

GCE

Chemistry A

Unit **F321**: Atoms, Bonds and Groups

Advanced Subsidiary GCE

Mark Scheme for June 2016

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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

Annotation	Meaning
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Ignore
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct response

Abbreviations

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

The following questions should be annotated with ticks , crosses , ignore , etc to show where marks have been awarded in the body of the text

2bi

2c

3d

Question		Answer	Mark	Guidance																
1	(a)	<table border="1"> <thead> <tr> <th>particle</th> <th>relative mass</th> <th>relative charge</th> <th>position within the atom</th> </tr> </thead> <tbody> <tr> <td>proton</td> <td>1</td> <td>+ 1</td> <td>nucleus</td> </tr> <tr> <td>neutron</td> <td>1</td> <td>nil/0</td> <td>nucleus</td> </tr> <tr> <td>electron</td> <td>1/2000</td> <td>- 1</td> <td>shell</td> </tr> </tbody> </table> <p>Relative mass column ✓</p> <p>Relative charge AND position columns ✓</p>	particle	relative mass	relative charge	position within the atom	proton	1	+ 1	nucleus	neutron	1	nil/0	nucleus	electron	1/2000	- 1	shell	2	<p>For relative masses ALLOW 1/1800 to 1/2000 for electron value (0.0005–0.00056) ALLOW 'negligible' for electron value IGNORE '+' in front of correct values DO NOT ALLOW '-' in front of 1/2000 DO NOT ALLOW 'nil' OR 'zero' for mass of electron</p> <p>For relative charges ALLOW 1+ and 'neutral' and 1- IGNORE '-' (ie a dash) for neutron DO NOT ALLOW '+' or '-' without '1' DO NOT ALLOW '1' without charge</p> <p>For position within the atom IGNORE 'middle OR 'centre' for 'nucleus'</p>
particle	relative mass	relative charge	position within the atom																	
proton	1	+ 1	nucleus																	
neutron	1	nil/0	nucleus																	
electron	1/2000	- 1	shell																	
1	(b)	(i)	<p>s-orbital = spherical AND p-orbital = dumb-bell shape ✓</p>	1	<p>For s-orbital IGNORE 'circular'</p> <p>For p-orbital ALLOW other words indicating 3-D shape of p-orbital eg 'Peanut-shaped' OR hour glass etc ALLOW 'figure of eight' OR 'figure of 8' IGNORE diagrams</p>															
1		(ii)	<p>p-orbitals have greater energy than s-orbitals ✓</p> <p>(three) p-orbitals have equal energy ✓</p>	2	<p>ALLOW reverse argument</p> <p>ALLOW suitable energy diagram for either part</p>															

Question	Answer	Mark	Guidance
1 (c)	$\begin{array}{c} \times \\ \times \\ \times \\ \times \\ \times \end{array} \text{N} \quad \begin{array}{c} \bullet \\ \bullet \\ \bullet \\ \bullet \\ \bullet \end{array} \text{N} \quad \bullet \bullet$	1	ALLOW all dots or all crosses.
1 (d)	<p>First check the answer line. If answer = $1.7(0) \times 10^{-3}$ award 2 marks.</p> <p>-----</p> <p>M1 (Dividing by 6.02×10^{23}) Number of N_2 molecules = $\frac{5.117 \times 10^{20}}{6.02 \times 10^{23}} = 8.5. \times 10^{-4}$</p> <p>OR 0.85×10^{-3} OR 0.085×10^{-2} OR 0.0085×10^{-1} OR 0.00085 ✓</p> <p>M2 (Correct conversion of molecules to atoms + standard form) M1 x 2 and in standard form ✓ From 0.0085, answer = $2 \times 0.00085 = 0.00170$ = $1.7(0) \times 10^{-3}$</p> <p><i>Alternative method</i> M1 (Correct conversion of molecules to atoms) $= 5.117 \times 10^{20} \times 2 = 1.02(34) \times 10^{21}$</p> <p>OR $10.2(34) \times 10^{20}$ OR $102.(34) \times 10^{19}$ etc</p> <p>M2 (Correct use of 6.02×10^{23} + standard form) $\frac{1.02(34) \times 10^{21}}{6.02 \times 10^{23}} = \mathbf{1.7(0) \times 10^{-3}}$</p>	2	<p>ALLOW one mark for 0.17×10^{-2} OR 0.017×10^{-1} OR 0.0017 (not standard form)</p> <p>ALLOW one mark for 4.25×10^{-4} (dividing by 2 in M2 + standard form)</p> <p>ALLOW one mark for 6.16×10^{44} (multiplying by 6.02×10^{23} in M1 + standard form)</p>

Question			Answer	Mark	Guidance
1	(e)	(i)	$\text{N}_2\text{O}_3 = +3$ $\text{NO} = +2$ $\text{NO}_2 = +4 \checkmark$	1	ALLOW '3' OR '3+' etc ALLOW oxidation numbers written over the equation but IGNORE if oxidation numbers are given on the answer lines
		(ii)	Disproportionation \checkmark	1	QWC 'disproportionation' spelled correctly.
1	(f)	(i)	(Actual) number of atoms of each element present in a molecule \checkmark	1	ALLOW 'compound' for 'molecule' IGNORE 'simplest whole' before 'number' ALLOW 'actual ratio' IGNORE 'ratio' alone DO NOT ALLOW 'simplest ratio'
		(ii)	$\text{HNO}_2 \checkmark$	1	ALLOW O_2HN etc
Total				12	

Question		Answer	Mark	Guidance
2	(a)	Simple molecular lattice ✓	1	ALLOW 'simple covalent' OR 'simple molecular' ie 'simple' must be seen. DO NOT ALLOW 'simple covalent <i>bonds</i> '
2	(b)	(i)	3	IGNORE use of 'atoms' for M1 and M2 ALLOW (random) movement of electrons ALLOW change in electron density ALLOW alternative expression for instantaneous dipole Eg transient dipole, oscillating dipole, momentary dipole, changing dipole DO NOT ALLOW the induction of an instantaneous or temporary dipole for M2 DO NOT ALLOW the idea of a permanent dipole OR formation of ions for M2 ALLOW resultant dipole on an adjacent molecule(s) IGNORE atoms for molecules IGNORE instantaneous/temporary for M3
		(ii)	2	ALLOW reverse argument throughout ALLOW chlorine has less electron shells IGNORE less shells IGNORE reference to chlorine has less shielding for M1 ALLOW vdW ALLOW 'intermolecular forces' OR 'dispersion forces' OR 'London Forces' OR induced dipole-dipole forces' for van der Waals' forces ALLOW 'less' for 'weaker' DO NOT ALLOW implication that any other attraction is broken for M2 eg Covalent bonds
		M1 <i>Electron mark</i> Bromine has more electrons (than chlorine) ✓ M2 <i>Relative force mark</i> Bromine has stronger (OR more) van der Waals' forces (between molecules) OR More energy is needed to break the van der Waals' forces in bromine ✓		

Question	Answer	Mark	Guidance
2 (c)	<p>M1 <i>Mixing of first pair of solutions</i> Adding (aqueous) barium chloride to bromine (water) OR $\text{BaCl}_2 + \text{Br}_2$</p> <p>M2 <i>Mixing of second pair of solutions</i> Adding (aqueous) calcium iodide to bromine (water) OR $\text{CaI}_2 + \text{Br}_2$ OR Adding aqueous magnesium bromide to aqueous iodine OR $\text{MgBr}_2 + \text{I}_2$</p> <p>M3 <i>Colours in cyclohexane</i> Colour for M1 is orange OR yellow AND Colour for M2 is purple OR violet OR mauve OR pink OR lilac</p> <p>M4 <i>Ionic equation mark</i> $\text{Br}_2 + 2\text{I}^- \rightarrow \text{I}_2 + 2\text{Br}^-$</p> <p>M5 <i>Use of M1 and one of M2 as only two experiments</i></p>	5	<p>For M1 and M2 ALLOW any halide for the named halides in the question eg 'potassium chloride' for barium chloride 'potassium bromide' DO NOT ALLOW 'barium chloride/BaCl' 'calcium iodine/CaI' 'magnesium bromine/MgBr' as the halide DO NOT ALLOW 'bromide' for 'bromine' OR 'iodide' for 'iodine' M1 can be seen anywhere</p> <p>M2 could be awarded from a correct ionic equation in M4 M2 can be seen anywhere</p> <p>If both M2 tests and M1 are given, this will nullify M5</p> <p>M3 is given for the correct resultant colour of pairs of solution given in M1 and M2. If both possible pairs of solutions in M2 are given, both colours must be correct. IGNORE colours of other combinations of solutions IGNORE colours in the aqueous layer if stated</p> <p>DO NOT ALLOW other colours for M1 and M2 (eg iodine is brown) M4 can be awarded anywhere M4 also scores M2 if not already awarded ALLOW multiples IGNORE state symbols IGNORE $\text{I}_2 + 2\text{Br}^- \rightarrow \text{I}_2 + 2\text{Br}^-$ IGNORE $\text{Br}_2 + 2\text{Cl}^- \rightarrow \text{Br}_2 + 2\text{Cl}^-$ DO NOT ALLOW other ionic equations DO NOT ALLOW if more than two experiment are attempted even if pointless eg 'barium chloride + calcium iodide' Place the 'tick' for M5 against the sub-total mark, [5], at the bottom right hand side of the answer space</p>
	Total	11	

Question		Answer	Mark	Guidance
3	(a)	Periodicity ✓	1	
3	(b)	Sodium OR Na ✓ Silicon OR Si ✓ Neon OR Ne ✓	3	
3	(c)	Ga ³⁺ ✓	1	
3	(d)	<p><i>M1 Number of bonding electrons mark</i> Magnesium has more outer OR bonding electrons ✓</p> <p><i>M2 Ionic charge mark</i> Magnesium ions have a greater (positive) charge (density) ✓</p> <p><i>M3 Attraction mark</i> Magnesium has a greater attraction between ions and delocalised electrons ✓</p>	3	<p>ALLOW reverse argument throughout ALLOW 'more delocalised electrons' for 'more outer electrons' DO NOT ALLOW 'Magnesium molecules' for M1</p> <p>ALLOW Mg²⁺ ion OR Mg ion for 'magnesium ion' ALLOW Mg²⁺ and Na⁺ for M2 (may be seen in a diagram) IGNORE magnesium has a greater charge but ALLOW magnesium has a greater ionic charge IGNORE nuclear charge DO NOT ALLOW 'atoms' or 'molecules' having a greater charge for M2</p> <p>ALLOW 'stronger metallic bonds' only when a clear description of metallic bonding is given. Eg 'The attraction of positive (metal) ions to delocalised electrons'</p> <p>QWC 'delocalised/delocalized' spelled correctly at least once in context of M3 (may be seen in M1 but used in M3)</p> <p>'delocalised' need not be directly next to electrons eg Mg has more delocalised electrons and the ions have a greater attraction to these electrons would secure M3</p>

Question		Answer	Mark	Guidance
3	(e)	<p>First check the answer line. If answer = 1200 cm³ award 3 marks.</p> <p>Mol of Mg(NO₃)₂ = $\frac{2.966}{148.3} = 2(.00) \times 10^{-2}$ OR 0.02(00) mol ✓</p> <p>Mol of gas = $2(.00) \times 10^{-2} \times 5/2 = 5(.00) \times 10^{-2}$ OR 0.05(00) mol ✓</p> <p>Vol of Gas = 0.05 x 24 000 = 1200 cm³ ✓</p>	3	<p>If answer = 960 cm³ award 2 marks. If answer = 240 cm³ award 2 marks.</p> <p>ALLOW ECF for answers to at least two significant figures up to calculator value, correctly rounded</p> <p>ALLOW separate numbers of mol of each gas for M2 (0.04(00) mol NO₂ and 0.0100 mol O₂)</p> <p>ALLOW a second mark if only volume of O₂ (240 cm³) OR only volume of NO₂ (960 cm³) is calculated</p>
3	(f)	(i)	1	IGNORE sulfur fluoride
		(ii)	2	<p>ALLOW multiples IGNORE state symbol ALLOW OF₂ for F₂O AND FNa for NaF</p> <p>ALLOW both marks for alternative equations which have both F₂O and NaF AND three products Eg 3F₂ + 2NaOH → 2F₂O + 2NaF + H₂ Eg 2F₂ + NaOH → F₂O + NaF + HF</p>
3	(g)	(i)	1	ALLOW δ ⁻ on each F AND δ ⁺ on O ✓
		(ii)	1	<p>Shape: non-linear</p> <p>AND</p> <p>Bond angle: 104.5° ✓</p> <p>For shape ALLOW alternative words eg 'V-shaped' 'bent' 'angular'. In the absence of words allow a diagram with a non-linear shape F – O – F bond angle > 90°. For bond angle ALLOW 106 > bond angle ≥ 102 (Actual = 102°)</p>
		(iii)	1	ALLOW 2+
Total			17	

Question			Answer	Mark	Guidance
4	(a)		$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$ ✓	1	ALLOW $4s^2 3d^{10}$
4	(b)	(i)	M1 The (weighted) mean mass of an atom (of an element) ✓ M2 Compared with $1/12^{\text{th}}$ (the mass) ✓ M3 Of (one atom of) carbon-12 ✓	3	ALLOW 'average' for 'mean' ALLOW 'mean mass of isotopes' but DO NOT ALLOW 'mean mass of isotope' (singular) DO NOT ALLOW 'mean mass of an element' For M2 and M3 ALLOW compared with the mass of carbon-12 which is 12 ALLOW for three marks Mass of one mole of atoms Compared to $1/12^{\text{th}}$ (mass of) one mole OR 12 g of carbon-12 ALLOW for three marks <u>Mass of one mole of atoms</u> $1/12^{\text{th}}$ (mass of) one mole OR 12 g of carbon-12
4	(b)	(ii)	First check the answer line. If answer = 65.44 award 2 marks. $\frac{(64 \times 49.0) + (66 \times 27.9) + (67 \times 4.3) + (68 \times 18.8)}{100}$ OR $31.36(0) + 18.414 + 2.881 + 12.784$ OR 65.439 ✓ = 65.44 ✓	2	ALLOW one mark for ECF from transcription error in the first sum provided the final answer is to two decimal places and is between 64 and 68 and is a correct calculation of the transcription
4	(c)	(i)	Effervescence OR fizzing OR bubbling OR gas produced AND The solid OR zinc carbonate would dissolve OR disappear ✓	1	ALLOW 'carbon dioxide produced' DO NOT ALLOW incorrectly named gas eg H_2

Question			Answer	Mark	Guidance
4	(c)	(ii)	$\text{ZnCO}_3 + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{CO}_2 + \text{H}_2\text{O} \checkmark$	1	ALLOW multiples IGNORE state symbols
4	(d)	(i)	Magnesium (atoms) has been oxidised AND Because it has lost two electrons \checkmark Copper (ions) has been reduced AND Because it has gained two electrons \checkmark	2	IGNORE use of oxidation numbers if electron gain/loss is mentioned. Electrons gain/loss could be in half equations In the absence of text look for evidence on the equation ALLOW 'donated' for 'lost' Assume 'Cu' refers to copper in 'CuSO ₄ ' ALLOW one mark two electrons gained and lost for each species but oxidation/reduction is incorrect or is omitted ALLOW one mark for correct oxidation and reduction if electron transfer is omitted and correct changes of oxidation state are shown (ie Mg 0 --> (+)2 AND Cu (+)2 to 0) ALLOW 'two electrons transferred from magnesium to copper'
4	(d)	(ii)	$\text{Mg(s)} + 2\text{H}_2\text{O(l)} \rightarrow \text{Mg(OH)}_2\text{(aq)} + \text{H}_2\text{(g)}$ Correct reactants and products \checkmark Balance and state symbols \checkmark	2	ALLOW multiples ALLOW Mg(OH) ₂ (s) ALLOW Mg(s) + H ₂ O(g) OR H ₂ O(l) --> MgO(s) + H ₂ (g) including state symbols for one mark

Question		Answer	Mark	Guidance	
4	(e)	<p>First check the answer line. If answer = 0.120 award 4 marks.</p> <p>M1 Mol of $\text{H}_2\text{SO}_4 = 3.00 \times 10^{-2} \times \frac{35.0}{1000} = 1.05 \times 10^{-3} \text{ mol} \checkmark$</p> <p>M2 Mol of $\text{Al}_2(\text{SO}_4)_3 = \frac{1.05 \times 10^{-3}}{3} = 3.5(0) \times 10^{-4} \text{ mol} \checkmark$</p> <p>M3 = 342.3 \checkmark</p> <p>M4 Mass $\text{Al}_2(\text{SO}_4)_3 = 3.5(0) \times 10^{-4} \times 342.3$ and $= 0.120 \text{ g} \checkmark$ Answer must be 3 sf</p>	4	<p>ALLOW ECF</p> <p>ALLOW 0.00105 mol</p> <p>ALLOW 0.00035(0) mol</p> <p>ALLOW 342</p> <p>DO NOT ALLOW 0.12</p>	
4	(f)	(i)	<p>$\text{Ca}(\text{OH})_2$ OR Calcium hydroxide OR CaO OR Calcium oxide \checkmark</p>	1	ALLOW Calcium carbonate OR CaCO_3
4	(f)	(ii)	<p>$6\text{Ca} + \text{P}_4 \rightarrow 2\text{Ca}_3\text{P}_2 \checkmark$</p>	1	<p>ALLOW multiples</p> <p>IGNORE state symbols</p>

Question	Answer	Mark	Guidance
(iii)	<p> $3x$ $\left[\begin{array}{c} xx \\ xCa\ x \\ x \\ xx \end{array} \right]^{2+}$ $2x$ $\left[\begin{array}{c} \bullet\bullet \\ \bullet\bullet \\ xP\ x \\ \bullet \\ \bullet x \end{array} \right]^{3-}$ </p> <p>Ca with 8 (or no) electrons AND phosphide ion with dot-and-cross outermost octet ✓</p> <p>Three Ca ions AND two phosphide ions with correct charges ✓</p>	2	<p>For first mark: If 8 electrons are shown on the cation then the extra electron in the anion must match the symbol chosen for the electrons in the cation. IGNORE inner shells IGNORE circles</p> <p>ALLOW one mark if both electron arrangements and charges are correct but only one of each ion is drawn.</p> <p>ALLOW (brackets not required) $3[Ca^{2+}]$ $3[Ca]^{2+}$ $[Ca^{2+}]_3$ $2[P^{3-}]$ $2[P]^{3-}$ $[P^{3-}]_2$</p> <p>DO NOT ALLOW $[Ca_3]^{2+}$ $[3Ca]^{2+}$ $[Ca]_3^{2+}$ $[P_2]^{3-}$ $[2P]^{3-}$ $[P]_2^{3-}$</p>
	Total	20	

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