Separate Science (Chemistry) Unit 4 Chemical change – mark scheme

Foundation

Question number	Description	Marks	Page number
4.4.1 Reactivity of metals			
1	**Conservation of mass**, multiple choice on physical states and oxidation reaction, simplifying percentage into a ratio, advantages of recycling copper	10	6
5	Why mass is lost in heating copper carbonate, calculating mean in results table, identifying anomalous result, suggesting improvement to method to ensure reaction is complete, drawing line of best fit on graph, graph interpolation, extrapolation calculation using values from graph	10	7
6	Matching variable from a method, completing a bar graph, (4.5.1 reason why reaction is not endothermic, reaction profile multiple choice), placing metals in order of reactivity, describing method to find position of a metal in reactivity series	12	9
4.4.2 Reactions of acids			
3	Calculating total mass from masses in a table in mg and then converting to g, gas produced multiple choice when calcium carbonate and hydrochloric acid react, elements from symbol formula, multiple choice to improve accuracy in method, multiple choice on variables	8	12
3	Ions found in acid and meaning of aq multiple choice, suggesting pH of solution after hydrochloric is added, describing method to identify three solids using information a results table of observations and pH when added to water and solubility of the solids in water	9	13
5	Skills question in context of calcium carbonate reacting with hydrochloric acid - state symbol, reason for decrease in mass when reaction happens, range in results table, calculate mean from results table, identifying variables, sentence gap fill, graph interpolation.	8	14
5	(4.1.1 elements, symbol and number of atoms in a compound), completing word equation for reaction, type of substance	13	15

	multiple choice, drawing labelled diagram for producing copper sulphate crystals, matching equipment to measurement, **calculate concentration in g/dm^3 from mass dissolved in cm^3**		
6	Matching measurement to equipment, calculating a mean temperature increase, improving accuracy multiple choice, completing word equation for hydrochloric acid and sodium hydroxide, matching up pH and colour of universal indicator	9	17
4.4.3 Electrolysis			
2	(4.4.2 acid for making a salt multiple choice, ordering stages of making salt), naming products for each electrode, reading change in Y and X axes and then calculating gradient, electrolysis of aluminium gap fill	11	19
4	Reading volume of gas in an inverted measuring cylinder, graph interpretation multiple choice, completing table on products at anode and cathode for different electrolytes	8	21
4	Balancing aluminium extraction symbol equation, explain why aluminium ions move toward electrode, how many electron aluminium ions gain at cathode, word equation for carbon dioxide production at anode, why anodes need to be replaced, explain why ceramic anode needs to have high melting point and be unreactive	14	22
5	Matching variable to description, reason for anomalous result multiple choice, predicting result from trend in results table, electrolysis gap fill, reason solid copper sulphate doesn't conduct electricity,	8	24

Common content

Question number	Description	Marks	Page number
4.4.1 Reactivity of metals			
1	Reactivity of metals from diagram of reaction with acid, naming control variables for experiment, naming independent variable, giving prediction and reason, **calculate concentration in g/dm^3 from mass dissolved in cm^3**	9	25
2	(4.1.1 and 4.1.3 number of subatomic particles in an atom, difference between group one and transition metal), explaining why carbon can be used to extract nickel from nickel oxide, **calculation atom economy for symbol equation**	11	28

4.4.2 Reactions of acids			
1	Naming type of substance that will form salt when reacted with acid, formula of calcium nitrate from ions, describe method to produce dry crystals of magnesium sulphate (6 marks)	8	30
2	Ions in acids, complete word equation, naming and reading volume in burette, describe how to carry out titration to find which of two samples is more concentrated (6 marks)	11	32
2	(4.8.2 gas test for carbon dioxide), method for describing dry pure crystals of magnesium chloride (6 marks)	8	34
2	Giving state symbol, formula of nitric acid, colour of universal indicator with different chemicals, results table to show change in pH when nitric acid added to ammonia solution, **calculate percentage by mass of oxygen in ammonium nitrate**	8	35
3	Describe method to prepare pure crystals of copper sulphate	6	36
4.4.3 Electrolysis			
1	Gas produced at anode, multiple choice about cathode product, calculate mean from results table, calculate trial 2 in results table where trial 1 and 3 and mean are given, **calculate mass of solute in given volume in cm^3 from concentration in g/dm^3**	8	37

Higher

Question number	Description	Marks	Page number
4.4.1 Reactivity of metals			
5	Plotting bar graph, describe method to find position of unknown metal in reactivity series (4.5.1 reaction profile)	10	38
5	Extraction of copper from copper oxide (4.5.1 explaining how observation shows a reaction in exothermic), calculate the mass of product produced from mass of reactant, explain why steps from method result in residue of copper, ion equation multiple choice	10	42
6	Formula of products when calcium carbonate is heated, **calculating A_r and naming unknown element in a compound,** calculate gradient on line on graph and give unit, extrapolation of graph reading	12	44

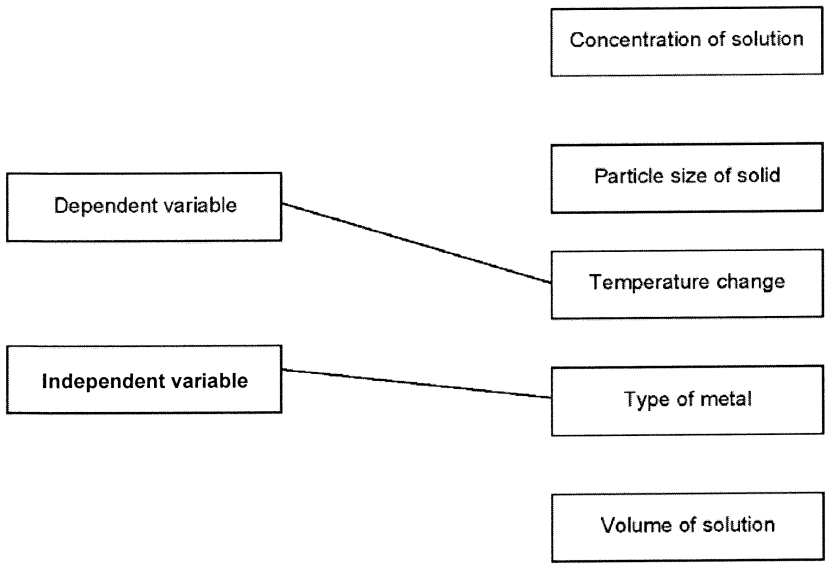
8	Name product of a reaction, suggest how to separate unreacted iron form iron chloride solution, **calculate mass of product produced in reaction from a given mass of one reactant**, explain which species is reduced in symbol equation for reaction – include half equations.	10	46
8	Suggesting reason for step in method, explaining a step in method, **determine mass of products from results table (conservation of mass), calculating number of moles of products to determine ratio and therefore which if two balanced equations is correct.**	8	48
4.4.2 Reactions of acids			
5	Calculating number of moles in a mass given in mg, writing balanced symbol equation, identifying dependent variable, suggesting changes to method to improve accuracy, selecting how to display results and reason	14	50
7	Interpreting information/results on tests on different solids, identify and explain answers (6 marks), calculating pH of a solution when volume is increased form $10cm^3$ to $1000cm^3$ when distilled water is added	8	53
7	Plotting results on a graph and drawing line of best fit, reading value from graph, resolution of temperature sensor in standard form, suggesting ways of increasing accuracy, describe and give reasons for how pH of solution changes as hydrochloric acid is added to sodium hydroxide, **calculate concentration in g/dm^3 from mass dissolved in cm^3**	16	55
8	Reason for adding excess copper oxide when reacting with sulphuric acid to make copper sulphate, suggesting and explaining two improvements to a method, **Determine how many moles copper oxide is in excess from mass of copper oxide and the volume and concentration of sulphuric acid**	10	57
9	Explain why acid can be strong and dilute, calculate pH of a solution, **calculate mean result from titration and then use this to calculate unknown concentration of solution**, explain why a pipette is used to measure volume of sulphuric acid into conical flask, **calculate mass of solute in given volume in cm^3 from concentration in mol/dm^3**	12	59
4.4.3 Electrolysis			

5	Why electrolysis is used to extract some metals, substances contained in molten mixture used to extract aluminium, half equation at cathode and anode, suggesting why deposited mass was less than expected, reading value from graph and then extrapolation, reading value from graph, calculate gradient and units for line of best fit	14	62
5	Substance produced at anode when coper sulphate electrolysed, explain the extent which results in table support a given conclusion, **calculate number of moles**, change in investigation in increase mass of product multiple choice	11	65
6	Explain why electrolysis would not work with sold zinc chloride, (4.2.3 explain why graphite conducts electricity), describe change in apparatus diagram to correct an error, describe the trend in results from a graph	11	68
7	Explain why cryolite used in aluminium extraction, cathode multiple choice, anode half equation for oxygen being produced, explain why graphite anode needs to be replaced, **calculate mass of product when given balanced symbol equation and mass of reactant**, explain why sodium chloride electrolysis doesn't produce sodium,	14	71
8	Calculate mass of product when given balanced symbol equation and mass of reactant, half equation for production of aluminium at cathode, explain why cryolite used when extracting aluminium, explain why electrolysis of aluminium oxide produces carbon dioxide, giving and explaining properties of ceramic anode	16	74

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	let the glow spread		1	AO3 4.7.3.3
01.2	1.27 (g)		1	AO2 4.5.2.2
01.3	solid		1	AO1 4.5.2.1
01.4	zinc		1	AO2 4.8.2.1
01.5	displacement		1	AO2 4.7.5.1
01.6	A		1	AO1 4.6.2.6
01.7	any **one** from: • (good electrical) conductor • can be bent easily • does not corrode	ignore malleability ignore does not rust allow is ductile	1	AO2 4.6.2.7
01.8	2 : 3		1	AO2 4.8.2.9
01.9	conserves copper ores less energy used		1 1	AO1 4.8.2.9
Total			**10**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	gas		1	AO1 4.2.2.2
05.2	the gas escapes	allow carbon dioxide escapes do **not** accept references to evaporation	1	AO1 4.3.1.3
05.3	5.12 (g)		1	AO2 4.3.1.3
05.4	4.00 (g) trial 1	allow 2.89 written in either space, or ringed in the table, unless contradicted by mass of copper carbonate or trial number	1	AO3 4.3.1.3
05.5	reheat (and reweigh) until constant mass	 an answer of heat to constant mass scores **2** marks if no other mark scored allow for **1** mark heat for longer **or** (heat at a) higher temperature **alternative approach**: (1) continue heating and pass gas through limewater (1) until the (lime)water stops bubbling **or** until the limewater no longer turns cloudy	1 1	AO3 4.3.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.6	straight line of best fit	must touch at least 5 of the 6 plots	1	AO2 4.3.1.3
05.7	correct value read from line of best fit in Figure 8	allow tolerance of ± ½ small square	1	AO2 4.3.1.3
05.8		a correctly calculated value from their answer to question **05.7** scores **2** marks		AO2 4.3.1.3
	(mass =) $168 \times \frac{\text{answer from question } \mathbf{05.7}}{8.4}$	allow (mass =) answer from question **05.7** × 20	1	
	correctly calculated value (g)		1	
Total			**10**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	 allow **one** mark if answers are reversed		1 1	AO1 4.5.1.1
06.2	polystyrene is a better insulator		1	AO3 4.5.1.1
06.3	both bars labelled both bars correctly plotted	 allow tolerance of ± ½ small square ignore width and spacing of bars if no other mark scored, allow **1** mark for any one bar correctly plotted and labelled	1 1	AO2 4.5.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	temperature increases **or** temperature does not decrease	ignore because it is exothermic allow (because) energy / 'heat' is transferred to the surroundings energy / 'heat' is not taken in from the surroundings allow the energy of the products is less than the energy of the reactants	1	AO3 4.5.1.1
06.5	(most reactive) magnesium (zinc) nickel	this order only	1	AO3 4.5.1.1 4.4.1.2
06.6	suitable method described the observations / measurements required to place in order an indication of how results would be used to place the unknown metal in the reactivity series **approaches that could be used:** **approach 1:** add the unknown metal to copper sulfate solution (1) measure temperature change (1) place the metals in order of temperature change (1)		1 1 1	AO3 4.4.1.2 4.5.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.6 cont.	**approach 2:** add the metal to salt solutions of the other metals **or** heat the metal with oxides of the other metals (1) measure temperature change (only if salt solutions used) **or** observe whether a chemical change occurs (1) compare temperature change or whether there is a reaction to place in correct order (1) **approach 3:** add all of the metals to an acid (1) measure temperature change or means of comparing rate of reaction (1) place the metals in order of temperature change or rate of reaction (1) **approach 4:** set up electrochemical cells with the unknown metal as one electrode and each of the other metals as the other electrode (1) measure the voltage of the cell (1) place the metals in order of voltage (1)			
06.7	D		1	AO1 4.5.1.2
06.8	C		1	AO1 4.5.1.2
Total			**12**	

Question 3

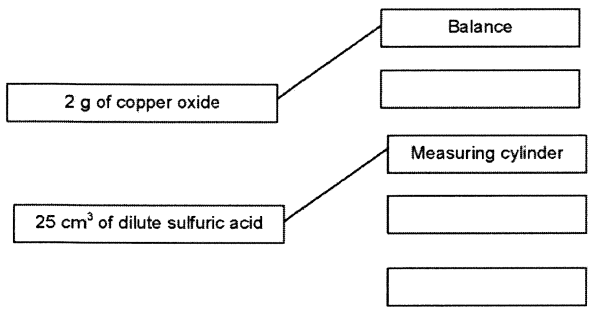
Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	(mass in mg =) 800 (mass in g =) 0.8	an answer of 0.8 (g) scores **2** marks allow correct unit conversion using incorrectly calculated mass in milligrams	1 1	AO2 4.7.3.1
03.2	carbon dioxide		1	AO1 4.7.3.2 4.7.3.1
03.3	4		1	AO2 4.5.2.1
03.4	add a lid to the top of the glass beaker use a polystyrene cup instead of the glass beaker		1 1	AO3 4.7.3.3
03.5	continuous variable independent variable		1 1	AO1 4.7.3.3
Total			**8**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	H^+		1	AO1 5.4.2.4
03.2	nitric (acid) **or** HNO_3 zinc (oxide) **or** ZnO	this order only	1 1	AO2 5.4.2.3
03.3	dissolved in water		1	AO1 5.1.1.1
03.4	any value from 0 to less than 8		1	AO2 5.4.2.4
03.5	**Level 2:** The method would lead to the production of a valid outcome. Key steps are identified and logically sequenced.		3–4	AO3
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.		1–2	AO2
	No relevant content		0	
	Indicative content • add universal indicator **or** wide range indicator indicator turns blue / purple / violet (because pH = 14) **or** has highest pH **or** is an alkali so A is sodium hydroxide indicator turns red (because pH = 2) **or** has lowest pH **or** is an acid so B is phosphorus oxide indicator turns green (because pH = 7) **or** neutral so C is silicon dioxide • add solid to water A and B dissolve; C does not so C is silicon dioxide			5.1.2.3 5.4.2.4
Total			**9**	

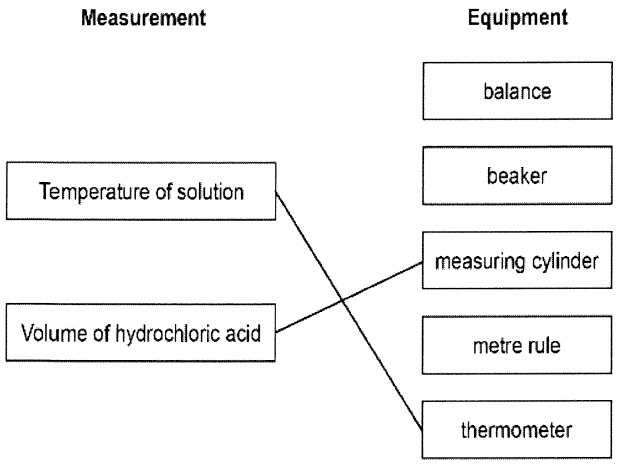
Question 5

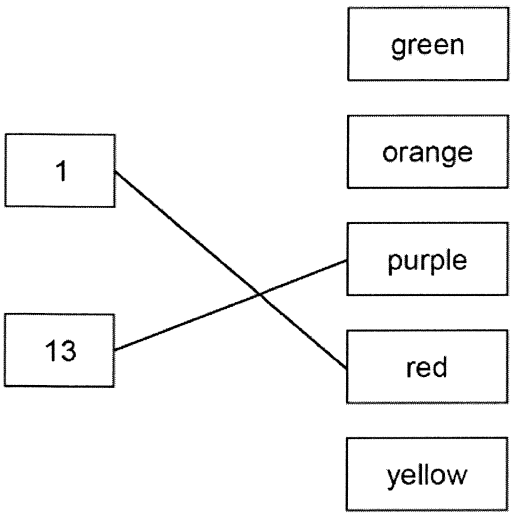
Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	s		1	AO2 4.2.2.2
05.2	a gas escapes		1	AO2 4.3.1.3
05.3	from 0.47 (g) to 0.86 (g)	allow from 0.86 (g) to 0.47 (g)	1	AO2 4.3.1.4
05.4	$\frac{0.84+0.79+0.86}{3}$ = 0.83 (g)	an answer of 0.83 (g) scores **2** marks an answer of 0.74 (g) scores **1** mark	1 1	AO3 AO2 4.3.1.3
05.5	independent		1	AO2 4.3.1.3
05.6	increases		1	AO2 4.3.1.3
05.7	1.3 (g)	allow 1.30 (g)	1	AO2 4.3.1.3
Total			**8**	

Question 5

<table>
<tr><th>Question</th><th>Answers</th><th>Extra information</th><th>Mark</th><th>AO / Spec. Ref.</th></tr>
<tr><td>05.1</td><td>
<table>
<tr><td>copper</td><td>Cu</td><td>1</td></tr>
<tr><td>sulfur</td><td>S</td><td>1</td></tr>
<tr><td>oxygen</td><td>O</td><td>4</td></tr>
</table>
If no rows correct, allow 1 mark for a correct column</td><td></td><td>1
1
1</td><td>AO2
4.5.2.1</td></tr>
<tr><td>05.2</td><td>copper oxide + sulfuric acid → copper sulfate (+ water)
allow correct formulae</td><td></td><td>1</td><td>AO2
4.5.2.1
4.7.3.2</td></tr>
<tr><td>05.3</td><td>a base</td><td></td><td>1</td><td>AO1
4.7.3.2</td></tr>
<tr><td>05.4</td><td>blue crystals and black powder</td><td></td><td>1</td><td>AO3
4.7.3.2</td></tr>
<tr><td>05.5</td><td>(filter) funnel and (filter) paper labelled
(conical) flask / beaker labelled
copper oxide (residue) labelled</td><td>
allow any suitable container labelled
allow excess</td><td>1
1
1</td><td>AO1
4.7.3.2</td></tr>
<tr><td>05.6</td><td> 
</td><td>extra line from measurement box negates the mark</td><td>1
1</td><td>AO1
4.7.3.2</td></tr>
</table>

05.7	$1 \times \frac{1\,000}{25}$ = 40 (g/dm^3)	an answer of 40 (g/dm^3) scores **2** marks an answer of 0.04 (g/dm^3) scores **1** mark allow correct calculation from an incorrect attempt at a unit conversion	1 1	AO2 4.5.2.6
Total			**13**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1			1 1	AO1 4.7.3.3
06.2	(mean =) $\frac{6.1 + 6.1 + 6.4}{3}$ = 6.2 (°C)	an answer of 6.2 (°C) scores **2** marks allow an answer of 6.6 (°C) for **1** mark	1 1	AO2 4.7.3.3
06.3	use a lid on the polystyrene cup		1	AO3 4.7.3.3
06.4	sodium chloride water	answers in either order allow NaCl allow H_2O	1 1	AO2 4.7.3.2 4.7.3.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.5			1 1	AO1 4.7.3.4
Total			**9**	

Question	Answers	Extra information	Mark	AO / Spec.
02.1	hydrochloric acid		1	AO1 5.4.2.3
02.2	(black) solid remains (after stirring)	allow copper oxide remains allow no more copper oxide reacts	1	AO1 5.4.2.3
02.3	first stage **B** second stage **A** third stage **C** fourth stage **D**	all 4 correct for **2** marks allow **1** mark if either first stage or fourth stage is correct	2	AO1 5.4.2.3
02.4	(negative electrode) copper (positive electrode) chlorine	allow Cu allow Cl_2 / Cl do **not** accept chloride or Cl^- if no other mark awarded allow **1** mark if elements are reversed	1 1	AO2 5.4.3.2

02.5	a reading of an increase in mass correct linked reading of the increase in time correct evaluation of gradient	e.g. 4 (mg) in 10 (mins) scores 2 marks e.g. ($\frac{4}{10}$ =) 0.4 (mg per min) allow correct calculation of gradient from incorrectly determined values for mass and/or time	1 1 1	AO2 5.4.3.4

02.6	cryolite oxide	this order only	1 1	AO1 5.4.3.3

Total			**11**

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	3.6 (cm^3)		1	AO2 4.4.3.4
04.2	hydrogen line only		1	AO3 4.4.3.4
04.3	both lines		1	AO3 4.4.3.4
04.4	graphite has delocalised electrons		1	AO1 4.2.3.2
04.5	**cathode** zinc (1) **anode** chlorine (1) hydrogen (1) bromine (1)	do **not** accept chloride allow **1** mark if chlorine and zinc the wrong way around do **not** accept bromide allow **1** mark if bromine and hydrogen the wrong way around	1+1 1+1	AO2 4.4.3.2 4.4.3.4
Total			**8**	

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	hydroelectricity		1	AO1 4.8.2.4
04.2	plentiful supply of cheap electricity		1	AO3 4.8.2.2 4.8.2.4
04.3	 4(Al) 3(O_2)	an answer of $2Al_2O_3 \rightarrow 4Al + 3O_2$ scores **2** marks	 1 1	AO2 4.5.2.1 4.8.2.2
04.4	reduction		1	AO1 4.8.2.1
04.5	(Al^{3+} ions are) positive (so) are attracted (to the negative electrode)	do **not** accept aluminium atoms are positive, but 2nd marking point can still be scored allow (so) opposite charges attract	1 1	AO1 4.7.5.2 4.8.2.2
04.6	3 / three		1	AO2 4.7.5.2 4.8.2.2
04.7	carbon dioxide	allow CO_2 allow carbon monoxide **or** CO ignore carbon oxide	1	AO2 4.5.2.1 4.8.2.2
04.8	electrode / carbon / graphite reacts to produce a gas	allow electrode / carbon / graphite is used up ignore wears away ignore corrodes / rusts	1	AO1 4.5.2.1 4.8.2.2

04.9	(high melting point) (so) will not melt		1	AO3 4.8.2.2
	in the high temperatures (in the electrolytic cell)	ignore the electrolytic cell is very hot	1	
	(unreactive) (so) will not react		1	
	with oxygen	allow (so) electrode doesn't need replacing	1	
	or			
	with aluminium oxide	ignore with aluminium		
Total			**14**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	switch		1	AO1 4.7.2.4
05.2	electrolysis		1	AO1 4.7.5.3
05.3	**Type of variable** / **Description** Independent variable → Concentration of copper sulfate solution Independent variable → Distance between electrodes Dependent variable → Mass of copper deposited Time circuit is switched on for 1 mark for each correct line		2	AO1 4.7.5.3
05.4	some copper fell off the electrode		1	AO3 4.7.5.3
05.5	0.16 (g)		1	AO3 4.7.5.3
05.6	a positive charge	answer line takes precedence	1	AO1 4.7.5.3
05.7	the ions cannot move		1	AO1 4.6.2.3 4.7.5.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	Ca Mg Zn Cu		1	AO3 5.4.1.2
01.2	any **two** from: • mass (of metal / element) • surface area (of metal / element) • concentration (of acid) • volume (of acid) • temperature (of acid)	 allow weight ignore size ignore length ignore pH ignore strength ignore room temperature	2	AO3 5.4.1.2
01.3	(type of) metal / element		1	AO2 5.4.1.2

01.4		allow converse answers for magnesium MP2 only if MP1 is correct		AO3 5.1.2.3 5.1.2.5 5.4.1.2
	(beryllium is) less reactive		1	
	any **one** from: • greater attraction between nucleus and outer electrons • more energy is needed to remove electrons • loss of electrons is more difficult • outer electrons closer to nucleus • less shielding	allow higher in group allow reactivity increases down the group ignore reactivity series	1	

01.5		an answer of 64 (g per dm^3) scores **3** marks an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps		AO2 5.3.2.5
	$\frac{50}{1000}$ (dm^3)		1	
	= 0.05 (dm^3)		1	
	($\frac{3.2}{0.05}$) = 64 (g per dm^3)		1	
	alternative approach: $\frac{3.2}{50}$ (1) = 0.064 (1) (× 1000) = 64 (g per dm^3) (1)			
	alternative approach: $\frac{1000}{50}$ (1) = 20 (1) (× 3.2) = 64 (g per dm^3) (1)			
		an answer of 0.16 / 0.064 / 0.64 / 6.4 / 6.4 × 10^{-5} (g per dm^3) gains **2** marks		

Total			**9**

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	FeS_2	do **not** accept equations	1	AO2 4.2.1.3
02.2	26 30 26	must be this order	1 1 1	AO2 4.1.1.4 4.1.1.5
02.3	any **two** from: • iron has a high(er) melting / boiling point • iron is dense(r) • iron is hard(er) • iron is strong(er) • iron is less reactive • iron has ions with different charges • iron forms coloured compounds • iron can be a catalyst	allow the converse statements for sodium allow transition metal for iron allow Group 1 metal for sodium ignore references to atomic structure ignore iron rusts allow iron is less malleable / ductile allow specific reactions showing difference in reactivity allow iron is magnetic	2	AO1 4.1.2.5 4.1.3.1 4.1.3.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.4	carbon is more reactive (than nickel)	allow converse	1	AO1 4.4.1.2 4.4.1.3
	(so) carbon will displace / replace nickel (from nickel oxide) **or** (so) carbon will remove oxygen (from nickel oxide)	allow (so) nickel ions gain electrons allow (so) carbon transfers electrons to nickel (ions)	1	
02.5		an answer of 67.8 (%) scores **3** marks an answer of 67.8160919 (%) or correctly rounded answer to 2, 4 or more sig figs scores **2** marks an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps		AO2 4.3.3.2
	(total M_r of reactants =) 87		1	
	(percentage atom economy) $= \frac{59}{87} \times 100$	allow (percentage atom economy) $= \frac{59}{\text{incorrectly calculated } M_r} \times 100$	1	
	= 67.8 (%)	allow an answer from an incorrect calculation to 3 sig figs	1	
Total			**11**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	any **one** from: • metal • (metal) hydroxide • (metal) carbonate • alkali	allow named example allow correct formula ignore base allow ammonium hydroxide allow ammonium carbonate allow soluble base allow ammonia	1	AO1 4.4.2.1 4.4.2.2 4.4.2.3
01.2	$Ca(NO_3)_2$	allow $Ca^{2+}(NO_3^-)_2$	1	AO2 4.4.2.2

Question	Answers	Mark	AO / Spec. Ref.
01.3	**Level 3:** The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.	5–6	AO1 4.4.2.3
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.	3–4	
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	
	No relevant content	0	
	Indicative content • use magnesium oxide and sulfuric acid • add sulfuric acid to a beaker • warm sulfuric acid • add magnesium oxide • stir • continue adding until magnesium oxide is in excess • filter • using a filter paper and funnel • to remove excess magnesium oxide • heat solution in an evaporating basin • to crystallisation point • leave to crystallise • pat dry with filter paper credit may be given for diagrams		
Total			**8**

Question 2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	H^+		1	AO1 4.4.2.4
02.2	hydrochloric (acid) water	allow HCl allow H_2O	1 1	AO2 4.4.2.2
02.3	burette	do **not** accept biuret	1	AO1 4.4.2.5
02.4	27.6 (cm^3)	allow 27.60 (cm^3)	1	AO2 4.4.2.5

Question 2 continued

Question	Answers	Mark	AO/ Spec. Ref
02.5	**Level 3**: The design/plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.	5–6	AO3 AO1
	Level 2: The design/plan would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.	3–4	AO1 x 2
	Level 1: The design/plan would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	AO1 x 2
	No relevant content	0	
	Indicative content allow converse using acid added to alkali Key steps • measure the volume of acid • add indicator to the acid • add sodium hydroxide solution • until the colour changes • record volume of sodium hydroxide solution added • repeat procedure with the other acid Use of results • compare the two volumes of sodium hydroxide solution to find which sample **P** or **Q** is more concentrated Other points • pipette to measure volume of acid • use a few drops of indicator • swirl • use a white tile • rough titration to find approximate end point • add dropwise near the endpoint • read volume from bottom of meniscus • repeat and take a mean		4.4.2.5
Total		**11**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	limewater (which) turns cloudy / milky (when carbon dioxide is added)	allow calcium hydroxide solution must link to limewater	1 1	AO1 4.7.3.1
02.2	**Level 3:** The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.		5–6	AO1 4.7.3.2
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.		3–4	
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.		1–2	
	No relevant content		0	
	Indicative content • use hydrochloric acid • place acid in suitable container eg beaker • add (a spatula of) magnesium carbonate • stir • continue adding magnesium carbonate until in excess • when solid remains **or** no more effervescence occurs • filter to remove excess magnesium carbonate • using filter paper and funnel • pour solution into evaporating dish • evaporate water till crystallisation point reached • using electric heater or Bunsen burner and a water bath • leave to cool • until crystals form • pour off excess water **or** filter • dry crystals in cool oven or with filter paper			
Total			**8**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	(aq)	allow aq ignore aqueous ignore formulae	1	AO1 5.2.2.2
02.2	HNO_3		1	AO1 5.1.1.1 5.4.2.2
02.3	red purple **or** blue	allow orange or yellow do **not** accept green allow shades of purple eg violet	1 1	AO1 5.4.2.4
02.4	D		1	AO3 5.4.2.4
02.5	 3 × 16 **or** 48 $\frac{48}{80}$ (×100) 60 (%)	an answer of 60 (%) scores **3** marks an answer of 20 (%) scores **2** marks for: $\frac{16}{80}$ (× 100) (1) = 20 (%) (1)	 1 1 1	AO2 5.3.1.2

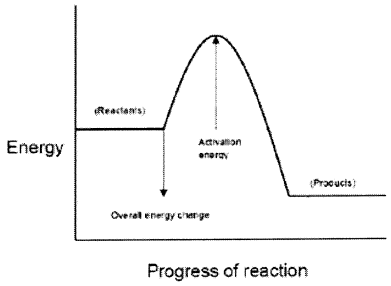
Question	Answers	Mark	AO / Spec. Ref.
03	**Level 3:** Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO3
	Level 2: Relevant points (reasons / causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.	3–4	AO3
	Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1–2	AO1
	No relevant content	0	
	Indicative content: • uses sulfuric acid not hydrochloric acid **or** sulfuric acid needed • uses copper carbonate / oxide not calcium carbonate **or** copper carbonate / oxide needed • add solid until solid remains **or** is in excess **or** no more reacts / dissolves so that most / all of the acid reacts • filter to remove excess **or** unreacted carbonate / oxide / solid • heat gently **or** partially evaporate **or** leave until crystals appear **or** to crystallise for **level 3** the correct chemicals must have been selected		5.4.2.3
Total			**6**

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	chlorine		1	AO2 5.4.3.4
01.2	copper is less reactive than hydrogen		1	AO2 5.4.3.4
01.3	1.8 (mg)	allow an answer in range 1.7–1.9	1	AO3 5.4.3.4
01.4	$\frac{3.02 + 3.01 + x}{3} = 3.06$ 3.15 (mg)	an answer of 3.15 (mg) scores **2** marks allow any other suitable method if no other mark awarded allow 9.18 for **1** mark	1 1	AO2 5.4.3.4
01.5	$\frac{50}{1000}$ **or** $\frac{1}{20}$ **or** 0.05 (0.05) × 300 15 (g) **or** $\frac{300}{1000}$ **or** $\frac{3}{10}$ **or** 0.03 (1) (0.3) × 50 (1) 15 (g) (1)	an answer of 15 (g) scores **3** marks the second mark is dependent on the first mark being scored the second mark is dependent on the first mark being scored if no other mark awarded allow 150 **or** 15 000 for **1** mark	1 1 1	AO2 5.3.2.5
Total			**8**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	all 4 metals labelled and suitable scale on *y*-axis	magnesium value must be at least half the height of the grid	1	AO2 4.4.1.2 4.5.1.1
	all bars correctly plotted	allow a tolerance of ± ½ a small square ignore width and spacing of bars allow **1** mark if copper not included and other 3 bars plotted correctly	1	
05.2	temperature increases **or** temperature does not decrease	ignore because it is exothermic ignore references to copper allow (because) energy / 'heat' is transferred to the surroundings allow energy / 'heat' is given out allow energy / 'heat' is not taken in (from the surroundings) allow the energy of the products is less than the energy of the reactants	1	AO3 4.5.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	suitable method described		1	AO3 4.4.1.2
	the observations / measurements required to place in order	dependent on a suitable method	1	4.5.1.1
	an indication of how results would be used to place the unknown metal in the reactivity series		1	
	a control variable to give a valid result		1	
	approaches that could be used **approach 1:** add the unknown metal to copper sulfate solution (1) measure temperature change (1) place the metals in order of temperature change (1) any **one** from (1): • same volume of solution • same concentration of solution • same mass / moles of metal • same state of division of metal **approach 2:** add the metal to salt solutions of the other metals **or** heat the metal with oxides of the other metals (1) measure temperature change (only if salt solutions used) **or** observe whether a chemical change occurs (1) place the metals in order of temperature change **or** compare whether there is a reaction to place in correct order (1) any **one** from (1): • same volume of salt solutions • same concentration of salt solutions • same (initial) temperature of salt solutions • same mass / moles of metal **or** metal oxide • same state of division of metal **or** metal oxide			

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3 cont.	**approach 3:** add all of the metals to an acid (1) measure temperature change or means of comparing rate of reaction (1) place the metals in order of temperature change or rate of reaction (1) any **one** from (1): • same volume of acid • same concentration of acid • same (initial) temperature of acid • same mass / moles of metal • same state of division of metal **approach 4:** set up electrochemical cells with the unknown metal as one electrode and each of the other metals as the other electrode (1) measure the voltage of the cell (1) place the metals in order of voltage (1) any **one** from (1): • same electrolyte • same concentration of electrolyte • same temperature of electrolyte			

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4		an answer of:  scores **3** marks		AO1 4.5.1.2
	correct shape for exothermic reaction	the reactant and product lines needed not be labelled do **not** accept incorrectly labelled reactant and product lines	1	
	labelled activation energy		1	
	labelled (overall) energy change	ignore arrow heads	1	
Total			**10**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	reference to glow		1	AO3 4.7.3.3
	(which) shows energy is being transferred to the surroundings	allow 'heat' for energy allow (which) shows energy is being given out	1	AO1 4.7.3.3
05.2		an answer of 1.27 (g) scores **3** marks an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps		AO2 4.5.2.5
	(M_r CuO =) 79.5		1	
	$\left(\text{moles copper oxide} = \frac{\text{mass}}{M_r}\right.$			
	$= \frac{1.59}{79.5}\left.\right) = 0.02$	allow an incorrectly calculated value for M_r from step 1	1	
	(mass Cu = 0.02 × 63.5) = 1.27 (g)		1	
		alternative approach: 79.5 (g) CuO → 63.5 (g) Cu (1) (mass Cu =) $\frac{63.5}{79.5}$ × 1.59 (1) (mass Cu) = 1.27 (g) (1)		

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	hydrochloric acid reacts with zinc oxide	allow hydrochloric acid and zinc oxide produce zinc chloride	1	AO2 4.7.3.2 4.7.5.1
	(to) form a solution (of zinc chloride)		1	AO2 4.7.3.2 4.7.5.1
	copper does not react (with dilute acid)		1	AO1 4.7.3.2 4.7.5.1
	(so copper) remains as a solid	allow (so copper) will collect in filter paper	1	AO2 4.7.3.2 4.7.5.1
05.4	zinc has been oxidised because the zinc atoms have lost electrons		1	AO2 4.7.5.5
Total			**10**	

<table>
<tr><th>Question</th><th>Answers</th><th>Extra information</th><th>Mark</th><th>AO / Spec. Ref.</th></tr>
<tr><td>06.1</td><td>CaO

CO_2</td><td>either order
ignore names</td><td>1

1</td><td>AO1
5.3.1.3</td></tr>
<tr><td>06.2</td><td>

[12 + (3 × 16)]
or 60

(197 − 60 =) 137

barium or Ba</td><td>an answer of 137 scores the 2 calculation marks

barium or Ba without working scores this mark</td><td>

1

1

1</td><td>AO2
5.3.1.2
5.3.1.3
5.1.1.5</td></tr>
<tr><td>06.3</td><td>

(working) Y increase <u>and</u> X increase measured from graph <u>and</u> substitution into $\frac{\Delta Y}{\Delta X}$

(answer) 167

(units) cm^3/g</td><td>an answer of 160–174 scores the 2 calculation marks

<table><tr><td>y-axis</td><td>80–85</td><td>162–170</td><td>248–252</td><td>330–335</td></tr><tr><td>x-axis</td><td>0.5</td><td>1.0</td><td>1.5</td><td>2.0</td></tr><tr><td>=</td><td>160–170</td><td>162–170</td><td>165–168</td><td>165–168</td></tr></table>
allow answer in range 160–174

allow $cm^3\ g^{-1}$

if no other mark awarded allow 1 mark for the inverse ($\frac{\Delta X}{\Delta Y}$)
or 0.006</td><td>

1

1

1</td><td>AO2
5.3.1.2
5.3.1.3</td></tr>
</table>

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4		an answer of 140–150 scores **4** marks an answer of 0.14–0.15 scores **3** marks		AO3 5.3.1.2 5.3.1.3
	(from graph) volume to 240 cm^3 mass = 1.45 g	allow answer based on any reading from the graph (eg 250 cm^3 = 1.5 g)	1	
	ratio is $\frac{1}{100}$ (ie $\frac{24\,000}{240}$)	allow ratio from their volume eg $\frac{24\,000}{250}$	1	
	100×1.45	$\left(\frac{24\,000}{250}\right) \times 1.5$	1	
	145	allow range 140–150	1	
	or			
	allow method using answer from question **06.3**			
	$x = \frac{y}{m}$ (1)	(rearrangement of y = mx where m = answer from question **06.3**)		
	24 (dm^3) to 24 000 (cm^3) (1)			
	$\frac{24\,000}{\text{answer from question 06.3}}$ (1)			
	144 (1)	allow range 140–150		
Total			**12**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	hydrogen **or** H_2	allow hydrogen gas ignore H without the 2 subscript	1	AO1 5.4.2.1
08.2	filtration / filter	allow magnet **or** decant ignore heating	1	AO1 5.1.1.2
08.3		an answer of 185–190 (mg) scores **5** marks an answer of 0.185–0.19 scores **4** marks		AO2 5.3.2.2
	(Mg) $\frac{0.12}{24}$ or 0.005 (moles)	mark is for ÷ by 24	1	
	(Fe) $\frac{2}{3} \times 0.005 = 0.00333$(moles)	mark is for $\times \frac{2}{3}$	1	
	(mass Fe) = 0.00333×56	mark is for × 56	1	
	= 0.1866 (g)		1	
	= 187 (mg)		1	
		an answer of 280 (mg) scores **4** marks an answer of 0.280 scores **3** marks (no ratio from equation) 184 scores **0** [=(3×24) + (2×56)]		
	OR (Mg) = $\frac{0.12}{(3 \times 24 =)\ 72}$ (1) = 0.00166 **or** $\frac{1}{600}$ (moles) (1) (mass of Fe) = 0.00166 **or** $\frac{1}{600} \times 112\ (2 \times 56)$ (1) = 0.1866 (g) (1) 187 (mg) (1)			

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.3 cont.	**OR** 72 g Mg → 112g Fe (1) 1 g Mg → $\frac{112}{72}$ **or** 1.56 g Fe (1) 0.12 g Mg → $\frac{112}{72}$ × 0.12 (1) = 0.1866 (g) (1) = 187 (mg) (1)			
08.4	Fe^{3+} (because) reduction is gain <u>of electrons</u> $Fe^{3+} + 3e^{(-)}$ → Fe	 allow change in oxidation state / (+)3 to 0 	1 1 1	AO2 AO1 AO2 5.4.1.2 5.4.1.4
Total			**10**	

Question 8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	to make sure all of the oxide (of copper) has reacted **or** to make sure all water (produced) is removed	ignore to ensure complete reaction unqualified ignore to make sure all of the hydrogen has reacted	1	AO3 4.3.2.3
08.2	to prevent hydrogen escaping (into the air) (because) hydrogen is explosive	 ignore hydrogen is flammable	1 1	AO3 4.3.2.3
08.3	(mass of copper) 8.66 (g) (mass of water) 2.45 (g)		1 1	AO2 4.3.2.3

08.4	moles Cu = 0.04 **or** $\frac{2.54}{63.5} = 0.04$ moles H_2O = 0.04 **or** $\frac{0.72}{18} = 0.04$ ratio = 1:1 so equation 2 is correct **alternative approach A** (calculating mass of water from copper) moles Cu= 0.04 **or** $\frac{2.54}{63.5} = 0.04$(1) 0.02 x 18 = 0.36 (g of water for equation 1) (1) 0.04 x 18 = 0.72 (g of water) so equation 2 is correct (1) **alternative approach B** (calculating mass of copper from water) moles H_2O=0.04 **or** $\frac{0.72}{18}$=0.04 (1) 0.08 x 63.5 = 5.08 (g of copper for equation 1) (1) 0.04 x 63.5 = 2.54 (g of copper) so equation 2 is correct (1)	**alternative approach C** (mass ratio) (copper : water for equation 1) 127 : 18 = 7.06 : 1 (1) (copper : water for equation 2) 63.5 : 18 = 3.53 : 1 (1) 2.54 : 0.72 = 3.53 : 1 = 63.5 : 18 so equation 2 is correct (1)	1 1 1	AO2 4.3.2.1 4.3.2.3
Total			**8**	

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	to alter / improve the taste of the tablet	allow to relax the muscles of the intestine allow to aid digestion	1	AO3 4.7.3.2
05.2		an answer of 0.000762 **or** 7.62×10^{-4} (moles) scores **3** marks an answer of 0.762 **or** 0.00076190476 (moles) scores **2** marks an answer of 0.76190476 (moles) scores **1** mark		AO2 4.5.2.4
	(conversion 64.0 mg to) 0.0640 g		1	
	(moles =) $\frac{0.0640}{84}$	allow 0.00076190476 allow correct expression using an unconverted or incorrectly converted value for mass	1	
	= 0.000762 (moles) **or** = 7.62×10^{-4} (moles)	allow an answer correctly rounded to 3 significant figures from an incorrect calculation using the masses in the question	1	

05.3		an answer of $MgCO_3+2HCl \rightarrow MgCl_2+CO_2+H_2O$ scores **3** marks		
	(reactants) $MgCO_3$ **and** HCl (products) CO_2 **and** H_2O		1	AO1
	(product) $MgCl_2$		1	AO2
	correct balancing of correct formulae	allow correct multiples	1	AO2 4.5.2.1 4.7.3.1 4.7.3.2
05.4	temperature change / increase	allow the highest temperature of the mixture ignore temperature unqualified	1	AO1 4.7.3.3

05.5	any **two** changes with corresponding reasons: (change) use a lid (reason) to reduce energy transfer	 ignore to prevent energy transfer	4	AO3 4.7.3.3
	(change) repeat (steps 1–4 for each mass) **and** calculate a mean (reason) to reduce effect of random errors	allow for **1** mark repeat (steps 1–4 for each mass) **and** discard anomalous results		
	(change) use a digital thermometer **or** use a temperature sensor **and** data logger (reason) to reduce instrument reading error	allow for **1** mark use a thermometer with a higher resolution		
	(change) use a smaller interval for mass (reason) to produce a better line of best fit			
05.6	line graph mass is a continuous variable	 dependent on scoring 1st marking point allow both variables are continuous allow data is continuous allow independent variable is continuous	1 1	AO3 AO1 4.7.3.3
Total			**14**	

Question	Answers	Mark	AO / Spec. Ref.
07.1	**Level 3:** Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO3
	Level 2: Relevant points (reasons / causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.	3–4	AO3
	Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1–2	AO1 AO2
	No relevant content	0	
	Indicative content: A is sodium oxide B is phosphorus oxide C is magnesium oxide D is silicon dioxide **linked statements:** A is sodium oxide because it has highest pH **or** pH = 14 **or** is a strong alkali B is phosphorus oxide because it has lowest pH **or** pH = 3 **or** is an acid C is magnesium oxide because it has 2nd highest pH **or** pH = 9 **or** is a (weak) alkali D is silicon dioxide because it is neutral **or** pH = 7 **or** A and B are sodium oxide **or** phosphorus oxide because both soluble **or** no solid remains C is magnesium oxide because it will be the colourless <u>solution</u> with solid remaining D is silicon dioxide because it will be the colourless <u>liquid</u> with solid remaining for **level 3** the solids must be correctly identified		5.1.2.3 5.4.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2		an answer of (pH=) 5 gains **2** marks		
	dilution by a factor of 100	allow pH changes by 1 when solution is diluted by factor of 10 **or** allow pH changes by 2	1	AO1 5.4.2.5
	(pH=) 5		1	AO3 5.4.2.5
Total			**8**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	all points correct line of best fit (0–20 cm^3 hydrochloric acid added) extrapolation of both lines to cross	allow a tolerance of ± half a small square allow **1** mark if 3 **or** 4 points are correct	2 1 1	AO2 4.7.3.3
07.2	correct value determined from their drawn lines of best fit	allow a tolerance of ± half a small square	1	AO3 4.7.3.3
07.3	1×10^{-2} °C		1	AO2 4.7.3.3
07.4	any **two** from: • repeat the experiment **and** calculate the mean • use a lid • insulate the polystyrene cup • measure sodium hydroxide with a pipette / burette • use smaller intervals for addition of hydrochloric acid	allow add hydrochloric acid in intervals of 1 or 2 cm^3 allow record temperature when 25 cm^3 of hydrochloric acid is added	2	AO3 4.7.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.5	any **six** from: • pH at start is 13 / 14 • because sodium hydroxide is an alkaline solution as it contains OH^- ions • as hydrochloric acid added the pH decreases • because the H^+ ions react with OH^- ions • this is a neutralisation reaction • when (excess) hydrochloric acid added, H^+ ion concentration increases • as H^+ ion concentration increases by a factor of 10, the pH value decreases by 1 • when excess hydrochloric acid added, pH is 0 / 1	ignore reference to indicator colours allow values between 8–14 allow pH values between 0–6	6	AO1 AO2 4.7.3.4 4.7.3.5
07.6	(concentration =) $1.4 \times \frac{1000}{25}$ = 56 (g/dm^3)	an answer of 56 (g/dm^3) scores **2** marks allow a correctly calculated answer from an incorrect attempt at volume conversion an answer of 0.056 (g/dm^3) scores **1** mark	1 1	AO2 4.5.2.6
Total			**16**	

Question 8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	to ensure all acid reacts		1	AO1 4.5.2.5 4.7.3.2
08.2	(improvement) filter (after step 4 and before step 5)		1	AO3
	(explanation) (so) excess copper oxide is removed		1	AO1
	(improvement) evaporate some of the water and then leave (to cool / crystallise)		1	AO3
	(explanation) (so) crystals form rather than powder	ignore to form larger crystals	1	AO2 4.7.3.2

08.3	(moles CuO) $= \frac{2}{79.5}$	an answer of 0.0127 moles in excess scores **5** marks an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps	1	AO2 4.5.2.4 4.5.2.5 4.5.2.6
	= 0.0252	allow 0.025157232	1	
	(moles sulfuric acid in 1 dm^3) $(= \frac{49}{98}) = 0.5$	allow (mass of sulfuric acid in 25 $cm^3 = \frac{49}{1\,000} \times 25) = 1.225$ g	1	
	$\left(\text{moles in 25 cm}^3 = \frac{0.5}{1\,000} \times 25\right)$ = 0.0125	allow $(\text{moles} = \frac{1.225}{98}) = 0.0125$	1	
	moles CuO in excess (= 0.0252 − 0.0125) = 0.0127	allow 0.012657232 correctly rounded to at least 2 significant figures allow correctly calculated and rounded answer using incorrectly calculated moles of CuO and / or moles of sulfuric acid	1	
Total			**10**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.1	(strong because) completely ionised (in aqueous solution)	ignore pH allow dissociated for ionised do **not** accept hydrogen is ionising do **not** accept H^+ are ionised	1	AO1 4.3.4 4.4.2.6
	(dilute because) small amount of acid per unit volume	ignore low concentration	1	AO1 4.3.4 4.4.2.6
09.2	5.0	allow 5	1	AO2 4.4.2.6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.3	(titre): chooses titrations 3, 4, 5	an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps	1	AO2 4.3.4 4.4.2.5
	average titre = 22.13 (cm^3)	allow average titre = 22.13(3…) (cm^3) allow a correctly calculated average from an incorrect choice of titrations	1	
	(calculation): (moles NaOH = $\frac{22.13}{1000} \times 0.105 = 0.002324$)	allow use of incorrect average titre from step 2	1	
	(moles H_2SO_4 = ½ × 0.002324 =) 0.001162	allow use of incorrect number of moles from step 3	1	
	(concentration = $\frac{0.001162}{25} \times 1000$) = 0.0465 ($mol/dm^3$)	allow use of incorrect moles from step 4	1	
		alternative approach for step 3, step 4 and step 5 $\frac{2}{1} = \frac{22.13 \times 0.105}{25.0 \times \text{conc. } H_2SO_4}$ (1) (concentration H_2SO_4 =) $\frac{22.13 \times 0.105}{25.0 \times 2}$ = 0.0465 (mol/dm^3) (1) an answer of 0.046473 **or** 0.04648 correctly rounded to at least 2 sig figs scores marking points 3, 4 and 5 an answer of 0.092946 **or** 0.09296 **or** 0.185892 **or** 0.18592 correctly rounded to at least 2 sig figs scores marking points 3 and 5		

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.4	pipette measures a fixed volume (accurately)		1	AO1 4.4.2.5
	(but) burette measures variable volume	allow can measure drop by drop	1	
09.5		an answer of 0.126 (g) scores **2** marks an answer of 126(g) scores **1** mark an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps		AO2 4.3.2.5 4.3.4 4.4.2.5
	(moles =) $\frac{30}{1000} \times 0.105$ **or** 0.00315 (mol) **or** (mass per dm^3 =) 0.105×40 **or** 4.2 (g)		1	
	(mass = $\frac{30}{1000} \times 0.105 \times 40$) = 0.126 (g)		1	
Total			**12**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	metal is too reactive to be extracted using carbon **or** metal reacts with carbon	allow metal is more reactive than carbon	1	AO1 5.4.3.3
05.2	aluminium oxide cryolite	either order ignore bauxite **or** aluminium ore	1 1	AO1 5.4.3.3
05.3	negative electrode: $Cu^{2+} + 2e^- \rightarrow Cu$ positive electrode: $2Cl^- \rightarrow Cl_2 + 2e^-$	allow multiples allow $2Cl^- - 2e^- \rightarrow Cl_2$	1 1	AO2 5.4.3.2 5.4.3.5
05.4	any **two** from: • concentration / volume of solution was different • impurities in solution • error in timing • copper falls off (electrode) • copper removed when drying electrode • electrode not dry (when weighed) • voltage / current was different	 allow copper at bottom of beaker ignore power supply ignore recorded mass inaccurately	2	AO3 5.4.3.4

05.5		an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps		AO2 5.4.3.4
	reading of mass at stated time	allow tolerance of ± ½ small square eg at 30 minutes value is 5.4 (mg)	1	
	factor from time to 24 hours	eg 5.4×48 $(= \frac{24 \text{ hours}}{30 \text{ minutes}})$ allow correct calculation using incorrectly read value for mass at time quoted	1	
	correct evaluation	eg = 259 (mg)	1	
	alternative approach:			
	calculates the gradient (1)	eg (1.8÷10) = 0.18		
	gradient × time in minutes in 24 hours (1)	eg 0.18 × 24 × 60 **or** eg 0.18 × 1440 allow correct use of incorrectly determined gradient		
	correct evaluation (1)	eg = 259 (mg)		

05.6	4.75 (g)	allow values in range 4.7–4.8 (g)	1	AO2 5.4.3.4

05.7		an answer in the range 0.18–0.25 scores **2** marks (**3** marks with correct unit)		AO2 5.4.3.4
	(working) Y increase **and** X increase measured from graph	allow ecf from question **05.6**		
	and substitution into $\frac{\text{Y increase}}{\text{X increase}}$	eg = $\frac{2.0}{10}$	1	
	correct evaluation	eg = 0.2	1	
	(units) g/hour	allow g/h **or** g/hr **or** g per hour	1	

Total			**14**

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	oxygen		1	AO1 4.7.5.3
05.2		any order of components		AO1 4.7.2.4
	correct symbol for cell / battery with positive terminal connected to anode	ignore + and − symbols on cell / battery do **not** accept voltmeter if connected in series	1	4.7.5.3
	correct symbol for ammeter connected in series		1	
	correct symbol for variable resistor connected in series	allow variable power supply in place of variable resistor ignore additional components that would not affect the circuit working	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	calculation / statement including data to show effect of doubling current on mass of copper deposited **or** calculation of **two** quotients, eg $\frac{0.24}{0.047} = 5.11$ $\frac{0.48}{0.095} = 5.05$	allow **1** mark for recognising that comparing doubling of one quantity to doubling of another is needed **or** allow **1** mark for recognising that a scaling factor needs to be applied could be opposite way round (giving around 0.2)	2	AO3 4.7.5.3
	(therefore) results support student **A** **or** results show direct proportionality	this mark must be supported by relevant calculations / statements	1	
	(however) there is an anomalous result at 0.36 A, 0.057 g	allow in terms of quotient (6.32 instead of ~5 or 0.16 instead of ~0.2)	1	
05.4		an answer of 2.24×10^{-3} scores **2** marks an answer of 0.00224 scores **1** mark		AO2 4.5.2.4
	$\frac{0.142}{63.5}$	allow an answer that rounds to 0.00224	1	
	$= 2.24 \times 10^{-3}$	allow an answer that rounds to 2.2×10^{-3}	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	increase the time the circuit is switched on for		1	AO3 4.7.5.3
Total			**11**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	solid (zinc chloride) does not conduct (electricity) **or** zinc chloride needs to be in solution **or** molten	allow liquid / aqueous	1	AO1 4.4.3.1
	(because) ions cannot move in the solid **or** (as) ions can (only) move in liquid / solution	do **not** accept references to movement of electrons in zinc chloride	1	
06.2		allow free electrons for delocalised electrons		AO1 4.2.3.2
	each carbon / atom forms 3 (covalent) bonds		1	
	one electron per carbon / atom is delocalised		1	
	(so) these electrons carry charge through the graphite **or** (so) these electrons move through the structure	ignore carry current / electricity	1	
		if no other mark scored, allow **1** mark for delocalised / free electrons		
06.3	use measuring cylinders (instead of test tubes)	allow use burettes allow use (gas) syringes allow Hoffmann voltameter	1	AO3 4.4.3.4
	(because) test tubes cannot measure volume **or** (because) test tubes have no graduations / scale	allow (so that) volume can be measured	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	any **three** from: • the volume of hydrogen collected is directly proportional to the time • the rate of collection of hydrogen is 0.45 (cm^3/min) • up to 8 minutes chlorine is collected at an increasing rate • after 8 minutes the rate of collection of chlorine is the same as that of hydrogen **or** after 8 minutes the rate of collection of chlorine is 0.45 (cm^3/min)	allow the (volume of) hydrogen is collected at a constant / steady rate allow any value from 6 to 8 minutes allow initially chlorine is collected at an increasing rate allow any value from 6 to 8 minutes allow after 8 minutes the (volume of) chlorine is collected at a constant / steady rate if neither bullet point 3 nor bullet point 4 is awarded allow **1** mark for chlorine is collected slowly up to 8 minutes and then more quickly allow any value from 6 to 8 minutes	3	AO2 4.4.3.4
06.5	chlorine reacts with water **or** chlorine dissolves (in the solution)		1	AO3 4.3.5 4.4.3.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.6		an answer of 2.75×10^{-4} (mol) or 2.8×10^{-4} (mol) scores **3** marks an answer of 0.000275 / 0.00028 / 2.75×10^{-1} / 2.8×10^{-1} (mol) / scores **2** marks an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps		AO2 4.3.5
	(volume=) $\frac{6.6}{1000}$ (dm^3) **or** 0.0066 (dm^3)	allow 6.5 (cm^3) for 6.6 (cm^3)	1	
	(moles=) $\frac{0.0066}{24}$	allow use of incorrect volume from step 1	1	
	= 2.75×10^{-4} (mol)	allow 2.8×10^{-4} (mol) allow answer from incorrect calculation given in standard form alternative approach for marking points 1 and 2 24 dm^3 = 24 000 cm^3 (1) (moles =) $\frac{6.6}{24\,000}$ (1)	1	
Total			**14**	

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	mixture has a lower melting point (than aluminium oxide) (so) less energy needed	allow cryolite lowers melting point (of aluminium oxide) ignore boiling point do **not** accept cryolite is a catalyst ignore cost	1 1	AO1 4.4.3.3
07.2	aluminium ions gain electrons		1	AO1 4.4.1.4 4.4.3.3
07.3	$2O^{2-} \rightarrow O_2 + 4e^-$	allow multiples allow **1** mark for an unbalanced equation containing correct species	2	AO2 4.1.1.1 4.4.3.1 4.4.3.3
07.4	the electrode reacts with oxygen the electrode is carbon / graphite (so) carbon dioxide is produced	 allow (so) the electrode / carbon / graphite is used up allow (so) the electrode / carbon / graphite is burned away ignore (so) the electrode / carbon / graphite is worn away ignore (so) the electrode / carbon / graphite is corroded	1 1 1	AO1 4.4.3.3

Question 7 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.5		an answer of 941 (kg) scores **4** marks		AO2 4.3.2.2
	(M_r of Al_2O_3 =) 102		1	
	$\left(\frac{2\,000\,000}{102} =\right)$ 19608 (mol Al_2O_3)	allow correct calculation using incorrectly calculated value of M_r of Al_2O_3	1	
	$\left(19\,608 \times \frac{3}{2} =\right)$ 29412 (mol O_2)	allow correct calculation using incorrectly calculated value of moles of Al_2O_3	1	
	$\left(\frac{29\,412 \times 32}{1000} =\right)$ 941 (kg)	allow 941.1764706 (kg) correctly rounded to at least 2 significant figures allow correct answer using incorrectly calculated value of moles of O_2	1	
	alternative approach: (2 M_r of Al_2O_3 =) 204 (1) 204 (kg of Al_2O_3) gives 96 (kg of O_2) (1) (2000 kg of Al_2O_3 gives) $\frac{2000}{204}$ × 96 (kg of O_2) **or** $\frac{2000000}{204}$ × 96 (g of O_2) (1) = 941 (kg) (1)			

07.6	hydrogen (gas) would be produced (instead of sodium) (because) sodium is more reactive than hydrogen		1 1	AO3 4.4.1.2 4.4.3.3 4.4.3.4

07.7	$\left(\frac{150\,000}{71} =\right)$ 2113 (mol of Cl_2) **or** (volume of 1 g of $Cl_2 = \frac{24}{71}$ =) 0.34 (dm^3) ($\frac{150\,000}{71}$ x 24) = 50700 (dm^3)	an answer of 50700 (dm^3) scores **2** marks an answer of 50.7 (dm^3) scores **1** mark allow 50704.22535 (dm^3) correctly rounded to at least 2 significant figures allow correct calculation using their calculated number of moles and/or calculated volume of 1 g	1 1	AO2 4.3.5
Total			**16**	

Question 8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	hydroelectric(ity)	allow HEP	1	AO1 4.8.2.4
08.2	plentiful supply of electricity **or** plentiful supply of renewable energy		1	AO3 4.8.2.2 4.8.2.4

08.3		an answer of 529 (kg) scores **4** marks		AO2 4.5.2.5
	(M_r Al_2O_3) 102		1	
	(moles Al_2O_3 = $\frac{1\ 000\ 000}{102}$)	allow correct calculation using incorrectly calculated value for M_r of Al_2O_3		
	= 9 804		1	
	(moles Al = 9 804 × 2 =) 19 608	allow correct calculation using incorrectly calculated value of moles of Al_2O_3	1	
	(mass Al = $\frac{19\ 608}{1\ 000}$ × 27)	allow correct answer using incorrectly calculated value of moles of Al		
	= 529 (kg)	allow 529.4117647 (kg) correctly rounded to at least 2 significant figures	1	
	alternative approach (M_r of Al_2O_3 =) 102 **or** (2 × M_r of Al_2O_3 =) 204 (1)			
	(proportion by mass of Al in Al_2O_3 =) $\frac{54}{102}$ **or** $\frac{108}{204}$ **or** 0.529 (1)			
	(mass of Al =)1 000 × $\frac{54}{102}$ **or** 1 000 x 0.529 (1)			
	= 529 (kg) (1)			

08.4	$Al^{3+} + 3e^- \rightarrow Al$		1	AO2 4.7.5.2 4.8.2.2
08.5	(mixture) has a lower melting point (than aluminium oxide)	allow cryolite lowers the melting point (of aluminium oxide) ignore boiling point do not accept cryolite is a catalyst	1	AO1 4.8.2.2
	(so) less energy is required (to melt the mixture)	ignore cost	1	
08.6		allow anode for positive electrode		AO1 4.8.2.2
	positive electrode is made out of carbon / graphite	allow both electrodes are made of carbon / graphite	1	
	oxygen is produced at positive electrode (during electrolysis)		1	
	(so) carbon and oxygen react (to produce carbon dioxide)	allow $C + O_2 \rightarrow CO_2$	1	
08.7	(property) high melting point	ignore boiling point	1	AO3 4.8.2.2
	(reason) (so) would not melt in the high temperatures (in the electrolytic cell)		1	
	(property) inert / unreactive	ignore low reactivity	1	
	(reason) (so) does not react with oxygen **or** (so) does not react with aluminium oxide	ignore (so) does not react with aluminium	1	
Total			**16**	