $dm^{-9}$ $s^{-1}$ | M1<br><br>M2<br><br>M3<br>(3 x AO1) |

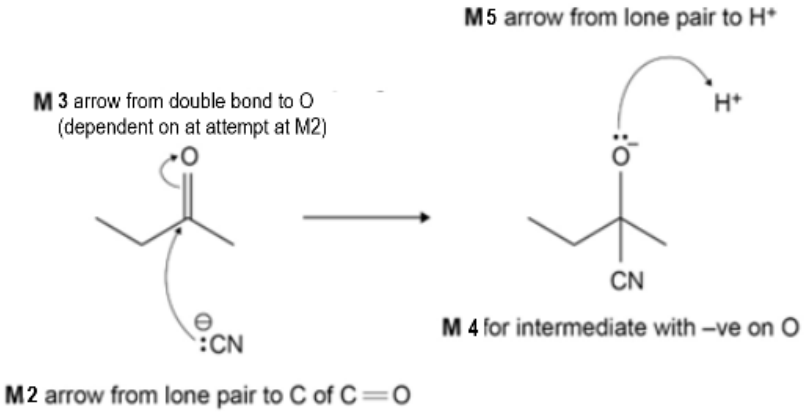
| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 01.3 | $3.6(25) \times 10^{-5}$ (mol $dm^{-3}$ $s^{-1}$) | Allow 3.59 x $10^{-5}$ to 3.63 x $10^{-5}$ | 1<br>(AO1) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 01.4 | Brown colour removed | Goes colourless<br>Allow (orange) brown to colourless<br>Allow purple to colourless | 1<br>(AO3) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 01.5 | As T increases rate (1/t ) increases OR time for completion decreases<br><br>Exponentially<br>OR<br>By a greater/ increasing factor<br><br><u>Many</u> more particles have $E \geq E_a$ | <br><br>Or rate increases more and more as temp increases i.e. description of exponential increase<br><br>NOT just higher collision frequency<br>NOT just more successful collisions | M1<br><br>M2<br><br>M3<br>(2 x AO1, 1 x AO2) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 01.6 | Time = $^{1}/_{0.03}$ = 33 s | | 1<br>(AO2) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 01.7 | ln (1.55 x $10^{-5}$ / 1.70 x $10^{-4}$) = $^{Ea}/_{R}$ ( $^{1}/_{333}$ – $^{1}/_{303}$)<br><br>–2.39 = $^{Ea}/_{R}$ (–2.97 × $10^{-4}$)<br><br>$^{2.39 \times 8.31}/_{2.97 \times 10^{-4}}$ = $E_a$<br><br>66937<br><br>66.9 kJ $mol^{-1}$ | Insertion of correct values<br><br>Evaluate LHS and fraction on RHS<br><br>Re-arrange for $E_a$<br><br>Evaluate<br><br>convert to kJ $mol^{-1}$<br><br>If only $k_1$ and $k_2$ reversed this gives a negative answer for $E_a$ Lose M1 and M5<br><br>If AE in M2 allow ECF<br><br>Allow ECF from M4 to M5 for a correct unit conversion<br><br>Allow range 66.3 – 67.1 | M1<br>M2<br>M3<br><br>M4<br>M5<br>(5 x AO2) |
| | | | |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 01.8 | Nucleophilic Addition<br><br> | ALLOW negative charge anywhere on cyanide<br>But attacking lone pair must be on C<br><br>Do not award M3 without attempt of M2<br><br>Allow M2 for attack to a positive carbon following breaking of C=O<br><br>Penalise covalent KCN in M2<br><br>M3 ignore partial charges unless wrong<br><br>Penalise M3 for incorrect connection between CN and C<br><br>NB Allow fully displayed or other structural formulae | M1<br>M2<br>M3<br>M4<br>M5<br>(1 x AO1, 4 x AO2) |

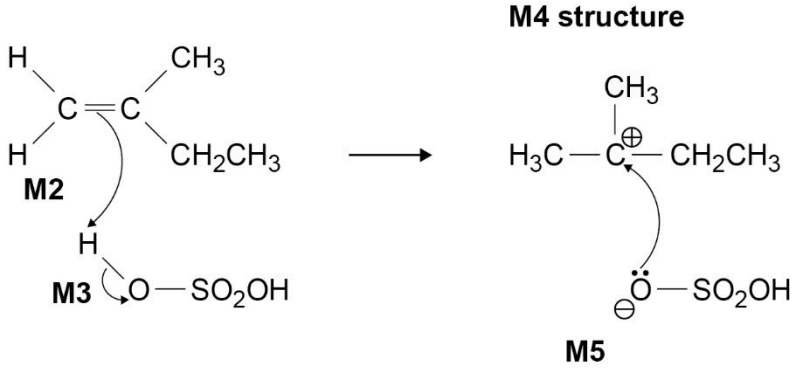
| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 02.1 | $C_2F_4$ = 0.865 mol<br><br>HCl = 1.73 mol | Award 1 mark if HCl = 2 × $C_2F_4$ | M1<br><br>M2<br>(2 x AO2) |

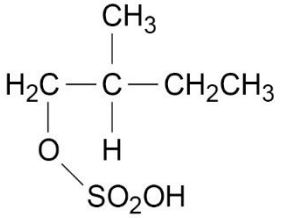
| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 02.2 | $K_c = \frac{[C_2F_4]\,[HCl]^2}{[CHClF_2]^2}$ | Penalise round brackets | 1<br>(AO2) |

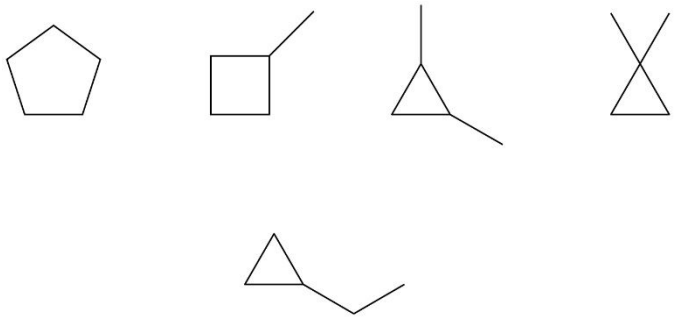
| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 02.3 | $K_c = \frac{[0.865/23.2][1.73/23.2]^2}{[0.27/23.2]^2}$ | Allow ecf for use of their answer(s) to Q2.1 and Q2.2<br>M1 for dividing by volume | M1 |
| | $K_c$ = 1.5(3) must be at least 2sf Allow 1.53-1.54<br><br>Units = mol $dm^{-3}$ | If no use of volume allow M2 for 35.5<br>If upside down can allow all 3 marks as ECF to Q2.2 Leads to an answer of 0.65(3) $mol^{-1}dm^3$ | M2<br><br>M3<br>(3 x AO2) |

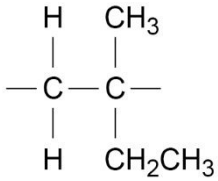
| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 02.4 | Yield would increase<br><br>Equilibrium opposes temperature increase<br><br>Moves in the endothermic direction | <br><br>Shifts /moves to reduce temperature<br><br>Ignore favours | M1<br><br>M2<br><br>M3<br>(3 x AO2) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 02.5 | Causes ozone depletion/decomposition/damage<br><br>Pentane does not have C-Cl bonds | Accept hole in the ozone layer<br><br>Accept does not produce Cl radicals<br><br>Accept does not contain chlorine | M1<br><br>M2<br><br>(2 x AO1) |

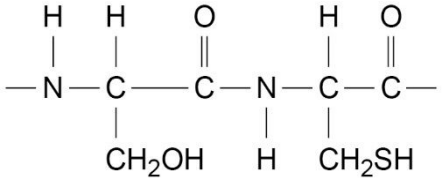
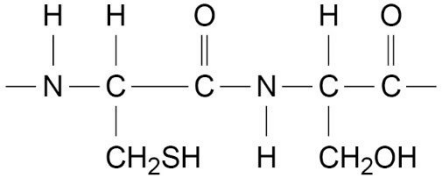
| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 03.1 | Electrophilic addition<br><br><br>**M2**: must show an arrow from = of C=C towards the H atom of the H–O bond or HO that is part of H–O–S–… on a compound with molecular formula $H_2SO_4$<br>**M2** could have arrow to $H^+$ in which case M3 would be for an independent H–O bond break on a compound with formula $H_2SO_4$<br><br>**M3**: must use an arrow to show the breaking of the H–O bond<br><br>**M4**: is for the correct carbocation structure<br><br>**M5**: must show an arrow from a lone pair of electrons on the correct oxygen of the negatively charged ion towards the positively charged carbon atom<br><br>**NB: The arrows are double-headed** | NB Allow fully displayed or other structural formulae<br><br>if $H_2O$ used as electrophile – max 4 ONLY<br><br>M3 ignore partial charges unless wrong<br><br>NOT M4 if primary carbocation shown.<br><br>M5 NOT $HSO_4$<br>credit as shown or as $:OSO_3H$ – in which case negative charge can be shown anywhere<br>ECF from $H_2SO_3$ in M2<br><br>**IGNORE** subsequent use of water to hydrolyse hydrogensulfate | M1<br>M2<br>M3<br>M4<br>M5<br>(1 x AO1, 4 x AO2) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 03.2 |  | If tertiary shown here allow as ECF for M1 if primary shown in 03.1 | M1 |
| | (major) product formed via more stable carbocation OR tertiary carbocation more stable (than primary) | Must be clear refers to intermediate and not product | M2 |
| | Due to electron-releasing character / (positive) inductive effect of three alkyl groups (as opposed to one) | Primary has one $e^-$ donating alkyl group | M3<br>(3 x AO2) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 03.3 | Skeletal formula of cycloalkane | <br>ignore structure of 2-methylbut-1-ene | 1<br>(AO1) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 03.4 | Addition (polymerisation)<br> | Not additional<br>Penalise incorrect attachment of ethyl group<br>Must have trailing bonds<br>Ignore n and brackets<br>Ignore structure of 2-methylbut-1-ene | M1<br>M2<br>(1 x AO1,<br>1 x AO2) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 04.1 | Primary | | 1<br>(AO1) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 04.2 | <br>OR<br> | M1 for correct peptide link (Allow -CONH- as a minimum)<br><br>M2 for the correct amino acid R groups<br><br>Dipeptide can only score M1<br><br>Trailing bonds **not** needed | M1<br><br>M2<br>(2 x AO2) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 04.3 | Water | Allow $H_2O$ | 1<br>(AO1) |

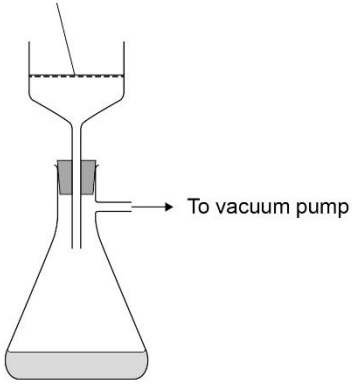
| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 04.4 | Two Cys R groups form a <u>disulfide</u> bridge/link stated or described<br><br>Ser and Asp R groups form <u>Hydrogen bonds</u><br><br>Disulfide bridges are strong<u>er</u> than Hydrogen bonds<br><br>Because disulfide bridges are covalent bonds (while Hydrogen bonds aren't) | Could score via a correct diagram showing minimum -S-S-<br>Allow H bonds<br><br>Interactions between cys R groups are strong<u>er</u><br><br>Because covalent bonds are stronger (than H bonds) | M1<br><br>M2<br><br>M3<br><br>M4<br>(2 x AO1, 2 x AO3) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 04.5 | Ionic (bond) | | 1<br>(AO3) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 05.1 | Wear gloves<br>Conc phosphoric acid is corrosive<br>OR<br>Use a fume cupboard<br>Volatile organic compounds are harmful / toxic<br>OR<br>Keep away from naked flames<br>Organic compounds are flammable<br>OR<br>Periodically release pressure inside separating funnel<br>Prevent build-up of pressure | Allow wash spillages with lots of water<br><br><br>Allow work in a well-ventilated lab space<br><br><br>Other valid suggestions eg heating mantle or electric heater<br>Not water bath | 1<br>1<br><br>(2 x AO3) |

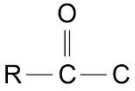
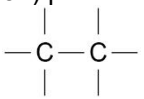
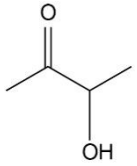
| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 05.2 | To remove (water) soluble impurities | Allow to remove (excess) acid | 1<br>(AO2) |

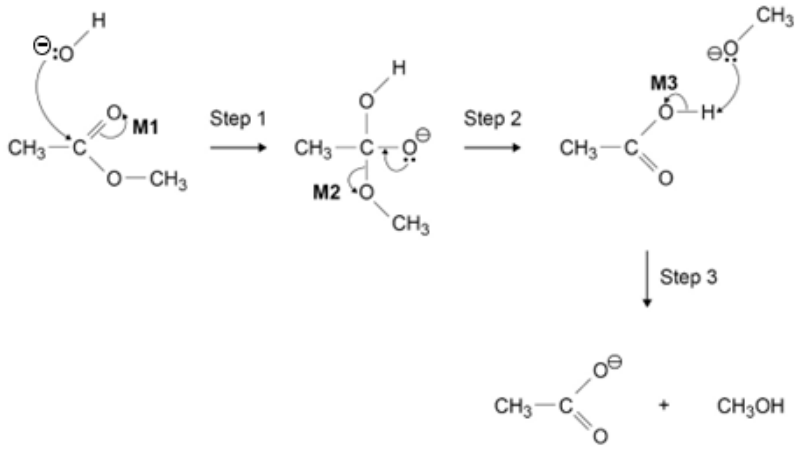
| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 05.3 | To remove water / absorb water / dry the liquid | Allow drying agent | 1<br>(AO2) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 05.4 |  | Deduct a mark(s) for error(s) / omission(s)<br><br>Minimum<br>• Cross sectional (ie funnel top and end shown open)<br>• Bung or collar drawn<br>• (Buchner) Funnel – approximate shape WITH label<br>• Filter paper – WITH label | 2<br><br>(2 x AO2) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 05.5 | Impurity: hexan-1-ol<br>Reason: It is likely to have a similar boiling point | If hexan-3-ol allow ecf for M2 | M1<br>M2<br>(2 x AO2) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 05.6 | Mass hex-1-ene = 11.0 × 0.678 (or = 7.46 g)<br><br>n hex-1-ene = $\frac{7.46}{84.0}$ (or = 0.0888)<br><br>Mass of product = 0.0888 × 0.31 x 102<br><br>Mass product = 2.8 g | Allow consequential marks for M2,M3,M4<br><br>Allow answers 2.8 or 2.9 only | M1<br><br>M2<br><br>M3<br><br>M4<br>(4 x AO2) |

<table>
<tr><th>Question</th><th colspan="2">Answers</th><th>Additional Comments/Guidelines</th><th>Mark</th></tr>
<tr><td rowspan="5">06.1</td><td colspan="2">This question is marked using Levels of Response. Refer to the Mark Scheme Instructions for Examiners for guidance.</td><td rowspan="5">Indicative Chemistry content<br>Stage 1: infrared<br>1a) (broad peak) at 3400 cm$^{-1}$ (any value from 3230-3550) indicates <u>OH in alcohols</u><br>1b) peak at 1720 cm$^{-1}$ (any value from 1680-1750) indicates C=O<br>Stage 2: $^{1}$H nmr<br>2a) peak at 3.9 ppm integration 1 so 1 H-C-O AND quartet so adjacent to $CH_3$ (stated or shown)<br>2b) peak at 3.7 ppm integration 1 so HO-C-(stated or shown)<br>2c) peak at 2.1 ppm integration 3 so H$_3$C-C=O AND singlet so no adjacent H (stated or shown)<br>2d) peak at 1.2 ppm integration 3 so H$_3$C- AND doublet so adjacent to CH (stated or shown)<br>2e) sum of integration values = 8 Hence $C_4H_8O_2$<br>Stage 3: $^{13}$C nmr<br>3a) peak at 210 ppm C=O <u>aldehydes or ketones</u><br>3b) peak at 75 ppm C–O (alcohols, ethers or esters)<br>3c) peak at 25 ppm<br><br>3d) peak at 20 ppm<br><br>3e) structure<br></td><td rowspan="5">6<br><br>(3 x AO1, 3 x AO3)</td></tr>
<tr><td>Level 3<br>5-6 marks</td><td>All stages are covered and each stage is generally correct and virtually complete.<br>Answer is communicated coherently and shows a logical progression from Stage 1 to Stages 2 and 3<br>Covers at least 1 point for stage 1, 3 for stage 2 and 3 for stage 3.</td></tr>
<tr><td>Level 2<br>3-4 marks</td><td>All stages are covered but stage(s) may be incomplete or may contain inaccuracies<br>Covers at least 1 point for stage 1 stage 2 and stage 3.<br>OR<br>two stages are covered and are generally correct and virtually complete.<br>Covers at least 1 point for stage 1, and 3 for stage 2 or stage 3 OR 3 for stage 2 and 3 for stage 3<br>Answer is communicated mainly coherently and shows a logical progression from Stage 1 to Stages 2 and 3.</td></tr>
<tr><td>Level 1<br>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.<br>Answer includes isolated statements but these are not presented in a logical order.</td></tr>
<tr><td>0 mark</td><td>Insufficient correct chemistry to gain a mark</td></tr>
</table>

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 07.1 |  | M1: Arrow from C=O bond to O<br>M2 Arrow from correct C-O bond to O<br>M3 Arrow from O-H bond to O | 3<br>(3 x AO3) |

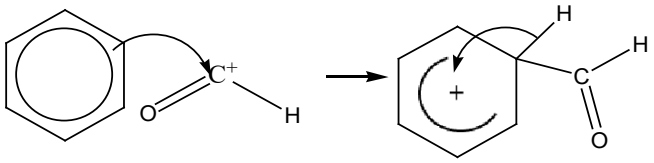
| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 07.2 | (Alkaline/base) hydrolysis | | 1<br>(AO1) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 07.3 | Base | Allow proton acceptor<br>Ignore ref to Bronsted Lowry | 1<br>(AO1) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 07.4 | Soap only | | 1<br>(AO1) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 08.1 | $C_6H_6 + HCOCl \rightarrow C_6H_5CHO + HCl$<br>Or shown as structural formulae<br><br>Benzaldehyde | <br><br>Allow phenyl methanal<br>Allow Benzenealdehyde or Benzene carbaldehyde<br>If ethanoyl chloride used allow ecf for name : phenyl ethanone | 1<br><br>1<br>(2 x AO2) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 08.2 | $AlCl_3$<br><br>$HCOCl + AlCl_3 \rightarrow [HCO]^+ + [AlCl_4]^-$ | Allow Aluminium chloride<br>Allow Iron (III) chloride / bromide or formulae<br>Allow + on C or O in equation<br>Can score M1 in equation | 1<br><br>1<br>(1 x AO1, 1 x AO2) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 08.3 |  | M1 Arrow from inside hexagon to C or + on C<br><br>M2 Structure of intermediate<br>• horseshoe centred on C1 and must not extend beyond C2 and C6, but can be smaller<br>• + in intermediate not too close to C1 (allow on or "below" a line from C2 to C6)<br><br>M3 Arrow from bond into hexagon (Unless Kekule)<br>• Can allow M3 arrow independent of wrong M2 structure<br>• + on H in intermediate loses M2 not M3<br>• Ignore $Cl^-$ and $AlCl_4^-$ used in M3 | M1<br><br>M2<br><br><br><br><br>M3<br>(3 x AO2) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 09.1 | Smaller titre will increase (%) uncertainty / error | | 1 |
| | amount $Br_2 = 0.025 \times {}^{30}/_{1000} = 7.5 \times 10^{-4}$ mol | Or 0.00075 | 1<br>(2 x AO3) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 09.2 | Ratio Y :bromine<br>M1 1 : 5 | Alternative calc using supplied answer | M1 |
| | M2 n Y in 25 $cm^3$ oil = $\frac{7.5 \times 10^{-4}}{5} = 1.5 \times 10^{-4}$<br>If no ratio must state n Y for M2 | n Y in 25 $cm^3$ oil = $\frac{6.25 \times 10^{-4}}{5} = 1.25 \times 10^{-4}$ | M2 |
| | M3 n Y in 250 $cm^3$ = M2 × 10 = $(1.5 \times 10^{-3})$ | n Y in 250 $cm^3 = 1.25 \times 10^{-4} \times 10 = (1.25 \times 10^{-3})$ | M3 |
| | M4 Mass = M3 × 880 = (1.32 g) | Mass = $1.25 \times 10^{-3} \times 880$ = (1.1 g) | M4 |
| | M5 Total mass oil needed = M4 × ${}^{100}/_{85}$ = 1.55 g | Total mass oil needed = $1.1 \times {}^{100}/_{85}$ = 1.29g<br>If wrong ratio used treat as AE and mark ECF | M5<br>(3 x AO2,<br>2 x AO3) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 09.3 | Extra step: Weigh the bottle after oil transfer (and record the mass)<br><br>Justification: Not all of the oil is transferred<br>Or so that the mass of oil left in the bottle is accounted for Or find the exact mass of oil used | OR Rinse the bottle with solvent after transfer and add the washings (to the volumetric flask)<br><br>To ensure all the oil is transferred<br><br>M2 is dependent on M1 | M1<br><br>M2<br>(2 x AO3) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 09.4 | To ensure the solution is homogeneous | Allow evenly mixed/ distributed OWTTE<br>Uniform solution | 1<br>(AO3) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 09.5 | $M_r$ = 345 – 1<br><br>$M_r$ ($C_5H_{10}O$) = 86<br>$^{M1}/_{86}$ = 4 Hence $C_{20}H_{40}O_4$ | Must show workings in both M1 and M2 | M1<br><br>M2<br>(2 x AO2) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 10.1 | Step 1 Conc $HNO_3$<br>Step 1 Conc $H_2SO_4$<br>Step 2 Sn and HCl | <br>If conc missing in both allow 1 for $HNO_3$ and $H_2SO_4$<br>Allow Fe and HCl or Ni and $H_2$ | M1<br>M2<br>M3<br>(3 x AO1) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 10.2 | (nucleophilic) addition-elimination | | 1<br>(AO1) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 10.3 | Chlorine<br>UV (light) | Allow $Cl_2$<br>Allow sunlight / High temp (above 300°c) | M1<br>M2<br>(2 x AO1) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 10.4 | In Step 5 further substitution / gives other amine products<br>In Step 2 only one amine | | 1<br>1<br>(2 x AO3) |

| Question | Answers | Additional Comments/Guidelines | Mark |
|---|---|---|---|
| 10.5 | In B Alkyl group is electron donating or positive inductive effect<br><br>Lone pair <u>on N</u> more available | Or in A lone pair (on N partially) delocalised<br><br>Lone pair <u>on N</u> less available | 1<br><br>1<br>(2 x AO2) |