Question			Answer	Marks	Guidance
1	(a)	(i)	Al^{3+} ✓ SO_4^{2-} ✓	2	
		(ii)	$Al_2O_3(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3H_2O(l)$ Correct species **AND** correctly balanced ✓ state symbols on **correct** species ✓	2	**ALLOW** multiples
		(iii)	(The number of) water(s) of crystallisation ✓	1	**IGNORE** hydrated **OR** hydrous **OR** 'contains water'
		(iv)	**First check the answer on the answer line.** **If answer** = 16, award 3 marks Correctly calculates amount of $Al_2(SO_4)_3$: 6.846 / 342.3 = 0.02(00) mol ✓ Correctly calculates amount of H_2O: 5.760 / 18.0 = 0.32(0) mol ✓ Correctly calculates whole number ratio of mol of H_2O: $Al_2(SO_4)_3$ to give x = 16 ✓	3	If there is an alternative answer, check to see if there is any ECF credit possible using working below **ALLOW** as ECF from 12.606/342.3 = 0.0368(273) **AND** 0.32/0.0368(273) To give x = 9 for two marks **ALLOW** calculator value or rounding to 2 significant figures or more **BUT IGNORE** 'trailing' zeroes, eg 0.200 allowed as 0.2. **ALLOW** ECF for calculation of correctly rounded **whole number** value of H_2O from incorrect mol of H_2O and / or incorrect mol of $Al_2(SO_4)_3$ **BUT** x must be a whole number **ALLOW** alternative method Mol of $Al_2(SO_4)_3$: 6.846 / 342.3 = 0.02(00) mol (first mark) Molar mass of $Al_2(SO_4)_3 \cdot xH_2O$: 12.606 / 0.02(00) = 630.3 g mol^{-1} (second mark) Mass of water per mol = 630.3 – 342.3 = 288 **AND** 288/18 to give x = 16 (third mark)

Question			Answer	Marks	Guidance
1	(b)	(i)	$Cl_2 + H_2O \rightarrow HCl + HClO$ ✓ H^+ ions are released **OR** HC*l* is acidic **OR** HC*l*O is acidic ✓	2	**ALLOW** HOC*l* **ALLOW** equilibrium sign **IGNORE** state symbols **ALLOW** formulae **OR** names *If correct equation is seen:* **ALLOW** 'product is acidic' **OR** 'acid is produced' **IGNORE** 'the solution is acidic' but **ALLOW** 'the solution formed is acidic' **DO NOT ALLOW** 'chlorine is acidic' ie acidity must be related to the product(s) *If an incorrect equation is seen:* **ALLOW** second mark if H^+ **OR** HC*l* **OR** HC*l*O is given as a product in the equation **AND** is stated as being acidic *If no equation is seen:* **ALLOW** second mark if H^+ **OR** HC*l* **OR** HC*l*O is produced **AND** is stated as being acidic
		(ii)	ClO^- ✓	1	**ALLOW** OCl^-
			Total	**11**	

Question			Answer	Marks	Guidance
2	(a)		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** $\frac{\text{mass of } \textbf{one mole} \text{ of atoms}}{\text{1/12th mass of } \textbf{one mole} \text{ OR } 12\textbf{g} \text{ of carbon-12}}$.
	(b)		**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 32.09 award 2 marks** $\frac{32 \times 95.02 + 33 \times 0.76 + 34 \times 4.22}{100}$ **OR** 30.4064 + 0.2508 + 1.4348 **OR** = 32.092 (calculator value) ✓ (A_r =) 32.09 ✓	2	**ALLOW** one mark for ECF from transcription error in first sum provided final answer is to 2 decimal places and is between 32 and 34 and is a correct calculation of the transcription Answer must be 2 decimal places

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>2</td><td>(c)</td><td></td><td>
<table>
<tr><th></th><th>protons</th><th>neutrons</th><th>electrons</th></tr>
<tr><td>^{33}S</td><td>16</td><td>17</td><td>16</td></tr>
<tr><td>$^{34}S^{2-}$</td><td>16</td><td>18</td><td>18</td></tr>
</table>
✓ ✓
</td><td>2</td><td>Mark by row</td></tr>
<tr><td></td><td>(d)</td><td></td><td>FIRST CHECK THE ANSWER ON THE ANSWER LINE
If answer = 5.78 × 10^{22} award 2 marks

(mol of atoms) = 0.0120 × 8 = 0.0960 (mol)
OR
(no. of molecules) = 0.0120 × 6.02 × 10^{23} = 7.224 x 10^{21}
OR
(no. of S atoms in 1 mole of S_8) = 8 x 6.02 x 10^{23} = 4.816 x 10^{24}✓

Correctly calculates (number of atoms) = 0.0120 × 8 × 6.02 × 10^{23}

= 5.78 × 10^{22} (atoms) ✓</td><td>2</td><td>If there is an alternative answer, check to see if there is any ECF credit possible using working below

ALLOW 5.8 x 10^{22} up to calculator value of 5.7792 x 10^{22}
ALLOW correct rounding of ECF to 2 significant figures or more up to calculator value
ALLOW answers in non standard form such as 0.578 × 10^{23} correctly rounded to 2 or more significant figures</td></tr>
<tr><td></td><td>(e)</td><td>(i)</td><td>Creating the dipole mark
Uneven distribution of electrons ✓

Type of dipole mark
Creates or causes an instantaneous dipole OR temporary dipole (in a molecule) ✓

Induction of a second dipole mark
Causes induced dipoles in neighbouring molecules ✓</td><td>3</td><td>Use annotations with ticks, crosses, ECF etc for this part
ALLOW movement of electrons
ALLOW changing electron density

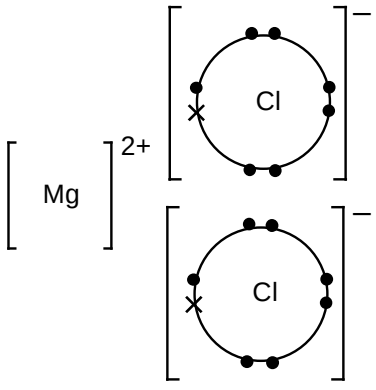
ALLOW ‘transient’, ‘oscillating’ ‘momentary’ ‘changing’
DO NOT ALLOW induces a temporary dipole for the second marking point

ALLOW induces a dipole in neighbouring molecules
ALLOW causes a resultant dipole in other molecules
ALLOW atoms for molecules</td></tr>
</table>

Question			er	Marks	Guidance
2	(e)	(ii)	Only one type of atom **OR** No (permanent) dipoles **OR** non-polar **OR** no polar bonds ✓	1	**ALLOW** no difference in electronegativity **IGNORE** 'No hydrogen bonding' **IGNORE** 'No lone pairs'
	(f)		+ 2 ✓	1	**ALLOW** 2(+)
	(g)	**(i)**	There are no waters of crystallisation ✓	1	**ALLOW** 'without water' 'no water' etc **IGNORE** dehydrated
		(ii)	248.2 ✓	1	**IGNORE** units **DO NOT ALLOW** 248
		(iii)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 7.91 (g) award 2 marks** (amount of $Na_2S_2O_3$•$5H_2O$) = 12.41/248.2 **OR** = 0.05(00) (mol) ✓ (mass of $Na_2S_2O_3$) = 0.05 x 158.2 = 7.91 (g) ✓	2	If there is an alternative answer, check to see if there is any ECF credit possible using working below **ALLOW** ECFs from answer to **(g)(ii)** for both marking points **ALLOW** ECF for calculated mol of $Na_2S_2O_3$•$5H_2O$ x 158.2 correctly calculated for the 2nd mark **ALLOW** calculator value or rounding to 3 significant figures or more but **IGNORE** 'trailing' zeroes, eg 0.200 allowed as 0.2

Question			er	Marks	Guidance
2	(h)	(i)	Sulfur has six bonded pairs (and no lone pairs) ✓ Electron pairs repel (one another equally) ✓	2	**ALLOW** 'It has six bonded pairs' **ALLOW** bonds for bonded pairs **IGNORE** regions **OR** areas of negative charge **ALLOW** 'bonds repel' **DO NOT ALLOW** 'Atoms repel' or 'electrons repel' 'Lone pairs repel more than bonded pairs' would score the second mark but would contradict the first mark if there is no reference to no lone pairs
		(ii)	The ability of an atom to attract electrons ✓ in a (covalent) bond ✓ (The octahedral shape) is symmetrical ✓	3	 **ALLOW** dipoles cancel out **IGNORE** polar bonds repel **IGNOR**E charges cancel
			Total	**23**	

Question			er	Mark	Guidance
3	(a)		<table><tr><td>particle</td><td>rel charge</td><td>rel mass</td><td>position</td></tr><tr><td>proton</td><td></td><td>1</td><td>nucleus</td></tr><tr><td>neutron</td><td>nil/</td><td>1</td><td>nucleus</td></tr><tr><td>electrons</td><td></td><td>1/2000</td><td>in shells</td></tr></table> ✓	1	1 mark for whole table **ALLOW** '+' on its own for rel charge of proton **DO NOT ALLOW** '1' on its own for rel charge of proton **DO NOT ALLOW** 'positive' for rel charge of proton For neutron **ALLOW** 'neutral' **ALLOW** '–' on its own for rel charge of electron **DO NOT ALLOW** 'negative' for rel charge of electron **IGNORE** '+' if precedes '1' for mass **IGNORE** 'middle/centre' for nucleus
	(b)		The energy required to remove an electron ✓ from each **atom** in **one mole** ✓ of **atoms** in the **gaseous** state ✓	1 1 1	**ALLOW** 'energy to remove one mole of electrons from one mole of gaseous atoms' for three marks **ALLOW** 'The energy required to remove an electron from one mole of gaseous atoms to form one mole of gaseous 1+ ions' for two marks as it does not meet the 2nd marking point For third mark: **ALLOW** ECF of wrong particle being gaseous If no attempt at a definition, **ALLOW one** mark for the equation below, including state symbols $X(g) \rightarrow X^+(g) + e^-$ **OR** $X(g) - e^- \rightarrow X^+(g)$ **ALLOW** e for electrons **IGNORE** state symbol for electron
	(c)		<table><tr><td>a 2p orbital</td><td>2 ✓</td></tr><tr><td>the 3s sub-shell</td><td>2 ✓</td></tr><tr><td>the 4th shell</td><td>32 ✓</td></tr></table>	1 1 1	
	(d)		A repeating pattern (of properties shown across different periods) ✓	1	**ALLOW** 'repeating trend' **DO NOT ALLOW** just 'trend' **OR** 'pattern'
	(e)	(i)	C ✓	1	
		(ii)	Al ✓	1	
		(iii)	N ✓	1	
		(iv)	Al ✓	1	
		(v)	Mg ✓	1	
			Total	13	

Question			er	Mark	Guidance
4	(a)		$MgCO_3 \rightarrow MgO + CO_2$ ✓	1	**IGNORE** state symbols
	(b)	(i)	$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$ Correct balanced equation ✓ Correct states for correct species ✓	1 1	**ALLOW** states mark if MgCl used in place of $MgCl_2$
		(ii)	Similarity: (Both) dissolve **OR** disappear. ✓ Difference: One effervesces **OR** fizzes **OR** bubbles **OR** gas produced ✓	1 1	**ALLOW** (both) 'go clear' **ALLOW** CO_2 produced **DO NOT ALLOW** incorrect gases **DO NOT ALLOW** responses which suggest **A** will effervesce e.g. as **B** will fizz more
		(iii)	203.3	1	**DO NOT ALLOW** 203 or 203.0 **IGNORE** units
		(iv)	 magnesium (ion) with 8 (or no) outermost electrons **AND** 2 x chloride (ions) with '*dot-and-cross*' outermost octet ✓ correct charges ✓	 1 1	**For 1st mark,** if 8 electrons shown around cation then 'extra' electron around anion must match symbol chosen for electrons in cation Shell circles not required **IGNORE** inner shell electrons **ALLOW** correct diagram of a $[Cl^-]$ ion with '2 x' **OR** '2' in front **OR** 'x 2' after the diagram. **ALLOW** correct diagram of $[Cl^-]$ ion with subscript 2. i.e. $[Cl^-]_2$. **DO NOT ALLOW** $[Cl^-_2]$ $[Cl]^-_2$ i.e. for first mark charges do not need to be seen

Question			er	Mark	Guidance
4	(c)		$\frac{1.82}{24.3}$ $\frac{1.05}{28.1}$ $\frac{2.40}{16.0}$ To give 0.0749 0.0374 0.150 Ratio of moles ✓	1	**ALLOW** '24' for Mg (giving 0.0758) and '28' for Si (giving 0.0375) **ALLOW** any correct ratios of moles as calculator value **OR** correct rounding **to 2 sig figs or more** **ALLOW** method from masses being converted to percentages
			Answer = Mg_2SiO_4 ✓	1	**ALLOW** correct answer from a ratio of moles where it is clear that the candidate has divided by the atomic numbers. **ALLOW** ECF for formula from incorrect ratio of moles due to over-rounding calculator error or upside down mole calculation
	(d)	(i)	$\frac{32.00}{1000} \times 0.500 = 1.60 \times 10^{-2}$ (mol) **OR** 0.0160 (mol)✓	1	**ALLOW** 0.016 (mol) **IGNORE** trailing zeroes
		(ii)	$\frac{1.60 \times 10^{-2}}{2} = 8.00 \times 10^{-3}$ (mol) **OR** 0.00800 (mol)✓	1	**ALLOW** ECF for answer **$\frac{\text{d(i)}}{2}$** **ALLOW** 0.008 or 8×10^{-3} (mol) Ignore trailing zeroes **ALLOW** 0.0080 or 8.0×10^{-3}
		(iii)	Molar mass $Mg(OH)_2$ = 58.3 ✓	1	**DO NOT ALLOW** 58 **OR** 58.0
			mass $Mg(OH)_2 = 58.3 \times 8.00 \times 10^{-3} = 0.466(4)$ g ✓	1	**ALLOW** answer to **d(ii)** × 58.3 **ALLOW** 0.47 **ALLOW** ECF for **d(ii)** × incorrect molar mass as calculator value **OR** correct rounding to 2 sig figs or more
			% $Mg(OH)_2 = \frac{0.4664}{0.500} \times 100 = 93.3\%$ ✓	1	**ALLOW** 93% **OR** 93.2% **OR** 93.28% **DO NOT ALLOW d(ii)**/0.5 x 100 **ALLOW** (answer to second marking point/0.500) × 100 as calculator value **OR** correct rounding to 2 sig figs or more **ALLOW** moles method for 3 marks Molar mass = 58.3 0.500/58.3 = =0.00857(6) 0.00800/0857(6) × 100 = 93.3% **ALLOW** correct answer without working for 3 marks
			Total	15	

Question			Expected Answers	Marks	Additional Guidance
5	a	i	^{118}Sn 50p 68n 50e Complete row ✓	1	
		ii	$^{120}_{50}$Sn has (two) more neutrons / 70 neutrons ✓ ora	1	**ALLOW** There is a different number of neutrons **IGNORE** correct reference to protons / electrons **DO NOT ALLOW** incorrect references to protons / electrons **ALLOW** ECF for stated number of neutrons from **1a(i)**
	b	i	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** $\frac{\text{mass of } \mathbf{one\ mole} \text{ of atoms}}{\text{1/12th mass of } \mathbf{one\ mole} \text{ OR } 12\mathbf{g} \text{ of carbon-12}}$
	c		moles of Sn = $\frac{2080}{118.7}$ = 17.52 ✓ $17.52 \times 6.02 \times 10^{23} = 1.05 \times 10^{25}$ atoms ✓	2	**ALLOW** 17.5 up to (correctly rounded) calculator value of 17.52316765 **DO NOT ALLOW** use of 118, which makes moles of Sn = 17.63 **ALLOW** 105×10^{23} atoms **DO NOT ALLOW** answers which are not to three sig figs for second marking point **ALLOW** two marks for answer only of 1.05×10^{25} **ALLOW** one mark for answer only if not 3 sig figs up to calculator value of $1.054894693 \times 10^{25}$ **Eg 100 × 1** **ALLOW** ECF for **any calculated** moles of Sn (based on use of any A_r value) × 6.02×10^{23} if shown to 3 sig figs **DO NOT ALLOW** mass of Sn × 6.02×10^{23}

Question			Expected Answers	Marks	Additional Guidance
5	**d**		$\frac{78.8}{118.7}$ and $\frac{2}{16.0}$ **OR** = 0.66(4) and = 1.3) ✓ $\frac{0.66(4)}{0.66(4)}$ = 1 $\frac{1.325}{0.66(4)}$ = 2 ans = SnO_2 ✓	2	**ALLOW** SnO_2 for one mark if no working shown **ALLOW** use of 118 for this part **IGNORE** incorrect rounding provided given to two sig figs **IGNORE** incorrect symbols e.g. T or Ti for Tin, as long as correct A_r of tin (118.7 or 118) used **ALLOW** Sn_2O for 1 mark ECF if **both** inverted mole calculations are shown **ALLOW** Sn_3O_5 with **evidence** of use of **both** atomic numbers for one mark **ALLOW** 2 marks if candidate has adopted the following approach 78.8% of mass = 118.7 100% of mass = 118.7/0.788 = 150.6 (151) 150.6 – 118.7 = 31.9 (32) **Both** masses would get one mark 31.9/16 = 2
			Total	**9**	