OCR
Oxford Cambridge and RSA

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.

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

Annotations

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

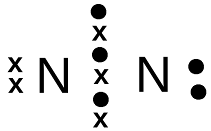
Abbreviations

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 I, etc to show where marks have been awarded in the body of the text

2bi
2c
3d

Question			Answer	Mark	Guidance
1	(a)		<table><tr><th>particle</th><th>relative mass</th><th>relative charge</th><th>position within the atom</th></tr><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></table> Relative mass column ✓ Relative charge **AND** position columns ✓	2	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 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 For position within the atom **IGNORE** 'middle **OR** 'centre' for 'nucleus'
1	(b)	(i)	s-orbital = spherical **AND** p-orbital = dumb-bell shape ✓	1	For s-orbital **IGNORE** 'circular' 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
1		(ii)	p-orbitals have greater energy than s-orbitals ✓ (three) p-orbitals have equal energy ✓	2	**ALLOW** reverse argument **ALLOW** suitable energy diagram for either part

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

Question			Answer	Mark	Guidance
1	**(e)**	**(i)**	N_2O_3 = +3 NO = +2 NO_2 = +4 ✓	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 ✓	1	QWC 'disproportionation' spelled correctly.
1	**(f)**	**(i)**	(Actual) number of atoms of **each element** present in a molecule ✓	1	**ALLOW** 'compound' for 'molecule' **IGNORE** 'simplest whole' before 'number' **ALLOW** 'actual ratio' **IGNORE** 'ratio' alone **DO NOT ALLOW** 'simplest ratio'
		(ii)	HNO_2 ✓	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 *bonds*'
2	**(b)**	**(i)**	M1 *Creating the dipole mark* Uneven distribution of **electrons** ✓ M2 *Type of dipole mark* This creates/causes an instantaneous dipole **OR** temporary dipole ✓ M3 *Induction of a second dipole mark* This causes an **induced dipole** on a neighbouring/adjacent molecule(s)/halogens ✓	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)	M1 *Electron mark* Bromine has **more electrons** (than chlorine) ✓ M2 *Relative force mark* 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 ✓	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

Question			Answer	Mark	Guidance
2	(c)		M1 *Mixing of first pair of solutions* Adding (aqueous) barium chloride to bromine (water) **OR** $BaCl_2 + Br_2$ M2 *Mixing of second pair of solutions* Adding (aqueous) calcium iodide to bromine (water) **OR** $CaI_2 + Br_2$ **OR** Adding aqueous magnesium bromide to aqueous iodine **OR** $MgBr_2 + I_2$ *M3 Colours in cyclohexane* Colour for M1 is orange **OR** yellow **AND** Colour for M2 is purple **OR** violet **OR** mauve **OR** pink **OR** lilac *M4 Ionic equation mark* $Br_2 + 2I^- \text{-->} I_2 + 2Br^-$ *M5 Use of M1 and **one** of M2 as only two experiments*	5	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 chlorine/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 M2 could be awarded from a correct ionic equation in M4 M2 can be seen anywhere If both M2 tests and M1 are given, this will nullify M5 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 **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** $I_2 + 2Br^- \text{-->} I_2 + 2Br^-$ **IGNORE** $Br_2 + 2Cl^- \text{-->} Br_2 + 2Cl^-$ **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
			Total	**11**	

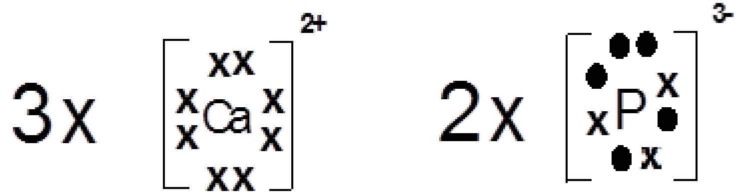
Question			Answer	Mark	Guidance
3	(a)		Periodicity ✓	1	
3	(b)		Sodium **OR** Na ✓ Silicon **OR** Si ✓ Neon **OR** Ne ✓	3	
3	(c)		Ga^{3+} ✓	1	
3	(d)		*M1 Number of bonding electrons mark* Magnesium has more outer **OR** bonding electrons ✓ *M2 Ionic charge mark* Magnesium **ions** have a greater (positive) charge (density) ✓ *M3 Attraction mark* Magnesium has a greater attraction between ions and delocalised electrons ✓	3	**ALLOW** reverse argument throughout **ALLOW** 'more delocalised electrons' for 'more outer electrons' **DO NOT ALLOW** 'Magnesium molecules' for M1 **ALLOW** Mg^{2+} ion **OR** Mg ion for 'magnesium ion' **ALLOW** Mg^{2+} **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 **ALLOW** 'stronger metallic bonds' **only** when a clear description of metallic bonding is given. Eg 'The attraction of positive (metal) ions to delocalised electrons' QWC 'delocalised/delocalized' spelled correctly at least once in context of M3 (may be seen in M1 but used in M3) '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

Question			Answer	Mark	Guidance
3	(e)		First check the answer line. If answer = 1200 cm^3 award 3 marks. Mol of $Mg(NO_3)_2$ = $\frac{2.966}{148.3}$ = 2(.00) x 10^{-2} **OR** 0.02(00) mol ✓ Mol of gas = 2(.00) x 10^{-2} x 5/2 = 5(.00) x 10^{-2} **OR** 0.05(00) mol ✓ Vol of Gas = 0.05 x 24 000 = 1200 cm^3 ✓	3	If answer = 960 cm^3 award 2 marks. If answer = 240 cm^3 award 2 marks. **ALLOW** ECF for answers to at least two significant figures up to calculator value, correctly rounded **ALLOW** separate numbers of mol of each gas for M2 (0.04(00) mol NO_2 **and** 0.0100 mol O_2) **ALLOW** a second mark if only volume of O_2 (240 cm^3) **OR** only volume of NO_2 (960 cm^3) is calculated
3	(f)	(i)	SF_6 **AND** Sulfur(**VI**) fluoride **OR** Sulfur **hexa**fluoride ✓	1	**IGNORE** sulfur fluoride
		(ii)	$2F_2 + 2NaOH \rightarrow F_2O + 2NaF + H_2O$ M1 F_2O AND NaF ✓ M2 Rest of equation (including balance) ✓	2	**ALLOW** multiples **IGNORE** state symbol **ALLOW** OF_2 for F_2O **AND** FNa for NaF **ALLOW** both marks for alternative equations which have both F_2O and NaF **AND** three products Eg $3F_2 + 2NaOH \rightarrow 2F_2O + 2NaF + H_2$ Eg $2F_2 + NaOH \rightarrow F_2O + NaF + HF$
3	(g)	(i)	δ– on each F **AND** δ+ on O ✓	1	**ALLOW** δ2+ **OR** δ+ δ+ on O
		(ii)	Shape: non-linear **AND** Bond angle: 104.5 ^{o} ✓	1	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^o. For bond angle **ALLOW** 106> bond angle ≥102 (Actual = 102^o)
		(iii)	+2 ✓	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 1/12th (the mass) ✓ M3 Of (one atom of) carbon-12 ✓	3	**ALLOW** 'average' for 'mean' **ALLOW** 'mean mass of isotope**s**' 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 1/12th (mass of) **one mole OR 12 g** of carbon-12 **ALLOW** for three marks $\frac{\text{Mass of one mole of atoms}}{1/12^{th}\text{ (mass of) one mole OR 12 g of carbon-12}}$
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)	$ZnCO_3 + 2HCl \rightarrow ZnCl_2 + CO_2 + H_2O$ ✓	1	**ALLOW** multiples **IGNORE** state symbols
4	(d)	(i)	Magnesium (atoms) has been oxidised **AND** Because it has lost **two** electrons ✓ Copper (ions) has been reduced **AND** Because it has gained **two** electrons ✓	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)	$Mg(s) + 2H_2O(l) \rightarrow Mg(OH)_2(aq) + H_2(g)$ Correct reactants and products ✓ Balance and state symbols ✓	2	**ALLOW** multiples **ALLOW** $Mg(OH)_2(s)$ **ALLOW** $Mg(s) + H_2O(g)$ **OR** $H_2O(l)$ --> $MgO(s) + H_2(g)$ including state symbols for **one** mark

Question			Answer	Mark	Guidance
4	(e)		First check the answer line. If answer = 0.120 award 4 marks. M1 Mol of H_2SO_4 = $3.00 \times 10^{-2} \times \frac{35.0}{1000}$ = 1.05×10^{-3} mol ✓ M2 Mol of $Al_2(SO_4)_3$ = $\frac{1.05 \times 10^{-3}}{3}$ = $3.5(0) \times 10^{-4}$ mol ✓ M3 = 342.3 ✓ M4 Mass $Al_2(SO_4)_3$ = $3.5(0) \times 10^{-4} \times 342.3$ **and** = 0.120 g ✓ **Answer must be 3 sf**	4	**ALLOW** ECF **ALLOW** 0.00105 mol **ALLOW** 0.00035(0) mol **ALLOW** 342 **DO NOT ALLOW** 0.12
4	(f)	(i)	$Ca(OH)_2$ **OR** Calcium hydroxide **OR** CaO **OR** Calcium oxide ✓	1	**ALLOW** Calcium carbonate **OR** $CaCO_3$
4	(f)	(ii)	$6Ca + P_4 \rightarrow 2Ca_3P_2$ ✓	1	**ALLOW** multiples **IGNORE** state symbols

Question			Answer	Mark	Guidance
		(iii)	 Ca with 8 (or no) electrons AND phosphide ion with dot-and-cross outermost octet ✓ Three Ca ions **AND** two phosphide ions with correct charges ✓	2	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 **ALLOW** one mark if both electron arrangements and charges are correct but only one of each ion is drawn. **ALLOW** (brackets not required) $3[Ca^{2+}]$ $3[Ca]^{2+}$ $[Ca^{2+}]_3$ $2[P^{3-}]$ $2[P]^{3-}$ $[P^{3-}]_2$ **DO NOT ALLOW** $[Ca_3]^{2+}$ $[3Ca]^{2+}$ $[Ca]_3^{2+}$ $[P_2]^{3-}$ $[2P]^{3-}$ $[P]_2^{3-}$
			Total	**20**	

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