



GCE

Chemistry A

H032/02: Depth in chemistry

AS Level

Mark Scheme for June 2023

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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MARKING INSTRUCTIONS**PREPARATION FOR MARKING****RM ASSESSOR**

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Online Training*; *OCR Essential Guide to Marking*.
2. Make sure that you have read and understood the mark scheme and the question paper for this unit.
3. Log-in to RM Assessor and mark the **required number** of practice responses (“scripts”) and the **required number** of standardisation responses.

MARKING

1. Mark strictly to the mark scheme.
2. Marks awarded must relate directly to the marking criteria.
3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.
4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the RM Assessor messaging system.

5. Work crossed out:

Crossed Out Responses

Where a candidate has crossed out a response and provided a clear alternative then the crossed out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed out response where legible.

Rubric Error Responses – Optional Questions

Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. Enter a mark for each question answered into RM assessor, which will select the highest mark from those awarded. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

Multiple Choice Question Responses

When a multiple choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).

When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses

When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only **one mark per response**)

Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth **two or more marks**)

If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space.)

Longer Answer Questions (requiring a developed response)

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Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.

7. There is a NR (No Response) option. Award NR (No Response)
 - if there is nothing written at all in the answer space
 - OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
 - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question.

Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The RM Assessor **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

If you have any questions or comments for your Team Leader, use the phone, the RM Assessor messaging system, or email.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by **levels of response**:

Read through the whole answer from start to finish, using the Level descriptors to help you decide whether it is a strong or weak answer. The indicative scientific content in the Guidance column indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance. Using a 'best-fit' approach based on the skills and science content evidenced within the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer.

Once the level is located, award the higher or lower mark:

The higher mark should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met.

The lower mark should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing.

In summary:

The skills and science content determines the level.

The communication statement determines the mark within a level.

Level of response questions on this paper are **3a and 4b(ii)**.

The only annotation on a level of response question should be the indication of the level.

A level annotation should be used where all marks for a level have been achieved e.g. a candidate has 6 marks, so they would have this annotation on their script:

L3

If a candidate has achieved 5 marks then they have reached Level 3 but with one mark omitted. They should have the following annotations on their scripts:

L3 















The same principle should be applied to Level 2 and Level 1.

No marks (0) should have a cross: 

Place the annotations alongside the mark for the question.

On additional pages, annotate using 

11. Annotations available in RM Assessor

Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
	Benefit of doubt given
	Contradiction
	Rounding error
	Error in number of significant figures
	Error carried forward
	Level 1
	Level 2
	Level 3
	Benefit of doubt not given
	Noted but no credit given
	Ignore

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12. Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
()	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

13. Subject-specific Marking Instructions

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

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Question			Answer				Marks	AO element	Guidance							
1	(a)	(i)	<p>FIRST CHECK ANSWER ON ANSWER LINE If answer = 47.92 (to 2 DP) seen award 2 marks</p> <p>$(46 \times 8.3) + (47 \times 7.4) + (48 \times 73.7) + (49 \times 5.4) + (50 \times 5.2)$ OR $381.8 + 347.8 + 3537.6 + 246.6 + 260$ OR $4791.8 \checkmark$</p> <p>$4791.8/100$ $= 47.92 \checkmark$ 2DP required</p>				2	AO2.2 AO1.1	ALLOW one mark for ECF from seen incorrect sum provided final answer between 46 and 50 and to 2 DP							
		(ii)	<p>$(1s^2)2s^22p^63s^23p^63d^24s^2 \checkmark$</p> <p>Look carefully at $(1s^2)2s^22p^63s^23p^6$ – there may be a mistake</p>				1	AO1.1	<p>ALLOW subscripts</p> <p>ALLOW 4s before 3d <i>i.e.</i> $(1s^2)2s^22p^63s^23p^64s^23d^2$</p> <p>ALLOW upper case D, etc and subscripts, e.g.3S₂3P⁶</p> <p>DO NOT ALLOW [Ar] as shorthand for $1s^22s^22p^63s^23p^6$</p>							
		(iii)	<table border="1"> <thead> <tr> <th></th> <th>Protons</th> <th>Neutrons</th> <th>Electrons</th> </tr> </thead> <tbody> <tr> <td>${}^{48}\text{Tl}^{2+}$</td> <td>22</td> <td>26</td> <td>20</td> </tr> </tbody> </table>		Protons	Neutrons	Electrons	${}^{48}\text{Tl}^{2+}$	22	26	20	✓		1	AO2.1	
	Protons	Neutrons	Electrons													
${}^{48}\text{Tl}^{2+}$	22	26	20													
	(b)	(i)	Titanium (IV) oxide ✓				1	AO2.5	DO NOT ALLOW titanium dioxide							

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Question			Answer	Marks	AO element	Guidance
1	(b)	(ii)	<p>FIRST CHECK ANSWER ON ANSWER LINE If answer = 2.67 kg award 4 marks</p> <p>-----</p> $n(\text{Ti}) = \frac{1000}{47.9} \text{ OR } 20.8768\dots (\text{mol}) \checkmark$ $n(\text{Na}) \text{ for } 72\% \text{ yield} = 20.88 \times 4 \text{ OR } 83.5073\dots (\text{mol}) \checkmark$ $n(\text{Na}) \text{ for } 100\% \text{ yield} = 83.51 \times \frac{100}{72} \text{ OR } 115.98237\dots (\text{mol}) \checkmark$ $\begin{aligned} \text{mass Na} &= 115.98 \times 23.0 &= 2667.659\dots (\text{g}) \\ & &= 2.67 (\text{kg}) \checkmark \\ & &\mathbf{3 \text{ SF AND kg required}} \end{aligned}$	4	AO2.2 × 4	<p>ALLOW ECF throughout TAKE CARE: values shown may be truncated calculator values.</p> <p>Steps can be calculated in any order which will change the intermediate answers. Marks are for the processing of the data.</p> <p>ALLOW 3SF up to calculated value throughout</p> <p>IGNORE rounding errors past 3SF</p> <p>Common Errors for 3 marks: 1.92 (missing yield) 1.38 (yield wrong way round) 0.673 (use of Mr 189.9 for TiCl₄ instead 47.9 for Ti)</p>
		(iii)	<p>Add water AND filter ✓</p> <p>Ti does not dissolve OR NaCl/ does dissolve ✓</p>	2	AO3.3 × 2	<p>ALLOW dissolve in water</p> <p>ALLOW Ti is insoluble OR NaCl is soluble/aqueous</p> <p>ALLOW Ti is the residue OR NaCl is the filtrate</p>

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Question			Answer	Marks	AO element	Guidance
2	(a)	(i)	Equation $\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2 + \text{H}_2$ All formulae and balancing correct ✓ Observation Effervescence/fizzing/bubbles OR Ca/solid disappears/dissolves OR Forms a white ppt/solid ✓	2	AO2.6 AO1.2	ALLOW correct multiples including fractions IGNORE state symbols, even if wrong IGNORE temperature change, pH change or gas formed i.e. must be an observable change. IGNORE turns cloudy DO NOT ALLOW Colour change
		(ii)	More vigorous effervescence/fizzing/bubbling OR Ba/solid disappears/dissolves faster OR White ppt formed less rapidly ✓	1	AO1.2	ORA if clearly references Ca ALLOW AW such as stronger/ rapid/ quicker/ more quickly/ more violent ALLOW less or no ppt (as barium hydroxide is more soluble) Note: Must reference observation not just reaction e.g. more vigorous reaction. IGNORE finishes first IGNORE more bubbles (need idea of rate) IGNORE exothermic
	(b)	(i)	$\text{Ba}(\text{NO}_3)_2(\text{aq}) + \text{Na}_2\text{SO}_4(\text{aq}) \rightarrow \text{BaSO}_4(\text{s}) + 2\text{NaNO}_3(\text{aq})$ Balanced equation ✓ State symbols ✓	2	AO2.5 x2	ALLOW ionic equation $\text{Ba}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$ M2 dependent on M1 IGNORE NaCl balanced on both sides

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Question			Answer	Marks	AO element	Guidance
2	(b)	(ii)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 26.6 % award 4 marks</p> <p>-----</p> $n(\text{BaSO}_4) = \frac{3.28}{233.4} \text{ OR } 0.014053\dots (\text{mol}) \checkmark$ $\text{mass Ba}(\text{NO}_3)_2 = 0.014053\dots \times 261.3$ $\text{OR } 3.672\dots(\text{g}) \checkmark$ $\text{mass NaCl} = 5.00 - 3.672\dots \text{ OR } 1.3279\dots (\text{g}) \checkmark$ $\% \text{ NaCl} = \frac{1.3279 \times 100}{5.00} = 26.6(\%) \quad \mathbf{3 SF} \checkmark$	4	AO3.1 ×3 AO3.2	<p>ALLOW ECF from incorrect equation in 2(b)(i) and throughout</p> <p>ALLOW 3SF up to calculated value throughout</p> <p>IGNORE rounding errors past 3SF</p> <p><i>Calculator:</i> 0.01405312768</p> <p><i>Calculator:</i> 3.672082262</p> <p><i>Calculator:</i> 1.327917738</p> <p>ALLOW ECF for use of calculated mass NaCl e.g. $0.014053\dots \times 58.5 = 0.8221\dots$ to give final % 16.4 to 3SF</p> <p>-----</p> <p>Alternative approach for last 2 marks</p> $\% \text{ Ba}(\text{NO}_3)_2 = \frac{3.672 \times 100}{5.00} = 73.44 \dots \checkmark$ $\% \text{ NaCl} = 100 - 73.44 = 26.6 \% \checkmark$
		(iii)	<p>Silver chloride/AgCl would be produced (as a precipitate) \checkmark</p> <p>(Mass of NaCl) can be calculated from the mass/moles of AgCl \checkmark</p>	2	AO3.4 × 2	<p>ALLOW Chloride reacts to give (white) ppt</p> <p>IGNORE incorrect formula of silver chloride</p> <p>ALLOW equation showing formation of AgCl(s)</p>

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								ALLOW Weigh AgCl and use to calculate %/mass/moles
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Question	Answer	Marks	AO element	Guidance																									
2 (c) (i)	<table border="1"> <tr> <td>Substance</td> <td>Magnesium sulfide</td> <td>Aluminium</td> <td>Silicon</td> <td>Phosphorus trichloride</td> </tr> <tr> <td>Melting point/°C</td> <td>2000</td> <td>660</td> <td>1414</td> <td>-94</td> </tr> <tr> <td>Electrical conductivity</td> <td></td> <td>Good</td> <td>Poor</td> <td></td> </tr> <tr> <td>Type of lattice structure</td> <td>Giant Ionic</td> <td>Giant Metallic</td> <td>Giant Covalent</td> <td>Simple Molecular</td> </tr> <tr> <td></td> <td>✓</td> <td>✓</td> <td>✓</td> <td>✓</td> </tr> </table>	Substance	Magnesium sulfide	Aluminium	Silicon	Phosphorus trichloride	Melting point/°C	2000	660	1414	-94	Electrical conductivity		Good	Poor		Type of lattice structure	Giant Ionic	Giant Metallic	Giant Covalent	Simple Molecular		✓	✓	✓	✓	4	AO1.1 × 2 AO2.1 × 2	ALLOW Simple covalent instead of simple molecular
Substance	Magnesium sulfide	Aluminium	Silicon	Phosphorus trichloride																									
Melting point/°C	2000	660	1414	-94																									
Electrical conductivity		Good	Poor																										
Type of lattice structure	Giant Ionic	Giant Metallic	Giant Covalent	Simple Molecular																									
	✓	✓	✓	✓																									
(ii)	<p>Melting points</p> <p>MgS: ionic bonds (between oppositely charged ions) ✓</p> <p>PCl₃: intermolecular forces ✓</p> <p>More energy needed (to separate ions in MgS) OR <u>Strong</u> ionic bonds AND <u>weak</u> intermolecular forces ✓</p> <p>Conductivity Al: mobile/delocalised electrons AND Si: no mobile/delocalised electrons OR no charge carriers OR no mobile ions</p>	4	AO1.1 AO2.1 AO3.1 × 2	<p>ALLOW London forces or permanent dipole dipole interactions</p> <p>ORA answer must be comparative</p> <p>ALLOW ECF from incorrect type of bonding i.e. stronger attraction/more energy</p> <p>IGNORE 'free electrons' for mobile/delocalised electrons</p>																									

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Question	Answer	Marks	AO element	Guidance
3 (a) *	<p><i>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.</i></p> <p>Level 3 (5–6 marks) A comprehensive explanation of relative reactivities of chlorine and iodine AND Uses an appropriate method to calculate volume of seawater allowing for an acceptable error</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3–4 marks) A comprehensive explanation of relative reactivities of chlorine and iodine AND Some attempt at calculation</p> <p>OR Explanation of relative reactivities of chlorine and iodine containing most details AND A reasonable attempt at calculation</p> <p>OR Explanation of relative reactivities of chlorine and iodine containing some details AND Uses an appropriate method to calculate volume of seawater allowing for an acceptable error</p>	6	AO1.1 × 2 AO1.2 × 1 AO2.6 × 3	<p><i>Indicative scientific points may include:</i></p> <p>Explanation of relative reactivities Comparison required throughout</p> <ul style="list-style-type: none"> Chlorine gains electron more easily OR forms negative ion more easily OR attracts an electron (to its outer shell) more easily Because chlorine (atom) is smaller OR outer shell of chlorine less shielded/closer Greater nuclear attraction (on chlorine electrons) ORA <p>IGNORE 'nuclear charge' for 'nuclear attraction'</p> <p>Determination of volume of seawater</p> <ul style="list-style-type: none"> $\text{Cl}_2(\text{g}) + 2\text{I}^-(\text{aq}) \rightarrow \text{I}_2(\text{aq}) + 2\text{Cl}^-(\text{aq})$ OR molar ratio $\text{I}^- : \text{I}_2 = 2:1$ $n(\text{I}_2) = \frac{1 \times 10^6}{253.8} = 3940(.11\dots)$ (mol) $n(\text{KI}) = 3940(.11\dots) \times 2 = 7880.(22\dots)$ (mol) $n(\text{KI})$ in 1 dm³ seawater = $\frac{0.150}{166}$ = $9.036(144\dots) \times 10^{-4}$ (mol) Volume of seawater = $\frac{7880.(22\dots)}{9.036(\dots) \times 10^{-4}}$ = $8.72\dots \times 10^6$ dm³

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Question	Answer	Marks	AO element	Guidance
	<p><i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> <p>Level 1 (1–2 marks) Explanation of relative reactivities of chlorine and iodine containing some details AND Some attempt at the calculation</p> <p>OR Explanation of relative reactivities containing most details</p> <p>OR A reasonable attempt at calculation</p> <p><i>The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.</i></p> <p>0 marks <i>No response or no response worthy of credit.</i></p>			<p>Alternative method:</p> <ul style="list-style-type: none"> $m(\text{KI}) = 7880.(22\dots) \times 166 \text{ (mol)}$ $= 1.308(116627) \times 10^6$ $\text{Volume of seawater} = \frac{1.308(116627) \times 10^6}{0.15}$ $= 8.72\dots \times 10^6 \text{ dm}^3$ <p>Acceptable errors:</p> <p>Volume of seawater obtained from:</p> <ul style="list-style-type: none"> Use of 126.9 to find $n(\text{I}_2)$ giving $1.74\dots \times 10^7$ Missing $\times 2$ ratio giving $4.36\dots \times 10^6$ <p>DO NOT ALLOW for L3 if both errors are present, please note it gives a volume of $8.72\dots \times 10^6 \text{ dm}^3$</p> <p>ALLOW minor slips in rounding, transcription errors, etc throughout</p>

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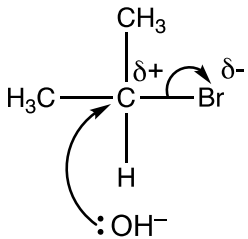
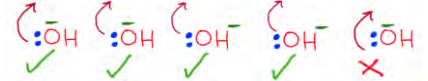
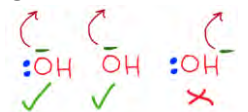

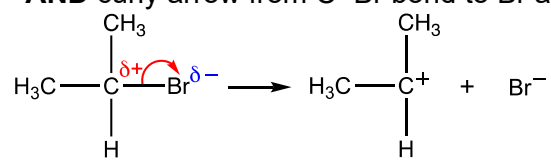
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Question		Answer	Marks	AO element	Guidance
3	(b)	<p>Disproportionation Oxidation AND reduction of same element/chlorine</p> <p>OR Chlorine/Cl/Cl₂ has been oxidised AND chlorine/Cl/Cl₂ has been reduced ✓</p> <p>Oxidation from 0 in Cl₂ to +1 in Ca(OCl)₂ OR ClO⁻ ✓</p> <p>Reduction from 0 in Cl₂ to -1 in CaCl₂ OR Cl⁻ ✓</p>	3	<p>AO1.1</p> <p>AO2.2</p> <p>AO2.2</p>	<p>IGNORE numbers around equation for oxidation numbers</p> <p>IGNORE 'species' or 'reactant' for element</p> <p>ALLOW 1+ for +1 AND 1- for -1</p> <p>NOTE for chlorine/Cl₂ from 0 only needs to be seen once, does not need to be stated twice</p> <p>ALLOW 1 mark for 3 oxidation numbers correct but no mention of words oxidation/reduction: e.g. 0 in Cl₂ AND -1 in CaCl₂ AND +1 in Ca(OCl)₂</p> <p>ALLOW 1 mark for species missing oxidised from 0 to +1 AND reduced (from 0) to -1</p>

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Question	Answer	Marks	AO element	Guidance
3 (c)	<p>Mechanism</p> <p>Curly arrow from OH⁻ to C atom of C–Br bond in 2-bromopropane ✓</p> <p>Dipole shown on C–Br bond, C^{δ+} and Br^{δ-}, AND curly arrow from C–Br bond to Br atom ✓</p>  <p>Name nucleophilic substitution ✓</p> <p>NOTE: Curly arrows can be straight, snake-like, etc. but NOT double headed or half headed arrows</p>	3	AO1.2 AO2.1 AO1.1	<p>1st curly arrow must</p> <ul style="list-style-type: none"> go to the C of C–Br <p>AND</p> <ul style="list-style-type: none"> start from, OR be traced back to any point across width of lone pair on O of OH⁻  <ul style="list-style-type: none"> OR start from – charge on O of OH⁻ ion  <p>(Lone pair NOT needed if curly arrow shown from O⁻)</p> <p>2nd curly arrow must start from, OR be traced back to, any part of C–Br bond and go to Br</p>  <hr/> <p>ALLOW S_N1 mechanism for 2 curly arrow marks</p> <p>First mark Dipole shown on C–Br bond, C^{δ+} and Br^{δ-}, AND curly arrow from C–Br bond to Br atom ✓</p>  <p>Second mark Curly arrow from OH⁻ AND to correct carbocation ✓</p> <p>Curly arrow must come from lone pair on O of HO⁻ OR OH⁻ OR from minus on O of HO⁻ ion (no need to show lone pair if curly came from negative charge) ✓</p>

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Question			Answer				Marks	AO element	Guidance
3	(d)	(i)	<i>Haloalkane</i>	<i>Formula</i>	<i>Colour</i>	✓	2	AO1.1 x 2	ALLOW 1 mark if correct formula for both OR correct colour for both
			<i>2-bromopropane</i>	AgBr	cream				
			<i>2-iodopropane</i>	AgI	yellow				
			Formula AND colour required for each mark						
		(ii)	AgI OR yellow (precipitate forms first)				1	AO2.3	ALLOW (precipitate from) 2-iodopropane ALLOW ECF from incorrect formula or colour ppt from 3(d)(ii) ALLOW C–I bond has a lower bond enthalpy OR C–I bond is longer ORA IGNORE references to bond length, polarity and electronegativity
			AND C–I bond is weaker (than C–Br bond) ✓						

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Question		Answer	Marks	AO element	Guidance
4	(a)	(The enthalpy change) for complete combustion ✓ of 1 mol (of substance)✓	2	AO1.1 × 2	DO NOT ALLOW energy required IGNORE energy released ALLOW combustion in excess oxygen/air OR reacts in excess oxygen OR reacts completely in oxygen ALLOW element OR compound OR reactant DO NOT ALLOW atoms IGNORE standard states/conditions
	(b)	(i) $\frac{2 \times 0.25}{31} \times 100 = 1.6 \% \checkmark$	1	AO2.8	ALLOW 1 d.p. up to calculator value of 1.612903226 correctly rounded

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Question	Answer	Marks	AO element	Guidance
4 (b)* (ii)	<p>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.</p> <p>Level 3 (5–6 marks) Calculates an acceptable value for $\Delta_c H$ AND Evaluates at least two differences from data book value AND suggests at least two suitable improvements.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3–4 marks) Use of results to calculate moles of butan-1-ol AND an attempt to calculate q AND Evaluate at least one difference from data book value AND suggests at least one suitable improvement.</p> <p>OR Calculates an acceptable value for $\Delta_c H$</p> <p><i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> <p>Level 1 (1–2 marks) Attempts to calculate moles of butan-1-ol OR attempts to calculate q AND Evaluate at least one difference from data book value OR suggests at least one suitable improvement.</p>	6	AO2.4 × 2 AO3.1 × 2 AO3.3 AO3.4	<p>Indicative scientific points may include:</p> <p>Calculation of q and n</p> <ul style="list-style-type: none"> mass butan-1-ol burnt = 1.31 g $\Delta T = 31\text{ }^\circ\text{C}$ $q = mc\Delta T = 200 \times 4.18 \times 31 = 259(16)\text{ J OR }25.9(16)\text{ (kJ)}$ $n(\text{butan-1-ol}) = \frac{1.31}{74} = 0.0177(017\dots)\text{ (mol)}$ <p>Calculation of $\Delta_c H$</p> <ul style="list-style-type: none"> $\Delta H = \frac{q}{0.0177017\dots}$ $\Delta H = (-)1460\text{ to }(-)1464\text{ (kJ mol}^{-1}\text{)}$ <p>ALLOW answer in J mol^{-1} if units are given</p> <p>ALLOW a single slip/rounding errors e.g. $M_r = 73$</p> <p>IF no calculation seen check 4(b)(i) /page 10 for any working.</p> <p>Difference from data book value</p> <ul style="list-style-type: none"> Heat losses Incomplete combustion Data book uses standard values Evaporation of alcohol from wick Evaporation of water from beaker <p>Examples of improvements</p> <ul style="list-style-type: none"> Burn in plentiful oxygen Draft shield

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			<p>OR Correct use of results to calculate moles of butan-1-ol AND an attempt to calculate q</p> <p>OR Evaluate at least one difference from data book value AND suggests at least one suitable improvement.</p> <p><i>The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.</i></p> <p>0 marks <i>No response or no response worthy of credit.</i></p>			<ul style="list-style-type: none"> • Copper can in place of beaker • Use a bomb calorimeter • Add lid to beaker • Place cap over wick when not burning • Reduce gap between burner and beaker • Use standard conditions • Use 3 DP balance OR digital thermometer • Heat for longer to reduce % uncertainty in mass/temperature measurements
4	(b)	(iii)	Mass burnt = 0.9825 (g) ✓	1	AO3.4	<p>ALLOW any value from 0.98 to 0.99 g</p> <p>ALLOW ECF from b(ii) i.e. $0.75 \times$ mass change calculated</p> <p>OR $q = 150 \times 4.18 \times 31 = 19437 \text{ J} = 19.4(37) \text{ kJ}$</p> <p>Mass burnt = $\frac{19.4(37)}{\text{calculated } \Delta H} \times 74$</p>

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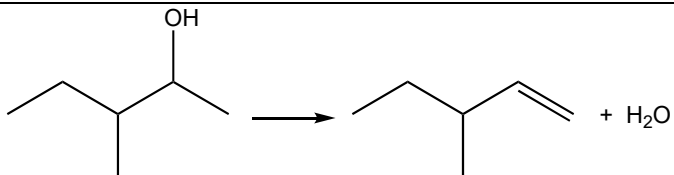
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Question			Answer	Marks	AO element	Guidance
4	(c)	(i)	<p>FIRST, CHECK ANSWER ON ANSWER LINE IF bond enthalpy = (+)805 (kJ mol⁻¹) award 4 marks IF bond enthalpy = (+)3220 (kJ mol⁻¹) award 3 marks</p> <p>-----</p> <p><i>Energy for bonds made: (6O-H)</i> 6×464 OR 2784 (kJ) ✓</p> <p><i>Energy for bonds broken:</i> <i>(1 C-C + 5C-H + 1C-O + 1O-H + 3O=O)</i> $347 + (5 \times 413) + 358 + 464 + (3 \times 498)$ OR 347 + 2065 + 358 + 464 + 1494 OR 4728 (kJ) ✓</p> <p><i>4C=O bond enthalpy correctly calculated</i> $-1276 = 4728 - (4C=O + 2784)$ $4C=O \text{ bond enthalpy} = 4728 - 2784 + 1276$ OR (+)3220 (kJ mol⁻¹) ✓</p> <p><i>C=O bond enthalpy correctly calculated</i> $C=O \text{ bond enthalpy} = \frac{3220}{4} = (+)805 \text{ kJ mol}^{-1} \checkmark$</p>	4	AO2.2 ×4	<p>FULL ANNOTATIONS MUST BE USED -----</p> <p>ALLOW ECF throughout</p> <p>IGNORE signs for first 3 marking points</p> <p>Alternative method ALLOW (5O-H) from bonds made if O-H is omitted from bonds broken. Made: 5×464 OR 2320 (kJ) ✓ Broken: $347 + (5 \times 413) + 358 + (3 \times 498)$ OR 4264 (kJ) ✓ $4C=O \text{ bond enthalpy} = 4264 - 2320 + 1276$ $= (+)3220 \text{ (kJ mol}^{-1}\text{)} \checkmark$</p> <p>DO NOT ALLOW – sign</p> <p>COMMON ERRORS for 3 marks -805 (Wrong Sign) (+)718(.25) (Missing C-C) (+)431.5 (Missing 3 x O=O) (+)167 (Incorrect rearrangement)</p>
	(c)	(ii)	<p>Less energy is required to break bonds in methoxymethane ✓</p> <p>Energy released in bond forming is same ✓</p>	2	AO3.2 × 2	<p>ORA ALLOW bonds in methoxymethane are weaker (than in ethanol) IGNORE calculations</p> <p>ALLOW Same bonds being formed</p>

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Question			Answer	Marks	AO element	Guidance
5	(a)	(i)	3-methylpentan-2-ol ✓	1	AO2.1	<p>IGNORE lack of hyphens or addition of commas</p> <p>ALLOW 3-methylpentane-2-ol</p> <p>DO NOT ALLOW</p> <ul style="list-style-type: none"> 2-methylpentan-3-ol 3-methylpent-2-ol 3-methpentan-2-ol 3-methypentan-2-ol 3-methylpentan-2-ol
		(ii)	 <p>Correct structure of organic product ✓</p> <p>Balanced equation ✓</p>	2	AO2.7 × 2	<p>ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous</p> <p>DO NOT ALLOW additional reactants such as H⁺ or [O] in the equation.</p> <p>ALLOW incorrect isomer 3-methylpent-2-ene for balancing mark.</p>

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Question			Answer	Marks	AO element	Guidance
5	(a)	(iii)	<p>Priority groups on same side ✓</p> <p>High(est) priority groups are CH₃CH₂ and CH₃ OR Low(est) priority groups are CH₃ and H ✓</p>	2	AO3.1 × 2	<p>ALLOW suitable alternatives to 'priority' e.g. Groups with highest atomic number or more important groups etc.</p> <p>ALLOW priority groups are both on the top</p> <p>IGNORE references to relative mass of groups, Ar, Mr,</p> <p>ALLOW identification by name e.g. ethyl and methyl, or by circling on the structure.</p> <p>IF 'priority' is not mentioned ALLOW 1 mark for CH₃CH₂ and CH₃ are on same side OR H and CH₃ are on same side</p>

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Question			Answer	Marks	AO element	Guidance
5	(b)	(i)	<p>Section of polymer</p> $ \begin{array}{cccc} \text{OH} & & \text{OH} & \\ & & & \\ \text{CH}_2 & \text{H} & \text{CH}_2 & \text{H} \\ & & & \\ \text{---C---} & \text{C---} & \text{C---} & \text{C---} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array} $ <p style="text-align: right;">✓</p> <p>-----</p> <p>Reason for solubility in water</p> <p><u>OH/alcohol</u> groups form hydrogen bonds <u>with water</u> ✓</p>	2	AO2.5	<p>ALLOW correct structural OR displayed OR skeletal formula.</p> <p>ALLOW alternating side chains i.e.</p> $ \begin{array}{cccc} \text{OH} & & & \text{OH} \\ & & & \\ \text{CH}_2 & \text{H} & \text{H} & \text{CH}_2 \\ & & & \\ \text{---C---} & \text{C---} & \text{C---} & \text{C---} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array} $ <p>IGNORE brackets and use of 'n'</p> <p>IGNORE incorrect connectivity for -CH₂OH DO NOT ALLOW -HO</p> <p>End bonds MUST be shown (solid or dotted)</p> <p>DO NOT ALLOW one repeat unit <i>Question asks for 2 repeat units.</i></p> <p>-----</p> <p>DO NOT ALLOW 'it forms hydrogen bonds'</p>
		(ii)	<p>Any two ✓✓</p> <ul style="list-style-type: none"> Recycled (to make other plastic materials) Combustion to generate energy / electricity 	2	AO1.1 × 2	<p>IGNORE Reused</p> <p>ALLOW Used as a fuel to generate energy / electricity</p>

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Question	Answer	Marks	AO element	Guidance
	<ul style="list-style-type: none">As (organic) feedstock			

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