



**GCE**

**Chemistry A**

Unit **H033/02**: Chemistry in depth

Advanced Subsidiary GCE

**Mark Scheme for June 2017**

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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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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## 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**.


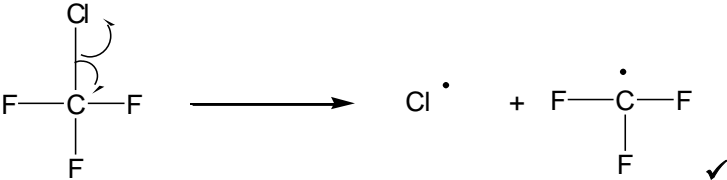
Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

## Annotations

<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

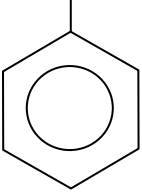
Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
<b>BOD</b>	Benefit of doubt given
<b>CON</b>	Contradiction
<b>RE</b>	Rounding error
<b>SF</b>	Error in number of significant figures
<b>FLF</b>	Error carried forward
<b>L1</b>	Level 1
<b>L2</b>	Level 2
<b>L3</b>	Level 3
<b>NEOD</b>	Benefit of doubt not given
<b>SEEN</b>	Noted but no credit given
<b>I</b>	Ignore

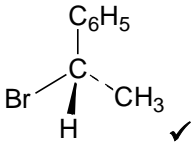
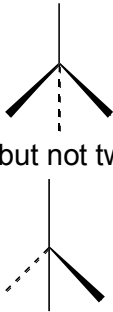
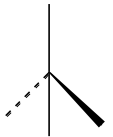
Question		Answer	Marks	Guidance
1	(a)	<p><i>heterogeneous</i> (the catalyst is in) a different state/phase (of matter to the reactants and products) ✓</p> <p><i>catalyst</i> (a substance that) increases the rate of/speeds up a (chemical) reaction/provides a route of lower activation enthalpy <b>AND</b> does not get used up (in the process) ✓</p>	2	<p>for <i>catalyst</i> <b>AND</b>, <b>IGNORE</b> 'does not take part in the reaction' unless it is included along with 'does not get used up' in which case it is a <b>CON ALLOW</b> 'not chemically changed' <b>IF</b> qualified by 'at end of reaction'</p> <p><b>NOT</b> simply provides an alternative route or lower the activation enthalpy (must have both)</p>
1	(b) (i)	<p>the student is incorrect</p> <p>the student should use equal amounts/number of moles /number of particles ✓</p>	1	<p>there is no mark for 'incorrect' – the mark is awarded for the explanation</p> <p><b>IGNORE</b> references to particle size as question states powdered compounds</p>
1	(b) (ii)	<p>Any two from: ✓ (for both)</p> <ul style="list-style-type: none"> <li>• concentration of hydrogen peroxide/solution</li> <li>• volume of solution</li> <li>• temperature (of solution)</li> </ul>	1	<b>NOT</b> 'amount' instead of 'volume'
1	(c) (i)	line of best fit drawn to exclude anomaly at (25, 55.0) ✓	1	look for a best fit line that goes above the anomalous point and levels off at 63
1	(c) (ii)	<p>manganese(IV) oxide (is the most effective catalyst)</p> <p>it produces most oxygen/gas in the shortest time/a given/stated time/at the fastest rate/it has the steepest curve ✓</p>	1	explanation must include reference to rate or time
1	(c) (iii)	<p><b>FIRST CHECK THE ANSWER ON THE ANSWER LINE</b></p> <p>If answer is <math>5.6 \times 10^{-5}</math> or <math>5.5 \times 10^{-5}</math> (2 or more sf) (mol s<sup>-1</sup>) award 2 marks</p> <p>(volume of O<sub>2</sub> at 15 s = 20.0 cm<sup>3</sup>)</p> <p>amount of O<sub>2</sub> at RTP = (20.0/24000) = <math>8.333 \times 10^{-4}</math> mol ✓</p> <p>(average rate =) (<math>8.333 \times 10^{-4}/15.0</math>) = <math>5.6 \times 10^{-5}</math> (mol s<sup>-1</sup>) ✓</p>	2	<p><b>Alternative method</b></p> <p>rate = 20/15 = 1.333 cm<sup>3</sup> s<sup>-1</sup> ✓</p> <p>= 1.333/24000 = <math>5.6 \times 10^{-5}</math> mol s<sup>-1</sup> ✓</p> <p><b>ALLOW</b> <math>5.5 \times 10^{-5}</math> (mol s<sup>-1</sup>) if amount is rounded to 2 sf</p> <p><b>ALLOW</b> ECF on final answer if MP1 is correctly calculated, but for manganese(IV) oxide.</p> <p>Answer is <math>1.3 \times 10^{-4}</math> (again, allow 2 or more sf)</p> <p><b>DO NOT ALLOW</b> calculation based on pV=nRT</p>

Question		Answer	Marks	Guidance
1	(d)	 <p>✓(for branched alkane, eg as shown) ✓ (for methylpropene)</p>	2	<b>ALLOW</b> any branched alkane containing 6-carbon atoms
1	(e) (i)	Stage 1 reactant(s) adsorbed/bond to surface of catalyst Stage 2 (reactant) bonds (weaken) and break Stage 3 (product) new bonds form Stage 4 product(s) desorbed from surface of catalyst ✓ (for Stages 1 and 4) ✓ (for Stages 2 and 3)	2	In Stage 1, 'absorbed' is a <b>CON</b> <b>ALLOW</b> '(reactant) forms <u>weak</u> bonds with catalyst' <b>ALLOW</b> reference to 'chemisorption'  In Stage 4, <b>ALLOW</b> 'leaves/diffuses' for 'desorbed from' but <b>DO NOT ALLOW</b> 'dissociates from'
1	(e) (ii)	(the poison) blocks the active sites/surface ✓	1	
1	(f) (i)		1	<b>ALLOW</b> both products without 'dot' but not one with, one without. <b>ALLOW</b> 'CF <sub>3</sub> ' instead of full structural.
1	(f) (ii)	<b>FIRST CHECK THE ANSWER ON THE ANSWER LINE</b> If answer is 346 (nm) award 3 marks  energy required to break a single C-Cl bond $= (346 / 6.02 \times 10^{23}) = 5.75 \times 10^{-22} \text{ (kJ)} \checkmark$ $E = h\nu$ $\therefore \nu = E/h$ (minimum) frequency of radiation required $= (5.75 \times 10^{-22} \times 1000 / 6.63 \times 10^{-34}) = 8.67 \times 10^{14} \text{ (Hz)} \checkmark$ $c = \nu\lambda$ $\therefore \lambda = c/\nu$ (maximum) wavelength of radiation required $= (3.00 \times 10^8 / 8.67 \times 10^{14}) = 3.46 \times 10^{-7} \text{ (m)}$ $= 346 \text{ (nm)} \text{ (3 sf)} \checkmark$	3	The working for an incorrect answer <b>MUST</b> be checked in detail. Do be aware that candidates may well multiply/divide the numbers in a different order to that shown in the answer column so the numbers in this method of working may not necessarily be seen. However, candidates should be using $E = h\nu$ , $c = \nu\lambda$ (or correct combination) and a conversion into nm.

1	(g)	<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></p> <p>Gives a detailed description (to include equations in parts 1 and 2) AND a comparison of relative effects.</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></p> <p>Less detailed description and comparison (equations may be included)</p> <p><b>OR</b></p> <p>Detailed description and no comparison ORA</p> <p><i>There is a line of reasoning presented with some structure. The information presented in the most part relevant and supported by some evidence.</i></p> <p><b>Level 1 (1-2 marks)</b></p> <p>Limited description and comparison</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p><b>0 marks</b></p> <p>No response or no response worthy of credit</p>	6	<p><b>1.1 (x4)</b></p> <p><b>3.1 (x2)</b></p>	<p><i>Indicative Scientific points include:</i></p> <p><b>AO1.1 Description of and comparison of oxygen and chlorine atoms in the breakdown of ozone</b></p> <p>Role of oxygen:</p> <ul style="list-style-type: none"> <li>○ atoms/radicals react with ozone (in the stratosphere)</li> <li>○ <math>O + O_3 \rightarrow 2O_2</math></li> </ul> <p>Role of Cl in removing <math>O_3</math></p> <ul style="list-style-type: none"> <li>○ chlorine radicals react with ozone</li> <li>○ <math>Cl + O_3 \rightarrow ClO + O_2</math></li> <li>○ <math>ClO</math> react with oxygen atoms regenerating the chlorine radical</li> <li>○ <math>ClO + O \rightarrow Cl + O_2</math></li> <li>○ overall reaction is the removal of ozone</li> <li>○ <math>O + O_3 \rightarrow 2O_2</math></li> </ul> <p><b>AO3.1 Make judgements: Comparison of relative effects</b></p> <ul style="list-style-type: none"> <li>• the chlorine radical is in a catalytic cycle AW</li> <li>• one Cl atom can remove many ozone molecules</li> <li>• one O atom can only remove one ozone molecule</li> </ul>
<b>Total</b>		<b>23</b>			



Question			Answer	Marks	Guidance
2	(a)		<p style="text-align: center;">– CH – CH<sub>2</sub> –</p>  <p>✓ (for C – C single bond <b>AND</b> single bonds extending either side of each C-atom)</p>	1	<p><b>ALLOW</b> C<sub>6</sub>H<sub>5</sub> for phenyl group</p> <p><b>IGNORE</b> brackets around repeating unit and use of 'n' to indicate a large number</p>
2	(b)	(i)	Bond <b>A</b> – pi/π(-bond) Bond <b>B</b> – sigma/σ(-bond) ✓	1	
2	(b)	(ii)	Bond angle <b>C</b> = 120(°) ✓  Explanation there are 3 groups of electrons around the C-atom ✓ (which) repel so that they are as far apart as possible ✓	3	<p><b>ALLOW</b> 'areas of electron density' for 'groups of electrons'</p> <p><b>ALLOW</b> arrange to minimise the repulsion between them</p> <p><b>DO NOT ALLOW</b> 'repel as much as possible' unless qualified by the idea of 'minimising repulsion'</p> <p><b>DO NOT ALLOW</b> 'three sets of bonding pairs'</p> <p><b>DO NOT ALLOW</b> 'bonds repel' unless qualified by reference to 'electrons'</p>
2	(c)	(i)	yellow/orange/brown to colourless ✓	1	<p><b>ALLOW</b> any colour or combination of colours but no other colour</p> <p><b>DO NOT ALLOW</b> 'decolorised' or 'loses its colour'</p> <p><b>IGNORE</b> clear</p> <p>Any reference to 'red' is a <b>CON</b></p>
2	(c)	(ii)	carbocation ✓	1	<p><b>ALLOW</b> carbonium ion</p> <p><b>DO NOT ALLOW</b> 'carbon cation'</p>
2	(c)	(iii)	chloride ions/Cl <sup>-</sup> can attack/react with/bond with/combine with the carbocation/intermediate (in the second step of the mechanism) as well as bromide ions/Br <sup>-</sup> ✓	1	Answer must refer to the carbocation/intermediate or if not, to the second step of the mechanism to get the mark

2	(d)	(there are) two different atoms/groups of atoms bonded/attached to the two carbon atoms of the double bond/C=C ✓ (and) there is no/limited (free) rotation about this bond/the C=C ✓	2	<b>DO NOT ALLOW</b> 'movement' unless qualified by 'rotational'
2	(e) (i)	HBr/hydrogen bromide ✓	1	<b>ALLOW</b> BrH
2	(e) (ii)	 <p><b>ALLOW</b> just 'C' for C<sub>6</sub>H<sub>5</sub> and/or CH<sub>3</sub> (it is the shape that is being examined)</p>	1	<b>ALLOW</b> other correct representations, eg  <p>but not two 'lines' opposite each other, i.e.</p> <p><b>ALLOW</b> 'dashed wedge' for 'dotted line'</p>
2	(e) (iii)	the hydroxyl group/OH/functional group is bonded to a carbon atom: with (only) one hydrogen atom <b>OR</b> attached to two carbon atoms ✓	1	<b>IGNORE</b> any reference to hydroxide (ion)/OH <sup>-</sup> <b>IGNORE</b> 'it' for the OH group
2	(e) (iv)	$\text{O} = \text{C} - \text{CH}_3$ 	1	<b>ALLOW</b> any unambiguous structure
<b>Total</b>			<b>14</b>	

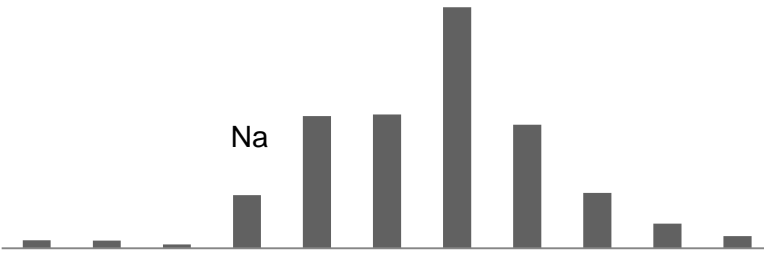
Question			Answer	Marks	Guidance
3	(a)	(i)	[ $M_r$ of NaOH = 40 g mol <sup>-1</sup> 0.5 tonne = 5 x 10 <sup>5</sup> g] amount of NaOH = (5 x 10 <sup>5</sup> / 40) = 12500 (mol) ✓	1	Answer only (to 2 or more sf) (not the working) scores the mark
3	(a)	(ii)	[amount of Cl <sub>2</sub> formed in same time as 0.5 mol NaOH = (½ x 12500) = 6250 (mol) M of Cl <sub>2</sub> = 71] mass of Cl <sub>2</sub> = [(6250 x 71) = 443750 g = ] 0.44 (tonnes) ✓ <b>ALLOW</b> ECF from (a)(i)	1	Answer only (to 2 or more sf) (not the working) scores the mark
3	(a)	(iii)	volume [= (6250 x 24) = 150 000 dm <sup>3</sup> ] = 150 m <sup>3</sup> ✓ <b>ALLOW</b> ECF from (a)(i) and/or (ii)	1	Answer only (to 2 or more sf) (not the working) scores the mark
3	(b)		similarity: chlorine is still produced (at the anode/positive electrode) difference: sodium is produced/hydrogen/hydroxide ion is not produced (at the cathode/negative electrode) ✓	1	
3	(c)		(i) anode (+): yellow/orange/brown (colour in solution) (ii) cathode (-): gas (evolved)/bubbles/effervescence /fizzing ✓ (for both i and ii)	1	<b>ALLOW</b> any of these colour or combination of them but no other colour at (i) <b>IGNORE</b> iodine at (i) and hydrogen at (ii)
3	(d)		(i) anode (+): 2Br <sup>-</sup> → Br <sub>2</sub> + 2e <sup>-</sup> ✓ (ii) cathode (-): 2H <sub>2</sub> O + 2e <sup>-</sup> → 2OH <sup>-</sup> + H <sub>2</sub> ✓	2	<b>ALLOW</b> multiples or halves of equations <b>ALLOW</b> 2Br <sup>-</sup> - 2e <sup>-</sup> → Br <sub>2</sub> <b>ALLOW</b> 2H <sup>+</sup> + 2e <sup>-</sup> → H <sub>2</sub> <b>ALLOW</b> 'e' for 'e <sup>-</sup> ' <b>IGNORE</b> state symbols
3	(e)	(i)	Brown/orange/yellow ✓	1	<b>ALLOW</b> any of these colours (or combination of them) but no other colour <b>IGNORE</b> colourless
3	(e)	(ii)	Br <sub>2</sub> + 2I <sup>-</sup> → I <sub>2</sub> + 2Br <sup>-</sup> ✓	1	<b>IGNORE</b> state symbols
3	(f)	(i)	2I <sup>-</sup> → I <sub>2</sub> + 2e <sup>-</sup> ✓	1	<b>ALLOW</b> I <sup>-</sup> → ½I <sub>2</sub> + e <sup>-</sup> <b>ALLOW</b> 'e' for 'e <sup>-</sup> ' <b>ALLOW</b> 2I <sup>-</sup> - 2e <sup>-</sup> → I <sub>2</sub>

3	(f)	(ii)	chlorine/Cl <sub>2</sub> ✓	1	<b>IGNORE</b> Cl
3	(g)		halogens/they increase in atomic radius/size/get bigger/the outer shell is further from the nucleus/core/shielding (by completed inner shells) from top to bottom of/going down the Group ✓  the (electrostatic) attraction between the nucleus/core and the outer electrons decreases from top to bottom of/going down the Group ✓  halogens/they gain an extra electron less readily/easily from top to bottom of/going down the Group ✓	3	<b>ALLOW</b> any reference to halogen as either atom or molecule
			<b>Total</b>	<b>14</b>	

Question			Answer	Marks	Guidance
4	(a)	(i)	<p>(statement 1): equations should have (g) for both state symbols ✓</p> <p>(statement 2): is correct ✓</p> <p>(statement 3): the outer (shell) electrons in barium are further from/more well shielded from the nucleus (than in calcium) ✓ (the electrostatic) attraction between the nucleus/core and the outer electrons in barium is less (than in calcium) ✓</p>	4	<p>MP1, 3 and 4 are awarded for correcting the incorrect chemistry and not for simply stating 'incorrect'</p> <p><b>DO NOT ALLOW</b> 'force' for 'attraction'</p>
4	(a)	(ii)	<p><b>FIRST CHECK ANSWER ON ANSWER LINE</b> if answer = 754 (cm<sup>3</sup>) award 2 marks (must be 3sf)</p> <p>amount of Ca = <math>(1.26/40.1) = 3.14 \times 10^{-2}</math> (mol) amount of H<sub>2</sub> = <math>3.14 \times 10^{-2}</math> (mol) volume of hydrogen = <math>(3.14 \times 10^{-2} \times 24000) = 754</math> (cm<sup>3</sup>) ✓ answer to 3sf ✓</p>	2	<p><b>ALLOW</b> ECF on sf from a correct seen calculation</p> <p><b>Note</b> that if A<sub>r</sub> of Ca is used as 40, answer is 756</p> <p><b>DO NOT ALLOW</b> an answer from calculation based on <math>pV=nRT</math> <b>BUT</b> the sf mark can still be awarded</p>

Question	Answer	Marks	Guidance
4	<p data-bbox="192 215 237 247">(b)</p> <p data-bbox="349 215 1111 279"><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 data-bbox="349 343 618 375"><b>Level 3 (5-6 marks)</b></p> <p data-bbox="349 391 1111 454">Detailed description of an experiment that would work with reason(s) AND detailed suggested expected results</p> <p data-bbox="349 470 1111 582"><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 data-bbox="349 646 618 678"><b>Level 2 (3-4 marks)</b></p> <p data-bbox="349 694 1111 758">Outline description of an experiment <b>either</b> with reason(s) <b>or</b> suggested expected results</p> <p data-bbox="349 774 394 805"><b>OR</b></p> <p data-bbox="349 821 1111 885">Detailed description of the experiment without reason(s) or suggested expected results</p> <p data-bbox="349 901 1111 1013"><i>There is a line of reasoning presented with some structure. The information presented in the most part relevant and supported by some evidence.</i></p> <p data-bbox="349 1077 618 1109"><b>Level 1 (1-2 marks)</b></p> <p data-bbox="349 1125 819 1157">Outline description of an experiment</p> <p data-bbox="349 1173 394 1204"><b>OR</b></p> <p data-bbox="349 1220 909 1252">Outline of suggestions for expected results</p> <p data-bbox="349 1268 1111 1348"><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p data-bbox="349 1364 461 1396"><b>0 marks</b></p>	6	<p data-bbox="1283 215 1731 247"><i>Indicative scientific points include</i></p> <p data-bbox="1283 263 1843 327"><b>A03.3 Develop practical techniques and procedures - Description of experiment</b></p> <p data-bbox="1283 343 1440 375">Description:</p> <ul data-bbox="1328 406 1888 790" style="list-style-type: none"> <li>• heating carbonate and bubbling gas into limewater / measuring volume of gas / measuring mass loss</li> <li>• equal amounts/number of moles of each carbonate heated</li> <li>• using the same Bunsen flame AW</li> <li>• the first to go cloudy has the lower thermal stability (or alternative methods based on amounts of cloudiness in certain time etc)</li> </ul> <p data-bbox="1283 805 1641 837">Reasons: <b>not</b> just 'fair test'</p> <ul data-bbox="1328 853 1865 933" style="list-style-type: none"> <li>• comparing same number of particles</li> <li>• delivering the same energy / heat</li> </ul> <p data-bbox="1283 949 1865 1013"><b>A03.4 Interpretation - Suggested expected results</b></p> <ul data-bbox="1328 1029 1888 1332" style="list-style-type: none"> <li>• <math>\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})</math> (or equation for strontium) or described in words</li> <li>• <math>\text{CO}_2</math> given off shown by limewater going cloudy / gas collected / loss of mass</li> <li>• calcium carbonate decomposes quicker than strontium carbonate AW</li> </ul>

Question			Answer	Marks	Guidance
			<i>No response or no response worthy of credit</i>		
4	(c)	(i)	it is the mean of 20.80 (cm <sup>3</sup> ) and 20.90 (cm <sup>3</sup> ) which are concordant/within 0.1(0) cm <sup>3</sup> <b>OR</b> 21.55 (cm <sup>3</sup> ) is a trial/rough titre/overshot the end-point/is an anomaly/outlier/not concordant/within 0.1(0) cm <sup>3</sup> ✓	1	
4	(c)	(ii)	(% error) = $([2 \times 0.05]/20.80) = 0.5$ (%) ✓	1	<b>ALLOW</b> 0.48 (%) <b>ALLOW</b> ±0.5/0.48 (%)
4	(c)	(iii)	<b>FIRST CHECK THE ANSWER ON THE ANSWER LINE</b> If answer is 1.54 (g dm <sup>-3</sup> ) (to 2 or more sf) award 3 marks  <i>(calculation of amount Ca(OH)<sub>2</sub> in titre):</i> amount of HCl = $(20.85/1000 \times 0.050) = 1.0425 \times 10^{-3}$ (mol) amount of Ca(OH) <sub>2</sub> in 25 cm <sup>3</sup> = $(\frac{1}{2} \times 1.0425 \times 10^{-3})$ = $5.2125 \times 10^{-4}$ (mol) ✓ <i>(calculation of amount Ca(OH)<sub>2</sub> per dm<sup>3</sup>):</i> [Ca(OH) <sub>2</sub> ] = $(5.2125 \times 10^{-4} \times 1000/25.0)$ = $2.085 \times 10^{-2}$ (mol dm <sup>-3</sup> ) ✓ <i>(calculation of mass Ca(OH)<sub>2</sub> per dm<sup>3</sup>):</i> M of Ca(OH) <sub>2</sub> = 40.1 + 2(16.0 + 1.0) = 74.1 (g mol <sup>-1</sup> ) concentration of Ca(OH) <sub>2</sub> = $(2.085 \times 10^{-2} \times 74.1)$ = 1.54 (g dm <sup>-3</sup> ) ✓	3	<b>ALLOW</b> ecf <b>ALLOW</b> 2 or more sf.
4	(d)		the number of protons in the nucleus/atom ✓	1	<b>NOT</b> just 'element'

Question		Answer	Marks	Guidance
4	(e)	 <p>correct position of Na ✓</p>	1	
<b>Total</b>			<b>19</b>	



**OCR (Oxford Cambridge and RSA Examinations)**  
**1 Hills Road**  
**Cambridge**  
**CB1 2EU**

**OCR Customer Contact Centre**

**Education and Learning**

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Facsimile: 01223 552627

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**OCR (Oxford Cambridge and RSA Examinations)**  
**Head office**  
**Telephone: 01223 552552**  
**Facsimile: 01223 552553**

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