

Question			er	Marks	Guidance
1	(a)	(The H ⁺ OR hydrogen ions OR protons in (sulfuric) acid have been replaced by ammonium ions OR NH ₄ ⁺ ✓	1	ALLOW 'a positive ion' for 'ammonium ions' BUT IGNORE 'a positive metal ion' OR 'metal ions' for 'ammonium ions' IGNORE references to being produced by the reaction of an acid and a base DO NOT ALLOW hydrogen atoms OR ammonia ions DO NOT ALLOW 'H for H ⁺ OR NH ₄ for NH ₄ ⁺
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE IF answer = 0.104 (mol) award 3 marks Amount of H ₂ SO ₄ = 0.100 × 32.5/1000 = 3.25 × 10 ⁻³ OR 0.00325 mol ✓ Amount of NH ₃ = (mol of H ₂ SO ₄) × 2 = 6.50 × 10 ⁻³ OR 0.0065 mol ✓ No. of mol of NH ₃ = (mol of NH ₃) × 400 / 25.0 = 0.104 (mol) ✓	3	If there is an alternative answer, check to see if there is any ECF credit possible using working below ALLOW ECF for amount of H ₂ SO ₄ × 2 ALLOW ECF for amount of NH ₃ × 400 / 25.0 ALLOW concentration approach for marking point 3 Conc ammonia = 6.50 × 10 ⁻³ × 1000 / 25.0 = 0.260 mol dm ⁻³ mol of NH ₃ = (conc of NH ₃) × 400 / 1000 = 0.104 (mol) ALLOW calculator value or rounding to 2 sig figs or more BUT IGNORE 'trailing' zeroes, eg 0.200 allowed as 0.2
	(b)		Predicted bond angle 107° ✓ <i>Explanation</i> There are 3 bonded pairs and 1 lone pair ✓ Electron pairs repel ✓ Lone pairs repel more than bonded pairs ✓	4	ALLOW range 106–108° ALLOW a response which is equivalent to 3 bp and 1 lp, eg 'There are four pairs of electrons. One is a lone pair' ALLOW 'bonds' for 'bonded pairs' ALLOW diagram showing N atom with 3 dot-and-cross bonds and 1 lone pair clearly drawn onto it for second mark IGNORE stick versions of bonding DO NOT ALLOW 'atoms repel' for 'electron pairs repel' IGNORE 'electrons repel' ALLOW 'bonds repel'

Question		er	Marks	Guidance
1	(c)	(1	Correct charge must be seen ALLOW OH ⁻ if seen as the ONLY negative product of an equation
		(ii)	1	ALLOW H ₂ N-NH ₃ ⁺ OR H ₃ N-NH ₃ ²⁺
	(d)	(3	<p>ALLOW 1(+), 1-. Only look for oxidation numbers seen above or below equation if not seen in text IGNORE Cl⁻ Cl⁺ DO NOT ALLOW If a second species is seen going down in oxidation number with the exception of N going from -3 to -4</p> <p>ALLOW 3 -, 2 -. Only look for oxidation numbers seen above or below equation if not seen in text IGNORE N³⁻ N²⁻ DO NOT ALLOW If a second species is seen going up in oxidation number</p> <p>ALLOW ECF for oxidation of any species showing an increase in oxidation number AND for reduction of any species showing a decrease in oxidation number</p> <p>IGNORE references to electron loss OR gain ALLOW 3 marks for labelled equation such as below</p> $2\text{NH}_3 + \text{NaClO} \rightarrow \text{N}_2\text{H}_4 + \text{NaCl} + \text{H}_2\text{O}$
		(ii)	1	ALLOW sodium chlorate(I) ✓ ALLOW sodium hypochlorite IGNORE bleach DO NOT ALLOW sodium chlorate (with no Roman numeral)
		(iii)	2	One mark for N ₂ One mark for NH ₄ Cl AND balancing
			Total	16

Question		Answer	Mark	Guidance
2	(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</p> <p>DO NOT ALLOW mean mass of an element</p> <p>ALLOW mean mass of isotopes OR average mass of isotopes</p> <p>DO NOT ALLOW the singular; 'isotope'</p> <p>For second AND third marking points</p> <p>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 _____ mass of one mole of atoms _____. 1/12th mass of one mole OR 12g 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		er	Mark	Guidance
2	(d)		1	DO NOT ALLOW 'circular' IGNORE unlabelled 2-D diagrams
	(e)	(i)	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)	3	Use annotations with ticks, crosses ECF etc. for this part Comparison should be used for each mark 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> ALLOW shielding is similar ALLOW screening for shielding IGNORE sub-shells DO NOT ALLOW 'distance is similar' ALLOW 'greater nuclear pull' for 'greater nuclear attraction' DO NOT ALLOW 'nuclear charge' for nuclear attraction ORA throughout

Question			er	Mark	Guidance
2	(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
3	(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)	<u>Answer 2a(ii)</u> 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
3	(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
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		Expected Answers	Marks	Additional Guidance
5	(a)	<p>Mass of the isotope compared to 1/12th OR mass of the atom compared to 1/12th ✓ (the mass of a) carbon-12 OR ^{12}C (atom) ✓</p>	2	<p>IGNORE Reference to average OR weighted mean (i.e. correct definition of relative atomic mass will score both marks)</p> <p>ALLOW mass of a mole of the isotope/atom with 1/12th the mass of a mole OR 12 g of carbon-12 for two marks.</p> <p>ALLOW 2 marks for: ‘Mass of the isotope OR mass of the atom compared to ^{12}C atom given a mass of 12.0’ i.e. ‘given a mass of 12’ OR C12 is 12 communicates the same idea as 1/12th.’</p> <p>ALLOW 12C OR C12</p> <p>ALLOW 2 marks for: $\frac{\text{mass of the isotope}}{\text{mass of 1/12th mass of carbon - 12}}$ i.e. fraction is equivalent to ‘compared to’</p> <p>ALLOW 1 mark for a mix of mass of atom and mass of mole of atoms, i.e. ‘mass of the isotope/mass of an atom compared with 1/12th the mass of a mole OR 12 g of carbon-12.’</p> <p>DO NOT ALLOW mass of ‘ions’ OR mass of element</p>
	(b)	<p>$\frac{(151 \times 47.77) + (153 \times 52.23)}{100}$ OR $72.1327 + 79.9119$ OR 152.0446 (calculator value) ✓ $A_r = 152.04$ ✓</p>	2	<p>ALLOW Correct answer for two marks</p> <p>ALLOW One mark for ECF from transcription error in first sum provided final answer is to 2 decimal points and is to between 151 and 153 and is a correct calculation of the transcription</p>

Question		Expected Answers	Marks	Additional Guidance
	(c) (i)	^{153}Eu has (2) more neutrons OR ^{153}Eu has 90 neutrons AND ^{151}Eu has 88 neutrons ✓	1	ALLOW There are a different number of neutrons IGNORE Correct references to protons / electrons DO NOT ALLOW Incorrect references to protons / electrons
	(ii)	(It has the) same number of protons AND electrons OR Both have 63 protons and 63 electrons ✓	1	ALLOW Same number of protons AND same electron configuration DO NOT ALLOW 'Same number of protons' without reference to electrons (and vice versa)

Question	Expected Answers	Marks	Additional Guidance
(d)	<p>Xe has a bigger atomic radius OR Xe has more shells ✓</p> <p>Xe has more shielding ✓</p> <p>The nuclear attraction decreases OR Outermost electrons of Xe experience less attraction (to nucleus) OR Increased shielding / distance outweighs the increased nuclear charge ✓ ORA throughout</p>	3	<p>ALLOW Xe has more energy levels ALLOW Xe has electrons in higher energy level ALLOW Xe has electrons further from nucleus IGNORE Xe has more orbitals OR more sub-shells DO NOT ALLOW 'different shell' or 'new shell'</p> <p>ALLOW More screening There must be a clear comparison ie more shielding OR increased shielding. i.e. DO NOT ALLOW Xe 'has shielding' ALLOW Xe has more electron repulsion from inner shells</p> <p>ALLOW Xe has less nuclear pull IGNORE Xe has less effective nuclear charge DO NOT ALLOW nuclear charge for nuclear attraction</p>
Total		9	

Question			Expected Answers	Marks	Additional Guidance
6	(a)	(i)	The H ⁺ ion in an (nitric) acid has been replaced by a metal ion OR by a Ca ²⁺ ion ✓	1	DO NOT ALLOW it has been produced by the reaction of an acid and a base as this is stated in the question. IGNORE references to replacement by NH ₄ ⁺ ions or positive ions. ALLOW H OR Hydrogen for H ⁺ ; DO NOT ALLOW Hydrogen atoms ALLOW Ca OR Calcium for Ca ²⁺ . DO NOT ALLOW Calcium atoms ALLOW 'metal' for 'metal ion'
		(ii)	2HNO ₃ (aq) + Ca(OH) ₂ (aq) → Ca(NO ₃) ₂ (aq) + 2H ₂ O(l) Formulae ✓ Balance AND states ✓	2	ALLOW multiples ALLOW (aq) OR (s) for Ca(OH) ₂
		(iii)	Accepts a proton OR accepts H ⁺ ✓	1	ALLOW H ⁺ + OH ⁻ → H ₂ O ALLOW OH ⁻ reacts with H ⁺ OR OH ⁻ takes H ⁺ ALLOW OH ⁻ 'attracts' H ⁺ if 'to form water' is seen DO NOT ALLOW OH ⁻ neutralises H ⁺ ('neutralises' is in the question)
	(b)	(i)	Calculates correctly $\frac{0.0880 \times 25.0}{1000} = 2.20 \times 10^{-3}$ mol OR 0.00220 mol ✓	1	ALLOW 0.0022 OR 2.2×10^{-3} mol
		(ii)	Calculates correctly $\frac{0.00220}{2} = 1.10 \times 10^{-3}$ mol OR 0.00110 mol ✓	1	ALLOW 0.0011 OR 1.1×10^{-3} mol ALLOW ECF for answer (i)/2 as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes
		(iii)	$\frac{0.00110 \times 1000}{17.60} = 0.0625$ mol dm ⁻³ OR 6.25×10^{-2} mol dm ⁻³ ✓	1	ALLOW 0.063 OR 6.3×10^{-2} mol dm ⁻³ ALLOW ECF for answer (ii) × 1000/17.60 OR ECF from (i) for answer (i)/2 × 1000/17.60 as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes

	(c)	(i)	(The number of) Water(s) of crystallisation ✓	1	IGNORE hydrated OR hydrous
		(ii)	142.1 ✓ $x = \frac{(322.1 - 142.1)}{18.0} = 10 \checkmark$	2	ALLOW 142 ALLOW M_r expressed as a sum ALLOW ECF from incorrect M_r and x is calculated correctly ALLOW ECF values of x from nearest whole number to calculator value ALLOW 2 marks if final answer is 10 without any working
			Total	10	