OCR
Oxford Cambridge and RSA

GCE

Chemistry A

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

Advanced Subsidiary GCE

Mark Scheme for June 2017

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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 RM Assessor.

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

Question			Answer	Mark	Guidance
1	(a)	(i)	**Atom(s)** of an element **AND** with different numbers of neutrons ✓	1	**ALLOW**: **Atom(s)** with same number of protons/atomic number **IGNORE** 'different mass number' **IGNORE** 'same number of electrons' **DO NOT ALLOW** 'different number of electrons'
1	(a)	(ii)	42 p **AND** 56 n **AND** 42 e ✓ $^{96}Mo^{2+}$ **AND** 42 p ✓	**2**	Mark by row
1	(b)		^{12}C **OR** C-12 **OR** carbon 12 **OR** carbon-12 ✓	**1**	**IGNORE** $1/12^{th}$
1	(c)	(i)	oxidised: Hydrogen/H/H_2 from 0 to +1 ✓ reduced: Molybdenum/Mo from +6 to 0 ✓	**2**	**ALLOW** 6+ **OR** 6 **OR** 1+ **OR** 1 **IGNORE** MoO_3 **ALLOW** 1 mark for elements **AND** all oxidation numbers correct, but Mo in oxidised line and H in reduced line **IGNORE** numbers around equation *(treat as rough working)*
1	(c)	(ii)	Check answer on the answer line. If answer = 1440 (cm^3) award 3 marks If answer = 480 (cm^3) award 2 marks (no multiplying by 3) $n(MoO_3) = \frac{2.878}{143.9}$ = 0.02(00) (mol) ✓ $n(H_2)$ = 0.02(00) × 3 = 0.06(00) (mol) ✓ volume of H_2 = 0.06(00) × 24000 = 1440 (cm^3) ✓	**3**	**ALLOW** calculator value or rounding to three significant figures or more but **IGNORE** 'trailing zeroes' **ALLOW ECF** **ALLOW ECF from** $n(H_2)$ **OR** $n(MoO_3)$ if ×3 missing → 480 (cm^3) Likely 2 marks

Question			Answer	Mark	Guidance
1	(d)		$(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7\ 4s^2$ ✓	1	**ALLOW** $4s^2\ 3d^7$ **IGNORE** $1s^2$ seen twice **ALLOW** upper case D, etc and subscripts, e.g. ….....$3S_2 3P^6$**…..**
1	(e)		Check the answer on the answer line. If answer = 7 award 3 marks $n(H_2O) = \frac{2.52}{18.0} = 0.14(0)$ (mol) ✓ $n(CoSO_4) = \frac{5.62 - 2.52}{155.0} = \frac{3.10}{155.0} = 0.02(00)$ (mol) ✓ $x = \frac{n(H_2O)}{n(CoSO_4)} = \frac{0.14}{0.02} = 7$ ✓	3	**ALLOW** calculator value or rounding to three significant figures or more but **IGNORE** 'trailing zeroes' --- **Common error** No subtracting 2.52 for 2nd mark $\rightarrow = \frac{5.62}{155.0} = 0.0363$ (mol) × $x = \frac{n(H_2O)}{n(CoSO_4)} = \frac{0.14}{0.0363} = 3.86 = 4$ ✓ x = 4 likely to be 2 marks
			Total	13	

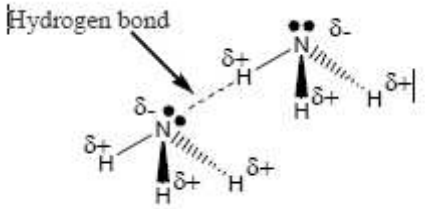
<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>2</td><td>(a)</td><td>(i)</td><td>
<table>
<tr><td>molecule</td><td>NCl_3</td><td>$SiCl_4$</td><td>BCl_3</td><td>Cl_2O</td><td></td></tr>
<tr><td>number of bonding pairs of electrons</td><td>3</td><td>4</td><td>3</td><td>2</td><td>✓</td></tr>
<tr><td>number of lone pairs of electrons</td><td>1</td><td>0</td><td>0</td><td>2</td><td>✓</td></tr>
</table>
</td><td>2</td><td>1 mark per row

‘0’ ‘0’ required.
DO NOT ALLOW spaces</td></tr>
<tr><td>2</td><td>(a)</td><td>(ii)</td><td>
<table>
<tr><th>molecule</th><th>shape</th><th>angle</th><th>polar (✓)</th></tr>
<tr><td>NCl_3</td><td>pyramidal</td><td>107(°)</td><td>TICK</td></tr>
<tr><td>$SiCl_4$</td><td>tetrahedral</td><td>109.5(°)</td><td></td></tr>
<tr><td>BCl_3</td><td>trigonal planar</td><td>120(°)</td><td></td></tr>
<tr><td>Cl_2O</td><td>non-linear</td><td>104.5(°)</td><td>TICK</td></tr>
</table>
Shape column ✓✓✓
Any two correct = 1 mark
Any three correct = 2 marks
All four correct = 3 marks

Bond angle column ✓✓
Any three correct = 1 mark
All four correct = 2 marks

Polarity column ✓
</td><td>6</td><td>For pyramidal, ALLOW ‘trigonal pyramid’
For non-linear, ALLOW ‘bent’ or ‘V-shaped’

For 107°, ALLOW 106 – 108
For 109.5°, ALLOW 109 – 110
For 104.5°, ALLOW 104 – 105</td></tr>
</table>

Question			Answer	Mark	Guidance
2	(b)		*Dipole* At least one $H^{\delta+}$ and one $N^{\delta-}$ on **BOTH** NH_3 molecules ✓ *Hydrogen bond* **Labelled** hydrogen bond between H in one NH_3 molecule and lone pair of N in adjacent NH_3 molecule ✓  	2	Only credit is dipoles on NH_3 molecules **ALLOW** H-bond as label Hydrogen bond must hit the lone pair
2	(c)	(i)	Check the answer on the answer line. If answer = H_3BO_3 **OR** BO_3H_3 award 2 marks *Mole ratio* B = $\frac{17.48}{10.8}$ O = $\frac{77.67}{16.0}$ H = $\frac{4.85}{1.0}$ **OR** 1.62 4.85 4.85 ✓ *Empirical formula* BO_3H_3 ✓	2	**ALLOW** 1.61 for 1.62 **IGNORE** $B(OH)_3$ *Not an empirical formula* 1
2	(c)	(ii)	$BCl_3(g) + 3H_2O(l) \rightarrow H_3BO_3(aq) + 3HCl(aq)$ Products: H_3BO_3 **AND** HCl **ONLY** ✓ Complete equation **AND** correctly balanced **AND** state symbols ✓	2	for H_3BO_3, **ALLOW** BO_3H_3 **OR** $B(OH)_3$ **ALLOW ECF** from empirical formula in 2c(i) **ALLOW** Multiples
			Total	14	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>3</td><td>(a)</td><td></td><td>
<table>
<tr><td>Na</td><td>Mg</td><td>Al</td><td>Si</td><td>P</td><td>S</td><td>Cl</td><td></td></tr>
<tr><td>98</td><td>649</td><td>660</td><td>1410</td><td>44</td><td>113</td><td>–101</td><td></td></tr>
<tr><td>G</td><td>G</td><td>G</td><td>G</td><td>S</td><td>S</td><td>S</td><td>✓</td></tr>
<tr><td>TICK</td><td>TICK</td><td>TICK</td><td></td><td></td><td></td><td></td><td>✓</td></tr>
</table>
</td><td>2</td><td>Mark by row

IGNORE tick in Si</td></tr>
<tr><td>3</td><td>(b)</td><td></td><td>FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED
ORA throughout

Forces/bonds
Cl_2 has van der Waals’ forces
AND between molecules/intermolecular ✓

Si has covalent bonds
AND between atoms ✓

Strength of forces
van der Waals’ forces/intermolecular forces are weaker than covalent bonds ✓

Melting points
Less energy need to break forces in chlorine ✓
(Needs ‘energy, not ‘more easily’)</td><td>4</td><td>Throughout, ALLOW for forces:
attractions OR interactions OR bonds

QWC: molecule(s) or intermolecular must be spelled correctly

IGNORE Cl_2 has covalent bonds

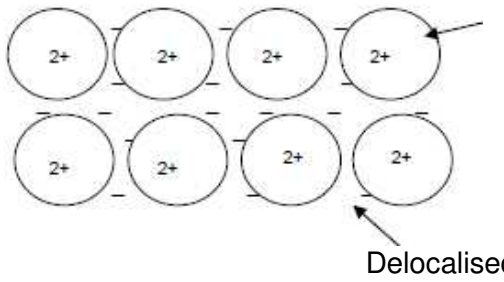
In Si, ALLOW forces between bonded pair and nuclei for ‘forces between atoms’

-

ALLOW van der Waals’ forces are weak AND covalent bonds are strong (anywhere)

DO NOT ALLOW unless in the context of correct particles: vdW (Cl_2) and covalent (Si)

ALLOW for van der Waals’,
• vdW
• induced/temporary/ instantaneous dipole forces</td></tr>
</table>

Question			Answer	Mark	Guidance
					• London forces
3	(c)	(i)	 *Lattice* Regular arrangement of Mg^{2+} ions **AND** electrons shown as – **OR** e^- ✓ *Electron labels* **Delocalised** electrons ✓	**2**	The regular arrangement must have minimum of two rows of 2+ ions with two 2+ ions per row **ALLOW** for Mg^{2+} label: Positive ions/cations **AND** 2+ within circle **QWC**: delocalised spelt correctly. **ALLOW** delocalized
3	(c)	(ii)	**ORA** throughout *Outer electrons* Mg has more **outer OR delocalised** electrons ✓ *Cation charge* Mg **ions** have a greater charge ✓ *Forces* Forces/attraction/metallic bonds between + ions and electrons ✓ *Comparison of strength of force and melting point* More energy to break **stronger** forces/attraction/bonds in Mg ✓	**4**	**FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED** **ALLOW** Mg has 2 outer electrons **AND** Na has 1 outer electron **ALLOW** Mg^{2+} **AND** Na^+ **ALLOW** 'charge density' for 'charge' **DO NOT ALLOW** unless in context of correct particles: metallic bonding/+ ions and electrons
3	(d)		A **repeating** pattern/trend across **period(s)** ✓	**1**	**ALLOW** an example of repeating trend across periods, e.g. atomic radius; ionisation energy
			Total	**13**	

Question			Answer	Mark	Guidance
4	(a)		Check the answers on the answer lines. If answers = 87.7 **OR** 87.8 **AND** Sr award 3 marks ***n*(OH$^-$) in 400 cm^3** $= \frac{6.56 \times 10^{-3} \times 400}{1000} = 2.62(4) \times 10^{-3}$ (mol) ✓ ***n*(M)** $= \frac{2.624 \times 10^{-3}}{2} = 1.312 \times 10^{-3}$ (mol) ✓ Molar mass of M = $\frac{0.115}{1.312 \times 10^{-3}} = 87.7$ (g mol^{-1}) **AND** M = Strontium **OR** Sr ✓ --- **ALLOW** alternative method for first two marks: **Concentration M^{2+} ions** $= \frac{6.56 \times 10^{-3}}{2} = 3.28 \times 10^{-3}$ (mol dm^{-3}) ***n*(M) in 400 cm^3** $= \frac{3.28 \times 10^{-3} \times 400}{1000} = 1.312 \times 10^{-3}$ (mol)	3	**ALLOW** calculator value or rounding to three significant figures or more but **IGNORE** 'trailing zeroes' **ALLOW ECF from *n*(OH$^-$)** **ALLOW** A_r of 87.8 (from 1.31×10^{-3} for *n*(M)) **ALLOW ECF BUT** M must be Group 2 metal with A_r closest to calculated molar mass --- **Common error** No ÷ 2 for 2nd mark likely to be 2 marks → *n*(M) = $2.62(4) \times 10^{-3}$ (mol) × Molar mass = $\frac{0.115}{2.62(4) \times 10^{-3}} = 43.8$ **OR** 43.9 **AND** M = Ca ✓
4	(b)	(i)	Turns yellow **OR** orange **OR** brown ✓	1	**ALLOW** shades of yellow, orange or brown **IGNORE** bubbles (Cl_2 is being bubbled into solution) **DO NOT ALLOW** purple **DO NOT ALLOW** observation containing a precipitate

Question			Answer	Mark	Guidance
4	(b)	(ii)	$Cl_2(g) + 2I^-(aq) \rightarrow I_2(aq) + 2Cl^-(aq)$ ✓ **State symbols required** *Check state symbol for I_2 first (commonest error)*	1	**ALLOW** multiples **ALLOW** $Cl_2(aq)$
4	(c)	(i)	**A** = BaO ✓ **B** = $BaCl_2$ ✓ **C** = $BaCO_3$ ✓ **D** = AgCl ✓	4	
4	(c)	(ii)	$Ba(NO_3)_2$ ✓	1	
4	(d)	(i)	Energy needed to remove an electron ✓ from **each atom** in **one mole** ✓ of gaseous atoms ✓	3	**ALLOW** for **three** marks: 'Energy to remove one mole of electrons from one mole of gaseous atoms' **ALLOW** for **two** marks: 'Energy to remove an electron from one mole of gaseous atoms' *One mole of electrons is not being removed* **IGNORE** 'to form one mole of gaseous 1+ ions' **ALLOW** idea of electron removal for 1st mark: e.g. 'Energy needed to remove electrons'
4	(d)	(ii)	$Sr^+(g) \rightarrow Sr^{2+}(g) + e^-$ ✓ **state symbols required**	1	**ALLOW** $Sr^+(g) - e^- \rightarrow Sr^{2+}(g)$ **ALLOW** e for e^- Element symbol must be Sr

Question			Answer	Mark	Guidance
4	(d)	(iii)	*Observations* ***1 mark*** Effervescence **OR** fizzing **OR** bubbling **OR** gas **AND** Solid/Mg/metal dissolves/disappears **OR** (colourless) solution forms ✓ *Trend in reactivity* ***1 mark*** Reactivity increases down the group **AND** Faster fizzing **OR** dissolves quicker **OR** more vigorous ✓ *Reasons for reactivity trend* ***3 marks*** Atomic radius increases **OR** more shells/energy levels ✓ **More** shielding ✓ **Less** nuclear attraction (on outer electrons) **OR** (outer) electrons are attracted less strongly (to the nucleus) ✓ *Energy to remove electrons* ***1 mark*** Ionisation energy decreases **OR** less energy required to remove electron ✓	6	**FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED** **IGNORE** 'hydrogen produced' but **ALLOW** 'hydrogen gas produced' **DO NOT ALLOW** an incorrectly named gas (e.g. CO_2) **IGNORE** 'more orbitals' **OR** 'more sub-shells' **ALLOW** 'greater repulsion from inner shells' **ALLOW '**pull' for 'attraction' **IGNORE** just 'less attraction' **OR** less force **OR** less strongly held
			Total	**20**	

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