

CHEMISTRY 5 | Energy changes

AQA Combined Science Trilogy • Core knowledge first • Purple panels are Higher Tier

1 Energy in or energy out?

EXOTHERMIC **WARMER**
Reacting chemicals → Energy → Surroundings

ENDOTHERMIC **COOLER**
Reacting chemicals ← Energy ← Surroundings

Exothermic: transfers energy **to** the surroundings. Products have **less** chemical energy than reactants.

Endothermic: takes energy **from** the surroundings. Products have **more** chemical energy than reactants.

Energy is conserved: transferred, not created or destroyed. EXO = exits; ENDO = enters.

2 Examples and temperature change

Exothermic: combustion, many oxidation reactions, neutralisation.

Uses: hand warmers; self-heating cans.

Endothermic: thermal decomposition; citric acid + sodium hydrogencarbonate.

Uses: some instant cooling / injury packs.

20 °C → 31 °C

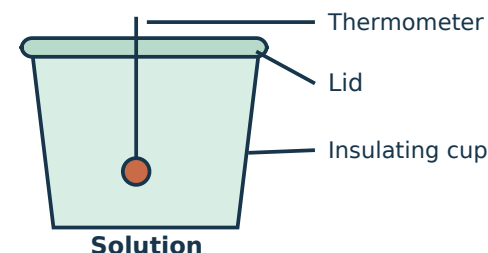
Rise = 31 – 20 = 11 °C

Change = highest or lowest – start.

A rise is evidence for an exothermic reaction; a fall is evidence for an endothermic reaction.

Compare packs using the data: temperature, duration, cost per use and waste. Hottest is not always best.

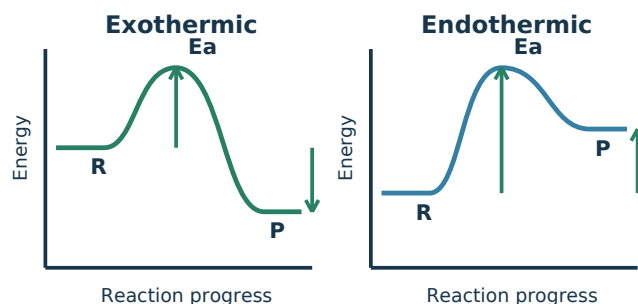
3 Required practical 10



1. Wear eye protection; support cup in beaker.
2. Measure fixed solution volumes. Bring both to the same start temperature; record it.
3. Mix, fit lid, stir; read temperature often.
4. Record the maximum (or minimum); subtract the start temperature.

Change: acid concentration. **Control:** volumes, alkali concentration, start temperature, apparatus. **Repeat:** calculate means.

4 Reaction profiles



R = reactants; P = products.

Exothermic: P lower. Endothermic: P higher.

Activation energy (E_a): minimum energy needed for reacting collisions. Arrow: **reactants up to the peak.**

Overall change: between R and P levels, not from the peak. The x-axis is **not time.**

5 Higher Tier: bonds and energy

BREAK bonds → energy IN

FORM bonds → energy OUT

Overall energy change = breaking – forming.

Negative → **exothermic.**

Positive → **endothermic.** Use **kJ/mol.**

Exothermic: forming releases more than breaking needs. **Endothermic:** breaking needs more than forming releases.

Count all bonds, including coefficients.

$2\text{H}_2\text{O}$ has **4 O-H** bonds.

2O_2 has **2 O=O** double bonds. Use the supplied double-bond energy once for each O=O.

6 Higher Tier: worked calculation



Bond energies supplied in kJ/mol:

H-H = 436; Cl-Cl = 243; H-Cl = 431.



BREAK: 1 H-H and 1 Cl-Cl
 $436 + 243 = 679 \text{ kJ/mol.}$

FORM: 2 H-Cl
 $2 \times 431 = 862 \text{ kJ/mol.}$

Overall: $679 - 862 = -183 \text{ kJ/mol.}$
Negative → **exothermic.**

For 1 mol of reaction as written, making 2 mol HCl.