



**GCE**

**Chemistry A**

**H032/01: Breadth in chemistry**

Advanced Subsidiary GCE

**Mark Scheme for June 2019**



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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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Annotations available in RM Assessor

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>ECF</b>	Error carried forward
<b>L1</b>	Level 1
<b>L2</b>	Level 2
<b>L3</b>	Level 3
<b>NBOD</b>	Benefit of doubt not given
<b>SEEN</b>	Noted but no credit given
<b>I</b>	Ignore



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



### SECTION A

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



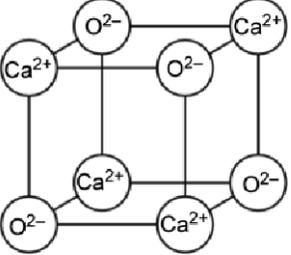
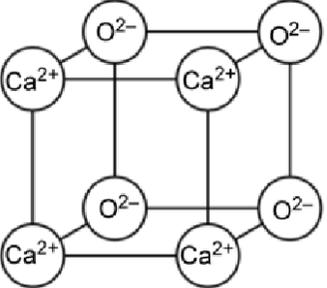
## SECTION B

Question		Answer	Marks	AO element	Guidance																					
21	(a)	<p><b>TWO correct responses from ✓</b></p> <ul style="list-style-type: none"> <li>• Different numbers of neutrons</li> <li>• Different (atomic) masses/mass numbers</li> <li>• Different <b>physical</b> properties</li> </ul> <p><i>Physical required</i></p>	1	AO1.1	<p><b>IGNORE</b> heavier/lighter</p> <p><b>DO NOT ALLOW</b> different <b>relative atomic</b> masses <b>BUT ALLOW</b> different relative <b>isotopic</b> masses</p> <p><b>DO NOT ALLOW</b> different <b>chemical</b> properties <b>OR</b> different properties</p> <p><b>IGNORE</b> different abundances</p>																					
	(b)	<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr style="background-color: #cccccc;"> <th>Element</th> <th>Mass number</th> <th>Protons</th> <th>Neutrons</th> <th>Electrons</th> <th>Charge</th> <th></th> </tr> </thead> <tbody> <tr> <td style="color: green;">Fe</td> <td style="color: green;">54</td> <td>26</td> <td>28</td> <td style="color: green;">26</td> <td>0</td> <td>✓</td> </tr> <tr> <td style="color: green;">Se</td> <td style="color: green;">80</td> <td style="color: green;">34</td> <td style="color: green;">46</td> <td>36</td> <td>2-</td> <td>✓</td> </tr> </tbody> </table> <p style="color: blue; margin-top: 10px;"><b>Mark by row</b></p>	Element	Mass number	Protons	Neutrons	Electrons	Charge		Fe	54	26	28	26	0	✓	Se	80	34	46	36	2-	✓	2	AO1.2 ×2	<p><b>THREE responses for each mark</b> <i>Easiest to check element first</i></p> <p><b>ALLOW</b> Se<sup>2-</sup> <b>ALLOW</b> names for elements</p>
Element	Mass number	Protons	Neutrons	Electrons	Charge																					
Fe	54	26	28	26	0	✓																				
Se	80	34	46	36	2-	✓																				
	(c)	<p><b>Sub-shells labels</b></p> <p>2s (single box) <b>AND</b> 2p (3 boxes) ✓</p> <p><b>Electrons as arrows</b></p> <p>unpaired electrons in 3 boxes: ↑↓ ↑ ↑</p> <p><b>AND</b></p> <p>Paired electrons in single box: ↑↓ ✓</p>	2	AO1.1  AO1.2	<p style="text-align: center; margin-top: 10px;"><b>ALLOW</b> single headed arrows, e.g. <math>\uparrow</math></p>																					

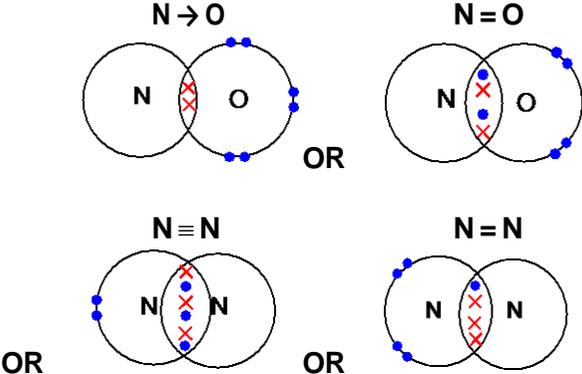
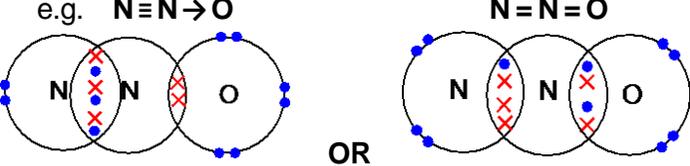
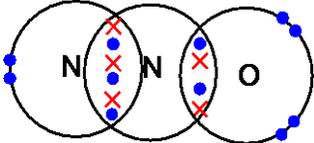


Question		Answer	Marks	AO element	Guidance
(d)	(i)	$3 \left[ \text{Ca} \right]^{2+} 2 \left[ \begin{array}{ccc} \cdot & \times & \\ \times & \text{N} & \times \\ \cdot & \cdot & \end{array} \right]^{3-}$ <p>Ca shown with either 0 or 8 electrons  <b>AND</b>            N shown with 8 electrons with 5 dots and 3 crosses (or vice versa) ✓</p> <p>3 Ca <b>AND</b> 2 N <b>AND</b> correct charges on ions, i.e. <math>3\text{Ca}^{2+} 2\text{N}^{3-}</math> ✓</p> <p>Circles <b>OR</b> Brackets <b>NOT</b> required</p>	2		<p><b>CARE:</b>  <b>ALLOW</b> any pairing if electrons correct, e.g.</p> $3 \left[ \text{Ca} \right]^{2+} 2 \left[ \begin{array}{ccc} & \times \times & \\ \cdot & \text{N} & \times \\ \cdot & \cdot & \end{array} \right]^{3-}$ <p><b>IF</b> 8 electrons shown around Ca, 'extra' 3 electrons around N must match symbol for Ca electrons, e.g.</p> $3 \left[ \begin{array}{ccc} \times \times & & \\ \times \times \text{Ca} \times \times & & \\ \times \times & & \end{array} \right]^{2+} 2 \left[ \begin{array}{ccc} \cdot & \times & \\ \times & \text{N} & \times \\ \cdot & \cdot & \end{array} \right]^{3-}$ <p><b>IGNORE</b> inner shells</p> <p><b>ALLOW</b> drawing with 3 <math>\text{Ca}^{2+}</math> and 2 <math>\text{N}^{3-}</math> e.g.</p> $\left[ \text{Ca} \right]_3^{2+} \left[ \begin{array}{ccc} & \times \times & \\ \cdot & \text{N} & \times \\ \cdot & \cdot & \end{array} \right]_2^{3-}$
(d)	(ii)	$\text{Ca}_3\text{N}_2 + 6\text{H}_2\text{O} \rightarrow 3\text{Ca}(\text{OH})_2 + 2\text{NH}_3$ <p><math>\text{Ca}(\text{OH})_2</math> <b>OR</b> <math>\text{NH}_3</math> as product ✓</p> <p>All species correct <b>AND</b> correct balancing ✓</p>	2	AO2.6 ×2	<p><b>ALLOW</b> <math>\text{NH}_4\text{OH}</math> for <math>\text{NH}_3</math></p> <p><b>ALLOW</b> <math>\text{Ca}_3\text{N}_2 + 8\text{H}_2\text{O} \rightarrow 3\text{Ca}(\text{OH})_2 + 2\text{NH}_4\text{OH}</math></p> <p><b>IGNORE</b> other products</p>



Question	Answer	Marks	AO element	Guidance
(d) (iii)	 <p>Ca<sup>2+</sup> shown alternately in <b>FOUR</b> circles ✓</p> <p>O<sup>2-</sup> shown alternately in <b>FOUR</b> circles ✓</p>	2	AO1.1 ×2	<p><b>ALLOW</b> labels if seen outside circles provided it clear which circle the label applies to</p> <p><b>ALLOW</b> 1 mark for Ca <b>AND</b> O shown alternately, each in <b>FOUR</b> circles <i>i.e. with no charges or incorrect charges</i></p> <p><b>ALLOW</b> 1 mark for <b>2+ / +2 AND 2- / -2</b> shown alternately in <b>FOUR</b> circles (with no Ca and O)</p> <p><b>DO NOT ALLOW</b> All circles with same ion, <i>i.e. all Ca<sup>2+</sup> OR all O<sup>2-</sup></i></p> <p><b>ALLOW</b> 1 mark for 4 Ca<sup>2+</sup> <b>AND</b> 4 O<sup>2-</sup> but <b>NOT</b> shown alternately <i>e.g.</i></p>  <p style="text-align: right;">✓</p>



Question	Answer	Marks	AO element	Guidance
(d) (iv)	<p>'Dot and cross' of central N to O OR N ✓</p>  <p>OR</p> <hr/> <p>Rest of 'dot and cross' diagram correct ✓</p> <p>e.g. <math>N \equiv N \rightarrow O</math> OR <math>N = N = O</math></p> 	2	AO2.5 x2	<p>Electrons do NOT need to be shown paired.</p> <p>'Dot and cross' of <math>NO_2</math> ALLOW 1st mark for <math>N \rightarrow O</math> OR <math>N = O</math></p> <p>DO NOT ALLOW ions</p> <p>CARE For 2nd mark, watch for stray paired OR unpaired electrons on central N</p> <p>ALLOW 10 electrons around central N atom for 2 marks, i.e.</p> 
	Total	13		



Question			Answer	Marks	AO element	Guidance					
22	(a)	(i)	<table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>Titre/cm<sup>3</sup></td> <td>24.20</td> <td>23.85</td> <td>24.30</td> <td>✓</td> </tr> </table> <p>Correct subtractions to obtain titres <b>to 2 DP</b></p>	Titre/cm <sup>3</sup>	24.20	23.85	24.30	✓	2	AO2.4	<b>DO NOT ALLOW</b> 24.2 OR 24.3
Titre/cm <sup>3</sup>	24.20	23.85	24.30	✓							
		(ii)	<p>mean titre = <math>\frac{24.20 + 22.30}{2} = 24.25 \text{ (cm}^3\text{)} \checkmark</math>  <i>i.e. using concordant (consistent) titres</i></p>		AO2.4	<p><b>DO NOT ALLOW</b> mean of all three titres,  <i>i.e.</i> <math>\frac{24.20 + 23.85 + 22.30}{3} = 24.10/24.12</math></p> <p><b>ALLOW ECF</b> from incorrect concordant titres from 22a(i)</p>					
	(b)		<p><b>FIRST CHECK THE ANSWER ON ANSWER LINE  IF answer = 0.309 (mol dm<sup>-3</sup>) award 3 marks</b></p> <hr style="border-top: 1px dashed black;"/> <p><math>n(\text{Na}_2\text{CO}_3)</math>  <math>= 0.150 \times \frac{25.00}{1000} = 3.75 \times 10^{-3} \text{ (mol)} \checkmark</math></p> <p><math>n(\text{HCl})</math>  <math>= 2 \times n(\text{Na}_2\text{CO}_3) = 7.50 \times 10^{-3} \text{ (mol)} \checkmark</math></p> <p><b>[HCl] to 3 SF</b>  <math>= n(\text{HCl}) \times \frac{1000}{\text{mean titre from b(i)}}</math>  <math>= 7.50 \times 10^{-3} \times \frac{1000}{24.25} = 0.309 \text{ (mol dm}^{-3}\text{)} \checkmark</math>  <b>3 SF required</b></p>	3	AO2.8 ×3	<p><b>ALLOW 3SF</b> or more throughout  <b>IGNORE</b> trailing zeroes,  <i>e.g.</i> <b>ALLOW</b> 0.075 for 0.00750</p> <hr style="border-top: 1px dashed black;"/> <p><b>ALLOW ECF</b> from 2 × incorrect <math>n(\text{Na}_2\text{CO}_3)</math></p> <p><b>ALLOW ECF</b> from incorrect <math>n(\text{HCl})</math>,  <b>OR</b> from <math>n(\text{Na}_2\text{CO}_3)</math> if <math>n(\text{HCl})</math> stage omitted</p> <p><b>ALLOW ECF</b> from incorrect mean titre in <b>b(ii)</b></p> <hr style="border-top: 1px dashed black;"/> <p><b>COMMON ERROR for 3 marks</b>  From 24.10 cm<sup>3</sup> (mean of all 3 titres in <b>b(ii)</b>),  [HCl] = 0.311 (mol dm<sup>-3</sup>)</p>					



Question		Answer	Marks	AO element	Guidance
	(c)	<p><b>Pipette:</b>  <math display="block">\frac{0.04}{25.0} \times 100 = 0.16 \text{ OR } 0.2 (\%) \checkmark</math></p> <p><b>Burette:</b> (using any of 3 titres or mean titre), e.g.  <math display="block">\frac{0.05 \times 2}{24.20} \times 100 = 0.41 \text{ OR } 0.4 (\%) \checkmark</math></p> <p>Response does <b>NOT</b> need a statement of whether pipette or burette has greater % uncertainty.</p>	2	AO3.1 ×2	<p><b>ALLOW</b> % uncertainties to 1 SF or more, rounded correctly</p> <p>-----</p> <p>Other burette volumes:</p> $\frac{0.05 \times 2}{23.85} \times 100 = 0.42 \text{ OR } 0.4 (\%)$ $\frac{0.05 \times 2}{24.30} \times 100 = 0.41 \text{ OR } 0.4 (\%)$ $\frac{0.05 \times 2}{24.25} \times 100 = 0.41 \text{ OR } 0.4 (\%)$ <p><b>ALLOW</b> burette volume of 50 cm<sup>3</sup>, i.e.  <math display="block">\frac{0.05 \times 2}{50} \times 100 = 0.2\%</math></p> <p><b>ALLOW ECF</b> from incorrect titre in 22(a)</p> <p><b>IF BOTH</b> calculations are 'correct' but ×100 is omitted <b>BOTH</b> times, <b>ALLOW</b> 1 mark</p>
		<b>Total</b>	<b>7</b>		



Question		Answer	Marks	AO element	Guidance
23	(a)	<p><b>Electrons (down group)</b> number of <b>electrons</b> increases ✓</p> <p><b>Type of intermolecular force (ANYWHERE)</b> <b>induced</b> dipole(-dipole) interactions <b>OR</b> London forces ✓</p> <p><b>Link of energy with intermolecular forces (ANYWHERE)</b> (Down group,) more energy to break/overcome <b>intermolecular</b> forces <b>OR</b> more/stronger <b>intermolecular</b> forces ✓</p>	3	AO1.1 x3	<p><b><i>FULL ANNOTATIONS MUST BE USED</i></b></p> <hr style="border-top: 1px dashed blue;"/> <p><b>ALLOW</b> more <b>electron</b> shells</p> <p><b>IGNORE</b> 'more shells' <b>OR</b> more (electron) shielding</p> <p><b>IGNORE</b> comments about nuclear attraction, ionisation energy, etc.</p> <p><b>IGNORE</b> van der Waals' forces, vdw <b>IGNORE</b> abbreviations e.g. LDF, IDID</p> <p><b>IGNORE</b> less energy needed to break 'bonds' <b>OR</b> less energy needed to break 'London forces' <i>Too vague – needs idea of 'between molecules'</i></p> <p><b>IGNORE</b> 'covalent bonds' <i>between atoms</i> <b>BUT</b> response linking to breaking of covalent bonds is a <b>CON</b> for last marking point <b>ONLY</b>.</p>



Question	Answer	Marks	AO element	Guidance
(b)	<p><b>Test for Br<sup>-</sup> (anion) 2 marks</b></p> <p><i>Reagent AND observation</i> Silver nitrate/AgNO<sub>3</sub> <b>AND</b> cream (precipitate) ✓</p> <p><i>Equation</i> Ag<sup>+</sup> + Br<sup>-</sup> → AgBr ✓ <i>State symbols not required</i></p> <hr/> <p><b>Test for NH<sub>4</sub><sup>+</sup> (cation) 3 marks</b></p> <p><i>Reagent and conditions</i> (Heat with) NaOH/KOH/Ca(OH)<sub>2</sub>/OH<sup>-</sup>/hydroxide <b>BUT NOT</b> ammonia ✓</p> <p><i>Observation (Independent mark)</i> pH/indicator paper turns blue / purple / alkaline ✓</p> <p><i>Equation</i> NH<sub>4</sub><sup>+</sup> + OH<sup>-</sup> → NH<sub>3</sub> + H<sub>2</sub>O ✓ <i>State symbols not required</i></p>	5	AO3.3 x5	<p><b>FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc. MUST BE USED</b></p> <hr/> <p><b>IGNORE</b> confusion between <i>cation</i> and <i>anion</i> <b>IGNORE</b> nitric acid <b>ALLOW</b> 'bromine' for bromide in text</p> <p><b>IGNORE</b> responses about solubility in NH<sub>3</sub></p> <p><b>ALLOW</b> full equation: e.g. AgNO<sub>3</sub> + NH<sub>4</sub>Br → AgBr + NH<sub>4</sub>NO<sub>3</sub></p> <hr/> <p><b>ALLOW displacement by Cl<sub>2</sub></b> <i>Reagent</i> Cl<sub>2</sub>/chlorine <b>AND</b> <i>Observation</i> Orange (solution) ✓ <b>ALLOW</b> shade of orange <b>DO NOT ALLOW</b> precipitate</p> <p><i>Equation</i> 2Br<sup>-</sup> + Cl<sub>2</sub> → Br<sub>2</sub> + 2Cl<sup>-</sup> ✓ <b>ALLOW</b> full equation, e.g. 2NaBr + Cl<sub>2</sub> → Br<sub>2</sub> + 2NaCl</p> <hr/> <p><b>ALLOW</b> full equation: i.e. NH<sub>4</sub>Br + NaOH → NaBr + NH<sub>3</sub> + H<sub>2</sub>O</p> <p><b>ALLOW</b> NH<sub>4</sub>Br + NaOH → NaBr + NH<sub>4</sub>OH</p>
	<b>Total</b>	<b>8</b>		

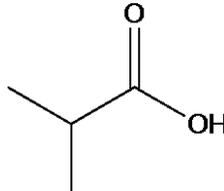
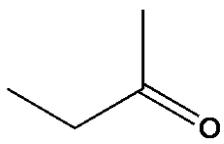


Question			Answer	Marks	AO element	Guidance
24	(a)	(i)	<p><b>Pressure:</b> Right-hand side has fewer (gaseous) moles <b>OR</b> 4 (gaseous) moles form 2 (gaseous) moles ✓</p> <p>High pressure ✓</p> <p><b>Temperature:</b> (Forward) reaction is exothermic/<math>\Delta H</math> is negative <b>OR</b> (Forward) reaction gives out heat ✓</p> <p>Low temperature ✓</p>	4		<p><b>FULL ANNOTATIONS MUST BE USED</b></p> <p>-----</p> <p><b>ALLOW</b> suitable alternatives for right-hand side, e.g.: towards <math>\text{NH}_3</math>/products <b>OR</b> forward direction <b>OR</b> increases yield</p> <p>For moles, <b>ALLOW</b> molecules/particles</p> <p><b>ALLOW reverse</b> reaction is endothermic /<math>\Delta H</math> is positive/takes in heat</p> <p><b>ORA for</b> reverse reaction</p>
		(ii)	<p><b>FIRST CHECK THE ANSWER ON ANSWER LINE</b> <b>IF answer = <math>2.86 \times 10^{-2}</math> award 2 marks</b></p> <p>-----</p> <p><b><math>K_c</math> expression</b></p> <p><math>(K_c =) \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}</math> <b>OR</b> <math>\frac{0.862^2}{1.25 \times 2.75^3}</math> <b>OR</b> 0.02858 ..... ✓</p> <p><b>Answer to 3 SF and in standard form</b> <math>K_c = 2.86 \times 10^{-2}</math> ✓</p>	2	AO2.6 ×2	<p><b>IF</b> there is an alternative answer, check for any <b>ECF</b> credit possible using working below.</p> <p>-----</p> <p><b>ALLOW</b> calculated value 0.02858291 correctly rounded to 3 or more SF for 1st marking point</p> <p><b>ALLOW ECF to 3 SF and standard form</b> <b>ONLY</b> from inverted <math>K_c</math> expression <math>\rightarrow 3.50 \times 10^1</math></p> <p><b>DO NOT ALLOW</b> <math>\frac{[\text{NH}_3]^2}{[\text{N}_2] + [\text{H}_2]^3} = 0.0337</math> (no marks)</p> <p><b>IGNORE</b> attempts at units</p>



Question		Answer	Marks	AO element	Guidance
	(b) (i)	298 K/25°C <b>AND</b> 100 kPa ✓	1	AO1.1	<b>ALLOW</b> 'a stated temperature' <i>To accept that other standard temperatures can be used and 298 should strictly be added as <math>\Delta H_{298}</math></i>  <b>ALLOW</b> $1 \times 10^5$ Pa, 101 kPa, $1.01 \times 10^5$ Pa, 1 atm, 1 bar
	(ii)	<b>FIRST, CHECK THE ANSWER ON ANSWER LINE</b> <b>IF answer = (+)90 (kJ mol<sup>-1</sup>) award 3 marks</b> <b>IF answer = -90 (kJ mol<sup>-1</sup>) award 2 marks</b> <b>IF answer = (+)360 (kJ mol<sup>-1</sup>) award 2 marks</b> ----- <b>Use of <math>\Delta_f H</math> values and balancing numbers</b> $\pm (4 \times -46)$ <b>OR</b> $\pm 184$ <b>AND</b> $\pm (6 \times -242)$ <b>OR</b> $\pm 1452$ seen anywhere ✓  <b>Correct subtraction using <math>\Delta H = -908</math></b> $4 \times \Delta_f H(\text{NO})$ $= (4 \times -46) - (6 \times -242) - 908$ $= -184 + 1452 - 908$ $= (+)360$ (kJ mol <sup>-1</sup> ) ✓  <b>Calculation of <math>\Delta_f H(\text{NO})</math> formation by <math>\div 4</math></b> $\Delta_f H(\text{NO}) = \frac{360}{4} = (+)90$ (kJ mol <sup>-1</sup> ) ✓	3	AO2.6 $\times 3$	<b>FULL ANNOTATIONS MUST BE USED</b> <b>ALLOW ECF if common errors not seen</b>  <b>IF <math>\Delta H</math> of -908 has NOT been used, ONLY award 1st mark</b> ----- <b>COMMON ERRORS</b>  <b>1 mark</b> Incorrect signs(s) <b>AND</b> missing $\div 4$ <b><math>\pm 2544</math> from</b> $\pm (184 + 1452 + 908)$ <b><math>\pm 728</math> from</b> $\pm (184 + 1452 - 908)$ <b><math>\pm 2176</math> from</b> $\pm (-184 + 1452 + 908)$ <b><math>-360</math> from</b> $-(-184 + 1452 - 908)$  <b>2 marks</b> Incorrect signs(s) <b><math>\pm 636</math> from</b> $\pm (184 + 1452 + 908) = \pm 2544 \div 4$ <b><math>\pm 182</math> from</b> $\pm (184 + 1452 - 908) = \pm 728 \div 4$ <b><math>\pm 544</math> from</b> $\pm (-184 + 1452 + 908) = \pm 2176 \div 4$ <b><math>-90</math> from</b> $-(-184 + 1452 - 908) = -360 \div 4$
<b>Total</b>			<b>10</b>		



Question			Answer	Marks	AO element	Guidance
25	(a)	(i)	<p><b>A</b> → </p> <p><b>B</b> → NONE</p> <p><b>C</b> → </p>	3	AO2.5 AO1.2 AO2.5	<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 STICKS IN STRUCTURES</b></p>
		(ii)	butan-2-ol ✓	1	AO1.2	<p><b>IGNORE</b> lack of hyphens, or addition of commas</p> <p><b>ALLOW</b> butane-2-ol</p> <p><b>DO NOT ALLOW</b> butan-3-ol <b>OR</b> but-2-ol</p>
		(iii)	$C_4H_{10}O + 6O_2 \rightarrow 4CO_2 + 5H_2O$ ✓	1	AO2.6	



Question		Answer	Marks	AO element	Guidance
(b)	(i)	<p><b>Initiation</b>  <math>\text{Cl}_2 \rightarrow 2\text{Cl}\cdot</math> <b>AND</b> UV ✓</p> <p><b>Propagation</b>  <math>\text{C}_4\text{H}_{10} + \text{Cl}\cdot \rightarrow \text{C}_4\text{H}_9\cdot + \text{HCl}</math> ✓</p> <p><math>\text{C}_4\text{H}_9\cdot + \text{Cl}_2 \rightarrow \text{C}_4\text{H}_9\text{Cl} + \text{Cl}\cdot</math> ✓</p>	3	AO1.1  AO2.5  AO2.5	<p>Dots <b>NOT</b> required for initiation  <b>IGNORE</b> temperature <b>OR</b> pressure</p> <p>Dots <b>required</b> in each propagation equation</p> <p><b>ALLOW</b> 1 mark for <b>BOTH</b> propagation equations with any dots missing or extra dots            e.g. <math>\text{C}_4\text{H}_{10} + \text{Cl} \rightarrow \text{C}_4\text{H}_9 + \text{HCl}</math>  <math>\text{C}_4\text{H}_9\cdot + \text{Cl}_2 \rightarrow \text{C}_4\text{H}_9\text{Cl} + \text{Cl}</math></p> <p><b>DO NOT ALLOW</b> charges</p>
	(ii)	$\text{C}_4\text{H}_{10} + 10 \text{Cl}_2 \rightarrow \text{C}_4\text{Cl}_{10} + 10 \text{HCl}$ ✓	1	AO2.6	<p><b>ALLOW</b> structural formulae, e.g.  <math>\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 + 10\text{Cl}_2</math>  <math>\rightarrow \text{CCl}_3\text{CCl}_2\text{CCl}_2\text{CCl}_3 + 10\text{HCl}</math></p>
	(iii)	<p><math>n(\text{E}) = \frac{78.0}{32500} = 2.4(0) \times 10^{-3}</math> (mol) ✓</p> <p><math>M(\text{E}) = \frac{0.636}{2.4(0) \times 10^{-3}}</math> <b>OR</b> 265 ✓</p> <p>Molecular formula = <math>\text{C}_4\text{H}_4\text{Cl}_6</math> ✓</p>	3	AO3.1 ×2  AO3.2	<p><b>ALLOW ECF</b> from incorrect <math>n(\text{E})</math></p> <p><b>ALLOW ECF</b> from incorrect <math>M(\text{E})</math> from <math>n(\text{E})</math></p> <p>-----</p> <p><b>COMMON ERROR</b>  <math>n(\text{E}) = \frac{78.0}{24000} = 3.25 \times 10^{-3}</math> (mol) ✗</p> <p><math>M(\text{E}) = \frac{0.636}{3.25 \times 10^{-3}} = 195.69</math> <b>OR</b> 196 ✓</p> <p>(3SF or more)</p> <p>Molecular formula = <math>\text{C}_4\text{H}_6\text{Cl}_4</math> ✓</p> <p><b>ALLOW ECF</b> for molecular formula but must be derived from a calculated value for <math>M(\text{E})</math></p>
<b>Total</b>			<b>12</b>		

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