Enthalpy

1. (a) $2220 \times \frac{30000}{44}$ **(1)**

=1 510 000 kJ (unit must be correct for value) **(1)**
ignore –ve sign
do not allow kJ mol^{-1} for unit

penalise significant figures (other than 3 or 4) once in (a) and (b) together 2

(b) (i) the energy / enthalpy needed to **break** 1 mol of bonds **(1)**

averaged over a number of molecules containing that bond
or 'different environments for the bond' **(1)**

reference to gas phase **or** to produce gaseous atoms **(1)**

ignore reference to s.t.p. or standard conditions 3

(ii) bonds broken: (2 × 348) + (8 × 412) + (5 × 496) = 6472 **(1)**
(condone wrong sign)

bonds formed: (6 × 743) + (8 × 463) = 8162 **(1)**
(condone wrong sign)

give one mark for correct 2:8:5 or 6:8 ratio if both totals above are wrong

enthalpy change = –1690 (ignore units) **(1)** 3

(iii) value in (c)(ii) used average / non-specific values **(1)**

H_2O is
in different states in the two equations / is a gas in (c) / is a liquid in (b) **(1)**

2

[10]

2. (a) Enthalpy change when 1 mol of compound 1
Is formed from it's elements 1
All substances in their standard state 1

(b) $\Delta H = \sum\Delta H^{\ominus}_c$ (reactants) – $\sum\Delta H^{\ominus}_c$ (products) 1
= (7x – 394) + (4 x – 286) – (– 3909) 1
= + 7 $kJmol^{-1}$ 1

(c) Heat change = m c ΔT 1
= 250 × 4.18 × 60 = 62700J = 62.7kJ 1

Moles C_7H_8 = 2.5 /92 = 0.0272 1

ΔH = 62.7 / 0.0272 = – 2307 kJ mol^{-1} 1
(allow –2300 to –2323)

	(d)	Mass of water heated = 25 + 50 = 75g	
		Temp rise = 26.5 – 18 = 8.5 ^{0}C	1
		*both for **(1)** mark*	
		Heat change = 75 × 4.18 × 8.5 = 2665 J = 2.665 kJ	1
		Moles HCl = <u>0.05</u>	1
		ΔH = – 2.665 / 0.05 = –53.3 kJmol^{-1}	1
		(allow –53 to –54)	
	(e)	Less heat loss	1
			[15]
3.	(a)	enthalpy change/ heat energy change when 1 mol of a substance	1
		is completely burned in oxygen	1
		at 298K and 100 kPa or standard conditions	1
	(b)	ΔH = ∑ bonds broken – ∑ bonds formed	1
		= (6 × 412) + 612 +348 + (4.5 × 496) – ((6 × 743) + (6 × 463))	1
		= – 1572 kJ mol^{-1}	1
	(c)	by definition ΔH_f is formation from an element	1
	(d)	$\Delta Hc = \sum \Delta H_f$ products -$\sum \Delta H_f$ reactants or cycle	1
		= (3 × – 394) + (3 × -242) – (+20)	1
		= − 1928 kJmol^{-1}	1
	(e)	bond enthalpies are mean/average values	1
		from a range of compounds	1
			[12]
4.	(a)	normal physical state **(1)**	
		at 100kPa and 298K **(1)**	2
	(b)	$\Delta H^\ominus_f = \Sigma \Delta H^\ominus_c$ reactants **-** $\Sigma \Delta H^\ominus_c$ prods **(1)** or cycle	
		$\Delta H^\ominus_f = 3 \times \Delta H^\ominus_f (CO_2) + 2{\cdot}5 \times \Delta H^\ominus_f (H_2O) + 3 \times \Delta H^\ominus_f (NO_2)$	
		(i.e number ratios) $-\Delta H^\ominus_c$ (N.G) **(1)**	
		= 3× –394 + 2·5 × –242 + 3 ×34 –(–1540) **(1)**	
		= – 145 **(1)**	4
	(c)	ΔH = $3 \times \Delta H^\ominus_f (CO_2) + 2{\cdot}5 \times \Delta H^\ominus_f (H_2O) - \Delta H^\ominus_f$ (N.G) **(1)**	
		= 3 × –394 + 2·5 × –242 – (–145) **(1)**	
		= –1642 **(1)**	
		(or ΔH = $\Delta H^\ominus_c$ (N.G) –3 × $\Delta H^\ominus_c$ (½N_2) **(1)**	
		= –1540 –3 × 34 **(1)** = –1642 **(1)**)	3

(d) does not require Oxygen **(1)**

(or lower E_a) 1

(e) +44 **(1)**

energy needed to break bonds **(1)** 2

[12]

5. (a) $2AgNO_3 + Zn \rightarrow Zn(NO_3)_2 + 2Ag$ **(1)**

Accept an ionic equation i.e. $\mathbf{2Ag^{+} + Zn \rightarrow 2Ag + Zn^{2+}}$

1

(b) Moles = mv / 1000 **(1) =** $0.20 \times 50/1000 = 1.00 \times 10^{-2}$ 2

(c) Heat energy change = $mC\Delta T$ **(1)** = $50 \times 418 \times 3.2$ J

= 669 J (Ignore signs) **(1)**

Allow 668, 67.0 0.67kJ

Penalise wrong units if given

2

(d) $\dfrac{2 \times 669}{1 \times 10^{-2}}$ = 134 kJ mol^{-1}

Mark one : 2 × (answer to (c))

Mark two : Dividing by answers to (b)

Allow 133 – 134

Penalise incorrect units

Mark conseq to equation in (a) for full marks, also to that in (c)

If No working is shown and answer is incorrect zero

2

(e) Incomplete reaction or Heat loss **(1)** 1

[8]