A-level
CHEMISTRY
7405/2

Paper 2 Organic and Physical Chemistry

Mark scheme

June 2023

Version: 1.0 Final

236A74052/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 (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.

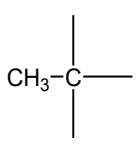
3.12 Organic structures

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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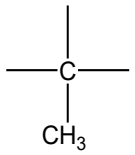

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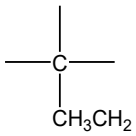

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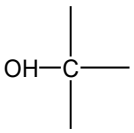

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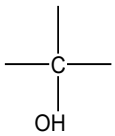

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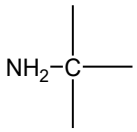

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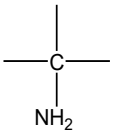

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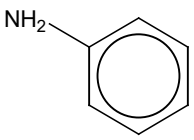

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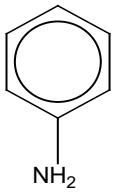

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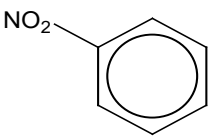

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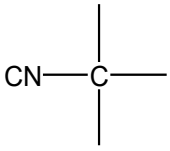

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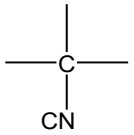

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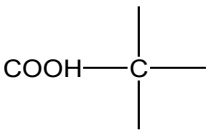

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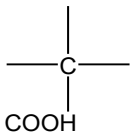

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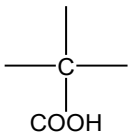

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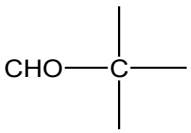

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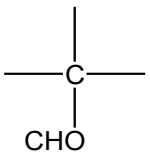

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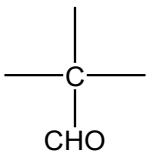

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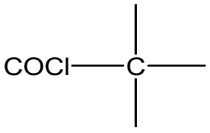

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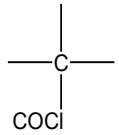

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- Representation of CH_2 by $C–H_2$ will be penalised
- Some examples are given here of **structures** for specific compounds that should **not** gain credit (but, exceptions may be made in the context of balancing equations)

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.

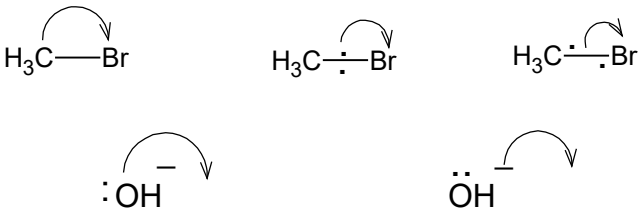
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

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**

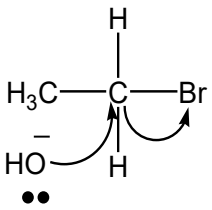
3.14 Organic reaction mechanisms

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.

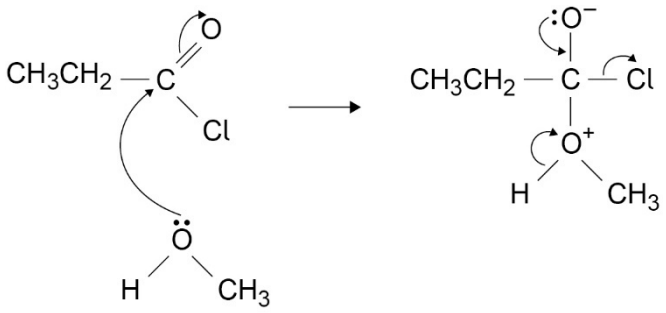
Question	Answers	Additional Comments/Guidelines	Mark
01.1	Reduces loss of liquid droplets	Allow description of reduction of loss of liquid	1 (AO3)

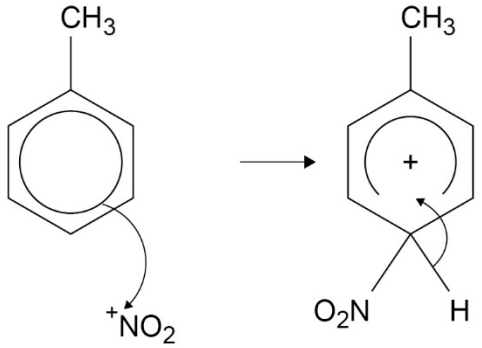
Question	Answers	Additional Comments/Guidelines	Mark
01.2	M1 Tangent drawn at 2 mins M2 Gradient of tangent = (0.50 +/– 0.05) M3 g min^{-1}	Conseq to their M1 If convert mins to sec M2 = 7.80 x 10^{-3} (7.0 x 10^{-3} to 8.6 x 10^{-3}) and award M3 conseq If M1 not awarded then allow average rate calculated M2 = 1.05 If M1 not awarded then allow average rate and if 120 sec used for time allow M2 =0.0175 and can score M3 for g s^{-1} Penalise g/min	3 (3 x AO2)

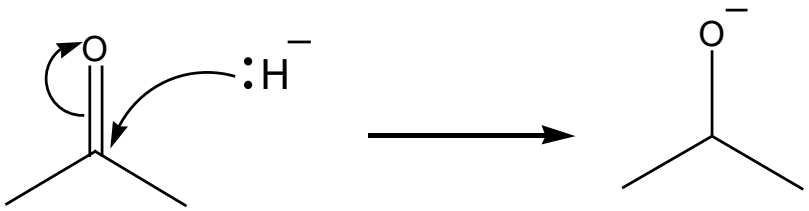
Question	Answers	Additional Comments/Guidelines	Mark
01.3	M1 Curve steeper at first & flattens at same point on y axis M2 Cl is an electron withdrawing group or negative inductive effect M3 Weakens the O-H bond / increase polarity of O-H bond	Allow opposite argument M2 CH_3 electron donating or positive inductive effect M3 Makes O-H bond stronger / decrease polarity of O-H bond Also allow answers that discuss the carboxylate ion M2 Cl Electron withdrawing group M3 makes $RCOO^-$ less negative / delocalises the negative charge more / more stable ion (so $RCOO^-$ less likely to accept H^+)	3 (3 x AO3)

Question	Answers	Additional Comments/Guidelines	Mark
02.1	M1 Relative rate = 1.00 M2 [B] = 0.16 M3 Relative rate = 1.35		3 (3 x AO2)

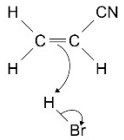
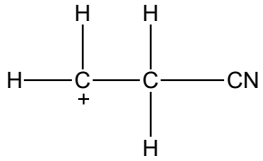
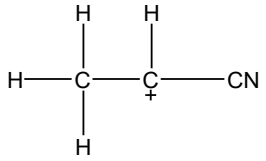
Question	Answers	Additional Comments/Guidelines	Mark
02.2	M1 Step 2 M2 (By the end of step 2) 1 × H^+ and 2 × B have been used	Allow slowest step	2 (2 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
03.1		M1 Structures of reactant species M2 Arrow from lp on O to C M3 Arrow from C=O bond to O M4 3 curly arrows and lp on intermediate Allow full marks for candidates who draw a second intermediate formed after formation of C=O and loss of Cl^- then loss of H^+ Ignore any attempt to show the final products	4 (4 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
03.2	 M4 Electrophilic substitution	M1 Structures of reactant species including + on N of $^+NO_2$ M2 Arrow from ring (inside hexagon) to N or + on N M3 Arrow from C-H bond into hexagon Apply list principle	4 (4 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
03.3	 M4 Nucleophilic addition	M1 Arrow from lp on hydride to C M2 Arrow from C=O to O M3 Intermediate structure / Allow displayed or abbreviated structures Ignore any attempt to show further steps if correct Penalise further incorrect steps Apply list principle	4 (4 x AO1)

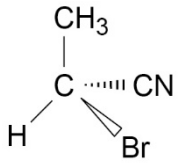
Question	Answers	Additional Comments/Guidelines	Mark
04.1	3-bromopropanenitrile	Allow 3-bromopropane-1-nitrile	1 (AO1)

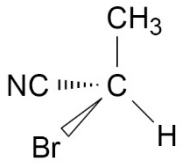
Question	Answers		Additional Comments/Guidelines	Mark
04.2	This question is marked using Levels of Response. Refer to the Mark Scheme Instructions for Examiners for guidance.		**Indicative Chemistry content** **Stage 1 Types of Isomers formed** 1a $CH_3CHBrCN$ 1b Exists as two Optical isomers / enantiomers **Stage 2 Mechanism** 2a 2 curly arrows  2b Intermediate structure primary carbocation OR  2c Alternative Intermediate structure secondary carbocation OR 	6 (3 x AO1, 3 x AO3)
	Level 3 5–6 marks	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.		
	Level 2 3–4 marks	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.		
	Level 1 1–2 marks	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.		
	0 mark	Insufficient correct chemistry to gain a mark.		

Stage 3 Optical isomerism

3a 2-bromo isomer has chiral carbon / C with four different groups / non superimposable mirror images

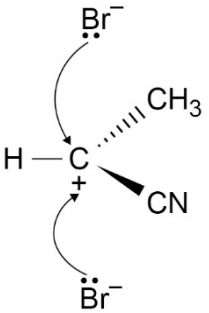
OR





3b Optical because (secondary) C^+ planar

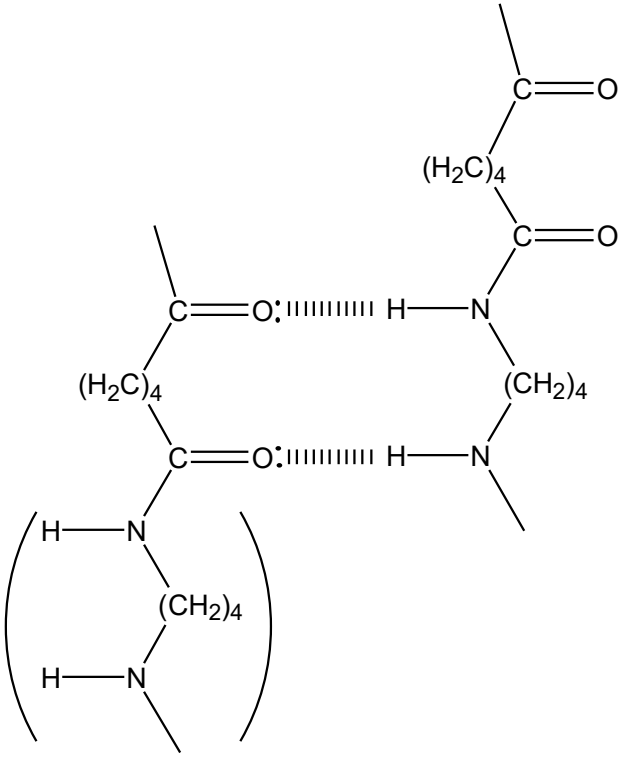
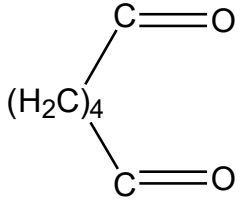
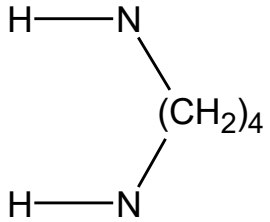
3c So can be attacked from above or below

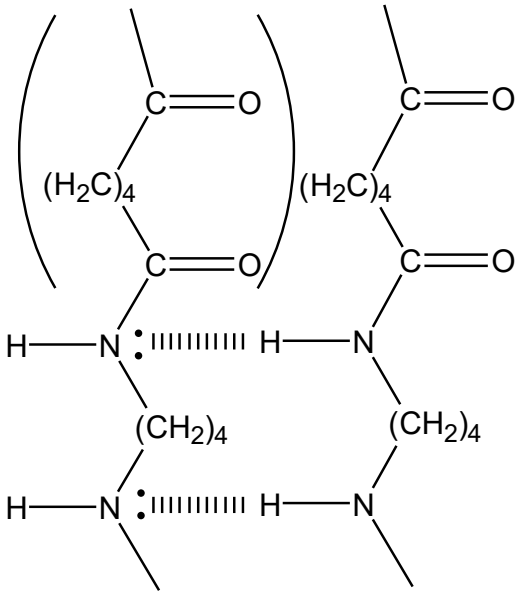


Question	Answers	Additional Comments/Guidelines	Mark
04.3	M1 KCN or NaCN M2 Aqueous AND ethanol (alcohol)	Penalise acid in M1	2 (2 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
04.4	M1 H_2 and Ni/Pt/Pd M2 $NCCH_2CH_2CN + 4H_2 \rightarrow H_2N(CH_2)_4NH_2$	Allow $LiAlH_4$ and (Dry) ether BUT <u>not</u> $NaBH_4$ (ignore heat and pressure) Allow with 8[H]	2 (1 x AO1, 1 x AO2)

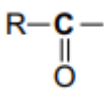
Question	Answers	Additional Comments/Guidelines	Mark
04.5	M1 $x = 5$ M2 $y = 9$		2 (2 x AO1)

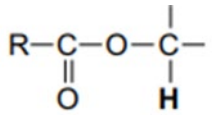
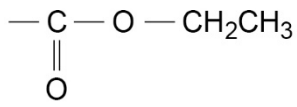
Question	Answers	Additional Comments/Guidelines	Mark
04.6		Structure shown on the left of the given structure. The correct answer is the same irrespective of whether it's drawn on the left or right of the polymer section. Deduct a mark(s) for error(s)/omission(s) Must have the following: • Minimum correct structure  Or  • Lp on O or N • 2 Linear dashed lines from O or N to H Allow alternative connection below	2 (2 x AO2)

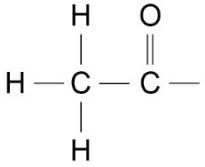
			

Question	Answers	Additional Comments/Guidelines	Mark
05.1	C=O		1 (AO1)

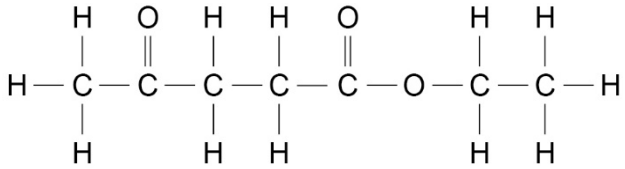
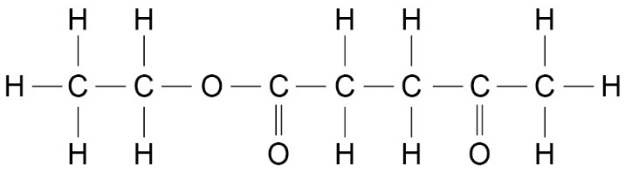
Question	Answers	Additional Comments/Guidelines	Mark
05.2	Tick in the box for 7 ONLY		1 (AO1)

Question	Answers	Additional Comments/Guidelines	Mark
05.3	 esters	Ignore acids	1 (AO1)

Question	Answers	Additional Comments/Guidelines	Mark
05.4	M1 (Quartet) because neighbouring C has 3H M2 (At δ = 4.1 ppm) because connected to single bonded O of ester or  M3 (Triplet) because neighbouring C has 2H M4 (At δ = 1.26 ppm) because R_2CH_2 or RCH_3 M5 	Ignore use of integration	5 (5 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
05.5			1 (AO2)

Question	Answers	Additional Comments/Guidelines	Mark
05.6	Cannot deduce splitting patterns of peaks (at about δ = 2.60) Or No integration values	Allow Peaks at δ = 2.60 and δ = 2.56 ppm overlap OR spectrum at δ = 2.60 is second order	1 (AO3)

Question	Answers	Additional Comments/Guidelines	Mark
05.7			1 (AO2)

Question	Answers	Additional Comments/Guidelines	Mark
06.1	Use H_2SO_4	Allow HCl / H_3PO_4 Ignore conc / dilute	1 (AO1)

Question	Answers	Additional Comments/Guidelines	Mark
06.2	M1 Cool test 2 warm (water bath) M2 Gas is tested with lighted splint in test 3 Bubble into limewater	 Allow heat / hot Allow no test on gas needed	2 (2 x AO3)

Question	Answers	Additional Comments/Guidelines	Mark
06.3	M1 J and M M2 Test 1 (Orange solution goes) green M3 M M4 Test 2 (Blue solution gives a brick) red precipitate M5 J and L M6 Test 3 (Colourless gas that turns) limewater cloudy M7 K M8 Test 4 (Orange solution goes) colourless	 Allow (Brown-red/orange/orange-red) Allow M6 Test 3 fizz / effervescence Allow (Brown/Brown-red/yellow/yellow-orange) Allow decolorises bromine	8 (8 x AO3)

Question	Answers	Additional Comments/Guidelines	Mark
06.4	M1 S – Fractionating column M2 Both T – Water out AND U – Water in M3 Liquids K and M are likely to have similar boiling points	M1 Allow beads	3 (3 x AO3)

Question	Answers	Additional Comments/Guidelines	Mark
07.1	M1 n(propanone) = $\frac{0.146}{58}$ (= 2.52×10^{-3}) M2 Conversion of T and P (T = 368K and P = 103000Pa) M3 V = $\frac{nRT}{P}$ rearranged for V as subject (in algebraic or numbers) M4 their evaluated M3 × 1 × 10^6 = 75 cm^3	V = $\frac{M1 \times 8.31 \times 368}{103000}$ scores M2 and M3 Allow 74-75	4 (4 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
07.2	M1 V = $\frac{348}{368}$ × M4 = 71 cm^3 M2 Decrease = M4 – M1 = 4 cm^3	Marked with Q7.1 Using alternate answer M1 V = $\frac{348}{368}$ × 89 = 84 cm^3 M2 89 – 84= 5 cm^3 Allow answer for M1 calculated as 70.8 cm^3 after substitution of values into pV = nRT. Could then lead to a difference of 18.2 cm^3 if compared to the alternate value for M4 of 89 cm^3	2 (2 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
07.3	M1 % uncertainty = $\frac{0.001}{0.146}$ × 100 = 0.685% M2 Vol uncertainty = $\frac{M1}{100}$ × M4 = 0.5 cm^3	Marked with Q7.1 Allow 0.6 cm^3 if 89 cm^3 used	2 (2 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
07.4	M1 Vol CO_2 formed = 3 × 600 = 1800 cm^3 M2 Total Vol left = 1800 + 400 = 2200 cm^3	If PV=nRT method used M1 n(CO_2) = 0.0651	2 (2 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
08.1	M1 3 $CH_3(CH_2)_{14}COOH$ M2 $CH_2(OH)CH(OH)CH_2OH$	Penalise additional product(s) once	2 (2 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
08.2	M1 M_r = 256 M2 $n(CH_3(CH_2)_{14}COOH) = \frac{0.387}{M1} = 1.51 \times 10^{-3}$ M3 Q = 150 × 4.18 × 13.6 = 8527.2 (J) M4 $\Delta H = \frac{M3}{M2} \div 1000 = (-)5641$ M5 ΔH = –5640 kJ mol^{-1}	Must be negative and 3sf (allow ecf on M4)	5 (5 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
08.3	M1 Less exothermic M2 Incomplete combustion	Allow Less negative (value) / Lower Allow products of incomplete combustion	2 (2 x AO2)

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidelines</th><th>Mark</th></tr>
<tr><td>08.4</td><td>
<table>
<tr><td></td><td></td><td>C
37.08</td><td>H
5.15</td><td>O
24.72</td><td>S
M1 = 33.05</td></tr>
<tr><td>M2</td><td>÷ A_r</td><td>= 3.09</td><td>= 5.15</td><td>= 1.55</td><td>= 1.030</td></tr>
<tr><td></td><td>÷ smallest</td><td>= 3</td><td>= 5</td><td>= 1.50</td><td>= 1</td></tr>
<tr><td>M3</td><td colspan="5">Empirical formula = $C_6H_{10}O_3S_2$</td></tr>
</table>
</td><td>M1 % S = 33.05

M2 Calculation of moles

M3 Ratio of moles AND Empirical Formula

If no Sulfur used ecf for M2 and M3
M2 3.09 : 5.15 : 1.55
M3 $C_6H_{10}O_3$</td><td>3
(1 x AO1,
2 x AO2)</td></tr>
</table>

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidelines</th><th>Mark</th></tr>
<tr><td>08.5</td><td>M1 Acid rain

M2 SO_2</td><td>Allow smog

Allow NOx</td><td>2
(2 x AO3)</td></tr>
</table>

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidelines</th><th>Mark</th></tr>
<tr><td>08.6</td><td>M1 Bonds broken = 9459 kJ mol^{-1}

(5C-C + 7C-O + 7C-H + 5O-H)

M2 Bonds formed = 9682 kJ mol^{-1}

(2C-C + 10C-H + 2C-O + 2O-H + 4C=O)

M3 ΔH = M1 – M2 = –223 kJ mol^{-1}</td><td>Allow if they cancel the common bonds

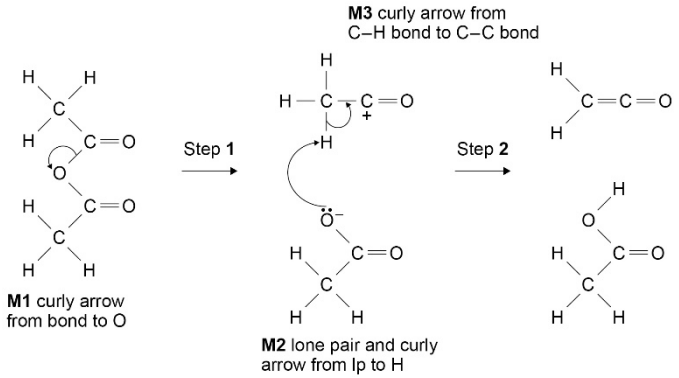
M1 4233

M2 4456

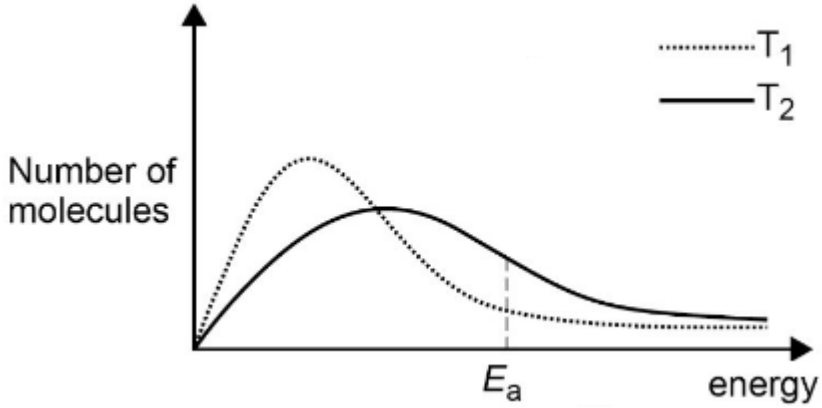
M3 can be awarded as ecf from their M1 and M2</td><td>3
(3 x AO2)</td></tr>
</table>

Question	Answers	Additional Comments/Guidelines	Mark
08.7	M1 ΔH = –235 – (2 × –394) – (3 × –242) M2 = +1279 kJ mol^{-1}	 If no sign assume positive	2 (2 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
09.1	$C_nH_{2n-2}O$	Allow $C_nH_{2n}CO$ or $(CH_2)_nCO$ or $C_nH_{2(n-1)}O$	1 (AO2)

Question	Answers	Additional Comments/Guidelines	Mark
09.2		Allow other C-O bond breaking for M1	3 (3 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
09.3	M1 $\frac{k}{A} = e^{-Ea/RT}$ M2 $8.302 = \frac{34500}{8.31 \times T}$ M3 T = 500 K	OR via $\ln k = \ln A - \frac{Ea}{RT}$ or shown with numbers	3 (3 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
09.4	 M5 At T_2 (many) more particles have $E \geq E_a$	M1 x axis labelled correctly (kinetic not required) AND y axis labelled correctly allow particles M2 Ea labelled on x axis M3 Distribution correct shape for T_1 M4 Peak at T_2 lower with max shifted right and only crosses once	5 (5 x AO1)