Question number	Answer	Marks	Guidance
1 (a)	$2C(s) + 3H_2(g) + ½O_2(g) \rightarrow C_2H_5OH(l)$	B1	
1 (b)	$C_6H_{14}(l) + 9½O_2(g) \rightarrow 6CO_2(g) + 7H_2O(l)$	B1	
1 (c)	$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$	B1	
1 (d)	$HBr(g) \rightarrow H(g) + Br(g)$	B1	
2 (a)	standard enthalpy change of formation is the enthalpy change for the formation of 1 mole of a substance from its constituent elements under standard conditions of 100 kPa and 298 K	B1 B1 B1	
2 (b)	$\Delta_r H$ = [0 + 5 × –394] – [(–158 + 5 × –110)] = –1262 kJ mol^{-1} 1 mark for use of 5 twice 1 mark for correct subtraction 1 mark for correct answer	B1 x 3	
3	Σ(Bond enthalpies of reactants) = N≡N + 3(H–H) = +941 + (3 × +436) = 2249 kJ $\Delta H^\ominus$ = Σ(Bond enthalpies of reactants) – Σ(Bond enthalpies of products) ∴ –97 = 2249 – 6(N–H) ∴ bond enthalpy N–H = (2249 + 97)/6 = 391 kJ mol^{-1}	B1 B1 B1	
4 (a)	$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$	B1	
4 (b)	n(Mg) = 0.766/24.3 = 0.0315 mol n(HCl) required = 2 × 0.0315= 0.0630 mol n(HCl) = 1.00 × 100/1000 = 0.100 mol which is greater than 0.0630 and in excess	B1 B1	
4 (c)	$q = mc\Delta T$ = 100 × 4.18 × 22.5 = 9405 J = 9.405 kJ	B1	
4 (d)	Reaction of 1 mol Mg with 2 mol HCl produces 9.405/0.0315 = 299 kJ. ∴ $\Delta_r H$ = –299 kJ mol^{-1} 1 mark for value 1 mark for sign	B1 x 2	

Question number	Answer	Marks	Guidance
5 (a)	Bond enthalpies involve bond breaking which requires energy	B1	
5 (b) (i)	Σ(Bond enthalpies of reactants) = 4(C–C) + 12(C–H) + 8(O=O) = (4 × +347) + (12 × +413) + (8 × +498) = 10 328 kJ Σ(Bond enthalpies of products) = 6(C=O) + 8(O–H) = (10 × +805) + (12 × +464) = 13 618 kJ $\Delta H^{\ominus}$ = Σ(Bond enthalpies of reactants) – Σ(Bond enthalpies of products) ∴ 10328 – 13618 = –3290 kJ mol^{-1}	B1 B1 B1	
5 (b) (ii)	$H_2O(g)$ has been formed whereas standard state for H_2O is a liquid	B1	
5 (b) (iii)	An average bond enthalpy is calculated using bond enthalpies from different chemical environments, not the actual bond enthalpy of the bond	B1	
6 (a)	The standard enthalpy change of neutralisation is the energy change that accompanies the reaction of an acid by a base to form one mole of $H_2O(l)$	B1	
6 (b)	$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$	B1	
6 (c)	Mass of solution = 25.0 + 25.0 = 50.0 g $q = mc\Delta T$ = 50 × 4.18 × 12.9 = 2696.1 J = 2.6961 kJ $n(H_2O)$ formed = n(HCl) = 2.00 × 25.0/1000 = 0.0500 mol [1] For 1 mol H_2O, energy change = 2.6961/0.0500 = 53.922 kJ. ∴ $\Delta_{neut}H$ = –53.9 kJ mol^{-1} 1 mark for value 1 mark for sign	B1 B1 B1 x 2	
6 (d)	Temperature change is the same as twice the energy is released but it is spread over twice the volume of solution The enthalpy change of neutralisation is the same as this value applied to formation of 1 mol of water. There is double the energy change but also double the amount of water formed	B1 B1	

Question number	Answer	Marks	Guidance
7 (a)	The enthalpy change from the complete combustion of 1 mole of a substance under standard conditions of 100 kPa and 298 K	B1 B1 B1	
7 (b)	$C_7H_{16}(l) + 11O_2(g) \rightarrow 7CO_2(g) + 8H_2O(l)$ 1 mark for species and state symbols 1 mark for balanced	B1 x 2	
7 (c)	$\Delta_c H$ = [(7 × –394) + (8 × –286)] – [–224 + 0] = –4822 kJ mol^{-1} 1 mark for use of 7 and 8 1 mark for correct subtraction 1 mark for correct answer	B1 x 3	
8 (a)	The enthalpy change from the complete combustion of 1 mole of a substance.	B1 B1	**ALLOW** energy change for combustion in excess oxygen **OR** energy released during complete combustion **OR** energy change for combustion in excess air **NOT** energy required This mark is not stand alone but must relate to statement about an enthalpy change even if the statement was not awarded a mark
8 (b) (i)	$q = mc\Delta T$ = 250 × 4.18 × 54.0 = 56 430 J = 56.430 kJ	B1	**ALLOW** 56.43 (kJ) OR 56.4 kJ OR 56 kJ **ALLOW** -56.43 i.e. ignore sign
8 (b) (ii)	$M(CH_3(CH_2)_4OH)$ = 88.0 g mol^{-1} $n(CH_3(CH_2)_4OH)$ = 1.76/88.0 = 0.0200 mol	B1 B1	**ALLOW** 88 **ALLOW** 0.02 **OR** ecf from wrong M_r **ALLOW** full marks for 0.02 with no working out
8 (b) (iii)	For 1 mol $CH_3(CH_2)_4OH$, energy change = 1.76/0.0200 = 2821.5 kJ ∴ $\Delta_c H$ = –2820 kJ mol^{-1} 1 mark for value	B1 B1 x 2	**ALLOW correct substitution into formula**(b)(i) ÷ (b)(ii) e.g. 56.4 ÷ 0.02 this is essentially a mark for the working **ALLOW** ecf from i.e. answer from (b)(i) ÷ (b)(ii)

Question number	Answer	Marks	Guidance
	1 mark for sign		The minus mark is stand alone and is independent of the numerical answer
8 (c) (i)	100 kPa and 298 K	B1	**units needed** **ALLOW** 1 bar **OR** 1 atm **OR** 760 mmHg **ALLOW** any stated temperature so for example 100 kPa and 40 °C would be credited with a mark **IGNORE** any reference to moles or concentration
8 (c) (ii)	$6C(s) + 7H_2(g) \rightarrow C_6H_{14}(l)$	B1	**ALLOW** graphite / gr
8 (c) (iii)	Carbon reacts with hydrogen to form many different hydrocarbons	B1	**ALLOW** can form different isomers **OR** can form different structures **IGNORE** reaction may be reversible
8 (c) (iv)	$\Delta_f H$ = [(6 × –394) + (7 × –286)] – [–4163] = –203 kJ mol^{-1} 1 mark for use of 6 and 7 1 mark for correct subtraction 1 mark for correct answer	B1 x 3	**ALLOW THREE** marks for –203 on its own with no working out or written on the answer line **ALLOW TWO** marks for +203,+3483, +1513, +1767 or -8529 on its own with no working out **ALLOW ONE** mark for or –3483, –1513, –1767 or +8529 on its own with no working out units **NOT** needed Positive sign not needed for endothermic answers