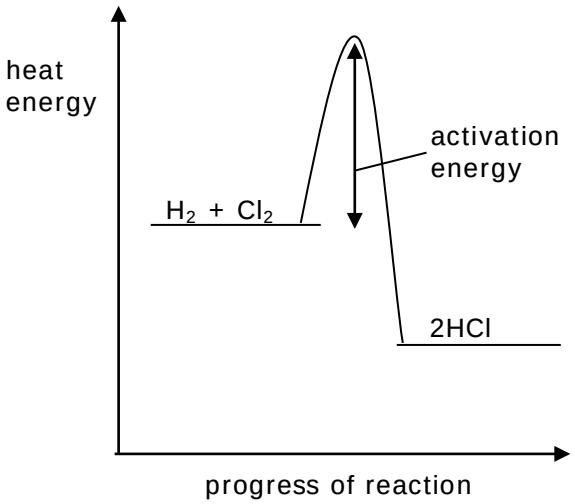
Question number	Answer	Mark
1(a)	B	(1)

Question number	Answer	Marks
1(b)	An answer that combines the following points to provide a plan: • measure known volume of sodium hydroxide solution (1) • add same volume of each of the acids (1) • stir the mixture (1) • record the initial and final temperatures/temperature change (1)	(4)

Question number	Answer	Mark
1(c)	 • product line, labelled (2)HCl/product(s), to right of and lower than reactant line, labelled $H^2 + Cl^2$/reactants (1) • curve drawn on diagram (1) • activation energy labelled (1)	**(3)**

Question number	Answer	Additional guidance	Mark
1(d)	• calculates energy needed to break bonds (1) • calculates energy released in forming bonds (1) • calculates energy change (1) • evaluation of final answer with negative sign (1)	<u>Example of calculation</u> Bonds broken = 436 + 243 = 679 ($kJ\ mol^{-1}$) Bonds formed = 2 × 432 = 864 ($kJ\ mol^{-1}$) Energy change = 679 – 864 = −185 ($kJ\ mol^{-1}$) Award full marks for correct numerical answer without working	**(4)**

Question Number	Answer	Acceptable answers	Mark
2(a)	An explanation linking two of the following temperature decreases (1) {heat / energy} taken in (1) (so process) endothermic (1)	 ignore references to bond breaking / making heat given out / exothermic = 1 max.	**(2)**

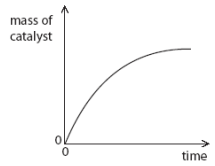
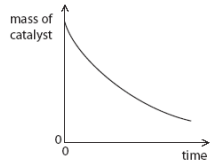
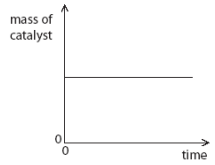
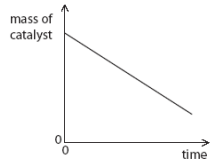
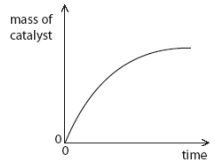
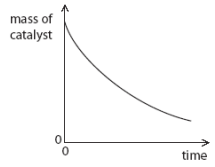
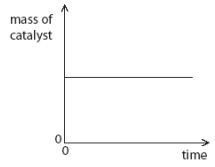
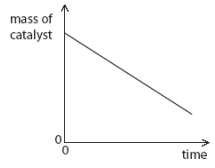
Question Number	Answer	Acceptable answers	Mark
2(b)	Shown correctly on diagram: horizontal line to right of reactant (1) product line below reactant line (1)	 ignore any connecting lines product label not needed	**(2)**

Question Number	Answer	Acceptable answers	Mark
2(c)	D : heat energy is required heat energy is released		**(1)**

Question Number		Indicative Content	Mark
QWC	***2(d)**	An explanation including some of the following points **smaller pieces of solid** of same mass larger surface area more frequent collisions higher rate of reaction **higher temperature** particles move faster more frequent collisions particles have more energy more collisions have required energy to react / activation energy more collisions successful higher rate of reaction ORA	**(6)**
Level	**0**	No rewardable content	
1	**1 - 2**	a limited explanation of one of factors e.g. at higher temperature higher rate e.g. when particles smaller size higher rate the answer communicates ideas using simple language and uses limited scientific terminology spelling, punctuation and grammar are used with limited accuracy	
2	**3 - 4**	a simple explanation e.g. at higher temperature particles move faster, more collisions so higher rate e.g. smaller sized particles (of same mass) have greater surface area so higher rate the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately spelling, punctuation and grammar are used with some accuracy	
3	**5 - 6**	a detailed explanation e.g. (when particles collide they) only react when they have sufficient energy/activation energy and at a higher temperature more of the particles have sufficient energy/activation energy so more collisions will be successful and when particles smaller size higher rate the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately spelling, punctuation and grammar are used with few errors	

Question Number	Answer	Acceptable answers	Mark
3(a)	A use hydrochloric acid which is more dilute		**(1)**

Question Number	Answer	Acceptable answers	Mark
3(b)	An explanation linking two of M1 {particles/reactants/collisions} have more energy (1) M2 more frequent collisions (1) M3 more {productive/successful/effective} collisions (1)	 atoms/ions/molecules as alternatives to particles reject electrons particles move faster more collisions per unit time ignore collisions are more likely/greater chance/probability of collisions/faster collisions more particles have required activation energy	**(2)**

Question Number	Answer	Acceptable answers	Mark
3(c)(i)	☐ A  ☐ B  ☐ C  ☐ D  ☐ A  ☐ B  ☐ C  ☐ D 		(1)

Question Number	Answer	Acceptable answers	Mark
3(c)(ii)	$2H_2O_2 \rightarrow 2H_2O + O_2$ (2) all formulae correct (1) balancing correct formulae (1)	multiples or halves reject other reactants or products ignore heat on arrow or elsewhere ignore state symbols ignore use of lower case h, lower case o, or use of superscripts or large numbers inside the formulae	**(2)**

Question Number	Answer	Acceptable answers	Mark
3(d)	An explanation linking M1 energy needed to break bonds / energy released when bonds formed (1) M2 more heat / energy is released than needed (1) M2 dependent on scoring M1	 bond breaking is endothermic / bond making is exothermic if any contradictory statements made in M1, the mark cannot be awarded (and so M2 cannot be awarded either) ignore numbers of bonds eg more bonds formed than broken "more energy is released forming bonds than needed to break bonds" (2)	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(a)(i)	$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$ reactants (1) products (1)	Accept multiples If not correctly balanced max 1 Must be subscripts where relevant	**(2)**

Question Number		Indicative Content	Mark
QWC	***4(a)**	A description including some of the following points **general points** • reactions occur when particles collide • more frequent collisions cause higher rate of reaction • mass and size of zinc pieces same so no effect on rate of reaction • because same surface area • two factors have been altered in the same experiment • cannot be certain of effect of each **concentration** • experiment 2 higher/triple concentration of acid • so more particles (in same volume) • so more frequent collisions between particles • more successful collisions **temperature** • experiment 2 higher temperature • particles move faster • particles have more energy • so more frequent collisions between particles (so increased rate) • more successful collisions • so more energetic collisions between particles • more particles have enough energy to react (activation energy) when they collide	**(6)**
Level	**0**	No rewardable content	
1	**1 - 2**	• a limited description e.g. temperature is higher and concentration is higher so reaction is faster e.g. temperature is higher so particles move faster so reaction is faster • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy	
2	**3 - 4**	a simple description e.g. temperature is higher so particles move faster and concentration is higher so more particles so reaction is faster eg when concentration is higher there will be more particles so more frequent collisions so faster reaction e.g. when temperature is higher particles move faster so more successful collisions so faster reaction • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology	

		appropriately • spelling, punctuation and grammar are used with some accuracy
3	**5 - 6**	• a detailed description e.g. higher concentration of acid so more particles so more frequent collisions so faster reaction and higher temperature so particles have more energy so more successful collisions so faster reaction • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

Question Number	Answer	Acceptable answers	Mark
4(b)(i)	B displacement		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(b)(ii)	Shown on diagram • horizontal reactant line above product line (1) • horizontal product line to right of reactant line (1)	lines must be correctly labelled eg reactants/Zn + $CuSO_4$ and products/ $CuSO_4$ and Cu ignore any extra lines/curves/labels if not drawn lines but just labels in correct relative positions max 1 If two lines drawn in correct positions but no labels max 1	**(2)**