Question Number	Acceptable Answer	Additional Guidance	Mark
1(a)	An answer that makes reference to the following points: • the **average/ mean** mass of atoms (of an element) (1) • on a scale where one atom of ^{12}C has mass 12 **or** • on a scale where the mass of one atom is compared to one twelfth of the mass of an atom of ^{12}C (1)	Do not award 'the **average/ mean** mass of **elements**…'	**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
1(b)(i)	An answer that makes reference to the following points: • neon has three isotopes/ atoms of neon can have three different numbers of neutrons **or** • isotopes have 10, 11 or 12 neutrons		**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
1(b)(ii)	• calculation showing sum of abundance x mass number ÷ total abundance (1) • evaluation of correct answer **to 3 sf** (1)	Example of calculation: $\frac{(93.9 \times 20 + 0.260 \times 21 + 5.84 \times 22)}{100}$ (=20.1194) = 20. 1 Correct answer with no working scores 2 Ignore any units	**2**

(Total for Question 1 = 5 marks)

Question Number	Answer	Additional Guidance	Mark
2(a)	**B** (Group 3)		**1**

Question Number	Answer	Additional Guidance	Mark
2(b)	**C** (Y_2Z)		**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
2(c)	An answer that makes reference to the following points: • the nuclear charge/ number of protons increases (1) • (increasing attraction on) electrons which are in the **same (main) shell** (and have about the same shielding) (1)		**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
2(d)	An answer that makes reference to one of the following points: • the electron being removed/ the outer electron is further from the nucleus **or** • the electron being removed is in a higher energy shell **or** • the electron being removed is screened/ shielded by extra (full electron) shells (1)		**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
2(e)(i)	$X^{+}(g) \rightarrow X^{2+}(g) + e^{(-)}$ • all species correct (1) • correct state symbols (1)	Mark independently	**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
2(e)(ii)	**B** (Na)		**1**

(Total for Question 2 = 8 marks)

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>*3</td><td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking point</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5-4</td><td>3</td></tr>
<tr><td>3-2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>

The following table shows how the marks should be awarded for structure and lines of reasoning.

<table>
<tr><th></th><th>Number of marks awarded for structure of answer and sustained line of reasoning</th></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning.</td><td>1</td></tr>
</table>
</td><td>Guidance on how the mark scheme should be applied

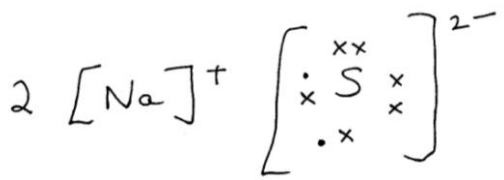
The mark for indicative content should be added to the mark for the lines of reasoning. For example, an answer with five indicative marking points that is partially structured with some linkages and lines of reasoning, scores 4 marks (3 for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).

If there are no linkages between points, the same five indicative points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td><td></td></tr>
</table>

	Answer has no linkages between points and is unstructured.	0		
	Indicative content: • only barium nitrate gives a precipitate with sulfate ions • $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$ • only magnesium nitrate gives a precipitate with hydroxide ions • $Mg^{2+} + 2OH^- \rightarrow Mg(OH)_2$ • magnesium nitrate decomposes faster than barium nitrate (as Mg^{2+} (radius) smaller than Ba^{2+}) • $2X(NO_3)_2 \rightarrow 2XO + 4NO_2 + O_2$ where X = Mg or Ba		Allow full equations / non-ionic equations for bullet points 2 and 4 Ignore state symbols Allow multiples	**6**

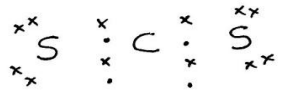
(Total for Question 3 = 6 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
4(a)	• $(1s^2 2s^2)\ 2p^6\ 3s^2 3p^4$	Allow numbers written as subscripts; $2p_x^2\ 2p_y^2\ 2p_z^2$; $3p_x^2\ 3p_y^1\ 3p_z^1$	**1**

Question number	Acceptable Answer	Additional Guidance	Mark
4(b)(i)	• two Na^+ with empty outer shell, or 8e representing second shell (1) • S^{2-} with 6 crosses and 2 dots (or vv) (1)	 Allow all dots or all crosses Allow $[Na]^+ + [Na]^+$ Do not award $[Na]_2^+$ Allow for one mark, correct dot and cross diagrams (with two sodiums) and charges missing	**2**

Question Number	Answer	Additional Guidance	Mark
4(b)(ii)	**C** (It conducts when liquid but not when solid)		**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
4(b)(iii)	An answer that makes reference to the following points: • attractive force between sodium ion and anion is greater with sulfide (1) • (because) the sulfide ion has a higher charge than the chloride ion/has charge 2- while chloride is 1- (1)		**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
4(c)(i)	• 2 electrons from C shared with 2 from each S to show 2 double bonds (1) • remaining 4 electrons on each S correct (1)		**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
4c(ii)	An answer that makes reference to the following points: • angle =180° (1) • there are two sets of bonding electrons/ two electron clouds (1) • which repel to maximum separation/ minimum repulsion (1)	Allow bonds repel Do not award atoms repel Do not award second and third MP if they refer to any lone pairs on carbon	**3**

Question Number	Answer	Additional Guidance	Mark
4(d)(i)	**D** (the energy released when sodium ions and sulfide ions are hydrated is greater than the energy required to break the bonding between sodium ions and sulfide ions)		**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
4d(ii)	An answer that makes reference to the following points: • no possibility of forming dipole dipole interactions / hydrogen bonds (1)	Allow carbon disulfide is non polar and water is polar	**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
4(e)	**D** (sulfur(IV) oxide and sodium sulfate(VI))		**1**

(Total for Question 4 = 14 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
5(a)(i)	• calculation of % by mass of oxygen and calculation of moles of oxygen (1) • evaluation of number of moles of C and H empirical formula is CH_2O ratio 1 : 2: 1 (1) • so the molecular formula is $C_2H_4O_2$ (1)	Example of calculation (% by mass of) **O** = 53.33(%) and mol of O = 53.33 / 16.0 = 3.333 C : H : O $\frac{40.00}{12.0}$: $\frac{6.67}{1.0}$: $\frac{53.33}{16.0}$ 3.333 : 6.67 : 3.333 $\frac{3.333}{3.333}$: $\frac{6.67}{3.333}$: $\frac{3.333}{3.333}$ = 1 : 2 : 1 Molar mass = 2x empirical formula mass = 2x 30 = 60	**3**

Question Number	Acceptable Answer	Additional Guidance	Mark
5(a)(ii)	**C** (4.82×10^{23})		**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
5(b)	$2Na(s) + 2H^+(aq) \rightarrow 2Na^+(aq) + H_2(g)$ • correct species (1) • balanced with state symbols correct (1)	Allow multiples	**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
5(c)	• calculation of moles of acid **and** CO_2 (1) • calculation of volume of CO_2 in cm^3 (1)	Example of calculation 8.00 g acid = 8/60 = 0.133 mol Mols of CO_2 = 0.133/2 = 0.0667 Volume gas = (24 × 0.0667) = 1.600 dm^3 = 1 600 cm^3	**2**

(Total for Question 5 = 8 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
6(a)	An explanation that makes reference to the following points: • chlorine is a gas, bromine is a liquid, iodine is a solid (1) • the number of electrons per molecule (X_2) increases going down the group (1) • so magnitude of London forces between molecules increases (1) • more energy required to separate molecules / more energy required to break the intermolecular forces (1)	Allow reverse argument for marking points 2, 3 and 4 Allow molecules increase in size / mass from chlorine to iodine OR surface area of molecules increases Allow van der Waals forces for 'London forces' Allow 'more London forces' for magnitude increases Allow 'more heat' needed to separate molecules **OR** Allow more energy required to overcome the intermolecular attractions Do not award marking points 3 and 4 for references to other types of intermolecular force or intramolecular bond	**4**

Question Number	Acceptable Answer	Additional Guidance	Mark
6(b)	An explanation that makes reference to the following points: • electronegativity difference between the atoms in HF is greater than in other hydrogen halides **OR** electronegativity difference in HF (1.9), HCl (0.9), HBr (0.7) and HI (0.4) (1) • (so) only HF forms hydrogen bonds (1) • the intermolecular forces in HF are stronger than in the other hydrogen halides **OR** Hydrogen bonds are stronger than London forces in other hydrogen halides (1)	Allow electronegativity of F (4.0), Cl (3.0), Br (2.8) and I (2.5)	**3**

Question Number	Acceptable Answer	Additional Guidance	Mark
6(c)(i)	• $H_2SO_4 + NaCl \rightarrow NaHSO_4 + HCl$ (1)	Allow multiples Allow $H_2SO_4 + 2NaCl \rightarrow Na_2SO_4 + 2HCl$ Ignore state symbols	**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
6(c)(ii)	An explanation that makes reference to the following points: • **Q** = NH_3 / ammonia (1) • Observation = white smoke / (dense) white fumes (1)	Do not award ammonium Do not award misty fumes	**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
6(d)(i)	**D** (purple)		**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
6(d)(ii)	• $2I^- \rightarrow I_2 + 2e^{(-)}$ (1)	Allow multiples Ignore state symbols	**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
6(d)(iii)	• $H_2SO_4 + 8H^+ + 8e^- \rightarrow H_2S + 4H_2O$ **OR** $SO_4^{2-} + 10H^+ + 8e^- \rightarrow H_2S + 4H_2O$ (1)	Allow multiples Ignore state symbols	**1**

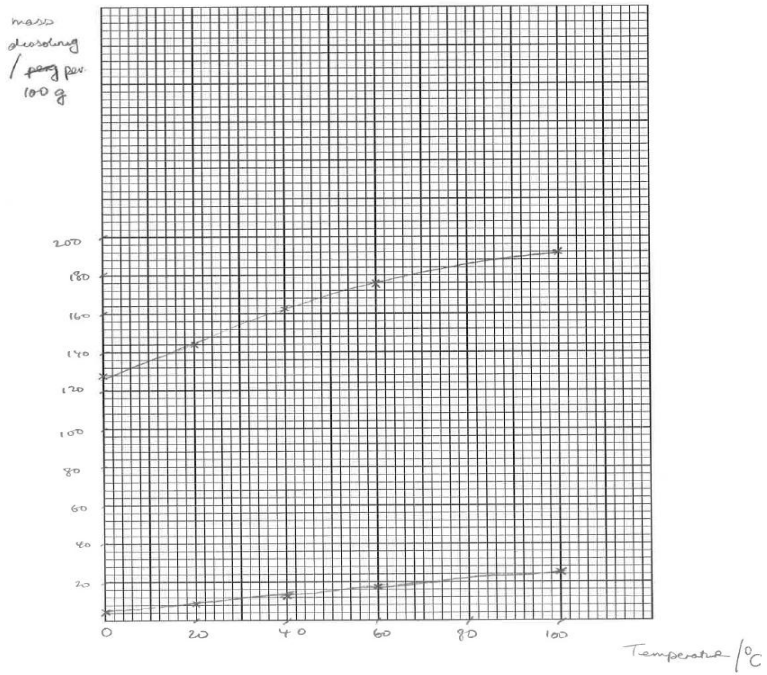
Question Number	Acceptable Answer	Additional Guidance	Mark
6(d)(iv)	• $H_2SO_4 + 8H^+ + 8I^- \rightarrow H_2S + 4H_2O + 4I_2$ **OR** $SO_4^{2-} + 10H^+ + 8I^- \rightarrow H_2S + 4H_2O + 4I_2$ (1)	Allow multiples, 8HI for $8H^+ + 8I^-$ Ignore state symbols	**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
6(e)(i)	An explanation that makes reference to the following points: • with $AgNO_3$: white precipitate forms (1) • with dilute NH_3: precipitate dissolves/ solution forms (1)		**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
6(e)(ii)	An explanation that makes reference to the following points: • no because conc NH_3 (would not distinguish AgCl as it) also would dissolve AgBr	Do not award AgI also dissolves in conc NH_3	**1**

(Total for Question 6 = 17 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
7(a)	An explanation that makes reference to the following points: • this is a redox reaction because I reduced from 0 to -1 (1) • and I oxidised from 0 to +5 (1)	Allow 'this is a disproportionation reaction' provided there is reference to reduction and oxidation	**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
7(b)(i)	• correct labelling of axes with suitable scales covering at least half the grid in each direction (1) • correct plotting of solubility of KI with a best fit line (1) • correct plotting of solubility of KIO_3 with a best fit line (1) 		**3**

Question Number	Acceptable Answer	Additional Guidance	Mark
7(b)(ii)	An explanation that makes reference to the following points: • realisation that only KIO_3 will crystallise out (1) • at 10°C ~0.63 g will remain in solution so 1.71 - 0.63 = 1.08 g will crystallise out (1)	Allow mass remains in solution between 0.6 and 0.65 so mass crystallises out between 1.06 g to 1.11 g	**2**

(Total for Question 7 = 7 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
8(a)	• mol Li and mol H_2 (1) • use of $pV=nRT$ in calculation including conversion of temperature to kelvin (1) • correct calculation (1) • 212 (cm^3) (1)	Example of calculation mol Li = (0.120/6.9) = 0.017391304/0.0174 Allow (0.120/7) = 0.0171 mol H_2 = 0.01739/2 = 0.008695 $V = \frac{(0.008695 \times 8.31 \times 293)}{1.00 \times 10^5}$ = 2.1172×10^{-4} / 2.12×10^{-4} (m^3)	**4**

Question Number	Acceptable Answer	Additional Guidance	Mark
8(b)(i)	An explanation that makes reference to: • volumetric (flask)		**1**

Question Number	Acceptable Answer		Additional Guidance	Mark
8(b)(ii)	• mol of HCl = mol of LiOH	(1)	<u>Example of calculation</u> (20.40 × 0.200)/1000 = 4.08 × 10^{-3}/0.00408	
	• calculation of concentration of LiOH	(1)	Concentration = 0.00408 x 1000/25 = 0.1632 mol dm^{-3}	
	• mol of Li in 100 cm^3	(1)	mol in 100 cm^3 = 0.1632 x 100/1000 = 0.01632	
	• mass of Li in 0.1200 g	(1)	mass Li = (6.9 × 0.01632) = 0.1126/0.113 (g)	
	• % purity	(1)	% purity = (0.1126/0.120) x 100 = 93.8 Allow (0.113/0.120) x 100 = 94.2 **OR** For 4th and 5th marks using data from (a) % purity = (0.01632/ 0.01739) = 93.8 Allow ecf for steps in calculation Ignore significant figures except one significant figure including for final answer dependent on rounding in steps of the calculation	**5**

Question Number	Acceptable Answer	Additional Guidance	Mark
8(c)(i)	$\frac{(2 \times 0.005 \times 100)}{0.120} = 8.33\%$		**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
8(c)(ii)	An explanation that makes reference to the following points: • greatest error is in finding mass (1) • because the mass is small compared to the volumes **OR** the errors in pipette and burette volumes are much smaller than the answer to (c)(i) (1)		**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
8(c)(iii)	An explanation that makes reference to the following points: • use a larger mass of lithium (and either a larger volume of water or a more concentrated solution of acid) (1) • the largest percentage error (in the mass) will then be reduced (1)		**2**

(Total for Question 8 = 15 marks)

TOTAL FOR PAPER = 80 MARKS