GCE

Chemistry A

H032/01: Breadth in chemistry

Advanced Subsidiary GCE

Mark Scheme for June 2019

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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 available in RM Assessor

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	**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

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AO element</th><th>Guidance</th></tr>
<tr><td>21</td><td>(a)</td><td></td><td>TWO correct responses from ✓
• Different numbers of neutrons
• Different (atomic) masses/mass numbers
• Different physical properties
Physical required</td><td>1</td><td>AO1.1</td><td>IGNORE heavier/lighter

DO NOT ALLOW different relative atomic masses
BUT ALLOW different relative isotopic masses

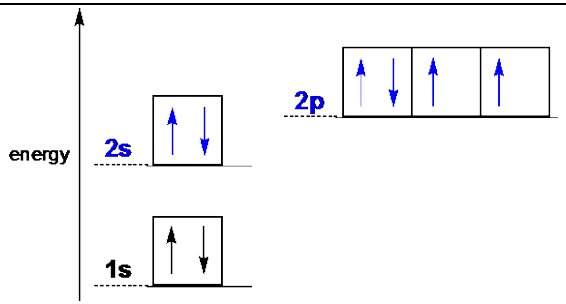
DO NOT ALLOW different chemical properties
OR different properties

IGNORE different abundancies</td></tr>
<tr><td></td><td>(b)</td><td></td><td><table><tr><th>Element</th><th>Mass number</th><th>Protons</th><th>Neutrons</th><th>Electrons</th><th>Charge</th></tr><tr><td>Fe</td><td>54</td><td>26</td><td>28</td><td>26</td><td>0</td></tr><tr><td>Se</td><td>80</td><td>34</td><td>46</td><td>36</td><td>2–</td></tr></table>✓ ✓

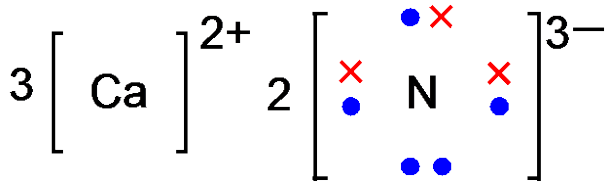
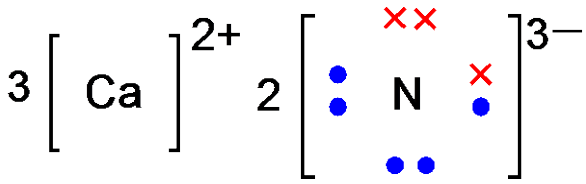
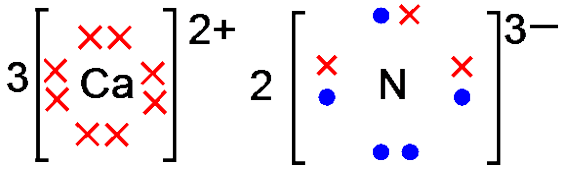
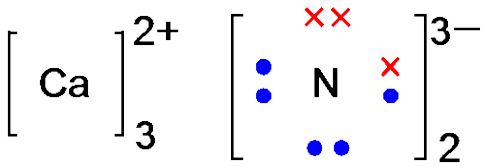
Mark by row</td><td>2</td><td>AO1.2
×2</td><td>THREE responses for each mark
Easiest to check element first

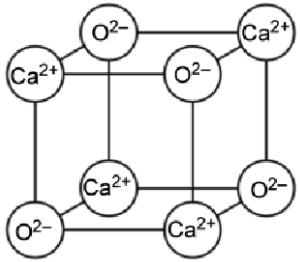
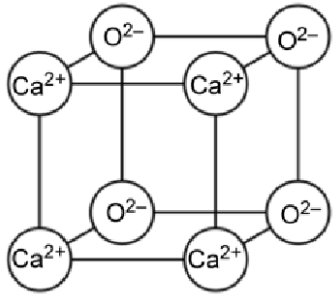
ALLOW Se^{2-}
ALLOW names for elements</td></tr>
<tr><td></td><td>(c)</td><td></td><td>Sub-shells labels
2s (single box) AND 2p (3 boxes) ✓

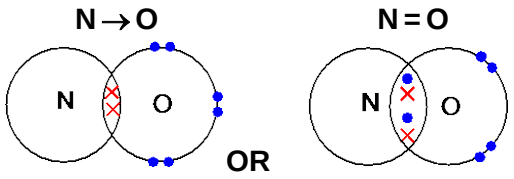
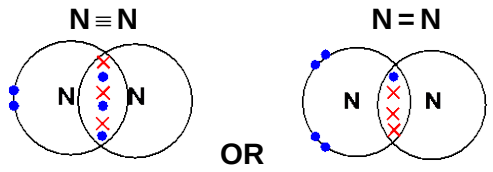
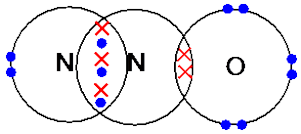
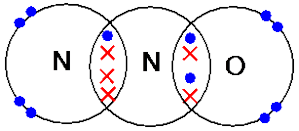
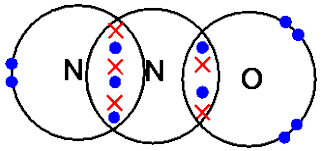
Electrons as arrows
unpaired electrons in 3 boxes: ↑↓ ↑ ↑
AND
Paired electrons in single box: ↑↓ ✓</td><td>2</td><td>AO1.1

AO1.2</td><td> 

ALLOW single headed arrows, e.g. ↑</td></tr>
</table>

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** ✓   **OR** **OR** --- **Rest of '*dot and cross*' diagram correct** ✓ e.g. **N ≡ N → O**  **OR** **N = N = O**  	**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)	<table><tr><td>Titre/cm^3</td><td>24.20</td><td>23.85</td><td>24.30</td><td>✓</td></tr></table> Correct subtractions to obtain titres **to 2 DP**	2	AO2.4	**DO NOT ALLOW** 24.2 **OR** 24.3
		(ii)	mean titre = $\frac{24.20 + 22.30}{2}$ = 24.25 (cm^3) ✓ *i.e. using concordant (consistent) titres*		AO2.4	**DO NOT ALLOW** mean of all three titres, i.e. $\frac{24.20 + 23.85 + 22.30}{3}$ = 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$_2$CO$_3$)** = 0.150 × $\frac{25.00}{1000}$ = 3.75 × 10^{-3} (mol) ✓ ***n*(HCl)** = 2 × *n*(Na$_2$CO$_3$) = 7.50 × 10^{-3} (mol) ✓ **[HCl] to 3 SF** = *n*(HCl) × $\frac{1000}{\text{mean titre from } \textbf{b(i)}}$ = 7.50 × 10^{-3} × $\frac{1000}{24.25}$ = 0.309 (mol dm^{-3}) ✓ **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$_2$CO$_3$) **ALLOW ECF** from incorrect *n*(HCl), **OR** from *n*(Na$_2$CO$_3$) if *n*(HCl) stage omitted **ALLOW ECF** from incorrect mean titre in **b(ii)** ---------- **COMMON ERROR for 3 marks** From 24.10 cm^3 (mean of all 3 titres in **b(ii)**), [HCl] = 0.311 (mol dm^{-3})

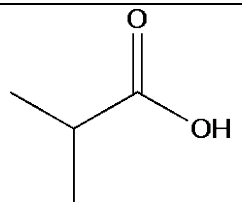
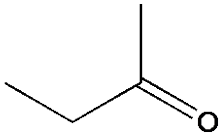
Question			Answer	Marks	AO element	Guidance
	(c)		***Pipette***: $\frac{0.04}{25.0} \times 100 = 0.16$ **OR** 0.2 (%) ✓ ***Burette***: (using any of 3 titres or mean titre), e.g. $\frac{0.05 \times 2}{24.20} \times 100 = 0.41$ **OR** 0.4 (%) ✓ Response does **NOT** need a statement of whether pipette or burette has greater % uncertainty.	**2**	AO3.1 ×2	**ALLOW** % uncertainties to *1 SF or more, rounded correctly* --- Other burette volumes: $\frac{0.05 \times 2}{23.85} \times 100 = 0.42$ **OR** 0.4 (%) $\frac{0.05 \times 2}{24.30} \times 100 = 0.41$ **OR** 0.4 (%) $\frac{0.05 \times 2}{24.25} \times 100 = 0.41$ **OR** 0.4 (%) **ALLOW burette volume of 50 cm^3, i.e.** $\frac{0.05 \times 2}{50} \times 100 = 0.2\%$ **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)		4		***FULL ANNOTATIONS MUST BE USED*** --- **ALLOW** suitable alternatives for right-hand side, e.g.: towards NH_3/products **OR** forward direction **OR** increases yield
			Pressure: Right-hand side has fewer (gaseous) moles **OR** 4 (gaseous) moles form 2 (gaseous) moles ✓		AO1.2	For moles, **ALLOW** molecules/particles
			High pressure ✓		AO2.1	
			Temperature: (Forward) reaction is exothermic/ΔH is negative **OR** (Forward) reaction gives out heat ✓		AO1.2	**ALLOW reverse** reaction is endothermic /ΔH is positive**/**takes in heat
			Low temperature ✓		AO2.1	**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 =) $\frac{[NH_3]^2}{[N_2]\,[H_2]^3}$ **OR** $\frac{0.862^2}{1.25 \times 2.75^3}$ **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 → 3.50×10^1 **DO NOT ALLOW** $\frac{[NH_3]^2}{[N_2] + [H_2]^3}$ = 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** ± (4 × –46) **OR** ± 184 **AND** ± (6 × –242) **OR** ± 1452 seen anywhere ✓ **Correct subtraction using ΔH = –908** $4 \times \Delta_f H$(NO) = (4 × –46) – (6 × –242) – 908 = –184 + 1452 – 908 = (+)**360** (kJ mol^{-1}) ✓ **Calculation of $\Delta_f H$(NO) formation by ÷4** $\Delta_f H(\text{NO}) = \frac{360}{4}$ = **(+)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** ± (184 + 1452 + 908) **±728 from** ± (184 + 1452 – 908) **±2176 from** ± (–184 + 1452 + 908) **–360 from** – (–184 + 1452 – 908) **2 marks** Incorrect signs(s) **±636 from** ± (184 + 1452 + 908) = ± 2544÷4 **±182 from** ± (184 + 1452 – 908) = ± 728÷4 **±544 from** ± (–184 + 1452 + 908) = ± 2176÷4 **–90 from** – (–184 + 1452 – 908) = – 360÷4
			Total	**10**		

Question			Answer	Marks	AO element	Guidance
25	(a)	(i)	**A** →  ✓ **B** → NONE ✓ **C** →  ✓	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)	$C_4H_{10}O + \mathbf{6}\,O_2 \rightarrow 4CO_2 + 5H_2O$ ✓	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)	$n(\mathbf{E}) = \frac{78.0}{32500} = 2.4(0) \times 10^{-3}$ (mol) ✓ $M(\mathbf{E}) = \frac{0.636}{2.4(0) \times 10^{-3}}$ **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** $n(\mathbf{E}) = \frac{78.0}{24000} = 3.25 \times 10^{-3}$ (mol) ✗ $M(\mathbf{E}) = \frac{0.636}{3.25 \times 10^{-3}} = 195.69$ **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**		

OCR (Oxford Cambridge and RSA Examinations)
The Triangle Building
Shaftesbury Road
Cambridge
CB2 8EA

OCR Customer Contact Centre

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