

Chemistry A

Advanced Subsidiary GCE

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

Mark Scheme for June 2012

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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

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
<u> </u>	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: **1(e)(i), 2(b), 3(b)(ii)**

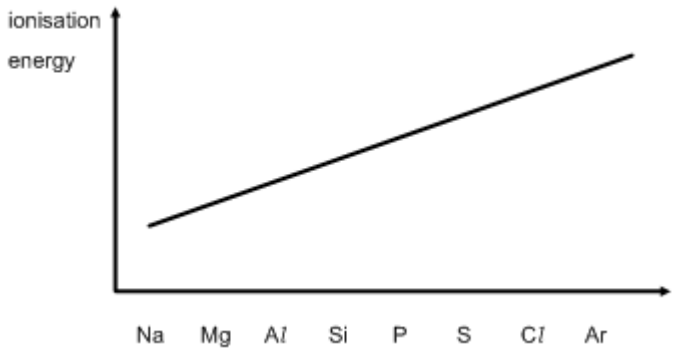
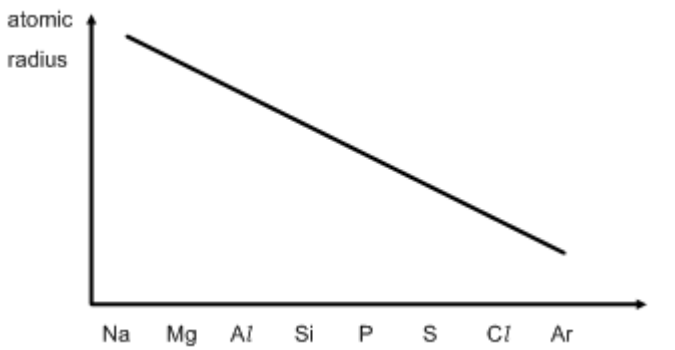
Question		Answer	Marks	Guidance
1	(a)	<p>The (weighted) mean mass of an atom (of an element) OR The (weighted) average mass of an atom (of an element) ✓</p> <p>compared with 1/12th (the mass) ✓</p> <p>of (one atom of) carbon-12 ✓</p>	3	<p>ALLOW average atomic mass DO NOT ALLOW mean mass of an element ALLOW mean mass of isotopes OR average mass of isotopes DO NOT ALLOW the singular; 'isotope'</p> <p>For second and third marking points ALLOW compared with (the mass of) carbon-12 which is 12</p> <p>ALLOW mass of one mole of atoms ✓ compared to 1/12th ✓ (mass of) one mole OR 12g of carbon-12 ✓</p> <p>ALLOW <u> mass of one mole of atoms </u> 1/12th mass of one mole OR 12g of carbon-12</p>
	(b)	<p>FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 32.09 award 2 marks</p> $\frac{32 \times 95.02 + 33 \times 0.76 + 34 \times 4.22}{100}$ <p>OR</p> $30.4064 + 0.2508 + 1.4348$ <p>OR</p> $= 32.092 \text{ (calculator value) } \checkmark$ <p>(A, =) 32.09 ✓</p>	2	<p>ALLOW one mark for ECF from transcription error in first sum provided final answer is to 2 decimal places and is between 32 and 34 and is a correct calculation of the transcription</p> <p>Answer must be 2 decimal places</p>

Question		Answer	Marks	Guidance															
1	(c)	<table border="1"> <thead> <tr> <th></th> <th>protons</th> <th>neutrons</th> <th>electrons</th> <th></th> </tr> </thead> <tbody> <tr> <td>^{33}S</td> <td>16</td> <td>17</td> <td>16</td> <td>✓</td> </tr> <tr> <td>$^{34}\text{S}^{2-}$</td> <td>16</td> <td>18</td> <td>18</td> <td>✓</td> </tr> </tbody> </table>		protons	neutrons	electrons		^{33}S	16	17	16	✓	$^{34}\text{S}^{2-}$	16	18	18	✓	2	Mark by row
	protons	neutrons	electrons																
^{33}S	16	17	16	✓															
$^{34}\text{S}^{2-}$	16	18	18	✓															
	(d)	<p>FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 5.78×10^{22} award 2 marks</p> <p>(mol of atoms) = $0.0120 \times 8 = 0.0960$ (mol) OR (no. of molecules) = $0.0120 \times 6.02 \times 10^{23} = 7.224 \times 10^{21}$ OR (no. of S atoms in 1 mole of S_8) = $8 \times 6.02 \times 10^{23} = 4.816 \times 10^{24}$ ✓</p> <p>Correctly calculates (number of atoms) = $0.0120 \times 8 \times 6.02 \times 10^{23}$ $= 5.78 \times 10^{22}$ (atoms) ✓</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 5.8×10^{22} up to calculator value of 5.7792×10^{22} ALLOW correct rounding of ECF to 2 significant figures or more up to calculator value ALLOW answers in non standard form such as 0.578×10^{23} correctly rounded to 2 or more significant figures</p>															
	(e) (i)	<p>Creating the dipole mark Uneven distribution of electrons ✓</p> <p>Type of dipole mark Creates or causes an instantaneous dipole OR temporary dipole (in a molecule) ✓</p> <p>Induction of a second dipole mark Causes induced dipoles in neighbouring molecules ✓</p>	3	<p>Use annotations with ticks, crosses, ECF etc for this part ALLOW movement of electrons ALLOW changing electron density</p> <p>ALLOW 'transient', 'oscillating' 'momentary' 'changing' DO NOT ALLOW induces a temporary dipole for the second marking point</p> <p>ALLOW induces a dipole in neighbouring molecules ALLOW causes a resultant dipole in other molecules ALLOW atoms for molecules</p>															

Question			Answer	Marks	Guidance
1	(e)	(ii)	Only one type of atom OR No (permanent) dipoles OR non-polar OR no polar bonds ✓	1	ALLOW no difference in electronegativity IGNORE 'No hydrogen bonding' IGNORE 'No lone pairs'
	(f)		+ 2 ✓	1	ALLOW 2(+)
	(g)	(i)	There are no waters of crystallisation ✓	1	ALLOW 'without water' 'no water' etc IGNORE dehydrated
		(ii)	248.2 ✓	1	IGNORE units DO NOT ALLOW 248
		(iii)	FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 7.91 (g) award 2 marks (amount of $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$) = $12.41/248.2$ OR = $0.05(00)$ (mol) ✓ (mass of $\text{Na}_2\text{S}_2\text{O}_3$) = $0.05 \times 158.2 = 7.91$ (g) ✓	2	If there is an alternative answer, check to see if there is any ECF credit possible using working below ALLOW ECFs from answer to (g)(ii) for both marking points ALLOW ECF for calculated mol of $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O} \times 158.2$ correctly calculated for the 2nd mark ALLOW calculator value or rounding to 3 significant figures or more but IGNORE 'trailing' zeroes, eg 0.200 allowed as 0.2

Question			Answer	Marks	Guidance
1	(h)	(i)	Sulfur has six bonded pairs (and no lone pairs) ✓ Electron pairs repel (one another equally) ✓	2	ALLOW 'It has six bonded pairs' ALLOW bonds for bonded pairs IGNORE regions OR areas of negative charge ALLOW 'bonds repel' DO NOT ALLOW 'Atoms repel' or 'electrons repel' 'Lone pairs repel more than bonded pairs' would score the second mark but would contradict the first mark if there is no reference to no lone pairs
		(ii)	The ability of an atom to attract electrons ✓ in a (covalent) bond ✓ (The octahedral shape) is symmetrical ✓	3	ALLOW dipoles cancel out IGNORE polar bonds repel IGNORE charges cancel
			Total	23	

Question		Answer	Marks	Guidance
2	(a)	Periodicity ✓	1	ALLOW phonetic versions
	(b)	<p>Al bonding mark Al has metallic (bonding) OR has (electrostatic) attraction between positive ions and (delocalised) electrons ✓</p> <p>Si bonding mark Si has covalent (bonding) OR has shared pairs of electrons between atoms ✓</p> <p>P bonding mark P has induced dipoles OR has van der Waals' forces (between molecules) ✓</p> <p>Structure mark 1 Al AND Si are Giant ✓</p> <p>Structure mark 2 P is Simple molecular OR simple covalent ✓</p> <p>Bond strength mark Metallic AND covalent are stronger than vdWs OR Bonds broken in Al AND in Si are stronger than the forces broken in P OR More energy is needed to overcome bonds in Al AND Si than the forces in P ✓</p>	6	<p>Use annotations with ticks, crosses, ECF etc for this part</p> <p>DO NOT ALLOW marking point 1 if Al has dipoles OR intermolecular forces OR molecules OR atoms OR attraction between nuclei and electrons OR attraction between oppositely charged ions</p> <p>DO NOT ALLOW marking point 2 if Si has dipoles OR intermolecular forces OR molecules but IGNORE 'molecule'</p> <p>Must be induced dipoles ALLOW vdW for van der Waals' IGNORE P has covalent bonds for marking point 3</p> <p>Quality of Written Communication: 'giant' spelled correctly once and used in context for the fourth marking point</p> <p>DO NOT ALLOW covalent bonds are broken in phosphorus for marking point 6, but ALLOW answers that inform Al and Si are stronger than P, ignoring incorrect forces or bonds used above IGNORE 'heat' but ALLOW 'heat energy'</p>

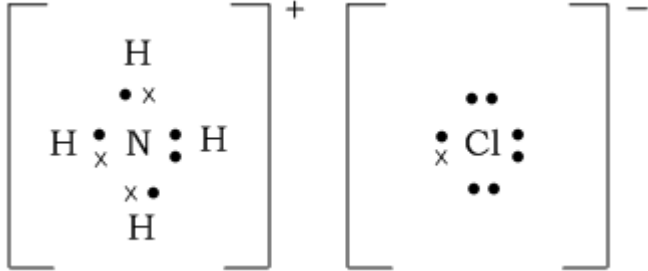
Question			Answer	Marks	Guidance
2	(c)	(i)	Increasing straight line OR curve from Na to Ar ✓ 	1	ALLOW bar charts OR points IGNORE the standard of drawing as long as the trend is clear IGNORE decrease between Mg/Al and P/S Essentially the mark is for Na < Mg < Si < P < Cl < Ar AND Al < Si AND S < Cl
		(ii)	Decreasing straight line OR curve from Na to Ar ✓ 	1	ALLOW bar charts OR points IGNORE the standard of drawing as long as the trend is clear IGNORE Ar Essentially the mark is for Na > Mg > Al > Si > P > S > Cl
Total				9	

Question		Answer	Marks	Guidance
3	(a)	$(1s^2) 2s^2 2p^6 3s^2$ ✓	1	IGNORE $1s^2$ seen twice ALLOW subscripts
	(b) (i)	$Mg^+(g) \rightarrow Mg^{2+}(g) + e^-$ Equation correct ✓ State symbols correct ✓	2	ALLOW $Mg^+(g) - e^- \rightarrow Mg^{2+}(g)$ for 2 marks The second mark is dependent upon the first mark except for the following close attempts for the first mark: ALLOW the following for one mark as states are correct $Mg(g) \rightarrow Mg^{2+}(g) + 2e^-$ $Mg(g) + e^- \rightarrow Mg^{2+}(g) + 2e^-$ ALLOW e for electron IGNORE states on electron
	(ii)	<i>Ionic radius mark</i> $Mg^{(+)}$ has smaller (ionic) radius OR has less shells ✓ <i>Shielding mark</i> (outermost electron) of $Mg^{(+)}$ experience less shielding ✓ <i>Nuclear attraction mark</i> More nuclear attraction on (outermost electrons) OR Outer electrons are attracted more strongly (to the nucleus) ✓ ORA throughout	3	Use annotations with ticks, crosses, ECF etc for this part ALLOW $Mg^{(+)}$ has less energy levels ALLOW $Mg^{(+)}$ has electrons in lower energy level ALLOW $Mg^{(+)}$ has electrons closer to nucleus IGNORE $Mg^{(+)}$ has less orbitals OR less sub-shells IGNORE atomic for ionic IGNORE 'different shell' ALLOW screening for shielding ALLOW $Mg^{(+)}$ has less electron repulsion from inner shells Quality of Written Communication: 'nuclear' OR 'nucleus' OR 'electron(s)' spelled correctly once and used in context for the third marking point ALLOW $Mg^{(+)}$ has more nuclear pull IGNORE $Mg^{(+)}$ has more effective nuclear charge DO NOT ALLOW more nuclear charge for more nuclear attraction for the third mark

Question			Answer	Marks	Guidance
3	(c)	(i)	Sr ²⁺ ✓ OH ⁻ ✓	2	ALLOW 2OH ⁻ ALLOW 2 marks for Sr(OH) ₂ → Sr ²⁺ + 2OH ⁻ ALLOW 1 mark for Sr ²⁺ + 2OH ⁻ → Sr(OH) ₂ IGNORE H ⁺
		(ii)	Sr has lost (two) electrons ✓	1	ALLOW Sr → Sr ²⁺ + 2e ⁻ IGNORE references to oxidation numbers
		(iii)	SrO AND H ₂ O ✓	1	ALLOW acceptable alternatives from Sr salts and alkalis eg SrCl ₂ + NaOH
	(d)	(i)	It shows the oxidation number of the sulfur OR the name without the IV is ambiguous ✓	1	DO NOT ALLOW 'the charge on sulfur' DO NOT ALLOW 'shows the oxidation number of the sulfate' ALLOW Otherwise it could be SrSO ₄ ALLOW Sulfur has different oxidation numbers AW
		(ii)	H ₂ SO ₃ ✓	1	
Total				12	

Question			Answer	Marks	Guidance
4	(a)	(i)	$\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{HClO} + \text{HCl} \checkmark$	1	
		(ii)	(Chlorine compounds are) carcinogenic OR (Chlorine compounds are) toxic OR poisonous \checkmark	1	ALLOW 'they' OR 'chlorinated hydrocarbons' OR 'it' for 'chlorine compounds' IGNORE harmful OR dangerous IGNORE references to HCl or HClO IGNORE chlorine is toxic DO NOT ALLOW chlorine is carcinogenic
	(b)	(i)	Precipitation \checkmark	1	
		(ii)	$\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{AgCl}(\text{s}) \checkmark$	1	Equation AND state symbols required for mark DO NOT ALLOW spectator ions
	(c)	(i)	$8.604/143.4 = 0.06(00) \text{ (mol)} \checkmark$	1	

Question		Answer	Marks	Guidance
4	(c) (ii)	<p>If a Group 2 chloride is used amount of Group 2 chloride = $\frac{1}{2} \times 0.0600$ OR = 0.0300 mol ✓</p> <p>Mass of 1 mol of Group 2 chloride = <u>2.86</u> = 95.3(3) ✓ 0.0300</p> <p>[Relative atomic mass of M = 95.3(3) – 71.0) = 24.3 (g mol⁻¹)] AND metal = Mg ✓</p>	3	<p>DO NOT ALLOW 24.3 and Mg without appropriate working</p> <p>Check to see if there is any ECF credit possible using working below</p> <p>ALLOW calculator value or rounding to 2 significant figures or more but IGNORE 'trailing' zeroes, eg 0.200 allowed as 0.2</p> <p>ALLOW ECF for correctly calculated $\frac{1}{2} \times$ answer to (c)(i)</p> <p>Must be at least 1 decimal place for second marking point</p> <p>ALLOW ECF for 2.86/mol of metal chloride seen above eg MCl will give 0.0600 mol of metal chloride and this will likely give 2.86/0.0600 = 47.7 eg MCl_3 will give 0.0200 mol of metal chloride and this will likely give 2.86/0.0200 = 143.0</p> <p>ALLOW ECF for mass of Group 2 chloride – 71.0 provided it is not a negative value</p> <p>ALLOW ECF even if molar mass of chloride was given as a whole number above</p> <p>ALLOW ECF for mass of metal chloride – 35.5 if amount of metal chloride = 0.0600 mol eg 47.7 – 35.5 = 12.2 AND Be</p> <p>ALLOW ECF for mass of metal chloride – 106.5 if amount of metal chloride = 0.0200 mol eg 143.0 – 106.5 = 36.5 AND Ca</p>

Question		Answer	Marks	Guidance
4	(d) (i)	A shared pair of electrons AND both electrons are donated by one atom ✓	1	
	(ii)	NH_4^+ AND Cl^- ✓	1	ALLOW $\text{NH}_4\text{Cl} \rightarrow \text{NH}_4^+ + \text{Cl}^-$ OR $\text{NH}_4^+ + \text{Cl}^- \rightarrow \text{NH}_4\text{Cl}$
	(iii)	Ammonium ion with three covalent ' <i>dot-and-cross</i> ' bonds AND one dative covalent bond ✓ Chloride ion with $8e^-$ AND 1 of these electrons different ✓ 	2	ALLOW other symbols for dots and crosses eg triangles IGNORE charges IGNORE 'dative' arrow within the lone pair of the N atom
	(e) (i)	(Thermal) decomposition ✓	1	

Question			Answer	Marks	Guidance
4	(e)	(ii)	<p>FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 242 (cm³) award 3 marks</p> <p>(amount of KClO₃) = 0.824/122.6 OR = 0.00672 (mol) ✓</p> <p>(amount O₂) = (mol of KClO₃) 0.00672 × 3/2 OR = 0.0101 (mol)</p> <p>(volume of O₂) = 0.0101 × 24 000 = 242 (cm³) ✓</p>	3	<p>IGNORE over rounding to two significant figures once DO NOT ALLOW over rounding to two significant figures twice eg ALLOW the following answer for 3 marks 241 (cm³) (0.00672 was rounded to 0.0067 OR 0.0101 was rounded to 0.010)</p> <p>ALLOW the following answers for 2 marks 240 (cm³) (0.00672 was rounded to 0.0067 AND 0.0101 was rounded to 0.010) 252 (cm³) (0.00672 was rounded to 0.007) 161 cm³ (no multiplying by 3/2)</p> <p>If there is an alternative answer, check to see if there is any ECF credit possible using working below ALLOW up to correctly rounded calculator value of 0.006721044046</p> <p>ALLOW up to correctly rounded calculator value ALLOW ECF for mol of KClO₃ × 3/2 for 2nd mark</p> <p>ALLOW ECF for (mol of KClO₃) × 3/2 × 24000</p>
			Total	16	

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