

Exercise walk-through

# 12.1

## Calorimetry and chemical energy

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International Baccalaureate · IB Diploma · Chemistry · SL

# 12.1 Calorimetry and chemical energy

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Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_ **Total: 10 marks**

**KEY WORDS** enthalpy change • exothermic

# Objective

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Calorimetry and chemical energy. Original classroom practice for IB SL; not an official IB paper.

## 1 Key knowledge and worked examples

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### ■ What would explain this observation?

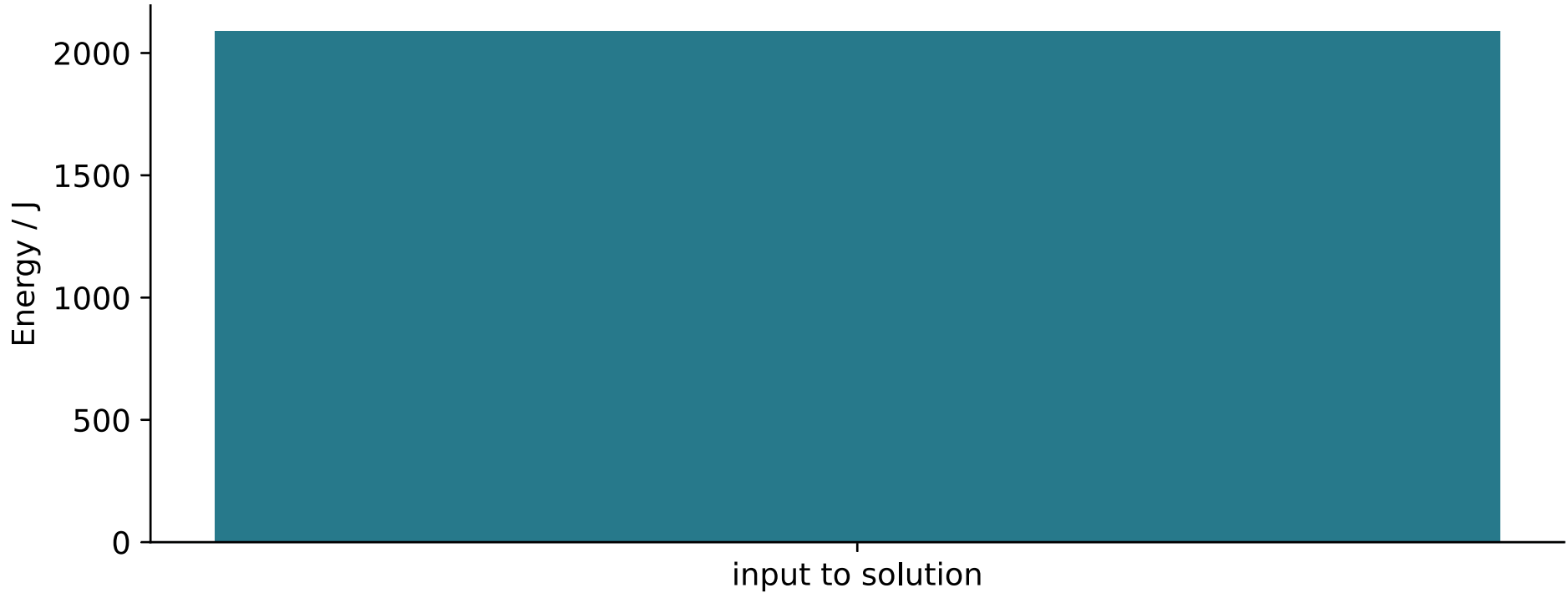
- A cup warms when two solutions react. The temperature rise measures energy transferred to the surroundings; it does not directly equal the **enthalpy change** .

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## ■ Build the model

- **Exothermic** reactions transfer energy to surroundings.
- Endothermic reactions take energy from surroundings.
- Bond breaking requires energy; bond formation releases energy.

- exothermic: Transferring energy to the surroundings.
- enthalpy change: Heat change at constant pressure for a stated process.



## ■ Choose evidence that can test it

- Use energy transferred = mass  $\times$  specific heat capacity  $\times$  temperature change.
- Convert joules to kilojoules before dividing by reaction amount.
- An exothermic molar enthalpy change has a negative sign.

**In the lab:** Use insulation and a lid, measure starting temperatures consistently, stir, and record a temperature-time series. Estimate the reaction temperature from an appropriate extrapolation rather than ignoring cooling during measurement.

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## ■ Work from known quantities

- Known: 100 g solution rises by 5.0 °C; specific heat capacity is 4.18 J per gram per degree.  $q = mc\Delta T$ .  $q = 100 \times 4.18 \times 5.0 = 2,090 \text{ J} = 2.09 \text{ kJ}$ .

- If 0.050 mol reacts,  $\Delta H = -q/n = -2.09/0.050 = -41.8$  kJ per mole.

**Your turn:** 50 g water rises 4 °C. Use  $c = 4.2$  J per gram per degree to find  $q$ .

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### ■ Check the conclusion and its limits

- Heat loss usually lowers the observed temperature rise.
- The solution gaining heat and the reaction losing heat have opposite signs.

**Not true:** Bond breaking releases energy. Bond breaking is endothermic - it requires energy. Bond forming releases energy. Confusing the two reverses the sign of every energy calculation.

**Key:**

- Exothermic reactions transfer energy to surroundings.
- Use energy transferred = mass  $\times$  specific heat capacity  $\times$  temperature change.
- Watch for: heat loss usually lowers the observed temperature rise.

■ **Write from 756 J and minus 37.8 kJ per mole**

- 60 g of solution rises by 3 degrees. Use  $c = 4.2$  J per gram per degree. 0.020 mol reacts.
- Find  $q$  and the enthalpy change per mole. Bond breaking requires energy.

## Exercises 2.1-2.3

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**2.1** Which process requires energy? Choose one answer.

- **A** Breaking a covalent bond
- **B** Forming every chemical bond
- **C** Cooling a hot solution

[1]

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**2.2** 50 g water rises 4 °C. Use  $c = 4.2 \text{ J per gram per degree}$  to find  $q$ . Show the relation, substitution and units.

[2]

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**2.3** Decide whether this claim is true and justify: Bond breaking is endothermic - it requires energy.

[2]

## Exercises 2.1·2.3

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**2.1** Which process requires energy? Choose one answer.

- **A** Breaking a covalent bond
- **B** Forming every chemical bond
- **C** Cooling a hot solution

[1]

**2.1 A** Breaking a bond always requires energy input to separate the atoms; forming a bond releases energy. A reaction is exothermic overall only when the energy released in bond formation exceeds the energy taken in for bond breaking.

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**2.2** 50 g water rises 4 °C. Use  $c = 4.2 \text{ J per gram per degree}$  to find  $q$ . Show the relation, substitution and units.

[2]

**2.2**  $q = mc\Delta T = (50 \text{ g}) \times (4.2 \text{ J/(g K)}) \times (4 \text{ K}) = 840 \text{ J}$ .

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**2.3** Decide whether this claim is true and justify: Bond breaking is endothermic - it requires energy.

[2]

**2.3** True. True. Bond breaking is endothermic - it requires energy. Bond forming releases energy. Confusing the two reverses the sign of every energy calculation.

## Exercises 2.4·3.1

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**2.4** Transferring energy to the surroundings: write the technical term. [1]

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**3.1** Fictional solution gains 1.5 kJ when 0.030 mol reacts. Find molar reaction enthalpy using the stated heat-transfer model, and explain the sign and effect of uncorrected heat loss. [4]

## Exercises 2.4·3.1

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**2.4** Transferring energy to the surroundings: write the technical term. [1]

**2.4** exothermic. exothermic means Transferring energy to the surroundings.

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**3.1** Fictional solution gains 1.5 kJ when 0.030 mol reacts. Find molar reaction enthalpy using the stated heat-transfer model, and explain the sign and effect of uncorrected heat loss. [4]

**3.1**  $\Delta H = -q/n = -1.5/0.030 = -50 \text{ kJ/mol}$ . Solution gains heat, reaction loses it. Uncorrected loss usually underestimates magnitude. Include container heat if relevant.