

Energy changes in reactions

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

By the end of this topic

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

Key terms & definitions

Exothermic reaction – A reaction that releases energy to its surroundings.

Endothermic reaction – A reaction that takes in energy from its surroundings.

Activation energy – The minimum energy needed for a successful reaction.

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

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

Fuel – A substance used to release useful energy, usually by burning.

Understand the idea

Reactions transfer energy

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

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

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 is the minimum energy reacting particles need 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

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.

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.

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

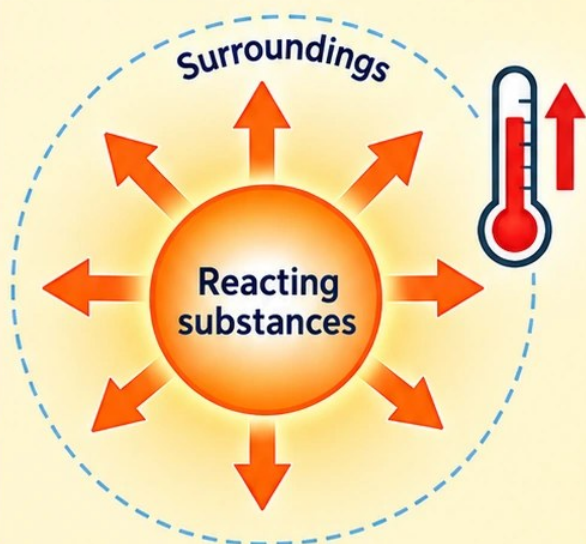
Open this topic online for videos, reference diagrams and practice.

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REACTIONS CAN TRANSFER ENERGY

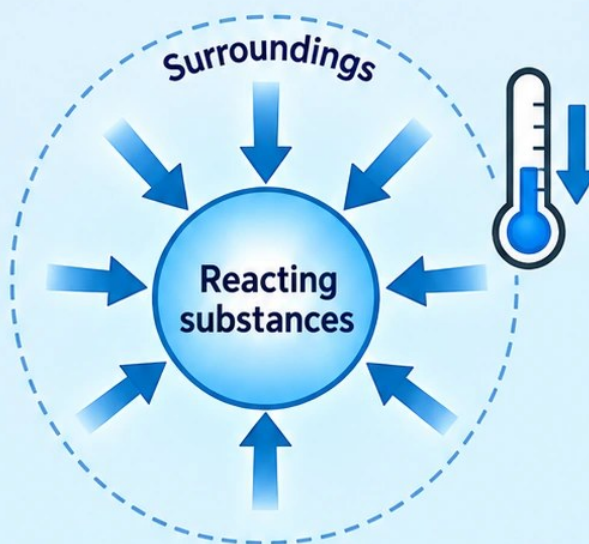
EXOTHERMIC

Energy goes **OUT** to the surroundings.
The surroundings usually warm up.
Example: a fuel burning.



ENDOTHERMIC

Energy goes **IN** from the surroundings.
The surroundings usually cool down.



GETTING STARTED

Activation energy is the minimum energy particles need to react.
A reaction can need energy to start and still release energy overall.

