

**GCE**

**Chemistry A**

**H032/02: Depth in chemistry**

AS Level

**Mark Scheme for June 2023**

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

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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)

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

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

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

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

Question			Answer	Marks	AO element	Guidance
1	(b)	(ii)	<p><b>FIRST CHECK ANSWER ON ANSWER LINE</b>  <b>If answer = 2.67 kg award 4 marks</b></p> <p>-----</p> <p><math>n(\text{Ti}) = \frac{1000}{47.9}</math> <b>OR</b> 20.8768... (mol) ✓</p> <p><math>n(\text{Na})</math> for 72% yield = <math>20.88 \times 4</math> <b>OR</b> 83.5073... (mol) ✓</p> <p><math>n(\text{Na})</math> for 100% yield = <math>83.51 \times \frac{100}{72}</math> <b>OR</b> 115.98237... (mol) ✓</p> <p>mass Na = <math>115.98 \times 23.0</math> = 2667.659... (g)  = 2.67 (kg) ✓  <b>3 SF AND kg required</b></p>	4	AO2.2 × 4	<p><b>ALLOW ECF</b> throughout  <b>TAKE CARE: values shown may be truncated calculator values.</b></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><b>ALLOW 3SF</b> up to calculated value throughout</p> <p><b>IGNORE</b> rounding errors past <b>3SF</b></p> <p><b>Common Errors for 3 marks:</b>  1.92 (missing yield )  1.38 (yield wrong way round)  0.673 (use of Mr 189.9 for <math>\text{TiCl}_4</math> instead 47.9 for Ti)</p>
		(iii)	<p>Add water <b>AND</b> filter ✓</p> <p>Ti does not dissolve <b>OR</b> NaCl/ does dissolve ✓</p>	2	AO3.3 × 2	<p><b>ALLOW</b> dissolve <b>in water</b></p> <p><b>ALLOW</b> Ti is insoluble <b>OR</b> NaCl is soluble/aqueous</p> <p><b>ALLOW</b> Ti is the residue <b>OR</b> NaCl is the filtrate</p>

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

Question			Answer	Marks	AO element	Guidance
2	(b)	(ii)	<p><b>FIRST CHECK THE ANSWER ON ANSWER LINE</b>  <b>If answer = 26.6 % award 4 marks</b></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	<p>AO3.1 ×3</p> <p>AO3.2</p>	<p><b>ALLOW ECF</b> from incorrect equation in 2(b)(i) and throughout</p> <p><b>ALLOW 3SF</b> up to calculated value throughout</p> <p><b>IGNORE</b> rounding errors past <b>3SF</b></p> <p><i>Calculator:</i> 0.01405312768</p> <p><i>Calculator:</i> 3.672082262</p> <p><i>Calculator:</i> 1.327917738</p> <p><b>ALLOW ECF</b> for use of calculated mass NaCl e.g. 0.014053...x 58.5 = 0.8221.... to give final % 16.4 to 3SF</p> <p>-----</p> <p><b>Alternative approach for last 2 marks</b></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) <math>\checkmark</math></p> <p>(Mass of NaCl) can be calculated from the mass/moles of AgCl <math>\checkmark</math></p>	2	AO3.4 × 2	<p><b>ALLOW</b> Chloride reacts to give (white) ppt</p> <p><b>IGNORE</b> incorrect formula of silver chloride</p> <p><b>ALLOW</b> equation showing formation of AgCl(s)</p>

							<b>ALLOW</b> Weigh AgCl and use to calculate %/mass/moles
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Question			Answer					Marks	AO element	Guidance
2	(c)	(i)	Substance	Magnesium sulfide	Aluminium	Silicon	Phosphorus trichloride	4	AO1.1 × 2  AO2.1 × 2	<b>ALLOW</b> Simple covalent instead of simple molecular
			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><b>Melting points</b></p> <p>MgS: ionic bonds (between oppositely charged ions) ✓</p> <p>PCl<sub>3</sub>: intermolecular forces ✓</p> <p>More energy needed (to separate ions in MgS) <b>OR</b> <u>Strong</u> ionic bonds <b>AND</b> <u>weak</u> intermolecular forces ✓</p> <p><b>Conductivity</b> Al: mobile/delocalised electrons <b>AND</b> Si: no mobile/delocalised electrons <b>OR</b> no charge carriers <b>OR</b> no mobile ions</p>					4	AO1.1  AO2.1  AO3.1 × 2	<p><b>ALLOW</b> London forces or permanent dipole dipole interactions</p> <p><b>ORA</b> answer must be comparative</p> <p><b>ALLOW ECF</b> from incorrect type of bonding i.e. stronger attraction/more energy</p> <p><b>IGNORE</b> 'free electrons' for mobile/delocalised electrons</p>

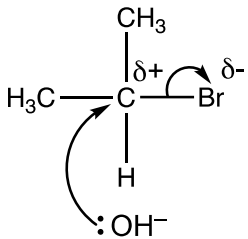
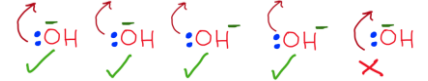
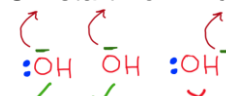

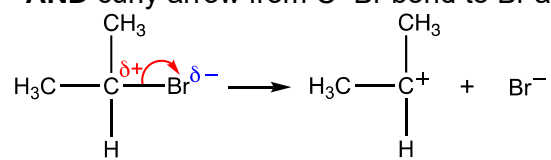
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Question	Answer	Marks	AO element	Guidance
3 (a) *	<p><i>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.</i></p> <p><b>Level 3 (5–6 marks)</b> A comprehensive explanation of relative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



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><b>Level 1 (1–2 marks)</b> Explanation of relative reactivities of chlorine and iodine containing <b>some</b> details <b>AND</b> Some attempt at the calculation</p> <p><b>OR</b> Explanation of relative reactivities containing <b>most</b> details</p> <p><b>OR</b> 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><b>0 marks</b> <i>No response or no response worthy of credit.</i></p>			<p><b>Alternative method:</b></p> <ul style="list-style-type: none"> <li>• <math>m(\text{KI}) = 7880.(22\dots) \times 166 \text{ (mol)}</math> <math>= 1.308(116627) \times 10^6</math></li> <li>•</li> </ul> $\text{Volume of seawater} = \frac{1.308(116627) \times 10^6}{0.15}$ $= 8.72\dots \times 10^6 \text{ dm}^3$ <p><b>Acceptable errors:</b></p> <p>Volume of seawater obtained from:</p> <ul style="list-style-type: none"> <li>• Use of 126.9 to find <math>n(\text{I}_2)</math> giving <math>1.74\dots \times 10^7</math></li> <li>• Missing <math>\times 2</math> ratio giving <math>4.36\dots \times 10^6</math></li> </ul> <p><b>DO NOT ALLOW</b> for L3 if both errors are present, please note it gives a volume of <math>8.72\dots \times 10^6 \text{ dm}^3</math></p> <p><b>ALLOW</b> minor slips in rounding, transcription errors, etc throughout</p>

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

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

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

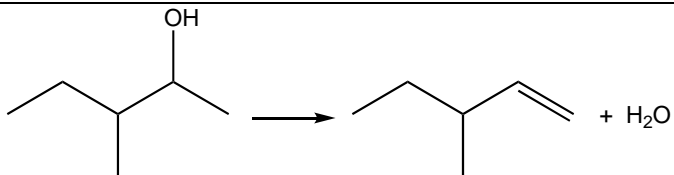
Question		Answer	Marks	AO element	Guidance
4	(a)	(The enthalpy change) for complete combustion ✓  of 1 mol (of substance)✓	2	AO1.1 × 2	<b>DO NOT ALLOW</b> energy required  <b>IGNORE</b> energy released  <b>ALLOW</b> combustion in excess oxygen/air <b>OR</b> reacts in excess oxygen <b>OR</b> reacts completely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

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><b>Level 3 (5–6 marks)</b> Calculates an acceptable value for <math>\Delta_c H</math> <b>AND</b> Evaluates at least two differences from data book value <b>AND</b> 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><b>Level 2 (3–4 marks)</b> Use of results to calculate moles of butan-1-ol <b>AND</b> an attempt to calculate <math>q</math> <b>AND</b> Evaluate at least one difference from data book value <b>AND</b> suggests at least one suitable improvement.</p> <p><b>OR</b> Calculates an acceptable value for <math>\Delta_c H</math></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><b>Level 1 (1–2 marks)</b> Attempts to calculate moles of butan-1-ol <b>OR</b> attempts to calculate <math>q</math> <b>AND</b> Evaluate at least one difference from data book value <b>OR</b> 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><b>Calculation of <math>q</math> and <math>n</math></b></p> <ul style="list-style-type: none"> <li>mass butan-1-ol burnt = 1.31 g</li> <li><math>\Delta T = 31\text{ }^\circ\text{C}</math></li> <li><math>q = mc\Delta T = 200 \times 4.18 \times 31 = 259(16)\text{ J OR }25.9(16)\text{ (kJ)}</math></li> <li><math>n(\text{butan-1-ol}) = \frac{1.31}{74} = 0.0177(017\dots)\text{ (mol)}</math></li> </ul> <p><b>Calculation of <math>\Delta_c H</math></b></p> <ul style="list-style-type: none"> <li><math>\Delta H = \frac{q}{0.0177017\dots}</math></li> <li><math>\Delta H = (-)1460\text{ to }(-)1464\text{ (kJ mol}^{-1}\text{)}</math></li> </ul> <p><b>ALLOW</b> answer in <math>\text{J mol}^{-1}</math> if units are given</p> <p><b>ALLOW</b> a single slip/rounding errors e.g. <math>M_r = 73</math></p> <p><b>IF</b> no calculation seen check <b>4(b)(i) /page 10</b> for any working.</p> <p><b>Difference from data book value</b></p> <ul style="list-style-type: none"> <li>Heat losses</li> <li>Incomplete combustion</li> <li>Data book uses standard values</li> <li>Evaporation of alcohol from wick</li> <li>Evaporation of water from beaker</li> </ul> <p><b>Examples of improvements</b></p> <ul style="list-style-type: none"> <li>Burn in plentiful oxygen</li> <li>Draft shield</li> </ul>

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

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



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

Question			Answer	Marks	AO element	Guidance
5	(a)	(iii)	<p>Priority groups on same side ✓</p> <p>High(est) priority groups are CH<sub>3</sub>CH<sub>2</sub> and CH<sub>3</sub>  <b>OR</b>            Low(est) priority groups are CH<sub>3</sub> and H ✓</p>	2	AO3.1 × 2	<p><b>ALLOW</b> suitable alternatives to 'priority' e.g. Groups with highest atomic number or more important groups etc.</p> <p><b>ALLOW</b> priority groups are both on the top</p> <p><b>IGNORE</b> references to relative mass of groups, Ar, Mr,</p> <p><b>ALLOW</b> identification by name e.g. ethyl and methyl, or by circling on the structure.</p> <p><b>IF</b> 'priority' is not mentioned <b>ALLOW</b> 1 mark for CH<sub>3</sub>CH<sub>2</sub> and CH<sub>3</sub> are on same side <b>OR</b> H and CH<sub>3</sub> are on same side</p>

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

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

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