Question number	Answer	Additional guidance	Mark
7(a)	$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$ • LHS (1) • RHS (1)	Allow products in any order	**(2)**

Question number	Answer	Mark
7(b)(i)	(line B) less steep/(line B) flattens later (1)	**(1)**

Question number	Answer	Mark
7(b)(ii)	• Slope = 60 ÷ 72 (1) • = 0.83(3) ($cm^3\ s^{-1}$) (1)	**(2)**

Question number	Answer	Mark
7(c)	An explanation that makes reference to: identification – knowledge (1 mark) and reasoning/justification – knowledge (1 mark): • fewer particles/as the reactants are used up there will be fewer particles to react/lower concentration of particles (1) • this will result in a lower frequency of collisions so fewer particles reacting in a given time (1)	**(2)**

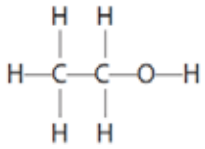
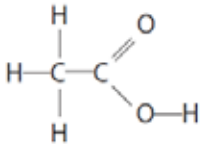
Question number	Answer	Mark
7(d)	C	**(1)**

Question number	Answer	Mark
7(e)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (2 marks): • the decrease in temperature will cause a decrease in rate of reaction (1) • and the increase in pressure will cause an increase in rate of reaction (1) • because the changes have opposite effects on the rate it is not possible which has the greater effect (1)	**(3)**

Question number	Answer	Mark
8(a)	Candidates relate information given to order of elements in the periodic table to predict: dark grey/black **and** solid/crystals	**(1)**

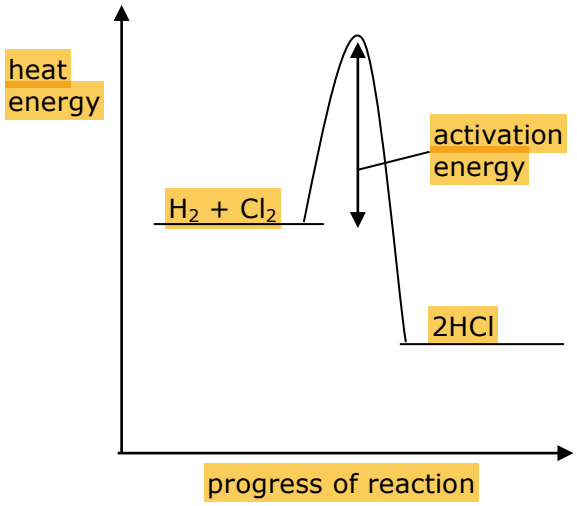
Level	Mark	Descriptor
	0	No awardable content.
Level 1	1–2	• The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2) • Lines of reasoning are unsupported or unclear. (AO2)
Level 2	3–4	• The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2) • Lines of reasoning mostly supported through the application of relevant evidence. (AO2)
Level 3	5–6	• The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2) • Lines of reasoning are supported by sustained application of relevant evidence. (AO2)

Question number	Answer	Marks
9(c)(i)	carboxylic acids	**(1)**

Question number	Answer	Marks
9(c)(ii)	A is  (1) B is  (1)	**(2)**

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

Question number	Answer	Marks
10(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
10(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
10(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)	Example of calculation 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
3(a)	**C** oxidation		**(1)**

Question Number	Answer	Acceptable answers	Mark
3(b)(i)	An explanation linking the following points • large(r) surface area (1) • more frequent collisions with catalyst / reaction will go faster (1)OWTE	large(r) {surface /area} more collisions	**(2)**

Question Number	Answer	Acceptable answers	Mark
3(b)(ii)	An explanation linking the following points • catalyst becomes warmer (1) • {reactions faster / catalyst works better} when hotter (1)	gas (particles){move faster/more energy}	**(2)**

Question Number	Answer	Acceptable answers	Mark
3(c)	$2\ CO + O_2 \rightarrow 2\ CO_2$ • LHS formulae (1) • RHS formula (1) • balancing correct formulae (1)	allow multiples	**(3)**

Question Number	Answer	Acceptable answers	Mark
3(d)	An explanation linking the following points • heat energy { given out / of reactants higher than products} / ORA (1) • (so) exothermic (1)	ignore bond making and breaking	**(2)**

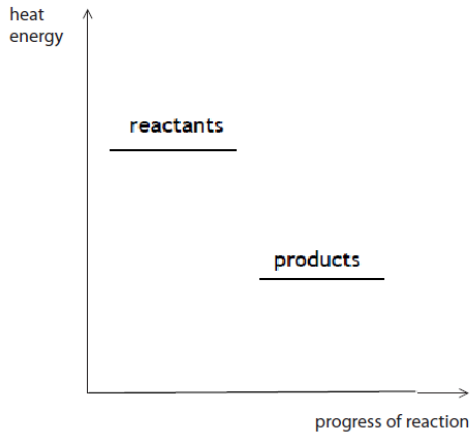
Question Number	Answer	Acceptable answers	Mark
5(a)	An explanation linking two of the following temperature decreases (1) {heat / energy} taken in (1) (so process) endothermic (1)	ignore references to bond breaking / making heat given out / exothermic = 1 max.	**(2)**

Question Number	Answer	Acceptable answers	Mark
5(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
5(c)	D : heat energy is required heat energy is released		**(1)**

Question Number		Indicative Content	Mark
QWC	***5(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	Answers	Acceptable Answers	Mark
3 (a)(i)	An explanation linking • (substance which) speeds up / increases the rate of (a reaction) **(1)** • (but is chemically) unchanged (at end of reaction) / not used up (in reaction) /mass remains the same **(1)**	Ignore any reference to enzymes Ignore changes/alters the rate Allow provides an alternative route for the reaction with a lower energy / lowers the activation energy / reduces the energy needed for {a reaction to take place/successful collisions} **(1)** Do not allow catalyst is a reactant /product Ignore does not change products of reaction Ignore {does not take part/is not used/is not involved} in the reaction	**(2)**

Question Number	Answers	Acceptable Answers	Mark
3 (a)(ii)	 • labelled horizontal reactant line above product line line can be labelled reactants /carbon monoxide + oxygen /CO + O_2 **(1)** • labelled horizontal product line to right of reactant line line can be labelled product(s) / carbon dioxide / CO_2 **(1)**	Allow 2 lines in the correct positions unlabelled/ with incorrect labels **(1)** Allow reactants and products written in the correct positions without horizontal lines **(1)** Ignore additional curves and arrows Ignore incorrect formulae if written in addition to correct words /names	**(2)**

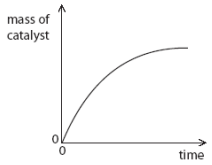
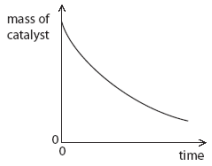
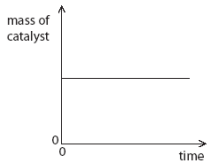
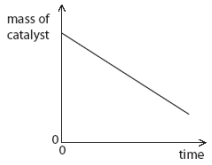
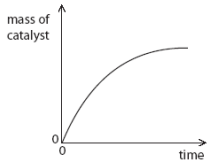
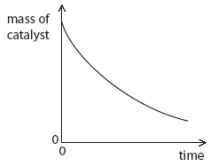
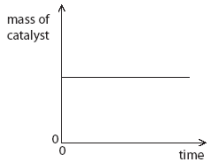
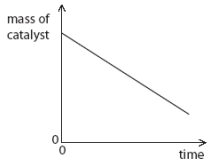
Question Number	Answers	Acceptable Answers	Mark
3 (a)(iii)	$C_7H_{16} + 11O_2 \rightarrow 7CO_2 + 8H_2O$ • correct formulae on lhs $C_7H_{16} + O_2$ **(1)** • correct formulae on rhs $CO_2 + H_2O$ **(1)** • balancing correct formulae **(1)**	Accept multiples Accept = for → Ignore state symbols, even if incorrect	**(3)**

Question Number	Answers	Acceptable Answers	Mark
3 (b)	An explanation linking • more particles (in the same volume) **(1)** • more frequent collisions (between solute particles) **or** (solute particles) collide more often **or** higher rate of collisions (between solute particles) **or** more collisions (between solute particles) in given time **(1)**	Maximum **(1)** if particles have more energy / move faster Accept this shown in diagrams Accept specific particles – molecules or ions but not atoms Allow (reacting) particles are closer together **(1)** Ignore just "more ({productive/ successful/ effective}) collisions" Ignore collisions are more likely Ignore greater {chance/ probability} of collisions Ignore faster collisions/collide more quickly	**(2)**

Total for Question 3 = 9 marks

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

Question Number	Answer	Acceptable answers	Mark
2(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
2(c)(i)	**C** ☐ A  ☐ B  ☐ C  ☐ D  ☐ A  ☐ B  ☐ C  ☐ D 		**(1)**

Question Number	Answer	Acceptable answers	Mark
2(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
2(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)**

(total for Question 2 = 8 marks)

Question number	Answer	Acceptable answers	Marks
1 (a)	A description linking a reaction that {takes in/absorbs} energy (1) {heat/thermal} (energy) (1)	second mark is dependent on first. less energy is given out making bonds than is taken in to break bonds (2)	**(2)**

Question number	Answer	Acceptable answers	Marks
1 (b)	An explanation linking two of the following • the products have less energy than the reactants / ORA (1) • reaction gives out heat (energy)/heat (energy) has been lost from reaction (1) • it is an exothermic reaction (1)	more energy is given out making bonds than is needed to break bonds (1)	**(2)**

Question number	Answer	Acceptable answers	Marks
1 (c) (i)	any three from larger surface area/use magnesium powder (1) higher temperature (1)	 Allow increased {mass/amount} of magnesium allow increase heat / heat the acid allow add a catalyst ignore increase volume of acid ignore increase concentration of acid ignore surface area alone ignore temperature alone ignore stirring	**(2)**

Question number	Answer	Acceptable answers	Marks
1 (c) (ii)	An explanation linking • more particles (of acid in same volume) (1) • more frequent collisions (1)	 allow ions/molecules/atoms allow more collisions per second ignore more chance of collisions ignore more successful collisions ignore more collisions alone Max 1 mark if answer refers to energy/particle speed	**(2)**

(Total for Question 1 = 8 marks)