A-level
CHEMISTRY
7405/2

Paper 2 Organic and Physical Chemistry

Mark scheme

June 2020

Version: 1.0 Final

206A7405/2/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.

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 two
3	1	1	The incorrect response cancels out one of the two correct responses that gained credit.
3	2	0	Two incorrect responses cancel out the two marks gained.
3	3	0	

3.2 Marking procedure for calculations

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

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

3.3 Errors carried forward, consequential marking and arithmetic errors

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

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

3.4 Equations

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

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

3.5 Oxidation states

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

3.6 Interpretation of 'it'

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

3.7 Phonetic spelling

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

3.8 Brackets

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

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

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

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

3.10 Marking crossed out work

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

3.11 Reagents

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

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

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

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

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

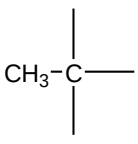
3.12 Organic structures

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

In general

- Displayed formulae must show all of the bonds and all of the atoms in the molecule, but need not show correct bond angles.
- Skeletal formulae must show carbon atoms by an angle or suitable intersection in the skeleton chain. Functional groups must be shown and it is essential that all atoms other than C atoms are shown in these (except H atoms in the functional groups of aldehydes, secondary amines and N-substituted amides which do not need to be shown).
- Structures must not be ambiguous, 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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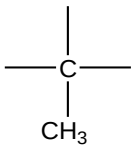

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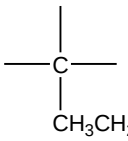

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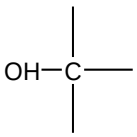

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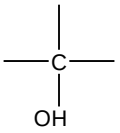

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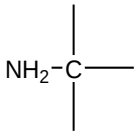

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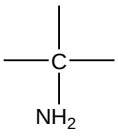

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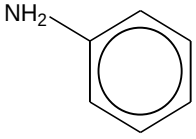

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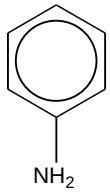

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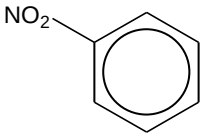

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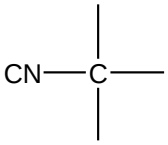

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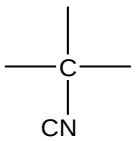

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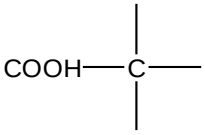

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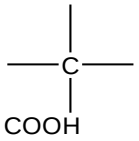

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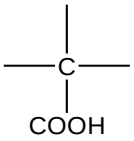

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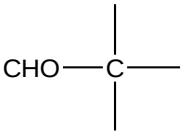

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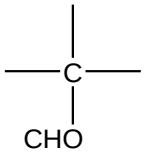

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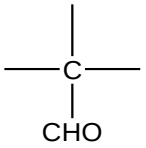

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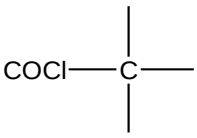

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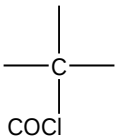

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- Representation of CH_2 by $C–H_2$ will be penalised
- Some examples are given here of **structures** for specific compounds that should **not** gain credit (but, exceptions may be made in the context of balancing equations).

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

- Each of the following **should gain credit** as alternatives to correct representations of the structures.

$CH_2 = CH_2$	for	ethene, $H_2C=CH_2$
$CH_3CHOHCH_3$	for	propan-2-ol, $CH_3CH(OH)CH_3$

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

3.13 Organic names

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

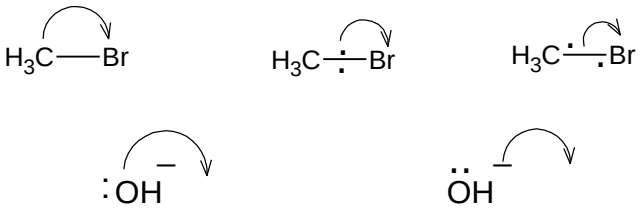
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

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

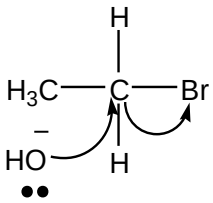
3.14 Organic reaction mechanisms

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

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



For example, the following would score zero marks



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

In free-radical substitution

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

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

3.15 Extended responses

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

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

Determining a level

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

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

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

- if the answer completely matches the communication descriptor, award the higher mark within the level
- if the answer does not completely match the communication descriptor, award the lower mark within the level.

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

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

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

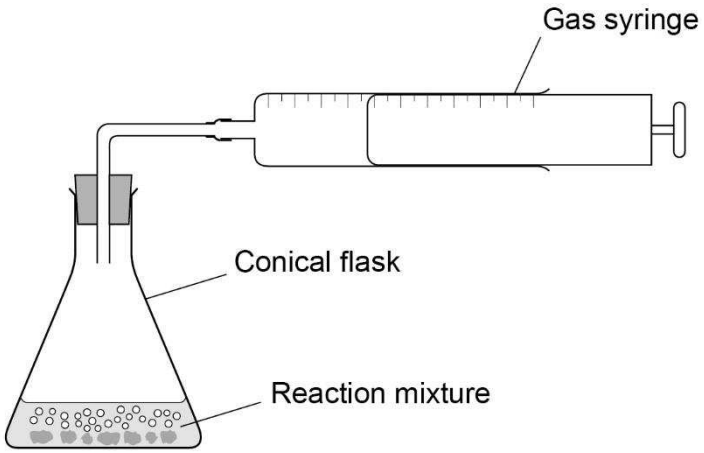
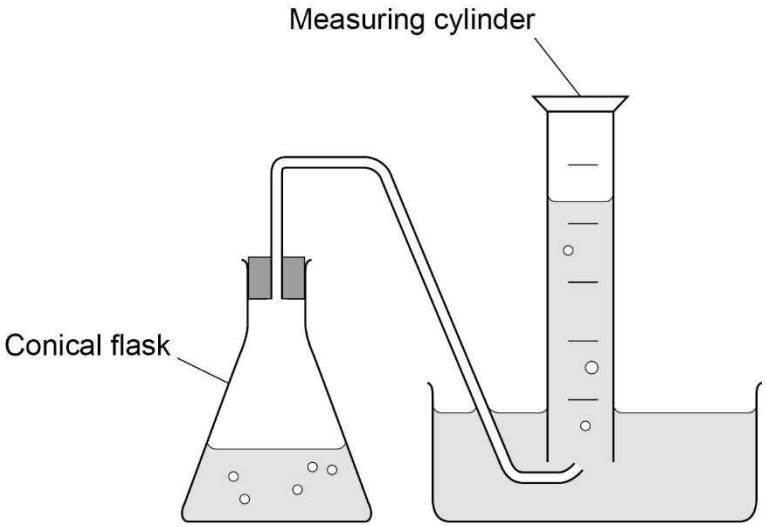
An answer which contains nothing of relevance to the question must be awarded no marks.

For other extended response answers:

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

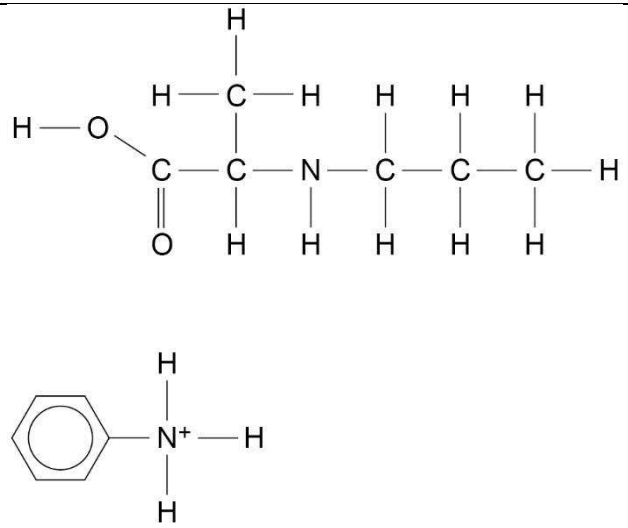
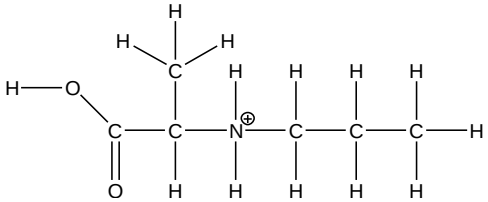
The mark schemes for some questions state that the maximum mark available for an extended response answer is limited if the answer is not coherent, relevant, substantiated and logically structured. During the standardisation process, the Lead Examiner will provide marked exemplar material to demonstrate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

Question	Answers	Additional comments/Guidelines	Mark
01.1	**M1** tangent drawn to the curve at 0,0	If tangent not drawn at 0,0 then allow conseq gradient calculation	1 1
	M2 Evidence of value used in calculation leading to initial rate = 5.5	Note allow 5 – 7	1
	M3 $cm^3\ s^{-1}$	NOT cm^3 / s	
01.2	**M1** $[H_2PO_2^-]^2 \propto 1/t$	Accept time argument eg if conc doubled time is quartered Accept suitable words that implies a square or square root relationship	1
	M2 Order = 2	Not simple description of as conc increases time decreases	1

01.3	 Either gas syringe or measuring cylinder over water	 Tubing shown should not be closed Syringe should have a plunger shown Allow lack of graduations	1

01.4	Falls by a factor of 8 OR Multiplied by $^{1}/_{8}$ OR Divided by 8	Allow halved then quartered / Decreases by 2^3	1

01.5	**M1** $[M]^2 = \frac{\text{Rate}}{k\,[L]}$ **M2** $[M]^2 = \frac{0.0250}{21.3 \times 0.0155}$ $(=7.57 \times 10^{-2})$ **M3** $[M] = \sqrt{7.57 \times 10^{-2}} = 0.275$ mol dm^{-3} (min 2 sf)	Re-arrangement Inserts correct numbers into their rearranged expression Takes square root (allow ecf for square root of their M2) Common error is to use 0.25 rather than 0.025. This leads to an answer of 0.870. Scores 2 Upside-down expression leads to an answer of 3.63. Scores 2	1 1 1
01.6	The sum of powers/indices (to which the concentrations are raised in the rate equation)	All the orders added/ sum of the (individual) orders This can be explained using a general rate equation stated as an example e.g. Rate = $k[A]^x[B]^y$ and the overall order is x + y	1

Question	Answers	Additional comments/Guidelines	Mark
02.1	One circled C atom only – The C attached to CH_3/C=O/ H and NH		1
02.2	Two ticks only for amine and amide		1
02.3		**M1** for choosing the correct bond to hydrolyse **M2** and **M3** for the correct structures of the products Allow protonated amino acid for M2  Allow $C_6H_5NH_3^+$ or + outside a square bracket	3

02.4	**M1** Enzyme has an <u>active site</u> **M2** The G-Enantiomer / Enzyme has the correct stereo chemistry / stereospecific Or The G-Enantiomer / Enzyme has the complementary shape	For M2 allow opposite argument for F-Enantiomer	1 1

Question	Answers	Additional comments/Guidelines	Mark
03.1	**M1** Q, R, S, T **M2** (Orange solution) turns green	M1 Allow the mark for candidates who correctly name or draw the isomers. Independent	1 1
03.2	**M1** T **M2** Silver mirror	As above Allow grey/black ppt	1 1
03.3	**M1** P, Q, R, S **M2** Sweet smelling (liquid) **M3** To react with (remove excess) acid / neutralise	As above Allow easier to identify the smell	1 1 1
03.4	Position	Allow positional	1

03.5	**M1** R & S have an O-H alcohols peak at 3230-3550 cm^{-1} **M2** T has C=O peak at 1680-1750 cm^{-1} **M3** R & S (unique) fingerprint region or below 1500 cm^{-1} **M4** Compare to a database / known spectra (and look for an exact match)	Allow value within the range	1 1 1 1
03.6	All have the same M_r	Allow same (molecular) ion M/Z peak same molecular formula	1

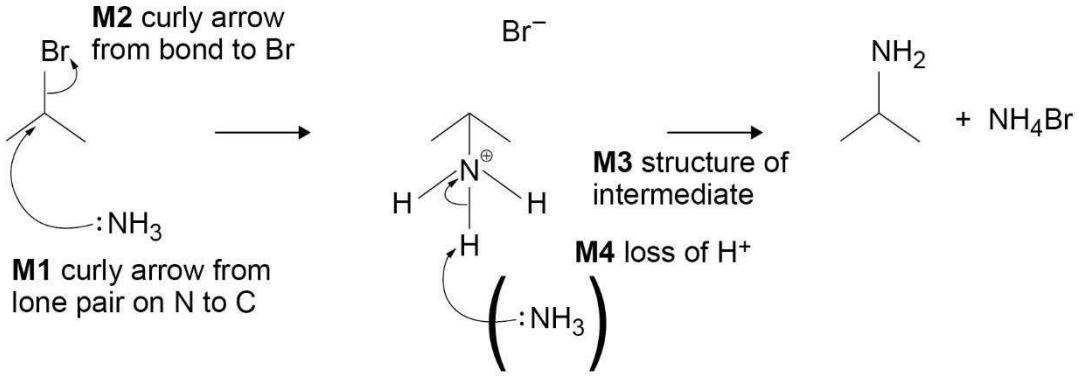
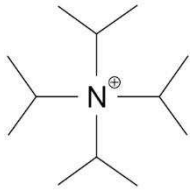
Question	Answers	Additional comments/Guidelines	Mark
04.1	**M1** (Re)weigh the empty boat **M2** In order to calculate the (exact) mass of salicylic acid added to the reaction mixture		1 1
04.2	10 cm^3 measuring cylinder (if volume given – allow between 10 to 50 cm^3) Or a 10 cm^3 pipette Or burette / graduated pipette Or 10 cm^3 syringe		1
04.3	Corrosive	Allow skin burn / permanent eye damage Ignore irritant / toxic	1
04.4	LHS + $(CH_3CO)_2O$ RHS + CH_3COOH		1
04.5	**M1** Amount salicylic acid = $^{6.01}/_{138}$ = 4.36×10^{-2} mol **M2** Mass $(CH_3CO)_2O$ = 10.5 × 1.08 = 11.34 g **M3** Amount $(CH_3CO)_2O$ = $^{11.34}/_{102}$ = 1.11×10^{-1} mol **M4** $(CH_3CO)_2O$ is in excess **M5** Mass aspirin = M1 × 0.841 × 180 = 6.59 g	Allow conseq from wrong mole ratio in 04.4 Must show and state that ethanoic anhydride is in excess For M4/M5 ecf from M1/M3 Allow 2 sf or more.	1 1 1 1 1 1

04.6	**M1** Value lower		1
	M2 Range of values	For M2 allow mpt not sharp or a larger range of melting points	1

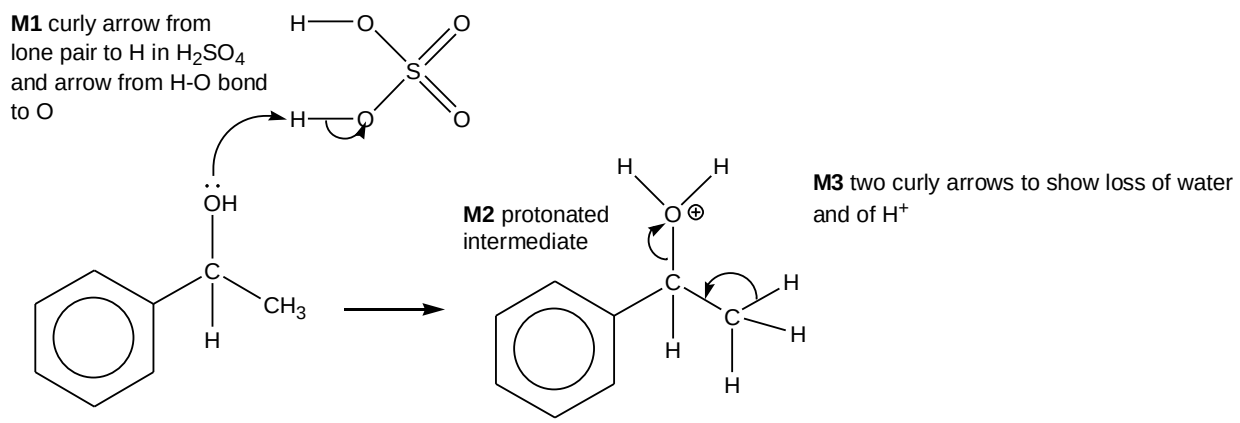
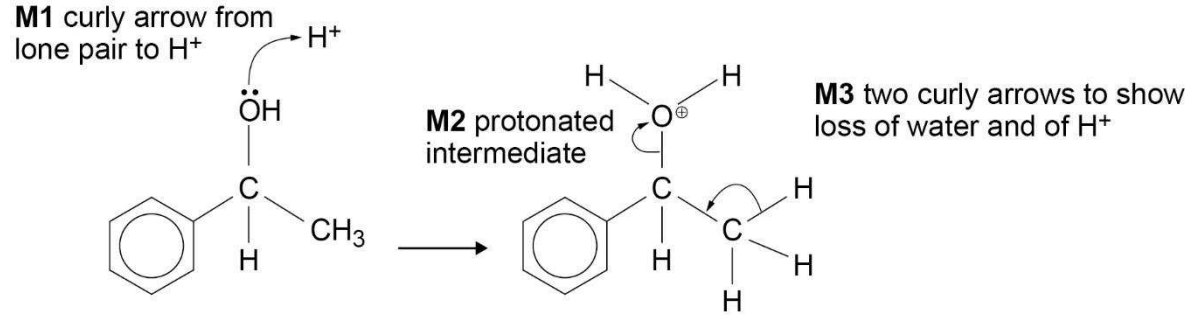
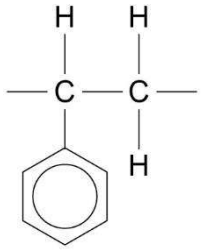
04.7	**M1** (Ethanol is flammable so) use a water bath to heat / do not use a Bunsen burner	Must give practical step, not just state hazard	1
	M2 Heat to temp below bp (so ethanol does not boil away)	Allow use min vol solvent	1

04.8	To remove any soluble impurities	Allow To avoid aspirin dissolving (small amount cold solvent used) Allow To remove/(wash away) any ethanolic solution on the product.	1

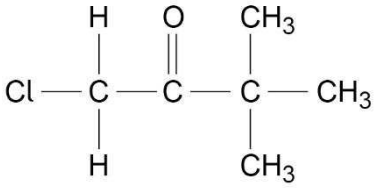
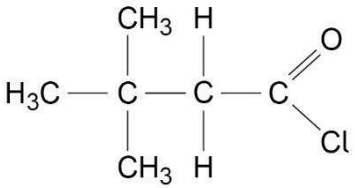
04.9	Pure product will have (larger) crystals / needle-like crystals / lighter in colour	Allow whiter, less grey, more crystalline, less powdery, shinier, single colour Must be tied to pure product Allow opposite points tied to the crude product	1

Question	Answers	Additional comments/Guidelines	Mark
05.1	**M1** The (relative) tendency of an atom to attract a pair of electrons/ the electrons/ electron density in a covalent bond **M2** Br is more electronegative than C (or vice versa) **M3** So Br is δ- and C is δ+		1 1 1
05.2		**M4** Penalise loss of H^+ using Br^- Allow S_n1	4
05.3	 **M1** **M2** Use: (Hair) conditioner / (Cationic) surfactant / disinfectant	Allow + outside square brackets Allow fabric softener	1 1

Question	Answers	Additional comments/Guidelines	Mark
06.1	**M1** Acylation **M2** CH_3COCl OR Ethanoyl chloride **M3** $AlCl_3$ OR Aluminium chloride (mark could be awarded in space for M2)	Allow electrophilic substitution Allow ethanoic anhydride for M2 M3 dependent on M2 Allow Dry/anhydrous for M3 Apply list principle to extra incorrect conditions	1 1 1
06.2	**M1** Nucleophilic addition **M2** $NaBH_4$ **M3** 1-phenyl ethan(-1-)ol	Allow $LiAlH_4$ for M2 If H_2/Ni stated allow M2 and M3 but to score a matching M1 it would have to be Catalytic addition	1 1 1

06.3	 	Penalise **M1** for mistakes on structure of H_2SO_4 Allow H^+ attacked in **M1** Allow **M3** as two steps Allow displayed formulae	3
06.4		Must show trailing bonds Ignore brackets and any use of n Allow C_6H_5 for phenyl group	1

<table>
<tr><th>Question</th><th colspan="2">Answers</th><th>Additional Comments/Guidelines</th><th>Mark</th></tr>
<tr><td rowspan="5">07.1</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
Stage 1:
1a $CDCl_3$ or CCl_4 solvent
1b TMS as reference / calibration / standard / peak at 0 (ppm)
1c Inert (so unlikely to react with the sample allow if inert tied to either TMS or $CDCl_3$ or CCl_4)
Stage 2 CCl_4 or $CDCl_3$ as solvent:
2a (Both) have no H (atoms so give no signals in spectrum) tied to either $CDCl_3$ or CCl_4
2b CCl_4 non polar (- good solvent for non-polar organic molecules)
2c $CDCl_3$ polar covalent molecule (– good solvent for polar organic compounds)
Stage 3 TMS as reference:
3a (Lots (12) of equivalent H to) give one signal / single environment
3b Signal in an area away from other typical H signals / peak upfield from others
OR
(Low electronegativity of Si shifts) signal right
3c Easy to remove / volatile / low bp</td><td rowspan="5">6</td></tr>
<tr><td>Level 3
5-6 marks</td><td>All stages are covered and each stage is generally correct and virtually complete.
Answer is communicated coherently and shows a logical progression from Stage 1 to Stages 2 and 3.</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.
Answer is communicated mainly coherently and shows a logical progression from Stage 1 to Stages 2 and 3.</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.
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>

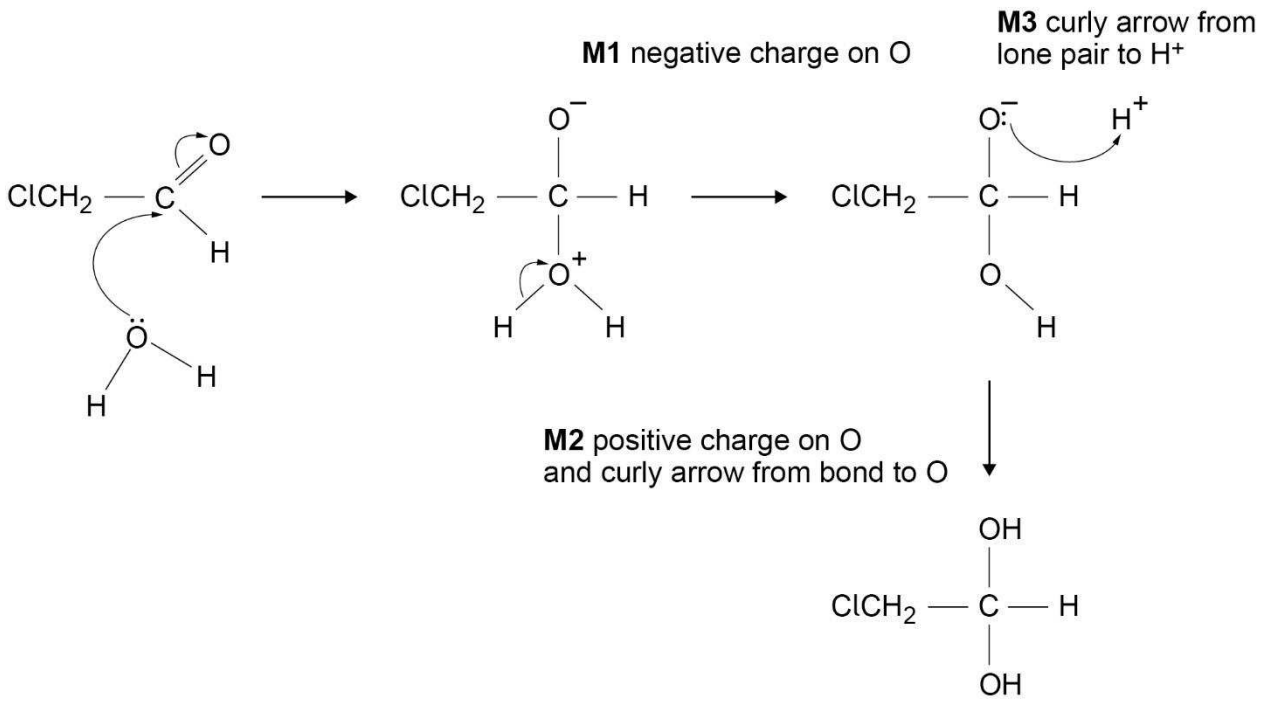
07.2	**M1** x – doublet **M2** y – quartet **M3** z – doublet	Allow similar words eg double, quadruplet Allow numbers Allow diagrams with correct numbers of lines	1 1 1
07.3	H attached to both C-Cl and adjacent to C=O so doesn't fit with data in table B		1
07.4	**M1**  **M2** 	Allow abbreviated structural formulae	1 1

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th></tr>
<tr>
<td>08.1</td>
<td>
M1 Amount CO_2 = $^{1.89}/_{44}$ = 0.043 = mol C
M2 Amount H_2O = $^{0.643}/_{18}$ = 0.0357 mol
M3 Amount H = 0.036 x 2 = 0.0714 mol
M4 Amount O = $^{0.913}/_{16}$ = 0.057 mol
<table>
<tr><td></td><td>C</td><td>H</td><td>O</td></tr>
<tr><td></td><td>0.043</td><td>0.0714</td><td>0.057</td></tr>
<tr><td rowspan="2">M5</td><td>1</td><td>1.66</td><td>1.33</td></tr>
<tr><td>3</td><td>5</td><td>4</td></tr>
</table>
</td>
<td>
Alternate method
M1 mass C = 1.89 – (1.89 x $\frac{32}{44}$) = 0.515 g
M2 mass H = 1.5 – (0.515 + 0.913)
M3 = 0.0715 g
OR mass M2 H = 0.643 – (0.643 x $\frac{16}{18}$)
M3 = 0.0714 g
<table>
<tr><td></td><td>C</td><td>H</td><td>O</td></tr>
<tr><td>M4</td><td>$\frac{0.515}{12}$ = 0.043</td><td>$\frac{0.0715}{1}$ = 0.0715</td><td>$\frac{0.913}{16}$ = 0.057</td></tr>
<tr><td rowspan="2">M5</td><td>1</td><td>1.66</td><td>1.33</td></tr>
<tr><td>3</td><td>5</td><td>4</td></tr>
</table>
</td>
<td>1
1
1
1
1</td>
</tr>
</table>

08.2	**M1** Amount $H_2O = {}^{0.26}/_{18} = 0.014$ mol **M2** Amount $H_3Y.xH_2O = {}^{3}/_{210} = 0.014$ mol or Amount of $H_3Y = 2.74/192 = 0.014$ mol (hence ratio 1:1)	Common alternate method **M1** Amount $H_3Y.xH_2O = {}^{3}/_{210} = 0.0143$ mol **M2** $M_r\ H_3Y = \frac{2.74}{0.0143} = 192$ $M_r\ xH_2O = 210 - 192 = 18$ (hence $x = 1$)	1 1
08.3	2(-) Hydroxy		1
08.4	Number of peaks = 4	Allow Four	1

Question	Answers	Additional comments/Guidelines	Mark
09.1	**M1** EQM amount A = 0.25 – 0.015 = 0.235 mol **M2** EQM amount B = 0.25 – (2 x 0.015) = 0.22 mol	Allow 0.24 mol for M1	1 1
09.2	**M1** $K_c = \frac{[C]}{[A][B]^2}$		1
	M2 $\frac{\frac{0.02}{0.35}}{\frac{0.30}{0.35} \times \left(\frac{0.25}{0.35}\right)^2}$	Correct insertion of numbers and use of volume Allow ecf from their K_c Scores M1 here (even if volume not used)	1
	M3 = 0.13 **M4** Units $mol^{-2}\ dm^6$	Kc = 1.067 if vol not used Max 3 Kc = 7.63 if expression upside down Max 3 Allow answers using cm^3 and then the corresponding units i.e. $1.31 \times 10^5\ mol^{-2}\ cm^6$ Allow conseq units to wrong K_c	1 1
09.3	$[H_2O]$ / conc of water is (effectively) constant (because it it so much larger than the other concentrations)		1

09.4	**M1** Initial amount $ClCH_2CHO = {}^{4.71}/_{78.5} = 0.06$ mol **M2** EQM amount $ClCH_2CHO = (0.06 - x)$ mol EQM amount $ClCH_2CH(OH)_2 = x$ mol	Calculates initial mol Sets up algebraic expressions for EQM mol of both If no M2 can only score M3 and M5 conseq leads to 44.4 mol dm^{-3} via $[ClCH_2CHO] = \frac{0.06}{0.05}$	1 1
	M3 $37 = \frac{\frac{x}{V}}{\frac{(0.06-x)}{V}}$	Inserts into K Does not need to show V as it cancels but allow expressions that do show V and subsequent calculations	1
	M4 $37(0.06 - x) = x$ $2.22 = 38x$ $x = 0.058421$ **M5** $[ClCH_2CH(OH)_2] = \frac{0.058421}{0.05} = 1.17$ mol dm^{-3}	Solve for x Calculate concentration	1 1

09.5	 M1 negative charge on O M3 curly arrow from lone pair to H+ M2 positive charge on O and curly arrow from bond to O	3

09.6	**M1** C in C=O is less δ+ / less electron deficient **M2** Because CH_3 attached is electron donating Or CH_3 has a (positive) inductive effect **M3** So higher E_a	Allow converse Ignore discussion in terms of C-Cl bond polarity Allow for **M3** water less attracted to δ+C / electron deficient C / C in C=O (so lower collision frequency/ fewer collisions with correct orientation)	1 1 1