GCE

Chemistry A

H032/01: Breadth in chemistry

Advanced Subsidiary GCE

Mark Scheme for June 2019

Oxford Cambridge and RSA Examinations

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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 available in RM Assessor

Annotation	Meaning
✔	Correct response
✘	Incorrect response
^	Omission mark
BOD	Benefit of doubt given
CON	Contradiction
RE	Rounding error
SF	Error in number of significant figures
ECF	Error carried forward
L1	Level 1
L2	Level 2
L3	Level 3
NBOD	Benefit of doubt not given
SEEN	Noted but no credit given
I	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	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	
	Total	**20**		

SECTION B

Question			Answer	Marks	AO element	Guidance
21	(a)		**TWO correct responses from** ✓ • Different numbers of neutrons • Different (atomic) masses/mass numbers • Different **physical** properties *Physical required*	1	AO1.1	**IGNORE** heavier/lighter **DO NOT ALLOW** different **relative atomic** masses **BUT ALLOW** different relative **isotopic** masses **DO NOT ALLOW** different **chemical** properties **OR** different properties **IGNORE** different abundancies
	(b)		 **Mark by row**	2	AO1.2 ×2	**THREE responses for each mark** *Easiest to check element first* **ALLOW** Se^{2-} **ALLOW** names for elements
	(c)		**Sub-shells labels** 2s (single box) **AND** 2p (3 boxes) ✓ **Electrons as arrows** unpaired electrons in 3 boxes: ↑↓ ↑ ↑ **AND** Paired electrons in single box: ↑↓ ✓	2 AO1.1 AO1.2		 **ALLOW** single headed arrows, e.g. ↑
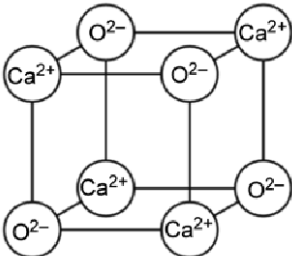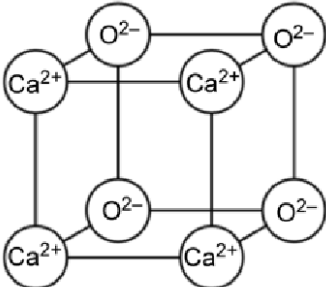
The table for (b):

Element	Mass number	Protons	Neutrons	Electrons	Charge	
Fe	54	26	28	26	0	✓
Se	80	34	46	36	2–	✓
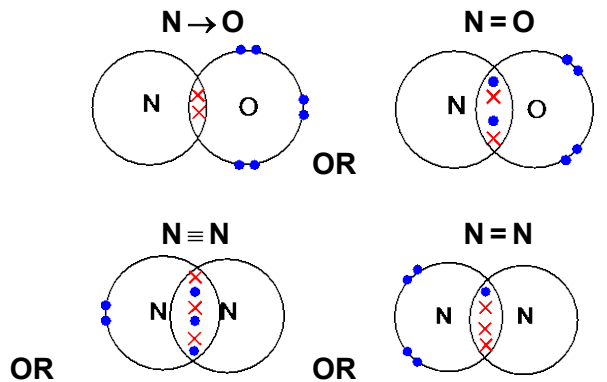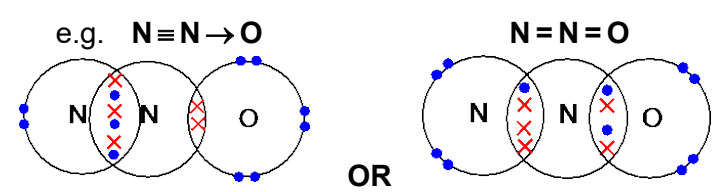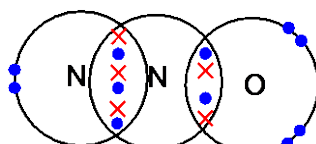
Question		Answer	Marks	AO element	Guidance
(d)	(i)	Ca shown with either 0 or 8 electrons **AND** N shown with 8 electrons with 5 dots and 3 crosses (or vice versa) ✓ 3 Ca **AND** 2 N **AND** correct charges on ions, i.e. $3Ca^{2+}$ $2N^{3-}$ ✓ Circles **OR** Brackets **NOT** required	2	AO2.5 AO1.2	**CARE:** **ALLOW any** pairing if electrons correct, e.g. **IF** 8 electrons shown around Ca, 'extra' 3 electrons around N must match symbol for Ca electrons, e.g. **IGNORE** inner shells **ALLOW** drawing with 3 Ca^{2+} and 2 N^{3-} e.g.
(d)	(ii)	$Ca_3N_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2NH_3$ $Ca(OH)_2$ **OR** NH_3 as product ✓ All species correct **AND** correct balancing ✓	2	AO2.6 ×2	**ALLOW** NH_4OH for NH_3 **ALLOW** $Ca_3N_2 + 8H_2O \rightarrow 3Ca(OH)_2 + 2NH_4OH$ **IGNORE** other products

Question			Answer	Marks	AO element	Guidance
(d)	(iii)		 Ca^{2+} shown alternately in **FOUR** circles ✓ O^{2-} shown alternately in **FOUR** circles ✓	2	AO1.1 ×2	**ALLOW** labels if seen outside circles provided it clear which circle the label applies to **ALLOW** 1 mark for Ca **AND** O shown alternately, each in **FOUR** circles *i.e. with no charges or incorrect charges* **ALLOW** 1 mark for **2+/+2 AND 2–/–2** shown alternately in **FOUR** circles (with no Ca and O) **DO NOT ALLOW** All circles with same ion, *i.e. all Ca^{2+} **OR** all O^{2-}* **ALLOW** 1 mark for 4 Ca^{2+} **AND** $4O^{2-}$ but NOT shown alternately e.g. ✓

Question			Answer	Marks	AO element	Guidance
	(d)	(iv)	**'*Dot and cross*' of central N to O OR N** ✓ **Rest of '*dot and cross*' diagram correct** ✓ 	2	AO2.5 ×2	**Electrons do NOT need to be shown paired.** **'Dot and cross' of NO$_2$** **ALLOW** 1st mark for N→O **OR** N=O **DO NOT ALLOW** ions **CARE** For 2nd mark, watch for stray paired **OR** unpaired electrons on central N **ALLOW** 10 electrons around central N atom for 2 marks, i.e.
			Total	13		

Question			Answer	Marks	AO element	Guidance
22	(a)	(i)	Titre/cm³ | 24.20 | 23.85 | 24.30 | ✓ Correct subtractions to obtain titres **to 2 DP**	2	AO2.4	**DO NOT ALLOW** 24.2 **OR** 24.3
		(ii)	mean titre = $\dfrac{24.20 + 22.30}{2}$ = 24.25 (cm³) ✓ *i.e. using concordant (consistent) titres*		AO2.4	**DO NOT ALLOW** mean of all three titres, i.e. $\dfrac{24.20 + 23.85 + 22.30}{3}$ = 24.10/24.12 **ALLOW ECF** from incorrect concordant titres from 22a(i)
	(b)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **IF answer = 0.309 (mol dm⁻³) award 3 marks** -- $n(Na_2CO_3)$ $\quad = 0.150 \times \dfrac{25.00}{1000}$ $\quad = 3.75 \times 10^{-3}$ (mol) ✓ $n(HCl)$ $\quad = 2 \times n(Na_2CO_3)$ $\quad = 7.50 \times 10^{-3}$ (mol) ✓ **[HCl] to 3 SF** $\quad = n(HCl) \times \dfrac{1000}{\text{mean titre from } \mathbf{b(i)}}$ $\quad = 7.50 \times 10^{-3} \times \dfrac{1000}{24.25}$ $\quad = 0.309$ (mol dm⁻³) ✓ $\quad\quad\quad\quad\quad\quad\quad$ **3 SF required**	3	AO2.8 ×3	**ALLOW 3SF** or more throughout **IGNORE** trailing zeroes, e.g. **ALLOW** 0.075 for 0.00750 --- **ALLOW ECF** from 2 × incorrect $n(Na_2CO_3)$ **ALLOW ECF** from incorrect $n(HCl)$, **OR** from $n(Na_2CO_3)$ if $n(HCl)$ stage omitted **ALLOW ECF** from incorrect mean titre in **b(ii)** --- **COMMON ERROR for 3 marks** From 24.10 cm³ (mean of all 3 titres in **b(ii)**), [HCl] = 0.311 (mol dm⁻³)

Question			Answer	Marks	AO element	Guidance
	(c)		***Pipette***: $\dfrac{0.04}{25.0} \times 100 = 0.16$ **OR** 0.2 (%) ✓ ***Burette***: (using any of 3 titres or mean titre), e.g. $\dfrac{0.05 \times 2}{24.20} \times 100 = 0.41$ **OR** 0.4 (%) ✓ Response does **NOT** need a statement of whether pipette or burette has greater % uncertainty.	2	AO3.1 ×2	**ALLOW** % uncertainties to *1 SF or more, rounded correctly* --- Other burette volumes: $\dfrac{0.05 \times 2}{23.85} \times 100 = 0.42$ **OR** 0.4 (%) $\dfrac{0.05 \times 2}{24.30} \times 100 = 0.41$ **OR** 0.4 (%) $\dfrac{0.05 \times 2}{24.25} \times 100 = 0.41$ **OR** 0.4 (%) **ALLOW burette volume of 50 cm³, i.e.** $\dfrac{0.05 \times 2}{50} \times 100 = 0.2\%$ **ALLOW ECF** from incorrect titre in **22(a)** **IF BOTH** calculations are 'correct' but ×100 is omitted **BOTH** times, **ALLOW** 1 mark
			Total	7		

Question			Answer	Marks	AO element	Guidance

23	(a)		**Electrons (down group)**
			    number of **electrons** increases ✓
			
			Type of intermolecular force (ANYWHERE)
			    induced dipole(–dipole) interactions
			    OR
			    London forces ✓
			
			Link of energy with intermolecular forces (ANYWHERE)
			(Down group,)
			  more energy to break/overcome **intermolecular** forces
			  OR
			  more/stronger **intermolecular** forces ✓
				3	AO1.1
					×3
						FULL ANNOTATIONS MUST BE USED
						--- 	
						ALLOW more **electron** shells
						
						IGNORE 'more shells'
						        OR more (electron) shielding
						
						IGNORE comments about nuclear attraction, ionisation energy, etc.
						
						IGNORE van der Waals' forces, vdw
						IGNORE abbreviations e.g. LDF, IDID
						
						IGNORE less energy needed to break 'bonds'
						OR less energy needed to break 'London forces'
						*Too vague – needs idea of '**between molecules**'*
						
						IGNORE 'covalent bonds' *between atoms*
						BUT response linking to breaking of covalent bonds is a **CON for last marking point ONLY**.

Question			Answer	Marks	AO element	Guidance

	(b)		**Test for Br⁻ (anion)** **2 marks**
			
			*Reagent **AND** observation*
			    Silver nitrate/$AgNO_3$ **AND** cream (precipitate) ✓
			
			Equation
			    $Ag^+ + Br^- \rightarrow AgBr$ ✓
			    State symbols not required
			
			-- 	
			Test for NH_4^+ (cation) **3 marks**
			Reagent and conditions
			    (Heat with) $NaOH$/KOH/$Ca(OH)_2$/OH^-/hydroxide
			    BUT NOT ammonia ✓
			Observation (Independent mark)
			    pH/indicator paper turns blue / purple / alkaline ✓
			Equation
			    $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$ ✓
			    State symbols not required
				5	AO3.3
					×5
						FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc. MUST BE USED
						-- 	
						IGNORE confusion between *cation* and *anion*
						IGNORE nitric acid
						ALLOW 'bromine' for bromide in text
						
						IGNORE responses about solubility in NH_3
						
						ALLOW full equation:
						    e.g. $AgNO_3 + NH_4Br \rightarrow AgBr + NH_4NO_3$
						-- 	
						ALLOW displacement by Cl_2
						Reagent Cl_2/chlorine
						  AND
						Observation Orange (solution) ✓
						                  ALLOW shade of orange
						                  DO NOT ALLOW precipitate
						
						Equation $2Br^- + Cl_2 \rightarrow Br_2 + 2Cl^-$ ✓
						                  ALLOW full equation, e.g.
						                  $2NaBr + Cl_2 \rightarrow Br_2 + 2NaCl$
						-- 	
						
						ALLOW full equation:
						    i.e. $NH_4Br + NaOH \rightarrow NaBr + NH_3 + H_2O$
						
						ALLOW $NH_4Br + NaOH \rightarrow NaBr + NH_4OH$

			Total	8		

Question			Answer	Marks	AO element	Guidance

24	(a)	(i)	**Pressure**:
			Right-hand side has fewer (gaseous) moles
			OR 4 (gaseous) moles form 2 (gaseous) moles ✓
			
			High pressure ✓
			
			Temperature:
			(Forward) reaction is exothermic/ΔH is negative
			OR (Forward) reaction gives out heat ✓
			
			Low temperature ✓
				4	AO1.2
					
					AO2.1
					
					AO1.2
					
					AO2.1
						FULL ANNOTATIONS MUST BE USED
						-- 	
						ALLOW suitable alternatives for right-hand side, e.g.: towards NH_3/products
						        OR forward direction
						        OR increases yield
						
						For moles, **ALLOW** molecules/particles
						
						ALLOW reverse reaction is endothermic /ΔH is positive/takes in heat
						
						ORA for reverse reaction

		(ii)	**FIRST CHECK THE ANSWER ON ANSWER LINE**
			IF answer = 2.86×10^{-2} award 2 marks
			--- 	
			
			K_c **expression**
			$(K_c =) \dfrac{[NH_3]^2}{[N_2][H_2]^3}$ **OR** $\dfrac{0.862^2}{1.25 \times 2.75^3}$
			                OR 0.02858 ………… ✓
			
			Answer to 3 SF and in standard form
			    $K_c = 2.86 \times 10^{-2}$ ✓
				2	AO2.6
					×2
						IF there is an alternative answer, check for any **ECF** credit possible using working below.
						-- 	
						
						ALLOW calculated value 0.02858291 correctly rounded to 3 or more SF for 1st marking point
						
						ALLOW ECF to 3 SF and standard form
						ONLY from inverted K_c expression $\rightarrow 3.50 \times 10^1$
						
						DO NOT ALLOW $\dfrac{[NH_3]^2}{[N_2] + [H_2]^3}$ = 0.0337 (no marks)
						
						IGNORE attempts at units
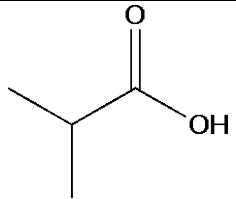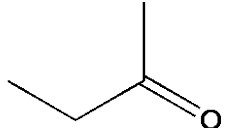
Question			Answer	Marks	AO element	Guidance
(b)	(i)		298 K/25ºC **AND** 100 kPa ✓	1	AO1.1	**ALLOW** 'a stated temperature' *To accept that other standard temperatures can be used and 298 should strictly be added as $\Delta H_{298}^{\ominus}$* **ALLOW** 1×10^5 Pa, 101 kPa, 1.01×10^5 Pa, 1 atm, 1 bar
		(ii)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer = (+)90 (kJ mol^{-1}) award 3 marks** **IF answer = −90 (kJ mol^{-1}) award 2 marks** **IF answer = (+)360 (kJ mol^{-1}) award 2 marks** -- **Use of $\Delta_f H$ values and balancing numbers** $\pm (4 \times -46)$ **OR** ± 184 **AND** $\pm (6 \times -242)$ **OR** ± 1452 seen anywhere ✓ **Correct subtraction using $\Delta H = -908$** $4 \times \Delta_f H(NO)$ $= (4 \times -46) - (6 \times -242) - 908$ $= -184 + 1452 - 908$ $= (+)360$ (kJ mol^{-1}) ✓ **Calculation of $\Delta_f H(NO)$ formation by ÷4** $\Delta_f H(NO) = \dfrac{360}{4} = (+)90$ (kJ mol^{-1}) ✓	3	AO2.6 ×3	**FULL ANNOTATIONS MUST BE USED** **ALLOW ECF if common errors not seen** **IF ΔH of −908 has NOT been used, ONLY award 1st mark** -- **COMMON ERRORS** **1 mark** Incorrect signs(s) **AND** missing ÷4 **±2544 from** $\pm (184 + 1452 + 908)$ **±728 from** $\pm (184 + 1452 - 908)$ **±2176 from** $\pm (-184 + 1452 + 908)$ **−360 from** $-(-184 + 1452 - 908)$ **2 marks** Incorrect signs(s) **±636 from** $\pm (184 + 1452 + 908) = \pm 2544÷4$ **±182 from** $\pm (184 + 1452 - 908) = \pm 728÷4$ **±544 from** $\pm (-184 + 1452 + 908) = \pm 2176÷4$ **−90 from** $-(-184 + 1452 - 908) = -360÷4$
			Total	10		

Question			Answer	Marks	AO element	Guidance
25	(a)	(i)		3	AO2.5 AO1.2 AO2.5	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **DO NOT ALLOW STICKS IN STRUCTURES**
		(ii)	butan-2-ol ✓	1	AO1.2	**IGNORE** lack of hyphens, or addition of commas **ALLOW** butane-2-ol **DO NOT ALLOW** butan-3-ol **OR** but-2-ol
		(iii)	$C_4H_{10}O + \textbf{6}\,O_2 \rightarrow 4CO_2 + 5H_2O$ ✓	1	AO2.6	

Question			Answer	Marks	AO element	Guidance
(b)	(i)		**Initiation** $Cl_2 \rightarrow 2Cl\bullet$ **AND** UV ✓ **Propagation** $C_4H_{10} + Cl\bullet \rightarrow C_4H_9\bullet + HCl$ ✓ $C_4H_9\bullet + Cl_2 \rightarrow C_4H_9Cl + Cl\bullet$ ✓	3	AO1.1 AO2.5 AO2.5	Dots **NOT** required for initiation **IGNORE** temperature **OR** pressure Dots **required** in each propagation equation **ALLOW** 1 mark for **BOTH** propagation equations with any dots missing or extra dots e.g. $C_4H_{10} + Cl \rightarrow C_4H_9 + HCl$ $C_4H_9\bullet + Cl_2\bullet \rightarrow C_4H_9Cl + Cl$ **DO NOT ALLOW** charges
		(ii)	$C_4H_{10} + 10\,Cl_2 \rightarrow C_4Cl_{10} + 10\,HCl$ ✓	1	AO2.6	**ALLOW** structural formulae, e.g. $CH_3CH_2CH_2CH_3 + 10Cl_2$ $\rightarrow CCl_3CCl_2CCl_2CCl_3 + 10HCl$
		(iii)	$n(\mathbf{E}) = \dfrac{78.0}{32500} = 2.4(0) \times 10^{-3}$ (mol) ✓ $M(\mathbf{E}) = \dfrac{0.636}{2.4(0) \times 10^{-3}}$ **OR** 265 ✓ Molecular formula = $C_4H_4Cl_6$ ✓	3	AO3.1 ×2 AO3.2	**ALLOW ECF** from incorrect $n(\mathbf{E})$ **ALLOW ECF** from incorrect $M(\mathbf{E})$ from $n(\mathbf{E})$ --- **COMMON ERROR** $n(\mathbf{E}) = \dfrac{78.0}{24000} = 3.25 \times 10^{-3}$ (mol) ✗ $M(\mathbf{E}) = \dfrac{0.636}{3.25 \times 10^{-3}} = 195.69$ **OR** 196 ✓ (3SF or more) Molecular formula = $C_4H_6Cl_4$ ✓ **ALLOW ECF** for molecular formula but must be derived from a calculated value for $M(\mathbf{E})$
			Total	12		

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