Energy changes in reactions

Teacher review edition. Ask your teacher if anything is unclear.

Why do some reactions warm their surroundings while others cool them?

What you will learn

- Explain exothermic and endothermic reactions.
- Describe activation energy.
- Read a simple energy profile.
- Explain how a catalyst affects an energy profile.

Reactions transfer energy

> **Surroundings**
> The solution, container, air and other things around the reacting substances.

Reactions transfer energy between reacting substances and their surroundings.

- The surroundings include the solution, container and nearby air.
- A temperature rise shows that the surroundings gained energy.
- A temperature fall shows that the surroundings lost energy.

Exothermic reactions

> **Exothermic reaction**
> A reaction that releases energy to its surroundings.
>
> **Fuel**
> A substance used to release useful energy, usually by burning.

An exothermic reaction releases energy to its surroundings: “exo” means out.

- The surroundings usually become warmer.
- Examples: burning a fuel and many neutralisation reactions.

Endothermic reactions

> **Endothermic reaction**
> A reaction that takes in energy from its surroundings.

An endothermic reaction takes in energy from its surroundings: “endo” means in.

- The surroundings usually become cooler.
- In a laboratory reaction, a fall in the solution’s temperature can show energy being taken in.

- Photosynthesis is an energy-taking process powered by light. It does not rely on cooling the surroundings.

Activation energy: getting started

> **Activation energy**
> The minimum energy needed for a successful reaction.

- Even an exothermic reaction may need energy to start: a match must be struck before it burns.
- Think of activation energy as an initial hurdle.
- It is different from the overall energy released or taken in.

Reading an energy profile

> **Energy profile**
> A diagram showing the energy of reactants, products and the energy hurdle between them.

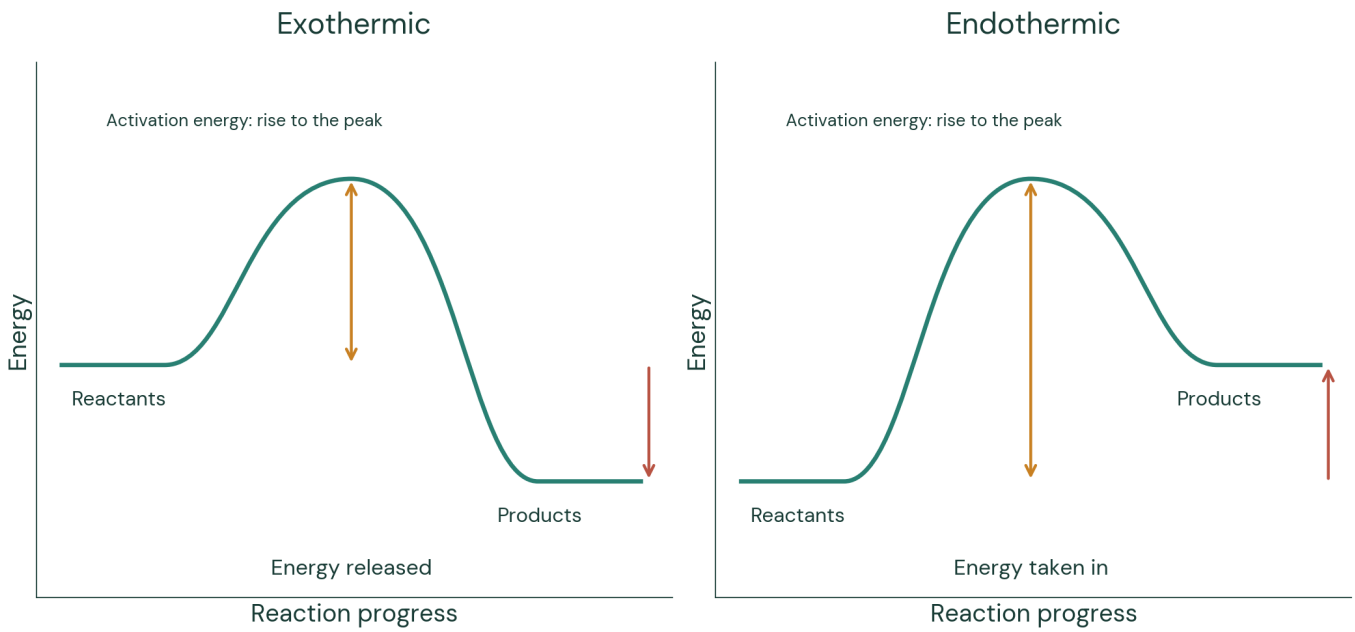
An energy profile is a diagram showing energy before, during and after a reaction. The vertical axis shows energy. The horizontal axis shows the progress of the reaction.

- Reactants are shown at the starting level.
- The peak shows the energy hurdle.
- The rise from the reactant level to the peak is the activation energy.
- Products are shown at the final level.

Comparing the starting and final levels

Compare the reactant and product energy levels to find the overall energy change.

- Exothermic: products are lower; the difference is energy released.
- Endothermic: products are higher; the difference is energy taken in.
- Energy is transferred, not created or destroyed.



Exothermic reactions finish at a lower energy level; endothermic reactions finish higher. Activation energy is the rise from the reactant level to the peak. Reaction progress is not time.

What does a catalyst change?

A catalyst provides a route with lower activation energy.

- The energy-profile peak is lower, so more particles can react successfully.
- The reaction is faster.
- Reactant and product levels stay the same, so the overall energy change stays the same.

Comparing temperature changes

Use a fair test when comparing reactions using temperature changes.

- Keep the amounts of substances and apparatus the same.
- Insulation reduces energy loss to the air.
- A larger temperature rise does not automatically mean a better fuel: fuel mass, water amount and energy losses affect the result.
- Fuel choices also involve cost, availability and pollution.

Worked examples

An example energy profile shows reactants at 80 units, a peak at 120 units and products at 30 units. Find the activation energy and the energy released.

Work through it

1. Activation energy is the rise from reactants to the peak: 120 − 80 = 40 units.
2. Energy released is the drop from reactants to products: 80 − 30 = 50 units.
3. The products are lower than the reactants, so the reaction is exothermic. These are example energy units.

Common mistakes

Common mistake: Exothermic means energy is taken into the reaction.

Remember: Exothermic means energy leaves the reaction and enters the surroundings, which usually warm up.

Common mistake: A catalyst changes the total energy released.

Remember: A catalyst lowers activation energy but leaves the reactant and product energy levels unchanged.

Answering questions

- On an energy profile, measure activation energy from the reactant level to the peak, not from zero.
- Use the reactant and product levels to decide whether the reaction is exothermic or endothermic, then state the direction of energy transfer.

Try an investigation

Read a teacher-supplied energy profile and label the reactants, products and activation energy. In a supervised temperature-change experiment, record the starting and final temperatures and decide whether the surroundings gained or lost energy.

Plan, record and review

- Question and prediction: What are you testing, and what do you think will happen? Give a reason.
- Change, measure, keep the same: What will you deliberately change? What will you measure, and in what units? What stays the same to make it a fair test? For an observation, say what you will record consistently instead.
- Record and look for a pattern: Use a table with headings and units. Look for a pattern or a result that does not fit.
- Conclude from evidence: Answer your question using a result or observation. Say if the evidence is unclear.
- Improve the investigation: What would you repeat or change, and how would that make the evidence better?

Do practical work with your teacher and follow the laboratory safety instructions.