OCR
Oxford Cambridge and RSA

GCE

Chemistry A

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

Advanced Subsidiary GCE

Mark Scheme for June 2015

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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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations available in Scoris.

Annotation	Meaning
BOD	Benefit of doubt given
CON	Contradiction
	Incorrect response
ECF	Error carried forward
I	Ignore
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error
SF	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

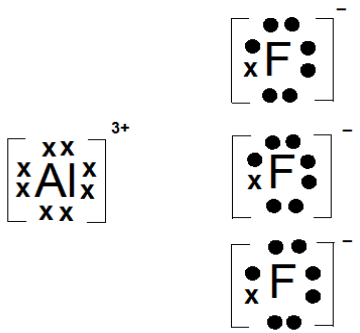
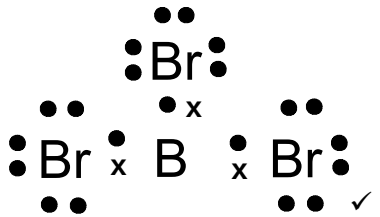
The following questions should be annotated with ticks to show where marks have been awarded in the body of the text:

Q2d Q6b

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td>(i)</td><td>
<table>
<tr><th>Particle</th><th>Relative charge</th><th>Number of particles present in a $^{140}Ce^{2+}$ ion.</th></tr>
<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>
</table>
One mark per column ✓ ✓</td><td>2</td><td>DO NOT ALLOW ‘+’ or ‘-‘ without ‘1’
DO NOT ALLOW 1 without charge
ALLOW 1+ AND 1–
IGNORE ‘–‘ (ie a dash) for relative charge of a neutron</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td>Hydrogen ✓</td><td>1</td><td>ALLOW H_2
IGNORE ‘H’</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>$Ce_2(SO_4)_3$ ✓

(Cerium) loses three electrons (to form 3+ ion) ✓</td><td>2</td><td>ALLOW alternative phrases for ‘loses’ eg ‘gives away’, ‘donates’
IGNORE ‘3 electrons transferred’ unless a correct direction is given eg ALLOW (Ce) transfers 3 electrons to … OR (Ce) transfers 3 electrons forming Ce^{3+}
IGNORE references to sulfate gaining electrons
IGNORE references to reduction and oxidation</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>A hydrogen ion (of an acid) has been replaced by a metal ion ✓</td><td>1</td><td>For hydrogen ion:
ALLOW ‘H^+’ OR ‘proton’
but DO NOT ALLOW ‘H’ OR ‘hydrogen’ without ‘ion’
For metal ion:
ALLOW ‘cerium ion’ OR ‘Ce^{3+}’ OR ‘Ce^{2+}’ OR ‘Ce ion’
But DO NOT ALLOW ‘Ce’ without ‘ion’ OR ‘cerium’ without ‘ion’
IGNORE ‘ammonium ion’</td></tr>
</table>

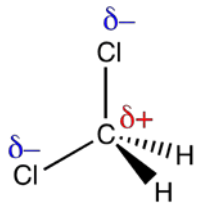
Question			Answer	Mark	Guidance
	(c)		**Check the answer line.** **If answer = 1080 cm^3 award 2 marks** Amount of Eu = 9.12/ 152.0 = 0.06(00) mol ✓ Amount of O_2 = 0.0600 x 3/4 = 0.045(0) mol **and** Volume of O_2 = 0.0450 x 24000 = 1080 cm^3 ✓	2	**If there is an alternative answer, check to see if 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. **ALLOW** incorrectly calculated *amount* 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)
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)	**Check the answer line.** **If answer = $O_{12}S_3Tm_2$ award 2 marks** 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 ✓ $O_{12}S_3Tm_2$ ✓	2	**ALLOW** 0.479 OR 0.48 for mol of S **ALLOW** 0.32 for mol of Tm **DO NOT ALLOW** $Tm_2(SO_4)_3$ as empirical formula **IGNORE** $Tm_2(SO_4)_3$ if seen in working.
	(e)	(i)	32 ✓	1	
		(ii)	9 ✓	1	
			Total	**13**	

Question			Answer	Mark	Guidance
2	(a)		$2Al + 3F_2 \rightarrow 2AlF_3$ ✓	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)	 Al with 8 (or no) outermost electrons **AND** 3 x fluoride (ions) with '*dot-and-cross*' outermost octet ✓ Correct charges ✓	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** $3[F^-]$ $3[F]^-$ $[F^-]_3$ (brackets not required) **DO NOT ALLOW** $[F_3]^-$ $[F_3]^{3-}$ $[3F]^{3-}$ $[F]_3^-$
	(c)	(i)	A shared pair of electrons.	1	
	(c)	(ii)	 ✓	1	

Question	Answer	Mark	Guidance
(d)	*Conductivity of Al mark* M1: Aluminium conducts in solid and molten states ✓ *Reason for conductivity of Al mark* M2: Aluminium has delocalised electrons ✓ *Conductivity and reason for molten AlF_3 mark* M3: Aluminium fluoride conducts when molten **AND** because it has mobile **ions** ✓ *Conductivity and reason for solid AlF_3 mark* 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 ✓	5	**ALLOW** 'carries charge' for conducts **IGNORE** 'charge carriers' for 'electrons' or 'ions' for M2, M3 and M4. *Quality of written communication:* 'delocalis(z)ed' spelled correctly and used in context for the second marking point. **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. **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' **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. **ALLOW** Solid BBr_3 is a poor conductor for M5 **ALLOW** electrons are fixed in position **OR** used in bonds

Question			Answer	Mark	Guidance
			Conductivity and reason for BBr_3 mark M5 Boron tribromide does not conduct in solid and molten states **AND** Boron tribromide has no mobile electrons **OR** no (mobile) ions **OR** no mobile charge carriers **OR** no mobile charged particles ✓		**IGNORE** 'there are no delocalised electrons' **OR** 'there are no free electrons' for M5 **DO NOT ALLOW** M5 if incorrect bonding is seen in BBr_3 eg 'ions are fixed in position' **ALLOW** 'no (free) ions'
2	**(e)**	**(i)**	$Al^{2+}(g) \rightarrow Al^{3+}(g) + e^{-}$ ✓	1	State symbols required (ignore states on electrons) **ALLOW** $Al^{2+}(g) - e^{-} \rightarrow Al^{3+}(g)$ **ALLOW** e for e^{-}
		(ii)	All (thirteen) ionisation energies show an increase ✓ The two largest increases are between the third and fourth **AND** the eleventh and twelfth ionisation energies ✓	2	**IGNORE** line if drawn **IGNORE** 0 if included **ALLOW** one mark for three lines (no crosses) showing an increase between: first and third; fourth and eleventh; twelfth and thirteenth **AND** Largest increases between each line **ALLOW** crosses outside grid
			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)		$Cl_2 + 2NaOH \rightarrow NaClO + NaCl + H_2O$ ✓	1	**ALLOW** multiples **IGNORE** state symbols **ALLOW** OH^- and ClO^-, i.e. $Cl_2 + 2OH^- \rightarrow ClO^- + Cl^- + H_2O$ **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)	 Correct orientation of 3-D tetrahedral arrangement of bonds around C atom ✓ δ+ on C atom **AND** δ– on both Cl atoms ✓	2	For a 3D structure, For bond in the plane of paper, a solid line is expected: For bond out of plane of paper, a solid wedge is expected: For bond into plane of paper, **ALLOW**: **ALLOW** a hollow wedge for 'in bond' **OR** an 'out bond', provided it is different from the other in or out wedge e.g.: **ALLOW** any 3D representation with a minimum of one bond into the plane of paper **AND** minimum of one out of plane of paper **ALLOW** 2 lines in the plane + 2 different bonds for M1 **IGNORE** dipole charges on H
		(iii)	The dipoles do not cancel out **OR** Because the molecule is non-symmetrical ✓	1	**ALLOW** partial charges do not cancel **IGNORE** charges do not cancel **ALLOW** (the more) electronegative atoms are on one side of the molecule
	(f)		55% ✓	1	
			Total	**12**	

Question			Answer	Mark	Guidance
4	(a)	(i)	Mol of H_2SO_4 = 0.100 x 18.00/1000 = 1.80 x 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 x 10^{-3} x 2 x 1000/25.0 = 0.144 mol dm^{-3} ✓	1	**ALLOW** ECF for (a)(i) x 2 x 1000/25
	(b)	(i)	**Check the answer line.** **If answer = 0.0184 mol award 2 marks** Mol of $NaHCO_3$ in 25.0 cm^3 = [0.100 x 11.50/1000] x 2 = 0.00230 mol ✓ Mol of $NaHCO_3$ in 200 cm^3 = 0.00230 x 200/25.0 = 0.0184 mol ✓	2	**If there is an alternative answer, check to see if there is any ECF credit possible using working below.** **ALLOW** for an alternative method for M1 Total mol of H_2SO_4 used = [0.100 x 29.50/1000] = 0.00295 mol Mol of H_2SO_4 reacting with $NaHCO_3$ = 0.00295 – answer to (a)(i) Expected answer = .00295 – 0.00180 = 0.00115 mol Mol of $NaHCO_3$ in 25.0 cm^3 = 0.00115 x 2 = 0.00230 mol **ALLOW** ECF for **mol** of $NaHCO_3$ x 200/25.0 For ECF in M2 titration values of 11.50 or 29.50 must have been used in M1 Second marking point is for scaling up number of mol of $NaHCO_3$ by 200/25.0 (Usually seen as '8')
		(ii)	Mass of $NaHCO_3$ = 0.0184 x 84.0 = 1.55 g ✓ **(must be three significant figures)**	1	**ALLOW** ECF for **(b)(i)** x 84.0 correctly calculated and rounded to three significant figures.
			Total	**5**	

Question			Answer	Mark	Guidance
5	(a)	(i)	$2Ca + O_2 \rightarrow 2CaO$ ✓	1	**ALLOW** multiples e.g. $Ca + ½O_2 \rightarrow CaO$ **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 ✓ $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$ ✓	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 ✓ $CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$ ✓	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 $H_2O + CO_2$
			Total	**8**	

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

Question	Answer	Mark	Guidance
(b)		5	*Quality of written communication:* 'molecule(s)' or 'intermolecular' spelled correctly once and used in context for the third marking point.
	M1 NH_3 forces mark NH_3 has hydrogen bonding ✓		**ALLOW** H-bonding for hydrogen bonding **IGNORE** van der Waals' forces **AND** permanent dipoles in M1 **IGNORE** covalent bonds for M1 **AND** M2
	*M2 F_2 **AND** Br_2 forces mark* F_2 **AND** Br_2 have van der Waals' (forces) ✓		**ALLOW**, for van der Waal's: vdWs **OR** induced dipole temporary **OR** instantaneous dipole (-dipole) forces **ALLOW** for forces: attractions **OR** interactions; **DO NOT ALLOW** M3, M4 or M5 if covalent **OR** ionic bonds are the forces between the particles in that mark
	M3 Type of particle mark 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 ✓		M3 can be seen anywhere eg in M1 NH_3 has hydrogen bonding between molecules **AND** the intermolecular force in Br_2 is stronger than that of F_2 eg a generic statement such as 'boiling point of these substances is determined by strength of *intermolecular bonding'* eg 'All these *molecules* are *held* together by weak forces'

Question			Answer	Mark	Guidance
			M4 Br_2 / F_2 comparison mark The van der Waals' forces in Br_2 are greater than in F_2 **AND** Because bromine has more electrons than fluorine ✓		If correct force is given in M2 **ALLOW**, for M4, 'intermolecular force in Br_2 is stronger than that in F_2' **ALLOW** more van der Waals' for greater van der Waals' **ALLOW** more shells of electrons
			M5 Br_2 / NH_3 / F_2 comparison mark The van der Waals' forces in Br_2 are greater than hydrogen bonding in NH_3 **AND** hydrogen bonding in NH_3 is stronger than van der Waals' forces in F_2 ✓		**IGNORE** 'permanent dipoles' in NH_3 for M5 if quoted in addition to hydrogen bonding If correct force is given in M1 **AND** M2 **ALLOW**, for M5, 'intermolecular force in Br_2 is stronger than that in NH_3' **AND** 'intermolecular force in NH_3 is stronger than that in F_2' 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
			Total	**7**	

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