A-level
CHEMISTRY
7405/2

Paper 2 Organic and Physical Chemistry

Mark scheme

June 2025

Version: 1.0 Final

256A7405/2/MS

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

No student should be disadvantaged on the basis of their gender identity and/or how they refer to the gender identity of others in their exam responses.

A consistent use of 'they/them' as a singular and pronouns beyond 'she/her' or 'he/him' will be credited in exam responses in line with existing mark scheme criteria.

Further copies of this mark scheme are available from aqa.org.uk

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AS and A-Level Chemistry
Mark Scheme Instructions for Examiners

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the examiner make his or her judgement and help to delineate what is acceptable or not worthy of credit or, in discursive answers, to give an overview of the area in which a mark or marks may be awarded.

The extra information in the 'Comments' column is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.

You should mark according to the contents of the mark scheme. If you are in any doubt about applying the mark scheme to a particular response, consult your Team Leader.

At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.

In general the right-hand side of the mark scheme is there to provide those extra details which might confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent.

The use of M1, M2, M3 etc in the right-hand column refers to the marking points in the order in which they appear in the mark scheme. So, M1 refers to the first marking point, M2 the second marking point etc.

2. Emboldening

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following bullet points is a potential mark.

2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.

2.3 Alternative answers acceptable for a mark are indicated by the use of **OR**. Different terms in the mark scheme are shown by a / ; eg allow smooth / free movement.

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which students have provided extra responses. The general 'List' principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error / contradiction negates each correct response. So, if the number of error / contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (often prefaced by 'Ignore' in the mark scheme) are not penalised.

For example, in a question requiring 2 answers for 2 marks:

Correct answers	Incorrect answers (ie incorrect rather than neutral)	Mark (2)	Comment
1	0	1	
1	1	1	They have not exceeded the maximum number of responses so there is no penalty.
1	2	0	They have exceeded the maximum number of responses so the extra incorrect response cancels the correct one.
2	0	2	
2	1	1	
2	2	0	
3	0	2	The maximum mark is 2
3	1	1	The incorrect response cancels out one of the two correct responses that gained credit.
3	2	0	Two incorrect responses cancel out the two marks gained.
3	3	0	

3.2 Marking procedure for calculations

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

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

3.3 Errors carried forward, consequential marking and arithmetic errors

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

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

3.4 Equations

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

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

3.5 Oxidation states

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

3.6 Interpretation of 'it'

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

3.7 Phonetic spelling

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

3.8 Brackets

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

3.9 Ignore / Insufficient / Do <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.

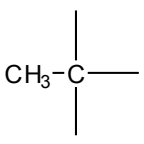
3.12 Organic structures

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.

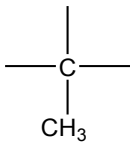
In general

- 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, 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, eg nitrile, carboxylic acid, aldehyde and acid chloride. The carbon-carbon bond should be clearly shown. Wrongly bonded atoms will be penalised **on every occasion**. (see the examples below)
- The same principle should also be applied to the structure of alcohols. For example, if students show the alcohol functional group as C ─ HO, they should be penalised **on every occasion**.
- Latitude should be given to the representation of C ─ C bonds in alkyl groups, given that CH_3─ is considered to be interchangeable with H_3C─ even though the latter would be preferred.
- Similar latitude should be given to the representation of amines where NH_2─ C will be allowed, although H_2N─ C would be preferred.
- Poor presentation of vertical C ─ CH_3 bonds or vertical C ─ NH_2 bonds should **not** be penalised. For other functional groups, such as ─ OH and ─ CN, the limit of tolerance is the half-way position between the vertical bond and the relevant atoms in the attached group.

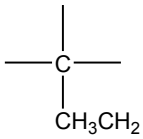
By way of illustration, the following would apply.



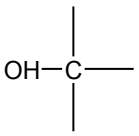
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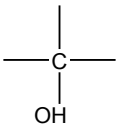
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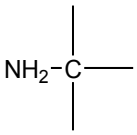
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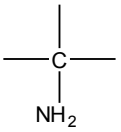
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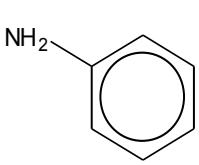
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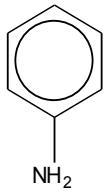
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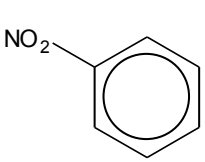
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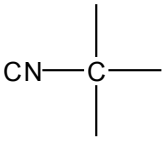
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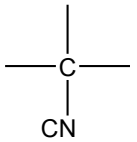
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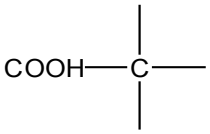
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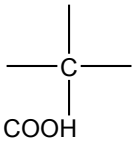
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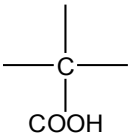
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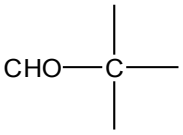
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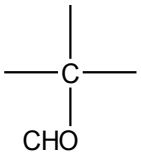
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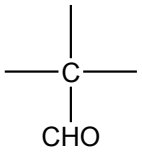
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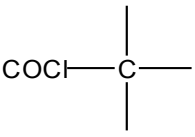
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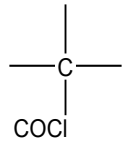
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- Representation of CH_2 by $C{-}H_2$ will be penalised
- Some examples are given here of **structures** for specific compounds that should **not** gain credit (but, exceptions **may** be made in the context of balancing equations)

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.

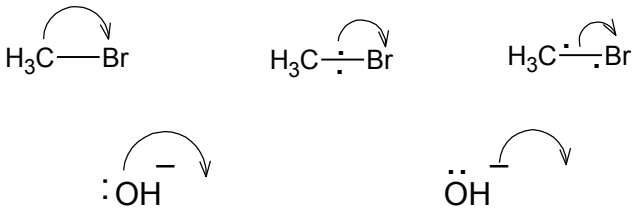
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

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**

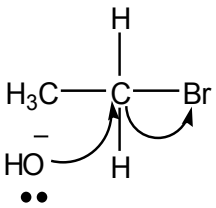
3.14 Organic reaction mechanisms

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.

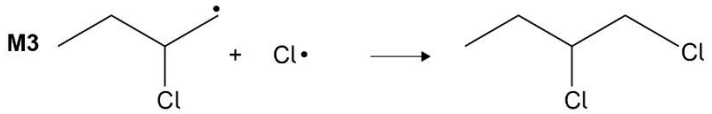
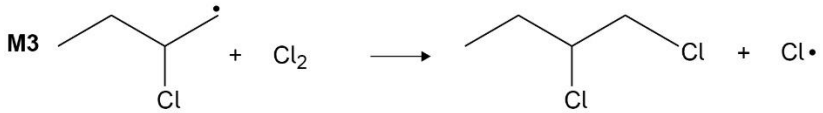
An answer which contains nothing of relevance to the question must be awarded no marks.

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.

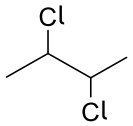
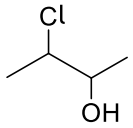
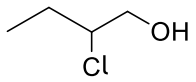
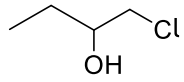
Question	Answers	Additional comments/Guidelines	Mark
01.1	M1 (Free) radical substitution M2 UV (light / radiation)	Allow high temperature Ignore heat/warm/pressure	2 (2 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
01.2	**M1** $Cl_2 \longrightarrow 2Cl\bullet$  **M2** + $Cl\bullet$ → + HCl  **M3** + $Cl\bullet$ → OR  **M3** + Cl_2 → + $Cl\bullet$ **M2** and **M3** can be scored with non-skeletal structures **M2** $CH_3CH_2CHClCH_3 + Cl^{\bullet} \rightarrow [CH_3CH_2CHClCH_2]^{\bullet} + HCl$ **M3** $[CH_3CH_2CHClCH_2]^{\bullet} + Cl_2 \rightarrow CH_3CH_2CHClCH_2Cl + Cl^{\bullet}$ OR **M3** $[CH_3CH_2CHClCH_2]^{\bullet} + Cl^{\bullet} \rightarrow CH_3CH_2CHClCH_2Cl$	Apply list principle to M3 Ignore alternative termination steps	3 (3 x AO2)

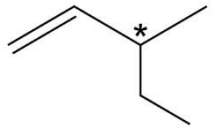
Question	Answers	Additional comments/Guidelines	Mark
01.3	Any two from: Reaction 1 could give rise to further substitution (polysubstitution) Reaction 1 could give rise to substitution in different positions Combination of radicals to get longer chain product	Allow chain reactions other isomers are possible	2 (2 x AO1)

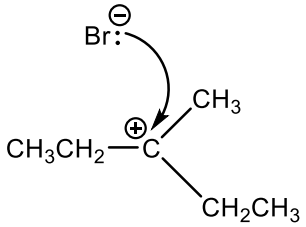
Question	Answers	Additional comments/Guidelines	Mark
01.4	**M1** KOH or NaOH (Formulae or names allow other strong alkalis) **M2** Hot / reflux / ethanolic	Ignore warm Can score both marks on same line provided no contradiction elsewhere	2 (1 x AO1, 1 x AO2)

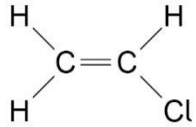
Question	Answers	Additional comments/Guidelines	Mark
01.5	**M1** Chlorine / Cl_2 **M2** Electrophilic addition	Allow chlorine water Apply list principle	2 (2 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
01.6	Any correct structure showing 2,3-dichlorobutane e.g. $CH_3CHClCHClCH_3$ or  	Allow $CH_3CH(OH)CHClCH_3$ or $CH_3CH_2CHClCH_2OH$ or $CH_3CH_2CH(OH)CH_2Cl$    	1 (1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
02.1	**M1** *Z*-3-methylpent-2-ene **M2** cannot rotate about C=C / double bond **M3** (Two) different groups attached to each C in C=C / double bond	M2 allow restricted/limited rotation	3 (2 x AO1, 1 x AO2)

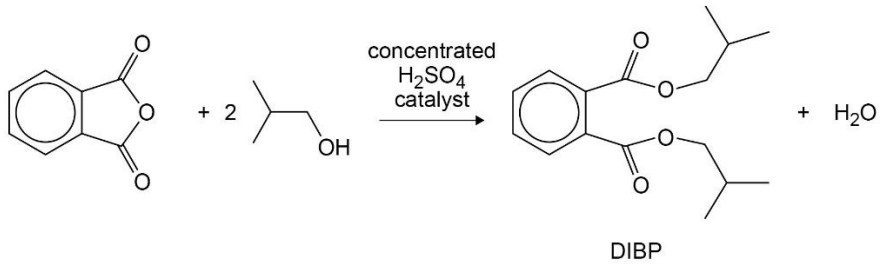
Question	Answers	Additional comments/Guidelines	Mark
02.2	**M1** CH_2=CHCH(CH_3)CH_2CH_3 OR other valid structural representation eg  **M2** It has a chiral centre or asymmetric carbon or a C with four different groups attached (need not be shown in structure)	M2 allow: can form two non-superimposable mirror images	2 (2 x AO2)

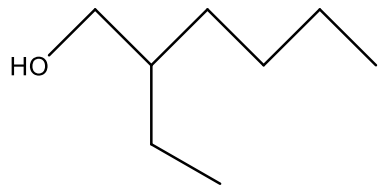
Question	Answers	Additional comments/Guidelines	Mark
02.3	 **M1** Structure of <u>tertiary</u> carbocation **M2** Curly arrow from lone pair on $Br:^-$ to C^+		2 (2 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
03.1	**M1** Chloroethene **M2** 	Allow vinyl chloride OR chloroethylene	2 (2 x AO1)

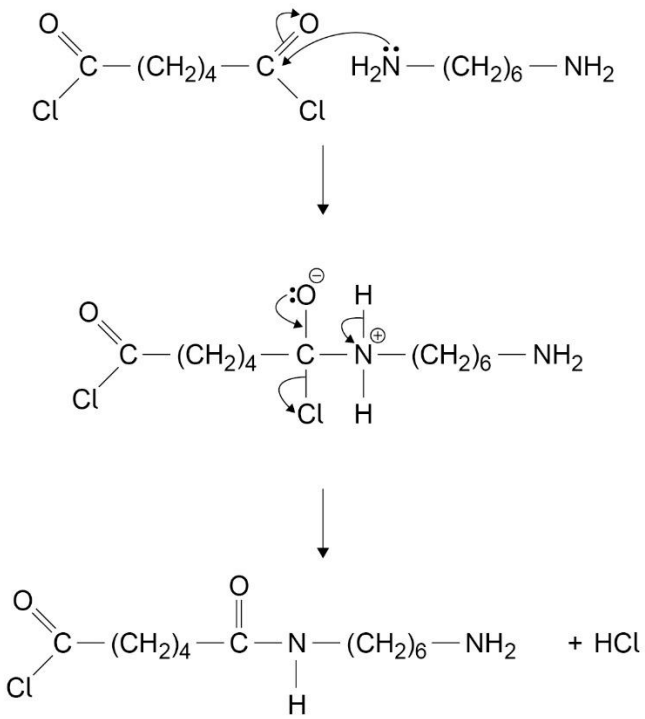
Question	Answers	Additional comments/Guidelines	Mark
03.2	Carbon Carbon bonds are non polar or (too) strong or not attacked by nucleophiles Or Carbon Carbon bonds cannot be hydrolysed		1 (1 x AO2)

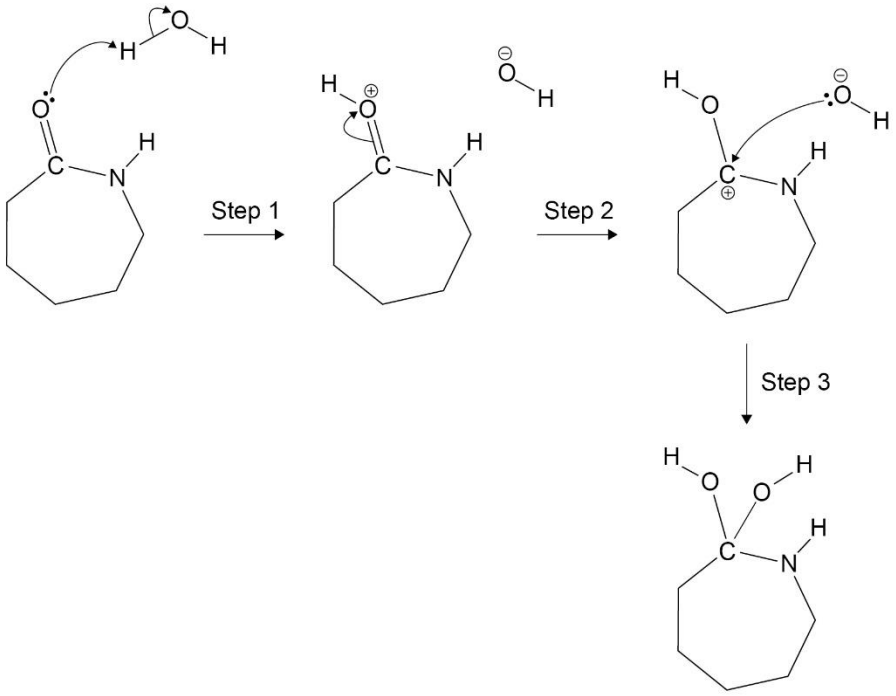
Question	Answers	Additional comments/Guidelines	Mark
03.3	(Makes the PVC) softer / more flexible OR Lowers the glass transition temperature	Must use comparative language	1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
03.4	 DIBP **M1** either formula of alcohol or water **M2** for balanced equation **M3** (Nucleophilic) Addition–elimination **M4** $C_8H_{11}O_2$		4 (1 x AO1, 3 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
03.5	2-ethylhexan-1-ol Or suitable structural formula eg $CH_3CH_2CH_2CH_2CH(CH_2CH_3)CH_2OH$ or 		1 (1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
03.6	**M1** The more fat is present, the larger the mass DEHA (is absorbed from plastic to the food) **M2** DEHA (and oils / fats / fatty acids) contain long alkyl chains OR DEHA is non-polar OR DEHA hydrophobic **M3** (Relatively strong / many) van der Waals' / London / dispersion forces are formed between DEHA and fats/butter	**M1** allow converse for water content **M2** DEHA doesn't have any O-H (groups) **M3** Water/milk doesn't form H bonds with DEHA	3 (1 x AO1, 2 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
03.7	 **M1** Arrow from lone pair on N to C **M2** Arrow from C=O bond to O **M3** Structure including –ve on O and +ve on N **M4** Three arrows; lone pair on O to C–O bond, C–Cl bond to Cl and N–H bond to N		4 (4 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
03.8	 Two arrows in step 1 **M1** Arrow from lone pair on O to H **M2** Arrow from O–H bond to O One arrow in step 2 **M3** Arrow from C=O to O One arrow in step 3 **M4** Arrow from lone pair on O of **:**OH^- to C+		4 (4 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
04.1	N_2O is unknown so should be treated as a toxic or N_2O can cause respiratory problems	Allow N_2O / cyclohexanol / methanol / nitric acid is harmful / irritant / corrosive / toxic	1 (1 x AO3)

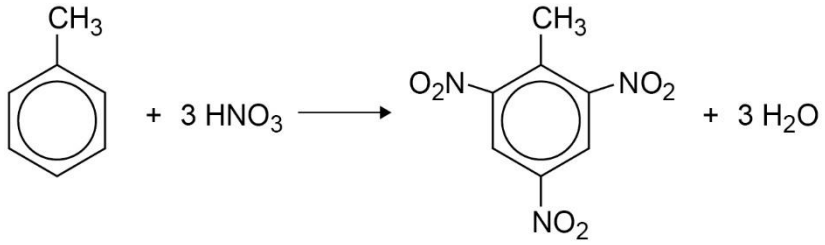
Question	Answers	Additional comments/Guidelines	Mark
04.2	Oxidising agent		1 (1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
04.3	**M1** Dissolve in minimum / small volume of hot methanol/solvent **M2** Hot Filtration (not Buchner) **M3** Cool/ leave (to crystallise) **M4** Filter (under reduced pressure) **M5** Dry between filter papers or in a warm place	**M1** allow Dissolve in hot methanol/solvent to make saturated solution	5 (5 x AO3)

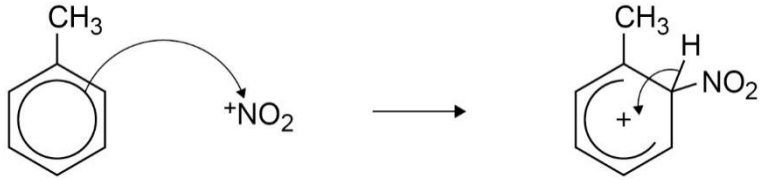
Question	Answers	Additional comments/Guidelines	Mark
04.4	(Use of water at room temperature) dissolves product OR Use of ice cold water prevents / reduces amount of product that dissolves		1 (1 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
04.5	Mistake: Water is being used to warm sample Problem caused: Temperature will not reach high enough (to melt sample) Mistake: Sample is much higher than bottom of thermometer Problem caused: Temperature of sample will be <u>lower / different</u> than reading on the thermometer	Mistake: no stirrer is in the boiling tube or boiling tube used instead of D-tube / Thiele tube Problem caused: variation in temperature	4 (4 x AO3)

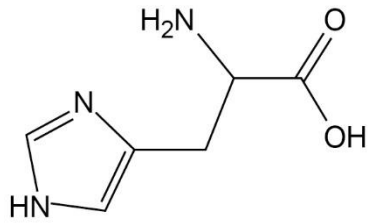
Question	Answers	Additional comments/Guidelines	Mark
04.6	Reason process is more sustainable: Any one from • Glucose is a renewable resource / feedstock • Biological reactant / *E. coli* bacteria is renewable • Pt catalyst can be re-used • Higher atom economy Reason process is less sustainable: Any one from • Synthesis is a 2-stage process • Hydrogen gas is a non-renewable • High pressures (are required in Stage 2) • Uses a Pt catalyst that has been mined from the earth		2 (2 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
05.1	**M1** for structure of TNT **M2** for the rest of the equation 		2 (2 x AO1)

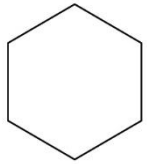
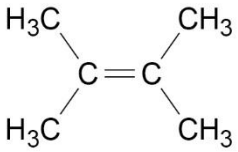
Question	Answers	Additional comments/Guidelines	Mark
05.2	**M1** Mass 1050 cm^3 methyl benzene = 1050 × 0.867 = 910.35 g **M2** n $C_6H_5CH_3$ = $\frac{M1}{92}$ **M3** n $C_6H_2CH_3(NO_2)_3$ = M2 × 0.425 **M4** Mass TNT = M3 × 227 = 955 g (3sf) allow 954.6 to 2 or more sf	**M2** n $C_6H_5CH_3$ = $\frac{910.35}{92}$ = 9.895 mol **M3** n $C_6H_2CH_3(NO_2)_3$ = 9.895 × 0.425 = 4.205 mol **M4** Mass TNT = 4.205 × 227 = 955 g (3sf) allow 954.6 or more sf	4 (4 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
05.3	**M1** $HNO_3 + 2\,H_2SO_4 \longrightarrow O_2N^+ + 2\,HSO_4^- + H_3O^+$ **M2** Electrophile  **M3** Positive must be on N and arrow from inside hexagon to N or + on N **M4** Intermediate structure with horseshoe not beyond C2–C6 **M5** Arrow from C–H bond back into the hexagon	**M1** $HNO_3 + H_2SO_4 \longrightarrow O_2N^+ + HSO_4^- + H_2O$ OR via two equations	5 (5 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
06.1	One reason for D_2O rather than CCl_4 **M1** D_2O is polar One reason why D_2O rather than water **M2** D_2O has no H atoms	Allow converse in both reasons Allow **M1** D_2O is a good solvent for lysine / Amino acids	2 (2 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
06.2		Allow zwitterion	1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
06.3	**M1** (before heating) α helix **M2** (after heating) β pleated sheet		2 (2 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
07.1	**M1** 84.09396 = (6 × 12.00000) + (12 × 1.00783) Hence C_6H_{12} **M2** and **M3** Structures e.g.   **M4** Look for a peak at 1620–1680 cm^{-1} **M5** Alkene has this peak for C=C or cycloalkane doesn't		5 (2 x AO1, 3 x AO2)

<table>
<tr><th>Question</th><th colspan="2">Answers</th><th>Additional Comments/Guidelines</th><th>Mark</th></tr>
<tr><td rowspan="3">07.2</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="3">Stage 1 ^{13}C NMR

1a (5 peaks so) there are 5 (different) C environments

1b (2) peaks with chemical shift 190–220 ppm so there are (2 different C=O) aldehyde / ketone groups

1c (3) peaks with chemical shift 5–50 ppm so could be C–C alone or C–C and R–CO–C

Stage 2 ^{1}H NMR chemical shift data

2a peak at chemical shift 0.7 – 1.4 R–CH_3 or R_2CH_2

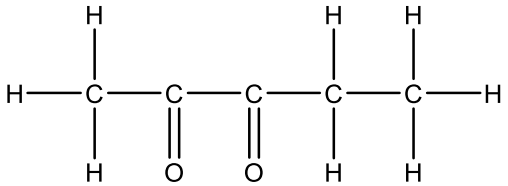
2b peak at chemical shift 2.1 – 2.6 R–CO–CH

2c peak at chemical shift 2.6 – 2.8 R–CO–CH</td><td rowspan="3">7
(3 x AO2,
4 x AO3)</td></tr>
<tr><td>Level 3
5–6 marks</td><td>All stages are covered and the explanation of each stage is correct and virtually complete
(i.e. two from stages 1, 2 and 3)

Answer communicates the whole explanation, including equations, coherently and shows a logical progression through all three stages</td></tr>
<tr><td>Level 2
3–4 marks</td><td>All stages are covered (NB ‘covered’ means min one from each stage) but the explanation of each stage may be incomplete or may contain inaccuracies

OR two stages covered and the explanations are generally correct and virtually complete
(i.e. two from 2 stages either 1, 2 or 3)

Answer is coherent and shows some progression through all three stages. Some steps in each stage may be incomplete</td></tr>
</table>

07.2 cont	Level 1 1–2 marks	Two stages are covered (NB 'covered' means min one from a stage) but the explanation of each stage may be incomplete or may contain inaccuracies **OR** only one stage is covered but the explanation is generally correct and virtually complete (i.e. two from stages 1, 2 or 3) Answer shows some progression between two stages	**Stage 3** ^{1}H splitting 3a Triplet (0.7 – 1.4 CH) next to CH_2 3b Singlet (2.1 – 2.6 CH) no H on adjacent C 3c Quartet (2.6 – 2.8 CH) next to CH_3 **M7** $CH_3CH_2COCOCH_3$ or 	
	Level 0	Insufficient correct chemistry to gain a mark.		

Question	Answers	Additional comments/Guidelines	Mark
08.1	Method 1 **M1** $n = \frac{PV}{RT}$ **M2** converting P to 101×10^3 AND V to 105×10^{-6} AND T to 428 K **M3** $n = \frac{101\,000 \times 0.000105}{8.31 \times 428}$ $(= 2.982 \times 10^{-3})$ **M4** mass of **Y** = 0.402 g **M5** $M_r = \frac{M4}{M3}$ = 135 (Allow 134.8) Method 2 **M1** $n = \frac{pV}{RT}$ **M2** $M_r = \frac{mRT}{pV}$ **M3** converting P to 101×10^3 AND V to 105×10^{-6} AND T to 428 K **M4** mass of **Y** = 0.402 g **M5** $M_r = \frac{0.402 \times 8.31 \times 428}{101\,000 \times 0.000105}$ = 135 (Allow 134.8)	**M1** for rearrangement of PV = nRT **M2** three unit conversions **M3** insertion of their numbers into rearranged expression	5 (5 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
08.2	**M1** % uncertainty for balance = $\frac{0.001}{\text{M4 from 8.1}} \times 100 = \frac{0.001}{0.402} \times 100$ = 0.249% (Allow 0.25%) **M2** Total % apparatus uncertainty = 0.95 + 0.12 + M1 (= 1.32%) **M3** M_r Range M5 from Q8.1 ± (M5 × $\frac{M2}{100}$) = (133.2 – 136.8 or 135 ± 1.8) To be marked with **8.1**	**M3** 'dummy' answer gives range 139.1 – 142.9 or 141 ± 1.9	3 (3 x AO3)

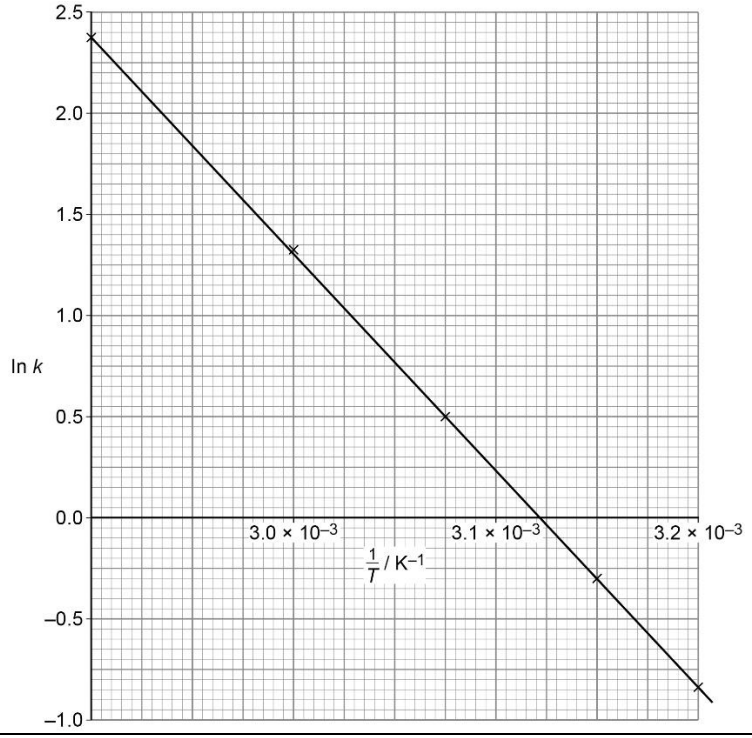
Question	Answers	Additional comments/Guidelines	Mark
08.3	Seal prevents evaporation / loss (of Y so the mass/volume recorded will be more accurate) OR Seal will cover the sharp needle making the experiment safer		1 (1 x AO3)

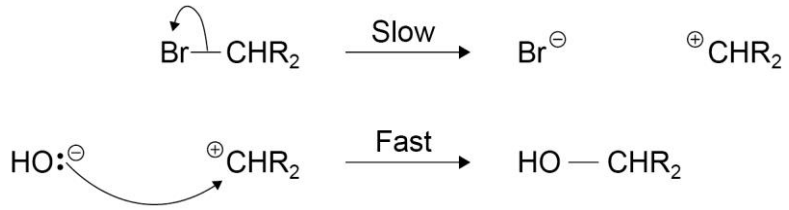
Question	Answers	Additional comments/Guidelines	Mark
08.4	M1 If vol CH_4 = *a* cm^3 then vol C_3H_8 = (40 – *a*) cm^3 M2 vol O_2 = 2*a* + 5(40 – *a*) = 170 cm^3 M3 30 = 3*a* so vol CH_4 = 10 cm^3 M4 vol C_3H_8 = 40 – M3 = 30 cm^3	Simultaneous equations where vol CH_4 = x cm^3 vol C_3H_8 = y cm^3 M1 x + y = 40 i.e. 2x + 2y = 80 M2 2x + 5y = 170 M3 3y = 90 so y = 30 M4 x = 40 – y = 10 OR via M2 x + 2x + y + 5y = 210 i.e. 3x + 6y = 210 Alternative method M1 If 100% CH_4 then vol O_2 = 80 M2 If 100% C_3H_8 then vol O_2 = 200 M3 Since vol O_2 = 170 ratio C_3H_8 : CH_4 = 3:1 M4 vol CH_4 = 10 cm^3 and vol C_3H_8 = 30 cm^3	4 (4 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
09.1	(The silver halide) product is a precipitate / insoluble		1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
09.2	Any 1 of these Start timer at the same point of addition View the cross from the same distance Light level Same swirling / agitation Same person observing 'disappearance of cross'		1 (1 x AO3)

Question	Answers	Additional comments/Guidelines	Mark
09.3	3.08×10^{-3}	Allow 0.003075 or 3.075×10^{-3} or 0.00308	1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
09.4	**M1** Appropriate x axis scale used **M2** All 4 points given in table 2 plotted correctly and suitable straight line drawn **M3** $-\frac{E_a}{R}$ = calculated gradient (between -10469 and -10830) **M4** E_a = - M3 × 8.31 (J mol^{-1}) **M5** E_a = M4 ÷ 1000 (between 87 and 90)  	**M1** data plotted covers at least half the x axis **M3** $-\frac{E_a}{R} = -\frac{2.38}{2.25 \times 10^{-4}}$ = -10578 **M4** E_a = 10578 × 8.31 (J mol^{-1}) = 87903 **M5** E_a = 87.9 kJ mol^{-1}	5 (5 x AO2)

Question	Answers	Additional comments/Guidelines	Mark
09.5	Option B 		1 (1 x AO1)

Question	Answers	Additional comments/Guidelines	Mark
09.6	**M1** (Br more electronegative than C so) Br is δ- and C is δ+ (and so the C–Br bond breaks when heated) **M2** (Lone pair of electrons on) HO^- attacks/attracted to C^+ (after C–Br bond breaks) OR δ+C (in C–Br bond) attracts / susceptible to attack by (lone pair of electrons on oxygen of) HO^-		2 (2 x AO2)