PEARSON EDEXCEL IGCSE CHEMISTRY · 4CH1

CHEMISTRY



MARK SCHEME

SECTION 3: PHYSICAL CHEMISTRY (PACK 2)

SCORE	PERCENTAGE
/223	%

STEMUP

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Mark Scheme

Q1.

Question number	Answer	Notes	Marks
(a)	<table><tr><th>Apparatus</th><th>Unit</th></tr><tr><td>(gas) syringe</td><td>cm^3</td></tr><tr><td>(top pan) balance **OR** (weighing) scales</td><td>g **OR** mg</td></tr></table>	**ALLOW** ml **ALLOW** words e.g.grams **ALLOW** weighing machine **ALLOW** kg 1 mark each correct row/column Mark horizontally or vertically (whichever benefits the candidate)	2
(b) (i)	M1 to cool (the water vapour/steam) M2 so the water vapour/steam condenses	**ALLOW** to keep condenser cool **ALLOW** so the water vapour/steam becomes liquid	2
(ii)	**M1** add silver nitrate/$AgNO_3$ (solution) **M2** white precipitate	**IGNORE** addition of nitric acid but **REJECT** addition of hydrochloric/sulfuric acid for M1 M2 dep on use of silver nitrate	2
(iii)	**M1** measure its boiling point **M2** (boiling point is) 100°C OR **M1** measure its freezing point **M2** (freezing point is) 0°C	**ALLOW** boil it **ALLOW** freeze it	2
		Total for question	= 8 marks

Q2.

Question number	Answer	Notes	Marks
(a) (i)	$4NH_3 + 5O_2 \rightleftharpoons 4NO + 6H_2O$	**ACCEPT** multiples and fractions	1
(ii)	reversible (reaction)	**ACCEPT** reaction that goes both ways / both forwards and backwards reactions occur **IGNORE** references to equilibrium	1
(iii)	to increase the rate of the reaction / to speed up the reaction OWTTE	**IGNORE** references to lowering the activation energy	1
(b)	$2NO + O_2 \rightarrow 2NO_2$	**ACCEPT** multiples and fractions	1
(c) (i)	• calculate M_r of NO_2 and HNO_3 • calculate the amount, in moles, of NO_2 • calculate the amount, in moles, of HNO_3 • calculate the mass in tonnes of HNO_3 Example calculation M1 M_r of NO_2 = 46 M_r of HNO_3 = 63 M2 $n(NO_2) = 11.5 \times 10^6 \div 46$ **OR** 250 000 (mol) M3 $n(HNO_3) = \frac{2 \times 250000}{3}$ **OR** 167 000 / 170 000 M4 (167 000 x 63 g) = 10.5 (tonnes)	**ALLOW** working in megamoles i.e. 11.5 ÷ 46 **OR** 0.25 **ALLOW** ECF from incorrect Mr of NO_2 calculator answer 166666.66 **ALLOW** working in megamoles i.e. $\frac{2 \times 0.25}{3}$ **OR** 0.167 / 0.17 **ALLOW** ECF from M2 10.5 (tonnes) with no working scores 4 **ACCEPT** 10.7 (if 170 000 used) **ALLOW** ECF from M3 **ALLOW** ECF from incorrect M_r of HNO_3	4
(ii)	can be (re)used in stage 2 / to make more nitrogen dioxide (in stage 2) / can be used to make more nitric acid	**IGNORE** can be recycled/reused unless qualified	1

Question number	Answer	Notes	Marks
(d)	• calculate the amount, in moles, of copper(II) nitrate • calculate the theoretical yield, in moles, of copper(II) nitrate • calculate the percentage yield Example calculation **M1** $n\text{Cu(NO}_3)_2$ formed = 15.3 ÷ 187.5 **OR** 0.0816 **M2** theoretical $n\text{Cu(NO}_3)_2$ = 0.200 ÷ 2 **OR** 0.100 **M3** (% yield) = $\frac{(0.0816 \times 100)}{(0.100)}$ = 81.6 (%) Alternative method • calculate the theoretical yield, in moles, of copper(II) nitrate • calculate the theoretical mass of copper nitrate that should be formed • calculate the percentage yield	**ALLOW** 0.082 **ACCEPT** 82 (%) Mark M3 CSQ on M1 and M2 40.8 scores 2	3

	Example calculation **M1** theoretical $n\text{Cu(NO}_3)_2$ = 0.200 ÷ 2 **OR** 0.100 **M2** theoretical mass of copper nitrate = 0.1 x 187.5 = 18.75 **M3** (% yield) = $\frac{15.3}{18.75}$ x 100 = 81.6 (%)	**ALLOW** 18.8 **ACCEPT** 82 (%) Mark M3 CSQ on M1 and M2 40.8 scores 2 81.6(%) with no working scores 3 marks	**Total 12**

Q3.

Question number	Answer	Notes	Marks
(a) (i)	M1 dissolving M2 diffusion	Answers can be in either order	2
(b) (i)	An explanation that links any two of the following points M1 crystals dissolve faster M2 (potassium iodide/ lead nitrate/ water) particles move faster / (lead/ iodide) ions move faster / rate of diffusion increases M3 therefore (lead and iodide) ions/ particles meet / collide after a shorter period of time/ sooner	**ALLOW** (potassium iodide /lead nitrate/ water) particles have more energy **ALLOW** molecules in place of particles if referring to water **IGNORE** references to more collisions or more energetic collisions	2
(c) (i) (aq) (ii)	3 / three 2+ /+2	 **ALLOW** Pb	1 1
(d)	$Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$	**ALLOW** multiples and fractions	1
			7 marks

Q4.

Question number	Answer	Notes	Marks
(a)	M1 magnesium loses two electrons M2 (each of two) chlorine atoms gains one electron	**ACCEPT** magnesium becomes 2.8 **ACCEPT** (each of two) chlorine atoms becomes 2.8.8 M1 and M2 can be scored from correct diagrams No M1 M2 if reference to covalent bonding or sharing electrons	2
(b) (i)	M1 $\frac{(35 \times 70) + (37 \times 30)}{100}$ M2 35.6(0)	 correct answer of 35.6(0) with or without working scores 2	2
(ii)	(both isotopes have) the same electron configuration / arrangement	**ALLOW** (both isotopes have) the same number of electrons (in their outer shell)	1
(c) (i)	M1 exothermic M2 the temperature increases	 **ALLOW** heat energy is given out	2
(ii)	Any one from: polystyrene is a (good) insulator to reduce/prevent heat loss (to the surroundings)	 **IGNORE** references to safety	1
(iii)	M1 $\Delta T = 27.5$ M2 $100 \times 4.2 \times 27.5$ M3 = 11 550	 **ALLOW** ecf from M1 **ALLOW** 2 or more significant figures **ALLOW** ecf from M2 Correct answer 11 550 with or without working scores 3 115.5 scores 2	3
		Total for question	= 11 marks

Q5.

Question number	Answer	Notes	Marks
(a)	$2\ H_2O_2 \rightarrow 2\ H_2O + (1)\ O_2$	**ALLOW** multiples and fractions	1
(b)	Relights a glowing splint/spill		1
(c)	Speeds up/increases rate of the reaction	**IGNORE** references to lowering activation energy	1
(d) (i)	All points plotted correctly	**ALLOW** ± half a square	1
(ii)	Point at 8 minutes circled		1
(iii)	Smooth curve of best fit		1
(iv)	took the reading too soon/before 8 minutes	**ACCEPT** misread the volume (of oxygen)	1
(v)	**M1** vertical line on graph drawn to curve from 3 mins		2
	M2 value obtained from candidate's graph	Expected value 29 or 30 cm^3 **ALLOW** ± half a square	

Question number	Answer	Notes	Marks
(e) (i)	**M1** curve drawn on graph that is less steep than curve of student's results.		2
	M2 curve levels off at 40 cm^3	**ALLOW** ± half a square	
(ii)	An explanation that links the following three points		3
	M1 reaction is slower		
	M2 fewer particles/molecules (in the same volume)	**ACCEPT** particles are further apart / less crowded	
	M3 fewer collisions per unit time	**ACCEPT** less frequent collisions **IGNORE** less chance of a collision	
			Total 14

Q6.

Question number	Answer	Notes	Marks
(a)	Any one from: M1 add more limewater (to cover tube on left) M2 the glass tube on the left should be longer/in the limewater		1

(b) (i)	M1 volume of carbon dioxide = 10 (cm^3) M2 10÷76 × 100 = 13.2 (%)	correct answer with or without working scores 2 marks. **ACCEPT** any number of significant figures except 1 **REJECT** incorrect rounding **ALLOW** ecf on incorrect volume of carbon dioxide **ALLOW** 66/76 x 100 = 86.8 for 1 mark	2
(ii)	limewater turns (from colourless to) cloudy or milky	**ALLOW** white precipitate	1
(iii)	M1 the percentage/amount of carbon dioxide in the air is too small M2 therefore the reading on the syringe would change by less than 1 cm^3	**ALLOW** there is 0.04% of carbon dioxide in the air **ALLOW** the change on the gas syringe would be too small **ALLOW** syringe not precise/accurate enough to measure small volume changes	2

(c) (i)	copper(II) oxide	**ALLOW** copper oxide /CuO **REJECT** copper (I) oxide	1
(ii)	the powder has a greater surface area (than larger pieces of copper)	**ALLOW** the powder reacts more quickly (than larger pieces of copper)	1
(iii)	M1 argon/it has a full outer shell of electrons M2 therefore does not lose or gain (or share) electrons	**ALLOW** has eight outer shell electrons	2
			10

Q7.

Question number	Answer	Notes	Marks
(a)	galvanising	**ACCEPT** galvanisation	1
(b) (i)	rust		1
(ii)	**M1** oxygen / air	**ACCEPT** O_2 **IGNORE** O	2
	M2 water	**ACCEPT** H_2O/moisture **ACCEPT** in either order	
(c) (i)	(a reaction which) gives out / produces / releases heat (energy) / thermal energy	**IGNORE** energy without mention of heat or thermal	1
(ii)	An explanation that links the following two points		2
	M1 aluminium/Al is more reactive than iron/Fe	**ACCEPT** aluminium/Al is higher in reactivity series than iron/Fe **ACCEPT** reverse argument	
	M2 (because) aluminium/Al displaces iron/Fe (from its oxide)	**ALLOW** replaces/takes place of	
(iii)	An explanation that links the following three points		3
	M1 aluminium is oxidised and iron/iron oxide is reduced	**ALLOW** both oxidation and reduction occur	
	M2 aluminium gains oxygen	**ALLOW** aluminium/Al loses electrons	
	M3 iron oxide/iron loses oxygen	**ALLOW** iron ions /Fe^{3+} gains electrons **ALLOW** correct references to changes in oxidation number for **M2** and **M3**	
			Total 10

Q8.

Question number	Answer	Additional guidance	Mark
(a)	thermometer reading at end/°C: (26.8) thermometer reading at start/°C: 18.7 temperature rise/°C: 8.1	1 mark for temperature at start 1 mark for temperature rise consequential on readings	2

Question number	Answer	Mark
(b)(i)	29.5	1

Question number	Answer	Mark
(b)(ii)	20.8	1

Question number	Answer	Additional guidance	Mark
(c)	• Calculation of volume/mass of mixture • Calculation of temperature increase • Substitution of values into $q=mc\Delta T$ • Calculation of heat energy released with unit Example calculation: 20.0 + 20.0 = 40.0 (cm^3) (1) 30.0−18.5 = 11.5 (°C) (1) q = 40.0 × 4.2 × 11.5 (1) q = 1900 J (1) (1932 J)	accept 1930 accept answers to three or more significant figures	4

Q9.

Question number	Answer	Notes	Marks
(a) (i)	zinc + copper(II) sulfate → **zinc sulfate + copper**	**REJECT** copper(II) as a product **ACCEPT** zinc(II) sulfate	1
(ii)	polystyrene is an insulator / prevents heat loss	**ALLOW** to prevent the cup falling over	1
(iii)	zinc is more reactive / higher in the reactivity series than copper	**ALLOW** reverse argument	1
(iv)	M1 temperature rise = 28.6°C M2 (75 × 4.2 × 28.6 =) 9009	correct answer without working scores 2 ALLOW 9010/9000 **IGNORE** any sign **ALLOW** ECF from M1	2

(b) (i)	M1 800÷1000 OR 0.8 (kJ) M2 0.65÷65 OR 0.01 (mol) M3 0.8÷0.01 = −80 (kJ/mol) OR M1 0.65÷65 OR 0.01 (mol) M2 800÷0.01 OR 80 000 (J/mol) M3 −80 (kJ/mol)	correct answer without working scores 3 **ALLOW** ECF but answer must have a − sign 80/+80 scores 2	3
(ii)	M1 zinc/Zn is oxidised because loses electrons M2 silver ion(s)/Ag^+ reduced because gain electrons OR M1 zinc/Zn is oxidised **and** silver ion(s)/Ag^+ reduced M2 zinc/Zn loses electrons **and** silver ion(s)/Ag^+ gain electrons		2
		Total for question = 10 marks	

Q10.

Question number	Answer	Notes	Marks
(a) (i)	OH^-	**ALLOW** HO^-/OH^{-1}/OH^{1-} **ALLOW** lower case letters	1
(ii)	Any value between 0 and 3 inclusive		1
(b)	An explanation that links the following two points **M1** polystyrene is an insulator **M2** less heat (energy) will be lost	**ALLOW** no heat (energy) will be lost	2
(c)	temperature in °C at end: 22.0 temperature in °C at start: 17.7 temperature change in °C: 4.3 1 mark each	**ALLOW** 22 If initial and final temperatures are reversed deduct 1 mark **ALLOW** ECF on temperature change	3

(d)	• give the expression for Q • substitute correct numbers into $Q = mc\Delta T$ • evaluation in J • conversion to kJ Example calculation M1 $Q = mc\Delta T$ M2 50 x 4.2 x 5.2 M3 1092 (J) M4 1.1 (kJ)	M2 subsumes M1 **ALLOW** ECF for M3 and M4 on incorrect values in M2 **ACCEPT** answers correctly rounded to 2 or more sig figs 1.1, 1.09, 1.092 without working scores 4 1100, 1090, 1092 without working scores 3 0.546, 0.55 without working scores 3 546, 550 without working scores 2 **ALLOW** use of 4.18 giving an answer of 1.0868	4 Total 11

Q11.

Question number	Answer	Notes	Marks
(a) (i)	Any one from: to increase the rate of reaction to give the particles enough energy to react	 ALLOW because copper does not react with oxygen when copper is cold ALLOW so that copper will react with oxygen	1
(ii)	because Ar does not (readily) gain / lose / share electrons	ACCEPT argon has a full outer shell / valence shell of electrons	1
(iii)	copper(II) oxide	ALLOW copper oxide REJECT copper(I) oxide	1

(b)	(i)	results are the same (at the end)	ALLOW results stop decreasing	1
	(ii)	M1 volume oxygen = 20 cm^3 M2 total volume = 253 cm^3 M3 (20÷253)×100 = 7.9%	ALLOW correct evaluation from M1 and M2 ALLOW any number of significant figures REJECT incorrect rounding Correct answer of 7.9% with or without working scores 3	3
	(iii)	Any one from: there is a leak in the apparatus temperature was not the same for all readings the apparatus was not left to cool (to room temperature)	IGNORE not all oxygen reacted	1
				Total for question = 8 marks

Q12.

Question number		Answer	Notes	Marks
(a)		to keep out of contact/prevent reaction with air/oxygen/water/moisture	ALLOW they react with air/oxygen/water/moisture	1
(b)	(i)	similarity: both fizz/move on surface/ produce flame	ALLOW both melt/form a ball/produce a gas/ produce hydrogen/form an alkaline solution	2
		difference caesium: faster/more violent reaction	ACCEPT reverse argument for potassium ALLOW caesium explodes	
	(ii)	$2Cs + 2H_2O \rightarrow 2CsOH + H_2$ M1 all symbols/formulae correct M2 correctly balanced	ACCEPT fractions and multiples M2 DEP M1	2

(c) (i)	a lid/cover		1
(ii)	explanation linking either M1 stir solution M2 to obtain more accurate (maximum) temperature OR M1 measure temperature of sodium hydroxide M2 to check if different to/same as temperature of (hydrochloric) acid	ALLOW reference to even temperature throughout/ heat evenly distributed OWTTE ALLOW take an average of temperature of sodium hydroxide and temperature of (hydrochloric) acid for 2 marks	2

Question number	Answer	Notes	Marks
(d) (i)	M1 correct temperature change/△T M2 correct substitution into Q = m x c x △T M3 correct evaluation Example calculation: M1 △T = (26.5 – 19.9) OR 6.6 M2 Q = 100 x 4.2 x 6.6 M3 = 2800 (J)	 M2 ECF M1 M3 ECF M2 IGNORE any sign ALLOW 2770, 2772 correct answer without working scores 3	3
(ii)	M1 answer to M3 from (i) ÷ 0.05 M2 correct evaluation in kJ/mol with negative sign expected answer M1 2800 ÷ 0.05 OR 56000 (J) M2 - 56 (kJ/mol)	 2770 gives 55400 2772 gives 55440 negative sign required ACCEPT -55.4 ACCEPT -55.44 ACCEPT -55 correct answer without working scores 2	2
		(Total for Question = 13)	

Q13.

Question number	Answer	Mark
(a)	• Increment in volume smaller/more precise (1) • Avoids refilling the measuring cylinder (1)	**2**

Question number	Answer	Additional guidance	Mark
(b)	thermometer reading at end/°C: (26.8) thermometer reading at start/°C: 18.7 temperature rise/°C: 8.1	1 mark for temperature at start 1 mark for temperature rise consequential on readings	2

Question number	Answer	Mark
(c)(i)	29.5	1

Question number	Answer	Mark
(c)(ii)	20.8	1

Question number	Answer	Mark
(d)	• Calculation of volume/mass of mixture • Calculation of temperature increase • Substitution of values into $q=mc\Delta T$ • Calculation of heat energy released with unit Example calculation: 20.0 + 20.0 = 40.0 (cm^3) (1) 30.0–18.5 = 11.5 (°C) (1) q = 40.0 × 4.2 × 11.5 (1) q = 1900 J (1) (accept 1932 J)	4

Question number	Answer	Mark
(e)	• Setting out of ΔH calculation • Division by 1000 to obtain answer in kJ/mol Example calculation: 1600 ÷ 0.040 (1) = −40 (kJ/mol) (1)	2

(Total for question = 12 marks)

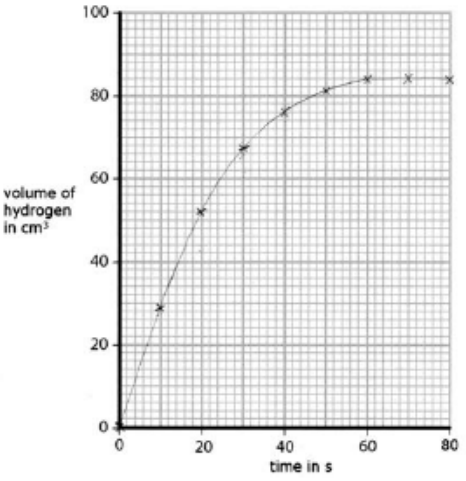
Q14.

Question number	Answer	Notes	Marks
(a) (i)	measuring cylinder	ALLOW pipette/burette	1 cler
(ii)	to ensure temperature same throughout solution OWTTE	ACCEPT to ensure heat evenly distributed throughout solution OWTTE	1 grad
(iii)	blue	IGNORE qualifiers eg light/dark REJECT blue-green	1 cler
(b)	<table><tr><td>**Maximum temperature in °C**</td><td>27.3</td></tr><tr><td>**Initial temperature in °C**</td><td>24.4</td></tr><tr><td>**Increase in temperature in °C**</td><td>2.9</td></tr></table> M1 27.3 M2 24.4 M3 2.9	If readings are correct but in reverse order award 1 mark for M1 and M2 ALLOW ECF for M3 if M1 and/or M2 incorrect	3 grad

Question number	Answer	Notes	Marks
(c) (i)	• substitution into $Q = mc\Delta T$ • calculation of heat energy in Joules Example calculation **M1** Q = 50 x 4.2 x 3.3 **M2** 693 J	 693 without working scores 2 marks	2 exp
(ii)	• calculate the amount, in moles, of $CuSO_4$ • divide Q by the amount in moles • conversion to KJ • give the correct sign Example calculation **M1** 1.70 ÷ 159.5 **OR** 0.0107 **M2** 693 ÷ 0.0107 **OR** 64766 (J/mol) **M3** 64.8 (kJ/mol) **M4** – 64.8 (kJ/mol)	 ALLOW any number of SF throughout except one Mark CQ from (i) ALLOW use of 700 use of 700 gives -65.02 693 & 0.011 gives -63 700 & 0.011 gives -63.64 correct answer with correct sign and without working scores 4 correct answer without sign or incorrect sign and without working scores 3	exp 4

(d)	M1 temperature decreases/falls M2 (so) endothermic		2 grad
			Total Q = 14

Q15.

Question number	Answer	Notes	Marks
a (i)		all points plotted correctly to + or – half a square	1
(ii)		curve of best fit drawn for points plotted	1

Question number	Answer	Notes	Marks
b i	**M1** curve Y starting at origin **and** below original curve **M2** levelling off at 42 cm^3 to + or – half a square		2
ii	**M1** curve Z starting at origin **and** above original curve **M2** levelling off at 84 cm^3 to + or – half a square	**ACCEPT** curves unlabelled If curves labelled incorrectly then deduct 1 mark	2
c	Any one from: **M1** some gas escapes before the bung is replaced/ before the syringe is connected **M2** the magnesium is impure/ the magnesium ribbon has an oxide coating	**IGNORE** gas escapes unqualified **IGNORE** magnesium didn't fully react /reaction didn't go to completion **ALLOW** some gas dissolves in the solution/acid/water	1

Question number	Answer	Notes	Marks
d	An explanation that links together the following two points: **M1** the acid is in excess **M2** therefore a precise/ an accurate measurement of the volume is not required	 **M2** dep on **M1**	**2**
e	An explanation that links the following points: **M1** the concentration of the acid/hydrogen ions/H^+ (ions) decreases **M2** therefore there are fewer (successful) collisions (between the hydrogen ions/H^+ ions and the magnesium atoms) **M3** per second/per unit time	 **ALLOW** there are fewer hydrogen ions/H^+ (ions) in the same volume **ALLOW** the surface area of the magnesium decreases less frequent collisions/ slower collision rate scores **M2** and **M3** **M3** dep on **M2** **IGNORE** less chance of collision **MAX 1** if reference to energy of particles changing	**3**

Q16.

Question number	Answer	Notes	Marks
(a)	prevents liquid / acid splashing out		1 Exp
(b) (i)	**M1** (1.8 ÷ 20 =) 0.090	**IGNORE** number of significant figures **ACCEPT** -0.090	2 Exp
	M2 grams per second	**ALLOW** grams/second or g/s or gs^{-1}	
(ii)	**M1** all points plotted ± half a square **M2** curve of best fit	**Max (1)** if first point not plotted / included in curve	2 Exp
(iii)	**M1** concentration (of hydrochloric acid) decreases / smaller amount/surface area of calcium carbonate	**ALLOW** fewer particles **ALLOW** any idea that either reactant is being used up (but not run out)	2 Exp
	M2 fewer collisions per unit time / less frequent collisions	**IGNORE** less chance of a collision	
(iv)	Any one from: **M1** the calcium carbonate has run out **M2** no more carbon dioxide is given off **M3** the reaction has finished	**REJECT** hydrochloric acid has run out	1 Grad

(c)	(i)	Any two from: **M1** concentration of hydrochloric acid **M2** volume of hydrochloric acid **M3** temperature	**ALLOW** amount of hydrochloric acid	2 Grad
	(ii)	**M1** (powder has a) greater surface area **M2** therefore there are more collisions (per unit time)		2 Exp
	(iii)	Any one from: **M1** the graph would be steeper **M2** the line would get to 146 g / flatten off / finish after a shorter time	**ALLOW** higher gradient / line decreases faster **REJECT** any reference to more carbon dioxide being produced.	1 Exp
			Total for question	13

Q17.

Question number		Answer	Notes	Marks
(a)	(i)	carbon dioxide/a gas is given off/escapes	**REJECT** incorrect gas	1
	(ii)	to prevent acid/ liquid/ solution/ spray from leaving the flask OWTTE		1
	(iii)	An explanation that links two of the following **M1** (insoluble) calcium sulfate will form **M2** which will form a coating/ layer on the marble chips **M3** slowing down/ preventing/ stopping the reaction	 M3 dep on M1 or M2	2

(b)	(i)	An explanation that links the following four points **M1** the curve is steep(est) at the start **M2** because the (acid) concentration is high(est) **M3** the curve becomes less steep as the solution/ acid is becoming more dilute **M4** the curve levels off/ stops going up when the acid has all been used up **OR** **M1** the curve is steep(est) at the start **M2** because the reaction is fast(est) at the start **M3** the curve becomes less steep because the reaction slows down **M4** the curve levels off/stops going up when the acid has all been used up	**ALLOW** there are the most (acid) particles in solution **ALLOW** the curve becomes less steep as there are fewer acid particles/particles in solution **IGNORE** references to particles of marble chips **IGNORE** references to energy	4
	(ii)	M1 curve drawn starting at the origin and below the original curve M2 curve levels off at 0.27 g + or – half a small square		2

Question number	Answer	Notes	Marks
(c)	An explanation that links the following four points **M1** the rate of reaction increases/ the reaction is faster/ the reaction speeds up and any three from **M2** because the particles gain (kinetic) energy /move faster **M3** there are more collisions per unit time **M4** more collisions/particles have energy greater than the activation energy **M5** more collisions are successful	there are more frequent successful collisions scores **M3** and **M5**	4 **Total 14**

Q18.

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>(a) (i)</td><td>→ magnesium chloride + hydrogen</td><td>ACCEPT in either order</td><td>1</td></tr>
<tr><td>(b) (i)</td><td><table><tr><td>temperature of the acid at the start in °C</td><td>22.4</td></tr><tr><td>highest temperature reached in °C</td><td>43.2</td></tr><tr><td>temperature rise in °C</td><td>20.8</td></tr></table></td><td>ALLOW ECF from incorrect starting temperature</td><td>2</td></tr>
</table>

(ii)	• substitute correct values into $Q = mc\Delta T$ • evaluation Example calculation **M1** $Q = 25 \times 4.2 \times 20.8$ **M2** 2184 (J)	Correct answer of 2184 or 2194 without working scores 2 **ALLOW** 25.12g for m **ACCEPT** any number of sig figs except 1 **ALLOW** ECF from M1	2
(iii)	• find the amount of magnesium in moles • divide Q by n • convert answer in J/mol to kJ/mol • answer including sign Example calculation **M1** $n(Mg) = 0.12 \div 24$ **OR** 0.005(0) **M2** $Q \div n$ **OR** $2184 \div 0.005(0)$ **OR** 436,800 (J/mol) **M3** $436{,}800 \div 1000$ **OR** 436.8 (kJ/mol) **M4** – 436.8 (kJ/mol)	 **ACCEPT** use of 2180 or 2200 **ALLOW** ECF on incorrect answer to (ii) and/or **M1** **ALLOW** ECF on incorrect answer to **M2** **ALLOW** ECF on incorrect answer to **M3** Correct answer with minus sign and without working scores 4 Correct answer without minus sign and without working scores 3 **ACCEPT** any number of sig figs except 1 throughout (ii) -438.8 or-438.9 also scores 4 (from 5.12g and 2194J in (ii))	4 **Total 9**

Q19.

Question number	Answer	Notes	Marks
(a) (i)	M1 and M2 all points correctly plotted to the nearest half a square	deduct 1 mark for each error	2
(ii)	smooth curve of best fit		1
(iii)	An explanation that links any **two** of the following points M1 polystyrene is an insulator M2 reduces thermal energy/heat coming in from the surroundings OWTTE M3 temperature decrease will be closer to true value OWTTE	 **ALLOW** results will be more accurate	2
(iv)	Any one from: M1 the student recorded the temperature before adding the sodium carbonate /the temperature had not stopped decreasing OWTTE M2 the student forgot to the stir the mixture	 **ALLOW** less than 0.5 g of/not enough sodium carbonate was added	1
(v)	(two) results at the end are the same	**ALLOW** the temperature stops decreasing	1
(vi)	An explanation that links together M1 the reaction is endothermic and either of the following points M2 it takes in thermal energy/heat from the surroundings **OR** M3 as shown by the temperature decrease (of the reaction mixture)	 **REJECT** exothermic for both marks **ALLOW** references to cooling No **M2** or **M3** if the statements contradict one another	2

Question number	Answer	Notes	Marks
(b) (i)	to prevent acid / liquid / solution splashing out		1
(ii)	M1 (M_r of sodium carbonate) = 106		3
	M2 (moles of sodium carbonate 2.12 ÷ 106 =) 0.02	ALLOW ecf from M1 M2 subsumes M1	
	M3 (mass of carbon dioxide 0.02 × 44 =) 0.88 (g)	ALLOW answer from M2 x 44 answer of 0.88 (g) with or without working scores 3	
(iii)	Any one from: M1 the sodium carbonate is impure M2 some of the carbon dioxide dissolves in the acid/solution		1
			14

Q20.

Question number	Answer	Notes	Marks
(a)	M1 two lithium atoms each lose one electron /give one electron to oxygen M2 oxygen gains two electrons M3 lithium (ion) has an electron configuration of 2 and oxide (ion) is 2,8	ALLOW lithium loses one electron /gives one electron to oxygen ALLOW oxygen becomes 2,8 All 3 marks can be scored from diagrams showing the electron configurations of the ions 0 marks if reference to sharing electrons	3

(b)	(i)	M1 (temperature after) = 27.7°C M2 temperature rise = 10.4 °C	 ALLOW ecf from M1	2
	(ii)	Example calculation M1 Use of 100 in Q = m x c (x ΔT) M2 Use of 10.4 in Q = (m x) c x ΔT M3 4368J M4 4400J	Correct answer of 4400J with or without working scores 4 ALLOW ecf from (b)(i) 100 x 4.2 x 10.4 scores M1 and M2 ALLOW ecf from M1 and M2 ALLOW ecf from M3 IGNORE + or - sign in front of answer	4
	(iii)	Example calculation M1 5210 ÷ 1000 or 5.21 M2 5.21 ÷ 0.0580 M3 -89.8(kJ/mol)	Correct answer of -89.8 (kJ/mol) scores 3 ALLOW -90 (kJ/mol) or any number of sig figs as long as correctly rounded.	3
	(iv)	polystyrene is a good insulator /poor conductor (of heat) OR to minimise/reduce heat loss	ALLOW prevent heat loss	1
				13 marks