# 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. A*ssistant 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
    a. **To determine the level** – start at the highest level and work down until you reach the level that matches the answer
    b. **To determine the mark within the level**, consider the following

| *Descriptor* | *Award mark* |
|---|---|
| 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.

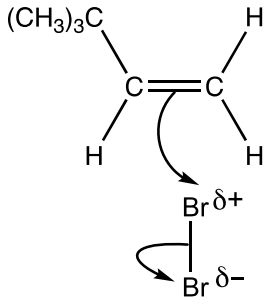
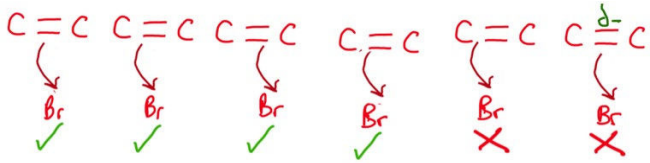
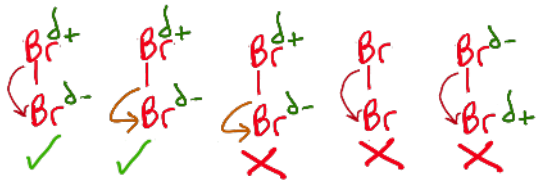
You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New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

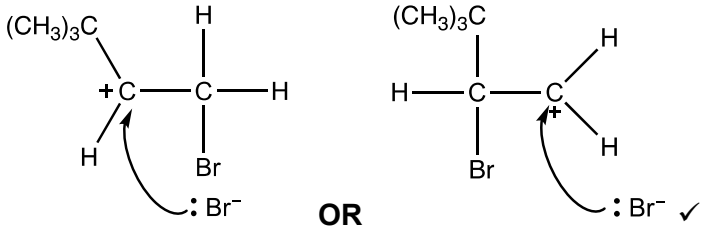
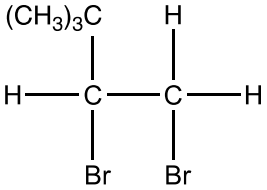
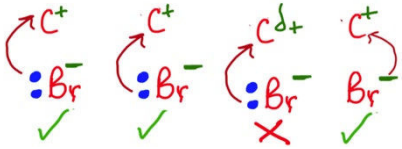
Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

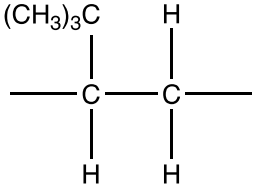
## SECTION A

| 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** | | |

## SECTION B

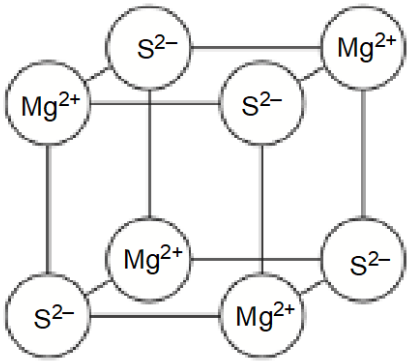
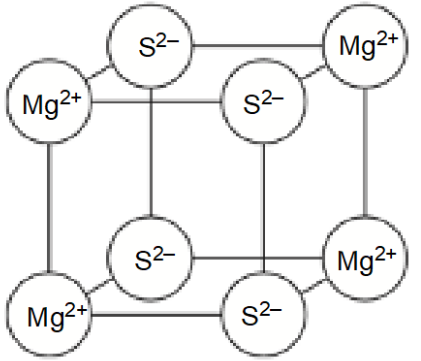
| Question | | | Answer | Marks | AO element | Guidance |
|---|---|---|---|---|---|---|
| 21 | (a) | (i) | 3,3-dimethylbut-1-ene ✓<br><br>**CARE**: Look for **di**methyl | 1 | AO1.2<br>×1 | **IGNORE** lack of hyphens, or addition of commas or spaces<br><br>**ALLOW** full stops or spaces between numbers e.g. 3.3 dimethyl but-1-ene<br><br>**DO NOT ALLOW** meth **OR** methy |
| | | (ii) | **ANNOTATE ANSWER WITH TICKS AND CROSSES**<br><br><br><br><br>**1st curly arrow (from ANY alkene)**<br>Curly arrow from double bond to Br of Br–Br ✓<br>**DO NOT ALLOW** partial charge on C=C<br><br>**2nd curly arrow**<br>Correct dipole on Br–Br<br>**AND** curly arrow for breaking of Br–Br bond ✓ | 5 | AO1.2<br><br>AO1.2 | **For curly arrows, ALLOW straight or snake-like arrows and small gaps (see examples):**<br>**1st curly arrow** must<br>• go to a Br atom of Br–Br<br>**AND**<br>• start from, **OR** be traced back to **any point across width** of C=C<br><br>**2nd curly arrow** must<br>• start from, **OR** be traced back to, **any part of** $^{\delta+}$Br–Br$^{\delta-}$ bond<br>• **AND** go to Br $^{\delta-}$<br> |

| Question | | | Answer | Marks | AO element | Guidance |
|---|---|---|---|---|---|---|
| | | | **3rd curly arrow**<br>**Correct carbocation** with + charge on C with 3 bonds<br>**AND** curly arrow from $Br^-$ to $C^+$ of carbocation<br><br>**DO NOT ALLOW** δ+ on C of carbocation<br><br><br>**OR**<br><br>*i.e.* ***ALLOW*** *carbonium + on either C atom*<br><br>**Correct product to match mechanism/intermediate** ✓<br><br><br>**DO NOT ALLOW** half headed or double headed arrows but allow **ECF** if seen more than once<br><br>Name of mechanism: Electrophilic addition ✓ | | AO2.5<br><br>AO2.5<br><br>AO1.1 | **IGNORE** connectivity of $CH_3$ groups in carbocation and product and **ALLOW** $C_4H_9$<br><br>**3rd curly arrow** must<br>• go to the $C^+$ of carbocation<br>**AND**<br>• start from, **OR** be traced back to **any point across width** of lone pair on :$Br^-$<br>• **OR** start from – charge on $Br^-$ ion<br><br>*(Lone pair **NOT** needed if curly arrow shown from – charge on $Br^-$)*<br><br>**ALLOW** bromonium ion<br><br>**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous<br><br>**NOTE: For a mechanism with HBr, ALLOW all marks EXCEPT for final product mark** |
| | **(b)** | **(i)** | | **1** | | **For repeat unit,** |

| Question | | | Answer | Marks | AO element | Guidance |
|---|---|---|---|---|---|---|
| | | | <br>Correct polymer with side links ✓ | | AO2.5 ×1 | • 'side bonds' required on either side of repeat unit from C atoms<br>• **ALLOW** more than one repeat unit<br>• **ALLOW** $C_4H_9$ for $C(CH_3)_3$<br><br>**IGNORE** brackets<br>• **IGNORE** *n*<br><br>**IGNORE** connectivity of $C(CH_3)_3$ group |
| | **(b)** | **(ii)** | **Advantage:**<br>Energy/electricity (produced)<br><br>**AND**<br><br>**Disadvantage:**<br>$CO_2$ produced<br>**OR** gases causing global warming/climate change<br>**OR** greenhouse gases, e.g $CO_2$<br><br>**BOTH advantage and disadvantage** ✓ | **1** | AO1.1 ×1 | **ALLOW** reduced use of fossil fuels<br><br>**IGNORE** produced $CO_2$ and $H_2O$<br><br>**ALLOW** less landfill / less harm to wildlife or environment (*not just harmful*)<br><br>**ALLOW** toxic/poisonous (waste) products/gases, e.g. CO<br><br>**IGNORE** harmful/dangerous |

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AO element</th><th>Guidance</th></tr>
<tr><td>22</td><td>(a)</td><td></td><td>FIRST CHECK ANSWER ON THE ANSWER LINE<br>IF answer = 190.47 (to 2 DP) award 2 marks<br><br>$\frac{(188 \times 12.13) + (189 \times 16.75) + (190 \times 27.23) + (192 \times 43.89)}{100}$<br><br>OR 190.4677 OR 190.468 ✓<br><br>= 190.47 (to 2 DP) ✓</td><td>2</td><td>AO1.2<br>×2</td><td>For 1 mark: ALLOW ECF → to 2 DP if:<br>• %s used with wrong isotopes ONCE<br>OR<br>• transposed decimal places for ONE %</td></tr>
<tr><td></td><td>(b)</td><td></td><td>
<table>
<tr><th>Element</th><th>Mass number</th><th>Protons</th><th>Neutrons</th><th>Electrons</th><th>Charge</th></tr>
<tr><td>Ni</td><td>62</td><td>28</td><td>34</td><td>$1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$</td><td>0</td></tr>
<tr><td>P</td><td>33</td><td>15</td><td>18</td><td>$1s^2 2s^2 2p^6 3s^2 3p^6$</td><td>3–</td></tr>
</table>
✓ ✓<br><br>Mark by row</td><td>2</td><td>AO1.2<br>×2</td><td>Easiest to check element first<br>ALLOW $P^{3-}$<br>ALLOW names for elements<br><br>IGNORE charges with element in 1st column, even if wrong.<br><br>For electron configuration,<br>ALLOW $4s^2$ before $3d^8$<br>i.e. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$<br><br>ALLOW upper case D, etc and subscripts,<br>e.g. …..$4S_2 3D_1$<br><br>ALLOW $[Ar]3d^8 4s^2$</td></tr>
</table>

| Question | Answer | Marks | AO element | Guidance |
|---|---|---|---|---|
| (c) | **Molar ratios**<br>Zn : H : N : O<br>= $\frac{21.99}{65.4} : \frac{4.04}{1.0} : \frac{9.41}{14.0} : \frac{64.56}{16.0}$<br>**OR** 0.336 : 4.04 : 0.672 : 4.04<br>**OR** 1 : 12 : 2 : 12 ✓<br><br>**Empirical formula**<br>$ZnH_{12}N_2O_{12}$ ✓<br>***Any order***<br><br>**With water of crystallisation**<br>$ZnN_2O_6•6H_2O$<br>**OR** $Zn(NO_3)_2•6H_2O$ ✓<br><br>---<br>**Inverse fractions → NO MARKS** | **3** | AO1.2 ×2<br><br>AO2.2 ×1 | **NOTE**: If only the correct answer of $ZnN_2O_6•6H_2O$ **OR** $Zn(NO_3)_2•6H_2O$ is seen with no working, award 1 mark only<br><br>**ALLOW ECF** from incorrect molar ratios of Zn : H : N : O<br>e.g. from use of atomic number(s)<br><br>**ALLOW** $Zn(NO_3)_2(H_2O)_6$<br><br>**ALLOW ECF** from incorrect empirical formula<br><br>e.g. $ZnNO_3•3H_2O$ from $ZnH_6NO_6$ |

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

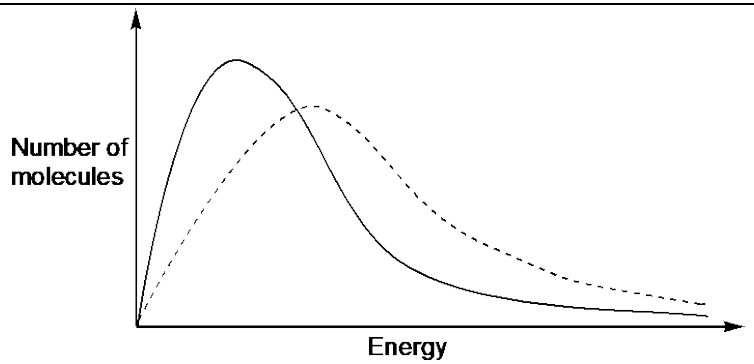
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<tr><td></td><td>(b)</td><td></td><td>
<table>
<tr><th>Name of oxyanion</th><th>Ionic charge</th><th>Formula of oxyanion</th></tr>
<tr><td>Bromate(III) ✓</td><td>1–</td><td>$BrO_2^-$</td></tr>
<tr><td>Sulfate(VI)</td><td>2–</td><td>$SO_4^{2-}$</td></tr>
<tr><td>Phosphate(V)</td><td>3–</td><td>$PO_4^{3-}$ ✓</td></tr>
</table>
</td><td>2</td><td>AO3.1<br>×2</td><td>ALLOW $PO_4^{-3}$</td></tr>
<tr><td></td><td>(c)</td><td></td><td>Structure<br>Giant ✓<br><br>Bonding<br>Metallic (bonding) ✓<br><br>Particles<br>2+ /$Ca^{2+}$ ions and delocalised electrons ✓<br><br>Conductivity<br>(Delocalised) electrons move/flow ✓<br>Idea of movement required<br><br>Delocalised can be seen anywhere</td><td>4</td><td>AO1.1<br>×4</td><td>ALLOW marks from labelled diagram<br><br>‘Giant metallic’ gains BOTH structure and bonding marks<br><br>ALLOW attraction between cations and electrons<br>Attraction between nucleus and electrons is CON<br><br>Watch for ‘metallic’ being CONNed within overall response<br><br>ALLOW charge flows ONLY when linked to electrons<br><br>IGNORE electrons carry charge<br>IGNORE electrons are free<br>BUT<br>ALLOW mobile electrons carry charge</td></tr>
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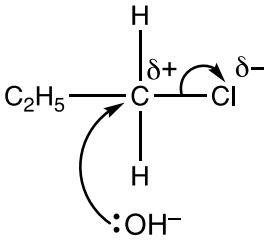
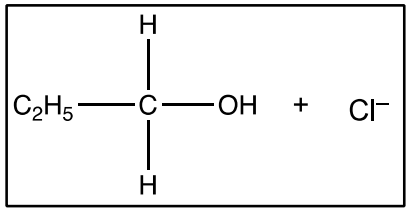
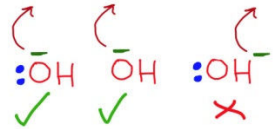
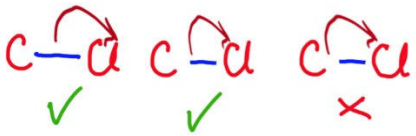
| Question | | | Answer | Marks | AO element | Guidance |
|---|---|---|---|---|---|---|
| 24 | (a) | (i) | Oxidation and reduction of the same **element** ✓<br><br>'Atom' is insufficient for element | 1 | AO1.1<br>×1 | **ALLOW** 'chlorine' **OR** 'C*l*' for same element<br>**IGNORE** 'species' for 'element' |
| | | (ii) | **Equation**<br>$Cl_2 + 2NaOH \rightarrow NaClO + NaCl + H_2O$ ✓<br><br>**Redox:**<br>C*l* is oxidised from 0 (in $Cl_2$) to +1 in NaC*l*O ✓<br><br>C*l* is reduced from 0 (in $Cl_2$) to –1 in NaC*l*/HC*l* ✓<br><br>**IGNORE** oxidation numbers shown in equation *(treat as rough working)*<br>**BUT**<br>If **no** oxidation numbers in explanation*, look at equation for oxidation numbers* | 3 | AO2.6<br>×1<br><br>AO2.1<br>×2 | **DO NOT ALLOW**<br>$Cl_2 + NaOH \rightarrow NaClO + HCl$<br><br>**ALLOW ECF** from HCl in equation<br><br>**ALLOW** 1 out of 2 redox marks if NaClO AND NaCl omitted, i.e.<br>C*l* is oxidised from 0 to +1<br>**AND**<br>C*l* is reduced from 0 to –1<br><br>**ALLOW** 1 out of 2 redox marks if oxidation number changes are **BOTH** correct<br>…**BUT** reduction/oxidation is incorrectly assigned, i.e.<br>C*l* is reduced from 0 (in $Cl_2$) to +1 in NaC*l*O<br><br>C*l* is oxidised from 0 (in $Cl_2$) to –1 in NaC*l*/HC*l*<br>**----------**<br>**General:**<br>**ALLOW number before sign in ox no,**<br>**i.e.** 1+ for +1 1– for –1<br><br>**IGNORE** ionic charges, e.g. $Cl^{1+}$<br>**IGNORE** '1' (signs required)<br><br>**IGNORE** references to electron loss/gain (even if wrong) |

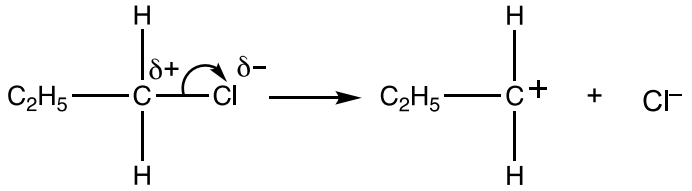
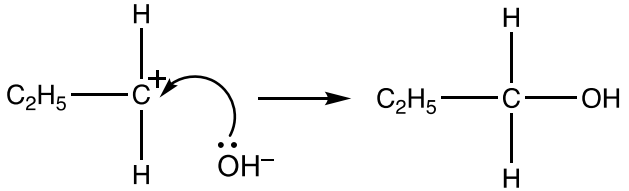
| Question | Answer | Marks | AO element | Guidance |
|---|---|---|---|---|
| (b) | **Identification of halide**<br>Add (aqueous) silver nitrate **OR** $AgNO_3$<br>**OR** $Ag^+$/silver ions ✓<br><br>**Observations – mark independently**<br>**Any 2 precipitate colours from**<br>Chloride/$Cl^-$ gives white precipitate<br>Bromide/$Br^-$ gives cream precipitate<br>Iodide/$I^-$ gives yellow precipitate ✓<br>**Precipitate/solid seen at least once**<br><br>**Equation for at least one halide**<br>e.g. $Ag^+ + Cl^- \rightarrow AgCl$<br>**ALLOW** $Ag^+ + X^- \rightarrow AgX$ ✓<br><br>***IGNORE*** *state symbols (ppt already assessed)*<br><br>**Identification of B and C**<br><br>**B**: NaBr **OR** sodium bromide ✓<br><br>**C**: $CaCl_2$ **OR** calcium chloride ✓ | **5** | AO3.3<br>×3<br><br>AO3.2<br>×2 | **ANNOTATE ANSWER WITH TICKS AND CROSSES**<br><br>**IGNORE** addition of $HNO_3$ but HCl **CONs** $AgNO_3$<br><br>**IGNORE** references to solubility in $NH_3$ (dil or conc), even if incorrect<br><br>**ALLOW** chlorine for chloride, etc<br><br>**ALLOW** equation with $Br^-$ **OR** $I^-$<br>e.g. $Ag^+ + Br^- \rightarrow AgBr$<br>**ALLOW** full/partial equations,<br>e.g. $AgNO_3 + Cl^- \rightarrow AgCl + NO_3^-$<br><br>**ALLOW** explanation for identification: i.e.<br><br>**B (Group 1):**<br>Subtract molar/atomic mass of halide/Br<br>from number in range 100–115/molar mass of B ✓<br><br>**C (Group 2):**<br>Subtract **2** × molar/atomic mass of halide/Cl<br>from number in range 100–115/molar mass of **C** ✓<br>---<br>**ALLOW** displacement by addition of halogen ✓<br>2 correct colours in water or organic solvent ✓<br>Equation, e.g. $Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ ✓ |

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

| Question | | | Answer | Marks | AO element | Guidance |
|---|---|---|---|---|---|---|
| | | | | | | **2 marks** for answers above with wrong sign or not to 3 SF<br><br>Other multiples by using *m* as 50 or 25:<br>Mark using same principal<br>Use of 50 → **–77.3** **3 marks**<br>Use of 25 → **–38.7** **3 marks** |
| | | **(ii)** | **Reason for incorrect conclusion**<br>neutralisation forms **1 mol $H_2O$**<br>**OR** $\Delta_r H$ forms 2 mol **$H_2O$** ✓<br><br>Value for $\Delta_{neut}H = \pm \frac{\text{answer to 25a(i)}}{2}$ (kJ $mol^{-1}$) ✓<br>**2 SF or more** | **2** | AO3.2<br>×1 | **$H_2O$ essential**<br><br>**IGNORE** sign, even if wrong<br><br>**ALLOW** 2 SF, e.g. 58 |

| Question | Answer | Marks | AO element | Guidance |
|---|---|---|---|---|
| (b) | <br>***Curve at higher temperature 1 mark***<br>Curve starts close to zero<br>**AND**<br>does not touch x axis at high energy<br>**AND**<br>maximum to right **AND** lower than provided curve<br>**AND**<br>finishing higher than provided curve ✓<br><br>***Labels 1 mark***<br>Axes labels correct:<br>• Number of molecules **AND** Energy ✓<br><br>***Explanation 1 mark***<br>More molecules have energy greater **than** $E_a$<br>**OR**<br>Greater area under curve **above** $E_a$ ✓<br>*Could be in diagram*<br><br>*If not stated, assume higher temperature* | 3 | AO1.2<br><br>AO1.1<br><br>AO1.1 | **ANNOTATE ANSWER WITH TICKS AND CROSSES**<br>---<br>**NOTE**: Look for marking criteria within annotations on Boltzmann distribution diagram<br><br>**IGNORE** slight inflexion on the curve<br><br>**For labels,**<br>**ALLOW** number of particles<br>**ALLOW** amount of molecules/particles<br>**IGNORE** number of atoms<br>**ALLOW** kinetic energy<br>**IGNORE** enthalpy for energy<br><br>**ORA at lower temperature**<br>**ALLOW** more molecules have the energy to react<br>more molecules can overcome/reach $E_a$<br>**IGNORE** atoms<br><br>**IGNORE** more successful collisions<br>**OR** collide more frequently<br><br>**DO NOT ALLOW** explanation is in terms of two activation energies (i.e. 'catalyst explanation) |

| Question | | | Answer | Marks | AO element | Guidance |
|---|---|---|---|---|---|---|
| 26 | (a) | | Curly arrow from $HO^-$ to C atom of C–Cl bond ✓<br><br>Dipole shown on C–Cl bond, $C^{\delta+}$ and $Cl^{\delta-}$<br>**AND**<br>curly arrow from C−Cl bond to Cl atom ✓<br><br><br><br><br>**IGNORE** presence of $Na^+$ but $OH^-$ needed<br>i.e. $Na^+OH^-$can be allowed if criteria met<br><br>**DO NOT ALLOW** $H_2O$ instead of $OH^-$<br>---<br><br>Correct organic product **AND** $Cl^-$ ✓<br><br><br><br><br>**IGNORE** presence of $Na^+$ but $Cl^-$ needed<br>i.e. $Na^+Cl^-$ can be allowed<br>**BUT** NaCl does **NOT** show $Cl^-$ | 3 | AO1.2<br><br>AO1.2<br><br>AO2.5<br>×1 | **ANNOTATE ANSWER WITH TICKS AND CROSSES**<br><br>**NOTE**: curly arrows can be straight, snake-like, etc. but **NOT** double headed or half headed arrows<br><br>**1st curly arrow** must<br>• go to C of C−Cl<br>**AND**<br>• start from, **OR** be traced back to **any point across width** of lone pair on O of $OH^-$<br><br>• **OR** start from – charge **on O** of $^-OH$ ion<br><br>*(Lone pair **NOT** needed if curly arrow shown from $O^-$ )*<br><br>**2nd curly arrow** must start from, **OR** be traced back to, **any part of** C–Cl bond and go to Cl<br><br><br>**ALLOW ECF** $NaCl^-$ **ONLY** from $NaOH^-$<br><br>--- |

| Question | Answer | Marks | AO element | Guidance |
|---|---|---|---|---|
| | | | | **ALLOW** $S_N1$ mechanism<br>**First mark**<br>Dipole shown on C–Cl bond, $C^{\delta+}$ and $Cl^{\delta-}$,<br>**AND** curly arrow from C−Cl bond to Cl atom ✓<br><br>**Second mark**<br>Correct carbocation **AND** curly arrow from $HO^-$ to carbocation<br><br>Curly arrow must come from lone pair on O of $HO^-$ **OR** $OH^-$<br>**OR** from minus on O of $HO^-$ ion (no need to show lone pair if curly came from negative charge) ✓<br>**Third mark**<br>Correct organic product **AND** $Cl^-$ ✓ |

| Question | Answer | Marks | AO element | Guidance |
|---|---|---|---|---|
| (b) | **FIRST check the molar mass on answer line MUST be derived from *pV* = *nRT*,**<br>**Award 4 marks for calculation for:**<br>• **answer = 136.9 OR 137**<br>---<br>*Rearranging ideal gas equation to make n subject*<br>$n = \frac{pV}{RT}$ ✓<br><br>*Substituting all values including conversion to $m^3$ and K*<br>$n = \frac{(1.01 \times 10^5) \times (74.0 \times 10^{-6})}{8.314 \times 373}$ ✓<br><br>$n$ = 2.410095443 $\times 10^{-3}$ (unrounded) → $2.41 \times 10^{-3}$ (mol) (rounded to 3 SF) ✓<br><br>*Calculation of molar mass, M*<br>$M = \frac{m}{n} = \frac{0.330}{2.410095443 \times 10^{-3}}$ = 136.9.. (g $mol^{-1}$)<br>$\rightarrow \frac{0.330}{2.41 \times 10^{-3}}$ = 136.9 (g $mol^{-1}$) ✓<br>**ALLOW** calculated *M* in range 136.9 – 137<br><br>*Molecular formula of* **D**<br>$C_4H_9Br$ ✓<br>---<br>**IF** candidate has failed to derive suitable value of *n*, **ALLOW** value of *M* from 0.330 **AND** 24000 with haloalkane closest to calculated value for last 2 marks **See Guidance column.** | **5** | AO2.4 ×4<br><br>AO3.2 | **ANNOTATE ANSWER WITH TICKS AND CROSSES**<br>---<br>**If there is an alternative answer, check to see if there is any ECF credit possible using working below**<br><br>1st mark may be implicit by direct substitution of correct values below into rearranged equation.<br><br>**ALLOW** use of 8.31 for $R \rightarrow 2.411 \times 10^{-3}$<br><br>**ONLY award this mark if *n* has been derived from correct rearranged ideal gas equation**<br>**ALLOW 3 SF up to calculator value, correctly rounded**<br><br>**$2.41 \times 10^{-3}$ OR 0.002411255537 → first 3 marks**<br>→ 136.868581616 → $C_4H_9Br$<br><br>**NOTE: ALLOW** 137 (i.e. to 3 SF)<br><br>**ALLOW** any unambiguous structure<br>**ALLOW ECF** provided that formula given is a haloalkane and matches *M* calculated from 0.330 g **AND** *pV* = *nRT*<br>---<br>$M = \frac{0.330}{74.0/24000}$ **OR** $\frac{0.330}{3.0833.. \times 10^{-3}}$<br>= **107 to 3 SF** ✓<br><br>From **107, ONLY ALLOW** = $C_2H_5Br$ (108.9) ✓ |

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