

GCE

Chemistry A

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

Advanced Subsidiary GCE

Mark Scheme for June 2015

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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 available in Scoris.

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, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

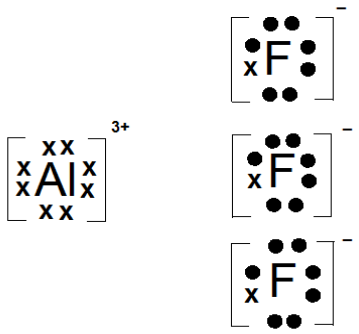
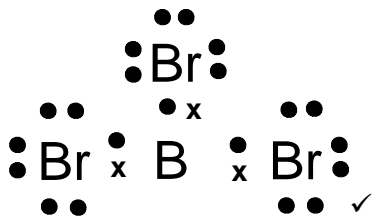
Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
()	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

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

Q2d Q6b

Question			Answer	Mark	Guidance												
1	(a)	(i)	<table border="1"> <thead> <tr> <th>Particle</th> <th>Relative charge</th> <th>Number of particles present in a $^{140}\text{Ce}^{2+}$ ion.</th> </tr> </thead> <tbody> <tr> <td>Protons</td> <td>+1</td> <td>58</td> </tr> <tr> <td>Neutrons</td> <td>Nil (or 0)</td> <td>82</td> </tr> <tr> <td>Electrons</td> <td>-1</td> <td>56</td> </tr> </tbody> </table> <p>One mark per column ✓ ✓</p>	Particle	Relative charge	Number of particles present in a $^{140}\text{Ce}^{2+}$ ion.	Protons	+1	58	Neutrons	Nil (or 0)	82	Electrons	-1	56	2	<p>DO NOT ALLOW '+' or '-' without '1'</p> <p>DO NOT ALLOW 1 without charge</p> <p>ALLOW 1+ AND 1-</p> <p>IGNORE '-' (ie a dash) for relative charge of a neutron</p>
			Particle	Relative charge	Number of particles present in a $^{140}\text{Ce}^{2+}$ ion.												
			Protons	+1	58												
			Neutrons	Nil (or 0)	82												
Electrons	-1	56															
(b)	(i)	Hydrogen ✓	1	<p>ALLOW H₂</p> <p>IGNORE 'H'</p>													
	(ii)	<p>Ce₂(SO₄)₃ ✓</p> <p>(Cerium) loses three electrons (to form 3+ ion) ✓</p>	2	<p>ALLOW alternative phrases for 'loses' eg 'gives away', 'donates'</p> <p>IGNORE '3 electrons transferred' unless a correct direction is given eg ALLOW (Ce) transfers 3 electrons to ... OR (Ce) transfers 3 electrons forming Ce³⁺</p> <p>IGNORE references to sulfate gaining electrons</p> <p>IGNORE references to reduction and oxidation</p>													
	(iii)	A hydrogen ion (of an acid) has been replaced by a metal ion ✓	1	<p>For hydrogen ion:</p> <p>ALLOW 'H⁺' OR 'proton'</p> <p>but DO NOT ALLOW 'H' OR 'hydrogen' without 'ion'</p> <p>For metal ion:</p> <p>ALLOW 'cerium ion' OR 'Ce³⁺' OR 'Ce²⁺' OR 'Ce ion'</p> <p>But DO NOT ALLOW 'Ce' without 'ion' OR 'cerium' without 'ion'</p> <p>IGNORE 'ammonium ion'</p>													

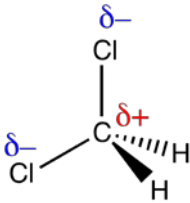


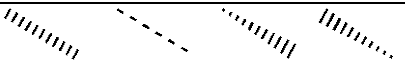

Question		Answer	Mark	Guidance	
	(c)	<p>Check the answer line. If answer = 1080 cm³ award 2 marks</p> <p>Amount of Eu = 9.12/ 152.0 = 0.06(00) mol ✓</p> <p>Amount of O₂ = 0.0600 x 3/4 = 0.045(0) mol and Volume of O₂ = 0.0450 x 24000 = 1080 cm³ ✓</p>	2	<p>If there is an alternative answer, check to see if there is any ECF credit possible using working below. ALLOW calculator value or rounding to 2 significant figures or more but IGNORE 'trailing zeroes' eg 0.200 is allowed as 0.2.</p> <p>ALLOW incorrectly calculated <i>amount</i> of Eu x 3/4 and x 24000 correctly calculated for 2nd mark Eg 2605.7 would come from (9.12/63) x 3/4 x 24000 (note: a mass of Eu x 3/4 and x 24000 would not score M2)</p>	
1	(d)	(i)	The simplest whole number ratio of atoms (of each element) present in a compound ✓	1	ALLOW smallest OR lowest for simplest ALLOW molecule for compound
		(ii)	<p>Check the answer line. If answer = O₁₂S₃Tm₂ award 2 marks</p> <p>O = 30.7/ 16.0 S 15.4/32.1 Tm = 53.9 / 168.9 OR 1.9(2) mol 0.480 mol 0.319 mol ✓</p> <p>O₁₂S₃Tm₂ ✓</p>	2	<p>ALLOW 0.479 OR 0.48 for mol of S ALLOW 0.32 for mol of Tm</p> <p>DO NOT ALLOW Tm₂(SO₄)₃ as empirical formula IGNORE Tm₂(SO₄)₃ if seen in working.</p>
	(e)	(i)	32 ✓	1	
		(ii)	9 ✓	1	
			Total	13	

Question		Answer	Mark	Guidance
2	(a)	$2\text{Al} + 3\text{F}_2 \rightarrow 2\text{AlF}_3$ ✓	1	ALLOW multiples IGNORE state symbols
	(b) (i)	Repeating pattern ✓ of oppositely charged ions ✓	2	ALLOW 'regular' OR 'alternating' OR 'uniform (arrangement)' for 'repeating pattern' ALLOW positive and negative ions OR aluminium ions and fluoride ions ALLOW oppositely charged ions from a labelled diagram
	(ii)	 <p>Al with 8 (or no) outermost electrons AND 3 x fluoride (ions) with 'dot-and-cross' outermost octet ✓ Correct charges ✓</p>	2	For first mark: If 8 electrons are shown in 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 ALLOW one mark if both electron arrangements and charges are correct but only one F is drawn. ALLOW one mark if incorrect symbol is the only error, unless ECF from 2(a) in which both marks are available DO NOT ALLOW any marks for BF_3 ALLOW $3[\text{F}^-]$ $3[\text{F}]^-$ $[\text{F}^-]_3$ (brackets not required) DO NOT ALLOW $[\text{F}_3]^-$ $[\text{F}_3]^{3-}$ $[3\text{F}]^{3-}$ $[\text{F}]_3^-$
	(c) (i)	A shared pair of electrons.	1	
	(c) (ii)		1	

Question	Answer	Mark	Guidance
(d)	<p><i>Conductivity of Al mark</i> M1: Aluminium conducts in solid and molten states ✓</p> <p><i>Reason for conductivity of Al mark</i> M2: Aluminium has delocalised electrons ✓</p> <p><i>Conductivity and reason for molten AlF_3 mark</i> M3: Aluminium fluoride conducts when molten AND because it has mobile ions ✓</p> <p><i>Conductivity and reason for solid AlF_3 mark</i> M4: Aluminium fluoride does not conduct when solid AND Solid aluminium fluoride has ions which are fixed (in position) OR ions are held (in position) OR ions are not mobile AND In an (ionic) lattice OR (ionic) structure OR by (ionic) bonds ✓</p>	5	<p>ALLOW 'carries charge' for conducts IGNORE 'charge carriers' for 'electrons' or 'ions' for M2, M3 and M4.</p> <p><i>Quality of written communication:</i> 'delocalis(z)ed' spelled correctly and used in context for the second marking point.</p> <p>DO NOT ALLOW M2 if incorrect bonding is seen for Al DO NOT ALLOW 'ions move' for solid Al. IGNORE 'ions move' for molten Al.</p> <p>IGNORE references to 'aqueous' AlF_3 for M3 IGNORE 'delocalised ions' OR 'free ions' for mobile ions in M3 DO NOT ALLOW M3 if incorrect bonding is seen in AlF_3 DO NOT ALLOW any mention of electrons moving for M3 DO NOT ALLOW suggestion that it is only positive or only negative ions moving for M3 For conductivity parts of M3 + M4 ALLOW 'AlF_3 only conducts when molten'</p> <p>ALLOW Solid AlF_3 is a poor conductor for M4 ALLOW second and third statements to be unlinked in separate sentences for M4 IGNORE 'there are no delocalised electrons' for M4 DO NOT ALLOW M4 if incorrect bonding is seen in AlF_3 Lattice OR structure OR ionic bonds can be seen anywhere in relation to AlF_3.</p> <p>ALLOW Solid BBr_3 is a poor conductor for M5 ALLOW electrons are fixed in position OR used in bonds</p>

Question			Answer	Mark	Guidance
			<p><i>Conductivity and reason for BBr₃ mark</i></p> <p>M5 Boron tribromide does not conduct in solid and molten states</p> <p>AND</p> <p>Boron tribromide has no mobile electrons OR no (mobile) ions OR no mobile charge carriers OR no mobile charged particles ✓</p>		<p>IGNORE 'there are no delocalised electrons' OR 'there are no free electrons' for M5</p> <p>DO NOT ALLOW M5 if incorrect bonding is seen in BBr₃ eg 'ions are fixed in position'</p> <p>ALLOW 'no (free) ions'</p>
2	(e)	(i)	$\text{Al}^{2+}(\text{g}) \rightarrow \text{Al}^{3+}(\text{g}) + \text{e}^{-} \checkmark$	1	<p>State symbols required (ignore states on electrons)</p> <p>ALLOW $\text{Al}^{2+}(\text{g}) - \text{e}^{-} \rightarrow \text{Al}^{3+}(\text{g})$</p> <p>ALLOW e for e⁻</p>
		(ii)	<p>All (thirteen) ionisation energies show an increase ✓</p> <p>The two largest increases are between the third and fourth</p> <p>AND</p> <p>the eleventh and twelfth ionisation energies ✓</p>	2	<p>IGNORE line if drawn</p> <p>IGNORE 0 if included</p> <p>ALLOW one mark for three lines (no crosses) showing an increase between: first and third; fourth and eleventh; twelfth and thirteenth</p> <p>AND</p> <p>Largest increases between each line</p> <p>ALLOW crosses outside grid</p>
			Total	15	

Question		Answer	Mark	Guidance
3	(a)	Cl (has been oxidised) from Cl = -1 to Cl = 0 ✓ Mn (has been reduced) from Mn = +4 to Mn = +2 ✓	2	ALLOW 4+ OR 4 OR 2+ OR 2 ALLOW oxidation numbers written above the equation but IGNORE these if oxidation numbers are given in the text ALLOW one mark for Cl is oxidised because the oxidation number increased by 1 AND Mn is reduced because the oxidation number decreased by 2 ALLOW one mark if all oxidation numbers are correct but redox is incorrect. IGNORE HCl is oxidised AND MnO ₂ is reduced IGNORE correct references to electron loss/gain DO NOT ALLOW incorrect references to electron loss/gain
	(b)	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ⁵ 4s ² ✓	1	ALLOW 4s ² 3d ⁵ IGNORE 1s ² seen twice
	(c)	Cl ₂ + 2NaOH → NaClO + NaCl + H ₂ O ✓	1	ALLOW multiples IGNORE state symbols ALLOW OH ⁻ and ClO ⁻ , i.e. Cl ₂ + 2OH ⁻ → ClO ⁻ + Cl ⁻ + H ₂ O ALLOW NaOCl
3	(d) (i)	(The solution would turn) yellow OR orange OR brown ✓	1	ALLOW shades and colours (eg dark yellow, yellow-orange) DO NOT ALLOW 'purple'
	(d) (ii)	Cl ₂ (g) + 2I ⁻ (aq) → I ₂ (aq) + 2Cl ⁻ (aq) ✓	1	ALLOW multiples State symbols required ALLOW Cl ₂ (aq)
	(e) (i)	The ability of an atom to attract electrons ✓ (Electron pair) in a (covalent) bond ✓	2	ALLOW 'Measure' for ability ALLOW 'attraction' for 'ability to attract' ALLOW 'The ability of an atom to attract a shared pair of electrons' for two marks

Question			Answer	Mark	Guidance
3	(e)	(ii)	 <p>Correct orientation of 3-D tetrahedral arrangement of bonds around C atom ✓</p> <p>δ+ on C atom AND δ- on both Cl atoms ✓</p>	2	<p>For a 3D structure,</p> <p>For bond in the plane of paper, a solid line is expected:</p>  <p>For bond out of plane of paper, a solid wedge is expected:</p>  <p>For bond into plane of paper, ALLOW:</p>  <p>ALLOW a hollow wedge for 'in bond' OR an 'out bond', provided it is different from the other in or out wedge e.g.:</p>  <p>ALLOW any 3D representation with a minimum of one bond into the plane of paper AND minimum of one out of plane of paper</p> <p>ALLOW 2 lines in the plane + 2 different bonds for M1</p> <p>IGNORE dipole charges on H</p>
		(iii)	<p>The dipoles do not cancel out OR Because the molecule is non-symmetrical ✓</p>	1	<p>ALLOW partial charges do not cancel</p> <p>IGNORE charges do not cancel</p> <p>ALLOW (the more) electronegative atoms are on one side of the molecule</p>
	(f)		55% ✓	1	
Total				12	

Question			Answer	Mark	Guidance
4	(a)	(i)	Mol of H ₂ SO ₄ = $0.100 \times 18.00/1000 = 1.80 \times 10^{-3}$ mol ✓	1	ALLOW calculator value or rounding to 2 significant figures or more but IGNORE 'trailing zeroes' throughout Q4. eg 0.200 is allowed as 0.2
		(ii)	Mol of NaOH in = $1.80 \times 10^{-3} \times 2 \times 1000/25.0 = 0.144$ mol dm ⁻³ ✓	1	ALLOW ECF for (a)(i) $\times 2 \times 1000/25$
	(b)	(i)	<p>Check the answer line. If answer = 0.0184 mol award 2 marks</p> <p>Mol of NaHCO₃ in 25.0 cm³ = $[0.100 \times 11.50/1000] \times 2 = 0.00230$ mol ✓</p> <p>Mol of NaHCO₃ in 200 cm³ = $0.00230 \times 200/25.0 = 0.0184$ mol ✓</p>	2	<p>If there is an alternative answer, check to see if there is any ECF credit possible using working below.</p> <p>ALLOW for an alternative method for M1 Total mol of H₂SO₄ used = $[0.100 \times 29.50/1000] = 0.00295$ mol</p> <p>Mol of H₂SO₄ reacting with NaHCO₃ = 0.00295 – answer to (a)(i) Expected answer = $.00295 - 0.00180 = 0.00115$ mol</p> <p>Mol of NaHCO₃ in 25.0 cm³ = $0.00115 \times 2 = 0.00230$ mol</p> <p>ALLOW ECF for mol of NaHCO₃ $\times 200/25.0$</p> <p>For ECF in M2 titration values of 11.50 or 29.50 must have been used in M1</p> <p>Second marking point is for scaling up number of mol of NaHCO₃ by 200/25.0 (Usually seen as '8')</p>
		(ii)	Mass of NaHCO ₃ = $0.0184 \times 84.0 = 1.55$ g ✓ (must be three significant figures)	1	ALLOW ECF for (b)(i) $\times 84.0$ correctly calculated and rounded to three significant figures.
Total				5	

Question			Answer	Mark	Guidance
5	(a)	(i)	$2\text{Ca} + \text{O}_2 \rightarrow 2\text{CaO}$ ✓	1	ALLOW multiples e.g. $\text{Ca} + \frac{1}{2}\text{O}_2 \rightarrow \text{CaO}$ IGNORE state symbols
		(ii)	Thermal decomposition ✓	1	
	(b)		Base: A substance which readily accepts H^+ ions (from an acid) ✓ Alkali: releases OH^- ions into (aqueous) solution ✓	2	ALLOW proton acceptor ALLOW Is soluble and releases OH^- ions (into aqueous solution)
	(c)		Effervescence OR fizzing OR bubbling OR gas produced AND The solid OR calcium OR the metal would dissolve OR disappear OR a (colourless) solution forms ✓ $\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2 + \text{H}_2$ ✓	2	IGNORE 'hydrogen produced' but ALLOW 'hydrogen gas produced' DO NOT ALLOW an incorrectly named gas (eg CO_2) produced ALLOW multiples IGNORE state symbols
	(d)		Nitric acid OR HNO_3 ✓ $\text{CaCO}_3 + 2\text{HNO}_3 \rightarrow \text{Ca}(\text{NO}_3)_2 + \text{H}_2\text{O} + \text{CO}_2$ ✓	2	ALLOW reagent mark if no response is seen but HNO_3 is seen in the equation IGNORE calcium carbonate on reagent line ALLOW multiples IGNORE state symbols DO NOT ALLOW H_2CO_3 for $\text{H}_2\text{O} + \text{CO}_2$
			Total	8	

Question	Answer	Mark	Guidance
6 (a)	<p>The attraction (between nuclei and outermost electrons) increases (across the period)</p> <p>AND</p> <p>The nuclear charge increases</p> <p>OR</p> <p>The number of protons increase ✓</p> <p>(Outer) electrons are in the same shell</p> <p>OR</p> <p>(Outer) electrons experience similar shielding</p> <p>OR</p> <p>Same number of shells</p> <p>OR</p> <p>Atomic radius decreases ✓</p>	2	<p>ALLOW There is no change in shielding But DO NOT ALLOW 'there is no shielding'</p> <p>DO NOT ALLOW electrons are at the same distance</p>

Question	Answer	Mark	Guidance
(b)	<p><i>M1 NH₃ forces mark</i> NH₃ has hydrogen bonding ✓</p> <p><i>M2 F₂ AND Br₂ forces mark</i> F₂ AND Br₂ have van der Waals' (forces) ✓</p> <p><i>M3 Type of particle mark</i> Forces OR attractions are between molecules OR are intermolecular for ammonia AND Forces OR attractions are between molecules OR are intermolecular for fluorine OR for bromine ✓</p>	5	<p><i>Quality of written communication:</i> 'molecule(s)' or 'intermolecular' spelled correctly once and used in context for the third marking point.</p> <p>ALLOW H-bonding for hydrogen bonding IGNORE van der Waals' forces AND permanent dipoles in M1 IGNORE covalent bonds for M1 AND M2</p> <p>ALLOW, for van der Waal's: vdWs OR induced dipole temporary OR instantaneous dipole (-dipole) forces ALLOW for forces: attractions OR interactions;</p> <p>DO NOT ALLOW M3, M4 or M5 if covalent OR ionic bonds are the forces between the particles in that mark</p> <p>M3 can be seen anywhere eg in M1 NH₃ has hydrogen bonding between molecules AND the intermolecular force in Br₂ is stronger than that of F₂ eg a generic statement such as 'boiling point of these substances is determined by strength of <i>intermolecular bonding</i>' eg 'All these <i>molecules</i> are <i>held</i> together by weak forces'</p>

Question	Answer	Mark	Guidance
	<p><i>M4 Br₂ / F₂ comparison mark</i> The van der Waals' forces in Br₂ are greater than in F₂ AND Because bromine has more electrons than fluorine ✓</p> <p><i>M5 Br₂ / NH₃ / F₂ comparison mark</i> The van der Waals' forces in Br₂ are greater than hydrogen bonding in NH₃ AND hydrogen bonding in NH₃ is stronger than van der Waals' forces in F₂ ✓</p>		<p>If correct force is given in M2 ALLOW, for M4, 'intermolecular force in Br₂ is stronger than that in F₂'</p> <p>ALLOW more van der Waals' for greater van der Waals' ALLOW more shells of electrons</p> <p>IGNORE 'permanent dipoles' in NH₃ for M5 if quoted in addition to hydrogen bonding</p> <p>If correct force is given in M1 AND M2 ALLOW, for M5, 'intermolecular force in Br₂ is stronger than that in NH₃' AND 'intermolecular force in NH₃ is stronger than that in F₂'</p> <p>If incorrect intermolecular force is given in M1 OR M2 ALLOW this as ECF for M5 but DO NOT ALLOW if the comparison is based only on van der Waals' forces Eg DO NOT ALLOW the van der Waals' forces in bromine are stronger than those in ammonia which in turn are stronger than those in fluorine</p>
	Total	7	

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