Name: _____

3.1 Energetics

ms

Date:

Time:

Total marks available:

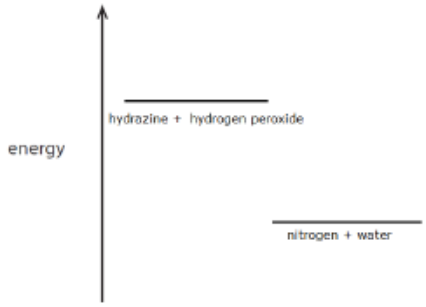
Total marks achieved: _____

Mark Scheme

Q1.

Question number	Answer	Additional guidance	Marks
(a) (i)	(bonds broken) 3861 (kJ)		1
(ii)	(bonds made) 4649 (kJ)		1
(iii)	**M1** subtraction of Σ(bonds made) made and Σ(bonds broken)	In (iii) ECF from (i) and (ii) must be applied Subtraction can be in any order	3
	M2 correct evaluation of the calculation shown in **M1**	**IGNORE** sign	
	M3 If Σ(bonds made) > Σ(bonds broken) final answer must be negative If Σ(bonds made) < Σ(bonds broken) final answer must be positive (and + sign given)	Expected final answer is −788 (kJ/mol) -788 with no working scores 3 (+) 788 scores 2	

(b)	An explanation that links together the following two points: **M1** more energy is given out when the bonds are made	If state/imply that energy required to make bonds OR If state/imply that energy released when bonds are broken scores 0/2	2
	M2 than is taken in when the bonds are broken	**ACCEPT** correct reverse argument	

Question number	Answer	Additional guidance	Marks
(c)	 **M1** right hand line below left hand line **M2** correct names/formulae of both reactants **M3** correct names/formulae of both products	**IGNORE** horizontal axis drawn **IGNORE** enthalpy change shown **IGNORE** activation energy shown If only use words *reactants* (on left) and *products* (on right) award 1 mark from M2 and M3	3

Q2.

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

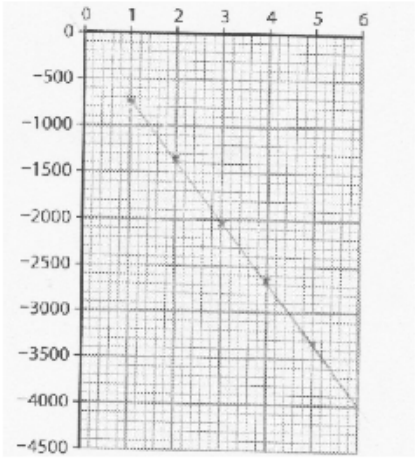
Question number	Answer	Additional guidance	Mark
(c)	• Calculation of volume/mass of mixture • Calculation of temperature increase • Substitution of values into $q=mc\Delta T$ • Calculation of heat energy released with unit Example calculation: 20.0 + 20.0 = 40.0 (cm^3) (1) 30.0−18.5 = 11.5 (°C) (1) q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

Q3.

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

Q4.

Question number	Answer	Notes	Marks
a	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 decrease in temperature (of the reaction mixture)	**REJECT** exothermic for both marks **ALLOW** references to cooling No M2 or M3 if the statements contradict each other	**2**

b	• calculation of temperature change • substitution into $Q = mc\Delta T$ • evaluation Example calculation **M1** 14.2 – 20.0 = (-)5.8 **M2** $Q = 100 \times 4.18 \times (-)5.8$ **M3** = (–)2420 (J)	100 x 4.18 x (20 – 14.2) scores **M1** and **M2** **ACCEPT** any number of sig figs greater than 2 Calculator answer is 2424.4 Negative sign not required If answer in kJ unit must be given. Use of 108 can score **M1** and **M3** (= 2618) 2400 alone scores 0 **ALLOW** use of 4.2 for all 3 marks (= 2436)	**3**

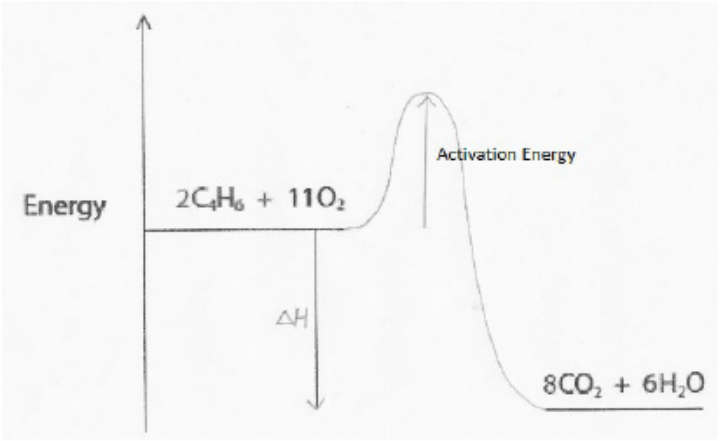
c	• calculation of moles (*n*) of ammonium nitrate • division of *Q* by *n* • conversion of J to kJ • answer given with + sign Example calculation **M1** $n[NH_4NO_3] = 8.00 \div 80$ **OR** 0.1(00) (mol) **M2** $\frac{Q}{n}$ **OR** $\frac{2420}{0.1(00)}$ **OR** $\frac{\text{answer to b}}{\text{answer to M1}}$ **M3** ΔH = (+)24.2 (kJ/mol) **M4** positive sign included	**ACCEPT** any number of sig figs in the numerator except 1 **ACCEPT** any number of sig figs except 1 **ALLOW** ecf from M2 correct answer with no working and no sign or incorrect sign scores 3 correct answer with no working and correct sign scores 4	**4**

Q5.

Question number	Answer	Notes	Marks
(a)	Explanation including following points M1 (unsaturated because) contains (carbon to carbon) double bond(s) M2 (hydrocarbon because) contains (the elements/atoms) carbon and hydrogen M3 only	 ALLOW contains C=C REJECT molecules M3 DEP on carbon and hydrogen	3 grad

(b)	(i)	from orange to colourless	ALLOW yellow for orange or any combination of orange/yellow IGNORE clear	1 grad
	(ii)	calculation including following steps M1 calculation of energy involved in bond breaking in reactants M2 calculation of energy involved in bond making in products M3 evaluation of difference M4 correct answer and sign Example calculation M1 2(612) + 1(348) + 6(412) + 2(193) OR 4430 M2 3(348) + 6(412) + 4(276) OR 4620 M3 (4620 - 4430 =) 190 M4 -190	 ECF from M1 and M2 IGNORE signs in M1 and M2 ACCEPT 2(612) + 2(193) OR 1610 for M1 and 2(348) + 4(276) OR 1800 for M2 IGNORE sign ACCEPT (1800 - 1610 =) 190 M3 M4 ECF from M1 and M2 If M1 > M2 answer for M4 must be positive If M1 < M2 answer for M4 must be negative -190 with or without working scores 4 (+) 190 with or without working scores 3	4 Exp

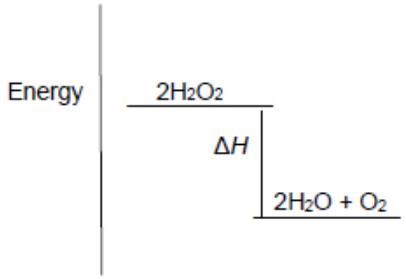
(c)	(i)	$2\,C_4H_6 + 7\,O_2 \rightarrow 2C + 4\,CO + 2\,CO_2 + 6H_2O$		1 Exp
	(ii)	Explanation including M1 CO/carbon monoxide M2 is poisonous/toxic/reduces capacity of blood to carry oxygen OWTTE **OR** M1 CO_2/carbon dioxide M2 is a greenhouse gas/contributes to global warming/ contributes to climate change OWTTE	M2 DEP M1 correct or missing **ACCEPT** prevents blood from carrying oxygen OWTTE ALLOW correct explanation in terms of haemoglobin eg prevents haemoglobin from carrying oxygen / forms carboxyhaemoglobin	2 Exp

(iii)	 M1 horizontal line below level of reactants with $8\,CO_2 + 6\,H_2O$ M2 profile curve rising from reactants level to form "hump" and then falling down to products level M3 activation energy correctly shown and labelled M4 $\triangle H$ correctly shown and labelled	ALLOW double headed arrow REJECT arrow pointing downwards ALLOW double headed arrow REJECT arrow pointing upwards ALLOW -3446 for $\triangle H$ label an endothermic reaction profile can score M2 M3 M4 ECF	4 Exp
		Total for Q = 15	

Q6.

Question number	Answer	Notes	Marks
(a)	**B** it relights a glowing splint A is incorrect as this is the test for hydrogen C is incorrect as oxygen is not an acidic gas D is incorrect as this is the test for carbon dioxide		1
(b)	An explanation that links the following two points **M1** provides an alternative pathway OWTTE **M2** with a lower activation energy OWTTE	**ACCEPT** more collisions with energy greater than the activation energy **ALLOW** lowers the energy needed to start the reaction	2

Question number	Answer	Notes	Marks
(c) (i)	• find energy needed to break bonds • find energy released when bonds form • correct subtraction to find ΔH Example calculation **M1** (4 x 463) + (2 x 143) **OR** 2138 (kJ) **M2** (4 x 463) + 498 **OR** 2350 (kJ) **M3** — 212 (kJ) **OR M1 – M2** correctly evaluated	**ACCEPT** (2 x 143)/286 for **M1** and 498 for **M2** **IGNORE** any signs in **M1** and **M2** — 212 with or without working scores 3 (+) 212 with or without working scores 2	3

(ii)	 **M1** horizontal line to show products in correct position and correctly labelled **M2** vertical line in correct position and labelled ΔH	Mark CQ on sign in (i) **ACCEPT** double headed arrow or arrow pointing from reactants level to products level **REJECT** arrow pointing from products level to reactants level **IGNORE** any attempts at including activation energy	2 **Total 8**

Q7.

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

Q8.

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)

Q9.

<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**

Q10.

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