Question number	Answer	Additional guidance	Mark
2(a)	An explanation that combines identification via a judgement (1 mark) to reach a conclusion via justification/reasoning (1 mark): • a negative ion must have more electrons than protons in the particle (1) • therefore Z will have a 2– charge (1)	Do not allow any comparison involving neutrons.	**(2)**

Question number	Answer	Additional guidance	Mark
2(b)	40 + 2 × (14 + 16 × 3) (1) = 164 (1)	Award full marks for correct numerical answer without working.	**(2)**

Question number	Answer	Mark
2(c)	• Li ion with empty outer shell (1) • 1+ charge on Li (1) • 8 electrons on outer shell of F (1) • 1– charge on F (1)	**(4)**

Question number	Answer	Mark
3(a)(i)	C	**(1)**

Question number	Answer	Mark
3(a)(ii)	C	**(1)**

Question number	Answer	Mark
3(b)	Any two of the following points. For the acid, use the same: • volume (1) • concentration (1) • temperature (1)	**(2)**

Question number	Answer	Mark
3(c)(i)	electrolysis (1)	**(1)**

Question number	Answer	Mark
3(c)(ii)	An answer that combines identification- knowledge (1 mark) and understanding (1 mark) and reasoning/justification- understanding (1 mark) • aluminium compounds are more stable than iron compounds (1) • so carbon is not a strong enough reducing agent to produce aluminium from its ore (1)	**(2)**

Question number	Answer	Mark
3(d)	$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$ • Correct formulae (1) • Balancing of correct formulae (1)	(2)

Question number	Answer	Mark
4(a)	<table><tr><th>salt</th><th>soluble</th><th>insoluble</th></tr><tr><td>ammonium chloride</td><td>✓</td><td></td></tr><tr><td>lithium sulfate</td><td>✓</td><td></td></tr><tr><td>magnesium carbonate</td><td></td><td>✓</td></tr></table> • All three correct (2) • Any two correct (1)	(2)

Question number	Answer	Additional guidance	Mark
4(b)	• mass values in correct places (1) • multiplication by 100 (1) • correct final answer to two significant figures (1)	$\frac{2.53}{2.85} \times 100 = 88.8\%$ 89% (to 2 s.f.) Award full marks for correct numerical answer without working.	(3)

Question number	Answer	Mark
4(c)	An explanation that combines identification – improvement of the experimental procedure (maximum 2 marks) and justification/reasoning, which must be linked to the improvement (maximum 2 marks): • add excess sodium sulfate solution rather than a few drops (1) • so more reaction occurs to form more lead sulfate (1) • filter the reaction mixture rather than pour off the liquid(1) • so none of the lead sulfate is lost on separation(1) • wash the lead sulfate (1) • so the impurities are removed (1) • place the lead sulfate in an oven/warm place (1) • so the lead sulfate is dry (1)	(4)

Question number	Answer	Mark
4(d)	• volumes of solution too large for titration method (1) • large volumes of liquid need to be heated and then allowed to crystallise (1)	(2)

Question number	Answer	Mark
5(a)(i)	C	(1)

Question number	Answer	Mark
5(a)(ii)	C	(1)

Question number	Answer	Mark
5(b)	reactants are being used up (1)	(1)

Question number	Answer	Mark
5(c)	An explanation that combines identification via a judgement (1 mark) to reach a conclusion via justification/reasoning (1 mark): • aluminium and copper have different size atoms (1) • and so this prevents the layers of metal atoms from sliding over one another (1)	(2)

Question number	Answer	Additional guidance	Mark
5(d)	proportion gold = 9 ÷ 24 (= 0.375) (1) mass = 0.375 × 12 = 4.5 (g) (1)	Award full marks for correct numerical answer without working.	(2)

Question number	Answer	Mark
6(a)	An explanation that combines identification – application of knowledge (1 mark) and reasoning/justification – application of understanding (1 mark): • **J** and **K** are electrolytes (1) • because their solutions conduct electricity and are decomposed (1)	(2)

Question number	Answer	Mark
6(b)	D	(1)

Question number	Answer	Mark
6(c)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (3 marks): • hydrogen (H^+) and sodium (Na^+) ions attracted to cathode, hydroxide (OH^-) ions and sulfate (SO_4^{2-}) ions attracted to anode (1) • because the ions are attracted to the oppositely charged electrode (1) • 2 hydrogen ions/2 H^+ accept 2 e to form hydrogen molecule/H_2 (1) • 4 hydroxide ions/4 OH^- lose 4 e to form oxygen molecule/O_2 (1)	(4)

Question number	Answer	Additional guidance	Mark
8(a)(i)	• particles are same size when they should be different sizes (1) • model is in 2D but crystal is 3D (1)	Allow reverse statements giving correct information.	**(2)**

Question number	Answer	Mark
8(a)(ii)	An explanation that combines identification – knowledge (1 mark) and reasoning/justification – understanding (2 marks): • very strong bonds/ionically bonded (1) • between 2+ cations and 2– anions (1) • so requires lot of energy to separate magnesium and oxide ions to melt the solid (1)	**(3)**

Question number	Answer	Additional guidance	Mark
8(b)(i)	$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$ • all formulae on correct side (2) • balancing (1)	Allow 3/4 formulae (1)	**(3)**

Question number	Answer	Additional guidance	Mark
8(b)(ii)	relative formula mass copper carbonate $= 63.5 + 12.0 + (3 \times 16.0)$ $= 123.5$ relative formula mass copper oxide $= 63.5 + 16.0$ $= 79.5$ (1) mass copper oxide $= \frac{15.0 \times 79.5}{123.5} = 9.7$ g to 2 s.f. (1) Answer must be to two significant figures OR moles of copper carbonate $= \frac{15.0}{123.5} = 0.12145$ (1) mass of copper oxide = moles $CuCO_3 \times 79.5$ = 9.7 g to 2sf (1) Answer must be to two significant figures	Award full marks for correct numerical answer without working.	**(2)**

Question number	Answer	Additional guidance	Mark
8(c)	2.4/24 moles Mg = 0.1 mol (1) and 0.2 moles H_2O has mass 0.2 × formula mass H_2O = 3.6 g (1) total mass reactants = 2.4 + 3.6 = 6.0 g is the same as total mass products = 5.8 + 0.2 = 6.0 g (1)	Award full marks for correct numerical answer without working.	**(3)**

Question number	Answer	Mark
9(a)(i)	An explanation that makes reference to: identification – knowledge (1 mark) and reasoning /justification – knowledge (1 mark): • a strong acid is completely ionised in solution/exists completely as ions (1) • but a weak acid is only partly ionised/exists mainly as molecules with very few ions present (1)	**(2)**

Question number	Answer	Mark
9(a)(ii)	hydroxide ions react with hydrogen ions and reduce the hydrogen ion concentration therefore increase pH (1)	**(1)**

Question number	Answer	Mark
9(b)	$ZnO + 2HNO_3 \rightarrow Zn(NO_3)_2 + 2H_2O$ • zinc nitrate formula (1) • full, balanced equation (1)	**(2)**

Question number	Answer	Additional guidance	Mark
9(c)	mass = $50 \times \frac{40}{1000}$ (1) = 2 (g) (1)	Award full marks for correct numerical answer without working.	**(2)**

Question number	Answer	Additional guidance	Mark
10(a)	Formula mass ammonium chloride = 14.0 + 4.00 + 35.5 = 53.5 moles of ammonium chloride = $\frac{10.0}{53.5}$ = 0.187 (1) volume ammonia = 0.187 × 24 = 4.49 dm^3 (1) or • 2 × 53.5 = 107 g ammonium chloride produces 2 × 24 = 48 dm^3 ammonia (1) • 10.0 g ammonium chloride produces $\frac{10.0}{2\times53.5} \times 2 \times 24 = 4.49\ dm^3$ ammonia (1)	Award full marks for correct numerical answer without working.	**(2)**

Question number	Answer	Additional guidance	Mark
10(b)(i)	25 ÷ 1000 × 0.1 = 0.0025 (1) 35 ÷ 1000 × 0.075 = 0.002 625 (1) The acid is in excess (1)	Third mark only awarded as conclusion from calculated data.	**(3)**

Question number	Answer	Mark
10(b)(ii)	$\frac{36.20 + 36.30}{2}$ = 36.25 (1)	**(1)**

Question number	Answer	Mark
10(b)(iii)	D	**(1)**

Question number	Answer	Additional guidance	Mark
10(c)	mol of acid = 24.80 ÷ 1000 × 0.200 (= 0.004 96 mol) (1) mol NaOH = 2 × 0.004 96 (= 0.009 92) (1) conc. of NaOH = 0.009 92 ÷ 25.0 × 1000 (1) = 0.3968/0.397 (mol dm^{-3}) (1) or (25.00 × conc NaOH) ÷ 2 = 24.80 × 0.200 (2) conc NaOH = 2 × 24.80 × 0.200 ÷ 25.00 (1) = 0.3968/0.397 (mol dm^{-3}) (1)	Award full marks for correct numerical answer without working. Allow max 3 marks if missing '2 ×' in step 2.	**(4)**

Question Number	Answer	Acceptable answers	Mark
4(a)	D		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(b)(i)	the mass (of product) is calculated (from the balanced equation) (1)		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(b)(ii)	$\frac{\text{actual yield}}{\text{theoretical yield}}$ / $\frac{2.8}{4.0}$ (1) x 100 (1)	allow formula described in words	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(b)(iii)	Any **two** from the following points • loss of product during experiment (1) • reaction does not complete (1) • not enough carbon in mixture (1) • other (unwanted) reactions occur (1)		**(2)**

Question Number	Answer	Acceptable answers	Mark
4 (c)	63.5 + (2 x 35.5) / 134.5 (1)		**(1)**

Question Number	Answer	Acceptable answers	Mark
4 (d)	• mass of oxygen = 14.3 – 12.7 (1) =1.6 copper atoms: oxygen atoms = 12.7/63.5 : 1.6/16 (1) 0.2 : 0.1 • Cu_2O (1)		**(3)**

Question Number	Answer	Acceptable answers	Mark
4(a)(i)	**C** $CuCl_2$		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(a)(ii)	An explanation linking the following points **Either** • the amount of product calculated (1) • using the equation (for the reaction) (1) **Or** • the maximum amount of {product / copper chloride} (1) • when all {reactant / copper} reacts (1)	using reacting masses amount of product when all {reactant / copper} reacts (2)	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(b)(i)	$2Fe(s) + 3Br_2(g) \rightarrow 2FeBr_3(s)$ reactant formulae (1) balancing correct formulae (1) state symbols (1) s and g must be lower case	**allow** state symbol mark even if other marks not awarded	**(3)**

Question Number	Answer	Acceptable answers	Mark
4(b)(ii)	56 + (3 x 80) (1) = 296	give full marks for correct answer with no working	**(1)**

Question Number	Answer	Acceptable answers	Mark
4(b)(iii)	ratio: 56/310 (1) % iron 56/310 x 100 (%) (1) (= 18 (%))	any number/310 x 100 (%) 18.06/18.1 give full marks for correct answer with no working	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(b)(iv)	HO	OH, O_1H_1, H_1O_1	**(1)**

Question Number	Answer	Acceptable answers	Mark
5(a)(i)	shared pair of electrons (between two atoms)	two shared electrons reject between two or more atoms	**(1)**

Question Number	Answer	Acceptable answers	Mark
5(a)(ii)	**D** it has a low boiling point		**(1)**

Question Number	Answer	Acceptable answers	Mark
5(b)	An description including **three** of the following points • cool (to about -200 °C) / liquefy (air) (1) • fractional distillation (1) • allow to warm / heat (1) • {nitrogen / lower boiling point} obtained from top of column (1) • {oxygen / higher boiling point} obtained from bottom of column (1)	mention of fractionating column/ fractionation ignore state of nitrogen ignore state of oxygen can be separated because they have different boiling points(1) alternative to last two points	**(3)**

Question Number	Answer	Acceptable answers	Mark
4(a)	to allow air/oxygen in	to ensure magnesium reacts/burns / combusts	**(1)**

Question Number	Answer	Acceptable answers	Mark
4(b)(i)	all points correctly plotted to half a small square (2) line of best fit (1)	Allow one mark for four or five correctly plotted points ecf their points	**(3)**

Question Number	Answer	Acceptable answers	Mark
4(b)(ii)	Any one from not all magnesium {burned / reacted} / some left / incomplete reaction not enough air/oxygen some magnesium oxide / smoke lost	 lid not lifted / not enough times lid left off too long (so loses MgO)	**(1)**

Question Number	Answer	Acceptable answers	Mark
4(c)	$2Mg + O_2 \rightarrow 2MgO$ left hand formulae (1) right hand formula (1) balancing correct formulae (1)	correct multiples	**(3)**

Question Number	Answer	Acceptable answers	Mark
4(d)	0.414 / 207 or 0.064 / 16 (1) 0.002 : 0.004 or 1 : 2 (1) empirical formula PbO_2 (1)	if 207 / 0.414 and 16 / 0.064 ratio 500 : 250 or 2 : 1 (1) empirical formula Pb_2O (1) allow 3 marks for 0.414 / 207 or 0.064 / 32 ratio 1 : 1 empirical formula PbO_2 allow 2 marks for if 0.414 / 207 and 0.064 / 32 ratio 1 : 1 empirical formula PbO	**(3)**

Question Number	Answers	Acceptable Answers	Mark
2(a)(i)	A displacement		**(1)**

Question Number	Answers	Acceptable Answers	Mark
2(a)(ii)	orange	Any colour or combination of colours from brown, red, orange and yellow Ignore shade of colours Reject other colours combined with these e.g. yellow-green	**(1)**

Question Number	Answers	Acceptable Answers	Mark
2(b)	**C**		**(1)**

Question Number	Answer	Acceptable answers	Mark
2(c)	(H_2 + Br_2 →) 2HBr • correct formula for HBr **(1)** • balancing of correct formulae **(1)**	Ignore state symbols Allow BrH **(1)**	**(2)**

Question Number	Answer	Acceptable answers	Mark
2(d)	[24 + 2x35.5] **(1)** (= 95)	95 with no working [24 + 2x35.5] with no answer or an incorrect answer scores **(1)**	**(1)**

Question Number	Answers	Acceptable Answers	Mark
2(e)	• relative formula mass =[23 + 19] **(1)** (= 42) • [(19/their relative formula mass) x100] **(1)** (=45.2(%)) **consequential** on their relative formula mass	(19/42) x 100 **(2)** (= 45.2 (%)) (19/[19+23]) x 100 **(2)** (= 45.2 (%)) 45/45.2 (%) with no working **(2)** Ignore additional significant figures Allow 42 seen in working **(1)** Allow (19/23) x 100 = {82.6% / 83%} **(1)**	**(2)**

Total for Question 2 = 8 marks

Question Number	Answer	Acceptable answers	Mark
4(a)(iv)	• (in 100 atoms) mass of copper-63 atoms = 63 x 70 / 63 x 0.7 / 63 x 7 **(1)** (= 4410 / 44.1 / 441) • mass of copper-65 atoms = 65 x 30 / 65 x 0.3 / 65 x 3 **(1)** (= 1950 / 19.5 / 195) • relative atomic mass = $\frac{(63 \times 70 + (65 \times 30)}{100}$ / $\frac{4410 + 1950}{100}$ 44.1 + 19.5/ $\frac{441+ 195}{10}$ **(1)** (= 63.6)	63.6 with no working **(3)** 63.5/64 with no working **(0)** Allow correct working shown to calculate 63.6 then final answer is rounded to 64 **(3)** Note: correct working shown to calculate 63.6 then final answer is incorrectly rounded to 63.5/63 **(2)** Ignore any unit e.g. g Allow TE for third mark e.g if percentages used the wrong way round 64.4 scores **(1)**	**(3)**

Question Number	Answer	Acceptable answers	Mark
4(b)(i)	• two electrons/ $2e^{(-)}$ **(1)** • {loses/gives away} electrons **(1)**	Reject any reference to a covalent bond or sharing electrons (0) $Cu \rightarrow Cu^{2+} + 2e^{(-)}$ **or** $Cu - 2e^{(-)} \rightarrow Cu^{2+}$ **(2)** Allow +2 for charge Allow transfers electrons to another atom **(1)** Allow electrons taken away **(1)** Ignore electrons are missing Ignore references to the nitrate ion/other non-metals Ignore references to full outer shell	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(b)(ii)	$Cu(NO_3)_2$	Formula must be totally correct including subscripts, letter case and brackets Allow $Cu^{2+}(NO_3^-)_2$ Ignore any balancing numbers in front of formula Ignore any working/attempted equation to find the formula	**(1)**

Total for Question 4 = 11 marks

Question Number	Answer	Acceptable answers	Mark
6(a)	Fe Cl 2.8/56 3.55/35.5 (1) 0.05 0.1 or 1 2 (1) $FeCl_2$ (1)	Cl_2Fe $FeCl_2$ with no working (3) Consequential errors: if "upside down" ie 56 / 2.8 and 35.5 / 3.55 ratio 20 : 10 or 2 : 1 (1) empirical formula Fe_2Cl (1) allow 3 marks for 2.8 / 56 and 3.55 / 71 ratio 0.05: 0.05 or 1 : 1 empirical formula $FeCl_2$ allow 2 marks for 2.8 / 56 and 3.55 / 71 ratio 0.05: 0.05 or 1 : 1 empirical formula FeCl allow 2 marks for Fe Cl 2.8/56 3.55/35.5 (1) 0.5 0.1 (0) Fe_5Cl (1) - ECF	**(3)**

Question Number	Answer	Acceptable answers	Mark
6(b)	**EITHER** 2x23 (1) g Na makes 2x58.5 (1) g NaCl 9.2 g Na makes (2x58.5)x9.2 g NaCl 46 (1) (= 23.4 g) **OR** 23 g Na makes 58.5 (1) g NaCl 9.2 g Na makes (58.5)x9.2(1) g NaCl 23(1) (1) (= 23.4 g) mark consequentially eg 46 (1) g Na makes (2x23+35.5) (0) g NaCl 9.2 g Na makes (2x23+35.5)x9.2 (1) g NaCl 46 (= 16.3 g)	23.4 g with no working (3) 23.4 g from any method (3) do not accept 23(.0) mol Na used = 9.2/23 (1) (= 0.4) mol NaCl = 0.4 (1) mass NaCl = 0.4 x 58.5 (1) (= 23.4 g) Ignore units throughout unless incorrect mark consequentially awarding 2 marks for 46.8 g,11.7 g and 16.3 g (see last example opposite).	**(3)**

Question number	Answer	Acceptable answers	Marks
4 (c)	$\frac{12.7}{63.5}$ = (0.2) **and** $\frac{3.2}{32}$ = (0.1) (1) 2 : 1 (1) Cu_2S (1)	reject $\frac{63.5}{12.7}$ = 5 and $\frac{32}{3.2}$ = 10 allow ECF allow Cu_2S with incorrect or no working (1) allow SCu_2	**(3)**

Question number	Answer	Acceptable answers	Marks
4 (d)	25.4 g copper = $\frac{25.4 \times 159}{127}$ = (31.8) (2) OR 25.4 g copper give = $\frac{25.4 \times 79.5}{63.5}$ = (31.8) (2) $\frac{159}{127}$ = (1.2519) (1) x 25.4 = (31.8) (1) OR $\frac{79.5}{63.5}$ = (1.2519) (1) x 25.4 = (31.8) (1)	31.8 / 31.75 alone gains 2 marks allow working using moles $\frac{25.4}{63.5}$ = (0.4) (1) 0.4 x 79.5 = (31.8) (1) OR $\frac{25.4}{127}$ = (0.2) (1) 0.2 x 159 = (31.8) (1) If no other mark scored allow {2 x 63.5 g / 127} copper gives {2 x 79.5 g /159} copper oxide (1)	**(2)**

(Total for Question 4 = 10 marks)

Question Number		Indicative Content	Mark
QWC	***5d**	An explanation to include some of the following points neon-22 has • 10 protons • 12 neutrons • 10 electrons • protons and neutrons in nucleus • electrons surround nucleus • electrons in shells/energy levels/2.8 • same number of • protons and electrons • different number of neutrons relative atomic mass • is the average mass of an atom in the sample / represents (a weighted mean of) a mixture of the two isotopes • more neon-20 than neon-22 • neon-20 less mass than neon-22 • (therefore) relative atomic mass closer to -20 • 20 x 90 (=1800) • 22 x 10 (=220) • $\frac{1800 + 220}{100}$ (=20.2)	**(6)**
Level	**0**	No rewardable content	
1	**1 - 2**	• A limited explanation of the structure of neon-22 • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy	
2	**3 - 4**	• A simple discussion of EITHER the structure of neon-22 and a qualitative treatment of the relative atomic mass OR a quantitative treatment of relative atomic mass of the sample OR a detailed discussion of the structure of the atom. • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy	
3	**5 - 6**	• A detailed explanation of why the relative atomic mass is 20.2 and a description of the atomic structure of neon 22 OR a qualitative discussion of why the relative atomic mass is 20.2 and a detailed discussion of the atomic structure. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors	

(Total for Question 5 = 12 marks)