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1	(a)	(	The H^+ **OR** hydrogen **ions OR** protons in (sulfuric) acid have been replaced by ammonium ions **OR** NH_4^+ ✓	1	**ALLOW** 'a positive ion' for 'ammonium ions' **BUT IGNORE** 'a positive metal ion' **OR** 'metal ions' for 'ammonium ions'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_2SO_4 = 0.100 × 32.5/1000 = 3.25×10^{-3} **OR** 0.00325 mol ✓ Amount of NH_3 = (mol of H_2SO_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_2SO_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} x 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 107º ✓ *Explanation* There are 3 bonded pairs **and** 1 lone pair ✓ Electron **pairs** repel ✓ Lone pairs repel more than bonded pairs ✓	4	**ALLOW** range 106–108º **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)	(	OH^- ✓	1	Correct charge must be seen **ALLOW** OH^- if seen as the ONLY negative product of an equation
		(ii)	$N_2H_5^+$ **OR** $N_2H_6^{2+}$ ✓	1	**ALLOW** $H_2N–NH_3^+$ **OR** $H_3N–NH_3^{2+}$
	(d)	(	C*l* goes from (+)1 to –1 ✓	3	**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
			N goes from –3 to –2 ✓		**ALLOW** 3 –, 2 –. Only look for oxidation numbers seen above or below equation if not seen in text **IGNORE** N^{3-} N^{2-} **DO NOT ALLOW** If a second species is seen going up in oxidation number
			C*l* is reduced **AND** N is oxidised ✓		**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 **IGNORE** references to electron loss **OR** gain **ALLOW** 3 marks for labelled equation such as below $2NH_3 + NaClO \rightarrow N_2H_4 + NaCl + H_2O$ – + – oxidation reduction
		(ii)	sodium chlorate(I) ✓	1	**ALLOW** sodium chlorate I (ie no brackets) **ALLOW** sodium hypochlorite **IGNORE** bleach **DO NOT ALLOW** sodium chlorate (with no Roman numeral)
		(iii)	$N_2H_4 + 2NH_2Cl \rightarrow 2NH_4Cl + N_2$ ✓✓	2	One mark for N_2 One mark for NH_4Cl **AND** balancing
			Total	**16**	

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

Question			er	Mark	Guidance
2	(d)		Spherical **OR** sphere ✓	1	**DO NOT ALLOW** 'circular' **IGNORE** unlabelled 2-D diagrams
	(e)	(i)	$Sr^{+}(g) \rightarrow Sr^{2+}(g) + e^{-}$ ✓	1	**ALLOW** e for electrons **ALLOW** $Sr^{+}(g) - e^{-} \rightarrow Sr^{2+}(g)$ **DO NOT ALLOW** $Sr^{+}(g) + e^{-} \rightarrow Sr^{2+}(g) + 2e^{-}$ **IGNORE** state symbols for electrons
	(e)	(ii)		3	**Use annotations with ticks, crosses ECF etc. for this part**
			Sr has one **more** proton **OR** great**er** nuclear charge ✓		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' ***Quality of Written Communication –*** *Nuclear* ***OR*** *proton(s)* ***OR*** *nucleus spelled correctly* ***ONCE*** *for the* ***first*** *marking point*
			(Outermost) electrons are in the same shell **OR** (outermost) electrons experience same shielding **OR** Atomic radius of Sr is small**er** ✓		**ALLOW** shielding is similar **ALLOW** screening for shielding **IGNORE** sub-shells **DO NOT ALLOW** 'distance is similar'
			Sr has great**er** nuclear attraction (on outer electrons / outer shell/s) **OR** the (outer) electrons are attracted more strongly (to the nucleus) ✓		**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)	2nd IE of Rb involves removing electron from shell closer to nucleus ✓	2	**IGNORE** new shell **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.
			Strong**er** nuclear attraction on (outermost electron) of Rb **OR** (outermost electron) of Rb experiences **less** shielding ✓		**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 **ORA**
			Total	**13**	

Question			Answer	Mark	Guidance
3	(a)	(i)	mol of H_xA = $\frac{25.00 \times 0.0500}{1000}$ = 1.25×10^{-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) × 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_2A	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 ✓ $CuO + 2HNO_3 \rightarrow Cu(NO_3)_2 + H_2O$ ✓	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)		$Cu(NO_3)_2•6H_2O$ ✓	1	**ALLOW** $Cu(NO_3)_26H_2O$ **ALLOW** $Cu(NO_3)_2(H_2O)_6$ **ALLOW** $Cu(NO_3)_2.6H_2O$ **DO NOT ALLOW** $CuN_2O_6•6H_2O$
			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 × 40.1 = 0.0525 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 × 24.0 = 0.0314 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 × 2 = 0.00262 **OR** 2.62×10^{-3} ✓ Mol of OH^- ions in 1 dm^3 = $0.00262 \times \frac{1000}{250}$ = 0.0105 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 Ba > A_r Ca
		(ii)	Idea of Ba having a quick**er** rate **OR more** vigorous reaction ✓	1	**ALLOW more** exothermic **OR** gets hot**ter 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)		**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) ✓	**2**	**IGNORE** Reference to average **OR** weighted mean (i.e. correct definition of relative atomic mass will score both marks) **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. **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.' **ALLOW** 12C **OR** C12 **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' **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.' **DO NOT ALLOW** mass of 'ions' OR mass of element
	(b)		$\frac{(151 \times 47.77) + (153 \times 52.23)}{100}$ **OR** 72.1327 + 79.9119 **OR** 152.0446 (calculator value) ✓ A_r = 152.04 ✓	**2**	**ALLOW** Correct answer for two marks **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

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)		Xe has a bigger atomic radius **OR** Xe has more shells ✓ Xe has **more** shielding ✓ 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	**3**	**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' **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 **ALLOW** Xe has less nuclear pull **IGNORE** Xe has less effective nuclear charge **DO NOT ALLOW** nuclear charge for nuclear attraction
			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)	$2HNO_3(aq) + Ca(OH)_2(aq) \rightarrow Ca(NO_3)_2(aq) + 2H_2O(l)$ Formulae ✓ Balance **AND** states ✓	2	**ALLOW** multiples **ALLOW** (aq) **OR** (s) for $Ca(OH)_2$
		(iii)	Accepts a **proton OR** accepts $\mathbf{H^+}$ ✓	1	**ALLOW** $\mathbf{H^+} + OH^- \rightarrow H_2O$ **ALLOW** OH^- reacts with $\mathbf{H^+}$ **OR** OH^- takes $\mathbf{H^+}$ **ALLOW** OH^- 'attracts' $\mathbf{H^+}$ 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 ✓ $x = \frac{(322.1 - 142.1)}{18.0} = 10$ ✓	**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**	