Question number	Answer	Marks	Guidance
1 (a)	The enthalpy change / heat (energy) change (at constant pressure) in a reaction is independent of the route / path taken (and depends only on the initial and final states)	1	Ignore the use of ΔH for enthalpy
1 (b)	$\Delta H_{exp} + \Delta H_2 - \Delta H_1 = 0$ ***OR*** $\Delta H_{exp} + \Delta H_2 = \Delta H_1$ ***OR*** $\Delta H_1 = \Delta H_{exp} + \Delta H_2$ ***OR*** $\Delta H_{exp} = \Delta H_1 - \Delta H_2$ ***OR*** $\Delta H_{exp} = \Delta H_1 + (-\Delta H_2)$	1	Any correct mathematical statement that uses all three terms
1 (c)	$\Delta H_{exp} = \Delta H_1 - \Delta H_2$ $\Delta H_{exp} = -156 - 12 = -$**168** kJ mol^{-1} Award the mark for the correct answer without any working	1	Ignore units
1 (d) (i)	**M1** $q = m\,c\,\Delta T$ OR calculation ($25.0 \times 4.18 \times 14.0$) **M2** = 1463 J OR 1.46 kJ (This also scores **M1**) **M3** must have both the correct value within the range specified **and** the minus sign For 0.0210 mol, therefore ΔH_1 = **– 69.67** to **– 69.52** kJ mol^{-1} ***OR*** ΔH_1 = **– 69.7** to **– 69.5** kJ mol^{-1} Accept answers to 3sf or 4sf in the range – 69.7 to – 69.5 Ignore -70 after correct answer	3	Award full marks for correct answer In **M1**, do not penalise incorrect cases in the formula Penalise **M3** ONLY if correct numerical value but sign is incorrect; e.g. **+69.5 to +69.7 gains 2 marks** (ignore +70 after correct answer) Penalise **M2** for arithmetic error but mark on ΔT = 287, score $q = m\,c\,\Delta T$ only If c = 4.81 (leads to 1684 J) penalise **M2** ONLY and mark on for **M3** = – 80.17 (range – 80.0 to – 80.2) Ignore incorrect units
1 (d) (ii)	The idea of heat loss ***OR***	1	NOT impurity NOT incompetence NOT incomplete combustion

	Incomplete reaction (of the copper sulfate) ***OR*** Not all the copper sulfate has dissolved		
1 (e)	Impossible to add / react the exact / precise amount of water ***OR*** Very difficult to measure the temperature rise of a solid ***OR*** Difficult to prevent solid dissolving ***OR*** (Copper sulfate) solution will form	1	Not just "the reaction is incomplete"
2 (a)	$3N_2H_4 \rightarrow 4NH_3 + N_2$	1	Or multiples Ignore state symbols
2 (b)	**M1** enthalpy / heat (energy) change / required / needed to break / dissociate a covalent bond (or a specified covalent bond) **M2** average / mean over different molecules / compounds / substances	2	Ignore bond making Ignore standard conditions **M2** requires an attempt at **M1**
2 (c)	**M1** $\sum$ (bonds broken) – $\sum$ (bonds formed) = ΔH ***OR*** Sum of bonds broken – Sum of bonds formed = ΔH **M2** (also scores **M1**) 4(+388) + 163 + 2(146) + 4(463) – 944 – 8(463) = ΔH OR broken +3859 (2007) formed – 4648 (2796) **M3** $\Delta H = -789$ kJ mol^{-1} Award 1 mark for +789 Students may use a cycle and gain full marks	3	M1 could stand alone Award full marks for correct answer Ignore units Two marks can score with an arithmetic error in the working Credit **one mark only** for calculating either the sum of the bonds broken or the sum of the bonds formed provided this is the only mark that is to be awarded

3 (a)	Heat (energy) change at constant pressure	1	Ignore references to standard conditions, but credit specified pressure.
3 (b)	The enthalpy change / heat (energy) change (at constant pressure) in a reaction is independent of the route / path taken (and depends only on the initial and final states)	1	
3 (c)	ΔH + 963 = –75 – 432 OR ΔH + 963 = – 507 (**M1**) ΔH = –75 – 432 – 963 (**M1** and **M2**) ΔH = **–1470** kJ mol^{-1} Award 1 mark for + 1470	3	Award full marks for correct answer Ignore units. Ignore numbers on the cycle **M1** and **M2** can score for an arithmetic error
4 (a)	enthalpy change / heat energy change when 1 mol of a substance is completely burned in oxygen at 298 K and 100 kPa or standard conditions	1 1 1	This definition is definitely worth learning. It is worth 3 marks.
4 (b)	ΔH = Σ(bonds broken) − Σ(bonds formed) = (6 × 412) + 612 + 348 + (4.5 × 496) − [(6 × 743) + (6 × 463)] = −1572 kJ mol^{-1}	1 1 1	Always write down the general expression for bond energy calculations as shown here in the first line.
4 (c)	by definition $\Delta_f H$ is formation from an element	1	
4 (d)	$\Delta_c H$ = Σ$\Delta_f H$ (products) – Σ$\Delta_f H$ (reactants or cycle) = (3 × −394) + (3 × −242) − (+20) = −1928 kJ mol^{-1}	1 1 1	Always write the first line as shown here for enthalpy calculations.
4 (e)	bond enthalpies are mean / average values from a range of compounds	1 1	