Exercise walk-through

Enthalpy of Formation ▪ 6.8

eXercise

You must be able to

- use standard enthalpies of formation ΔH_f°
- apply $\Delta H_{\text{rxn}} = \Sigma \Delta H_f(\text{products}) - \Sigma \Delta H_f(\text{reactants})$
- know that ΔH_f° of an element is zero

Method — Standard enthalpy of formation

ΔH_f° is the enthalpy change to make **1 mole** of a compound from its elements in their standard states. For an **element** in its standard state, $\Delta H_f^\circ = 0$.

Method — The formula

$$\Delta H^\circ_{\text{rxn}} = \sum \Delta H^\circ_f(\text{products}) - \sum \Delta H^\circ_f(\text{reactants}),$$

weighting each by its coefficient.

Method — A worked calculation

For $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$, with ΔH_f: $CH_4 = -75$, $CO_2 = -394$, $H_2O = -286$, $O_2 = 0$:

$$\Delta H = [(-394) + 2(-286)] - [(-75) + 0] = -966 + 75 = -891 \text{ kJ}.$$

Method — Don't forget coefficients

Multiply each ΔH_f by the species' coefficient before summing — a common lost mark.

Practice 2.1 ▪ 1 mark

What is ΔH_f° of an element in its standard state?

Solution 2.1

Method: Standard enthalpy of formation

Worked steps

Zero B1.

Practice 2.2 ▪ 1 mark

Write the formula for ΔH_{rxn} from formation enthalpies.

Solution 2.2

Method: The formula

Worked steps

$\Delta H_{\text{rxn}} = \Sigma \Delta H_f(\text{products}) - \Sigma \Delta H_f(\text{reactants})$ B1.

Practice 2.3 ▪ 2 marks

For products summing to -500 and reactants to -200 kJ, find ΔH_{rxn}.

Solution 2.3

Method: The formula

Worked steps

$-500 - (-200) = -300$ kJ M1 A1.

Exam-style 3.1 ▪ 1 mark

The standard enthalpy of formation of $O_2(g)$ is

A -286 kJ/mol

B 0

C $+286$ kJ/mol

D unknown

Solution 3.1

Method: Standard enthalpy of formation

A -286 kJ/mol

B 0 ✓

C $+286$ kJ/mol

D unknown

Worked steps

B — an element in its standard state has $\Delta H_f^\circ = 0$.

Exam-style 3.2 ▪ 1 mark

For $2H_2 + O_2 \rightarrow 2H_2O$, $\Delta H_f(H_2O) = -286$ kJ/mol.
(a) State ΔH_f of H_2 and O_2.
(b) Find ΔH_{rxn}.

Solution 3.2

Method: A worked calculation

Worked steps

(a) Both 0 (elements) B1. (b) $\Delta H = 2(-286) - [2(0) + 0] = -572$ kJ M1 M1 A1.

Exam-style 3.3 ▪ 4 marks

For $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$, with ΔH_f: $C_2H_4 = +52$, $CO_2 = -394$, $H_2O = -286$, find ΔH_{rxn}.

Solution 3.3

Method: A worked calculation

Worked steps

products $= 2(-394) + 2(-286) = -1360$ M1; reactants $= 52 + 3(0) = 52$ M1; $\Delta H = -1360 - 52 = -1412$ kJ M1 A1.