A-level
CHEMISTRY
7405/2

Paper 2 Organic and Physical Chemistry

Mark scheme

June 2021

Version 1.0: Final

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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 not 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.

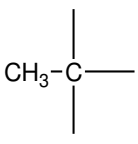
3.12 Organic structures

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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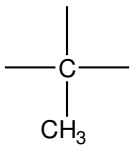

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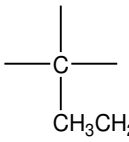

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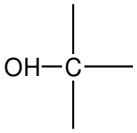

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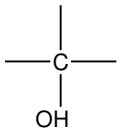

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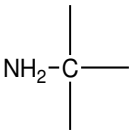

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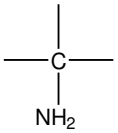

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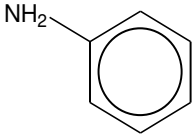

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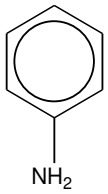

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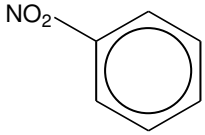

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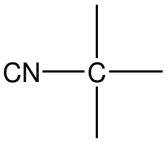

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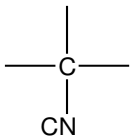

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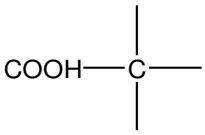

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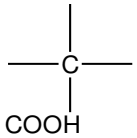

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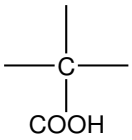

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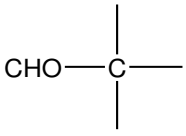

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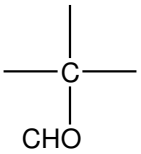

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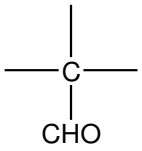

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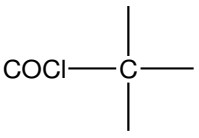

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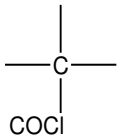

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- Representation of CH_2 by $C–H_2$ will be penalised
- Some examples are given here of **structures** for specific compounds that should **not** gain credit (but, exceptions may be made in the context of balancing equations)

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.

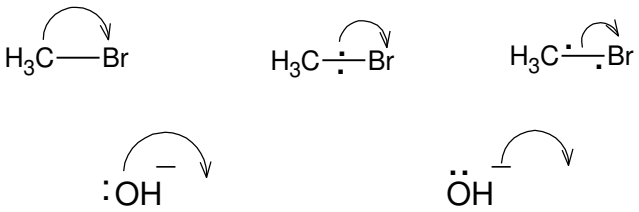
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

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**

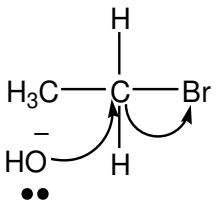
3.14 Organic reaction mechanisms

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	$CH_2OHCH(OH)CH_2OH$		1
	(Potassium) Carboxylate salt	Allow fatty acid salt / salt Salt of a carboxylic acid	1
	Soap	Allow detergent / surfactant	1

Question	Answers	Additional Comments/Guidelines	Mark
01.2	638 = 173 + 3(15 + 14n) M_r ester fragment = 173		M1
	Show substract 638 – (M1 + 45)		M2
	Division of M2 by 42 n = 10	n must be an integer	M3

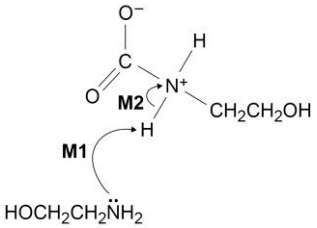
Question	Answers	Additional Comments/Guidelines	Mark
01.3	Amount HCl = 0.100 × 0.01565 = 1.565 ×10^{-3} mol		M1
	Initial amount KOH = $\frac{0.421}{56.1}$ = 7.50 ×10^{-3} mol		M2
	Amount KOH used = M2 – M1 = 5.939 ×10^{-3} mol		M3
	Amount ester = $\frac{5.935\times 10^{-3}}{3}$ = 1.980 ×10^{-3} mol (M3 / 3)		M4
	Mass ester = (1.980 ×10^{-3}) × 638 = 1.263 g (M4 x 638)		M5
	%age by mass = $\frac{1.263}{1.45}$ × 100 = 87.1 % ((M5 / 1.45) x 100)	Allow 87.0 to 87.1 Allow 2 sf Don't allow M6 for an answer >100%	M6

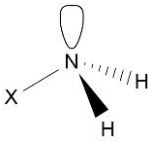
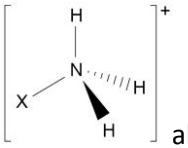
Question	Answers	Additional Comments/Guidelines	Mark
01.4	Allow to dissolve both oil and KOH	To act as a mutual solvent **OR** To ensure reactants are miscible	M1
	Precaution must be linked to heating e.g. Use a water bath for heating mixture	Allow electrical heater / mantle Allow sand bath	M2
	Prevents risk of fire / Ethanol is flammable	Allow KOH is corrosive/caustic/damages eyes if matches alternative precaution given	M3

Question	Answers	Additional Comments/Guidelines	Mark
02.1	A group of (hydrocarbons/compounds) with similar boiling points	Allow compounds that boil in a similar range of temperatures Compounds with similar (carbon) chain length with C5-C12 range or within range	1

Question	Answers	Additional Comments/Guidelines	Mark
02.2	zeolite All formulae correct Balanced equation $C_{16}H_{34} \rightarrow C_6H_{14} + 2\,C_5H_{10}$	Allow Aluminosilicate or aluminium oxide	M1 M2 M3

Question	Answers	Additional Comments/Guidelines	Mark
02.3	C=O bonds vibrate at the same frequency as IR	The difference in energy between the ground and first excited vibrational state of CO_2 is equal to the energy of the infrared radiation. Allow Bond vibrations match frequency of IR radiation C=O bonds vibrate in range 1680-1750cm^{-1} C=O bonds are polar	1

Question	Answers	Additional Comments/Guidelines	Mark
02.4	 2-aminoethanol Base	Curly arrow from N lp to H Curly arrow from N-H bond to N^+ Allow 2-hydroxyethylamine 2-hydroxyethanamine ethanolamine Allow proton acceptor / removes H^+ / electron pair donor	M1 M2 M3 M4

Question	Answers	Additional Comments/Guidelines	Mark
02.5	 allow with/without lone pair  allow with/without charge Smaller lone (or non-bonding) pair repulsion greater than bond pair repulsion	Allow these shapes with lines instead of wedges and dashed lines Allow comparison of correct numbers	M1 M2 M3 M4

Question	Answers		Additional Comments/Guidelines	Mark
02.6	This question is marked using Levels of Response. Refer to the Mark Scheme Instructions for Examiners for guidance.		**Indicative Chemistry content** Stage 1 names of processes 1a Photosynthesis (is the natural process in plants that takes CO_2 from the air) 1b Fermentation (is the process used to make bioethanol releasing some CO_2) 1c Combustion (is the process where bioethanol is burned and releases CO_2) Stage 2 Equations 2a $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$ 2b $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ 2c $2C_2H_5OH + 6O_2 \rightarrow 6H_2O + 4CO_2$ Stage 3 Carbon neutrality and environmental issues 3a Deforestation / Sacrifice land that could be used for food 3b Loss of biodiversity / habitat 3c $6CO_2$ in and $6CO_2$ out but It isn't actually C neutral as fuel is used in production, distribution, etc	6
	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 Covers at least 2 points for stage 1, 2 for stage 2 and 3 for stage 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. Covers at least 1 point for 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		

Question	Answers	Additional Comments/Guidelines	Mark
03.1	<table><tr><td></td><td>Temp/ °C</td><td></td><td>Mass /g</td></tr><tr><td>Initial</td><td></td><td>Burner before</td><td></td></tr><tr><td>Final</td><td></td><td>Burner after</td><td></td></tr><tr><td>(ΔT)</td><td></td><td>(Mass heptane burned)</td><td></td></tr></table>	M1 for Temperature data including units M2 for Burner mass data including units If either unit missing MAX 1	M1 M2

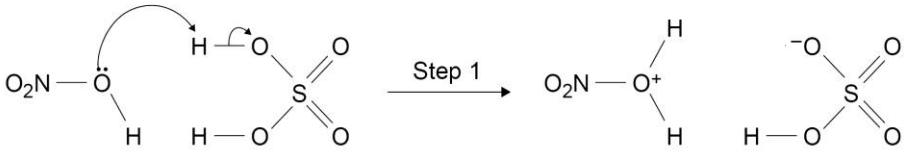
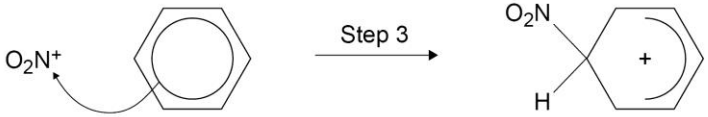
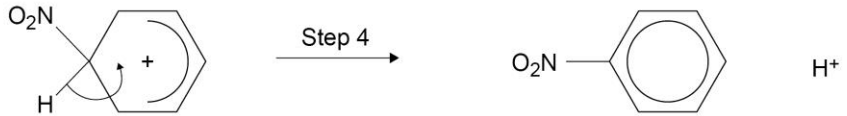
Question	Answers	Additional Comments/Guidelines	Mark
03.2	Any two from: Glass is a poorer conductor than copper Tripod and gauze would reduce heat transfer Tripod and gauze would have a fixed height above the flame	 Heat capacity of metal is less than glass or vice versa	M1 M2

Question	Answers	Additional Comments/Guidelines	Mark
03.3	Heat loss to surroundings or to copper/calorimeter Incomplete combustion		M1 M2

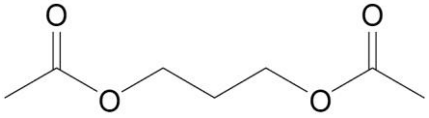
Question	Answers	Additional Comments/Guidelines	Mark
03.4	Use a wind shield(to reduce heat loss)	Allow use a lid Insulate the sides of the calorimeter	1

Question	Answers	Additional Comments/Guidelines	Mark
04.1	(3 x 612) + (3 x 348) + (6 x 412) = 5352 (6 x 715) + (6 x 218) = 5598 ΔH_2 = M2 - M1 - 83 = +163 kJ mol^{-1}	For LHS For RHS	M1 M2 M3

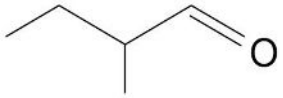
Question	Answers	Additional Comments/Guidelines	Mark
04.2	(π) electrons delocalised		1

Question	Answers	Additional Comments/Guidelines	Mark
04.3	M1 Electrophilic substitution		1
	M2 for a lone pair and two curly arrows 		1
	M3 for a curly arrow from the bond to the O 		1
	M4 for a curly arrow from inside the hexagon to the N or + on the N 		1
	M5 curly arrow from the bond back into the hexagon 		1

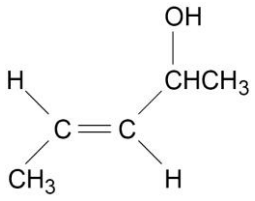
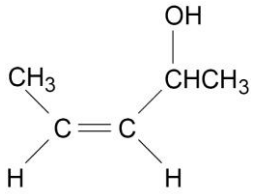
Question	Answers	Additional Comments/Guidelines	Mark
05.1	Amount Diester = 1 - $\frac{x}{2}$ Amount Water = 1- x Amount Diol = $\frac{x}{2}$		M1 M2 M3

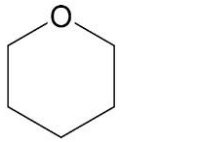
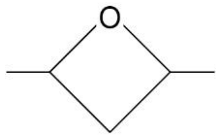
Question	Answers	Additional Comments/Guidelines	Mark
05.2		Allow other versions of the structure (abbreviated or displayed)	1

Question	Answers	Additional Comments/Guidelines	Mark
05.3	K_c = $\frac{0.452^2 \times 0.273}{0.971 \times (\text{amount } H_2O)^2}$ or $\frac{[\text{acid}]^2 \times [\text{diol}]}{[\text{diester}] \times [H_2O]^2}$ (Amount $H_2O)^2$ = $\frac{0.452^2 \times 0.273}{0.161 \times 0.971}$ or $\frac{[\text{acid}]^2 \times [\text{diol}]}{[\text{diester}] \times K_c}$ = (0.357) Amount H_2O = $\sqrt{0.357}$ = 0.597 mol	**OR** $K_c = \frac{\left(\frac{0.452}{V}\right)^2 \times \left(\frac{0.273}{V}\right)}{\left(\frac{0.971}{V}\right)\left(\frac{amount\ H2O}{V}\right)^2}$	M1 M2 M3

Question	Answers	Additional Comments/Guidelines	Mark
06.1			1

Question	Answers	Additional Comments/Guidelines	Mark
06.2	Use Plane polarised light rotates (the plane of) in opposite directions		M1 M2

Question	Answers	Additional Comments/Guidelines	Mark
06.3	 	Must be E isomer Must be Z isomer Allow 1 mark out of 2 for 2 correct structures but shown in the wrong boxes	M1 M2

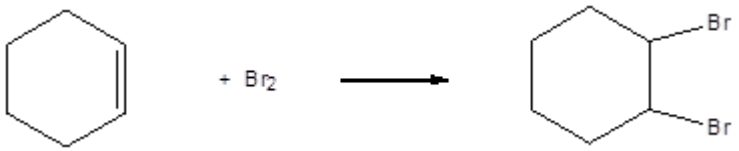
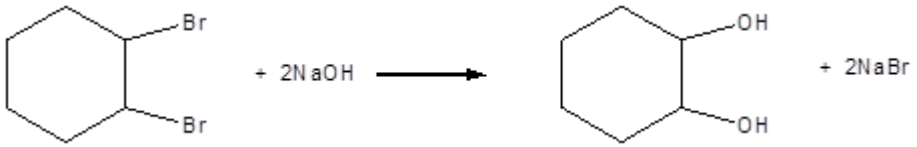
Question	Answers	Additional Comments/Guidelines	Mark
06.4	 		M1 M2

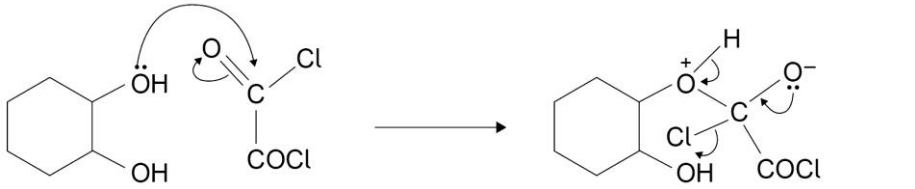
Question	Answers	Additional Comments/Guidelines	Mark
07.1	Tick in carbonyl box only		1

Question	Answers	Additional Comments/Guidelines	Mark
07.2	Peak at 2220-2260 cm^{-1} (for C≡N) disappears Peak at 3300-3500 cm^{-1} (for N-H) appears Fingerprint region different	If both C≡N disappears and N-H appears without wavenumbers scores 1	M1 M2 M3

Question	Answers	Additional Comments/Guidelines	Mark
07.3	Integration ratio 2:2:3 Peak at 3.95 triplet (integration 2) $Cl\text{-}CH_2$ next to CH_2 Peak at 3.65 triplet (integration 2) $O\text{-}CH_2$ next to CH_2 Peak at 3.35 singlet (integration 3) $O\text{-}CH_3$ no adjacent H Structure $CH_3\text{-}O\text{-}CH_2CH_2Cl$	If no link between delta value and oxygen and chlorine, then can award 1 mark for correct explanation of splitting of all 3 peaks If no explanation of splitting, then can award 1 mark for 3 correct links between delta value and oxygen and chlorine	M1 M2 M3 M4 M5

Question	Answers	Additional Comments/Guidelines	Mark
08.1	Dehydration Conc H_2SO_4	Allow (acid catalysed) Elimination Allow Conc H_3PO_4	M1 M2

Question	Answers	Additional Comments/Guidelines	Mark
08.2	Br_2  NaOH  	Allow bromine (water) Allow Cl_2 or I_2 Allow O_2 if epoxide route used allow conseq equation to H_2, H_2O, HBr, HCl. HI and H_2SO_4 An epoxide is a feasible alternative that could score here and consequentially M3 and M4 **Or** KOH or other suitable strong alkali Allow this equation with molecular formulae	M1 M2 M3 M4

Question	Answers	Additional Comments/Guidelines	Mark
08.3	**M1** (nucleophilic)addition-elimination  **M2** curly arrow from lp on O to C **M3** curly arrow from double bond to O **M4** for structure of intermediate **M5** for 3 curly arrows	Note lone pair required for M5	1 M2 M3 M4 M5

Question	Answers	Additional Comments/Guidelines	Mark
08.4	Less energy used **OR** Better yield Less waste **OR** Less pollution	**OR** reduces practical losses, simpler plant, **OR** maximises the use of raw materials in the process into useful products, saves resources	M1 M2

Question	Answers	Additional Comments/Guidelines	Mark
09.1	Absorbs/prevents harmful uv	Allow reduced risk of skin cancer from uv	1

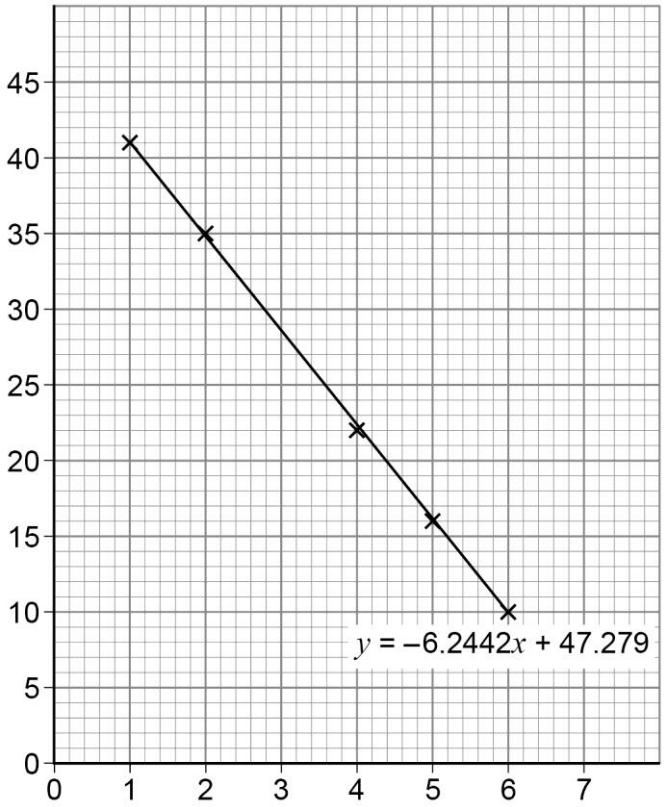
Question	Answers	Additional Comments/Guidelines	Mark
09.2	C-Cl bonds broken (homolytically)	Could show in an equation showing the bond	1

Question	Answers	Additional Comments/Guidelines	Mark
09.3	$Cl^{\bullet} + O_3 \rightarrow ClO^{\bullet} + O_2$ $ClO^{\bullet} + O_3 \rightarrow Cl^{\bullet} + 2O_2$		M1 M2

Question	Answers	Additional Comments/Guidelines	Mark
09.4	$Cl^{\bullet} + CH_2F_2 \rightarrow$ $\rightarrow CHClF_2 + Cl^{\bullet}$ Propagation	Penalise missing dot once only	M1 M2 M3

Question	Answers	Additional Comments/Guidelines	Mark
10.1	The sodium hydrogencarbonate solution neutralises the acid (catalyst) So stops the reaction		M1 M2

Question	Answers	Additional Comments/Guidelines	Mark
10.2	The concentration/amount of propanone is much larger than/200 times larger than the concentration/amount of iodine <u>Concentration</u> of propanone is (almost) constant	The change in concentration in propanone is negligible	M1 M2

Question	Answers	Additional Comments/Guidelines	Mark
10.3	 Suitable axes (plotted points must take up at least half of the grid) For all points correctly plotted to ± ½ small square For straight line of best fit which avoids the anomalous plot		M1 M2 M3

Question	Answers	Additional Comments/Guidelines	Mark
10.4	The graph is a straight line / has a constant gradient So the rate of reaction does not change as the concentration (of iodine) changes / the iodine is being used up at a constant rate.	Correct rate vs conc graph scores M2	M1 M2

Question	Answers	Additional Comments/Guidelines	Mark
10.5	Gradient = (−14.1 − −2.8) / (0.00180 − 0.00128) = −11.3 / 0.00052 = −21731 Gradient = $-E_a$ / R $-E_a$ = their answer x 8.31 (= 180583 J mol^{-1}) E_a = M2 ÷ 1000 (= 181 kJ mol^{-1})	Allow -21330 to -22130	M1 M2 M3