Enthalpy and Hess's Law

Student Worksheet | g10_u02_w06

I can: connect a signed heat-transfer model to enthalpy, and reverse, scale, and add thermochemical equations because enthalpy is a state function.
Frozen classroom value: $c_{\text{water}} = 4.184\ \text{J g}^{-1}\,^{\circ}\text{C}^{-1}$. Use $q = mc\Delta T$. Every prompt is a supplied paper/digital data card; no heating, mixing, or chemical handling is requested. Carry guard digits to the final reported value.

1. State the sign of ΔH for an exothermic reaction and for an endothermic reaction. Relate each sign to heat flow from/to the reaction system.

2. A reaction card has $\Delta H = -125$ kJ/mol. Is it exothermic or endothermic? What does "per mol" refer to?

3. A water card warms. Under the stated ideal boundary, assign signs to q_{water}, q_{rxn}, and ΔH_{rxn}.

4. A 100.0 g water card warms from 20.0°C to 24.5°C during 0.0250 mol reaction. Calculate q_{water} and ΔH_{rxn}.

5. A 125.0 g water card cools from 22.0°C to 19.0°C during 0.0300 mol reaction. Calculate q_{water}, q_{rxn}, and ΔH_{rxn}.

6. For $\text{H}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{H}_2\text{O(l)}$, $\Delta H = -285.8$ kJ. Write the doubled equation and its enthalpy.

7. Reverse item 6's original equation. State the new ΔH and explain why the sign changes.

8. Given $C + O_2 \rightarrow CO_2$, $\Delta H = -393.5$ kJ and $CO + \frac{1}{2}O_2 \rightarrow CO_2$, $\Delta H = -283.0$ kJ, use Hess's law to find ΔH for $C + \frac{1}{2}O_2 \rightarrow CO$.

9. Show the equation reversal/addition route for item 8. What cancels?

10. Given $N_2 + O_2 \rightarrow 2NO$, $\Delta H = +180.5$ kJ and $2NO + O_2 \rightarrow 2NO_2$, $\Delta H = -114.1$ kJ, find ΔH for $N_2 + 2O_2 \rightarrow 2NO_2$.

11. Why may thermochemical equations be added even when the physical path is different? State what Hess's law does not guarantee about reaction rate or mechanism.

12. A 150.0 g water record warms from 19.0°C to 22.0°C during 0.0250 mol reaction. Calculate ΔH_{rxn}.

13. A calorimeter card specifies 100.0 g water, $C_{\text{cal}} = 35.0$ J/°C, and $\Delta T = 4.00$°C for 0.0200 mol reaction. Calculate total surroundings heat and ΔH_{rxn}.

14. Name two assumptions or measurement limits that can make a calorimetry-derived ΔH an estimate rather than an exact value.

15. Data equations: X→Y, $\Delta H = +50$ kJ; Y→Z, $\Delta H = -120$ kJ. Find ΔH for X→Z.

16. Explain why a catalyst can change an activation-energy pathway without changing the ΔH found by Hess's law.

17. Use these data (all kJ): $\mathrm{C} + \mathrm{O_2} \rightarrow \mathrm{CO_2}$, $\Delta H = -393.5$; $2\mathrm{H_2} + \mathrm{O_2} \rightarrow 2\mathrm{H_2O(l)}$, $\Delta H = -571.6$; and $\mathrm{CH_4} + 2\mathrm{O_2} \rightarrow \mathrm{CO_2} + 2\mathrm{H_2O(l)}$, $\Delta H = -890.3$. Find ΔH_f for $\mathrm{CH_4}$ from elements.

18. In item 17, identify the reversed equation and the equations added. Why must physical states be retained in a thermochemical equation?

19. A learner multiplies an equation by 3 but keeps ΔH unchanged. Correct the error with a numerical example.

20. A report gives a calorimetry estimate and a Hess-law value that differ by 6 kJ/mol. Write a cautious conclusion and two next checks; do not declare either value “wrong” from one comparison.