

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.

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1. 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
	Noted but no credit given
	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).

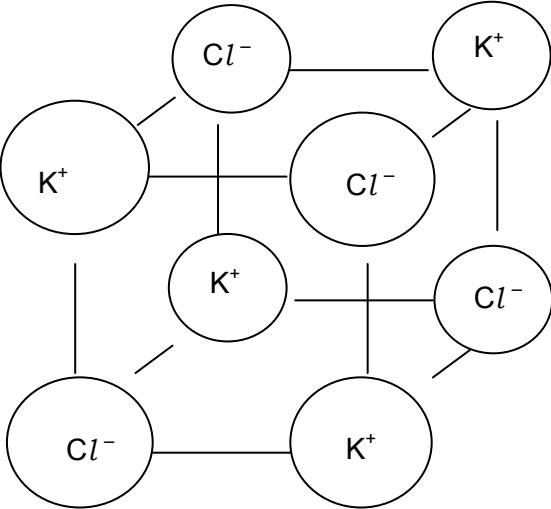
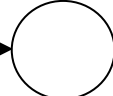
The following questions should be fully annotated with ticks, crosses and other relevant annotations to show where marks have been awarded in the body of the text:

3ai

4a

5ai

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

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

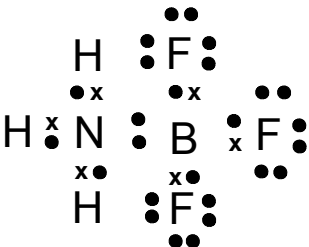
Question			Answer	Marks	Guidance
2	(a)	(i)	Al ³⁺ ✓ SO ₄ ²⁻ ✓	2	
		(ii)	Al ₂ O ₃ (s) + 3H ₂ SO ₄ (aq) → Al ₂ (SO ₄) ₃ (aq) + 3H ₂ O(l) Correct species AND correctly balanced ✓ state symbols on correct species ✓	2	ALLOW multiples
		(iii)	(The number of) water(s) of crystallisation ✓	1	IGNORE hydrated OR 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 ₂ O: 5.760 / 18.0 = 0.32(0) mol ✓ Correctly calculates whole number ratio of mol of H ₂ O: 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 ₂ O from incorrect mol of H ₂ O 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 · x H ₂ O: 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 HCl is acidic OR $HClO$ is acidic ✓	2	ALLOW $HOC/$ ALLOW equilibrium sign IGNORE state symbols ALLOW formulae OR names <i>If correct equation is seen:</i> 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) <i>If an incorrect equation is seen:</i> ALLOW second mark if H^+ OR HCl OR $HClO$ is given as a product in the equation AND is stated as being acidic <i>If no equation is seen:</i> ALLOW second mark if H^+ OR HCl OR $HClO$ is produced AND is stated as being acidic
		(ii)	ClO^- ✓	1	ALLOW OCl^-
Total				11	

Question			Answer	Marks	Guidance
3	(a)	(i)	<p>P in P₄ is 0 AND in PH₃ is -3 AND in NaH₂PO₂ is (+)1 ✓</p> <p>Phosphorus has been oxidised (from 0) to +1 ✓</p> <p>Phosphorus has been reduced (from 0) to -3 ✓</p>	3	<p>FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED</p> <p>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</p> <p>ALLOW 3- AND 1+ DO NOT ALLOW ions DO NOT ALLOW P³⁻ in PH₃ OR P⁺ in NaH₂PO₂ DO NOT ALLOW phosphide or phosphine or phosphate in place of phosphorus ALLOW P or P₄ 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</p> <p>If correct oxidation numbers are seen ALLOW second AND third marking points for: 'Phosphorus is oxidised to form NaH₂PO₂' AND 'Phosphorus is reduced to form PH₃'</p> <p>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</p>

Question		Answer	Marks	Guidance
3	(a) (ii)	<p>First check the answer on the answer line. If answer = 360 (cm³) award 2 marks</p> <p>Correctly calculates amount of P₄ = 1.86/124.0 = 0.015(0) mol ✓</p> <p>Correctly calculates volume of PH₃ = 0.015(0) x 24000 = 360 (cm³) ✓</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 ECF for wrong amount of P₄ x 24000 for second mark ALLOW one mark for (1.86/31.0) x 24000 = 1440</p> <p>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.</p>
	(b)	4PH ₃ + 8O ₂ → P ₄ O ₁₀ + 6H ₂ O ✓	1	<p>ALLOW correct multiples IGNORE state symbols</p>
	(c) (i)	The hydrogen ions OR H ⁺ OR protons (of phosphoric acid) are replaced by sodium ions OR Na ⁺ ✓	1	<p>ALLOW Na ions OR positive ions replace H ions OR metal ions have replaced hydrogen ions OR protons</p> <p>DO NOT ALLOW Na replaces H. Ions are key in either word or symbol form. DO NOT ALLOW incorrect charge on Na ions (eg Na²⁺)</p>
	(ii)	Correctly calculates 0.100 x 15 / 1000 = 1.5(0) x 10 ⁻³ OR 0.0015(0) ✓	1	
	(iii)	22.5 ✓	1	<p>ALLOW ECF from (ii) Answer from (ii) x (3/0.2) x 1000</p>
	(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	<p>ALLOW the energy needed to overcome the intermolecular forces in NH₃ is greater</p> <p>Check table in part (i)</p> <p>IF NH₃ = hydrogen bonds AND PH₃ = permanent dipoles OR van der Waal's forces; ALLOW 'Hydrogen Bonds are stronger' ORA</p> <p>IF NH₃ = permanent dipoles AND PH₃ = van der Waal's forces; ALLOW 'permanent dipoles are stronger' ORA</p> <p>IF NH₃ = permanent dipoles AND PH₃ = permanent dipoles; ALLOW 'permanent dipoles are stronger in NH₃' ORA</p> <p>DO NOT ALLOW PH₃ has weaker vdW's than NH₃ DO NOT ALLOW NH₃ has stronger hydrogen bonds than PH₃ DO NOT ALLOW implication that covalent bonds are broken</p>
	(e)	(i)	Both electrons have been donated by one atom ✓	1	<p>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</p>

Question			Answer	Marks	Guidance
3	(e)	(ii)	 <p>Correct '<i>dot-and-cross</i>' arrangement of B covalently '<i>dot-and-cross</i>' bonded to three F atoms, including full octet on F atoms AND Correct '<i>dot-and-cross</i>' arrangement of N covalently '<i>dot-and-cross</i>' bonded to three H atoms ✓ Dative covalent shown between N and B atoms ✓</p>	2	<p>Must be '<i>dot-and-cross</i>', but ALLOW other symbols for electrons of third and fourth atoms eg Δ, +, o, etc</p> <p>Circles for outer shells are not needed IGNORE inner shells IGNORE use of charges</p> <p>Non-bonding electrons of F do not need to be seen as pairs</p> <p>IGNORE dative-covalent arrows from N to B, but DO NOT ALLOW arrow from B to N</p> <p>DO NOT ALLOW two separate molecules for first mark</p> <p>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</p> <p>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</p>
		(iii)	<p>$\text{BF}_3 = 120(^{\circ})$ ✓ $\text{H}_3\text{NBF}_3 = 109.5(^{\circ})$ ✓</p>	2	<p>ALLOW 109–110($^{\circ}$) for H_3NBF_3</p>

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)	<p>Reactivity increases (down the group) ✓</p> <p><i>Increasing size mark</i> Atomic radius increases OR There are more shells ✓</p> <p><i>Increased shielding mark</i> There is more shielding ✓</p> <p><i>Nuclear attraction (to electron) mark</i> Nuclear attraction (to electron) decreases OR (outermost) electrons experience less attraction (to nucleus) OR Increased nuclear charge is outweighed by increased shielding/distance ✓</p> <p><i>Ease of electron loss mark</i> Easier to remove (outer) electron(s) OR Ionisation energy decreases ✓</p> <p>Quality of written communication <i>electron(s) OR ionisation OR ionization OR oxidise OR oxidize spelled correctly at least once for last marking point</i></p>	5	<p>FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED</p> <p>'Down the group' is not required ORA throughout</p> <p>ALLOW alternative phrases for 'reactivity increases'</p> <p>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'</p> <p>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'</p> <p>ALLOW 'there is less nuclear pull' OR 'electrons less tightly held' IGNORE there is less effective nuclear charge IGNORE 'nuclear charge' for 'nuclear attraction'</p> <p>If question is answered in terms of only Group 7, then ONLY marks 2, 3 and 4 can be awarded</p> <p>ALLOW easier to oxidise</p>

Question			Answer	Marks	Guidance
4	(b)	(i)	$\text{AgNO}_3(\text{aq})$ OR silver nitrate OR AgNO_3 ✓	1	ALLOW $\text{Ag}^+(\text{aq})$
		(ii)	Yellow AND precipitate ✓	1	ALLOW shades of yellow but not creamy yellow ALLOW ppt or solid for precipitate
		(iii)	$\text{Ag}^+(\text{aq}) + \text{I}^-(\text{aq}) \rightarrow \text{AgI}(\text{s})$ ✓	1	ALLOW correct multiples
		(iv)	concentrated (aqueous) NH_3 ✓	1	
			Total	9	

Question		Answer	Marks	Guidance
5	(a) (i)	<p><i>Nuclear charge mark</i> (Across the period) number of protons increases OR greater nuclear charge ✓</p> <p>Quality of written communication – nuclear OR proton(s) OR nucleus spelled correctly ONCE for the first marking point</p> <p><i>Distance / shielding mark</i> (Outermost) electrons are in the same shell OR (Outermost) electrons experience the same shielding OR Atomic radius decreases ✓</p> <p><i>Nuclear attraction (to electron) mark</i> Greater nuclear attraction (on outermost electrons) OR (outer) electrons are attracted more strongly (to the nucleus) ✓</p>	3	<p>FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED</p> <p>Comparison should be used for each mark</p> <p>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</p> <p>ALLOW shielding is similar BUT IGNORE 'there is shielding' DO NOT ALLOW sub-shells OR orbitals</p> <p>ALLOW greater nuclear pull for greater nuclear attraction DO NOT ALLOW use of greater nuclear charge for greater nuclear attraction for third mark</p>
	(ii)	(Diamond and graphite form) gaseous atoms (of carbon when they are ionised) ✓	1	ALLOW the atoms are in the gaseous state

Question		Answer			Marks	Guidance
	(b)		Lithium	Carbon (diamond)	Fluorine	<p>6</p> <p>ALLOW shared pair of electrons for covalent (bond)</p> <p>ALLOW vdw for van der Waals'</p> <p>ALLOW temporary–induced or instantaneous–induced for van der Waals'</p> <p>ALLOW Positive ions for Li⁺ ions</p> <p>IGNORE 'Lithium ions' but ALLOW 'Positive lithium ions'</p> <p>DO NOT ALLOW Li²⁺</p> <p>IGNORE C and IGNORE F₂</p> <p>IGNORE diagrams but ALLOW names of particles if seen as a label on a diagram</p> <p>DO NOT ALLOW implication that covalent bonds are broken in fluorine for the <i>particles</i> mark of fluorine as this implies the particles are atoms</p>
		Structure	Giant	Giant ✓	Simple	
		Force or bond overcome on melting	Metallic bond	Covalent (bond) ✓	van der Waals' (forces) OR induced dipoles ✓	
		Particles between which the force or bond is acting	Li ⁺ ions and (delocalised) electrons ✓	Atoms ✓	Molecules ✓	
				Total	10	

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