PEARSON EDEXCEL IGCSE CHEMISTRY · 4CH1

CHEMISTRY



MARK SCHEME

SECTION 3: PHYSICAL CHEMISTRY (PACK 3)

SCORE	PERCENTAGE
/232	%

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Mark Scheme

Q1.

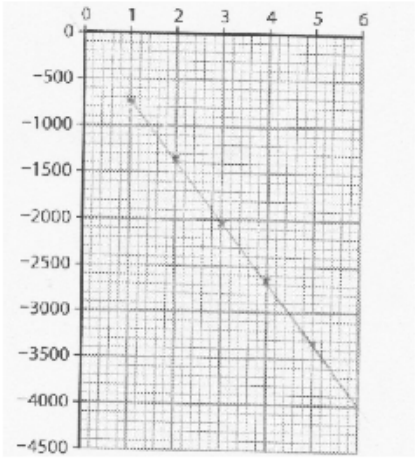
Question number	Answer	Notes	Marks
(a) (i)	Q		1 cler
(ii)	might be explosive/dangerous/unsafe		1 grad
(iii)	R S P Q		1 cler
(b) (i)	galvanising/galvanisation		1 grad
(ii)	Any one from paint/oil/grease/sacrificial protection OWTTE	IGNORE barrier method If answer to (i) missing or incorrect credit galvanising in (ii)	1 grad
(c) (i)	zinc displaces copper	ALLOW zinc replaces copper/zinc takes oxygen from copper	1 grad
(ii)	M1 copper(II) oxide/CuO M2 because copper(II) oxide/CuO/it loses oxygen	ALLOW because copper(II) oxide/CuO/it gives oxygen to zinc/is reduced M2 DEP M1 or near miss e.g. Cu as it gives oxygen to zinc scores 1 mark for M2 IGNORE references to electrons	2 expert
		Total for Q = 8 marks	

Q2.

Question number	Answer	Notes	Marks
(a)	to minimise/prevent (mass loss by) evaporation of the (liquid) fuel OWTTE	**ALLOW** to find mass of fuel used/burned	1
(b) (i)	soot/carbon	**REJECT** copper oxide	1
(ii)	An explanation that links the following two points. **M1** incomplete combustion (occurs) **M2** (because) the air/oxygen supply is limited OWTTE	**ALLOW** mark for soot/carbon if not seen in (i), unless copper oxide is mentioned in (i) If copper oxide in (i) ALLOW 1 mark for (because) copper reacts with oxygen (in air)	2

(c) (i)	• substitution into $Q = mc\Delta T$ • calculation of heat energy in Joules • conversion to kJ Example calculation **M1** Q = 100 x 4.2 x 30 **M2** = 12600 (J) **M3** = 12.6 kJ	 12600 (J) with no working scores M1 and M2 M2 ECF M1 **ALLOW** approximately = 13 kJ 12.6 kJ with no working scores 3	 3

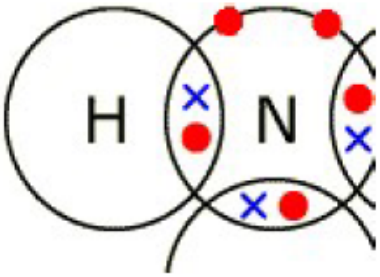
(ii)	• calculate the amount, in moles, of methanol • divide Q by the amount in moles • give the answer with the correct sign Example calculation **M1** 0.96 ÷ 32 **OR** 0.03 **M2** 12.6 ÷ 0.03 **OR** 420 (kJ/mol) **M3** – 420 (kJ/mol)	 **ACCEPT** 13 ÷ 0.03 **OR** 430/433 for **M2** **AND** – 430 / – 433 for **M3**	 3

Question number	Answer	Notes	Marks
(d) (i)	**M1** all points plotted correctly **M2** line of best fit drawn with a ruler  	does not need to start at (0,0)	2
(ii)	**M1** straight line extrapolated up to 6 carbon atoms **M2** value of ΔH read from their graph	**ALLOW** extra point shown at 6 carbon atoms negative sign needed	2
(iii)	The greater the number of carbon atoms (per molecule) the greater (the magnitude/ value of) ΔH	**ALLOW** ΔH is (directly) proportional to the number of carbon atoms per molecule **ALLOW** The greater the number of carbon atoms (per molecule) the more exothermic the ΔH value	1
			Total 15

Q3.

Question number	Answer	Notes	Marks
(a) (i)	$N_2 + O_2 \rightarrow 2NO$	**ALLOW** fractions and multiples **IGNORE** state symbols, even if incorrect	1
(ii)	the reaction has a high activation energy / E_a	**ACCEPT** to give the reactants enough energy to react **ACCEPT** a lot of energy is required to break the bonds in the reactants **ALLOW** nitrogen is unreactive	1
(iii)	acid rain	**ACCEPT** references to respiratory problems **ALLOW** a specific harmful effect of acid rain **ALLOW** references to smog **ALLOW** references to greenhouse gases / global warming / climate change **ALLOW** toxic	1

(b)	(i)	M1 catalyst provides an alternative reaction route/ pathway M2 with lower activation energy		2
	(ii)	M1 particles / molecules are closer together M2 therefore more collisions M3 per unit time	**ACCEPT** more particles in a smaller volume /space more frequent collisions scores M2 and M3 any reference to increasing energy max = 1	3

(c)	(i)	M1 one pair of electrons between the nitrogen and each hydrogen M2 two non-bonding electrons on the nitrogen  	 M2 dep on M1	2 2
	(ii)	M1 (electrostatic) attraction between nuclei M2 and shared pair(s) of electrons OR M1 (electrostatic) attraction between shared pair(s) of electrons M2 and nuclei (of both atoms)	nuclei must be plural **ALLOW** bonding pair(s) of electrons **ALLOW** bonding pair(s) of electrons nuclei must be plural	2
	(iii)	M1 forces between molecules/intermolecular forces (of attraction) are weak M2 and therefore require little energy to overcome	**ALLOW** intermolecular bonds are weak **IGNORE** less energy Mention of breaking covalent bonds = 0	
				14

Q4.

Question number	Answer	Notes	Marks
(a)	glowing splint relights		1
(b)	M1 filter off the solid M2 dry the solid M3 same mass of solid / 1 g of solid	ALLOW decant/pour off liquid	3
(c)	M1 (smooth) curve above original curve M2 levels out at 40 cm^3 (before 150 sec)		2
		Total for question	= 6 marks

Q5.

Question number	Answer	Mark
(a)	One reaction product is a gas and so escapes from the flask	1

Question number	Answer	Mark
(b)(i)	Any one of: • balance reading recorded too late • acid concentration greater than recorded	1

Question number	Answer	Mark
(b)(ii)	Loss in mass directly proportional to acid concentration	1

Question number	Answer	Additional guidance	Mark
(c)	An explanation that makes reference to the following two points: • more particles in the same volume (1) • so collide more frequently (with malachite) (1)	accept particles closer together	2

(Total for question = 5 marks)

Q6.

Question number	Answer	Notes	Marks
(a) (i)	water is needed for iron to rust / react	**ALLOW** reaction needs water (and oxygen) **ALLOW** increases rate of reaction	1
(ii)	brown (coating on iron)	**ALLOW** red-brown / orange-brown / orange / orange-red **IGNORE** red alone	1
(iii)	Fe_2O_3		1
(iv)	An explanation that links the following two points **M1** (the powder has) a larger surface area **M2** so the iron will rust quicker/ the reaction will be faster / the results are (obtained) more quickly	 **ALLOW** (the powder has) higher surface area:volume **IGNORE** references to the collision theory	2
(b)	syringe reading at start: 81 syringe reading at end: 16 change in volume in cm^3: 65	**ALLOW** ecf on syringe reading at start if syringe reading at end read incorrectly correct volumes the wrong way round scores 1	2

(c)	**M1** (volume of oxygen =) 90 – 22 **OR** 68 (cm^3) **M2** (total volume at start =) 260 + 90 **OR** 350 (cm^3) **M3** $\frac{68 \times 100}{350}$ = 19.4 (%)	correct answer without working scores 3 **ALLOW** ecf on **M1** and **M2** in **M3** as long as the answer is less than 100% **ACCEPT** any number of sig figs except 1 26.2 (%) scores 2 25.7 (%) scores 2 75.6 (%) scores 2 34.6 (%) scores 1	3 **Total 10**

Q7.

Question number	Answer	Notes	Marks
(a) (i)	potassium hydroxide + hydrochloric acid → potassium chloride + water	**ALLOW** correctly balanced chemical equation	1
(ii)	**M1** to mix (the two solutions more thoroughly)		2
	M2 (so that) more reactant particles come into contact with each other OWTTE	ALLOW references to increasing rate of reaction	
	M3 so that the heat energy is given out more quickly OWTTE		
	M4 so that the mixture is the same temperature throughout OWTTE		
(b)	Correct answer with or without working scores 2 • setting out of calculation • evaluation Example calculation **M1** $\frac{17.8 + 18.4}{2}$ **M2** 18.1		2

Question number	Answer	Notes	Marks
(c) (i)	Mean temperature at start in °C 17.2 Temperature at end in °C 22.4 Temperature rise in °C 5.2		2
(ii)	• calculation of volume/mass of mixture • substitution of values into $Q = mc\Delta T$ • evaluation Example calculation **M1** (volume/mass =) 25 + 25 **OR** 50 (cm^3 , (g) **M2** (Q =) 50 x 4.2 x 5.2 **M3** (Q =) 1092	**ALLOW** ecf if 25 used in calculation 1092 without working scores 3 marks	3

(iii)	• division of Q by moles of KOH • conversion of J to kJ • answer with correct sign Example calculation M1 $\frac{1092}{0.02}$ **OR** 54600 M2 conversion from J to kJ OR 54.6(00) M3 (ΔH =) − 54.6 (kJ/mol)	**ALLOW** ecf from answer to (ii) **ALLOW** any number of sig figs greater than 1 throughout **ACCEPT** 1092 or 1100 used in calculation **ALLOW** ecf from M1 Minus sign must be present **ALLOW** ecf from M2 **ACCEPT** any value between 54.5 and 55 **M3** dep on division of Q by moles Correct answer with correct sign and without working scores 3 Correct answer without sign or with incorrect sign and without working scores 2.	3 **Total 13**

Q8.

Question number	Answer	Notes	Marks
(a)	$Zn\ (s) + H_2SO_4\ (aq) \rightarrow ZnSO_4\ (aq) + H_2\ (g)$ all state symbols correct		1
all clip with graph (b) (i)	all points correctly plotted (within +/- half a square)		1
(ii)	circle around point at 6 min		1
(iii)	smooth curve of best fit		1
(iv)	student took reading too soon/before 6 min		1
(v)	mass from graph at 6 min	IGNORE UNITS	1
(c) (i)	**M1** curve becomes less steep /gradient decreases (as time increases) **M2** so rate of reaction decreases	 M2 DEP M1	2
(ii)	the (sulfuric) acid was in excess OWTTE	**ALLOW** not all (sulfuric) acid reacted **ALLOW** zinc was limiting reagent **ALLOW** zinc was not in excess	1

Question number	Answer	Notes	Marks
(d)	**M1** magnesium (more reactive than zinc so) would make reaction faster/increase the rate **M2** less concentrated acid would make reaction slower/decrease the rate **M3** (so) difficult/impossible to know whether rate will increase or decrease overall OWTTE	**REJECT** reference to different surface area **REJECT** references to differences in energy/speed of particles **ALLOW** difficult/impossible to know which change has greater effect OWTTE **ALLOW** idea of difficult/impossible to predict (overall) effect of changing two factors at same time OWTTE **ALLOW** idea of difficult/impossible to know if changes cancel each other out OWTTE	3
(e)	**M1** at higher temperature particles have more (kinetic) energy **M2** more (successful) collisions per unit time **M3** rate of reaction increases	**ACCEPT** more particles have the required activation energy **ALLOW** particles move faster **ALLOW** more frequent (successful) collisions	3

Q9.

Question number	Answer	Notes	Marks
(a)	M1 to prevent acid splashing out OR so only (carbon dioxide) gas leaves the flask M2 so the decrease in mass is close to the actual value OR so that the decrease in mass is only due to the gas	IGNORE solid leaving the flask REJECT prevents gas escaping	2
(b)	M1 $CaCO_3(s) + 2HCl(aq)$ M2 $H_2O(l) + CO_2(g)$		2
(c) (i)	the hydrochloric acid has all reacted		1
(ii)	mass stays the same / stops decreasing	ALLOW effervescence / fizzing stops ALLOW the curve levels off	1
(iii)	M1 0.98 M2 (0.98÷44) = 0.022	ALLOW any number of significant figures REJECT incorrect rounding ALLOW M1÷44 Correct answer of 0.022 moles with or without working scores 2 marks	2
(iv)	M1 tangent shown on graph M2 method of calculating gradient (change in y ÷ change in x) M3 rate of reaction in g/s	 ALLOW ECF from M2 Answer of 0.005 - 0.006 with a tangent shown on the graph scores 3 with or without other working.	3

		Answer of 0.015g/s (the average rate of reaction for the first 60s scores 1)	
(d) (i)	M1 the rate of reaction increases as the percentage concentration increases M2 the rate of reaction is (directly) proportional to the percentage concentration	 M2 subsumes M1	2
(ii)	M1 change in number of particles (per unit volume) M2 change in collisions per unit time	ALLOW particles are closer together or further apart ALLOW change in frequency of collisions REJECT increased / changed energy / speed	2
			Total for question = 15 marks

Q10.

Question number	Answer	Notes	Marks
(a) (i)	M1 copper(II) sulfate (solution) M2 shortest time taken to turn colourless	**ALLOW** copper sulfate **ALLOW** gave greatest increase in rate OWTTE **ALLOW** made reaction happen fastest OWTTE M2 dep on M1	2
(ii)	M1 a catalyst provides an alternative pathway M2 of lower activation energy	 Any reference to increasing energy/speed of particles scores 0	2
(b) (i)	An explanation with following four points **M1** the rate of reaction increases/ the reaction is faster/ the reaction speeds up **M2** because the particles gain (kinetic) energy /move faster **M3** there are more collisions per unit time **M4** more of the collisions are successful / more collisions/particles have energy greater than the activation energy	 **ACCEPT** more frequent collisions OWTTE No M4 if refer to lower activation energy there are more frequent successful collisions scores **M3** and **M4**	4
(ii)	M1 fewer particles per unit volume M2 (hence) fewer collisions per unit time	**ALLOW** particles less tightly packed / particles further apart **ALLOW** decrease in the frequency of collisions between particles Any reference to changing energy/speed of particles scores 0	2
		Total for question = 10 marks	

Q11.

Question number		Answer	Notes	Marks
(a)	(i)	$Mg + 2HCl \rightarrow MgCl_2 + H_2$	**IGNORE** state symbols even if incorrect	1
	(ii)	(squeaky) pop with lighted splint		1
	(iii)	**M1** amount of magnesium = 0.090 ÷ 24 **OR** 0.00375 (mol) **M2** amount of HCl needed = 2 × 0.00375 = 0.0075 (mol) (which is less than 0.025) **OR** **M1** amount of magnesium needed = 0.025÷2 **OR** 0.0125 (mol) **M2** mass of magnesium needed = 0.0125 × 24 = 0.3(g) (there is less magnesium than needed)	**ALLOW** any number of significant figures	2

(b)	(i)	all points plotted correctly to the nearest grid line		1
	(ii)	best fit curve starting at 0 and levelling off at 88 cm^3		1
	(iii)	**M1** vertical line on grid from 10 seconds to curve	**ALLOW** any mark at correct position on curve / either axis	2
		M2 volume correctly read from their graph to the nearest grid line	expected value 25 to 30 cm^3	
	(iv)	An explanation that links the following two points		2
		M1 concentration (of HCl) is greatest (at the start)	**REJECT** incorrect references to energy **ALLOW** more particles (of HCl / more H^+ ions) **ALLOW** more HCl molecules / greater surface area of Mg **IGNORE** greater mass /more Mg **IGNORE** references to the graph	
		M2 more collisions per unit time / more frequent collisions		

(c)	(i)	M1 curve starting at 0 and steeper than original curve	**ALLOW** a curve starting within 1 small square of the original	2
		M2 curve levelling off at same volume as original curve		
	(ii)	An explanation that links the following three points		3
		M1 particles gain more (kinetic) energy	**ALLOW** particles move faster	
		M2 more collisions have energy greater than the activation energy	**ACCEPT** more collisions are successful	
		M3 collision frequency increases **OR** rate of reaction increases	**ACCEPT** more (successful) collisions per unit time	
				Total 15

Q12.

Question number	Answer	Notes	Marks
(a) (i)	$Zn + 2HCl \rightarrow ZnCl_2 + H_2$		2
	M1 all symbols and formulae correct		
	M2 correctly balanced	M2 DEP M1	
(ii)	lighted splint (produces squeaky) pop		1
(b) (i)	52 (cm^3)	ALLOW 51.5-52.5	1
(ii)	M1 vertical line from 15 cm^3 acid to graph line	ALLOW extra point drawn at 15 cm^3	2
	M2 volume hydrogen from graph multiplied by 2	ALLOW 68-70	
	OR		
	M1 vertical line from 30 cm^3 acid to graph line	ALLOW extra point drawn at 30 cm^3	
	M2 volume hydrogen from graph	ALLOW 68-70	
(c)	explanation linking		3
	M1 more (acid) particles/(hydrogen) ions/H^+ in same volume	REJECT molecules once only ALLOW particles are closer together	
	M2 more (successful) collisions per second/unit time	ACCEPT more frequent collisions IGNORE more chance/probability of collision	
	M3 rate increases	ALLOW reaction is faster /speeds up MAX 1 if refer to particles moving faster/having more energy	

(d)	explanation including M1 (increase/decrease) surface area M2 increase surface area by using smaller pieces of zinc M3 more (successful) collisions per second/unit time (so rate increases)	 ACCEPT more frequent collisions IGNORE more chance/probability of collision M2 M3 ACCEPT reverse arguments	3
		(Total for Question = 12)	

Q13.

Question number	Answer	Notes	Marks
(a) (i)	**M1** white flame/light **M2** white powder/solid (formed)	 **ALLOW** white smoke **ALLOW** white ash **REJECT** white precipitate	2
(ii)	magnesium gains oxygen	**ACCEPT** magnesium loses electrons/ oxidation state (of Mg) increases / goes from / changes from 0 to +2	1
(b) (i)	gives out/releases heat (energy)/thermal energy	**IGNORE** energy alone	1
(ii)	$2Mg + CO_2 \rightarrow 2MgO + C$	**ALLOW** multiples and fractions	1
(iii)	Any one from the fire would keep burning OR the carbon dioxide would not put out the fire OR a large amount of heat/thermal energy would be released	 **ALLOW** Any other sensible suggestion	1

Question number	Answer	Notes	Marks
(c)	An explanation giving two linked changes **M1** (the student should) lift and replace the lid **M2** (to allow) oxygen/air to enter the crucible (to react with the magnesium) AND **M3** reheat and reweigh / heat to constant mass **M4** to make sure that all the magnesium has reacted		4 **Total 10**

Q14.

Question number	Answer	Notes	Marks
(a) (i)	glowing splint relights	**REJECT** burning splint	1
(ii)	A description that refers to the following three points M1 filter out manganese(IV) oxide / solid M2 leave to dry M3 same mass/ 1g of manganese(IV) oxide / solid		3
(b) (i)	M1 280 ÷ 120 M2 2.33	 **ALLOW** ecf from M1 **ALLOW** any number of significant figures except 1	2
(ii)	An explanation that links the following three points M1 the concentration of hydrochloric acid is greatest M2 therefore there are more collisions M3 per unit time	 **ALLOW** the surface area of zinc is greatest **ALLOW** greatest number of/more particles (of hydrochloric acid/ zinc) More frequent collisions scores M2 and M3 Max 1 if incorrect reference to energy	3 2
(iii)	M1 curve above original and starts at 0 M2 curve goes flat at same volume (410cm^3)		

(iv)	M1 greater surface area M2 more collisions per unit time / more frequent collisions		2
(c)	M1 8.46×10^{-3} mol of zinc M2 therefore 1.69×10^{-2} mol hydrochloric acid needed (which is less than 2.50×10^{-2} mol) **OR** M1 1.25×10^{-2} mol of zinc are needed M2 therefore 0.8(13) g of zinc is needed (and there is only 0.55g)	**ALLOW** any number of sig figs including one e.g. 0.008 moles of zinc, therefore 0.016 moles of acid needed scores M1 and M2	2
			15 marks

Q15.

Question number	Answer	Mark
(a)	Reversible arrow	**1**

Question number	Answer	Additional guidance	Mark
(b)(i)	• (X) ammonium chloride (1) • (Y) ammonia and hydrogen chloride (1)	accept formulae	**2**

Question number	Answer	Mark
(b)(ii)	D (subliming)	**1**

Question number	Answer	Additional guidance	Mark
(c)	An explanation that makes reference to the following three points: • C (1) • because ammonia molecules have lower mass or smaller M_r (hence travel faster) (1) • and so travel further in the same time (1)	accept reverse arguments for hydrogen chloride	**3**

(Total for question = 7 marks)

Q16.

Question number	Answer	Notes	Marks
(a) (i)	fractional distillation	**ALLOW** distillation **REJECT** simple distillation	1
(ii)	evaporation	**ALLOW** evaporating /boiling	1
(iii)	condensation	**ALLOW** condensing	1

(b)	(i)	**M1** (mass ethanol 15.50×0.79 =) 12.245 (g) **M2** (moles ethanol = $12.245 \div 46$ =) 0.266 (mol) **OR** **M1** (1 cm^3 ethanol = $0.79 \div 46$ =) 0.0172 mol **M2** (15.5 cm^3 ethanol = 0.0172×15.5 =) 0.267 (mol)	**ALLOW** any number of significant figures except 1 **ALLOW** ecf from M1 **ALLOW** any number of significant figures except 1 **ALLOW** ecf from M1 correct answer with or without working scores 2.	2
	(ii)	answer from (b)(i) $\times 6 \times 10^{23}$ e.g. ($0.266 \times 6.0 \times 10^{23}$ =) 1.60×10^{23}	**ALLOW** any number of significant figures except 1 **ALLOW** answer in ordinary form	1

Question number	Answer	Notes	Marks
(c) (i)	M1 add anhydrous copper sulfate M2 turns blue	**ALLOW** add white copper sulfate M2 dependent on M1 **ALLOW** M1 add anhydrous cobalt chloride/ cobalt chloride paper M2 turns pink M2 dependent on M1	2
(ii)	M1 measure boiling point M2 is 100°C	 **ALLOW** melting/freezing point is 0°C for both marks	2

(d) (i)	M1 $\Delta T = 49.5°C$ M2 $Q = mc\Delta T$ **OR** $100 \times 4.2 \times 49.5$ M3 20 790 J	correct answer with or without working scores 3 **ALLOW** ecf from M1 **ALLOW** 20 800	3
(ii)	M1 20.790 kJ M2 (20.790 ÷ 0.0200 =) -1039.5 (kJ/mol)	**ALLOW** answer to 10(c)(i) ÷ 1 000 **ALLOW** any number of significant figures from 3 **ALLOW** M1 ÷ 0.0200 as long as answer is negative. **REJECT** incorrect rounding. **REJECT** positive answer.	2
			15

Q17.

Question number	Answer	Notes	Marks
(a) (i)	M1 (molecules / compounds containing) hydrogen and carbon (atoms)		2 grad
	M2 only	M2 dep on M1 or near miss	
(ii)	propane		1 Clerical
(iii)	C_2H_6		1 Grad
(iv)	M1 add bromine water	**REJECT** bromine or bromide or bromide water	2 Exp
	M2 decolourised	**ALLOW** turns (from orange / yellow to) colourless **M2** dependent on **M1** unless **M1** is bromine, bromide or bromide water	
(b) (i)	M1 structure is simple molecular / simple covalent		3 Exp
	M2 intermolecular forces (of attraction) are weak	**ALLOW** intermolecular bonds, if clearly not covalent bonds	
	M3 and require little energy to overcome / break	**ALLOW** low / less energy Any reference to breaking covalent bonds do not award **M2** and **M3**.	
(ii)	The intermolecular forces in R are stronger (than the intermolecular forces in S) OR reverse argument	**ALLOW** R has a higher Mr / surface area than S / has more Cs and Hs **ALLOW** R has stronger bonds / more bonds than S if breaking bonds is mentioned in (b)(i)	clip

(c)	(i)	Any one from: **M1** heat lost to the atmosphere **M2** heat absorbed by the beaker / calorimeter / thermometer **M3** some hydrocarbon evaporates (rather than burning)		1 Grad
	(ii)	$C_6H_{14} + \mathbf{5}\ O_2 \rightarrow 3\ C + \mathbf{3}\ CO + \mathbf{7}\ H_2O$	**ALLOW** multiples or fractions	1 Grad
	(iii)	**M1** (carbon monoxide is) toxic / poisonous **M2** (because it) reduces the capacity of the blood to transport oxygen	**ALLOW** correct references to haemoglobin	2 Exp

(iv)	**M1** calculates temperature increase **M2** substitution of values into $Q=mc\Delta T$ **M3** calculation of heat energy released Example calculation ΔT = 37.5(°C) Q = 100 x 4.2 x 37.5 Q = 15 750 J	ALLOW ecf from **M1** **IGNORE** sign of answer **IGNORE** units, unless answer is divided by 1000 to give 15.75 **kJ** Correct answer with or without working scores 3 marks.	3 Exp
		Total for question	17

Q18.

Question number	Answer	Notes	Marks
(a)	Award 1 mark each for any six of the following: **Method 1** **M1** polystyrene (insulator so) reduces/prevents heat loss (to atmosphere) OWTTE **M2** no lid so heat/thermal energy will be lost (to atmosphere) **M3** stirring will ensure even temperature / more accurate (highest) temperature OWTTE **M4** no lid so possibility of spillage **OR** polystyrene cup (containing thermometer) unstable/may fall over OWTTE **Method 2** **M5** glass bottle poor insulator so heat/thermal energy loss occurs OWTTE **M6** bung helps reduce/prevent heat/thermal energy loss (to atmosphere) **M7** bung so no spillage **M8** cannot stir so cannot ensure even temperature / cannot ensure accurate (highest) temperature OWTTE	**ALLOW** references to heat/thermal energy evenly spread (throughout solution) OWTTE **IGNORE** references to increases rate of reaction **ALLOW** references to heat /thermal energy not evenly spread (throughout solution) OWTTE	6

(b)	**M1** 0.025 mol $CuSO_4$ reacts with 0.025 mol Zn **M2** mass Zn needed = 0.025 x 65 = 1.625 g (3g > 1.625g so having 3g Zn is excess) OR **M1** 0.025 mol $CuSO_4$ reacts with 0.025 mol Zn **M2** 3g Zn = $\frac{3}{65}$ = 0.046 mol (0.046 > 0.025 so having 3g Zn is excess)	**ALLOW** reference to 1:1 molar ratio or (only) 0.025 mol Zn needed **M2** subsumes **M1** **ALLOW** reference to 1:1 molar ratio or (only) 0.025 mol Zn needed	2

Question number	Answer	Notes	Marks
(c) (i)	**M1** calculation of temperature rise **M2** correct substitution into Q = m x 4.2 x temp rise **M3** correct evaluation of Q Example calculation **M1** (40.6 - 21.1) OR 19.5 **M2** Q = 50 x 4.2 x 19.5 **M3** = 4100 (J)	ALLOW 4095 IGNORE sign	3
(ii)	**M1** answer to (i) ÷ 0.025 **M2** correct evaluation in J **M3** correct conversion to kJ and minus sign Example calculation **M1** 4095 ÷ 0.025 **M2** = 163 800 (J) **M3** = −160 kJ	**ACCEPT** use of 4000 **ACCEPT** 160 000/ 164 000 **ACCEPT** −163.8/−164 160/163.8/164 scores 2	3
(d)	**M1** Zn/zinc is oxidised because loses electrons **M2** Cu^{2+}/copper ions reduced because gains electrons		2

Q19.

Question number	Answer	Notes	Marks
a	**C** (it has a low density) A is not correct as the colour of the gas is irrelevant B is not correct as the solubility of the gas is irrelevant D is not correct as the smell of the gas is irrelevant		**1**
b	**M1** helium is inert / helium does not react (with air/oxygen) **M2** hydrogen is flammable/explosive (in air/oxygen)	**ALLOW** helium is unreactive **ALLOW** helium is not flammable/ not explosive	**2**
c i	$N_2 + 3H_2 \rightarrow 2NH_3$	**ACCEPT** reversible arrow **IGNORE** Fe if added to both sides of the equation	**1**
ii	to increase the rate of reaction / to speed up the reaction / to produce a reaction pathway that has a lower activation energy	**ALLOW** to lower the activation energy / to make it easier to break the (covalent) bonds (in the molecules)	**1**

Q20.

Question number		Answer	Notes	Marks
(a)	(i)	$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$		1
	(ii)	carbon dioxide/CO_2/gas escapes/is given off OWTTE	**IGNORE** carbon dioxide is a gas alone	1
	(iii)	to stop acid/liquid/solution leaving flask/spitting out OWTTE	**REJECT** to stop carbon dioxide/gas escaping	1

(b)	(i)	An explanation that links four of the following points 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 **OR** 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	**ALLOW** there are the most (acid) particles in solution/per unit volume OWTTE **ALLOW** the curve becomes less steep as there are fewer acid particles/particles in solution /per unit volume **IGNORE** references to energy	4
	(ii)	M1 curve starting at the origin and steeper than the original curve M2 curve levelling off before and at the same level as the original curve		2
				Total 9