GCE

Chemistry A

Advanced Subsidiary GCE

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

Mark Scheme for June 2013

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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.

1. 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
SEEN	Noted but no credit given
REP	Repeat

2. **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

All questions must be annotated with a tick where the mark is given.

Additional pages/objects: You **must** annotate the additional pages (before Question 1) and the additional objects for each script you mark. If no credit is to be awarded for the additional object, please use a suitable annotation (either ^ or SEEN).

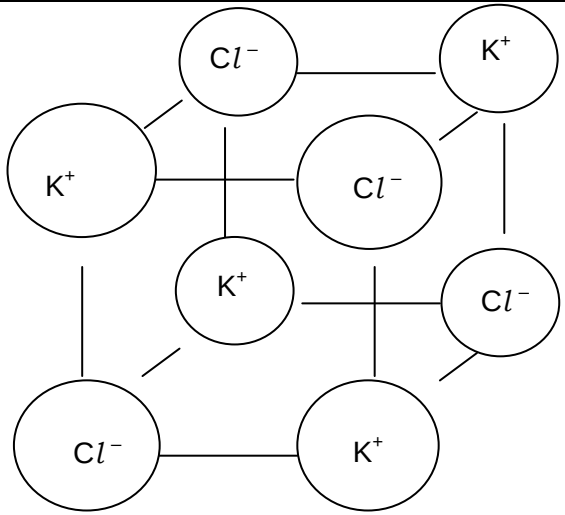
The following questions should be fully annotated with ticks, crosses and other relevant annotations to show where marks have been awarded in the body of the text:

3ai

4a

5ai

Question			Answer	Marks	Guidance
1	(a)	(i)	**Mass** of the **isotope** compared to 1/12th **OR** **mass** of the **atom** compared to 1/12th ✓ (the mass of an atom of) ^{12}C ✓	2	**ALLOW** for ^{12}C: carbon-12 **OR** C-12 **OR** C 12 **OR** 12C **ALLOW** mass of a **mole** of the isotope **OR** mass of a mole of atoms compared to 1/12th the mass of **mole** or 12 **g** of ^{12}C for two marks **ALLOW** mass of the isotope or mass of the atom compared to ^{12}C which has a mass of 12(.0) for two marks **ALLOW** one mark for responses which have individual atoms compared to one mole of 12C and vice versa eg mass of the isotope or mass of the atom compared to ^{12}C which has a mass of 12(.0) **g** eg mass of an atom compared to 1/12th mass of one mole of ^{12}C eg mass of one mole of atoms compared to 1/12th the mass of an atom of 12C **ALLOW** 2 marks for responses expressed as a fraction eg $\frac{\text{mass of the isotope}}{\text{mass of 1/12th mass of } ^{12}C}$ **IGNORE** (weighted) mean **OR** average **DO NOT ALLOW** mass of element or mass of ion
		(ii)	19p and 20n ✓ $^{41}K^{+}$ and 19p ✓	2	Mark by row **ALLOW** 41K+
	(b)		$(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^2$ ✓	1	**ALLOW** $1s^2$ repeated **ALLOW** subscripts **AND** upper case etc

Question			Answer	Marks	Guidance
1	(c)	(i)	**First check the answer on the answer line.** **If answer** = 3.01 x 10^{22} award 3 marks 170.1 ✓ (**ALLOW** in working shown as 28.1 + 35.5 x 4) Correctly calculates amount of molecules 8.505 / 170.1 = 0.05(00) mol ✓ Correctly calculates number of molecules 0.05 x 6.02 x 10^{23} = 3.01 x 10^{22} ✓	3	**ALLOW** 0.301 x 10^{23} for three marks If there is an alternative answer, check to see if there is any ECF credit possible using working below. **ALLOW** ECF from incorrect molar mass of $SiCl_4$ **ALLOW** 0.05(00) (mol) for two marks **ALLOW** ECF for incorrect number of mol of $SiCl_4$ **ALLOW** calculator value or rounding to 3 significant figures or more **BUT IGNORE** 'trailing' zeroes, eg 0.200 allowed as 0.2. **DO NOT ALLOW** any marks for: 8.505 x 6.02 x 10^{23} = 5.12 x 10^{24}
		(ii)	 4 K and 4 C*l* correctly arranged ✓ 4 K^+ and 4 Cl^- correctly arranged ✓	2	**ALLOW** the structure with **ALL** Cl^- and K^+ transposed **ALLOW** labels if seen outside circles but linked with an arrow eg K^+ → ○
			Total	**10**	

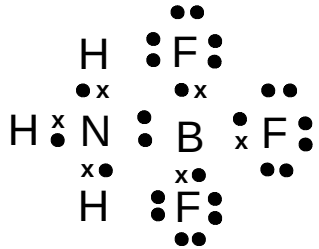
Question			Answer	Marks	Guidance
2	(a)	(i)	Al^{3+} ✓ SO_4^{2-} ✓	2	
		(ii)	$Al_2O_3(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3H_2O(l)$ Correct species **AND** correctly balanced ✓ state symbols on **correct** species ✓	2	**ALLOW** multiples
		(iii)	(The number of) water(s) of crystallisation ✓	1	**IGNORE** hydrated **OR** hydrous **OR** 'contains water'
		(iv)	**First check the answer on the answer line.** **If answer** = 16, award 3 marks Correctly calculates amount of $Al_2(SO_4)_3$: 6.846 / 342.3 = 0.02(00) mol ✓ Correctly calculates amount of H_2O: 5.760 / 18.0 = 0.32(0) mol ✓ Correctly calculates whole number ratio of mol of H_2O: $Al_2(SO_4)_3$ to give ***x*** = 16 ✓	3	If there is an alternative answer, check to see if there is any ECF credit possible using working below **ALLOW** as ECF from 12.606/342.3 = 0.0368(273) **AND** 0.32/0.0368(273) To give ***x*** = 9 for two marks **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 calculation of correctly rounded **whole number** value of H_2O from incorrect mol of H_2O and / or incorrect mol of $Al_2(SO_4)_3$ **BUT** ***x*** must be a whole number **ALLOW** alternative method Mol of $Al_2(SO_4)_3$: 6.846 / 342.3 = 0.02(00) mol (first mark) Molar mass of $Al_2(SO_4)_3 \cdot xH_2O$: 12.606 / 0.02(00) = 630.3 g mol^{-1} (second mark) Mass of water per mol = 630.3 – 342.3 = 288 **AND** 288/18 to give ***x*** = 16 (third mark)

Question			Answer	Marks	Guidance
2	(b)	(i)	$Cl_2 + H_2O \rightarrow HCl + HClO$ ✓ H^+ ions are released **OR** HC*l* is acidic **OR** HC*l*O is acidic ✓	2	**ALLOW** HOC*l* **ALLOW** equilibrium sign **IGNORE** state symbols **ALLOW** formulae **OR** names *If correct equation is seen:* **ALLOW** 'product is acidic' **OR** 'acid is produced' **IGNORE** 'the solution is acidic' but **ALLOW** 'the solution formed is acidic' **DO NOT ALLOW** 'chlorine is acidic' ie acidity must be related to the product(s) *If an incorrect equation is seen:* **ALLOW** second mark if H^+ **OR** HC*l* **OR** HC*l*O is given as a product in the equation **AND** is stated as being acidic *If no equation is seen:* **ALLOW** second mark if H^+ **OR** HC*l* **OR** HC*l*O is produced **AND** is stated as being acidic
		(ii)	ClO^- ✓	1	**ALLOW** OCl^-
			Total	**11**	

Question			Answer	Marks	Guidance
3	(a)	(i)	P in P_4 is 0 **AND** in PH_3 is –3 **AND** in NaH_2PO_2 is (+)1 ✓ Phosphorus has been oxidised (from 0) to +1✓ Phosphorus has been reduced (from 0) to –3 ✓	3	**FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED** **ALLOW** oxidation states written above the equation if not seen in the text BUT **IGNORE** oxidation states written above the equation if seen in the text **ALLOW** 3– **AND** 1+ **DO NOT ALLOW ions** **DO NOT ALLOW** P^{3-} in PH_3 **OR** P^{+} in NaH_2PO_2 **DO NOT ALLOW** phosph**ide** or phosph**ine** or phosphate in place of phosphorus **ALLOW** P or P_4 for phosphorus **ALLOW** ECF for the second and third marks if **ONE** incorrect oxidation number is assigned but directional changes are correct eg P = 0 and –3 and +2 instead of 0 and –3 and +1. **IGNORE** references to electron loss / gain If correct oxidation numbers are seen **ALLOW** second **AND** third marking points for: 'Phosphorus is oxidised to form NaH_2PO_2' **AND** 'Phosphorus is reduced to form PH_3' **IF** neither second and third marks have been awarded **ALLOW** for **ONE** mark: Phosphorus has been both oxidised and reduced **OR** Phosphorus's oxidation number has increased and decreased

Question			Answer	Marks	Guidance
3	(a)	(ii)	**First check the answer on the answer line.** **If answer** = 360 (cm^3) award 2 marks Correctly calculates amount of P_4 = 1.86/124.0 = 0.015(0) mol ✓ Correctly calculates volume of PH_3 = 0.015(0) x 24000 = 360 (cm^3) ✓	2	If there is an alternative answer, check to see if there is any ECF credit possible using working below **ALLOW** ECF for wrong amount of P_4 x 24000 for second mark **ALLOW** one mark for (1.86/31.0) x 24000 = 1440 **DO NOT ALLOW** 2nd mark for 1.86 x 24000 = 44640 **ALLOW** calculator value or rounding to 2 significant figures or more **BUT IGNORE** 'trailing' zeroes, eg 0.200 allowed as 0.2.
	(b)		$4PH_3 + 8O_2 \rightarrow P_4O_{10} + 6H_2O$ ✓	1	**ALLOW** correct multiples **IGNORE** state symbols
	(c)	(i)	The hydrogen **ions OR** H^+ **OR** protons (of phosphoric acid) are replaced by sodium **ions OR** Na^+ ✓	1	**ALLOW** Na ions **OR** positive ions replace H ions **OR** metal ions have replaced hydrogen ions **OR** protons **DO NOT ALLOW** Na replaces H. Ions are key in either word or symbol form. **DO NOT ALLOW** incorrect charge on Na ions (eg Na^{2+})
		(ii)	Correctly calculates 0.100 x 15 / 1000 = 1.5(0) x 10^{-3} **OR** 0.0015(0) ✓	1	
		(iii)	22.5 ✓	1	**ALLOW** ECF from (ii) Answer from (ii) x (3/0.2) x 1000
	(d)	(i)	hydrogen bonding ✓ Permanent dipole(–dipole interactions) ✓	2	

Question			Answer	Marks	Guidance
3	(d)	(ii)	the intermolecular forces are weaker in PH_3 ✓	1	**ALLOW** the energy needed to overcome the intermolecular forces in NH_3 is greater Check table in part (i) **IF** NH_3 = hydrogen bonds **AND** PH_3 = permanent dipoles **OR** van der Waal's forces; **ALLOW** 'Hydrogen Bonds are stronger' **ORA** **IF** NH_3 = permanent dipoles **AND** PH_3 = van der Waal's forces; **ALLOW** 'permanent dipoles are stronger' **ORA** **IF** NH_3 = permanent dipoles **AND** PH_3 = permanent dipoles; **ALLOW** 'permanent dipoles are stronger **in NH_3**' **ORA** **DO NOT ALLOW** PH_3 has weaker vdW's than NH_3 **DO NOT ALLOW** NH_3 has stronger hydrogen bonds than PH_3 **DO NOT ALLOW** implication that covalent bonds are broken
	(e)	(i)	Both electrons have been donated by one atom ✓	1	**ALLOW** 'they' for electrons **IGNORE** elements for atom **DO NOT ALLOW** 'transfer' in place of 'donated' **DO NOT ALLOW** more than one electron pair is donated

Question			Answer	Marks	Guidance
3	(e)	(ii)	 Correct '*dot-and-cross*' arrangement of B covalently '*dot-and-cross*' bonded to three F atoms, including full octet on F atoms **AND** Correct '*dot-and-cross*' arrangement of N covalently '*dot-and-cross*' bonded to three H atoms ✓ Dative covalent shown between N and B atoms ✓	2	Must be '*dot-and-cross*', but **ALLOW** other symbols for electrons of third and fourth atoms eg ∆, +, o, etc Circles for outer shells are not needed **IGNORE** inner shells **IGNORE** use of charges Non-bonding electrons of F do not need to be seen as pairs **IGNORE** dative-covalent arrows from N to B, but **DO NOT ALLOW** arrow from B to N **DO NOT ALLOW** two separate molecules for first mark **DO NOT ALLOW** dative covalent bond mark if electron pair matches the B electrons ie to be correct the dative pair must be the same symbol as non-bonding electrons on F atoms if only two symbols are used **DO NOT ALLOW** dative covalent bond mark if F atoms have no non-bonding electrons **UNLESS** B has different electron symbol to N or H atoms
		(iii)	BF_3 = 120(◦) ✓ H_3NBF_3 = 109.5(◦) ✓	2	**ALLOW** 109–110(◦) for H_3NBF_3

Question			Answer	Marks	Guidance
3	**(e)**	**(iv)**	(N in) NH_3 has three bonding pairs and one lone pair of electrons ✓ (N in) H_3NBF_3 has **four** bonding pairs (and no lone pairs) of electrons **OR** Lone pair on N now becomes bonding pair ✓ Lone pair of electrons repels **more** than bonding pairs ✓	3	**ALLOW** 'bonds' for 'bonding pairs' **IGNORE** 'electrons repel' **DO NOT ALLOW** 'atoms repel'
			Total	**20**	

Question			Answer	Marks	Guidance
4	(a)			5	**FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED** 'Down the group' is not required **ORA** throughout
			Reactivity increases (down the group) ✓		**ALLOW** alternative phrases for 'reactivity increases'
			Increasing size mark Atomic radius increases **OR** There are more shells ✓		**ALLOW** 'there are more energy levels' **ALLOW** 'electrons are in higher energy levels' **ALLOW** 'electrons are further from the nucleus' **IGNORE** there are more orbitals **OR** more sub-shells **ALLOW** 'different shell' **OR** 'new shell'
			Increased shielding mark There is **more** shielding ✓		There must be clear comparison ie 'more shielding' **OR** 'increased shielding' **ALLOW** there is **more** electron repulsion from inner shells **DO NOT ALLOW** responses which have no comparative eg 'there is shielding'
			Nuclear attraction (to electron) mark Nuclear attraction (to electron) decreases **OR** (outermost) electrons experience less attraction (to nucleus) **OR** Increased nuclear charge is outweighed by increased shielding/distance ✓		**ALLOW** 'there is less nuclear pull' **OR** 'electrons less tightly held' **IGNORE** there is less effective nuclear charge **IGNORE** 'nuclear charge' for 'nuclear attraction' If question is answered in terms of only Group 7, then **ONLY** marks 2, 3 and 4 can be awarded
			Ease of electron loss mark Easier to remove (outer) electron(s) **OR** Ionisation energy decreases ✓		**ALLOW** easier to oxidise
			Quality of written communication *electron(s)* ***OR*** *ionisation* ***OR*** *ionization* ***OR*** *oxidise* ***OR*** *oxidize spelled correctly at least once for last marking point*		

Question			Answer	Marks	Guidance
4	**(b)**	**(i)**	$AgNO_3$(aq) **OR** silver nitrate **OR** $AgNO_3$ ✓	1	**ALLOW** Ag^+(aq)
		(ii)	Yellow **AND** precipitate ✓	1	**ALLOW** shades of yellow but not creamy yellow **ALLOW** ppt or solid for precipitate
		(iii)	Ag^+ (aq) + I^-(aq) ➔ AgI(s) ✓	1	**ALLOW** correct multiples
		(iv)	**concentrated** (aqueous) NH_3 ✓	1	
			Total	**9**	

Question			Answer	Marks	Guidance
5	(a)	(i)	*Nuclear charge mark* (Across the period) number of protons increases **OR** greater nuclear charge ✓ ***Quality of written communication*** *– nuclear* ***OR*** *proton(s)* ***OR*** *nucleus spelled correctly ONCE for the first marking point* *Distance / shielding mark* (Outermost) electrons are in the same shell **OR** (Outermost) electrons experience the same shielding **OR** Atomic radius decreases ✓ *Nuclear attraction (to electron) mark* Greater nuclear attraction (on outermost electrons) **OR** (outer) electrons are attracted more strongly (to the nucleus) ✓	3	**FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED** Comparison should be used for each mark **IGNORE** atomic number increases, but **ALLOW** proton number increases **IGNORE** nucleus gets bigger **IGNORE** 'effective nuclear charge increases' **DO NOT ALLOW** 'charge' increases without reference to nuclear **ALLOW** shielding is similar BUT **IGNORE** 'there is shielding' **DO NOT ALLOW** sub-shells **OR** orbitals **ALLOW** greater nuclear pull for greater nuclear attraction **DO NOT ALLOW** use of greater nuclear charge for greater nuclear attraction for third mark
		(ii)	(Diamond and graphite form) **gaseous atoms** (of carbon when they are ionised) ✓	1	**ALLOW** the **atoms** are in the **gaseous** state

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td></td><td>(b)</td><td></td><td>
<table>
<tr><th></th><th>Lithium</th><th>Carbon (diamond)</th><th>Fluorine</th></tr>
<tr><td>Structure</td><td>Giant</td><td>Giant ✓</td><td>Simple</td></tr>
<tr><td>Force or bond overcome on melting</td><td>Metallic bond</td><td>Covalent (bond) ✓</td><td>van der Waals' (forces) OR induced dipoles ✓</td></tr>
<tr><td>Particles between which the force or bond is acting</td><td>Li^+ ions and (delocalised) electrons ✓</td><td>Atoms ✓</td><td>Molecules ✓</td></tr>
</table>
</td><td>6</td><td>ALLOW shared pair of electrons for covalent (bond)

ALLOW vdw for van der Waals'
ALLOW temporary–induced or instantaneous–induced for van der Waals'

ALLOW Positive ions for Li^+ ions
IGNORE 'Lithium ions' but ALLOW 'Positive lithium ions'
DO NOT ALLOW Li^{2+}

IGNORE C and IGNORE F_2
IGNORE diagrams but ALLOW names of particles if seen as a label on a diagram

DO NOT ALLOW implication that covalent bonds are broken in fluorine for the particles mark of fluorine as this implies the particles are atoms</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>10</td><td></td></tr>
</table>

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