

GCE

Chemistry A

H032/01: Breadth in chemistry

Advanced Subsidiary GCE

Mark Scheme for November 2020

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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Annotations

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

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

SECTION A

Question	Answer	Marks	AO element	Guidance
1	C	1	1.2	
2	C	1	1.2	
3	B	1	1.1	
4	A	1	1.1	
5	A	1	2.1	
6	A	1	1.2	
7	B	1	1.2	
8	C	1	1.2	ALLOW 4
9	A	1	2.2	
10	B	1	2.6	
11	C	1	2.6	
12	D	1	1.1	
13	B	1	1.2	ALLOW 0.054(0)
14	A	1	1.2	
15	C	1	1.1	
16	C	1	1.1	
17	A	1	1.2	
18	C	1	2.8	ALLOW 36.7
19	B	1	1.2	
20	C	1	2.6	
	Total	20		

SECTION B

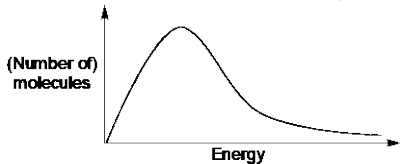
Question		Answer					Marks	AO element	Guidance	
21	(a)	Shell	1st shell	2nd shell	3rd shell	4th shell	1	1.1		
		Electrons	2	8	18	32				
		Requires all 4 numbers to be correct ✓								
	(b)	Differences: (Different number of) neutrons ✓ Similarities: (Same number of) protons AND electrons ✓					2	1.1×2	IGNORE different masses/mass numbers throughout <i>(Question asks for atomic structures)</i> ALLOW 'amount' for 'number' ALLOW 'electron configuration' for electrons	
	(c)	(i)	FIRST CHECK ANSWER ON THE ANSWER LINE If answer = 35.48 (to 2 DP) award 2 marks $\frac{(35 \times 75.76) + (37 \times 24.24)}{100} \text{ OR } 35.4848 \text{ OR } 35.485 \checkmark$ = 35.48 (to 2 DP) ✓					2	1.2×2	For 1 mark: ALLOW ECF → to 2 DP if: <ul style="list-style-type: none"> • %s used with wrong isotopes ONCE OR <ul style="list-style-type: none"> • transposed decimal places for ONE % AND <ul style="list-style-type: none"> • calculated A_r is between 35 and 37
	(c)	(ii)	$m/z = 72: {}^{35}\text{Cl}{}^{37}\text{Cl}$ OR Contains chlorine-35 AND chlorine-37 ✓ m/z values: 70 AND 74 ✓					2	3.1 3.2	

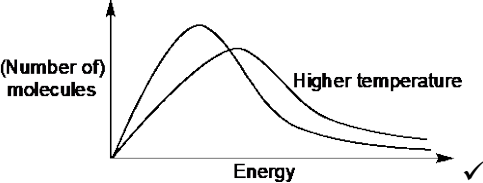
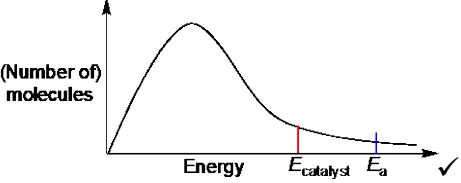
Question			Answer	Marks	AO element	Guidance
22	(a)	(i)	$(1s^2)2s^22p^63s^23p^63d^{10}4s^24p^5$ ✓ Look carefully at $1s^22s^22p^63s^23p^6$ – there may be a mistake	1	1.2	ALLOW 3d after 4s ² , e.g. $1s^22s^22p^63s^23p^64s^23d^{10}4p^5$ ALLOW upper case D, etc and subscripts, e.g.4S ₂ 3D ₁ DO NOT ALLOW [Ar] as shorthand for $1s^22s^22p^63s^23p^6$ IGNORE 1s ² repeated
	(a)	(ii)	$P_4 + 6Br_2 \rightarrow 4PBr_3$ ✓	1	2.6	ALLOW multiples
	(b)		Giant ionic ✓ In solid state/lattice, ions are fixed (in position) OR cannot move AND In liquid state, ions are mobile OR can move ✓	2	1.1 1.2	‘ Giant ’ is essential Mark independently of 1st structure mark IGNORE comments about electrons for solid IGNORE ‘free’ ions

Question	Answer	Marks	AO element	Guidance
(c)	<p>FIRST CHECK ANSWER LINES If molecular formula = BrF₅ AND 174.6/175 AND working showing use of ideal gas equation Award 5 marks for calculation</p> <p>-----</p> <p>Rearranging ideal gas equation $n = \frac{pV}{RT}$ ✓</p> <p>Unit conversion AND substitution into $n = \frac{pV}{RT}$:</p> <ul style="list-style-type: none"> $R = 8.314$ OR 8.31 $V = 76(.0) \times 10^{-6} (\text{m}^3)$ T in K: 373 K <p>e.g. $\frac{1.00 \times 10^5 \times 76.0 \times 10^{-6}}{8.314 \times 373}$ ✓</p> <p>Calculation of n using p, V, R AND T $n = 2.45 \times 10^{-3} (\text{mol})$ ✓</p> <p>Calculation of M $M = \frac{0.428}{2.45 \times 10^{-3}} = 174.6$ ✓</p> <p>Molecular formula BrF₅ OR F₅Br ✓</p>	5	2.2×4 3.2	<p>ALLOW ECF throughout</p> <p>IF $n = \frac{pV}{RT}$ is omitted, ALLOW when values are substituted into rearranged ideal gas equation.</p> <p>ALLOW conversion of V into dm^3 AND p in kPa <i>Gives same answer in powers of 10</i></p> <p>Calculator value: from 8.314 = 2.450725899 × 10⁻³ from 8.31 = 2.45190555 × 10⁻³ IGNORE figures after 5 in 2.45</p> <p>ALLOW ECF from a value of n that has been derived from $pV = nRT$</p> <p>e.g. 0.174.6 OR 0.175 from 2.45</p> <p>ALLOW ECF matching ECF M from $pV = nRT$</p>
	<p>Use of 24 dm³</p> <p>Final 2 marks possible for use of 76.0 cm³ OR 0.760 dm³ by ECF</p> <p>e.g. $n = \frac{76.0}{24000} = 3.17 \times 10^{-3}$ No mark (calculation much simpler)</p> <p>$M = \frac{0.428}{3.17 \times 10^{-3}} = 135$ ✓ ECF</p> <p>BrF₃ ✓ ECF</p>			

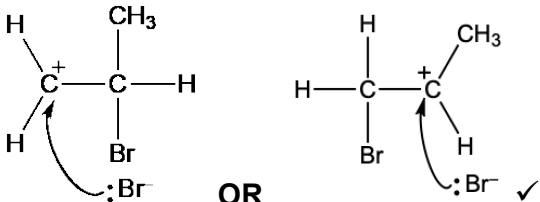
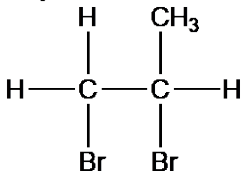
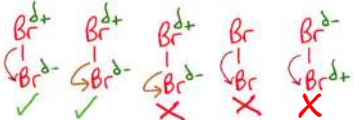
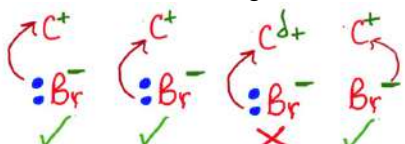
Question		Answer	Marks	AO element	Guidance	
23	(a)	<p>FIRST CHECK ANSWER ON THE ANSWER LINE If answer = 0.454 (mol dm⁻³) award 3 marks If answer = 0.227 (mol dm⁻³) award first 2 marks</p> <hr style="border-top: 1px dashed blue;"/> <p>$n(\text{Ba}(\text{OH})_2)$ in 100 cm³ 1 mark</p> $= \frac{3.89}{171.3} = 0.0227\dots (\text{mol}) \checkmark$ <p style="text-align: right;">3 SF or more</p> <p>Concentration of OH⁻ 2 marks</p> $n(\text{Ba}(\text{OH})_2) \times 2 = 2 \times 0.0227$ $= 0.0454\dots (\text{mol}) \checkmark$ <p>Use of $\times 10$ $= 10 \times 0.0454$</p> $\text{Concentration of OH}^- = 0.454 (\text{mol dm}^{-3}) \checkmark$ <p style="text-align: right;">3 SF required</p>	3		<p>ALLOW ECF throughout</p> <p>ALLOW use of 171 within working (Use of Ar: Ba 137 rather than 137.3)</p> <p>Calculator: 0.02270869819</p> <p>IGNORE figures after 7 in 0.0227</p> <p>ALLOW working with $\times 10$ before $\times 2$</p> <p>Use of $\times 10$ $= 10 \times 0.0227$ $= 0.227\dots (\text{mol}) \checkmark$</p> <p>Use of $\times 2$ $= 2 \times 0.227$</p> $\text{Concentration of OH}^- = 0.454 (\text{mol dm}^{-3}) \checkmark$ <p style="text-align: right;">3 SF required</p> <p>Common error</p> <p style="text-align: center;">0.227 no $\times 2$ 2 marks</p>	
	(b)	(i)	(Titres that agree) within 0.1 cm ³ ✓	1	2.3	<p>ALLOW within 0.05 cm³</p> <p>ALLOW ml for cm³</p> <p>If cm³ units are absent, ASSUME cm³ BUT DO NOT ALLOW incorrect units, e.g. dm³; mol dm⁻³</p>

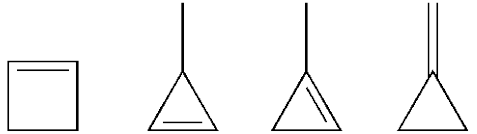
Question		Answer	Marks	AO element	Guidance
(b)	(ii)	<p>FIRST CHECK ANSWER ON THE ANSWER LINE If answer = 0.0856 (mol dm⁻³) award 3 marks</p> <hr/> $n(\text{HNO}_3) = 0.160 \times \frac{26.75}{1000} = 4.28 \times 10^{-3} \text{ (mol) } \checkmark$ $n(\text{Ba}(\text{OH})_2) \text{ in } 25.0 \text{ cm}^3 = \frac{4.28 \times 10^{-3}}{2} = 2.14 \times 10^{-3} \text{ (mol) } \checkmark$ $\text{Concentration} = 2.14 \times 10^{-3} \times \frac{1000}{25} = 0.0856 \text{ (mol dm}^{-3}\text{)} \checkmark$	3	2.8x2 2.4	<p>Use ECF throughout</p> <p>DO NOT ALLOW 4.3×10^{-3} BUT remaining marks available by ECF e.g. $4.3 \times 10^{-3} \div 2 = 2.15 \times 10^{-3} \checkmark$ ECF $2.15 \times 10^{-3} \times \frac{1000}{25} = 0.086 \checkmark$ ECF</p>
(c)		<p>Route 1 <i>Reactant:</i> Add water (to Ba) OR H₂O in equation \checkmark</p> <p><i>Balanced equation:</i> $\text{Ba} + 2\text{H}_2\text{O} \rightarrow \text{Ba}(\text{OH})_2 + \text{H}_2 \checkmark$</p> <p>Route 2 <i>Balanced equation with O₂</i> $2\text{Ba} + \text{O}_2 \rightarrow 2\text{BaO} \checkmark$</p> <p><i>Balanced equation with H₂O</i> $\text{BaO} + \text{H}_2\text{O} \rightarrow \text{Ba}(\text{OH})_2 \checkmark$</p>	4	3.3 2.6 3.3 3.3	<p>ALLOW multiples in equations</p> <p>Balanced equation automatically collects 2 marks for Route 1</p> <p>ALLOW 1 mark for BOTH reactants in route 2: i.e. React with O₂ AND then with H₂O</p> <p>NOTE 3 correct balanced equations → 4 marks</p>

Question		Answer	Marks	AO element	Guidance
24	(a)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = -46 (kJ mol^{-1}) award 3 marks</p> <p>Use of $\Delta_c H$ values and balancing numbers $\pm (+180 + (3 \times -286))$ OR ± 678 AND $\pm (2 \times -293)$ OR ± 586 seen anywhere ✓</p> <p>Correct subtraction using ΔH $(-678) - (-586)$ $= -92$ (kJ mol^{-1}) ✓</p> <p>Calculation of $\Delta_f H(\text{NH}_3)$ formation $\Delta_f H(\text{NH}_3) = \frac{-92}{2} = -46$ (kJ mol^{-1}) ✓</p>	3	2.6 × 3	<p>FULL ANNOTATIONS MUST BE USED</p> <p>ALLOW ECF throughout</p> <p>COMMON ERRORS</p> <p>-92 omission of $\div 2$ for $\Delta_f H(\text{NH}_3)$ 2 marks $(+)$46 Incorrect subtraction 2 marks $(+)$92 Incorrect subtraction & no $\div 2$ 1 mark</p> <p>-385 no $\times 2$ for -293 and no $\div 2$ 1 mark -192.5 no $\times 2$ for -293 2 marks</p> <p>$(+)$480 no $\times 3$ for -286 and no $\div 2$ 1 mark $(+)$240 no $\times 3$ for -286 2 marks</p> <p>$(+)$187 no $\times 3$ for -286 AND no $\times 2$ for -293 AND no $\div 2$ 1 mark</p> <p>$(+)$93.5 no $\times 3$ for -286 AND no $\times 2$ for -293 2 marks</p>
	(b)	<p>Boltzmann distribution (seen anywhere) 2 marks</p>  <p>Curve Curve starts close to origin (ALLOW flexibility) AND curve does not touch x axis at high energy ✓</p> <p>Labels (Number of) molecules/particles AND Energy ✓</p>	5	1.1 × 2	<p>FULL ANNOTATIONS THROUGHOUT</p> <p>NOTE: Look for marking criteria within annotations on Boltzmann distribution diagram</p> <p>IGNORE slight inflexion on the curve IGNORE small increase at end of curve For labels, ALLOW kinetic energy IGNORE number of atoms IGNORE enthalpy for energy</p>

Question	Answer	Marks	AO element	Guidance
	<p>Curves for two temperatures 1 mark</p>  <p>Catalyst and activation energy 1 mark</p>  <p>Molecules and activation energy, E_a 1 mark</p> <p>Explanation At higher temperature OR in presence of catalyst</p> <p>More molecules/particles/collisions</p> <ul style="list-style-type: none"> • have energy above activation energy OR have enough energy to overcome E_a ✓ <p>Could be shown on diagram(s) using shaded area with annotations</p>		1.2×3	<p>Temperature Drawing of two labelled curves AND higher temperature peak at higher energy AND lower on molecules IGNORE curves meeting at higher energy</p> <p>Higher temperature curve must cross over</p> <p>ASSUME that T_2 is higher temperature than T_1</p> <p>Catalyst E_c shown at lower energy than E_a on Boltzmann distribution</p> <p>IGNORE catalyst provides a lower activation energy <i>Boltzmann distribution not used</i></p> <p>ALLOW more molecules have energy to react</p> <p>ALLOW E_a for activation energy ALLOW E_c for activation energy with catalyst</p> <p>IGNORE more successful collisions OR collide more frequently</p>

Question		Answer	Marks	AO element	Guidance
25	(a)	<p>polymerisation</p> <p>HBr</p> <p>one repeat unit</p>	3	2.5×3	<p>ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous</p> <p>For repeat unit,</p> <ul style="list-style-type: none"> • 'side bonds' required on either side of repeat unit from C atoms • DO NOT ALLOW > one repeat unit <p>IGNORE brackets</p> <ul style="list-style-type: none"> • IGNORE n <p>ALLOW in either order</p>
	(b)	<p>1st curly arrow Curly arrow from double bond to Br of Br-Br ✓ DO NOT ALLOW partial charge on C=C</p> <p>2nd curly arrow Correct dipole on Br-Br AND curly arrow for breaking of Br-Br bond ✓</p>	4	1.2 1.2	<p>ANNOTATE ANSWER For curly arrows, ALLOW straight or snake-like arrows and small gaps (see examples)</p> <p>-----</p> <p>1st curly arrow must</p> <ul style="list-style-type: none"> • go to a Br atom of Br-Br <p>AND</p> <ul style="list-style-type: none"> • start from, OR be traced back to any point across width of C=C <p>2nd curly arrow must</p> <ul style="list-style-type: none"> • start from, OR be traced back to, any part of $\delta^+ \text{Br}-\text{Br} \delta^-$ bond • AND go to Br δ^-

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><i>i.e. ALLOW carbonium + on either C atom</i></p> <p>Correct product to match mechanism ✓</p>  <p>DO NOT ALLOW half headed or double headed arrows but allow ECF if seen more than once</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>(Lone pair NOT needed if curly arrow shown from - charge on Br⁻)</p> <p>2.5</p> <p>2.5</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</p>
(c)	(i)	2	1.1×2	<p>IGNORE reference to physical properties IGNORE same general formula DO NOT ALLOW same empirical OR molecular formula</p> <p>Differs by CH₂ is not sufficient (<i>no successive</i>) ALLOW differs by CH₂ each time AW</p>

Question		Answer	Marks	AO element	Guidance
(c)	(ii)	C_nH_{2n-2} ✓	1	3.2	ALLOW $C_nH_{2(n-1)}$
(c)	(iii)	$H_3C-C\equiv C-H + 2Br_2 \longrightarrow H_3C-\overset{\overset{Br}{ }}{C}-\overset{\overset{Br}{ }}{C}-H$ <p>Left-hand side, i.e. Reactants, balanced with $2Br_2$ ✓ Right-hand side, i.e. Product ✓</p>	2	2.5 2.6	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous ALLOW C_3H_4 for $H_3CC\equiv CH$ <i>Questions asks only for structure of product</i> ALLOW $H_3CCBr_2CHBr_2$ OR $H_3CCBr_2CBr_2H$
(c)	(iv)	Any 2 structures from: $H_3C-C\equiv C-CH_3$ $H_2C=C(H)-C(H)=CH_2$ $H_2C=C(H)-CH_3$ 	2	3.2×2	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous
(c)	(v)	$H_3C-\overset{\overset{CH_3}{ }}{C}-C\equiv C-\overset{\overset{CH_3}{ }}{C}-CH_2-CH_3$ ✓	1	2.5	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous

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