

Chemistry A

Advanced Subsidiary GCE

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

Mark Scheme for January 2011

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Question		Answer	Mark	Guidance
1	(a)	Rb-87 has (two) more neutrons ✓	1	<p>ALLOW Different numbers of neutrons</p> <p>ALLOW 2 neutrons</p> <p>ALLOW Rb-85 has 48 neutrons AND Rb-87 has 50 neutrons</p> <p>IGNORE correct references to protons and electrons</p> <p>DO NOT ALLOW incorrect references to protons and electrons</p>
	(b)	<p>The (weighted) mean mass of an atom (of an element) OR The (weighted) average mass of an atom (of an element) ✓</p> <p>compared with 1/12th (the mass) ✓</p> <p>of (one atom of) carbon-12 ✓</p>	3	<p>ALLOW average atomic mass DO NOT ALLOW mean mass of an element ALLOW mean mass of isotopes OR average mass of isotopes DO NOT ALLOW the singular; 'isotope'</p> <p>For second AND third marking points ALLOW compared with (the mass of) carbon-12 which is 12</p> <p>ALLOW mass of one mole of atoms ✓ compared to 1/12th ✓ (mass of) one mole OR 12 g of carbon-12 ✓</p> <p>ALLOW $\frac{\text{mass of one mole of atoms}}{1/12\text{th mass of one mole OR }12\text{g of carbon-12}}$.</p>
	(c)	$\frac{(85.00 \times 72.15) + (87.00 \times 27.85)}{100} =$ <p>OR 61.3275 + 24.2295</p> <p>OR 85.557 ✓</p> <p>$A_r = 85.56$ (to 2 decimal places) ✓</p>	2	<p>ALLOW two marks for correct answer $A_r = 85.56$ (with no working)</p> <p>ALLOW one mark for ECF from seen incorrect sum provided final answer is between 85 and 87 and is to 2 decimal places, e.g. 85.567 gives ECF of 85.57 for one mark</p>

Question		Answer	Mark	Guidance
1	(d)	Spherical OR sphere ✓	1	DO NOT ALLOW 'circular' IGNORE unlabelled 2-D diagrams
	(e) (i)	$\text{Sr}^+(\text{g}) \rightarrow \text{Sr}^{2+}(\text{g}) + \text{e}^-$ ✓	1	ALLOW e for electrons ALLOW $\text{Sr}^+(\text{g}) - \text{e}^- \rightarrow \text{Sr}^{2+}(\text{g})$ DO NOT ALLOW $\text{Sr}^+(\text{g}) + \text{e}^- \rightarrow \text{Sr}^{2+}(\text{g}) + 2\text{e}^-$ IGNORE state symbols for electrons
	(e) (ii)	<p>Sr has one more proton OR greater nuclear charge ✓</p> <p>(Outermost) electrons are in the same shell OR (outermost) electrons experience same shielding OR Atomic radius of Sr is smaller ✓</p> <p>Sr has greater nuclear attraction (on outer electrons / outer shell/s) OR the (outer) electrons are attracted more strongly (to the nucleus) ✓</p>	3	<p>Use annotations with ticks, crosses ECF etc. for this part</p> <p>Comparison should be used for each mark</p> <p>ALLOW Sr has more protons ALLOW 'across the period' for 'Sr' IGNORE 'atomic number increases', but ALLOW 'proton number' increases IGNORE 'nucleus gets bigger' 'Charge increases' is insufficient ALLOW 'effective nuclear charge increases' OR 'shielded nuclear charge increases' <i>Quality of Written Communication – Nuclear OR proton(s) OR nucleus spelled correctly ONCE for the first marking point</i></p> <p>ALLOW shielding is similar ALLOW screening for shielding IGNORE sub-shells DO NOT ALLOW 'distance is similar'</p> <p>ALLOW 'greater nuclear pull' for 'greater nuclear attraction' DO NOT ALLOW 'nuclear charge' for nuclear attraction ORA throughout</p>

Question			Answer	Mark	Guidance
1	(e)	(iii)	<p>2nd IE of Rb involves removing electron from shell closer to nucleus ✓</p> <p>Stronger nuclear attraction on (outermost electron) of Rb OR (outermost electron) of Rb experiences less shielding ✓</p>	2	<p>IGNORE new shell</p> <p>ALLOW There is one shell fewer in Rb⁽⁺⁾ (than Sr⁽⁺⁾) ALLOW Rb⁽⁺⁾ has a smaller radius (than Sr⁽⁺⁾) ALLOW Rb⁽⁺⁾ loses an electron from the 4th shell AND Sr⁽⁺⁾ loses an electron from the 5th shell.</p> <p>ALLOW responses which do not specifically say 'nuclear' attraction (e.g. Rb has greater attraction) as long as nucleus is seen in first point A comparison of Rb to Sr must be used, e.g. 'Because of shielding' is not enough</p> <p>ORA</p>
			Total	13	

Question		Answer	Mark	Guidance
2	(a) (i)	mol of H _x A = $\frac{25.00 \times 0.0500}{1000} = 1.25 \times 10^{-3}$ OR 0.00125 mol ✓	1	ALLOW 0.0013 OR 1.3×10^{-3} ALLOW correct answer only without working
	(ii)	mol of NaOH = $\frac{12.50 \times 0.200}{1000} = 2.5(0) \times 10^{-3}$ OR 0.0025(0) mol ✓	1	ALLOW correct answer without working
	(iii)	Answer 2a(ii) rounded to nearest whole number ✓ Answer 2a(i) If 2a(i) and 2a(ii) are correct this will be $x = \frac{2.50 \times 10^{-3} \text{ mol}}{1.25 \times 10^{-3} \text{ mol}} = 2$ OR H ₂ A	1	ALLOW answer without working if answers to 2a(i) AND 2a(ii) are seen DO NOT ALLOW responses without seeing answers in 2a(i) AND 2a(ii)
	(b) (i)	HNO ₃ ✓ CuO + 2HNO ₃ → Cu(NO ₃) ₂ + H ₂ O ✓	2	IGNORE state symbols ALLOW correct multiples
	(ii)	(Electrostatic) attraction between oppositely charged ions ✓	1	Attraction is essential IGNORE references to metal and non-metal
	(iii)	Ions are mobile OR ions can move ✓	1	IGNORE 'free ions' IGNORE 'delocalised ions' IGNORE ions can move when molten IGNORE charge carriers DO NOT ALLOW Any mention of electrons moving ALLOW ions move when in a liquid IGNORE responses which give liquid ions
	(iv)	(+) 5 ✓	1	ALLOW V

Question		Answer	Mark	Guidance
2	(c)	$\text{Cu}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ ✓	1	ALLOW $\text{Cu}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ ALLOW $\text{Cu}(\text{NO}_3)_2(\text{H}_2\text{O})_6$ ALLOW $\text{Cu}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ DO NOT ALLOW $\text{CuN}_2\text{O}_6 \cdot 6\text{H}_2\text{O}$
Total			9	

Question	Answer	Mark	Guidance
3 (a)	The ability of an atom to attract electrons ✓ in a covalent bond ✓	2	ALLOW 'attraction of an atom for electrons' ALLOW 'pull' for 'attract' DO NOT ALLOW 'element' for 'atom' ALLOW 'shared pair' or 'bond(ing) pair' for 'covalent bond'
(b)	$\delta^+N-F\delta^-$ AND $\delta^-N-Br\delta^+$ ✓	1	ALLOW d+ / d- DO NOT ALLOW + / -
(c) (i)	octahedral OR octahedron ✓	1	
	<p>(ii)</p>  <p>Diagram of BF_3 showing three 'dot-and-cross' bonds between B and F and all F atoms with complete octet of electrons ✓</p> <p>Diagram of NH_3 showing three 'dot-and-cross' bonds between N and H and N atom has a lone pair ✓</p> <p>Marking points 3, 4 and 5 may be awarded independently</p> <p>electron pairs repel ✓</p> <p>NH_3 has one lone pair and three bonding pairs of electrons AND lone pair of electrons repels more than bonding pairs ✓</p> <p>BF_3 has three (bonding) pairs of electrons (which repel equally) ✓</p>	5	<p>Use annotations with ticks, crosses ECF etc. for this part</p> <p>ALLOW diagrams without circles Must be 'dot-and-cross'</p> <p>IGNORE 'electrons repel' DO NOT ALLOW 'atoms repel' ALLOW 'bonds repel'</p> <p>ALLOW 'bonds' for 'bonding pairs' ALLOW 'four pairs' in place of 'one lone pair and three bonding pairs'</p> <p>The third marking point can be gained from statements seen in fourth or fifth marking points</p>

Question			Answer	Mark	Guidance
3	(c)	(iii)	BF ₃ is symmetrical ✓ The dipoles cancel out ✓	2	IGNORE 'polar bonds cancel' IGNORE 'charges cancel'
			Total	11	

Question		Answer	Mark	Guidance
4	(a)	Used to neutralise acidic soils ✓ Excess will result in soils becoming too alkaline (to sustain crop growth) ✓	2	ALLOW raises the pH of the soil IGNORE references to fertilisers ALLOW pH becomes too high IGNORE 'harmful' IGNORE 'corrosive'
	(b) (i)	$0.00131 \times 40.1 = 0.0525 \text{ g}$ OR 5.25×10^{-2} ✓	1	ALLOW 0.053 OR 0.05253 OR 0.052531 g IGNORE 0.05 if correct answer seen in working DO NOT ALLOW 0.052 OR 0.0524
	(ii)	$0.00131 \times 24.0 = 0.0314 \text{ dm}^3$ OR 3.14×10^{-2} ✓	1	ALLOW 0.031 OR 0.03144 dm^3 IGNORE 0.03 if correct answer seen in working DO NOT ALLOW 31.4
	(iii)	Mol of OH^- ions = $0.00131 \times 2 = 0.00262$ OR 2.62×10^{-3} ✓ Mol of OH^- ions in $1 \text{ dm}^3 = 0.00262 \times \frac{1000}{250} = 0.0105 \text{ mol dm}^{-3}$ ✓	2	ALLOW 0.0026 ALLOW 0.01048 OR 0.01(0) ALLOW ECF from incorrect mol of OH^- DO NOT ALLOW 2nd mark as ECF if 0.0525 is used as no of mol of OH^- ions DO NOT ALLOW 2nd mark as ECF if 0.0314 is used as no of mol of OH^- ions 0.00524 mol dm^{-3} is a likely ECF as a result of not multiplying 0.00131 by 2, but 0.00131 must be seen in working
	(c) (i)	Fewer moles of Ba (in 0.0525 g) OR Fewer atoms of Ba (in 0.0525) ✓	1	ORA Assume candidate is referring to Ba if not stated IGNORE $A_r \text{ Ba} > A_r \text{ Ca}$
	(ii)	Idea of Ba having a quicker rate OR more vigorous reaction ✓	1	ALLOW more exothermic OR gets hotter OR fizzes more Assume candidate is referring to Ba if not stated Comparison is essential IGNORE 'Ba more reactive' ORA
Total			8	

Question			Answer	Mark	Guidance
5	(a)	(i)	<p>Creating the dipole mark uneven distribution of electrons ✓</p> <p>Type of dipole mark creates an instantaneous dipole OR temporary dipole ✓</p> <p>Induction of a second dipole mark causes induced dipole(s) in neighbouring molecules ✓</p>	3	<p>Use annotations with ticks, crosses ECF etc. for this part ALLOW movement of electrons ALLOW changing electron density</p> <p>ALLOW 'transient', 'oscillating', 'momentary', 'changing'</p> <p>ALLOW 'induces a dipole in neighbouring molecules' ALLOW 'causes a resultant dipole in neighbouring molecules' ALLOW 'atoms' for 'molecules'</p>
		(ii)	<p>boiling points increase down the group ✓</p> <p>greater number of electrons OR stronger intermolecular forces OR stronger van der Waals' forces ✓</p> <p>more energy needed to break intermolecular OR van der Waals' forces ✓</p>	3	<p>Use annotations with ticks, crosses ECF etc. for this part ALLOW Bpt of iodine is highest OR Bpt of chlorine is lowest ALLOW Cl for chlorine etc. For 'down the group' ALLOW 'as molecules get bigger'</p> <p>ALLOW number of electron shells increases IGNORE 'more shells' (if no reference to electrons) ALLOW 'more' for 'stronger' ALLOW iodine has most electrons ALLOW chlorine has fewest electrons</p> <p>DO NOT ALLOW any implication that the attraction is between atoms not molecules for third mark</p>
	(b)		Same number of outer(most) electrons OR same outer(most) electron structure ✓	1	<p>ALLOW same number of electrons in outer shell ALLOW It has seven outer electrons IGNORE same group DO NOT ALLOW 'same number of electrons'</p>

Question	Answer	Mark	Guidance
5 (c) (i)	<p>Colours: (Add Br₂ to NaCl,) (Cyclohexane layer) turns orange OR yellow ✓</p> <p>(Add Br₂ to NaI,) (Cyclohexane layer) turns purple OR lilac OR violet OR pink OR mauve ✓</p> <p>Equation: Br₂ + 2I⁻ → I₂ + 2Br⁻ ✓</p> <p>Reactivity: Reactivity decreases down the group OR Oxidising power decreases down the group ✓</p> <p>Explanations: Chlorine will gain electron easiest OR form negative ion easiest ✓</p> <p>Because chlorine (atom) is smallest OR Outer(most) shell of chlorine least shielded OR Nuclear attraction on electrons of chlorine is greatest ✓</p>	6	<p>Use annotations with ticks, crosses ECF etc. for this part</p> <p>ALLOW any combination of these but no others</p> <p>ALLOW any combination of these but no others</p> <p>DO NOT ALLOW 'precipitate' with either colour</p> <p>DO NOT ALLOW equation mark if incorrect equation(s) also seen</p> <p>IGNORE Br₂ + 2Cl⁻ → Br₂ + 2Cl⁻</p> <p>IGNORE correct non-ionic version of equation</p> <p>IGNORE state symbols</p> <p>ALLOW Chlorine is the most reactive</p> <p>ALLOW Cl for chlorine etc.</p> <p>ALLOW Iodine is the least reactive</p> <p>ALLOW chlorine is best at electron capture</p> <p>ALLOW chlorine has 'greatest' electron affinity</p> <p>IGNORE chlorine is most electronegative</p> <p>DO NOT ALLOW explanations in terms of displacement</p> <p><i>Quality of Written Communication – Electron(s) OR negative spelled correctly at least ONCE for marking point 5</i></p> <p>ALLOW Chlorine atom has fewest shells</p> <p>ALLOW outer(most) shell closest to the nucleus</p> <p>ALLOW Chlorine atom has lowest shielding</p> <p>ORA for marking points 4, 5 and 6</p>

Question			Answer	Mark	Guidance
5	(c)	(ii)	Bromine is toxic ✓	1	ALLOW cyclohexane is toxic ALLOW bromine irritates the lungs DO NOT ALLOW Cl ₂ is toxic IGNORE 'strong smelling' IGNORE 'halogens' are toxic
	(d)	(i)	2F ₂ + 2H ₂ O → 4HF + O ₂ ✓	1	ALLOW correct multiples, including use of ½ O ₂ ALLOW 4FH IGNORE state symbols
		(ii)	Oxygen has been oxidised as (oxidation number has increased from) O = -2 to O = 0 ✓ Fluorine has been reduced as (oxidation number has decreased from) F = 0 to F = -1 ✓	2	IGNORE references to oxygen in any incorrect products DO NOT ALLOW O ₂ = -2 → O = 0 but ALLOW F ₂ = 0 → F = -1 ALLOW 'F is reduced from 0 to -1' regardless of product (or no product) in 5d(i) except ALLOW ECF for F = -2 if H ₂ F is seen ALLOW one mark for O = -2 and O ₂ = 0 AND F ₂ = 0 and F = -1 if no reference OR incorrect reference to oxidation / reduction is seen Look at equation in 5d(i) for oxidation numbers if not seen in 5d(ii) IGNORE reference to electron loss / gain if correct DO NOT ALLOW incorrect reference to electron loss / gain
	(e)	(i)	(1s ²) 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ¹⁰ 4s ² 4p ¹ ✓	1	IGNORE 1s ² twice ALLOW 4s ² before 3d ¹⁰ ALLOW '3D'
		(ii)	GaF ₃ ✓	1	
Total				19	

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