

GCE

Chemistry A

H032/01: Breadth in chemistry

AS Level

Mark Scheme for June 2022

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.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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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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. Award No Response (NR) if:
 - there is nothing written in the answer space

Award Zero '0' if:

- anything is written in the answer space and is not worthy of credit (this includes text and symbols).
















Team Leaders must confirm the correct use of the NR button with their markers before live marking commences and should check this when reviewing scripts.

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 e-mail.
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: Not applicable in F501
- To determine the level** – start at the highest level and work down until you reach the level that matches the answer
 - To determine the mark within the level**, consider the following

<i>Descriptor</i>	<i>Award mark</i>
On the borderline of this level and the one below	At bottom of level
Just enough achievement on balance for this level	Above bottom and either below middle or at middle of level (depending on number of marks available)
Meets the criteria but with some slight inconsistency	Above middle and either below top of level or at middle of level (depending on number of marks available)
Consistently meets the criteria for this level	At top of level

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
	Blank page

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.

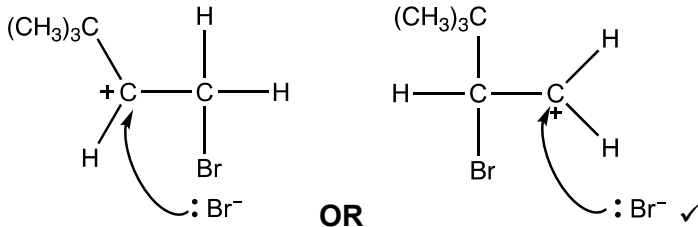
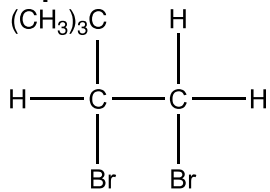
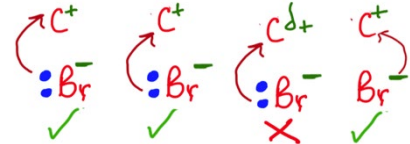
You should ensure that you have copies of these materials.

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.

SECTION A

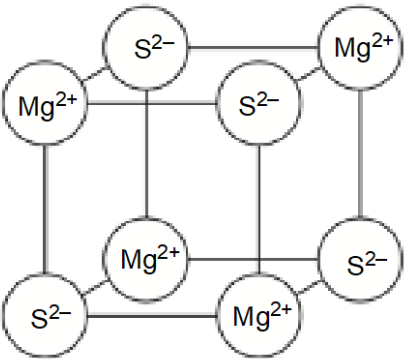
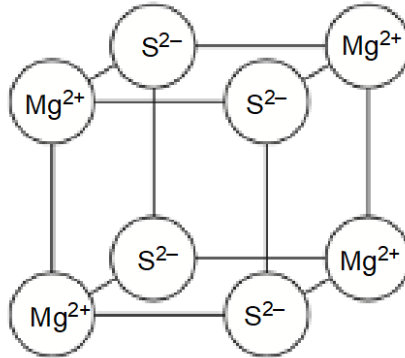
Question	Answer	Marks	AO element	Guidance
1	B	1	AO1.1	
2	A	1	AO1.1	
3	D	1	AO1.1	
4	C	1	AO2.1	ALLOW 7
5	D	1	AO1.2	ALLOW Ar
6	B	1	AO2.1	
7	C	1	AO2.2	
8	B	1	AO2.4	
9	D	1	AO2.6	
10	D	1	AO1.1	
11	A	1	AO2.2	
12	D	1	AO1.1	
13	A	1	AO2.6	
14	D	1	AO1.2	ALLOW 9
15	C	1	AO1.2	ALLOW 12
16	D	1	AO2.6	
17	D	1	AO1.2	
18	B	1	AO1.1	
19	A	1	AO2.5	
20	C	1	AO2.5	
	Total	20		

Question	Answer	Marks	AO element	Guidance
	<p>3rd curly arrow Correct carbocation with + charge on C with 3 bonds AND curly arrow from Br⁻ to C⁺ of carbocation</p> <p>DO NOT ALLOW δ⁺ on C of carbocation</p>  <p style="text-align: center;">OR</p> <p><i>i.e. ALLOW carbonium + on either C atom</i></p> <p>Correct product to match mechanism/intermediate ✓</p>  <p>DO NOT ALLOW half headed or double headed arrows but allow ECF if seen more than once</p> <hr/> <p>Name of mechanism: Electrophilic addition ✓</p>	1	AO2.5 AO2.5 AO1.1	<p>IGNORE connectivity of CH₃ groups in carbocation and product and ALLOW C₄H₉</p> <p>3rd curly arrow must</p> <ul style="list-style-type: none"> • go to the C⁺ of carbocation <p>AND</p> <ul style="list-style-type: none"> • start from, OR be traced back to any point across width of lone pair on :Br⁻ • OR start from – charge on Br⁻ ion  <p><i>(Lone pair NOT needed if curly arrow shown from – charge on Br⁻)</i></p> <p>ALLOW bromonium ion</p> <p>ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous</p> <p>NOTE: For a mechanism with HBr, ALLOW all marks EXCEPT for final product mark</p>
(b) (i)		1		For repeat unit,

Question		Answer	Marks	AO element	Guidance
		$ \begin{array}{c} (\text{CH}_3)_3\text{C} \quad \text{H} \\ \quad \\ \text{---C---C---} \\ \quad \\ \text{H} \quad \text{H} \end{array} $ <p>Correct polymer with side links ✓</p>		AO2.5 ×1	<ul style="list-style-type: none"> • 'side bonds' required on either side of repeat unit from C atoms • ALLOW more than one repeat unit • ALLOW C₄H₉ for C(CH₃)₃ <p>IGNORE brackets</p> <ul style="list-style-type: none"> • IGNORE <i>n</i> <p>IGNORE connectivity of C(CH₃)₃ group</p>
(b)	(ii)	<p>Advantage: Energy/electricity (produced)</p> <p>AND</p> <p>Disadvantage: CO₂ produced OR gases causing global warming/climate change OR greenhouse gases, e.g CO₂</p> <p>BOTH advantage and disadvantage ✓</p>	1	AO1.1 ×1	<p>ALLOW reduced use of fossil fuels</p> <p>IGNORE produced CO₂ and H₂O</p> <p>ALLOW less landfill / less harm to wildlife or environment (<i>not just harmful</i>)</p> <p>ALLOW toxic/poisonous (waste) products/gases, e.g. CO</p> <p>IGNORE harmful/dangerous</p>

Question		Answer	Marks	AO element	Guidance																		
22	(a)	<p>FIRST CHECK ANSWER ON THE ANSWER LINE IF answer = 190.47 (to 2 DP) award 2 marks</p> $\frac{(188 \times 12.13) + (189 \times 16.75) + (190 \times 27.23) + (192 \times 43.89)}{100}$ <p>OR 190.4677 OR 190.468 ✓ = 190.47 (to 2 DP) ✓</p>	2	AO1.2 ×2	<p>For 1 mark: ALLOW ECF → to 2 DP if:</p> <ul style="list-style-type: none"> %s used with wrong isotopes ONCE <p>OR</p> <ul style="list-style-type: none"> transposed decimal places for ONE % 																		
	(b)	<table border="1"> <thead> <tr> <th>Element</th> <th>Mass number</th> <th>Protons</th> <th>Neutrons</th> <th>Electrons</th> <th>Charge</th> </tr> </thead> <tbody> <tr> <td>Ni</td> <td>62</td> <td>28</td> <td>34</td> <td>1s²2s²2p⁶3s²3p⁶3d⁸4s²</td> <td>0 ✓</td> </tr> <tr> <td>P</td> <td>33</td> <td>15</td> <td>18</td> <td>1s²2s²2p⁶3s²3p⁶</td> <td>3- ✓</td> </tr> </tbody> </table> <p>Mark by row</p>	Element	Mass number	Protons	Neutrons	Electrons	Charge	Ni	62	28	34	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ⁸ 4s ²	0 ✓	P	33	15	18	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶	3- ✓	2	AO1.2 ×2	<p><i>Easiest to check element first</i> ALLOW P³⁻ ALLOW names for elements</p> <p>IGNORE charges with element in 1st column, even if wrong.</p> <p>For electron configuration, ALLOW 4s² before 3d⁸ i.e. 1s²2s²2p⁶3s²3p⁶4s²3d⁸</p> <p>ALLOW upper case D, etc and subscripts, e.g.4S₂3D₁</p> <p>ALLOW [Ar]3d⁸4s²</p>
Element	Mass number	Protons	Neutrons	Electrons	Charge																		
Ni	62	28	34	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ⁸ 4s ²	0 ✓																		
P	33	15	18	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶	3- ✓																		

Question	Answer	Marks	AO element	Guidance
(c)	<p>Molar ratios</p> $\begin{array}{cccc} \text{Zn} & : & \text{H} & : & \text{N} & : & \text{O} \\ = & \frac{21.99}{65.4} & : & \frac{4.04}{1.0} & : & \frac{9.41}{14.0} & : & \frac{64.56}{16.0} \end{array}$ <p>OR 0.336 : 4.04 : 0.672 : 4.04 OR 1 : 12 : 2 : 12 ✓</p> <p>Empirical formula $\text{ZnH}_{12}\text{N}_2\text{O}_{12}$ ✓ Any order</p> <p>With water of crystallisation $\text{ZnN}_2\text{O}_6 \cdot 6\text{H}_2\text{O}$ OR $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ ✓</p> <hr style="border-top: 1px dashed black;"/> <p>Inverse fractions → NO MARKS</p>	3	AO1.2 ×2 AO2.2 ×1	<p>NOTE: If only the correct answer of $\text{ZnN}_2\text{O}_6 \cdot 6\text{H}_2\text{O}$ OR $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ is seen with no working, award 1 mark only</p> <p>ALLOW ECF from incorrect molar ratios of Zn : H : N : O e.g. from use of atomic number(s)</p> <p>ALLOW $\text{Zn}(\text{NO}_3)_2(\text{H}_2\text{O})_6$</p> <p>ALLOW ECF from incorrect empirical formula e.g. $\text{ZnNO}_3 \cdot 3\text{H}_2\text{O}$ from ZnH_6NO_6</p>

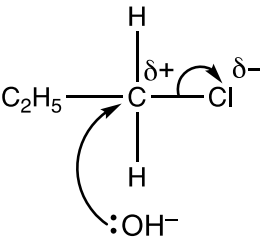
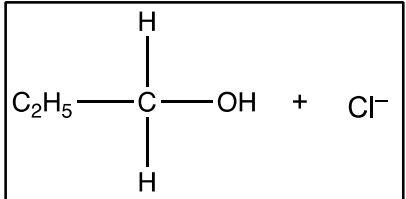
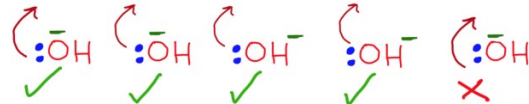
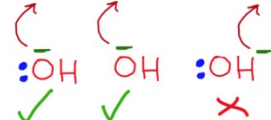

Question			Answer	Marks	AO element	Guidance
23	(a)	(i)	(Electrostatic) attraction between oppositely charged OR + and – ions ✓	1	AO1.1 ×1	Attraction is essential IGNORE references to metal and non-metal
		(ii)	 <p>Mg²⁺ shown alternately in FOUR circles ✓</p> <p>S²⁻ shown alternately in FOUR circles ✓</p>	2	AO1.2 ×2	<p>ALLOW labels if seen outside circles provided it clear which circle the label applies to</p> <p>ALLOW 1 mark for Mg AND S shown alternately, each in FOUR circles <i>i.e. with no charges or incorrect charges</i></p> <p>ALLOW 1 mark for 2+/-+2 AND 2-/-2 shown alternately in FOUR circles (with no Mg and S)</p> <p>DO NOT ALLOW All circles with same ion, <i>i.e. all Mg²⁺ OR all S²⁻</i></p> <p>ALLOW 1 mark for 4 Mg²⁺ AND 4S²⁻ but NOT shown alternately <i>e.g.</i></p>  <p style="text-align: right;">✓</p>

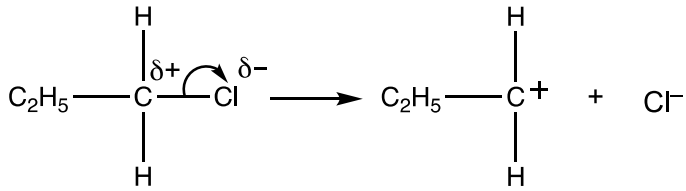
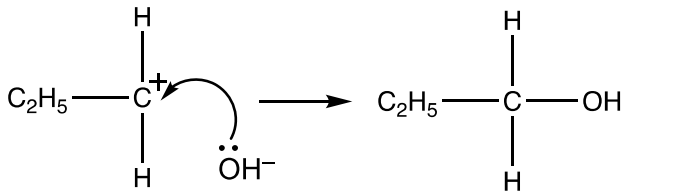
Question		Answer	Marks	AO element	Guidance												
	(b)	<table border="1"> <thead> <tr> <th>Name of oxyanion</th> <th>Ionic charge</th> <th>Formula of oxyanion</th> </tr> </thead> <tbody> <tr> <td>Bromate(III) ✓</td> <td>1-</td> <td>BrO₂⁻</td> </tr> <tr> <td>Sulfate(VI)</td> <td>2-</td> <td>SO₄²⁻</td> </tr> <tr> <td>Phosphate(V)</td> <td>3-</td> <td>PO₄³⁻ ✓</td> </tr> </tbody> </table>	Name of oxyanion	Ionic charge	Formula of oxyanion	Bromate(III) ✓	1-	BrO ₂ ⁻	Sulfate(VI)	2-	SO ₄ ²⁻	Phosphate(V)	3-	PO ₄ ³⁻ ✓	2	AO3.1 ×2	ALLOW PO ₄ ⁻³
Name of oxyanion	Ionic charge	Formula of oxyanion															
Bromate(III) ✓	1-	BrO ₂ ⁻															
Sulfate(VI)	2-	SO ₄ ²⁻															
Phosphate(V)	3-	PO ₄ ³⁻ ✓															
	(c)	<p>Structure Giant ✓</p> <p>Bonding Metallic (bonding) ✓</p> <p>Particles 2+ /Ca²⁺ ions and delocalised electrons ✓</p> <p>Conductivity (Delocalised) electrons move/flow ✓ Idea of movement required</p> <p>Delocalised can be seen anywhere</p>	4	AO1.1 ×4	<p>ALLOW marks from labelled diagram</p> <p>'Giant metallic' gains BOTH structure and bonding marks</p> <p>ALLOW attraction between cations and electrons Attraction between nucleus and electrons is CON</p> <p>Watch for 'metallic' being CONNed within overall response</p> <p>ALLOW charge flows ONLY when linked to electrons</p> <p>IGNORE electrons carry charge IGNORE electrons are free BUT ALLOW mobile electrons carry charge</p>												

Question			Answer	Marks	AO element	Guidance
24	(a)	(i)	Oxidation and reduction of the same element ✓ 'Atom' is insufficient for element	1	AO1.1 ×1	ALLOW 'chlorine' OR 'Cl' for same element IGNORE 'species' for 'element'
		(ii)	Equation $\text{Cl}_2 + 2\text{NaOH} \rightarrow \text{NaClO} + \text{NaCl} + \text{H}_2\text{O}$ ✓ Redox: Cl is oxidised from 0 (in Cl ₂) to +1 in NaClO ✓ Cl is reduced from 0 (in Cl ₂) to -1 in NaCl/HCl ✓ IGNORE oxidation numbers shown in equation (<i>treat as rough working</i>) BUT If no oxidation numbers in explanation, <i>look at equation for oxidation numbers</i>	3	AO2.6 ×1 AO2.1 ×2	DO NOT ALLOW $\text{Cl}_2 + \text{NaOH} \rightarrow \text{NaClO} + \text{HCl}$ ALLOW ECF from HCl in equation ALLOW 1 out of 2 redox marks if NaClO AND NaCl omitted, i.e. Cl is oxidised from 0 to +1 AND Cl is reduced from 0 to -1 ALLOW 1 out of 2 redox marks if oxidation number changes are BOTH correct ... BUT reduction/oxidation is incorrectly assigned, i.e. Cl is reduced from 0 (in Cl ₂) to +1 in NaClO Cl is oxidised from 0 (in Cl ₂) to -1 in NaCl/HCl ----- General: ALLOW number before sign in ox no, i.e. 1+ for +1 1- for -1 IGNORE ionic charges, e.g. Cl ¹⁺ IGNORE '1' (signs required) IGNORE references to electron loss/gain (even if wrong)

Question			Answer	Marks	AO element	Guidance
25	(a)	(i)	<p>FIRST, CHECK THE ANSWER ON ANSWER LINE IF $\Delta_r H = -116$ (kJ mol⁻¹) award 4 marks IF $\Delta_r H = +116$ (kJ mol⁻¹) award 3 marks</p> <p>-----</p> <p>Energy released in J OR kJ $= 75.0 \times 4.18 \times 18.5 = 5799.75$ (J) OR 5.79975 (kJ) ✓</p> <p>Correctly calculates $n(\text{Ba}(\text{OH})_2)$ OR $n(\text{HNO}_3)$ $n(\text{Ba}(\text{OH})_2) = 2 \times \frac{25.0}{1000} = 0.05(00)$ (mol) OR $n(\text{HNO}_3) = 2 \times \frac{50.0}{1000} = 0.1(00)$ (mol) ✓</p> <p>ΔH per mole $\text{Ba}(\text{OH})_2$ in J OR kJ Answer <i>MUST</i> divide energy by $n(\text{Ba}(\text{OH})_2)$ OR $2 \times n(\text{HNO}_3)$</p> <p>$\pm \frac{5799.75}{0.05}$ OR $\pm 2 \times \frac{5799.75}{0.1} = \pm 115995$ (J) OR $\pm \frac{5.79975}{0.05}$ OR $\pm 2 \times \frac{5.79975}{0.1} = \pm 115.995$ (kJ) ✓</p> <p>ΔH in kJ mol⁻¹ to 3 SF AND – sign $\Delta_r H = -116$ (kJ mol⁻¹) ✓</p>	4		<p>ANNOTATE ANSWER WITH TICKS AND CROSSES</p> <p>-----</p> <p>AO2.4 ALLOW 5799.8 OR 5800 J OR 5.7998 OR 5.8 kJ DO NOT ALLOW < 3 SF EXCEPT 5.8 <i>(trailing zeroes)</i></p> <p>IGNORE any sign</p> <p>AO2.4 IGNORE units <i>i.e.</i> ALLOW correctly calculated number in J OR kJ OR no units</p> <p>ALLOW 3SF or more OR use of 5800 J OR 5.8 kJ</p> <p>AO2.8 Sign NOT needed</p> <p>3 SF needed</p> <p>-----</p> <p>AO2.8 Common errors 3 marks</p> <p>$\frac{5799.75}{0.1} \rightarrow -58.0$ no $2 \times$ using 0.1</p> <p>$\frac{5799.75}{0.15} \rightarrow -38.7$ \div by 0.05 + 0.10</p> <p>$2 \times \frac{5799.75}{0.15} \rightarrow -77.3$</p>

Question			Answer	Marks	AO element	Guidance
						<p>2 marks for answers above with wrong sign or not to 3 SF</p> <p>Other multiples by using m as 50 or 25: Mark using same principal Use of 50 → -77.3 3 marks Use of 25 → -38.7 3 marks</p>
		(ii)	<p>Reason for incorrect conclusion neutralisation forms 1 mol H₂O OR $\Delta_r H$ forms 2 mol H₂O ✓</p> <p>Value for $\Delta_{\text{neut}}H = \pm \frac{\text{answer to 25a(i)}}{2}$ (kJ mol⁻¹) ✓ 2 SF or more</p>	2	AO3.2 ×1	<p>H₂O essential</p> <p>IGNORE sign, even if wrong</p> <p>ALLOW 2 SF, e.g. 58</p>

Question	Answer	Marks	AO element	Guidance
26 (a)	<p>Curly arrow from HO⁻ to C atom of C–Cl bond ✓</p> <p>Dipole shown on C–Cl bond, C^{δ+} and Cl^{δ-} AND curly arrow from C–Cl bond to Cl atom ✓</p>  <p>IGNORE presence of Na⁺ but OH⁻ needed i.e. Na⁺OH⁻ can be allowed if criteria met</p> <p>DO NOT ALLOW H₂O instead of OH⁻</p> <hr/> <p>Correct organic product AND Cl⁻ ✓</p> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;">  </div> <p>IGNORE presence of Na⁺ but Cl⁻ needed i.e. Na⁺Cl⁻ can be allowed BUT NaCl does NOT show Cl⁻</p>	3	AO1.2 AO1.2 AO2.5 ×1	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES</p> <p>NOTE: curly arrows can be straight, snake-like, etc. but NOT double headed or half headed arrows</p> <p>1st curly arrow must</p> <ul style="list-style-type: none"> go to C of C–Cl <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–Cl bond and go to Cl</p>  <p>ALLOW ECF NaCl⁻ ONLY from NaOH⁻</p> <hr/>

Question	Answer	Marks	AO element	Guidance
				<p>ALLOW S_N1 mechanism</p> <p>First mark Dipole shown on C–Cl bond, C^{δ+} and Cl^{δ-}, AND curly arrow from C–Cl bond to Cl atom ✓</p>  <p>Second mark Correct carbocation AND curly arrow from HO⁻ to 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> <p>Third mark Correct organic product AND Cl⁻ ✓</p> <p>-----</p>

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