

6.9 Hess's Law

Name: _____ Class: _____ Date: _____

Total: 11 marks

KEY WORDS hess's law • state function

Objective

Build the skills to answer exam questions on **Hess's law**.

You must be able to:

- combine known reactions to find an unknown ΔH (**Hess's law**)
- reverse** a reaction (flip ΔH sign) and **scale** it (multiply ΔH)
- add the steps so intermediates cancel

1 Key knowledge and worked examples

Study these first. Each one shows the method for a question type used later – follow the steps and you can do the Practice and Exam-style questions yourself.

■ Hess's law

 ΔH depends only on the **start and end** states, not the path. So you can add known reactions to reach the target reaction, and add their ΔH values.

■ Two allowed moves

- Reverse** a reaction $\rightarrow$ change the sign of its ΔH .
- Multiply** a reaction by a factor $\rightarrow$ multiply its ΔH by the same factor.

■ A worked combination

Target: $\text{C} + \frac{1}{2}\text{O}_2 \rightarrow \text{CO}$. Given (1) $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$, $\Delta H = -394$; (2) $\text{CO} + \frac{1}{2}\text{O}_2 \rightarrow \text{CO}_2$, $\Delta H = -283$. Reverse (2): $\Delta H = +283$. Add (1) + reversed (2): CO_2 cancels, giving $\Delta H = -394 + 283 = -111$ kJ.

■ Cancel the intermediates

Arrange the steps so the species not in the target reaction cancel between the two sides. What remains must be the target equation.

2 Practice

Now apply the methods above.

2.1 State Hess's law in one sentence. [1]

2.2 If reversing a reaction, what happens to ΔH ? [1]2.3 A reaction has $\Delta H = -100$ kJ. What is ΔH if you multiply the reaction by 2? [1]

3 Exam-style questions

3.1 Hess's law works because ΔH is a [1]

- ☐ A state function (path-independent)
- ☐ B rate
- ☐ C catalyst
- ☐ D temperature

3.2 Find ΔH for $\text{N}_2 + 2\text{O}_2 \rightarrow 2\text{NO}_2$ using: (1) $\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO}$, $\Delta H = +180$ kJ; (2) $2\text{NO} + \text{O}_2 \rightarrow 2\text{NO}_2$, $\Delta H = -112$ kJ.

(a) State how to combine (1) and (2). [1]

(b) Find the target ΔH . [2]3.3 Find ΔH for $\text{C} + \frac{1}{2}\text{O}_2 \rightarrow \text{CO}$ using $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$ (-394 kJ) and $\text{CO} + \frac{1}{2}\text{O}_2 \rightarrow \text{CO}_2$ (-283 kJ). Show your reasoning. [4]

Solutions

Each answer shows the steps, then the **result**.

2.1

- The enthalpy change of a reaction is the same regardless of the path taken

2.2

- Its sign changes

2.3

- -200 kJ

3.1 A

- ΔH is a state function

3.2

(a)

- Add (1) and (2) directly – the 2NO cancels

(b)

- $\Delta H = 180 + (-112) = +68 \text{ kJ}$

3.3

- Keep reaction 1 as is (-394); reverse reaction 2 ($\text{CO}_2 \rightarrow \text{CO} + \frac{1}{2}\text{O}_2$, $+283$); add – CO_2 cancels, leaving $\text{C} + \frac{1}{2}\text{O}_2 \rightarrow \text{CO}$; $\Delta H = -394 + 283 = -111 \text{ kJ}$