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Unit 2 Organic 1 and Physical 1

Mark scheme

January 2021

Version: 1.0 Final



2 1 1 X C H 0 2 / M S

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 Assessment Writer.

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

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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. Boldening

- 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 **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 (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 $\text{Ag}(\text{NH}_3)_2^+$ 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.

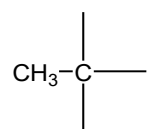
3.12 Organic structures

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.

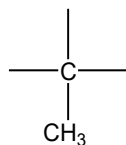
In general

- 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 $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$ and not as the molecular formula $\text{C}_3\text{H}_7\text{Br}$ 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 $\text{C} - \text{HO}$, they should be penalised **on every occasion**.
- Latitude should be given to the representation of $\text{C} - \text{C}$ bonds in alkyl groups, given that CH_3- is considered to be interchangeable with $\text{H}_3\text{C}-$ 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 $\text{H}_2\text{N}-\text{C}$ would be preferred.
- Poor presentation of vertical $\text{C} - \text{CH}_3$ bonds or vertical $\text{C} - \text{NH}_2$ bonds should **not** be penalised. For other functional groups, such as $-\text{OH}$ and $-\text{CN}$, the limit of tolerance is the half-way position between the vertical bond and the relevant atoms in the attached group.

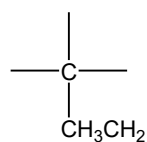
By way of illustration, the following would apply.



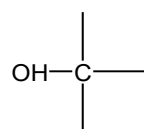
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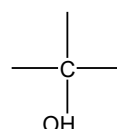
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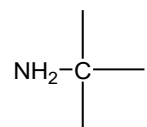
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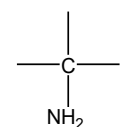
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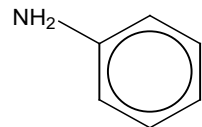
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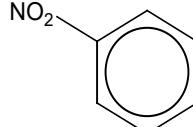
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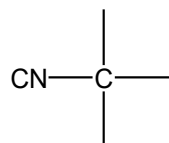
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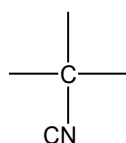
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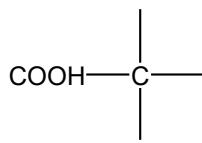
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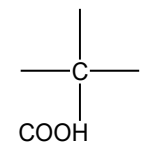
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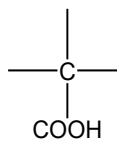
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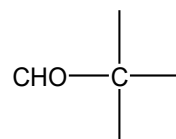
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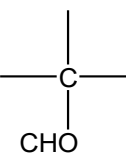
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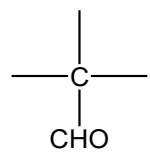
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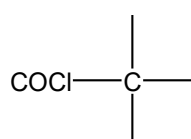
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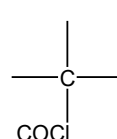
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- Representation of CH_2 by C-H_2 will be penalised
- Some examples are given here of **structures** for specific compounds that should **not** gain credit (but, exceptions may be made in the context of balancing equations)

CH_3COH for ethanal

$\text{CH}_3\text{CH}_2\text{HO}$ for ethanol

OHCH_2CH_3 for ethanol

$\text{C}_2\text{H}_6\text{O}$ for ethanol

CH_2CH_2 for ethene

$\text{CH}_2.\text{CH}_2$ for ethene

$\text{CH}_2:\text{CH}_2$ for ethene

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

$\text{CH}_2 = \text{CH}_2$ for ethene, $\text{H}_2\text{C}=\text{CH}_2$

$\text{CH}_3\text{CHOHCH}_3$ for propan-2-ol, $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$

- 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

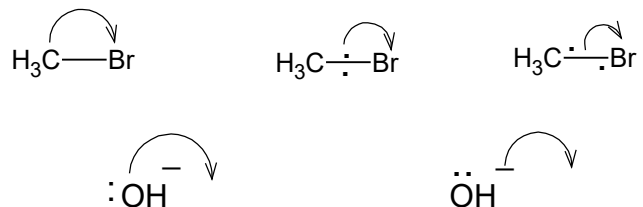
As a general principle, non-IUPAC names or incorrect spelling or incomplete names should **not** gain credit. Some illustrations are given here.

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-methylpropan-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

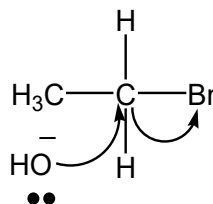
3.14 Organic reaction mechanisms

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.

Question	Marking guidance	Mark	Comments
01.1	homolytic fission or one electron from the bonding pair goes to each atom	1	
	initiation	1	

Question	Marking guidance	Mark	Comments
01.2	$C_7H_{15}Cl$ or number of H atoms = 15 or $15 (+ 84 + 35.5)$	1	allow moles or mass of H = 15 (g) allow structure
	134.5	1	

Question	Marking guidance	Mark	Comments
01.3	1,2-dichloro-1,1,2,2-tetrafluoroethane	1	allow 1,2-dichlorotetrafluoroethane

Question	Marking guidance	Mark	Comments
01.4	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br} + \text{:OH}^- \longrightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} + \text{Br}^-$	1 1	arrow from lone pair on O of OH ⁻ to C arrow from C–Br bond to Br atom ignore partial charges unless incorrect

Question	Marking guidance	Mark	Comments
01.5	base (dissolved) in ethanol or ethanolic or alcoholic	1 1	allow proton acceptor

Total		9	
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Question	Marking guidance	Mark	Comments
02.1	rate of forward reaction is equal to the rate of the reverse reaction	1	allow in either order
	concentration of reactants and products remains constant	1	do not accept concentrations are the same

Question	Marking guidance	Mark	Comments
02.2	(amount of D =) 0.15 (mol)	1	
	(amount of E =) 0.10 (mol)	1	

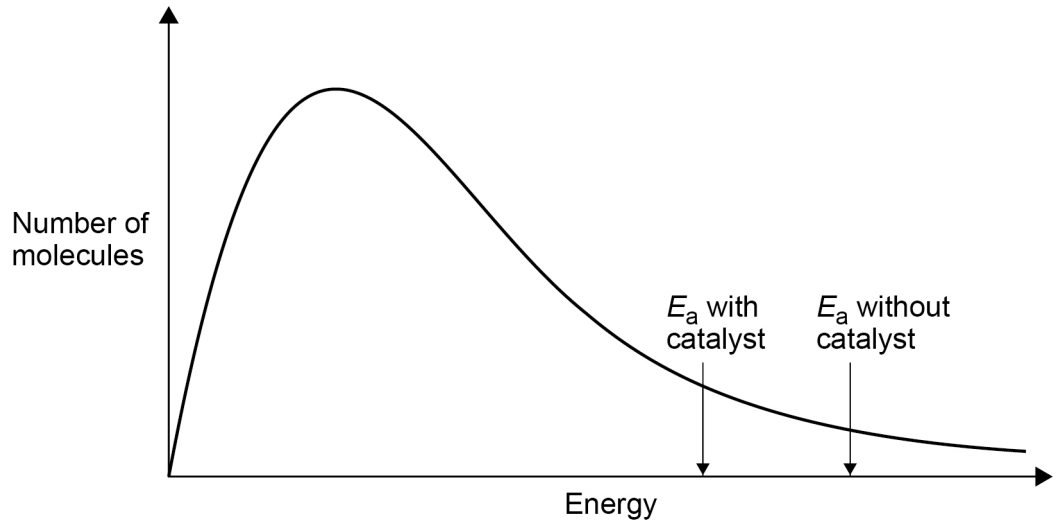
Question	Marking guidance	Mark	Comments
02.3	$(K_c =) \frac{[F]}{[D] [E]^2}$	1	
	$[E]^2 = \frac{0.4}{0.8 \times 4.2} (= 0.119)$	1	
	$E = 0.345$	1	allow 0.35

Question	Marking guidance	Mark	Comments
02.4	K_c stays the same	1	

Question	Marking guidance	Mark	Comments
02.5	colour becomes more blue	1	

Question	Marking guidance	Mark	Comments
02.6	forward reaction is exothermic	1	allow backwards reaction/reaction to left is endothermic
	equilibrium moves to left or less F produced	1	
	to minimise the temperature increase or to oppose the increase in temperature	1	allow to decrease the temperature

Total		12	
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Question	Marking guidance	Mark	Comments
03.1	 E_a with <u>and</u> E_a without catalyst marked on Figure 1 catalyst provides an alternative route (with a lower activation energy) so more particles have $E > E_a$ increasing the number of successful collisions <u>in a given time</u> or increasing the <u>frequency</u> of successful collisions	1 1 1 1	

Question	Marking guidance	Mark	Comments
03.2	less reactant available (to collide with catalyst)	1	allow fewer collisions (between reactants)
	frequency of collisions decreases or number of successful collisions in a given time decreases	1	

Question	Marking guidance	Mark	Comments
03.3	increasing temperature has a very large effect on the number of particles with $E > E_a$	1	do not accept no effect
	increasing the concentration has a small / negligible effect on the number of particles with $E > E_a$	1	

Total		8	
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Question	Marking guidance	Mark	Comments
04.1	$\text{CH}_2=\text{CH}_2 + \frac{1}{2} \text{O}_2 \rightarrow \text{C}_2\text{H}_4\text{O}$ or $\text{CH}_2=\text{CH}_2 + \frac{1}{2} \text{O}_2 \rightarrow \begin{array}{c} \text{O} \\ \diagup \quad \diagdown \\ \text{H}_2\text{C} \text{---} \text{CH}_2 \end{array}$	1	allow displayed / skeletal formulae allow multiples ignore state symbols

Question	Marking guidance	Mark	Comments
04.2	(approx.) 60° ring is strained	1 1	allow considerable repulsion between bonding pairs

Question	Marking guidance	Mark	Comments
04.3	Reaction mechanism for the acid-catalyzed ring-opening of ethylene oxide with methanol: Step 1: Ethylene oxide reacts with H^+ to form a protonated intermediate (oxiranium ion). An arrow from a lone pair on oxygen to H^+ is shown. The intermediate has a positive charge on oxygen and a hydrogen atom bonded to it. An arrow from the C–O bond to the oxygen is labeled M1. Step 2: Methanol ($\text{H}_3\text{C}-\ddot{\text{O}}\text{H}$) attacks the oxiranium ion. An arrow from a lone pair on the methanol oxygen to one of the carbons of the oxiranium ring is shown. The resulting intermediate has a positive charge on oxygen and a hydrogen atom bonded to it. An arrow from the O–H bond to the oxygen is labeled M2. Step 3: The final products are H^+, $\text{HO}-\text{CH}_2-\text{CH}_2-\text{OH}$, and $\text{CH}_3-\text{CH}_2-\text{O}-\text{CH}_2-\text{CH}_3$.	2	M1 + charge on O and arrow from C–O bond to O^+ M2 + charge on O and arrow from O–H bond to O^+ if both charges missed allow 1 mark for both arrows being correct

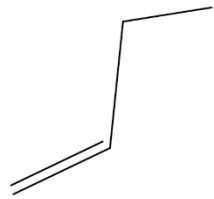
Question	Marking guidance	Mark	Comments
04.4	solvent or surfactant or antifreeze	1	

Total		6	
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Question	Marking guidance	Mark	Comments
05.1	elimination	1	
	conc. H_2SO_4 or conc. H_3PO_4 or Al_2O_3	1	allow name

Question	Marking guidance	Mark	Comments
05.2	$ \begin{array}{cc} \text{CH}_3 & \text{H} \\ & \\ -\text{C} & -\text{C}- \\ & \\ \text{H} & \text{H} \end{array} $	1	must show trailing bonds ignore brackets ignore n

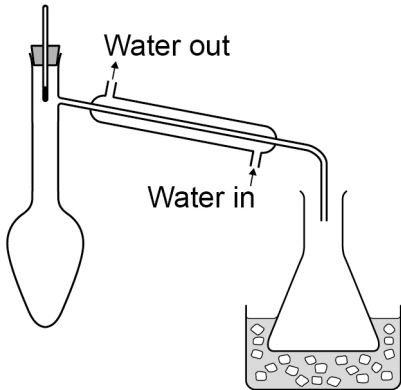
Question	Marking guidance	Mark	Comments
05.3	polymer has higher melting (or boiling) point or more viscous or polymer is a solid at room temperature	1	allow higher density
	polymer is unreactive	1	allow inert

Question	Marking guidance	Mark	Comments
05.4		1	must be skeletal

Question	Marking guidance	Mark	Comments
05.5	plasticiser separates chains or weakens the intermolecular forces between chains	1 1	allow forces the chains apart

Total		8	
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Question	Marking guidance	Mark	Comments
06.1	acidified potassium dichromate(VI) or acidified $\text{K}_2\text{Cr}_2\text{O}_7$	1	must be acidified allow H^+ allow named acid but not ethanoic acid allow acidified KMnO_4

Question	Marking guidance	Mark	Comments
06.2		2	M1 an attempt to draw apparatus for (fractional) distillation which includes a condenser allow diagram with no thermometer if sealed at the top ignore any fractionating column between the flask and still head M2 suitable drawing of distillation apparatus with condenser attached to side of distillation head • as this is a cross-section, there should be a continuous flow through the diagram from the flask to the end of the open condenser (there should be no lines drawn across implying a seal of any sort) • condenser must have outer tube for water that is sealed at the ends but have two openings for water in/out (that are open) • water in/out must be labelled • condenser must have downwards slope • condenser must be open at each end • there must be no gaps at joints between apparatus where vapour could escape • there must be some opening to the system at the collection end

Question	Marking guidance	Mark	Comments
06.3	to reduce the evaporation of propanal	1	allow prevents evaporation of propanal allow to ensure all (propanal) vapour condenses

Question	Marking guidance	Mark	Comments
06.4	$n(\text{propan-1-ol}) (= \frac{5.00 \times 0.803}{60.0}) = 0.0669 \text{ mol}$	1	
	max mass of propanal = $0.0669 \times 58.0 = 3.88 \text{ g}$	1	M2 = M1 × 58.0
	% yield ($= \frac{2.68}{3.88} \times 100$) = 69.1 %	1	answer must be to 3 sig figs $M3 = \frac{2.68}{M2} \times 100$
	alternative approach		
	$n(\text{propan-1-ol}) (= \frac{5.00 \times 0.803}{60.0}) = 0.0669 \text{ mol}$ $n(\text{propanal}) (= \frac{2.68}{58.0}) = 0.0462 \text{ mol}$ % yield ($= \frac{0.0462}{0.0669} \times 100$) = 69.1 %		

Question	Marking guidance	Mark	Comments
06.5	there should be no absorption between 2500-3000 cm ⁻¹	1	

Question	Marking guidance	Mark	Comments
06.6	the reaction should be carried out under reflux or with vertical condenser	1	allow description of vertical condenser
	to ensure complete oxidation	1	

Total		10	
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Question	Marking guidance	Mark	Comments
07.1	$\text{C}_6\text{H}_{12} + 9 \text{O}_2 \rightarrow 6 \text{CO}_2 + 6 \text{H}_2\text{O}$	1	allow multiples
	$n \text{C}_6\text{H}_{12} (= \frac{5.6}{84.0}) = 0.0667 \text{ mols}$	1	
	mass $\text{CO}_2 (= 0.0667 \times 6 \times 44) = 17.6 \text{ (g)}$	1	allow 18 (g) $M3 = M2 \times 6 \times 44$

Question	Marking guidance	Mark	Comments
07.2	$\text{C}_8\text{H}_{18} \rightarrow \text{C}_3\text{H}_6 + \text{C}_5\text{H}_{12}$	1	
	high temperature or high pressure	1	allow temperature between 500–1500 K or 227–1227 °C allow pressure between 1000–7000 kPa

Question	Marking guidance	Mark	Comments
07.3	bromine (water) or $\text{Br}_2(\text{aq})$	1	
	decolourises or orange to colourless	1	

[illegible]

Question	Marking guidance	Mark	Comments
08.1	functional group	1	do not accept positional

Question	Marking guidance	Mark	Comments
08.2	Tollens' or silver nitrate in aqueous ammonia	1	allow correct formulae for reagents if reagent is incomplete mark on
	silver mirror or silver ppt	1	
	no visible change or remains colourless	1	do not accept nothing or no observation allow no reaction
	alternative reagent		
	Fehling's reagent (1)		allow Benedict's solution
	(brick) red ppt (1)		
	no visible change or remains blue (1)		
	alternative reagent		
	acidified potassium dichromate(VI) or acidified $K_2Cr_2O_7$ (1)		
	orange to green (1)		
	no visible change or remains orange (1)		

Question	Marking guidance	Mark	Comments
08.3	72	1	

Question	Marking guidance	Mark	Comments
08.4	3230-3550 (cm ⁻¹) or 1620-1680 (cm ⁻¹)	1	

Total		6	
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