| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| 1 | (a) | | Rb-87 has (two) more neutrons ✓ | 1 | **ALLOW** Different numbers of neutrons<br><br>**ALLOW** 2 neutrons<br><br>**ALLOW** Rb-85 has 48 neutrons **AND** Rb-87 has 50 neutrons<br><br>**IGNORE** correct references to protons and electrons<br><br>**DO NOT ALLOW** incorrect references to protons and electrons |
| | (b) | | The (weighted) mean **mass** of an **atom** (of an element)<br>**OR**<br>The (weighted) average **mass** of an **atom** (of an element) ✓<br><br>compared with 1/12th (the mass) ✓<br><br>of (one atom of) carbon-12 ✓ | 3 | **ALLOW** average atomic mass<br>**DO NOT ALLOW** mean mass of an element<br>**ALLOW** mean mass of isotope**s OR** average mass of isotope**s**<br>**DO NOT ALLOW** the singular; 'isotope'<br><br>For second **AND** third marking points<br>**ALLOW** compared with (the mass of) carbon-12 which is 12<br><br>**ALLOW** mass of **one mole** of **atoms** ✓<br>compared to 1/12th ✓<br>(mass of) **one mole OR** 12 **g** of carbon-12 ✓<br><br>**ALLOW**<br>mass of **one mole** of atoms / 1/12th mass of **one mole** OR 12**g** of carbon-12 |
| | (c) | | $\frac{(85.00 \times 72.15) + (87.00 \times 27.85)}{100}$ =<br><br>**OR** *61.3275 + 24.2295*<br><br>**OR** *85.557* ✓<br><br>$A_r$ = 85.56 (to 2 decimal places) ✓ | 2 | **ALLOW** two marks for correct answer $A_r$ = 85.56 (with no working)<br><br>**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 | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| 1 | (d) | | Spherical **OR** sphere ✓ | 1 | **DO NOT ALLOW** 'circular'<br>**IGNORE** unlabelled 2-D diagrams |
| | (e) | (i) | $Sr^{+}(g) \rightarrow Sr^{2+}(g) + e^{-}$ ✓ | 1 | **ALLOW** e for electrons<br>**ALLOW** $Sr^{+}(g) - e^{-} \rightarrow Sr^{2+}(g)$<br>**DO NOT ALLOW** $Sr^{+}(g) + e^{-} \rightarrow Sr^{2+}(g) + 2e^{-}$<br>**IGNORE** state symbols for electrons |
| | (e) | (ii) | | 3 | **Use annotations with ticks, crosses ECF etc. for this part**<br><br>Comparison should be used for each mark |
| | | | Sr has one **more** proton<br>**OR** great**er** nuclear charge ✓ | | **ALLOW** Sr has more protons **ALLOW** 'across the period' for 'Sr'<br>**IGNORE** 'atomic number increases', but **ALLOW** 'proton number' increases<br>**IGNORE** 'nucleus gets bigger'<br>'Charge increases' is insufficient<br>**ALLOW** 'effective nuclear charge increases' **OR** 'shielded nuclear charge increases'<br>***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<br>**OR** (outermost) electrons experience same shielding<br>**OR** Atomic radius of Sr is small**er** ✓ | | **ALLOW** shielding is similar<br>**ALLOW** screening for shielding<br>**IGNORE** sub-shells<br>**DO NOT ALLOW** 'distance is similar' |
| | | | Sr has great**er** nuclear attraction (on outer electrons / outer shell/s)<br>**OR** the (outer) electrons are attracted more strongly (to the nucleus) ✓ | | **ALLOW** 'greater nuclear pull' for 'greater nuclear attraction'<br>**DO NOT ALLOW** 'nuclear charge' for nuclear attraction<br>**ORA** throughout |

| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| 1 | (e) | (iii) | 2nd IE of Rb involves removing electron from shell closer to nucleus ✓ | 2 | **IGNORE** new shell<br><br>**ALLOW** There is one shell fewer in $Rb^{(+)}$ (than $Sr^{+}$)<br>**ALLOW** $Rb^{(+)}$ has a smaller radius (than $Sr^{+}$)<br>**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<br>A comparison of Rb to Sr must be used, e.g. 'Because of shielding' is not enough<br><br>**ORA** |
| | | | **Total** | **13** | |

| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| 2 | (a) | (i) | mol of $H_xA$ = $\frac{25.00 \times 0.0500}{1000}$ = $1.25 \times 10^{-3}$ **OR** 0.00125 mol ✓ | 1 | **ALLOW** 0.0013 **OR** $1.3 \times 10^{-3}$<br><br>**ALLOW** correct answer only without working |
| | | (ii) | mol of NaOH =<br><br>$\frac{12.50 \times 0.200}{1000}$ = 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 ✓<br>Answer **2a(i)**<br><br>If **2a(i)** and **2a(ii)** are correct this will be<br><br>$x = \frac{2.50 \times 10^{-3} \text{ mol}}{1.25 \times 10^{-3} \text{ mol}} = 2$<br><br>**OR** $H_2A$ | 1 | **ALLOW** answer without working if answers to **2a(i) AND 2a(ii)** are seen<br><br>**DO NOT ALLOW** responses without seeing answers in **2a(i) AND 2a(ii)** |
| | (b) | (i) | $HNO_3$ ✓<br>$CuO + 2HNO_3 \rightarrow Cu(NO_3)_2 + H_2O$ ✓ | 2 | **IGNORE** state symbols<br>**ALLOW** correct multiples |
| | | (ii) | (Electrostatic) **attraction** between **oppositely** charged **ions** ✓ | 1 | **Attraction** is essential<br>**IGNORE** references to metal and non-metal |
| | | (iii) | **Ions** are mobile **OR** ions can move ✓ | 1 | **IGNORE** 'free ions'<br>**IGNORE** 'delocalised ions'<br>**IGNORE** ions can move when molten<br>**IGNORE** charge carriers<br>**DO NOT ALLOW** Any mention of electrons moving<br>**ALLOW** ions move when **in** a liquid<br>**IGNORE** responses which give liquid ions |
| | | (iv) | (+) 5 ✓ | 1 | **ALLOW** V |

| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| 2 | (c) | | $Cu(NO_3)_2•6H_2O$ ✓ | 1 | **ALLOW** $Cu(NO_3)_26H_2O$<br>**ALLOW** $Cu(NO_3)_2(H_2O)_6$<br>**ALLOW** $Cu(NO_3)_2.6H_2O$<br><br>**DO NOT ALLOW** $CuN_2O_6•6H_2O$ |
| | | | **Total** | **9** | |

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

| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| 3 | (c) | (iii) | $BF_3$ is **symmetrical** ✓<br>The **dipoles** cancel out ✓ | 2 | **IGNORE** 'polar bonds cancel'<br>**IGNORE** 'charges cancel' |
| | | | **Total** | **11** | |

| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| 4 | (a) | | Used to neutralise **acidic** soils ✓<br><br>Excess will result in soils becoming **too** alkaline (to sustain crop growth) ✓ | 2 | **ALLOW** raises the pH of the soil<br>**IGNORE** references to fertilisers<br><br>**ALLOW** pH becomes **too** high<br>**IGNORE** 'harmful'<br>**IGNORE** 'corrosive' |
| | **(b)** | **(i)** | 0.00131 × 40.1 = 0.0525 g **OR** $5.25 \times 10^{-2}$ ✓ | 1 | **ALLOW** 0.053 **OR** 0.05253 **OR** 0.052531 g<br>**IGNORE** 0.05 **if correct answer seen in working**<br>**DO NOT ALLOW** 0.052 **OR** 0.0524 |
| | | **(ii)** | 0 00131 × 24.0 = 0.0314 $dm^3$ **OR** $3.14 \times 10^{-2}$ ✓ | 1 | **ALLOW** 0.031 **OR** 0.03144 $dm^3$<br>**IGNORE** 0.03 **if correct answer seen in working**<br>**DO NOT ALLOW** 31.4 |
| | | **(iii)** | Mol of $OH^-$ ions = 0.00131 × 2 = 0.00262 **OR** $2.62 \times 10^{-3}$ ✓<br><br>Mol of $OH^-$ ions in 1 $dm^3$ = $0.00262 \times \frac{1000}{250}$ = 0.0105 mol $dm^{-3}$ ✓ | 2 | **ALLOW** 0.0026<br><br>**ALLOW** 0.01048 **OR** 0.01(0)<br>**ALLOW ECF** from incorrect mol of $OH^-$<br>**DO NOT ALLOW** 2nd mark as **ECF** if 0.0525 is used as no of mol of $OH^-$ ions<br>**DO NOT ALLOW** 2nd mark as **ECF** if 0.0314 is used as no of mol of $OH^-$ ions<br>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)<br>**OR Fewer** atoms of Ba (in 0.0525) ✓ | 1 | **ORA**<br>Assume candidate is referring to Ba if not stated<br>**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<br>Assume candidate is referring to Ba if not stated<br>Comparison is essential<br>**IGNORE** 'Ba more reactive'<br>**ORA** |
| | | | **Total** | **8** | |

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

| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| 5 | (c) | (i) | ***Colours:***<br>(Add $Br_2$ to NaCl,) (Cyclohexane layer) turns orange **OR** yellow ✓<br><br>(Add $Br_2$ to NaI,) (Cyclohexane layer) turns purple **OR** lilac **OR** violet **OR** pink **OR** mauve ✓<br><br>***Equation:***<br>$Br_2 + 2I^- \rightarrow I_2 + 2Br^-$ ✓<br><br>***Reactivity:***<br>Reactivity decreases down the group **OR** Oxidising power decreases down the group ✓<br><br>***Explanations:***<br>Chlorine will gain electron easiest **OR** form negative ion easiest ✓<br><br>Because chlorine (atom) is smallest **OR** Outer(most) shell of chlorine least shielded **OR** Nuclear attraction on electrons of chlorine is greatest ✓ | 6 | **Use annotations with ticks, crosses ECF etc. for this part**<br><br>**ALLOW** any combination of these but no others<br><br>**ALLOW** any combination of these but no others<br><br>**DO NOT ALLOW** 'precipitate' with either colour<br><br>**DO NOT ALLOW** equation mark if incorrect equation(s) also seen<br>**IGNORE** $Br_2 + 2Cl^- \rightarrow Br_2 + 2Cl^-$<br>**IGNORE correct** non-ionic version of equation<br>**IGNORE** state symbols<br><br>**ALLOW** Chlorine is the most reactive<br>**ALLOW** Cl for chlorine etc.<br>**ALLOW** Iodine is the least reactive<br><br>**ALLOW** chlorine is best at electron capture<br>**ALLOW** chlorine has 'greatest' electron affinity<br>**IGNORE** chlorine is most electronegative<br>**DO NOT ALLOW** explanations in terms of displacement<br>***Quality of Written Communication –*** *Electron(s)* ***OR*** *negative spelled correctly at least* ***ONCE*** *for marking point 5*<br><br>**ALLOW** Chlorine atom has fewest shells<br>**ALLOW** outer(most) shell closest to the nucleus<br>**ALLOW** Chlorine atom has lowest shielding<br>**ORA** for marking points 4, 5 and 6 |

| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| 5 | (c) | (ii) | Bromine is toxic ✓ | 1 | **ALLOW** cyclohexane is toxic<br>**ALLOW** bromine irritates the lungs<br>**DO NOT ALLOW** $Cl_2$ is toxic<br>**IGNORE** 'strong smelling'<br>**IGNORE** 'halogens' are toxic |
| | (d) | (i) | $2F_2 + 2H_2O \rightarrow 4HF + O_2$ ✓ | 1 | **ALLOW** correct multiples, including use of ½ $O_2$<br>**ALLOW** 4FH<br>**IGNORE** state symbols |
| | | (ii) | Oxygen has been oxidised as (oxidation number has increased from) O = –2 to O = 0 ✓<br><br>Fluorine has been reduced as (oxidation number has decreased from) F = 0 to F = –1 ✓ | 2 | **IGNORE** references to oxygen in any incorrect products<br><br>**DO NOT ALLOW** $O_2$ = –2 → O = 0 but **ALLOW** $F_2$ = 0 → F = –1<br>**ALLOW** 'F is reduced from 0 to –1' regardless of product (or no product) in **5d(i)** except **ALLOW ECF** for F = –2 **if** $H_2F$ is seen<br><br>**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<br>Look at equation in **5d(i)** for oxidation numbers **if not seen in 5d(ii)**<br>**IGNORE** reference to electron loss / gain if correct<br>**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<br>**ALLOW** $4s^2$ before $3d^{10}$<br>**ALLOW** '3D' |
| | | (ii) | $GaF_3$ ✓ | 1 | |
| | | | **Total** | **19** | |

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