

Why some changes heat up and others cool

Grade 8 science (Year 9 · Class 8) · Lesson

Quick answer: An exothermic reaction releases energy to its surroundings, so the temperature rises, as in a hand warmer or a burning candle. An endothermic reaction absorbs energy from its surroundings, so the temperature falls, as in an instant cold pack. A thermometer shows which type it is.

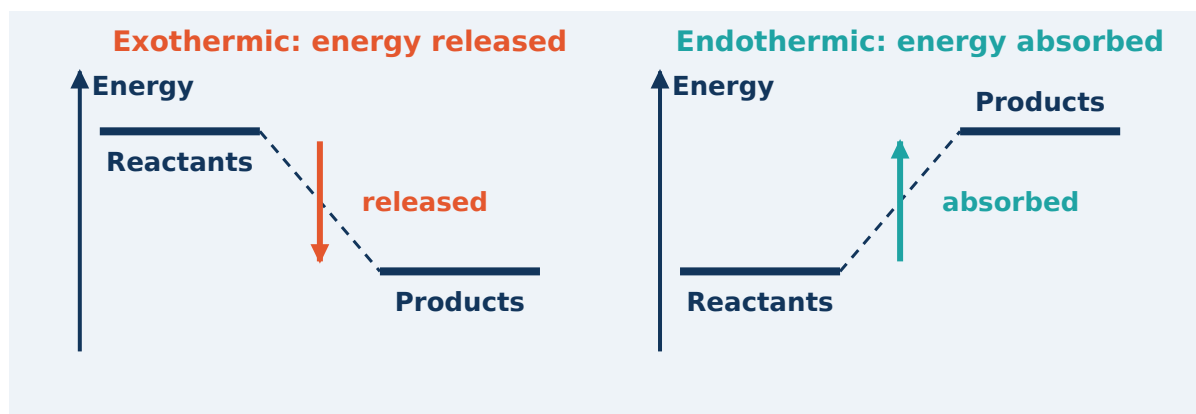
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What are exothermic and endothermic reactions?

Every chemical reaction involves a transfer of energy between the reacting substances and their surroundings. Sometimes you feel it directly: a candle flame warms your hand and an instant cold pack chills your ankle. The energy moves as heat, and a thermometer in the mixture tells you which way it goes.

Definition

An **exothermic** process releases energy to the surroundings, so the temperature of the surroundings rises. An **endothermic** process absorbs energy from the surroundings, so their temperature falls.



Energy diagrams for exothermic and endothermic changes.

In the diagram the vertical axis is the stored energy of the substances. In an exothermic change the products store less energy than the reactants, so the difference leaves as heat. In an endothermic change the products store more energy, and the extra comes from the surroundings. Energy is never created or lost, it only moves.

Key law

Energy is conserved. Energy released by the substances is gained by the surroundings, and energy absorbed by the substances is lost by the surroundings.

How can you tell which type it is?

Measure the temperature before and after, then find the change. Subtract the start value from the end value.

Formula

ΔT = final temperature – start temperature

ΔT in °C. A positive ΔT means exothermic, and a negative ΔT means endothermic.

Worked example

Wanjiru in Nairobi mixes two solutions in a cup. The temperature goes from 22.0 °C to 31.5 °C.

$\Delta T = 31.5 - 22.0 = +9.5$ °C. It is positive, so the reaction is exothermic.

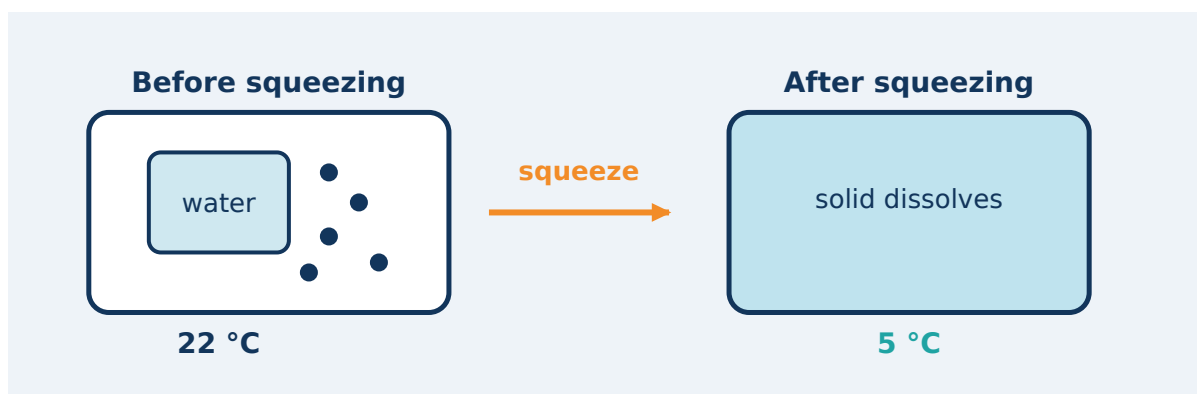
Where do you meet these changes?

Process	Type	What you notice
Burning a candle	Exothermic	Flame gives heat and light
Rusting of iron	Exothermic	Slow, so you rarely feel it
Neutralising an acid	Exothermic	Mixture warms up
Photosynthesis	Endothermic	Plant takes in light energy
Dissolving ammonium nitrate	Endothermic	Water gets colder
Melting ice	Endothermic	Surroundings cool down

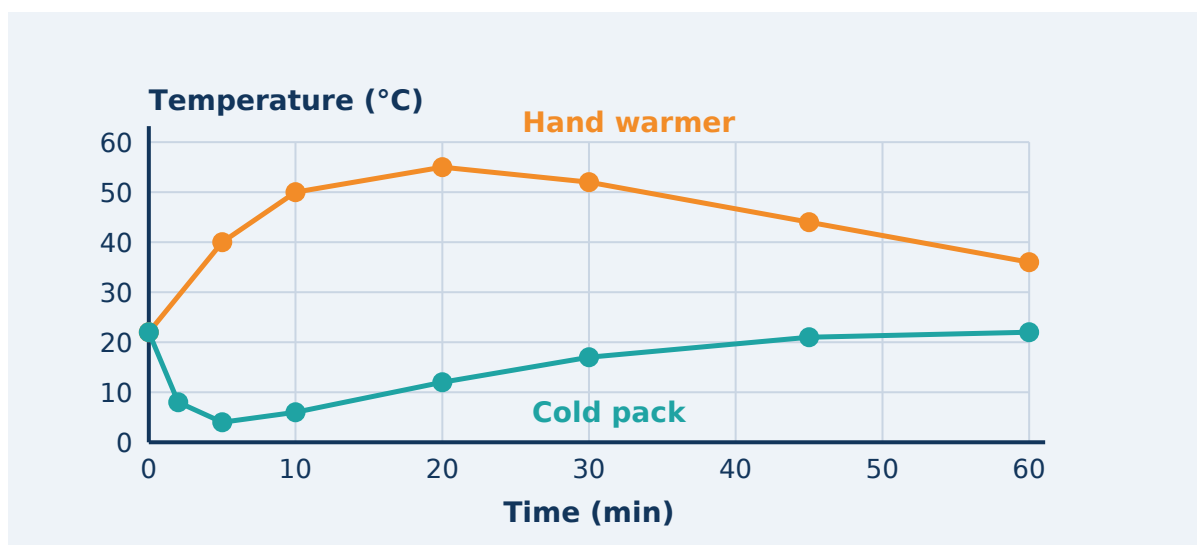
How do hand warmers and cold packs work?

A disposable hand warmer holds iron powder, salt, water and a little carbon. When the sachet is exposed to air, the iron reacts with oxygen in a slow form of rusting. The reaction is exothermic and keeps the pack warm for hours. It stops when the iron is used up.

An instant cold pack has a pouch of water inside a bag of solid such as ammonium nitrate. Squeezing the bag breaks the pouch, and the solid dissolves. Dissolving this solid is endothermic, so it takes energy from the water and from your skin.



An instant cold pack works by dissolving a solid.



Temperature of a hand warmer and a cold pack over one hour.

Common mistake

A cold pack does not pass 'cold' to your body. Energy flows from your warm skin into the colder pack. Likewise, exothermic does not mean the reaction creates energy: it only changes stored energy into heat.

How much energy is transferred?

You can measure the energy gained or lost by water around a reaction.

Formula

$$Q = m \times c \times \Delta T$$

Q is the energy in joules (J), m is the mass of water in grams (g), $c = 4.2 \text{ J/(g } ^\circ\text{C)}$ is the energy needed to warm 1 g of water by 1 °C, and ΔT is the temperature change in °C.

Worked example

Diego in Texas finds that 50 g of water warms by 6.0 °C when a chemical dissolves in it.

$$Q = 50 \times 4.2 \times 6.0 = \mathbf{1260 \text{ J}} \text{ (1.26 kJ) was released into the water.}$$

Lina's tip

Exo means exit and endo means enter. Think of energy as a person: in an exothermic change it exits the substances, and in an endothermic change it enters them.

Key points to remember

- Exothermic: energy is released and the temperature rises (ΔT is positive).
- Endothermic: energy is absorbed and the temperature falls (ΔT is negative).
- ΔT = final temperature – start temperature.
- $Q = m \times c \times \Delta T$, with $c = 4.2 \text{ J/(g } ^\circ\text{C)}$ for water.
- Energy is conserved: it moves between substances and surroundings.

Why some changes heat up and others cool: frequently asked questions

What is the difference between exothermic and endothermic?

An exothermic change releases energy and warms the surroundings. An endothermic change absorbs energy and cools them.

How does a hand warmer produce heat?

Iron powder reacts with oxygen from the air in an exothermic reaction like rusting. Salt and water make the reaction fast enough to feel.

Why does a cold pack feel cold?

The solid dissolves in the water and absorbs energy. That energy comes from the water and from your skin, so heat flows out of your body.

Is melting exothermic or endothermic?

Melting is endothermic, because particles need energy to move apart. Freezing is the opposite and is exothermic.

How do you measure the energy of a reaction?

React the substances in water, measure the temperature change and use $Q = m \times c \times \Delta T$. A lidded polystyrene cup reduces heat loss.