

Exercise walk-through

2.1.3

Energy diagrams, Hess cycles and cooling correction

Pearson Edexcel · International A-Level · Chemistry

Opposite solubility trends explain the evidence

- 1 **Set up** $\text{Ba}(\text{OH})_2$ is more soluble: its equal saturated volume contains more OH^- and needs more acid.
- 2 **Reason** BaSO_4 is less soluble: equal initial cation amounts give more solid with excess sulfate.
- 3 **Conclude** Solubility controls dissolved amount; it is different from dissociation strength.

Controls distinguish chemical evidence from contamination

- 1 Set up** Match measured amounts, particle size, apparatus and heating rate; compare sample temperature at a consistent decomposition criterion.
- 2 Reason** CO_2 : milky limewater; O_2 : glowing splint relights; NO_2 : brown and acidic.
- 3 Conclude** Clean flame-test wire and keep the flame region/loading consistent. Na yellow, K lilac, Ca brick-red, Sr crimson-red; sodium carry-over can mask another colour.

Independent identification

Your turn

$\text{C}_3\text{H}_6\text{O}$ has a carbonyl IR absorption and gives a positive Fehling's test. Which structure fits all evidence?

- A. CH_3COCH_3
- B. $\text{CH}_3\text{CH}_2\text{CHO}$
- C. $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
- D. CH_3COOH

Exercises 2.1·2.2

2.1 At standard conditions, $2\text{C}_2\text{H}_4(\text{g}) + 6\text{O}_2(\text{g}) \rightarrow 4\text{CO}_2(\text{g}) + 4\text{H}_2\text{O}(\text{l})$ has $\Delta\text{H} = -2822 \text{ kJ mol}^{-1}$ for the equation as written. Define the standard enthalpy change of this reaction and calculate the value for $\text{C}_2\text{H}_4(\text{g}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$. [3]

2.2 Distinguish the bond enthalpy of H–H in gaseous H_2 from a tabulated mean C–H bond enthalpy. Explain why a gas-phase bond calculation cannot directly give the exact combustion enthalpy when liquid water is a product. [3]

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2.1 The heat change at constant pressure for the equation as written under specified standard conditions, with reactants/products in their standard states. Halving every coefficient halves ΔH : $-1411 \text{ kJ mol}^{-1}$. The word reaction does not force a coefficient of one for every species.

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2.2 Bond enthalpy is the energy needed to break one mole of the specified gaseous bonds. A mean C–H value averages different molecular environments. Liquid water has intermolecular/phase-energy differences not included in simply forming gaseous O–H bonds, so phase information is needed as well as the averaging limitation.

Exercise 2.3

2.3 Comparable C–Br and C–Cl bond enthalpies are 276 and 338 kJ mol^{-1} . Which is easier to break, and what tentative indication does this give about the first cleavage? Explain why these values alone do not give a numerical reaction rate. [3]

3 Exam-style questions

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2.3 C–Br needs less energy to break, so it may cleave more readily/first in otherwise comparable pathways. Actual rate depends on the whole activation mechanism and conditions, so bond enthalpy alone does not fix a rate.

Exercise 3.1

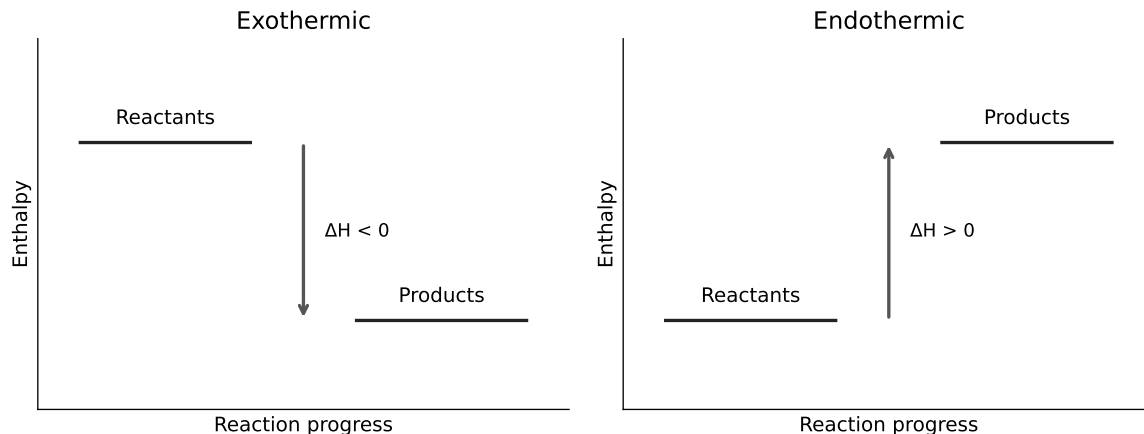
3.1 Draw separate labelled enthalpy-level diagrams for an exothermic and an endothermic reaction. Show reactant/product levels, the direction of the ΔH arrow and the sign. Do not add a time axis.

[4]

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3.1



For each diagram, B1 for correct relative labelled levels and B1 for correctly directed/signed ΔH (four marks total).

Exercise 3.2

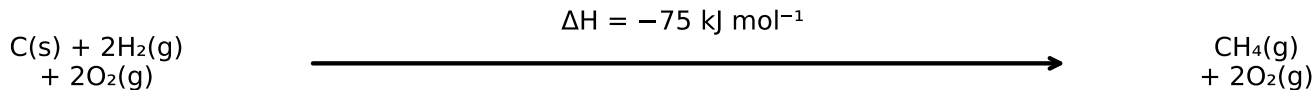
3.2 Construct a complete combustion Hess cycle for $\text{C}(\text{s, graphite}) + 2\text{H}_2(\text{g}) \rightarrow \text{CH}_4(\text{g})$, using standard combustion enthalpies: $\text{C} -394$, $\text{H}_2 -286$ and $\text{CH}_4 -891 \text{ kJ mol}^{-1}$. Include all species, amounts, states and arrow directions, then calculate the formation enthalpy of methane. [5]

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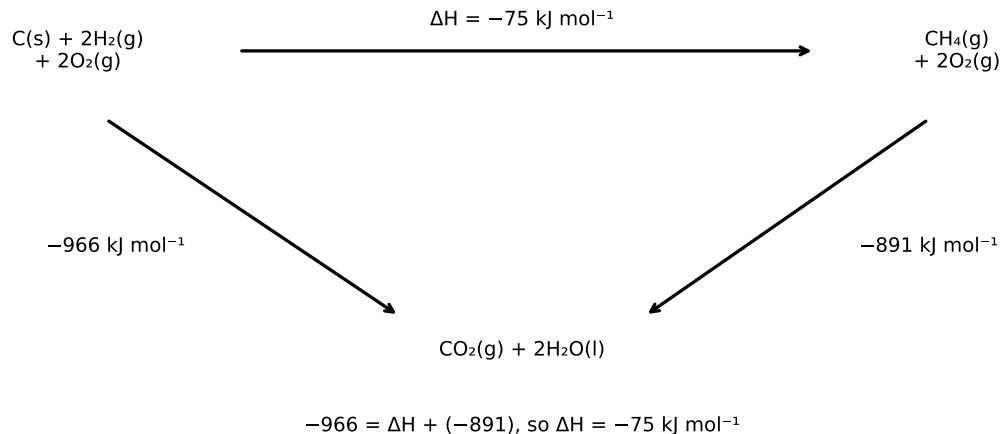
Same initial and final states: include oxygen on both top routes



Full solution 3.2

3.2

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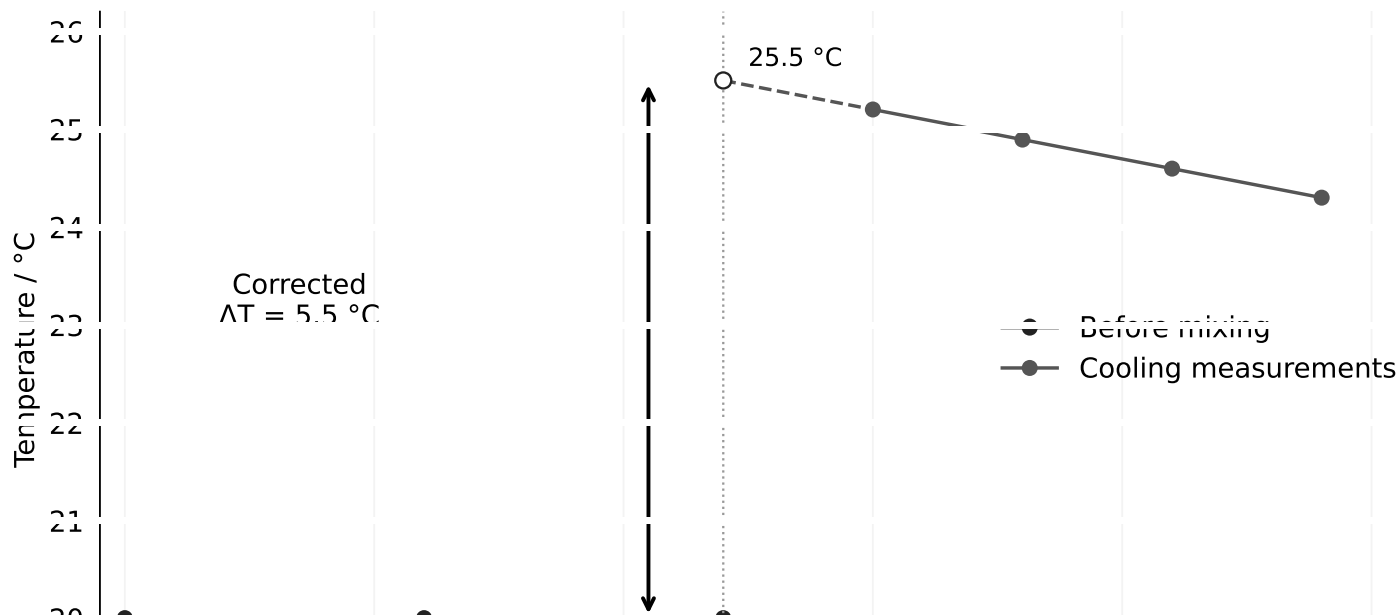
Common products $\text{CO}_2\text{(g)} + 2\text{H}_2\text{O(l)}$; correctly scaled left route $-394 + 2(-286) = -966 \text{ kJ mol}^{-1}$; consistent downward arrow directions and spectator O_2 on both top routes. $-966 = \Delta H - 891$, giving $\Delta H = -75 \text{ kJ mol}^{-1}$.

Exercise 3.3

3.3 40.0 cm^3 each of 1.00 mol dm^{-3} HCl and NaOH are mixed at 120 s. Before mixing,

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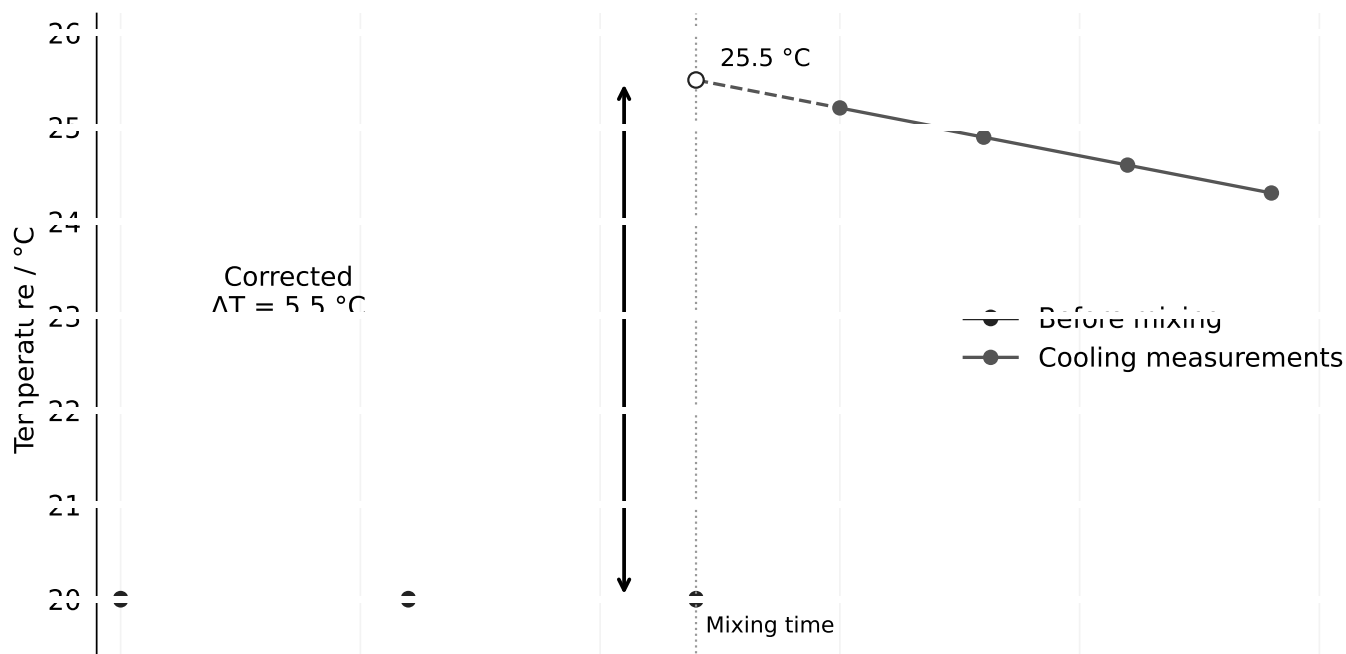
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Full solution on next slide

Full solution 3.3 (1/2)

3.3



Full solution 3.3 (2/2)



Correct axes/scales and plotted measurements; cooling line extrapolated to 25.5 °C at 120 s; corrected rise = 5.5 °C. $q = mc\Delta T = 80.0 \times 4.18 \times 5.5 = 1839.2 \text{ J} = 1.8392 \text{ kJ}$. $n(\text{H}_2\text{O}) = cV = 1.00 \times 0.0400 = 0.0400 \text{ mol}$. $\Delta H = -q/n = -1.8392/0.0400 = -46.0 \text{ kJ mol}^{-1}$. The first measured maximum has already lost heat, so using 5.2 °C gives a less negative value. The correction assumes the observed cooling trend reasonably represents heat loss near mixing; changing heat-loss rate, slow mixing or reaction continuing during cooling limits it.