Question			Expected Answers	Marks	Additional Guidance
1	a	i	Any **two** from ✓✓ H^+ SO_4^{2-} HSO_4^-	2 max	**DO NOT ALLOW** OH^- **IGNORE** state symbols Charge is essential **ALLOW** H_3O^+ for H^+ and SO_4^{-2} for SO_4^{2-} One answer incorrect = 1 mark max Two answers incorrect = 0 marks
		ii	Effervescence **OR** fizzing **OR** bubbling **OR** gas produced ✓ K_2CO_3 dissolves **OR** disappears **OR** colourless solution is formed ✓ $H_2SO_4 + K_2CO_3 \rightarrow K_2SO_4 + CO_2 + H_2O$ ✓	3	**DO NOT ALLOW** 'carbon dioxide produced' without 'gas' **DO NOT ALLOW** incorrectly named gas produced **DO NOT ALLOW** 'precipitate forms' = CON **ALLOW** 'it' for K_2CO_3 **DO NOT ALLOW** mark for 'dissolves' from state symbols in equation **DO NOT ALLOW** 'potassium' **IGNORE** state symbols **ALLOW** ionic equation
	b	i	$\frac{24.6}{1000} \times 0.100 = 0.00246$ mol ✓ (2.46×10^{-3} mol)	1	**DO NOT ALLOW** 0.0025 as this would lead to 100% in part **(iii)** **DO NOT ALLOW** 0.0024 due to incorrect rounding
		ii	$0.00246 \times 2 = 0.00492$ mol ✓ (4.92×10^{-3} mol)	1	**ALLOW** ECF for ans **(i)** × 2
		iii	Moles of NaOH in 250 cm^3 = $0.00492 \times \frac{250}{25} = 0.0492$ mol ✓ Mass of NaOH in original sample $= 0.0492 \times 40.0 = 1.968$ g ✓ % purity $\frac{1.968}{2.00} \times 100 = 98.4\%$ ✓	3	**ALLOW** ECF for ans **(ii)** × 10 **ALLOW** 1.97g **ALLOW** ECF for moles of NaOH × 40 **ALLOW** 98.5% (from use of 1.97) **ALLOW** ECF for $\frac{\text{mass of NaOH}}{2.00} \times 100$ **DO NOT ALLOW** ECF for 3rd marking point if answer >100% **ALLOW** ECF for 3rd marking point if answer = 100% **ALLOW** molar approach for second and third marks i.e. mol of (expected) NaOH in 2.00 g = 2/40 = 0.05(00) mol (0.0492/0.0500) × 100 = 98.4% 1.6% (the percentage of the impurity present) is likely to be 2 marks, but please check 9.84% has not multiplied up by 10 for first marking point is likely to be 2 marks, but please check
			Total	**10**	

Question			Expected Answers	Marks	Additional Guidance
2	**a**		3d 4p ✓	1	Correct order is essential **ALLOW** '3D'
	b	**i**	A region (within an atom) that can hold (up to) two electrons ✓ (with opposite spin)	1	**ALLOW** 'can be found' for 'can hold' **ALLOW** 'area' **OR** 'volume' **OR** 'space' for region **DO NOT ALLOW** 'place' for region **DO NOT ALLOW** path of an electron **IGNORE** references to 'orbitals being parts of sub-shells'
		ii	11 ✓	1	
	c		18 ✓	1	
	d	**i**	2nd, 3rd **OR** 1817, 2745 ✓ 10th, 11th **OR** 38458, 42655 ✓	2	Mark as pairs **IGNORE** references to 12th and 13th Three answers with one correct pair = 1 mark Four answers with one correct pair = 1 mark Five answers with both pairs correct = 1 mark Five answers with only one pair correct = 0 marks Six (or more) answers = 0 marks
		ii	$Al^{2+}(g) \rightarrow Al^{3+}(g) + e^{-}$ ✓✓	2	**ALLOW** $Al^{2+}(g) - e^{-} \rightarrow Al^{3+}(g)$ for 2 marks **ALLOW** 1 mark for $Al(g) \rightarrow Al^{3+}(g) + 3e^{-}$ as states are correct **ALLOW** 1 mark for $Al^{2+}(g) + 2e^{-} \rightarrow Al^{3+}(g) + 3e^{-}$ as states are correct **ALLOW** 1 mark if symbol of Al is incorrect, but equation is otherwise fully correct. **ALLOW** e for electron (i.e. no charge) **IGNORE** states on electron
			Total	**8**	

<table>
<tr><th colspan="3">Question</th><th>Expected Answers</th><th>Marks</th><th>Additional Guidance</th></tr>
<tr><td>3</td><td>(a)</td><td>(i)</td><td>
<table>
<tr><th></th><th>protons</th><th>neutrons</th><th>electrons</th></tr>
<tr><td>^{24}Mg</td><td>12</td><td>12</td><td>12</td></tr>
<tr><td>^{25}Mg</td><td>12</td><td>13</td><td>12</td></tr>
</table>
^{24}Mg line correct ✓
^{25}Mg line correct ✓</td><td>2</td><td>mark by row</td></tr>
<tr><td></td><td></td><td>(ii)</td><td><u>24 x 78.60 + 25 x 10.11 + 26 x 11.29</u>
100

OR 18.8640 + 2.5275 + 2.9354

OR 24.3269 ✓

A_r = 24.33 (to 4 sig figs) ✓</td><td>2</td><td>ALLOW two marks for A_r = 24.33 with no working out

ALLOW one mark for ecf from incorrect sum provided final answer is between 24 and 26 and is to 4 significant figures, e.g. 24.3235 ✖ gives ecf of 24.32 ✓</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>The (weighted) mean mass of an atom
OR (weighted) average mass of an atom ✓

relative to 1/12th (the mass) ✓

of (one atom of) ^{12}C ✓</td><td>3</td><td>ALLOW The (weighted) mean mass
OR (weighted) average mass of an atom
OR average atomic mass ✓
compared with (the mass of) carbon-12 ✓
which is 12 ✓

For 1st marking point, ALLOW mean mass of the isotopes
OR average mass of the isotopes
Do NOT ALLOW the singular: isotope

ALLOW mass of one mole of atoms ✓
compared to 1/12th ✓
(the mass) of one mole / 12 g of carbon-12 ✓</td></tr>
</table>

Question			Expected Answers	Marks	Additional Guidance
					mass of one mole of atoms ✓ 1/12th ✓ the mass of one mole / 12 g of carbon-12 ✓
	(b)	**(i)**	Mg ✓ oxidation number changes from 0 to (+)2 **OR** oxidation number increases by 2 ✓	**2**	**ALLOW** correct oxidation numbers shown in equation 2nd mark is dependent on identification of Mg **IGNORE** electrons
		(ii)	Mg/solid dissolves **OR** Mg/solid disappears **OR** (Mg/solid) forms a solution ✓ bubbles **OR** fizzes **OR** effervesces **OR** gas produced ✓	**2**	**IGNORE** metal reacts **IGNORE** temperature change **IGNORE** steam produced **DO NOT ALLOW** carbon dioxide gas produced **DO NOT ALLOW** hydrogen produced without **gas**
	(c)	**(i)**	$M(MgSO_4)$ = 120.4 OR 120 (g mol^{-1}) ✓ mol $MgSO_4$ = $\frac{1.51}{120.4}$ = *0.0125 mol* ✓	**2**	 **ALLOW** 0.013 up to calculator value of 0.012541528 correctly rounded (from M = 120.4 g mol^{-1}) **ALLOW** 0.013 up to calculator value of 0.012583333 correctly rounded (from M = 120 g mol^{-1}) **ALLOW** ecf from incorrect M i.e. 1.51 ÷ M
		(ii)	$\frac{1.57}{18.0}$ = 0.0872(2) (mol) ✓	**1**	**ALLOW** 0.09 up to calculator value of 0.08722222
		(iii)	***x*** = 7 ✓	**1**	**ALLOW** ecf i.e. answer to (ii) ÷ answer to (i) **ALLOW** correctly calculated answer from 1 significant figure up to calculator value, ie, ***x*** does not have to be a whole number. Likely response = 6.95 ✓
			Total	**15**	

Question			Expected Answers	Marks	Additional Guidance
4	(a)	(i)	mol HCl = 1.50×10^{-2} ✓ volume HCl(aq) = 75.0 ✓	2	**ALLOW** answers to 2 significant figures **ALLOW** ecf from wrong number of moles i.e. $\frac{\text{moles of HCl} \times 1000}{0.200}$ **ALLOW** one mark for 37.5 (from incorrect 1:1 ratio)
		(ii)	180 ✓	1	No other acceptable answer
	(b)		$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$ equation ✓ state symbols ✓	2	state symbols are **dependent** on correct formulae of $CaCO_3$, CaO and CO_2 **DO NOT ALLOW** the 'equation mark' if O_2 is seen on both sides (but note that the 'state symbol mark' may still be accessible)
	(c)	(i)	$Ca(OH)_2$ ✓	1	**IGNORE** charges, even if wrong
		(ii)	$Ca(NO_3)_2$ ✓	1	**IGNORE** charges, even if wrong
			Total	7	

<table>
<tr><th colspan="3">Question</th><th>er</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>5</td><td>(a)</td><td>(</td><td>mass of the isotope compared to 1/12th
OR
mass of the atom compared to 1/12th ✓

(the mass of a) ^{12}C (atom) ✓</td><td>2</td><td>ALLOW for ^{12}C: carbon-12 OR C-12 OR C 12 OR 12 C

IGNORE reference to average OR weighted mean
(ie correct definition of relative atomic mass scores 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 ✓

ALLOW 2 marks for:
‘mass of the isotope OR mass of the atom compared to ^{12}C atom given a mass of 12.0’
ie ‘given a mass of 12’ communicates the same idea as 1/12th’

ALLOW FOR 2 MARKS:
$\frac{\text{mass of the isotope}}{\text{mass of 1/12th mass of carbon-12}}$

ie fraction is equivalent to ‘compared to’

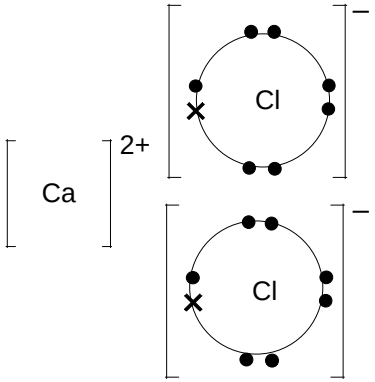
ALLOW 1 MARK FOR a mix of mass of atom and mass of mole of atoms, ie:
‘mass of the isotope/mass of an atom compared with 1/12th the mass of a mole OR 12 g of carbon-12’

DO NOT ALLOW mass of ion OR mass of element
BUT ALLOW mass of an atom of an element</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Both rows completed correctly ✓
<table>
<tr><th></th><th>protons</th><th>neutrons</th></tr>
<tr><td>iodine-127</td><td></td><td>74</td></tr>
<tr><td>iodine-131</td><td></td><td>78</td></tr>
</table></td><td>1</td><td>ALL four entries in table correct for 1 mark</td></tr>
</table>

Question			er	Marks	Guidance
5	(b)	(	FIRST CHECK THE ANSWER ON ANSWER LINE IF answer = 91.6 (µg), must be 3 sf, award 2 marks Amount of I^- mark: = $70.0 \times 10^{-6} / 126.9$ **OR** = 5.52×10^{-7} ✓ (mol) Mass of KI = $(5.52 \times 10^{-7} / 10^{-6}) \times 166.0$ = 91.6 (µg) must be 3 sf ✓	2	If there is an alternative answer, check to see if there is any ECF credit possible **FOR ONE MARK ONLY** using working below **ALLOW** $70.0 \times 10^{-x} / 126.9$ OR 5.52×10^{-x} (ie wrong conversion of µg and g) **ALLOW** calculator values which round to 5.52×10^{-x}, ie 3 significant figures or more **ALLOW** ECF for incorrect calculated amount of I^- x 166.0, must be 3 sf **ALLOW** calculator value or rounding to 3 significant figures or more **BUT IGNORE** 'trailing' zeroes, eg 0.200 allowed as 0.2. Answers with 91.6×10^{-x} (ie wrong conversion of µg and g) would get one mark
		(ii)	***Ethical implications*** Some people feel it is wrong to put additives into the national diet **OR** ***Dietary issues*** Food **OR** diet contains sufficient amounts of iodide ✓	1	**ALLOW** some people disapprove of additives in their food Assume 'it' refers to KI **IGNORE** economic reasons **ALLOW** (excess) potassium **OR** $K^{(+)}$ **OR** KI is harmful **OR** toxic **ALLOW too much** iodine **OR** iodide **OR** $I^{(-)}$is harmful **OR** toxic **ALLOW** iodine **OR** iodide **OR** $I^{(-)}$ **OR** KI is radioactive **ALLOW** any effect which would be detrimental to human health **OR** well-being **OR** eg 'lead to heart problems' **ALLOW** some table salt already contains iodide (eg sea salt) **ALLOW** some countries do not have (access to) KI **IGNORE** references to dangerous **OR** taste **IGNORE** responses referring solely to intake going above GDA **IGNORE** carcinogenic
	(c)	(	$Cl_2 + 2I^- \rightarrow 2Cl^- + I_2$ ✓	1	**IGNORE** state symbols

Question			er	Marks	Guidance
5	(c)	(i	***Two alternative explanations to award the two marks:***	2	
					***Quality of Written Communication*:** **'dipole' OR 'permanent' spelled correctly at least once and in context for marking point 1 in explanation 1**
			Explanation 1 IC*l* has **permanent dipole** (–dipole) (interactions) **AND** Cl_2 has (only) van der Waals' forces ✓		**ALLOW** 'vdW' for van der Waals' **IGNORE** references to van der Waals' forces in IC*l* in explanation 1 **DO NOT ALLOW** 'dipole–dipole interactions' without reference to these being permanent for marking point 1
			Forces are stronger in IC*l* **ORA** **OR** More energy is needed to overcome forces in IC*l* ✓ **ORA**		**DO NOT ALLOW** marking point 2 for comparison of IC*l* having stronger ionic **OR** covalent bonds than Cl_2
					***Quality of Written Communication* – 'electrons' spelled correctly once and used in context for marking point 1 of explanation 2**
			Explanation 2 IC*l* has more electrons ✓ **ORA**		**ALLOW** I has more electrons
			Stronger van der Waals' forces in IC*l* (than in Cl_2) **ORA** **OR** More energy is needed to overcome van der Waals' forces in IC*l* ✓ **ORA**		**ALLOW** more van der Waals' forces **ALLOW** 'vdW' for van der Waals'
			Total	**9**	

Question			er	Marks	Guidance
6	(a)		Add (aqueous) silver nitrate OR $AgNO_3$ **OR** Ag^+ ions ✓ white **AND** precipitate ✓	2	**IGNORE** references to nitric acid **DO NOT ALLOW** references to any other additional reagent added to silver nitrate for marking point 1 **ALLOW** 'solid' **OR** 'ppt' for 'precipitate'. Both colour **AND** state is needed. **IGNORE** references to solubility in ammonia for marking point 2 if colour of precipitate is stated **BUT** **ALLOW** 'dissolves in **dilute** ammonia' if **no** colour of precipitate is given **DO NOT ALLOW** marking point 2 if additional reagent leads to invalid test
	(b)		The mixture effervesced **OR** fizzed **OR** bubbled **OR** produced a **gas** ✓ **X** is $CaCO_3$ **OR** calcium carbonate ✓	2	**ALLOW** CaO would not fizz **IGNORE** name of gas
	(c)	(i)	Contains water (of crystallisation) ✓	1	**ALLOW** 'with water' **OR** 'has water' **DO NOT ALLOW** 'in solution' **OR** 'in water'
		(ii)	Working must be marked first 219.1 – 111.1 = 108 ✓ 108/18 (= 6) **AND** $CaCl_2 \cdot 6H_2O$ ✓	2	**ALLOW** $CaCl_2(H_2O)_6$ **ALLOW** $CaCl_2 6H_2O$ (ie no 'dot') **ALLOW** [219.1 – (40.1 + 2 x 35.5)] / 18 **AND** $CaCl_2 \cdot 6H_2O$ for two marks **ALLOW** ECF for incorrectly calculated mass of H_2O / 18 provided final answer is rounded to nearest whole number for marking point 2

Question			er	Marks	Guidance
6	(d)		 Ca shown with either 8 or 0 electrons **AND** Cl shown with 8 electrons with 7 crosses and one dot (or *vice versa*) ✓ correct charges on both sets of ions ✓	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)		Ba is more reactive than Ca ✓ **ORA** Br_2 is less reactive than Cl_2 ✓ **ORA**	2	**ALLOW** reactivity increases down Group 2 **ORA** Provided Ca **and** Ba have been identified as Group 2 elements **ALLOW** reactivity decreases down Group 7 **ORA** Provided C*l* **and** Br have been identified as Group 7 elements **ALLOW** one mark for both sentences if no ascribing to groups **ALLOW** Br for Br_2 and C*l* for Cl_2 **DO NOT ALLOW** Br^{-} for Br_2 **OR** Cl^{-}
			Total	**11**	