Question	Answers	Extra information	Mark	AO / Specification reference
01.1	thermal decomposition – endothermic citric acid with sodium hydrogencarbonate – endothermic neutralisation – exothermic combustion – exothermic		1 1 1 1	AO1 4.5.1.1
01.2	it transfers energy to the surroundings		1	AO1 4.5.1.1
01.3	exothermic		1	AO2 4.5.1.1
02.1	curved line going from reactants to products, peaking above reactants arrow from reactants line vertically down to level of products with arrow down		1 1	AO1 4.5.1.2
02.2	energy of products is lower than energy of reactants showing that energy is transferred to the surroundings		1 1	AO1 4.5.1.1 4.5.1.2
02.3	energy needed to break bonds = 436 + 242 = 678 energy released on making bonds = 431 × 2 = 862 energy change = 678 - 862 = -184 kJ/mol	award three marks for correct answer if working is not shown	1 1 1	AO2 4.5.1.3
03.1	insulated container/cup (with lid) reduce energy transfers to the surroundings		1 1	AO3 4.5.1.1

Question	Answers	Extra information	Mark	AO / Specification reference
03.2	stir to ensure that the solution is the same temperature throughout/make it dissolve faster		1 1	AO3 4.5.1.1
03.3	C		1	AO3 4.5.1.1
03.4	temperature increase would be less		1	AO3 4.5.1.1
04.1	$2H_2 + O_2 \rightarrow 2H_2O$	one mark for reactants one mark for products	2	AO2 4.5.2.2
04.2	hydrogen		1	AO1 4.5.2.2

Question	Answers	Extra information	Mark	AO / Specification reference
04.3	any **four** from: advantages: • produces water/no pollutants produced • does not need to be electrically recharged disadvantages: • hydrogen fuel cell cars do not perform as well as standard electric cars at present/runs for less miles before it needs to be recharged • difficult to obtain hydrogen • hydrogen is very flammable • hydrogen fuel cell cars are more expensive • release of water as a product may have currently unknown negative effect on environment	one mark for each correct answer must have at least one advantage and one disadvantage to gain full marks	4	AO3 4.5.2.2
05.1	A (4 × 412) + (2 × 496) = +2640 (kJ/mol) B (2 × 743) + (4 × 463) = -3338 (kJ/mol) C +2640 - 3338 = -698 (kJ/mol)		1 1 1	AO2 4.5.1.3
05.2	overall energy change of reaction	allow 'enthalpy' for 'energy'	1	AO1 4.5.1.2
05.3	activation energy/the minimum amount of energy the particles must have in order to react		1	AO1 4.5.1.2
06.1	temperature change		1	AO2 4.5.1.1

Question	Answers	Extra information	Mark	AO / Specification reference
06.2	any **two** from: • concentration of acid • volume of acid • amount of acid • amount of metal	one mark for each correct answer accept other suitable answers	2	4.5.1.1
06.3	copper does not react with dilute hydrochloric acid		1	AO2 4.4.1.2
06.4	magnesium 17.7; zinc 6.1	both values required for the mark	1	AO2
06.5	magnesium		1	AO2 4.5.1.1
07.1	B and C	both answers required for the mark	1	AO3 4.5.1.2
07.2	B		1	AO3 4.5.1.2
07.3	C		1	AO3 4.5.1.2

Question	Answers	Extra information	Mark	AO / Specification reference
08.1	$CuCO_3(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + CO_2(g) + H_2O(l)$	one mark for formulae and state symbols of reactants one mark for formulae and state symbols of reactants **or** one mark for correct formulae one mark for correct state symbols one mark for balancing	3	AO2 4.4.2.3
08.2	**Level 3:** The description of the method is detailed and accurate. Apparatus and variables are named correctly. The description is clear and coherent.		5-6	AO1 4.5.1.1
	Level 2: The description of the method is correct, although lacks detail. Apparatus **or** variables are named correctly. The description lacks some clarity and coherence		3-4	
	Level 1: The method is outlined correctly. The names of one or two pieces of apparatus are given or the names of one or two variables. The description overall lacks clarity and coherence.		1-2	
	No relevant content.		0	

Question	Answers	Extra information	Mark	AO / Specification reference
	Indicative content • measure out a given volume of acid with a measuring cylinder and transfer to an insulated container with a lid • measure the temperature of the acid with a thermometer • add a given mass/amount of carbonate • stir the mixture • measure the temperature again • repeat with the other two metal carbonates • independent variable – metal carbonate • dependent variable – temperature change • control variables – amount/volume of acid, concentration of acid, mass of carbonate, type of acid			
08.3	the reaction with the greatest increase in temperature is the most exothermic		1	AO3 4.5.5.1
09.1	iron largest difference in reactivity with copper		1 1	AO1 4.5.2.1
09.2	too reactive/it would react with water/it would oxidise		1	AO2 4.5.2.1
09.3	$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^{-}$		1	AO2 4.5.2.1

Question	Answers	Extra information	Mark	AO / Specification reference
10.1	methane/CH_4		1	AO2 4.5.1.1
10.2	$C_9H_{20} + 14O_2 \rightarrow 9CO_2 + 10H_2O$	one mark for formulae of reactants one mark for formulae of products one mark for balancing	3	AO2 4.5.1.1
10.3	**Level 3:** The calculations are correct and each step is clearly explained. The analysis is correct and well-argued.		5-6	AO3 4.5.1.1
	Level 2: The calculations are correct, but the steps are not clearly explained. The analysis has some merit, but is not clearly argued.		3-4	
	Level 1: The calculations are partly correct, but include mistakes. The steps are not explained. The analysis lacks clarity and detail and is not clearly argued.		1-2	
	No relevant content		0	

Question	Answers	Extra information	Mark	AO / Specification reference
	Indicative content • energy transferred per gram of fuel: methane: $\frac{890}{12+(4\times1)}$ = 55.63 kJ/g nonane: $\frac{6125}{(9\times12)+(20\times1)}$ = 47.85 kJ/g • so more energy transferred per gram for methane, indicating that a smaller mass of methane is needed for a given amount of energy to be transferred • energy transferred per gram of carbon dioxide made: methane: 1 mol methane makes 1 mol of carbon dioxide so transferring 890 kJ of energy makes 44 g of carbon dioxide and $\frac{890}{44}$ = 20.2 kJ energy produced per g of CO_2 nonane: 1 mol of nonane makes 9 mol of CO_2 so transferring 6125 kJ makes (9 × 44) = 396 g of CO_2 and $\frac{6125}{396}$ = 15.5 kJ energy per g of CO_2 • so more energy transferred per gram of CO_2 produced for methane than for nonane • environmental impacts of methane are less on both measures			

Question	Answers	Extra information	Mark	AO / Specification reference
11.1	**Level 3:** The deductions are correct, comprehensive and clearly explained.		5-6	AO1 × 2 AO3 × 4 4.4.2.6
	Level 2: The deductions are correct, but are not clearly explained and lack detail.		3-4	
	Level 1: One deduction has been made correctly. It is not clearly explained and lacks detail.		1-2	
	No relevant content.		0	
	Indicative content • pH of W and X is the same, so as HCl is the stronger acid, its concentration must be less than 1 mol / dm^3 • pH of Y is greater than W, so as the acid is the same in both cases, the concentration of acid W must be greater than the concentration of acid Y • as a decrease in pH of one unit indicates an increase in hydrogen ion concentration by a factor of 10, the concentration of Y must be one hundredth the concentration of W/concentration of Y = 0.01 mol/dm^3			
11.2	for a concentration of 1.0 mol/dm^3 the pH of chloroethanoic acid is lower than that of ethanoic acid this means that chloroethanoic acid has a greater degree of dissociation than ethanoic acid		1 1	AO3 4.4.2.6
11.3	$H^+ + OH^- \rightarrow H_2O$	ignore state symbols	1	AO1 4.4.2.4

Question	Answers	Extra information	Mark	AO / Specification reference
12.1	**Level 3:** A detailed and coherent comparison is given, demonstrating a sound knowledge and understanding of reactions of the Group 1 metals and magnesium with water.		5-6	AO1 4.1.2.5 4.4.1.2
	Level 2: Correct descriptions of the reactions are given. Some comparisons are made, but not all are clearly articulated.		3-4	
	Level 1: Some correct points are made about the reactions. Few comparisons are made, and these are not clearly articulated.		1-2	
	No relevant content.		0	
	Indicative content • all react with cold water to make hydrogen gas and the metal hydroxide • potassium reacts most vigorously, and a purple/lilac flame is seen as the metal whizzes around on the surface of the water • magnesium reacts very slowly indeed, with small bubbles being observed on the surface of the magnesium • the reactivity of lithium is intermediate, with no flame seen but the metal whizzing around on the surface of the water			

Question	Answers	Extra information	Mark	AO / Specification reference
12.2	hydrogen and caesium hydroxide	both names required to achieve the mark	1 1	AO2 4.1.2.5
12.3	the tendency to form positive ions increases down the group so reactivity increases down the group		1 1	AO2 4.1.2.5 4.4.1.2
13.1	lead oxide		1	AO1 4.4.1.3
13.2	$PbSO_4 + 2NaOH \rightarrow Na_2SO_4 + Pb(OH)_2$	one mark for formulae of reactants one mark for formulae of reactants one mark for balancing	3	AO2 4.1.1.1
13.3	no SO_2 made in method B no raw material used	allow other suitable answers	2	AO3 4.4.1.3