Exercise walk-through

Bond Enthalpies ▪ 6.7

eXercise

You must be able to

- use $\Delta H \approx \Sigma(\text{bonds broken}) - \Sigma(\text{bonds formed})$
- calculate a reaction enthalpy from bond energies
- explain the sign from bond breaking vs forming

Method — The bond-enthalpy method

$$\Delta H \approx \sum(\text{bond enthalpies of bonds broken}) - \sum(\text{bond enthalpies of bonds formed}).$$

Breaking bonds costs energy $(+)$; forming bonds releases energy $(-)$.

Method — A worked calculation

For $H_2 + Cl_2 \rightarrow 2HCl$: bonds broken = H–H (436) + Cl–Cl $(242) = 678$; bonds formed = $2\times$H–Cl $(2 \times 431 = 862)$. So $\Delta H = 678 - 862 = -184$ kJ (exothermic).

Method — The sign logic

If the bonds **formed** are stronger (release more) than those **broken**, ΔH is negative (exothermic). If breaking costs more than forming releases, it is endothermic.

Method — An estimate, not exact

Bond enthalpies are **averages**, so this method gives an approximate ΔH — good for gases where all species have well-defined bonds.

Practice 2.1 ▪ 1 mark

Write the bond-enthalpy formula for ΔH.

Solution 2.1

Method: The bond-enthalpy method

Worked steps

$\Delta H \approx \Sigma(\text{bonds broken}) - \Sigma(\text{bonds formed})$ **B1**.

Practice 2.2 ▪ 1 mark

Breaking bonds — does it absorb or release energy?

Solution 2.2

Worked steps

Absorbs energy **B1**.

Practice 2.3 ▪ 2 marks

If bonds formed release 900 kJ and bonds broken cost 700 kJ, find ΔH.

Solution 2.3

Worked steps

$\Delta H = 700 - 900 = -200$ kJ M1 A1.

Exam-style 3.1 ▪ 1 mark

A reaction is exothermic when the bonds formed are

A weaker than the bonds broken

B stronger than the bonds broken

C equal to the bonds broken

D all single bonds

Solution 3.1

A weaker than the bonds broken

B stronger than the bonds broken ✓

C equal to the bonds broken

D all single bonds

Worked steps

B — stronger bonds formed release more energy, giving a negative ΔH.

Exam-style 3.2 ▪ 1 mark

For $H_2 + Br_2 \rightarrow 2HBr$: H–H $= 436$, Br–Br $= 193$, H–Br $= 366$ kJ/mol.

(a) Find the total energy to break the reactant bonds.

(b) Find the total energy released forming the product bonds.

(c) Find ΔH and classify it.

Solution 3.2

Method: The bond-enthalpy method

Worked steps

(a) $436 + 193 = 629$ kJ **B1**. (b) $2 \times 366 = 732$ kJ **B1**. (c) $\Delta H = 629 - 732 = -103$ kJ, exothermic **M1** **A1**.

Exam-style 3.3 ▪ 2 marks

Explain why bond-enthalpy calculations give only an approximate ΔH.

Solution 3.3

Worked steps

Bond enthalpies are **average** values over many molecules, so the actual bond strengths differ slightly, making the result approximate **M1** **A1**.