AQA GCSE Chemistry (Separate Science) Unit 5 Energy Changes Knowledge Organiser

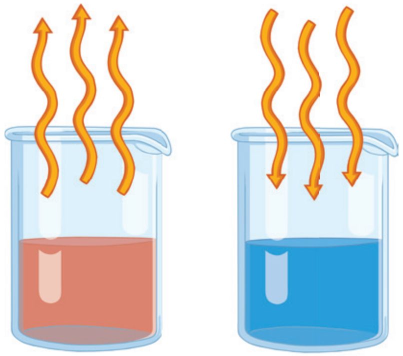
Exothermic and Endothermic Reactions

When a chemical reaction takes place, **energy** is involved. Energy is transferred when chemical **bonds are broken** and when new **bonds are made.**

Exothermic reactions are those which involve the transfer of energy **from the reacting chemicals to** the surroundings. During a practical investigation, an exothermic reaction would show an i**ncrease in temperature** as the reaction takes place.

Examples of exothermic reactions include **combustion, respiration and neutralisation** reactions. Hand-warmers and self-heating cans are examples of everyday exothermic reactions.

Endothermic reactions are those which involve the transfer of energy **from the surroundings to** the reacting chemicals. During a practical investigation, an endothermic reaction would show a **decrease in temperature** as the reaction takes place.



Exothermic Endothermic

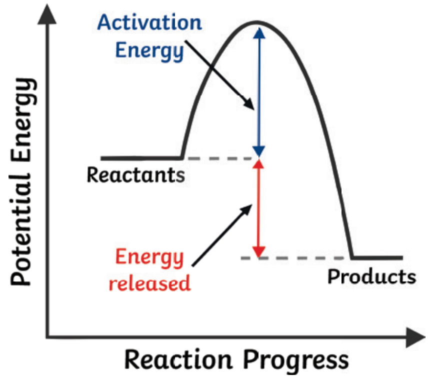
Examples of endothermic reactions include the **thermal decomposition** of calcium carbonate.
Eating **sherbet** is an everyday example of an endothermic reaction. When the sherbet dissolves in the saliva in your mouth, it produces a cooling effect. Another example is **instant ice packs** that are used to treat sporting injuries.

Reaction Profiles – Exothermic

Energy level diagrams show us what is happening in a particular chemical reaction. The diagram shows us the **difference in energy** between the reactants and the products.

In an exothermic reaction, the **reactants** are at a **higher** energy level than the products.

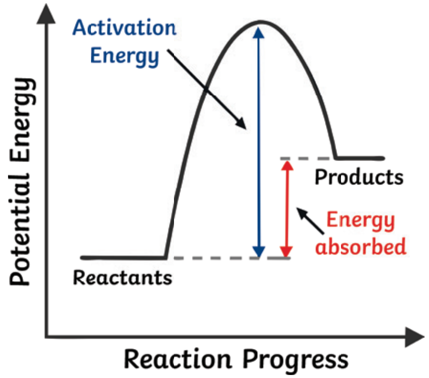
In an **exothermic** reaction, the difference in energy is **released** to the surroundings and so the **temperature** of the surroundings **increases**.



Reaction Profiles – Endothermic

In an **endothermic** reaction, the **reactants** are at a **lower** energy level than the products.

In an **endothermic** reaction, the difference in energy is **absorbed** from the surroundings and so the **temperature** of the surroundings **decreases**.



Activation Energy – the minimum amount of energy required for a chemical reaction to take place.

Catalysts – increase the rate of a reaction. Catalysts provide an alternative pathway for a chemical reaction to take place by **lowering** the activation energy.

Bond Making and Bond Breaking

In an **endothermic** reaction, energy is needed to break chemical bonds. The **energy change (ΔH)** in an endothermic reaction is **positive.**

You may also find, in some textbooks, **ΔH** referred to as the **enthalpy change.**

In an **exothermic** reaction, energy is needed to form chemical bonds. The **energy change (ΔH)** in an exothermic reaction is **negative.**

Bond energies are measured in **kJ/mol.**

Calculations Using Bond Energies (Higher Tier Only)

Bond energies are used to calculate the change in energy of a chemical reaction.

Calculate the change in energy for the reaction: $2H_2O_2 \longrightarrow 2H_2O + O_2$

The first step is to write the symbol equation for the reaction. Once you have done this, work out the bonds that are breaking and the ones that are being made.

2H–O–O–H ⟶ 2H–O–H + O=O

Bond	Bond Energy kJ/mol
H-O	464
O-O	146
O=O	498

On the **left-hand side** of the equation, the **bonds are breaking.**

There are two **O–H** bonds and one **O–O** bond.

So 464 + 146 + 464 = 1074

There are two moles of H_2O_2 therefore the answer needs to be multiplied by two.

So 1074 × 2 = 2148

On the **right-hand** side of the equation, the **bonds are made.**

There are two **H–O** bonds

So 464 + 464 = 928

Two moles of H_2O are made therefore the answer needs to be multiplied by two.

So 928 × 2 = 1856

There is also one **O=O** bond with a bond energy of 498

So 1856 + 498 = 2354

ΔH = sum (bonds broken) – sum (bonds made)

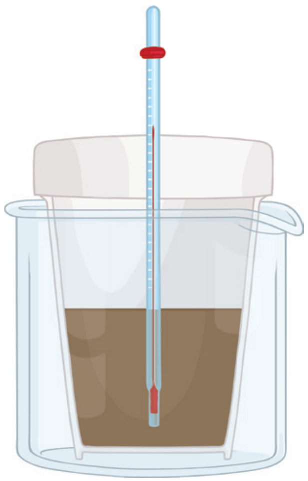
ΔH = 2148 – 2354 = -206 kJ/mol

The reaction is exothermic as ΔH is negative.

Required Practical

Aim

To investigate the variables that affect temperature changes in reacting solutions, e.g. acid plus metals, acid plus carbonates, neutralisations and displacement of metals.



Equipment

- polystyrene cup
- measuring cylinder
- thermometer
- 250cm^3 glass beaker
- measuring cylinder
- top pan balance

Method

Reaction between a metal and an acid.

1. Gather the equipment.
2. Place the polystyrene cup inside the beaker. This will prevent the cup from falling over.
3. Using a measuring cylinder, measure out 30cm^3 of the acid. Different acids such as hydrochloric or sulfuric acid may be used. Pour this into the polystyrene cup.
4. Record the temperature of the acid using a thermometer.
5. Using a top pan balance, measure out an appropriate amount of the solid (for example, 10g) or use one strip of a metal such as magnesium.
6. Add the solid to the acid and record the temperature. You may choose to record the temperature of the acid and metal every minute for 10 minutes.

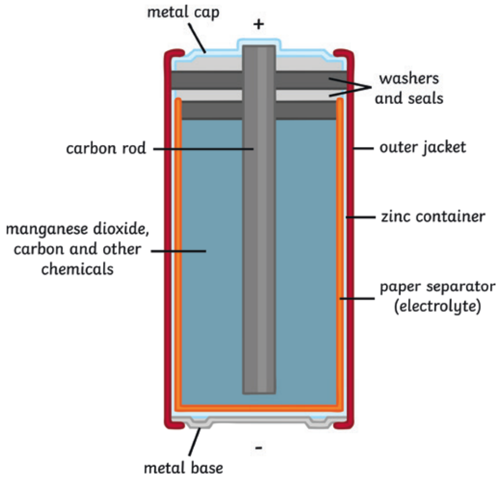
Chemical Cells

A chemical cell converts **chemical energy** into **electrical energy.** More than one cell connected in series is called a battery.

There are two types of chemical cell, **rechargeable** and **non-rechargeable.**

Non-rechargeable cells will produce a **voltage** until the chemicals inside are used up. Once this occurs, the cell is no longer useful and can then be recycled.

Rechargeable cells and batteries can be recharged multiple times. An electrical current is passed backwards through the cell. This works by **reversing** the chemical reactions and the cell or battery can then be used again to produce more electricity. Mobile phones contain rechargeable batteries.

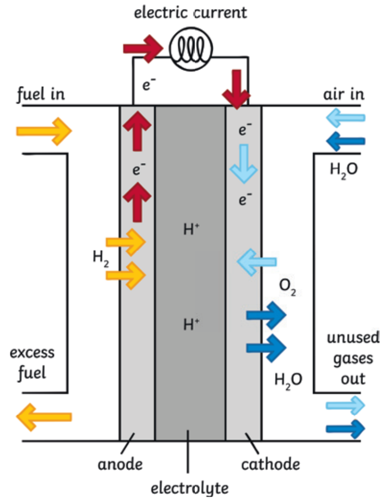


Fuel Cells

Fuels cells work differently to chemical cells in that they need to be supplied with a fuel and oxygen. The constant supply of these two ingredients will allow a fuel cell to produce a voltage continuously.

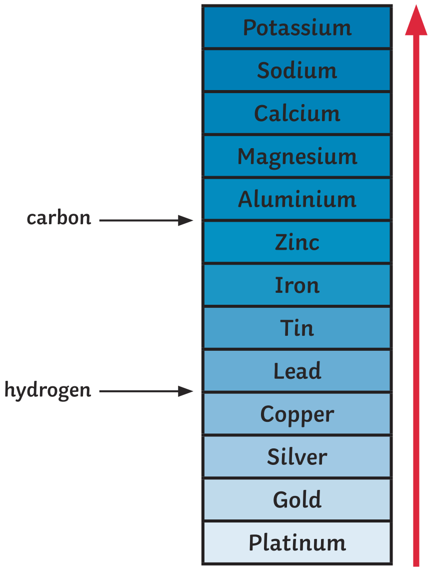
Inside the fuel cell, hydrogen is **oxidised** electrochemically; the fuel is **not combusted.** This allows the reaction to take place at a lower temperature.

Hydrogen-oxygen fuel cells are an alternative to rechargeable batteries and cells as the only product that is produced is water.



Voltage

The voltage of a cell is affected by the combination of metals used inside it. The bigger the difference in the **reactivity** of the two metals, the bigger the **voltage** produced. For example, if the metals used inside the cell are magnesium and zinc, then the voltage produced will be **small** as the two metals are **close together** in the **reactivity series.** By comparison, if magnesium and copper are used, then the voltage produced will be **larger** as the metals are **further apart** in the **reactivity series.**



Ionic Equations

hydrogen + oxygen → water

$2H_2 + O_2 \rightarrow 2H_2O$

At the **cathode:** $2H_2 + 4OH^- \rightarrow 4H_2O + 4e^-$

At the **anode:** $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

In the fuel cell, **oxygen** is being **reduced** (reduction is the gaining of electrons) whilst **hydrogen** is being **oxidised** (oxidation is the loss of electrons). Oxidation and reduction happen simultaneously – this is called a **redox reaction.**