OCR
RECOGNISING ACHIEVEMENT

GCE

Chemistry A

Advanced Subsidiary GCE

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

Mark Scheme for January 2013

Oxford Cambridge and RSA Examinations

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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

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)

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td>(i)</td><td>Atom(s) of an element

AND

with different numbers of neutrons (and with different masses) ✓</td><td>1</td><td>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)</td></tr>
<tr><td></td><td></td><td>(ii)</td><td><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></td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>(iii)</td><td>^{12}C OR C-12 OR carbon 12 OR carbon-12 ✓</td><td>1</td><td>IGNORE 1/12th AND amu</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td>(Oxidised):
H (oxidation number has increased) from H = 0 to H = +1 ✓

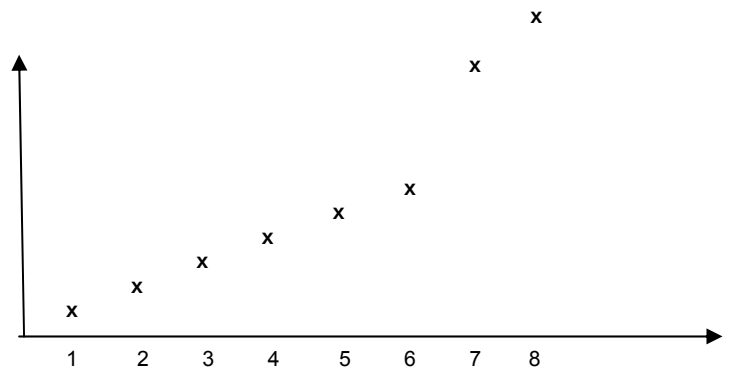
(Reduced):
W (oxidation number has decreased) from W = +6 to W = 0 ✓</td><td>2</td><td>ALLOW 6+ OR 6 OR 1+ OR 1
ALLOW one mark for correct oxidation number changes H = 0 to H = +1 AND W = +6 to W = 0
ALLOW oxidation states written above the equation if not seen in the text BUT IGNORE oxidation states 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 WO_3 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</td></tr>
</table>

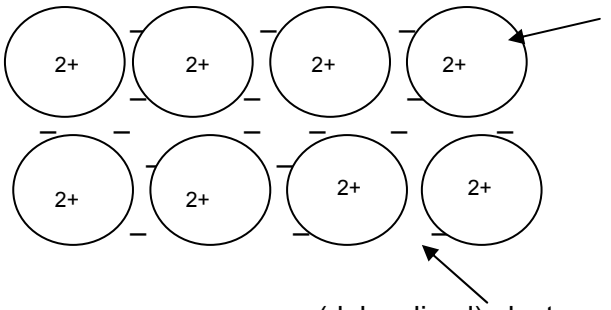
Question			Answer	Marks	Guidance
1	(b)	(ii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **IF answer = 3.6(0) (dm^3) award 3 marks**	3	**If there is an alternative answer, check to see if there is any ECF credit possible using working below** **ALLOW** calculator value or rounding to 2 significant figures 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)** dm^3 award 2 marks (not multiplying by 3)
			Amount of WO_3 = (11.59 / 231.8 =) 0.05(00) (mol) ✓		**ALLOW** use of inexact M_r (eg 232) – if it still gives 0.05
			Amount of H_2 = 0.0500 x 3 = 0.15(0) (mol) ✓		**ALLOW** amount of WO_3 x 3 correctly calculated for 2nd mark
			Volume of H_2 = 0.150 x 24.0 = 3.6(0) (dm^3) ✓		**ALLOW** amount of H_2 x 24.0 correctly calculated for 3rd mark **ALLOW** 1 mark for **incorrect** amount of WO_3 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** XeF_4 **DO NOT ALLOW** SCl_6 **DO NOT ALLOW** stated complexes (simple molecule is asked for)
			Total	**6**	

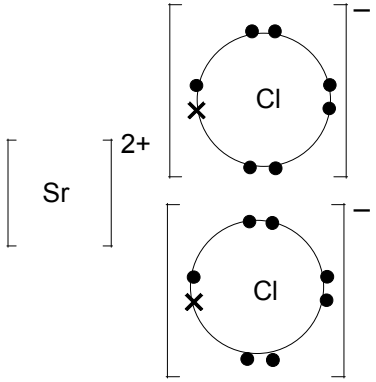
Question			Answer	Marks	Guidance
3	(a)		Energy (needed) to remove an electron ✓ from **each atom** in **one mole** ✓ of **gaseous atoms** ✓	3	**ALLOW** 'energy to remove one mole of electrons from one mole of gaseous atoms' for three marks **IGNORE** 'element' **ALLOW** 'energy needed to remove an electron 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)			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
			Nuclear charge mark 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 ✓		**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'
			Atomic radius/shielding mark (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 ✓		**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
			Nuclear attraction mark 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 ✓		**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**	

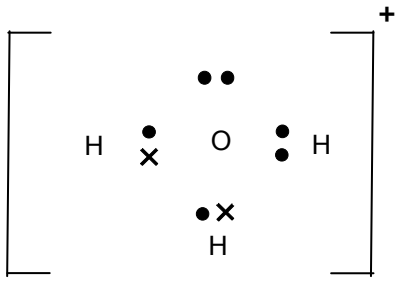
Question			Answer	Marks	Guidance
4	(a)		 Diagram showing a regular arrangement of **labelled** '**Ba^{2+} ions**' or '**2+ ions**' and some attempt to show electrons ✓ Scattering of labelled electrons between other species **AND** statement anywhere of **delocalised** electrons (can be in text or in 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 Ba^{2+} ions: circles with **Ba^{2+}** 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 *Quality of written communication:* 'electron(s)' spelled correctly and used in context for the **third** marking point **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)	$Ba(s) + 2H_2O(l) \rightarrow Ba(OH)_2(aq) + H_2(g)$ $Ba(OH)_2$ as product ✓ Rest of equation + state symbols ✓	2	**ALLOW** multiples
		(ii)	Any value or the range $7 < pH \leq 14$ ✓	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 ✓ $SrCO_3 + 2HCl \rightarrow SrCl_2 + H_2O + CO_2$ ✓	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** $[Cl_2]^-$ $[Cl_2]^{2-}$ $[2Cl]^{2-}$ $[Cl]_2^-$
	(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)	$Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ ✓	1	**ALLOW** multiples **IGNORE** state symbols

Question			Answer	Marks	Guidance
4	e	(iii)	*The electron* GAIN *mark* Chlorine will form a negative ion more easily than bromine **OR** Chlorine will gain an electron more easily than bromine ✓	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** C*l* 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
			Atomic size mark (An atom of) chlorine is smaller (than bromine) ✓		**ALLOW** chlorine has fewer shells **ALLOW** the electron is added to the (outer) shell closer to the nucleus
			Shielding mark (Outermost shell of) chlorine is less shielded (than bromine) ✓		
			Stronger nuclear attraction mark 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 ✓		**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)		*F_2 forces mark* F_2 has van der Waals' (forces) **OR** F_2 has induced dipole attractions **OR** interactions **OR** F_2 has temporary **OR** instantaneous dipole(–dipole) attraction **OR** interactions ✓ *HCl forces mark* HCl has **permanent** dipole(–dipole) attractions **OR** interactions ✓ *Comparison of strength of forces between molecules mark* intermolecular force in HCl is stronger than that in F_2 **OR** permanent dipoles are stronger (than induced dipoles) ✓ *Boiling point mark* 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** F_2 has covalent bond for this mark **IGNORE** F_2 has 'intermolecular forces' *Quality of written communication:* 'dipole(s)' spelled correctly and used in context for the **second** marking point **IGNORE** HCl has 'intermolecular forces' **IGNORE** van der Waals' forces in HC*l* **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 F_2 BUT **DO NOT ALLOW** this mark if HCl or F_2 has covalent bonds broken **OR** if HCl has ionic bonds broken (the question asks for forces between molecules) **IGNORE** HC*l* has stronger van der Waals' (forces) than F_2 (as they both have the same number of electrons) **DO NOT ALLOW** fourth mark if covalent bonds are broken in HC*l* or F_2 **OR** if ionic bonds are broken in HCl **IGNORE** 'heat' but **ALLOW** 'heat energy'

Question			Answer	Marks	Guidance
5	(b)	(i)	 Two *dot-and-cross* 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 '*dot-and-cross*' Must be H_3O 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 *dot-and-cross* 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 cm^3 = 0.0800 x 381.2 = 30.496 g **OR** 30.50 g **OR** 30.5g ✓ Correctly calculates the mass of borax in 250 cm^3 = 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 cm^3 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 cm^3) **ALLOW** [mass of borax in 1000 cm^3] / 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 x 22.5/1000 = 1.8(0) x 10^{-3} mol **OR** 0.0018(0) mol ✓	1	
		(ii)	Correctly calculates the amount of HC*l* used = 1.8(0) x 10^{-3} x 2 mol = 3.6(0) x 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 HC*l* = 3.6(0) x 10^{-3} / (25 / 1000) = 0.144 (mol dm^{-3}) ✓	1	**ALLOW** [incorrect amount of HC*l*] / (25/1000) correctly calculated for the 3rd mark given to 3 SF
			Total	**12**	

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