OCR
RECOGNISING ACHIEVEMENT

GCE

Chemistry A

Advanced Subsidiary GCE

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

Mark Scheme for June 2012

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, OCR Nationals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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.

Any enquiries about publications should be addressed to:

OCR Publications
PO Box 5050
Annesley
NOTTINGHAM
NG15 0DL

Telephone: 0870 770 6622
Facsimile: 01223 552610
E-mail: publications@ocr.org.uk

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
__	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)		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 **ALLOW** mass of **one mole** of **atoms** ✓ compared to 1/12th ✓ (mass of) **one mole OR** 12**g** of carbon-12 ✓ **ALLOW** $\frac{\text{mass of one mole of atoms}}{\text{1/12th mass of one mole OR 12g of carbon-12}}$.
	(b)		**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 32.09 award 2 marks** $\frac{32 \times 95.02 + 33 \times 0.76 + 34 \times 4.22}{100}$ **OR** 30.4064 + 0.2508 + 1.4348 **OR** = 32.092 (calculator value) ✓ (A_r =) 32.09 ✓	2	**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 Answer must be 2 decimal places

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>1</td><td>(c)</td><td></td><td>
<table>
<tr><th></th><th>protons</th><th>neutrons</th><th>electrons</th></tr>
<tr><td>^{33}S</td><td>16</td><td>17</td><td>16</td></tr>
<tr><td>$^{34}S^{2-}$</td><td>16</td><td>18</td><td>18</td></tr>
</table>
✓
✓
</td><td>2</td><td>Mark by row</td></tr>
<tr><td></td><td>(d)</td><td></td><td>FIRST CHECK THE ANSWER ON THE ANSWER LINE
If answer = 5.78 × 10^{22} award 2 marks

(mol of atoms) = 0.0120 × 8 = 0.0960 (mol)
OR
(no. of molecules) = 0.0120 × 6.02 × 10^{23} = 7.224 x 10^{21}
OR
(no. of S atoms in 1 mole of S_8) = 8 x 6.02 x 10^{23} = 4.816 x 10^{24}✓

Correctly calculates (number of atoms) = 0.0120 × 8 × 6.02 × 10^{23}

= 5.78 × 10^{22} (atoms) ✓</td><td>2</td><td>If there is an alternative answer, check to see if there is any ECF credit possible using working below

ALLOW 5.8 x 10^{22} up to calculator value of 5.7792 x 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</td></tr>
<tr><td></td><td>(e)</td><td>(i)</td><td>Creating the dipole mark
Uneven distribution of electrons ✓

Type of dipole mark
Creates or causes an instantaneous dipole OR temporary dipole (in a molecule) ✓

Induction of a second dipole mark
Causes induced dipoles in neighbouring molecules ✓</td><td>3</td><td>Use annotations with ticks, crosses, ECF etc for this part
ALLOW movement of electrons
ALLOW changing electron density

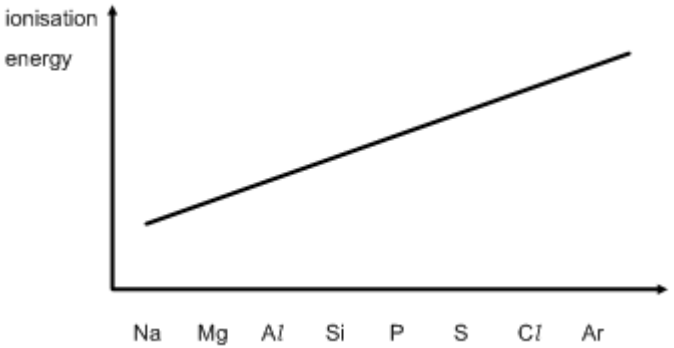
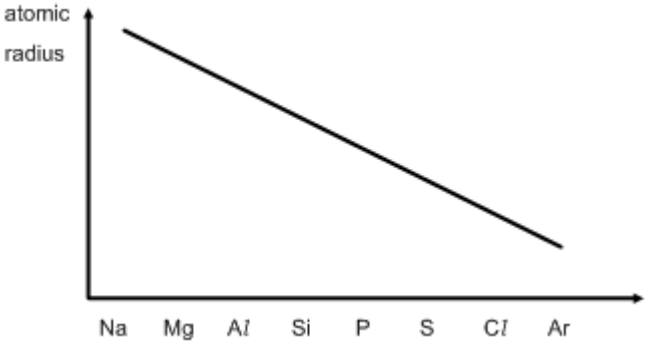
ALLOW ‘transient’, ‘oscillating’ ‘momentary’ ‘changing’
DO NOT ALLOW induces a temporary dipole for the second marking point

ALLOW induces a dipole in neighbouring molecules
ALLOW causes a resultant dipole in other molecules
ALLOW atoms for molecules</td></tr>
</table>

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 $Na_2S_2O_3 \cdot 5H_2O$) = 12.41/248.2 **OR** = 0.05(00) (mol) ✓ (mass of $Na_2S_2O_3$) = 0.05 x 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 $Na_2S_2O_3 \cdot 5H_2O$ x 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 **IGNOR**E charges cancel
			Total	**23**	

Question			Answer	Marks	Guidance
2	(a)		Periodicity ✓	1	**ALLOW** phonetic versions
	(b)		***Al bonding mark*** Al has metallic (bonding) **OR** has (electrostatic) attraction between positive ions and (delocalised) electrons ✓ ***Si bonding mark*** Si has covalent (bonding) **OR** has shared pairs of electrons between atoms ✓ ***P bonding mark*** P has **induced** dipoles **OR** has van der Waals' forces (between molecules) ✓ ***Structure mark 1*** Al **AND** Si are Giant ✓ ***Structure mark 2*** P is Simple molecular **OR** simple covalent ✓ ***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 ✓	6	**Use annotations with ticks, crosses, ECF etc for this part** **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 **DO NOT ALLOW** marking point 2 if Si has dipoles **OR** intermolecular forces **OR** molecule**s** but **IGNORE** 'molecule' Must be induced dipoles **ALLOW** vdW for van der Waals' **IGNORE** P has covalent bonds for marking point 3 **Quality of Written Communication: 'giant' spelled correctly once and used in context for the fourth marking point** **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'

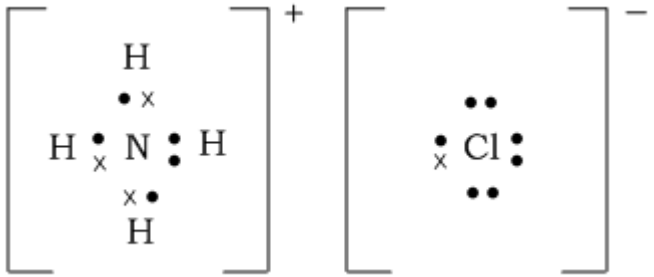
Question			Answer	Marks	Guidance
2	(c)	(i)	Increasing straight line **OR** curve from Na to Ar ✓  	1	**ALLOW** bar charts **OR** points **IGNORE** the standard of drawing as long as the trend is clear **IGNORE** decrease between Mg/Al and P/S Essentially the mark is for Na < Mg < Si < P < Cl < Ar **AND** 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)	***Ionic radius mark*** $Mg^{(+)}$ has smaller (ionic**)** radius **OR** has less shells ✓ ***Shielding mark*** (outermost electron) of $Mg^{(+)}$ experience less shielding ✓ ***Nuclear attraction mark*** 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 $Sr(OH)_2 \rightarrow Sr^{2+} + 2OH^-$ **ALLOW** 1 mark for $Sr^{2+} + 2OH^- \rightarrow Sr(OH)_2$ **IGNORE** H^+
		(ii)	Sr has lost (two) electron**s** ✓	1	**ALLOW** $Sr \rightarrow Sr^{2+} + 2e^-$ **IGNORE** references to oxidation numbers
		(iii)	SrO **AND** H_2O ✓	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_2SO_3 ✓	1	
			Total	**12**	

Question			Answer	Marks	Guidance
4	(a)	(i)	$Cl_2 + H_2O \rightarrow HClO + HCl$ ✓	1	
		(ii)	(Chlorine compounds are) carcinogenic **OR** (Chlorine compounds are) toxic **OR** poisonous ✓	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 ✓	1	
		(ii)	$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ ✓	1	Equation **AND** state symbols required for mark **DO NOT ALLOW** spectator ions
	(c)	(i)	8.604/143.4 = 0.06(00) (mol) ✓	1	

Question			Answer	Marks	Guidance
4	(c)	(ii)	If a Group 2 chloride is used amount of Group 2 chloride = ½ × 0.0600 **OR** = 0.0300 mol ✓ Mass of 1 mol of Group 2 chloride = $\frac{2.86}{0.0300}$ = 95.3(3) ✓ [Relative atomic mass of M = 95.3(3) – 71.0) = 24.3 (g mol^{-1})] **AND** metal = Mg ✓	3	**DO NOT ALLOW** 24.3 and Mg without appropriate working 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 allowed as 0.2 **ALLOW** ECF for correctly calculated ½ × answer to **(c)(i)** Must be at least 1 decimal place for second marking point **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* **ALLOW** ECF for mass of Group 2 chloride – 71.0 provided it is not a negative value **ALLOW** ECF even if molar mass of chloride was given as a whole number above **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 ***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*

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** $NH_4Cl \rightarrow NH_4^+ + Cl^-$ **OR** $NH_4^+ + Cl^- \rightarrow NH_4Cl$
		(iii)	Ammonium ion with three covalent '*dot-and-cross*' 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)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 242 (cm^3) award 3 marks**	3	**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** (cm^3) (0.00672 was rounded to 0.0067 **OR** 0.0101 was rounded to 0.010) **ALLOW** the following answers for 2 marks **240** (cm^3) (0.00672 was rounded to 0.0067 **AND** 0.0101 was rounded to 0.010) **252** (cm^3) (0.00672 was rounded to 0.007) **161** cm^3 (no multiplying by 3/2)
			(amount of $KClO_3$) = 0.824/122.6 **OR** = 0.00672 (mol) ✓		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
			(amount O_2) = (mol of $KClO_3$) 0.00672 × 3/2 **OR** = 0.0101 (mol)		**ALLOW** up to correctly rounded calculator value **ALLOW** ECF for mol of $KClO_3$ × 3/2 for 2nd mark
			(volume of O_2) = 0.0101 × 24 000 = 242 (cm^3) ✓		**ALLOW** ECF for (mol of $KClO_3$) × 3/2 × 24000
			Total	**16**	

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored