Oxford Cambridge and RSA

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.

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

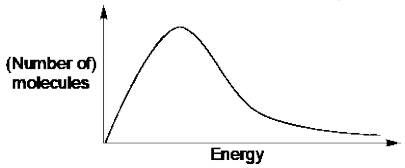
Question			Answer	Marks	AO element	Guidance
21	(a)		<table><tr><td>Shell</td><td>1st shell</td><td>2nd shell</td><td>3rd shell</td><td>4th shell</td></tr><tr><td>Electrons</td><td>**2**</td><td>**8**</td><td>**18**</td><td>**32**</td></tr></table> Requires all 4 numbers to be correct ✓	1	1.1	
	(b)		**Differences**: (Different number of) neutrons ✓ **Similarities**: (Same number of) protons **AND** electrons ✓	2	1.1×2	**IGNORE** different masses/mass numbers throughout (*Question asks for atomic structures*) **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** $\frac{(35 \times 75.76) + (37 \times 24.24)}{100}$ **OR** 35.4848 **OR** 35.485 ✓ = 35.48 (to 2 DP) ✓	2	1.2×2	**For 1 mark: ALLOW ECF** → to 2 DP if: • %s used with wrong isotopes **ONCE** **OR** • transposed decimal places for **ONE** % **AND** • calculated A_r is between 35 and 37
	(c)	(ii)	m/z = 72: $^{35}Cl^{37}Cl$ **OR** Contains chlorine-35 **AND** chlorine-37✓ m/z values: 70 **AND** 74 ✓	2	3.1 3.2	

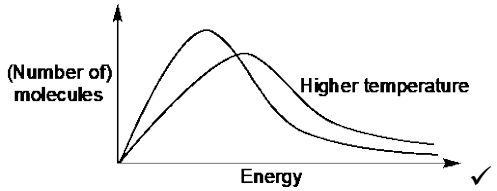
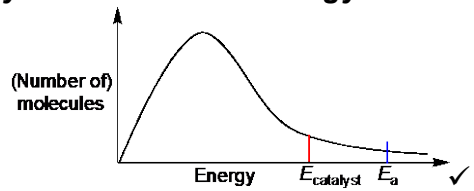
Question			Answer	Marks	AO element	Guidance
22	(a)	(i)	$(1s^2)2s^22p^63s^23p^63d^{10}4s^24p^5$ ✓ Look carefully at $1s^22s^22p^63s^23p^6$ – there may be a mistake	1	1.2	**ALLOW** 3d after $4s^2$, e.g. $1s^22s^22p^63s^23p^64s^23d^{10}4p^5$ **ALLOW** upper case D, etc and subscripts, e.g. ……$4S_2 3D_1$ **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

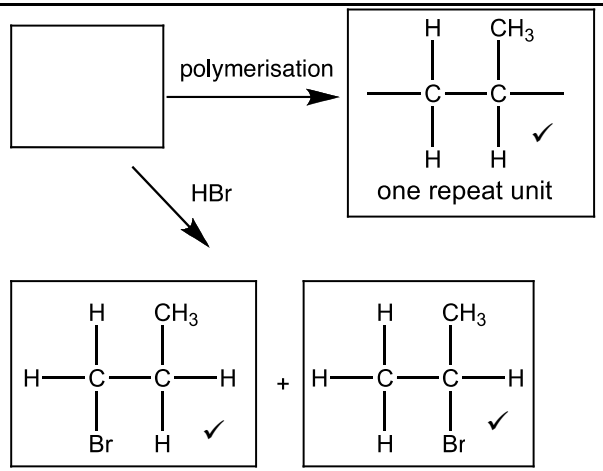
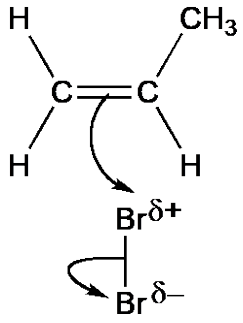
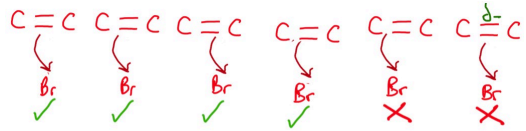
Question			Answer	Marks	AO element	Guidance
	(c)		**FIRST CHECK ANSWER LINES** **If molecular formula = BrF_5 AND 174.6/175 AND working showing use of ideal gas equation** **Award 5 marks for calculation** --- ***Rearranging ideal gas equation*** $n = \frac{pV}{RT}$ ✓ ***Unit conversion AND substitution into $n = \frac{pV}{RT}$:*** • *R = 8.314* ***OR*** *8.31* • *V* = 76(.0) × 10^{-6} (m^3) • *T in K:* 373 K *e.g.* $\frac{1.00 \times 10^5 \times 76.0 \times 10^{-6}}{8.314 \times 373}$ ✓ ***Calculation of n using p, V, R AND T*** $n = 2.45 \times 10^{-3}$ (mol) ✓ ***Calculation of M*** $M = \frac{0.428}{2.45 \times 10^{-3}} = 174.6$ ✓ ***Molecular formula*** BrF_5 **OR** F_5Br ✓	**5**	**2.2×4** **3.2**	**ALLOW ECF throughout** **IF** $n = \frac{pV}{RT}$ is omitted, **ALLOW** when values are substituted into rearranged ideal gas equation. **ALLOW** conversion of *V* into dm^3 **AND** *p* in kPa *Gives same answer in powers of 10* Calculator value: from 8.314 = **2.45**0725899 × **10^{-3}** from 8.31 = **2.45**190555 × **10^{-3}** **IGNORE** figures after 5 in 2.45 **ALLOW ECF** from a value of *n that has been derived from pV = nRT* e.g. 0.174.6 **OR** 0.175 from 2.45 **ALLOW ECF** matching **ECF *M*** from *pV = nRT*
		Use of 24 dm^3	Final 2 marks possible for use of 76.0 cm^3 **OR** 0.760 dm^3 by **ECF** e.g. $n = \frac{76.0}{24000} = 3.17 \times 10^{-3}$ **No mark** (*calculation much simpler*) $M = \frac{0.428}{3.17 \times 10^{-3}} = 135$ ✓ **ECF** BrF_3 ✓ **ECF**			

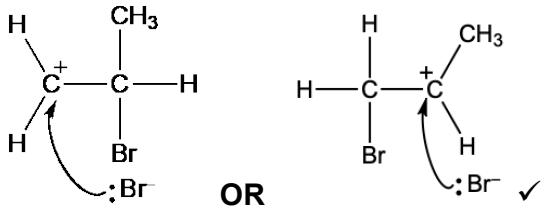
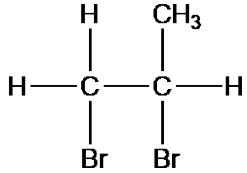
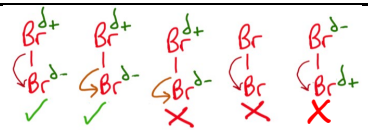
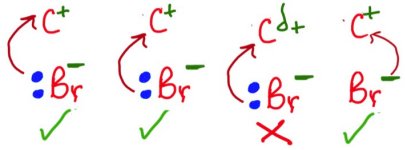
Question			Answer	Marks	AO element	Guidance
23	(a)		**FIRST CHECK ANSWER ON THE ANSWER LINE** **If answer = 0.454 (mol dm^{-3}) award 3 marks** **If answer = 0.227 (mol dm^{-3}) award first 2 marks** --- **n(Ba(OH)$_2$) in 100 cm^3** ***1 mark*** $= \frac{3.89}{171.3}$ = 0.0227…. (mol) ✓ ***3 SF or more*** **Concentration of OH$^-$** ***2 marks*** n(Ba(OH)$_2$) ×2 = **2** × 0.0227 = 0.0454…. (mol) ✓ Use of ×10 = **10** × 0.0454 Concentration of OH$^-$ = 0.454 (mol dm^{-3}) ✓ ***3 SF required***	3	**3.1×2** **3.2**	**ALLOW ECF** throughout **ALLOW** use of 171 within working (Use of A_r: Ba 137 rather than 137.3) Calculator: 0.02270869819 **IGNORE** figures after 7 in 0.0227 **ALLOW working with ×10 before ×2** Use of ×10 = **10** × 0.0227 = 0.227…. (mol) ✓ Use of ×2 = **2** × 0.227 Concentration of OH$^-$ = 0.454 (mol dm^{-3}) ✓ ***3 SF required*** **<u>Common error</u>** 0.227 no × 2 ***2 marks***
	(b)	(i)	(Titres that agree) within 0.1 cm^3 ✓	1	**2.3**	**ALLOW** within 0.05 cm^3 **ALLOW** ml for cm^3 If cm^3 units are absent, **ASSUME** cm^3 **BUT** **DO NOT ALLOW** incorrect units, e.g. dm^3; mol dm^{-3}

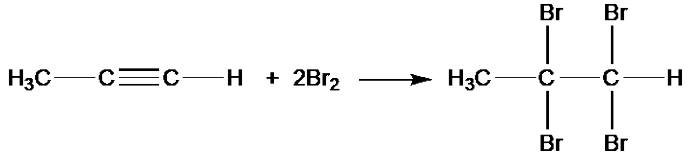
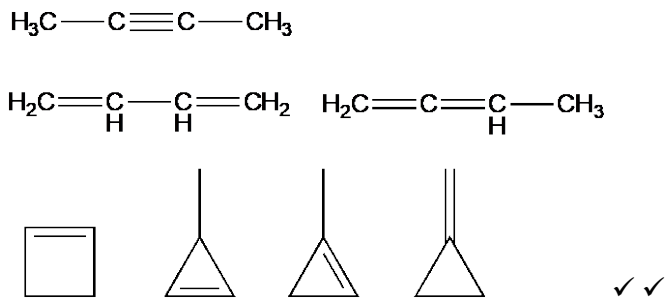
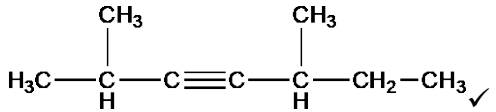
Question			Answer	Marks	AO element	Guidance
	(b)	(ii)	**FIRST CHECK ANSWER ON THE ANSWER LINE** **If answer = 0.0856 (mol dm^{-3}) award 3 marks** --- $n(HNO_3) = 0.160 \times \frac{26.75}{1000}$ $= 4.28 \times 10^{-3}$ (mol) ✓ $n(Ba(OH)_2)$ in 25.0 cm^3 $= \frac{4.28 \times 10^{-3}}{2}$ $= 2.14 \times 10^{-3}$ (mol) ✓ Concentration $= 2.14 \times 10^{-3} \times \frac{1000}{25}$ $= 0.0856$ (mol dm^{-3}) ✓	3	**2.8×2** **2.4**	**Use ECF throughout** **DO NOT ALLOW** 4.3×10^{-3} **BUT** remaining marks available by **ECF** e.g. $4.3 \times 10^{-3} \div 2 = 2.15 \times 10^{-3}$ ✓ **ECF** $2.15 \times 10^{-3} \times \frac{1000}{25} = 0.086$ ✓ **ECF**
	(c)		**Route 1** *Reactant:* Add water (to Ba) **OR** H_2O in equation ✓ *Balanced equation:* $Ba + 2H_2O \rightarrow Ba(OH)_2 + H_2$ ✓ **Route 2** *Balanced equation with O_2* $2Ba + O_2 \rightarrow 2BaO$ ✓ *Balanced equation with H_2O* $BaO + H_2O \rightarrow Ba(OH)_2$ ✓	4	**3.3** **2.6** **3.3** **3.3**	**ALLOW** multiples in equations Balanced equation automatically collects 2 marks for Route 1 **ALLOW** 1 mark for **BOTH** reactants in route 2: i.e. React with O_2 **AND** then with H_2O **NOTE** 3 correct balanced equations → 4 marks

Question			Answer	Marks	AO element	Guidance
24	(a)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = –46 (kJ mol^{-1}) award 3 marks** **Use of $\Delta_c H$ values and balancing numbers** ± (+180 + (3 × –286)) **OR** ± 678 **AND** ± (2 × –293) **OR** ± 586 seen anywhere ✓ **Correct subtraction using ΔH** (–678) – (–586) = –92 (kJ mol^{-1}) ✓ **Calculation of $\Delta_f H$(NH$_3$) formation** $\Delta_f H(NH_3) = \frac{-92}{2}$ = –46 (kJ mol^{-1}) ✓	3	2.6 ×3	**FULL ANNOTATIONS MUST BE USED** **ALLOW ECF** throughout **COMMON ERRORS** –92 omission of ÷2 for $\Delta_f H$(NH$_3$) **2 marks** (+)46 Incorrect subtraction **2 marks** (+)92 Incorrect subtraction & no ÷2 **1 mark** –385 no ×2 for –293 and no ÷2 **1 mark** –192.5 no ×2 for –293 **2 marks** (+)480 no ×3 for –286 and no ÷2 **1 mark** (+)240 no ×3 for –286 **2 marks** (+)187 no ×3 for –286 **AND** no ×2 for –293 **AND** no ÷2 **1 mark** (+)93.5 no ×3 for –286 **AND** no ×2 for –293 **2 marks**
	(b)		***Boltzmann distribution (seen anywhere) 2 marks***  ***Curve*** Curve starts close to origin (**ALLOW** flexibility) **AND** curve does not touch x axis at high energy ✓ ***Labels*** (Number of) molecules/particles **AND** Energy ✓	5	1.1×2	**FULL ANNOTATIONS THROUGHOUT** **NOTE**: Look for marking criteria within annotations on Boltzmann distribution diagram **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

Question	Answer	Marks	AO element	Guidance
	Curves for two temperatures ***1 mark***  ✓ ***Catalyst and activation energy*** ***1 mark***  ✓ ***Molecules and activation energy, E_a*** ***1 mark*** ***Explanation*** At higher temperature **OR** in presence of catalyst More molecules/particles/collisions • have energy above activation energy **OR** have enough energy to overcome E_a ✓ *Could be shown on diagram(s) using shaded area with annotations*		**1.2×3**	**Temperature** Drawing of **two** labelled curves **AND** higher temperature peak at higher energy **AND** lower on molecules **IGNORE** curves meeting at higher energy Higher temperature curve must cross over **ASSUME** that T_2 is higher temperature than T_1 **Catalyst** E_c shown at lower energy than E_a on Boltzmann distribution **IGNORE** catalyst provides a lower activation energy *Boltzmann distribution not used* **ALLOW** more molecules have energy to react **ALLOW** E_a for activation energy **ALLOW** E_c for activation energy with catalyst **IGNORE** more successful collisions **OR** collide more frequently

Question			Answer	Marks	AO element	Guidance
25	(a)			3	2.5×3	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **For repeat unit,** • 'side bonds' required on either side of repeat unit from C atoms • **DO NOT ALLOW** > one repeat unit **IGNORE** brackets • **IGNORE** *n* **ALLOW** in either order
	(b)		 **1st curly arrow** Curly arrow from double bond to Br of Br–Br ✓ **DO NOT ALLOW** partial charge on C=C **2nd curly arrow** Correct dipole on Br–Br **AND** curly arrow for breaking of Br–Br bond ✓	4	1.2 1.2	**ANNOTATE ANSWER** **For curly arrows, ALLOW straight or snake-like arrows and small gaps (see examples)** --- **1st curly arrow** must • go to a Br atom of Br–Br **AND** • start from, **OR** be traced back to **any point across width** of C=C  **2nd curly arrow** must • start from, **OR** be traced back to, **any part of** $^{\delta+}$Br–Br$^{\delta-}$ bond • **AND** go to Br $^{\delta-}$

Question			Answer	Marks	AO element	Guidance
			3rd curly arrow **Correct carbocation** with + charge on C with 3 bonds **AND** curly arrow from Br^- to C^+ of carbocation **DO NOT ALLOW** δ+ on C of carbocation  **OR** ✓ *i.e.* ***ALLOW*** *carbonium + on either C atom* **Correct product to match mechanism** ✓  **DO NOT ALLOW** half headed or double headed arrows but allow **ECF** if seen more than once		2.5 2.5	 **3rd curly arrow** must • go to the C^+ of carbocation **AND** • start from, **OR** be traced back to **any point across width** of lone pair on $:Br^-$ • **OR** start from – charge on Br^- ion  *(Lone pair* ***NOT*** *needed if curly arrow shown from – charge on* Br^-*)* **ALLOW** bromonium ion **ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **NOTE:** For a mechanism with HBr, **ALLOW** all marks **EXCEPT** for final product
	(c)	**(i)**	(series of organic compounds with the) same functional group **OR** same/similar reactions / chemical properties ✓ each successive member differs by CH_2 ✓	**2**	**1.1×2**	**IGNORE** reference to physical properties **IGNORE** same general formula **DO NOT ALLOW** same empirical **OR** molecular formula Differs by CH_2 is **not** sufficient (*no successive*) **ALLOW** differs by CH_2 each time **AW**

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

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