OCR
Oxford Cambridge and RSA

GCE

Chemistry A

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

Advanced Subsidiary GCE

Mark Scheme for June 2014

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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.

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These are the annotations, (including abbreviations), including those used in scoris, which are used when marking

Annotation	Meaning
BP	Blank Page – this annotation **must** be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
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
SEEN	Noted but no credit given
REP	Repeat

Subject-specific Marking Instructions

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

All questions must be annotated with a tick placed close to where the mark is given but **NOT** obscuring the text (please refer to Scoris Annotations document from your Team Leader).

Additional pages/objects: You **must** annotate the additional pages (before Question 1) and the additional objects for each script you mark. If no credit is to be awarded for the additional object, please use a suitable annotation (either BP for blank page or SEEN).

ECF should also be used in the following questions where applicable**: 2a, 3b, 3c, 3d, 5cii, 6b**.

The following questions should be fully annotated with ticks, crosses and other relevant annotations to show where marks have been awarded in the body of the text: **4aii, 4d, 5a**

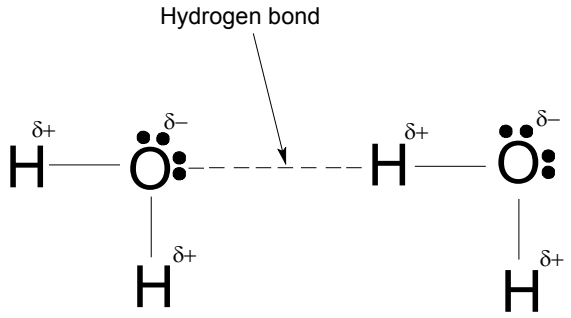
Question			Answer	Mark	Guidance
1	(a)		period = 5 **AND** block = p ✓	1	
1	(b)	(i)	**Atom(s)** of an element **AND** with different numbers of neutrons (and with different masses) ✓	1	**ALLOW** for '**atoms** of an element': **Atoms** of the same element **OR** **Atoms** with the same number of protons **OR** **Atoms** with the same atomic number **IGNORE** different relative atomic masses **IGNORE** different mass number **IGNORE** same number of electrons **DO NOT ALLOW** different number of electrons **DO NOT ALLOW** 'atoms of elements' for 'atoms of an element' **DO NOT ALLOW** 'an element with different numbers of neutrons) (ie atom(s) is essential)
1	(b)	(ii)	same number of electrons in outer shell **OR** same electron configuration **OR** electron structure ✓	1	**IGNORE** same number of protons **IGNORE** same number of electrons **IGNORE** they are the same element
1	(b)	(iii)	51p 70n 51e ✓	1	

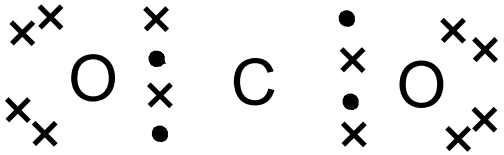
Question			Answer	Mark	Guidance
1	(c)	(i)	The (weighted) mean **mass** of an **atom** (of an element) **OR** The (weighted) average **mass** of an **atom** (of an element) ✓ compared with 1/12th (the mass) ✓ of (one atom of) carbon-12 ✓	3	**ALLOW** average atomic mass **DO NOT ALLOW** mean mass of an element **ALLOW** mean mass of isotope**s OR** average mass of isotope**s** **DO NOT ALLOW** the singular 'isotope' For second **AND** third marking points **ALLOW** compared with (the mass of) carbon-12 which is 12 For three marks; **ALLOW** mass of **one mole** of **atoms** compared to 1/12th (mass of) **one mole OR** 12**g** of carbon **OR** **ALLOW** $\frac{\text{mass of one mole of atoms}}{\text{1/12th mass of one mole OR 12g of carbon-12}}$
1	(c)	(ii)	123 ✓	1	**ALLOW** ^{123}Sb **OR** Sb-123 **OR** antimony-123 **ALLOW** 123.0 **IGNORE** working
1	(d)	(i)	(Trigonal) Pyramidal ✓ (Sb has) three bonding pairs **AND** one lone pair of electrons ✓ **Pairs** of electrons repel ✓	3	**ALLOW** alternative phrases/words to repel eg 'push apart' **ALLOW** lone pairs repel more than bonding pairs **ALLOW** bonds for bonded pairs **ALLOW** lp and bp **IGNORE** electrons repel **DO NOT ALLOW** atoms repel

Question			Answer	Mark	Guidance
1	(d)	(ii)	There is a difference in electronegativities (between Sb and C*l*) **OR** (Sb-Cl) bonds are polar **OR** have a dipole **OR** Dipoles seen on the diagram ✓ The molecule is not symmetrical **AND** dipoles do not cancel ✓	**2**	**ALLOW** Because C*l* is more electronegative (than Sb) OR Because Sb is more electronegative (than C*l*) **ALLOW** description that electrons are drawn along a covalent bond **IGNORE** single δ+ or single δ- for dipole **IGNORE** diagram if M1 awarded in text **ALLOW** partial charges do not cancel **IGNORE** references to lone pair causing dipoles
			Total	**13**	

Question			Answer	Mark	Guidance
2	(a)		FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = CH_4N_2O award 2 marks C H N O 20.00/12.0 6.67/1.0 46.67/14.0 26.66/16.0 **OR** 1.67 6.67 3.33 1.67 ratio of mol ✓ to give CH_4N_2O ✓	2	**ALLOW** 1.66 for C **OR** 1.66 for O **IGNORE** Significant figures beyond the 3rd significant figure. (eg **ALLOW** 3.3335 for N **OR** 1.666 for C) **ALLOW** ECF from incorrectly calculated ratio of mol, **DO NOT ALLOW** ECF from using an atomic number **OR** any original sums inverted (eg 12.00/20.00) **ALLOW** any order of atoms
2	(b)		NH_4^+ ✓ NO_3^- ✓	2	Mark incorrect ions first
2	(c)	(i)	H_3PO_4 ✓	1	**ALLOW** formula if seen as reactant in an equation **IGNORE** name
2	(c)	(ii)	Calcium oxide **OR** calcium hydroxide **OR** calcium carbonate ✓	1	**IGNORE** formulae **IGNORE** lime, quicklime and limestone
			Total	6	

Question			Answer	Mark	Guidance
3	(a)		Oxidised **AND** because aluminium has lost (three) electron**s** ✓	1	**ALLOW** 'donated' for 'lost' **IGNORE** where electrons are transferred to **IGNORE** Al → Al^{3+} + $3e^-$ **DO NOT ALLOW** 'an electron' or incorrect number of electrons
	(b)		FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 2.88 dm^3 award 2 marks Mol of H_2 = 0.12 ✓ Volume of H_2 = 0.12 x 24.0 = 2.88 dm^3 ✓	2	 ALLOW ECF from incorrectly calculated moles of H_2 0.08 x 24 = 1.92 gets 1 mark
	(c)		FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 10.7 g award 2 marks Correctly calculates molar mass of $AlCl_3$ = 133.5 g ✓ Mass of $AlCl_3$ formed = 0.0800 x 133.5 = 10.7 (g) ✓	2	If there is an alternative answer, check to see if there is any ECF credit possible using working below **ALLOW** ECF for incorrect molar mass of $AlCl_3$ multiplied by 0.0800 and correctly rounded to 3 significant figures
	(d)		FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 200(.0) cm^3 award 2 marks Correctly calculates moles of HCl needed = 0.0800 x 3 = 0.24(0) mol ✓ Volume of HCl = 0.24(0) x 1000/1.2 = 200 cm^3 ✓	2	If there is an alternative answer, check to see if there is any ECF credit possible using working below **ALLOW** ECF for incorrect mol of HCl x 1000/1.20 **ALLOW** 66.7 (66.67 or 66.667 etc) for 1 mark **DO NOT ALLOW** 66.6 (66.66 or 66.666 etc)
			Total	7	

Question			Answer	Mark	Guidance
4	(a)	(i)	*The Dipole Mark* At least one $H^{\delta+}$ **AND** one $O^{\delta-}$ shown correctly on each water molecule (see diagram) ✓  *The Hydrogen bonding Mark* **One** Hydrogen bond between H in one water molecule and a lone pair of O in an adjacent water molecule ✓	2	**DO NOT ALLOW** $H^{\delta-}$ **OR** $O^{\delta+}$ **IGNORE** lone pairs for first marking point All Hydrogen bonds must hit a lone pair Hydrogen bond does NOT need to be labelled but it must be different from the covalent bond if it is not labelled **ALLOW** H-bond as label **ALLOW** only one lone pair on O atom **ALLOW** additional, correctly drawn Hydrogen bonded water molecules with correct dipoles **DO NOT ALLOW** more than two lone pairs on O atom

Question			Answer	Mark	Guidance
4	(a)	(ii)	*Property 1* Ice is less dense than water ✓ *Explanation 1* The molecules in ice are held apart by hydrogen bonds ✓ **OR** ice has an open lattice **OR** structure *Property 2* Ice has a relatively high melting point ✓ *Explanation 2* Hydrogen bonds are relatively strong OR Hydrogen bonds are stronger (than other intermolecular attractions or forces) OR More energy is needed to overcome hydrogen bonding	4	**ALLOW** ice floats (on water) **ALLOW** ice contracts when it melts **ALLOW** ice (water) has a higher melting point than expected **OR** predicted **ALLOW** other expressions which convey that the melting point is anomalously high eg 'Ice has an unusually high melting point' **IGNORE** boiling point **IGNORE** the following unqualified statements 'Ice has a higher melting point' or 'Ice has a high melting point' **IGNORE** references to surface tension as a property **IGNORE** explanations of surface tension **ALLOW** hydrogen bonds are the strongest intermolecular attraction or force **DO NOT ALLOW** 'hydrogen bonds are strong' but **ALLOW** this as part of a qualified statement (eg 'hydrogen bonds are strong compared with weak van der Waals forces')
4	(b)		 '*dot-and-cross*' of CO_2 ✓	1	Lone pairs on O must be seen Lone pairs may be seen as 4 individual electrons **ALLOW** correct use of three different symbols

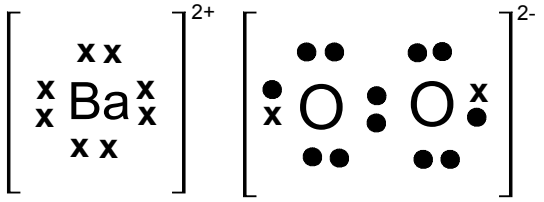
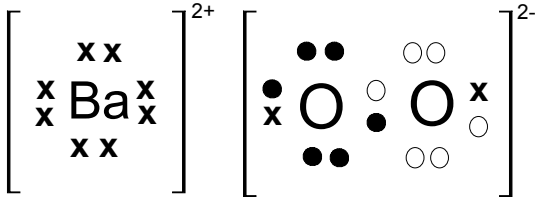
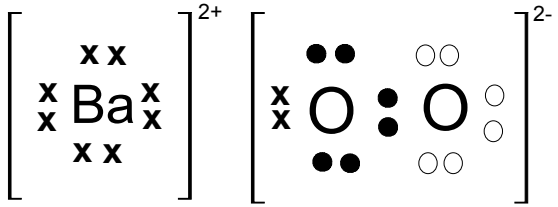
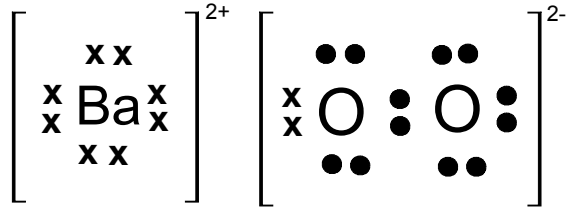
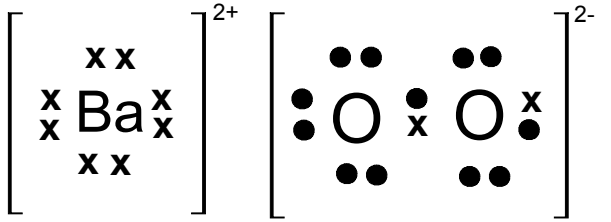
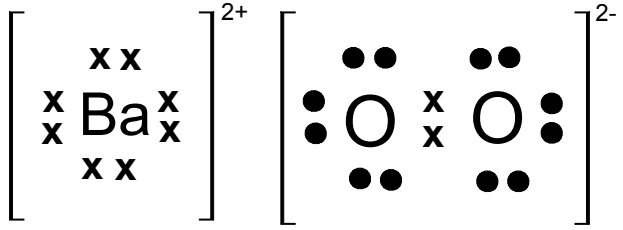
Question			Answer	Mark	Guidance
4	(c)		Giant covalent (lattice) ✓	1	**ALLOW** 'Giant lattice with covalent bonds' **ALLOW** 'Giant covalent bonds' **IGNORE** ' Giant molecular' or 'macromolecular' **DO NOT ALLOW** 'Covalent bonds between molecules'
4	(d)		*Conductivity of Na mark* M1: Sodium conducts in the solid and molten states ✓ *Reason for conductivity of Na mark* M2: Sodium has delocalised electrons (in both solid and liquid state) ✓ *Conductivity of Na_2O mark* M3: Na_2O conducts when molten and not when solid ✓ *Reason for conductivity of Na_2O marks* M4: Molten Na_2O has **ions** which are mobile ✓ M5: Solid Na_2O has **ions** which are fixed (in position) **OR ions** are held (in position) **OR ions** are not mobile **AND** in an (ionic) lattice **OR** structure ✓	5	Quality of written communication 'delocalis(z)ed spelled correctly once and used in context for second marking point **ALLOW** 'carries charge' for conducts for M1 and M3 **IGNORE** 'charge carriers' for electrons **OR** ions for M2, M4 and M5 **DO NOT ALLOW** M2 if incorrect bonding is seen for Na **DO NOT ALLOW** ions move for solid Na for M2 **IGNORE** ions move for molten Na for M2 **ALLOW** solid Na_2O is a poor conductor for M3 **IGNORE** references to aqueous Na_2O for M3 **IGNORE** references to aqueous Na_2O for M4 **IGNORE** 'delocalised ions' **OR** 'free ions' for 'mobile ions' for M4 **DO NOT ALLOW** M4 **AND** M5 if incorrect bonding is seen in Na_2O **DO NOT ALLOW** any mention of electrons moving for M4 **DO NOT ALLOW** suggestion that it is only positive or only negative ions move for M4 **IGNORE** 'there are no delocalised electrons' for M5 **ALLOW** first and second statements of M5 to be unlinked in separate sentences **ALLOW** 'ions fixed in position by ionic bonds' for M5
			Total	13	

Question			Answer	Mark	Guidance
5	(a)		M1 *Trend **AND** nuclear charge mark* (from Li to F) atomic radius decreases **AND** nuclear charge increases or number of protons increases✓ M2 *same shell/shielding mark* (outer) electrons are in same shell **OR** (outer) electrons experience similar or same shielding ✓ **OR** same number of shells M3 *nuclear attraction mark* Greater **nuclear** attraction on (outer) **electrons** or **shells** **OR** (Outer) **electrons** or **shells** are attracted more strongly to the **nucleus** ✓	3	**ALLOW ORA** throughout if it is clear that the Period is being crossed right to left **ALLOW** 'proton number increases' **IGNORE** 'atomic number increases' **IGNORE** 'nucleus gets bigger' **IGNORE** 'effective nuclear charge increases' **DO NOT ALLOW** 'charge increases' without reference to nuclear' **IGNORE** there is shielding **DO NOT ALLOW** sub-shells **OR** orbitals **DO NOT ALLOW** 'electrons are at a similar distance' This will also contradict M1 **ALLOW** 'there is no change in shielding' **IGNORE** 'shielding has no effect' **DO NOT ALLOW** 'there is no shielding' Quality of written communication 'nucleus' **OR** 'nuclear' spelled correctly once and used in context for third marking point **ALLOW** pull for attraction **IGNORE** for M3, 'electrons are pulled closer to nucleus' as this is a re-statement of the trend mark. **DO NOT ALLOW** 'greater nuclear charge' for 'greater nuclear attraction' for M3

Question			Answer	Mark	Guidance
5	(b)	(i)	$(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6$ ✓	1	**ALLOW** ... $4s^2\ 3d^{10}4p^6$ **ALLOW** subscripts **AND** 3D **IGNORE** $1s^2$ seen twice
5	(b)	(ii)	Cream **AND** precipitate ✓	1	**ALLOW** solid **OR** ppt for precipitate **IGNORE** 'does not dissolve' OR 'partially dissolves'
5	(b)	(iii)	$Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$ ✓	1	Equation **AND** state symbols required
5	(c)	(i)	***Equation*** $2NaOH + Cl_2 \rightarrow NaCl + NaClO + H_2O$ ✓ ***Conditions*** cold **AND** dilute (sodium hydroxide) ✓	2	**ALLOW** correct multiples **IGNORE** state symbols **ALLOW** room temperature OR ≤ 20^OC for cold

Question			Answer	Mark	Guidance
(5)	(c)	(ii)	*Definition of disproportionation mark* M1 (Disproportionation) is the (simultaneous) oxidation and reduction of the same element (in the same redox reaction) ✓ M2 Assigning of oxidation numbers Cl in Cl_2 is 0 **AND** Cl in NaCl is -1 **AND** Cl in $NaClO_3$ is +5 ✓ M3 Chlorine has been oxidised from 0 to +5 AND Chlorine has been reduced from 0 to –1 ✓ 'Chlorine has been oxidised from 0 in Cl_2 to +5 in $NaClO_3$ and chlorine has been reduced from 0 in Cl_2 to -1 in NaCl' would secure M2 and M3 $3Cl_2 + 6NaOH \rightarrow 5NaCl + NaClO_3 + 3H_2O$ 0 -1 +5 reduction oxidation This diagram, along with a correct definition, would secure all three marks.	3	**ALLOW** 'an element' OR 'a species' for 'the same element' Assume 'it' means disproportionation M1 can be awarded for 'chlorine is oxidised and reduced **and** this is disproportionation' **ALLOW** oxidation numbers written above the equation if not seen in the text but **IGNORE** oxidation numbers written above the equation if seen in the text **ALLOW** 1– **AND** 5 **AND** 5+ **DO NOT ALLOW** chloride in place of chlorine except for NaCl **DO NOT ALLOW** Cl^- in NaCl AND Cl^{5+} in $NaClO_3$ (ie do not allow ionic charges for oxidation numbers) **ALLOW** Cl **OR** Cl_2 for chlorine **DO NOT ALLOW** M2 if incorrect oxidation numbers of other elements are seen in the text eg H = +2 **ALLOW ECF** for third marks if ONE incorrect oxidation number is assigned but directional changes are correct eg Cl = 0 and -1 and +3 instead 0 and -1 and +5 **DO NOT ALLOW** ECF if two oxidation numbers are incorrectly assigned **IGNORE** references to electron loss/gain If oxidation numbers are correct ALLOW third mark for: chlorine is oxidised to form $NaClO_3$ **AND** chlorine is reduced to form NaCl
			Total	**11**	

Question			Answer	Mark	Guidance
6	(a)	(i)	$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ ✓	1	
6	(a)	(ii)	$BaCO_3$ **OR** $RaCO_3$ ✓	1	**ALLOW** formula if seen as reactant in an equation **IGNORE** name
6	(b)		FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = $SrCl_2 \cdot 2H_2O$ award 3 marks M1 Correctly calculates Mol of $SrCl_2 \cdot 6H_2O$ = (5.332 / 266.6) = 0.02 mol ✓ M2 Correctly calculates Mol of water given off [(5.332 – 3.892)/18] = 0.08 mol ✓ M3 Correctly calculates 0.08/0.02 = 4 mol of water lost from one mol of $SrCl_2 \cdot 6H_2O$ Therefore Answer = $SrCl_2 \cdot 2H_2O$ ✓	3	**Allow alternative methods** **eg** M1 Correctly calculates mol of $SrCl_2 \cdot 6H_2O$ as 5.332/266.6 = 0.02(00) mol **DO NOT ALLOW** M1 if a second mass is divided by 266.6 M2 Correctly calculates molar mass of partially hydrated product as 3.892/ 0.02(00) = 194.6 M3 Correctly calculates mass of H_2O present as 194.6 – 158.6 = 36.0 **AND** product is $SrCl_2 \cdot 2H_2O$ **ALLOW** ECF for the third mark for showing 158.6 taken from an incorrect stated molar mass leading to an ECF formula **OR** **ALLOW** 266.6 – 194.6 = 72.0 to find amount of water lost
6	(c)	(i)	**Reaction 1:** $Ba + 2H_2O \rightarrow Ba(OH)_2 + H_2$ ✓ **Reaction 2:** $Ba_3N_2 + 6H_2O \rightarrow 3Ba(OH)_2 + 2NH_3$ Correct products ✓ Balancing ✓	3	Ignore state symbols
6	(c)	(ii)	Giant ionic (lattice) ✓	1	**ALLOW** 'Giant lattice with ionic bonds' **ALLOW** 'Giant ionic bonds' **DO NOT ALLOW** 'atoms or molecules or dipoles'

Question			Answer	Mark	Guidance
		(iii)	 **OR**  **OR**  **OR** 	1	Ba must have a 2+ charge Ba can be with or without octet. **IGNORE** lack of charge on O_2^{2-} ion O_2^{2-} ion to have 12 electrons belonging to O atoms + 2 other electrons of another symbol. The 2 other electrons must match Ba if Ba has an octet. If O electrons are shown as 6 of one symbol and 6 of another, each O must have six electrons of the same symbol **ALLOW**  **OR** 
			Total	**10**	

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