OCR
RECOGNISING ACHIEVEMENT

GCE

Chemistry A

Advanced Subsidiary GCE

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

Mark Scheme for June 2011

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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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<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td></td><td>
<table>
<tr><td>particle</td><td>rel charge</td><td>rel mass</td><td>position</td></tr>
<tr><td>proton</td><td>+1</td><td>1</td><td>nucleus</td></tr>
<tr><td>neutron</td><td>nil/0</td><td>1</td><td>nucleus</td></tr>
<tr><td>electrons</td><td>-1</td><td>1/2000</td><td>in shells</td></tr>
</table>
✓</td><td>1</td><td>1 mark for whole table

ALLOW '+' on its own for rel charge of proton
DO NOT ALLOW '1' on its own for rel charge of proton
DO NOT ALLOW 'positive' for rel charge of proton

For neutron ALLOW 'neutral'

ALLOW '–' on its own for rel charge of electron
DO NOT ALLOW 'negative' for rel charge of electron

IGNORE '+' if precedes '1' for mass
IGNORE 'middle/centre' for nucleus</td></tr>
<tr><td></td><td>(b)</td><td></td><td>The energy required to remove an electron ✓

from each atom in one mole ✓

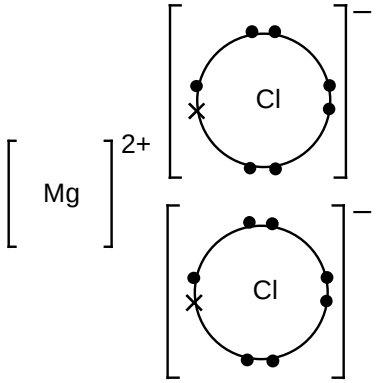
of atoms in the gaseous state ✓</td><td>1

1

1</td><td>ALLOW 'energy to remove one mole of electrons from one mole of gaseous atoms' for three marks
ALLOW 'The energy required to remove an electron from one mole of gaseous atoms to form one mole of gaseous 1+ ions' for two marks as it does not meet the 2nd marking point

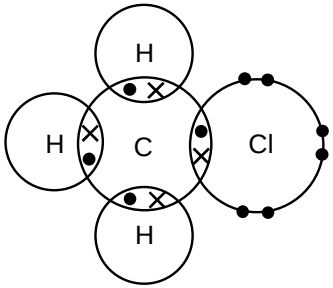
For third mark:
ALLOW ECF of wrong particle being gaseous

If no attempt at a definition, ALLOW one mark for the equation below, including state symbols
$X(g) \rightarrow X^+(g) + e^-$ OR $X(g) - e^- \rightarrow X^+(g)$
ALLOW e for electrons
IGNORE state symbol for electron</td></tr>
<tr><td></td><td>(c)</td><td></td><td>
<table>
<tr><td>a 2p orbital</td><td>2 ✓</td></tr>
<tr><td>the 3s sub-shell</td><td>2 ✓</td></tr>
<tr><td>the 4th shell</td><td>32 ✓</td></tr>
</table>
</td><td>1
1
1</td><td></td></tr>
<tr><td></td><td>(d)</td><td></td><td>A repeating pattern (of properties shown across different periods) ✓</td><td>1</td><td>ALLOW 'repeating trend'
DO NOT ALLOW just 'trend' OR 'pattern'</td></tr>
<tr><td></td><td>(e)</td><td>(i)</td><td>C ✓</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Al ✓</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>(iii)</td><td>N ✓</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>(iv)</td><td>Al ✓</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>(v)</td><td>Mg ✓</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>13</td><td></td></tr>
</table>

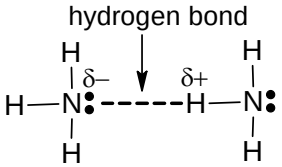
Question			Answer	Mark	Guidance
2	(a)		$MgCO_3 \rightarrow MgO + CO_2$ ✓	1	**IGNORE** state symbols
	(b)	(i)	$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$ Correct balanced equation ✓ Correct states for correct species ✓	1 1	**ALLOW** states mark if MgCl used in place of $MgCl_2$
		(ii)	Similarity: (Both) dissolve **OR** disappear. ✓ Difference: One effervesces **OR** fizzes **OR** bubbles **OR** gas produced ✓	1 1	**ALLOW** (both) 'go clear' **ALLOW** CO_2 produced **DO NOT ALLOW** incorrect gases **DO NOT ALLOW** responses which suggest **A** will effervesce e.g. as **B** will fizz more
		(iii)	203.3	1	**DO NOT ALLOW** 203 or 203.0 **IGNORE** units
		(iv)	 magnesium (ion) with 8 (or no) outermost electrons **AND** 2 x chloride (ions) with '*dot-and-cross*' outermost octet ✓ correct charges ✓	1 1	**For 1st mark,** if 8 electrons shown around cation then 'extra' electron around anion must match symbol chosen for electrons in cation Shell circles not required **IGNORE** inner shell electrons **ALLOW** correct diagram of a $[Cl^-]$ ion with '2 x' **OR** '2' in front **OR** 'x 2' after the diagram. **ALLOW** correct diagram of $[Cl^-]$ ion with subscript 2. i.e. $[Cl^-]_2$. **DO NOT ALLOW** $[Cl^-_2]$ $[Cl]^-_2$ i.e. for first mark charges do not need to be seen

Question			Answer	Mark	Guidance
2	(c)		$\frac{1.82}{24.3}$ $\frac{1.05}{28.1}$ $\frac{2.40}{16.0}$ To give 0.0749 0.0374 0.150 Ratio of moles ✓	1	**ALLOW** '24' for Mg (giving 0.0758) and '28' for Si (giving 0.0375) **ALLOW** any correct ratios of moles as calculator value **OR** correct rounding **to 2 sig figs or more** **ALLOW** method from masses being converted to percentages
			Answer = Mg_2SiO_4 ✓	1	**ALLOW** correct answer from a ratio of moles where it is clear that the candidate has divided by the atomic numbers. **ALLOW** ECF for formula from incorrect ratio of moles due to over-rounding calculator error or upside down mole calculation
	(d)	(i)	$\frac{32.00}{1000}$ x 0.500 = 1.60 x 10^{-2} (mol) **OR** 0.0160 (mol)✓	1	**ALLOW** 0.016 (mol) **IGNORE** trailing zeroes
		(ii)	$\frac{1.60 \times 10^{-2}}{2}$ = 8.00 x 10^{-3} (mol) **OR** 0.00800 (mol)✓	1	**ALLOW** ECF for answer **d(i)** / 2 **ALLOW** 0.008 or 8 × 10^{-3} (mol) Ignore trailing zeroes **ALLOW** 0.0080 or 8.0 × 10^{-3}
		(iii)	Molar mass $Mg(OH)_2$ = 58.3 ✓	1	**DO NOT ALLOW** 58 **OR** 58.0
			mass $Mg(OH)_2$ = 58.3 × 8.00 x 10^{-3} = 0.466(4) g ✓	1	**ALLOW** answer to **d(ii)** × 58.3 **ALLOW** 0.47 **ALLOW** ECF for **d(ii)** × incorrect molar mass as calculator value **OR** correct rounding to 2 sig figs or more
			% $Mg(OH)_2$ = $\frac{0.4664}{0.500}$ × 100 = 93.3% ✓	1	**ALLOW** 93% **OR** 93.2% **OR** 93.28% **DO NOT ALLOW d(ii)**/0.5 x 100 **ALLOW** (answer to second marking point/0.500) × 100 as calculator value **OR** correct rounding to 2 sig figs or more **ALLOW** moles method for 3 marks Molar mass = 58.3 0.500/58.3 = =0.00857(6) 0.00800/0857(6) × 100 = 93.3% **ALLOW** correct answer without working for 3 marks
			Total	**15**	

Question			Answer	Mark	Guidance
3	(a)		$2NaOH + Cl_2 \rightarrow NaClO + NaCl + H_2O$ ✓	1	**ALLOW** NaOCl **IGNORE** state symbols
	(b)	(i)	Sodium chlorate(V) ✓	1	**ALLOW** sodium chlorate V **DO NOT ALLOW** sodium chlorate 5
		(ii)			***USE annotations with ticks, crosses, con, ECF, etc for this part.***
			Cl in $NaClO_3$ is (+)5 **AND** Cl in $NaClO_4$ is (+)7 **AND** Cl in NaCl is –1 ✓	1	**ALLOW** 5+, 7+ 1– Look for oxidation numbers seen above equation. **DO NOT ALLOW** Cl^- in NaCl
			Chlorine has been both oxidised and reduced **OR** The oxidation number of chlorine has increased **AND** decreased ✓	1	**The second and third marking points must refer to chlorine** **ALLOW** 'it' for 'chlorine' if oxidation numbers of chlorine are given **ALLOW** Cl for 'chlorine' **DO NOT ALLOW** Cl_2 for 'chlorine'
			Chlorine has been oxidised from (+)5 to (+)7 **AND** chlorine has been reduced from (+)5 to –1 ✓ (These points would secure marking points 2 and 3) $4NaClO_3 \rightarrow 3NaClO_4 + NaCl$ +5 +7 –1 oxidation reduction	1 This diagram gets all 3 marks	**ALLOW** 'correct' references to oxidation and reduction even if based on incorrect oxidation numbers of chlorine **IGNORE** references to electron loss / gain if correct. **DO NOT ALLOW** 3rd mark for reference to electron loss/gain If oxidation numbers are correct, **ALLOW** 1 mark for 'chlorine is oxidised to form $NaClO_4$' **ALLOW** 1 mark for 'chlorine is reduced to form NaCl' **ALLOW** one mark for 'disproportionation is when a species is both oxidised and reduced' whether or not chlorine is mentioned
	(c)	(i)	Chlorinated hydrocarbons are carcinogens **OR** toxic **OR** Chlorine is toxic **OR** poisonous ✓ (Chlorine) kills bacteria **OR** 'kills germs' 'kills micro-organisms' **OR** 'makes water safe to drink' **OR** 'sterilises water' **OR** 'disinfects' ✓	1 1	**ALLOW** CH_3Cl for 'chlorinated hydrocarbons' **IGNORE** 'harmful' **IGNORE** 'carcinogenic' for chlorine **DO NOT ALLOW** 'antiseptic' **ALLOW** 'to make water potable' **ALLOW** 'removes' for 'kills' **IGNORE** 'virus' **IGNORE** 'purifies water' **IGNORE** 'cleans water'

Question			Answer	Mark	Guidance
3	(c)	(ii)	Electron pairs in covalent bonds shown correctly using dots and crosses in a molecule of CH_3Cl **AND** lone pairs correct on Cl ✓  	**1**	Must be '*dot-and cross'* **ALLOW** different symbol for third 'type' of electron Circles for outer shells not needed **IGNORE** inner shells Non-bonding electrons of chlorine do not need to be shown as pairs
		(iii)	Tetrahedral **OR** tetrahedron ✓	**1**	
	(d)		Add $AgNO_3$(aq) **OR** Ag^+(aq) **OR** silver nitrate **OR** $AgNO_3$ ✓	**1**	**ALLOW** Ag^+(aq) seen in the ionic equation **IGNORE** references to nitric acid **IGNORE** references to adding water or dissolving the brine **DO NOT ALLOW** references to any other additional reagent as well as the silver nitrate for the first mark
			White precipitate ✓	**1**	White **AND** precipitate required **DO NOT ALLOW** hint of any other colour **IGNORE '**turns grey' **ALLOW** solid as alternative for precipitate
			$Ag^+ + Cl^- \rightarrow AgCl$ ✓	**1**	**IGNORE** states
			Add dilute NH_3 and precipitate (completely) dissolves **OR** disappears ✓	**1**	**DO NOT ALLOW** conc. NH_3 **DO NOT ALLOW** any mention of incomplete dissolving **ALLOW** (for 4th mark) 'add Cl_2(aq)' **AND '**no colouration would be seen' **OR** 'no change' **OR** 'no reaction'
			Total	**13**	

Question			Answer	Mark	Guidance
4	(a)	(i)	The hydrogen **ions OR** H^+ **OR** protons (of hydrochloric acid) are replaced by zinc **ions OR** Zn^{2+} ✓	1	**ALLOW** Zn ions **OR** positive ions replace H **ions OR** a metal ion has replaced a hydrogen ion **OR** protons **DO NOT ALLOW** Zn replaces H. Ions are key either in word form or symbol form **DO NOT ALLOW** Zn^+ i.e. if charge is shown it must be correct
		(ii)	$Zn_3(PO_4)_2$ ✓	1	**ALLOW** $ZnHPO_4$ **OR** $Zn(H_2PO_4)_2$ **ALLOW** $Zn_3P_2O_8$
	(b)				***USE annotations with ticks, crosses, con, ECF, etc for this part.***
			reactivity increases (down the group) ✓	1	'down the group' not required **ALLOW** alternative phrases for 'reactivity increases'
			Increasing size mark atomic radii increases **OR** there are more shells ✓	1	**ALLOW** 'there are more energy levels' **ALLOW** 'electrons are in a higher energy level' **ALLOW** 'the electrons are further from nucleus' **IGNORE** there are more orbitals **OR** more sub-shells **IGNORE** 'different shell' or 'new shell'
			Increased shielding mark there is **more** shielding ✓	1	**ALLOW** '**more** screening' There must be a clear comparison i.e. '**more** shielding' **OR** '**increased** shielding'. i.e. **DO NOT ALLOW** 'there is shielding' **ALLOW** 'there is **more** electron repulsion from inner shells' *'**more'** is essential*
			Nuclear attraction mark The nuclear attraction decreases **OR** (outermost) electrons experience less attraction (to nucleus) **OR** Increased shielding / distance outweighs the increased nuclear charge ✓	1	**ALLOW** 'there is less nuclear pull' **OR** 'electrons less tightly held' **IGNORE** 'there is less effective nuclear charge' **IGNORE** 'nuclear charge' for 'nuclear attraction'
			easier to remove (outer) electrons **OR** ionisation energy decreases ✓ **ORA** throughout	1	**ALLOW** 'easier to oxidise' ***Quality of Written Communication –*** *'electron(s)'* ***OR*** *'ionisation'* ***OR*** *'ionization'* ***OR*** *'oxidise'* ***OR*** *oxidize' spelled correctly at least once for 5th marking point*
			Total	7	

Question			Answer	Mark	Guidance
5	(a)		Metallic lattice has delocalised **OR** mobile electrons **OR** metallic bonding has delocalised **OR** mobile electrons ✓	1	**IGNORE** 'free electrons' for 'mobile electrons' **DO NOT ALLOW** references to incorrect bonding
			Ionic lattice has no mobile ions **OR** ionic solid has no mobile ions ✓	1	**ALLOW** 'ions are fixed in place' **IGNORE** 'no mobile electrons' for solid ionic **IGNORE** 'no mobile charge carriers' for solid ionic
			molten ionic (compounds) have mobile ions ✓	1	**IGNORE** 'delocalised ions' **OR** 'free ions' for 'mobile ions' **DO NOT ALLOW** any mention of electrons moving **IGNORE** 'aqueous ionic compounds have mobile ions'
	(b)	(i)	Two (or more) ammonia molecules with at least one Hδ+ and at least one Nδ- (can be on the same or different molecules) ✓	1	There must be 3H atoms bonded to one N atom **DO NOT ALLOW** any Hδ- **OR** Nδ+ **ALLOW** 2-D NH_3 molecules **IGNORE** lone pair(s) for first marking point
			H-bond between H in one ammonia and lone pair of N in another ammonia molecule ✓  	1	All H-bonds drawn must hit the lone pair H-bond does not need to be labelled but must be different from covalent bond **DO NOT ALLOW** more than one lone pair on N for second marking point **ALLOW** a pair of molecules with two 'correct' hydrogen bonds forming a 'dimer'
		(ii)	Ice has stronger hydrogen bonds ✓	1	**ALLOW** 'more' for 'stronger' **OR** Ice has twice as many hydrogen bonds as ammonia **ALLOW** ice has strong**er** intermolecular forces than ammonia **OR** big**ger** permanent dipole than ammonia **DO NOT ALLOW** comparisons between different types of force **DO NOT ALLOW** reference to van der Waals' **IGNORE** 'more energy needed'
			O has two lone pairs (**AND** N has one) **OR** O more electronegative (than N) ✓	1	**ALLOW** O has more lone pairs

Question			Answer	Mark	Guidance
5	(c)				***USE annotations with ticks, crosses, con, ECF, etc for this part.***
			SiO_2 is **giant covalent** (lattice)✓	1	**ALLOW** macromolecular **OR** giant atomic **ALLOW** SiO_2 is a 'giant structure with covalent bonds' **ALLOW** even if reference to 'covalent' only appears later in answer. **DO NOT ALLOW** any reference to 'ionic' **OR** 'intermolecular' **OR** 'metallic' **Quality of Written Communication -** Covalent **OR** macromolecular **OR** atomic spelt correctly **ONCE** and used in context of the first marking point
			$SiCl_4$ is **simple molecular** (lattice) ✓	1	**ALLOW** simple covalent **DO NOT ALLOW** any reference to 'giant' **OR** 'ionic' **OR** 'metallic' **If neither of the 1st 2 marks have been awarded,** **ALLOW** 1 mark for SiO_2 is giant **AND** $SiCl_4$ is simple **OR** molecular
			van der Waals' forces in $SiCl_4$ ✓	1	**ALLOW** induced dipoles **DO NOT ALLOW** permanent dipoles
			Covalent bonds broken in SiO_2 ✓	1	**ALLOW** alternative words to broken e.g. overcome
			Forces **OR** bonds are stronger in SiO_2 (than in $SiCl_4$) **OR** more energy is needed to break forces **OR** bonds in SiO_2 (than in $SiCl_4$) ✓ **ORA**	1	**ALLOW** incorrect forces in $SiCl_4$ **OR** SiO_2 for this mark
			Total	**12**	

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