

Chemistry A

Advanced Subsidiary GCE

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

Mark Scheme for January 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.

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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

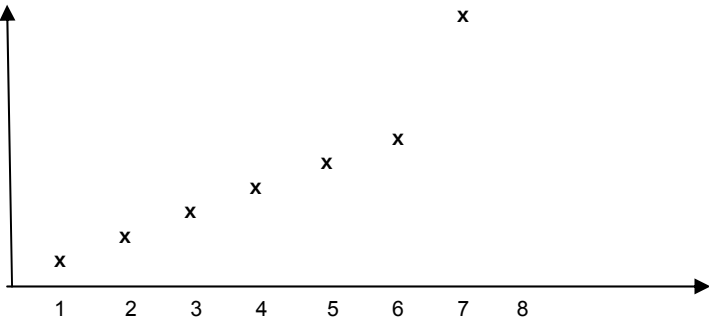
The following questions should be fully annotated with ticks, crosses, ecf etc to show where marks have been awarded in the body of the text:

3(c), 4(e)(iii) and 5(a)

Question			Answer	Marks	Guidance								
1	(a)	(i)	Atom(s) of an element AND with different numbers of neutrons (and with different masses) ✓	1	ALLOW for 'atoms of an element': Atoms of the same element OR atoms with the same number of protons OR atoms with the same atomic number IGNORE 'different relative atomic masses' IGNORE different mass number IGNORE same number of electrons DO NOT ALLOW different numbers of electrons DO NOT ALLOW 'atoms of elements' for 'atoms of an element' DO NOT ALLOW 'an element with different numbers of neutrons' (ie atom(s) is essential)								
		(ii)	<table><tr><th>Protons</th><th>Neutrons</th><th>Electrons</th><th></th></tr><tr><td>74</td><td>110</td><td>74</td><td>✓</td></tr></table>	Protons	Neutrons	Electrons		74	110	74	✓	1	
Protons	Neutrons	Electrons											
74	110	74	✓										
		(iii)	¹² C OR C-12 OR carbon 12 OR carbon-12 ✓	1	IGNORE 1/12 th AND amu								
	(b)	(i)	(Oxidised): H (oxidation number has increased) from H = 0 to H = +1 ✓ (Reduced): W (oxidation number has decreased) from W = +6 to W = 0 ✓	2	ALLOW 6+ OR 6 OR 1+ OR 1 ALLOW one mark for correct oxidation number changes H = 0 to H = +1 AND W = +6 to W = 0 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 for one mark: (Oxidised) H has increased by 1 AND (Reduced) W has decreased by 6 IGNORE WO₃ is reduced IGNORE references to electron loss / gain if correct DO NOT ALLOW incorrect references to electron loss / gain DO NOT ALLOW 'H oxidised and W reduced' without reference to oxidation number changes								

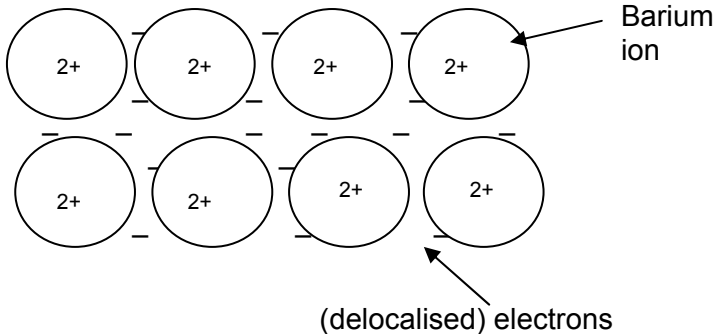
Question			Answer	Marks	Guidance
1	(b)	(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE IF answer = 3.6(0) (dm³) award 3 marks Amount of WO₃ = (11.59 / 231.8 =) 0.05(00) (mol) ✓ Amount of H₂ = 0.0500 x 3 = 0.15(0) (mol) ✓ Volume of H₂ = 0.150 x 24.0 = 3.6(0) (dm³) ✓	3	If there is an alternative answer, check 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 if wrong M_r produces such numbers throughout. IF answer = 1.2(0) dm³ award 2 marks (not multiplying by 3) ALLOW use of inexact M_r (eg 232) – if it still gives 0.05 ALLOW amount of WO₃ x 3 correctly calculated for 2nd mark ALLOW amount of H₂ x 24.0 correctly calculated for 3rd mark ALLOW 1 mark for incorrect amount of WO₃ x 24.0 (not multiplied by 3 ie scores third mark only)
			Total	8	

Question			Answer	Marks	Guidance
2	(a)		A shared pair of electrons ✓	1	DO NOT ALLOW 'shared electrons'
	(b)	(i)	Pairs of (electrons surrounding a central atom) repel ✓ The shape is determined by the number of bond pairs AND the number of lone pairs (of electrons) ✓	2	ALLOW alternative phrases/words to repel eg 'push apart' ALLOW lone pairs repel OR bond(ing) pairs repel ALLOW 'the number of bonding pairs and number of lone pairs decides the orientation of the surrounding atoms' ALLOW 'how many' for 'number of' ALLOW the second mark for a response which has 2 of the following including at least one shape involving lone pairs (of electrons) BUT mark incorrect responses first 2 bonding pairs = linear 3 bonding pairs = trigonal planar 4 bonding pairs = tetrahedral 6 bonding pairs = hexagonal 3 bonding pairs and 1 lone pair = pyramidal 2 bonding pairs and 2 lone pairs = non-linear IGNORE 'number of electron pairs decides shape of molecule' as this is in the question
		(ii)	O–B–O = 120° ✓ B–O–H = 104.5° ✓	2	ALLOW 104–105°
	(c)		SF ₆ OR sulfur hexafluoride OR sulfur(VI) fluoride ✓	1	ALLOW XeF₄ DO NOT ALLOW SCl₆ DO NOT ALLOW stated complexes (simple molecule is asked for)
			Total	6	

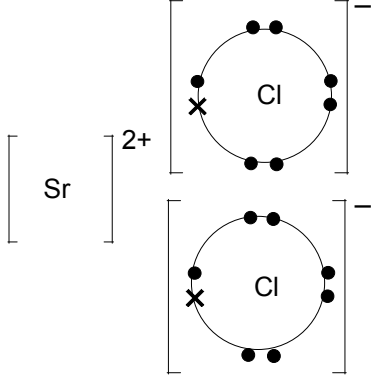
Question	Answer	Marks	Guidance
3 (a)	Energy (needed) to remove an electron ✓ from each atom in one mole ✓ of gaseous atoms ✓	3	ALLOW 'energy to remove one mole of electrons from one mole of gaseous atoms' for three marks IGNORE 'element' ALLOW 'energy needed to remove an electron from one mole of gaseous atoms to form one mole of gaseous 1+ ions' for two marks For third mark: ALLOW ECF if wrong particle is used in second marking point but is described as being gaseous eg 'molecule' instead of 'atom' IGNORE equations
(b) (i)	$O^+(g) \rightarrow O^{2+}(g) + e^-$ ✓	1	ALLOW $O^+(g) - e^- \rightarrow O^{2+}(g)$ ALLOW e for electron (ie charge omitted) IGNORE states on the electron
(ii)	 All eight ionisation energies showing an increase ✓ The biggest increase between the sixth and seventh ionisation energy AND 8th ionisation energy is higher than 7th ✓	2	IGNORE the 2p/2s true jump IGNORE line if seen IGNORE 0, if included by candidate IGNORE missing 1st IE point BUT DO NOT ALLOW first ionisation energy higher than second DO NOT ALLOW either mark if ionisations energies 3 to 8 inclusive are not shown Place tick for second mark on the x-axis between 6 and 7

Question	Answer	Marks	Guidance
3 (c)	<i>Nuclear charge mark</i> O has (one) less proton(s) OR O has smaller nuclear charge OR F has (one) more proton(s) OR F has greater nuclear charge ✓ <i>Atomic radius/shielding mark</i> (Outermost) electrons are in the same shell OR energy level OR (Outermost) electrons experience the same shielding OR Atomic radius of O is larger OR Atomic radius of F is smaller ✓ <i>Nuclear attraction mark</i> Less nuclear attraction (on outermost electrons) in O OR (outer) electrons are attracted less strongly (to the nucleus) in O OR More nuclear attraction (on outermost electrons) in F OR (outer) electrons are attracted more strongly (to the nucleus) in F ✓	3	Use annotations ie ticks crosses ECF ^ etc for this part Comparison should be used for each mark. Look for ORA from perspective of F throughout. ALLOW all three marks applied to 'as you go across the period' BUT assume the response refers to 'as you go across the period' if not stated ALLOW O has lower proton number BUT IGNORE O has lower atomic number IGNORE O has a smaller nucleus IGNORE 'O has a smaller charge' ie must be nuclear charge IGNORE 'O has smaller effective nuclear charge' ALLOW sub-shell for shell but IGNORE orbitals ALLOW shielding is similar ALLOW outermost electrons of O are further DO NOT ALLOW 'distance is the same' for second mark ALLOW 'less nuclear pull' for 'less nuclear attraction' DO NOT ALLOW 'less nuclear charge' instead of 'less nuclear attraction' for the third mark IGNORE 'not pulled as close' for 'pulled less strongly'

Question			Answer	Marks	Guidance
3	(d)		$1s^2 2s^2 2p^4$ AND $1s^2 2s^2 2p^6$ ✓ (In the reaction) oxygen has formed a negative ion (by gaining (two) electrons) ✓	2	ALLOW subscripts, capitals ALLOW oxidation number of oxygen has decreased ALLOW non metals form negative ions IGNORE oxygen has gained electrons (this is shown in the electron configurations)
	(e)	(i)	SO_3^{2-} ✓ ClO_2^- ✓	2	
		(ii)	$Al(NO_3)_3$ ✓	1	
		(iii)	Aluminium oxide OR aluminium hydroxide ✓ HNO_3 ✓	2	IGNORE correct formula (ie Al_2O_3 or $Al(OH)_3$) DO NOT ALLOW correct name with incorrect formula IGNORE correct name (ie nitric acid or nitric(V) acid) DO NOT ALLOW correct formula with incorrect name ALLOW one mark for Al_2O_3 or $Al(OH)_3$ AND nitric acid or nitric(V) acid (ie name answer and formulae answer has been transposed)
			Total	16	

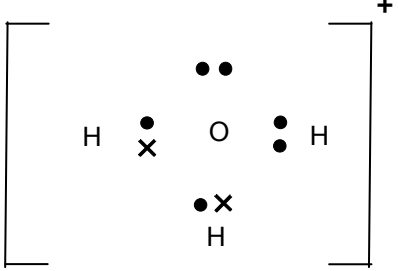
Question	Answer	Marks	Guidance
4 (a)	 Diagram showing a regular arrangement of labelled 'Ba²⁺ ions' or '2+ ions' and some attempt to show electrons ✓ Scattering of labelled electrons between other species AND statement anywhere of delocalised electrons (can be in text or in diagram) ✓ The attraction between (positive) ions and (delocalised) electrons is strong ✓	3	Regular arrangement must have at least two rows of correctly charged ions and a minimum of two ions per row ALLOW as label: positive ions, cations if correct charge is seen within circle ALLOW for labelled Ba²⁺ ions: circles with Ba²⁺ inside DO NOT ALLOW incorrect charge for ions eg + , 3+ etc DO NOT ALLOW for label of ions: nuclei OR positive atom OR protons ALLOW e⁻ or 'e' or – as symbol for electron within the lattice for first marking point if not labelled as 'electrons'. ALLOW mobile or 'sea of' for delocalised <i>Quality of written communication: 'electron(s)' spelled correctly and used in context for the third marking point</i> ALLOW a lot of energy is needed to break OR overcome the attraction between (positive) ions and (delocalised) electrons IGNORE 'heat' but ALLOW 'heat energy' DO NOT ALLOW references to incorrect particles or incorrect attractions eg 'intermolecular attraction' OR 'nuclear attraction' IGNORE 'strong metallic bonds' without seeing correct description of metallic bonding

Question			Answer	Marks	Guidance
4	(b)	(i)	$\text{Ba(s)} + 2\text{H}_2\text{O(l)} \rightarrow \text{Ba(OH)}_2\text{(aq)} + \text{H}_2\text{(g)}$ Ba(OH) ₂ as product ✓ Rest of equation + state symbols ✓	2	ALLOW multiples
		(ii)	Any value or the range $7 < \text{pH} \leq 14$ ✓	1	DO NOT ALLOW if pH 7 is in a quoted range
		(iii)	OH ⁻ OR HO ⁻ ✓	1	DO NOT ALLOW Ba ²⁺ DO NOT ALLOW any reference to electrons
	(c)		Magnesium hydroxide OR magnesium oxide ✓	1	ALLOW magnesium carbonate ALLOW correct formulae: Mg(OH) ₂ , MgO, MgCO ₃ IGNORE 'milk of magnesia'
	(d)	(i)	Effervescence OR fizzing OR bubbling OR gas produced AND Strontium carbonate OR solid dissolves OR disappears OR a colourless solution is formed ✓ $\text{SrCO}_3 + 2\text{HCl} \rightarrow \text{SrCl}_2 + \text{H}_2\text{O} + \text{CO}_2$ ✓	2	DO NOT ALLOW 'carbon dioxide produced' without 'gas' DO NOT ALLOW 'hydrogen gas produced' OR any other named gas ALLOW 'it' for strontium carbonate ALLOW strontium for strontium carbonate if SrCO ₃ seen in equation IGNORE 'reacts' IGNORE references to temperature change IGNORE 'steam produced' IGNORE state symbols

Question	Answer	Marks	Guidance
4 (d) (ii)	 Strontium ion with eight (or no) outermost electrons AND 2 x chloride (ions) with 'dot-and-cross' outermost octet ✓ correct charges ✓	2	For first mark, if eight electrons are shown in the cation then the 'extra' electron in the anion must match symbol chosen for electrons in the cation IGNORE inner shell electrons Circles not essential ALLOW One mark if both electron arrangement and charges are correct but only one Cl is drawn ALLOW 2[Cl⁻] 2[Cl]⁻ [Cl⁻]₂ (brackets not required) DO NOT ALLOW [Cl₂]⁻ [Cl₂]²⁻ [2Cl]²⁻ [Cl]₂⁻
(e) (i)	The mixture would turn orange ✓	1	ALLOW shades and colours containing (eg dark orange, yellow-orange) ALLOW the following: yellow, yellow-brown, brown, brown-red BUT DO NOT ALLOW red alone IGNORE initial colours DO NOT ALLOW any response that includes 'precipitate' OR solid
(ii)	Cl ₂ + 2Br ⁻ → Br ₂ + 2Cl ⁻ ✓	1	ALLOW multiples IGNORE state symbols

Question			Answer	Marks	Guidance
4	e	(iii)	<i>The electron GAIN mark</i> Chlorine will form a negative ion more easily than bromine OR Chlorine will gain an electron more easily than bromine ✓ <i>Atomic size mark</i> (An atom of) chlorine is smaller (than bromine) ✓ <i>Shielding mark</i> (Outermost shell of) chlorine is less shielded (than bromine) ✓ <i>Stronger nuclear attraction mark</i> Nuclear attraction (on the electron to be gained) by chlorine is greater (than bromine) OR the electron (to be gained) is attracted more strongly (to the nucleus) in chlorine ✓	4	Use annotations ie ticks crosses ECF ^ etc for this part Look for ORA from perspective of Br throughout. ALLOW all four marks applied to 'as you go up OR as you down the group' ALLOW Cl for chlorine AND Br for bromine ALLOW ORA DO NOT ALLOW the use of 'ide' BUT ALLOW use of 'ide' as an ECF ALLOW chlorine is better at electron capture ALLOW chlorine has greater electron affinity IGNORE chlorine is more electronegative IGNORE chlorine has more oxidising power than bromine IGNORE explanations given in terms of displacement ALLOW chlorine has fewer shells ALLOW the electron is added to the (outer) shell closer to the nucleus IGNORE 'easily' for 'greater' or for 'stronger' ALLOW 'chlorine has greater nuclear attraction (on its outermost electrons)' OR '(the outermost) electrons in chlorine are more attracted (to the nucleus)'
			Total	18	

Question	Answer	Marks	Guidance
5 (a)	<i>F₂ forces mark</i> F₂ has van der Waals' (forces) OR F₂ has induced dipole attractions OR interactions OR F₂ has temporary OR instantaneous dipole(–dipole) attraction OR interactions ✓ <i>HCl forces mark</i> HCl has permanent dipole(–dipole) attractions OR interactions ✓ <i>Comparison of strength of forces between molecules mark</i> intermolecular force in HCl is stronger than that in F₂ OR permanent dipoles are stronger (than induced dipoles) ✓ <i>Boiling point mark</i> more energy is required to break stronger (intermolecular) forces ✓	4	Use annotations ie ticks crosses ECF ^ etc for this part ALLOW vdWs for van der Waals' IGNORE F₂ has covalent bond for this mark IGNORE F₂ has 'intermolecular forces' <i>Quality of written communication: 'dipole(s)' spelled correctly and used in context for the second marking point</i> IGNORE HCl has 'intermolecular forces' IGNORE van der Waals' forces in HCl DO NOT ALLOW hydrogen bonding DO NOT ALLOW ionic bonding Look for strength of force comparison anywhere in the answer ALLOW ECF for hydrogen bonding in HCl being stronger than the stated intermolecular forces in F₂ BUT DO NOT ALLOW this mark if HCl or F₂ has covalent bonds broken OR if HCl has ionic bonds broken (the question asks for forces between molecules) IGNORE HCl has stronger van der Waals' (forces) than F₂ (as they both have the same number of electrons) DO NOT ALLOW fourth mark if covalent bonds are broken in HCl or F₂ OR if ionic bonds are broken in HCl IGNORE 'heat' but ALLOW 'heat energy'

Question	Answer	Marks	Guidance
5 (b) (i)	 Two <i>dot-and-cross</i> bonding pairs of electrons and one dative covalent bond pair of electrons consisting of either two dots or two crosses ✓ One non-bonding pair of electrons AND which match the dative covalent bond pair of electrons ✓	2	Must be '<i>dot-and-cross</i>' Must be H₃O for either mark Circles for shells not needed IGNORE inner shells IGNORE lack of positive charge and square brackets DO NOT ALLOW second marking point if negative charge is shown on the ion Non-bonding electrons do not have to be seen as a pair ALLOW second mark for one non-bonding pair of electrons and three <i>dot-and-cross</i> bonding pairs of electrons

Question	Answer	Marks	Guidance
5 (c) (i)	FIRST CHECK THE ANSWER ON ANSWER LINE IF answer = 7.624 OR 7.62 (g) award 3 marks Molar mass of borax = 381.2 (g mol⁻¹) ✓ Correctly calculates the mass of borax in 1000 cm³ = 0.0800 x 381.2 = 30.496 g OR 30.50 g OR 30.5g ✓ Correctly calculates the mass of borax in 250 cm³ = 30.496/4 = 7.624 g OR 7.62 g ✓ OR Molar mass of borax = 381.2 (g mol⁻¹) ✓ Amount of borax in 250 cm³ of solution = 0.0800 x 250 /1000 = 0.02(00) mol ✓ Mass of borax = 0.02(00) x 381.2 of borax = 7.624 g OR 7.62 g ✓	3	If there is an alternative answer, check to see if there is any ECF credit possible using working below ALLOW 381 DO NOT ALLOW 380 ALLOW 0.0800 x [molar mass of borax] correctly calculated for 2nd mark (ie mass of borax in 1000 cm³) ALLOW [mass of borax in 1000 cm³] / 4 correctly calculated for 3rd mark ALLOW calculator value or rounding to three significant figures or more IGNORE (if seen) a second rounding error ALLOW 381 DO NOT ALLOW 380 ALLOW [incorrect amount of borax] x 381.2 OR [incorrect amount of borax] x [incorrect molar mass of borax] OR 0.02(00) x [incorrect molar mass of borax] correctly calculated for this mark ALLOW calculator value or rounding to three significant figures or more IGNORE (if seen) a second rounding error

Question			Answer	Marks	Guidance
5	(d)	(i)	Correctly calculates the amount of borax used = $0.0800 \times 22.5/1000$ = $1.8(0) \times 10^{-3}$ mol OR $0.0018(0)$ mol ✓	1	
		(ii)	Correctly calculates the amount of HCl used = $1.8(0) \times 10^{-3} \times 2$ mol = $3.6(0) \times 10^{-3}$ mol OR $0.0036(0)$ mol ✓	1	ALLOW [incorrect amount of borax] x 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
		(iii)	Correctly calculates the concentration of HCl = $3.6(0) \times 10^{-3} / (25 / 1000) = 0.144$ (mol dm ⁻³) ✓	1	ALLOW [incorrect amount of HCl] / (25/1000) correctly calculated for the 3rd mark given to 3 SF
			Total	12	

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