Topic 5: Energy changes

AQA GCSE Chemistry (8462), topic 4.5

Energy changes: follow the energy transfer

- classify reactions as exothermic or endothermic from temperature changes, and judge products such as hand warmers;
- carry out the required practical on temperature changes in reacting solutions;
- draw and read reaction profiles, including **activation energy**;

Energy changes: follow the energy transfer (2)

- (higher tier) calculate energy changes from bond energies;
- (chemistry only) explain how cells, batteries and hydrogen fuel cells produce electricity.

Exothermic and endothermic reactions

- Energy is conserved in every reaction: it is not made or destroyed, only moved between the chemicals and their **surroundings** .
- An **exothermic** reaction transfers energy to the **surroundings**, so the temperature rises. **Combustion** , many **oxidation** reactions and **neutralisation** are exothermic.

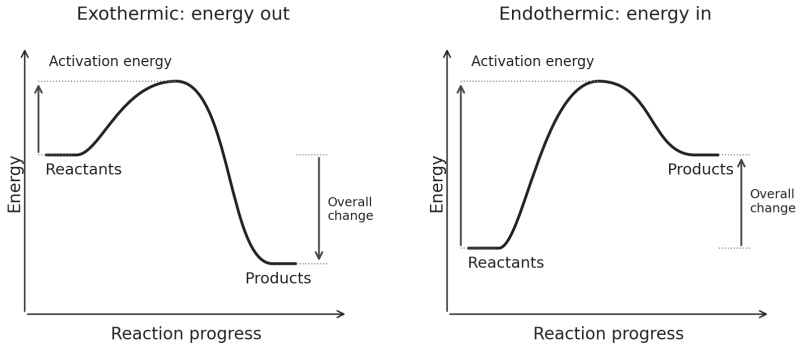
Exothermic and endothermic reactions (2)

- A **hand warmer** uses an exothermic reaction: iron powder slowly oxidises in air and keeps your hands warm for hours.
- An **endothermic** reaction takes in energy from the **surroundings**, so the temperature falls. **Thermal decomposition** is endothermic, and so is the reaction between citric acid and sodium hydrogencarbonate.

Reaction profiles

- In an exothermic reaction, the products are lower than the reactants.
- In an endothermic reaction, the products are higher than the reactants.
- Both kinds of reaction have an **activation energy**.

Figure: Reaction profiles



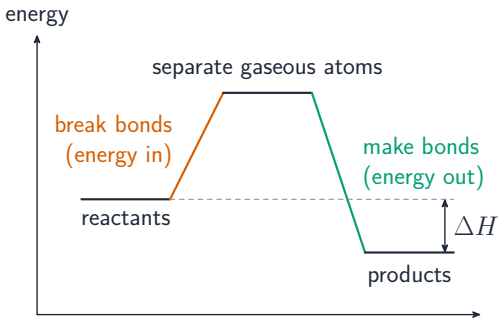
- Exothermic and endothermic reaction profiles with **activation energy** and overall change.
- Match each part of the diagram to the text.

Bond energies (higher tier)

- Bonds broken: two H–H and one O=O **double bond** : $2(436) + 498 = 1370$ kJ/mol.
- Bonds made: each water molecule has two O–H bonds, so two molecules have four: $4(464) = 1856$ kJ/mol.
- Overall change $= 1370 - 1856 = -486$ kJ/mol. The reaction is exothermic.

overall energy change = energy to break bonds − energy released making bonds

Figure: Bond energies (higher tier)

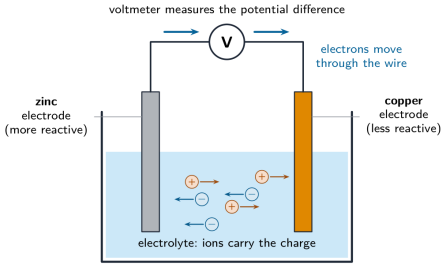


- Breaking bonds takes in energy.
- Making bonds gives out energy.

Cells and batteries (chemistry only)

- A **cell** uses a chemical reaction to produce electricity.
- A simple **cell** has two different metals as each **electrode**, dipped in an **electrolyte**, and joined by wires in an **external circuit**.
- Electrons flow through the wire; ions carry the charge through the **electrolyte**.
- A **voltmeter** measures the **potential difference**, or voltage.

Figure: Cells and batteries (chemistry only)



voltage depends on the two metals, the electrolyte and the conditions

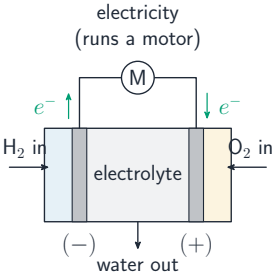
- Simple zinc/copper **cell** with **electrolyte** and **voltmeter**; electron and ion paths distinguished.
- Match each part of the diagram to the text.

Hydrogen fuel cells (chemistry only)

- A **fuel cell** is supplied with a fuel, such as hydrogen, and with oxygen from the air.
- It produces electricity for as long as the supply continues.
- In a hydrogen fuel cell, hydrogen is **oxidised** to make water:
- Neither choice is free of pollution.

$$2H_2 + O_2 \rightarrow 2H_2O$$

Figure: Hydrogen fuel cells (chemistry only)



overall: $2H_2 + O_2 \rightarrow 2H_2O$

- Hydrogen and oxygen meet at separate electrodes.
- The only product is water.

Sources for this lesson

- AQA, *GCSE Chemistry (8462) specification*, section 4.5, and the required practicals handbook.
- NASA, *Apollo 13 Mission Operations Report* (1970) and the *Report of the Apollo 13 Review Board* (15 June 1970).
- NASA Glenn Research Center, "Fuel cells: a history" (Apollo command and service module power system).
- International Energy Agency, *Global Hydrogen Review 2024*, on how hydrogen is produced.

Common errors

- Saying that an endothermic reaction "gives out cold"; it takes in energy from the **surroundings**.
- Drawing the **activation energy** arrow from the products, or the overall change from the peak.
- Saying a **catalyst** changes the overall energy change; it only lowers the activation energy.

Common errors (2)

- Saying bond making takes in energy; making bonds releases energy.
- Forgetting to multiply bonds by the numbers in front of formulae.
- Saying fuel cells produce no pollution at all; making the hydrogen can release carbon dioxide.

Key terms

- **Exothermic**: describes a reaction that transfers energy to the **surroundings**.
- **Endothermic**: describes a reaction that takes in energy from the surroundings.
- **Activation energy**: the minimum energy that particles need to react when they collide.

Key terms (2)

- **Reaction profile**: a diagram of the energy of reactants and products during a reaction.
- **Bond energy**: the energy needed to break one **mole** of a particular bond.
- **Cell**: a device that uses a chemical reaction to produce a **potential difference**.
- **Fuel cell**: a **cell** supplied with fuel and oxygen, which it oxidises to produce electricity.

Check yourself

- 1.
- The temperature of a mixture rises from 19 °C to 31 °C.
- Is the reaction exothermic or endothermic?
- What is the temperature change? 2.