Energy Changes

Keyword	Definition
Reactants	The elements and compounds reacting.
Products	The elements and compounds produced from chemical reactions.
Exothermic	When energy is transferred to the surroundings from a chemical reaction.
Endothermic	When more energy is absorbed from the surroundings than is transferred to it from a chemical reaction.
Thermal decomposition	The breakdown of a compound (decomposition) as a result of heating it.
Conservation of energy	The total energy of a system must remain constant (regardless if it is exothermic or endothermic).
Activation energy	The minimum amount of energy required to cause atoms or molecules to undergo a chemical change.
Reaction profile	A diagram showing the change in chemical potential energy for a single chemical reaction.
Bond energy [HIGHER]	The energy absorbed to break chemical bonds or released from making new bonds.
Electrochemical cell [CHEM ONLY]	Electrical current flow as a result of a chemical change.
Reversible reaction	A chemical reaction where the reactants form products that can return back to reactants again.

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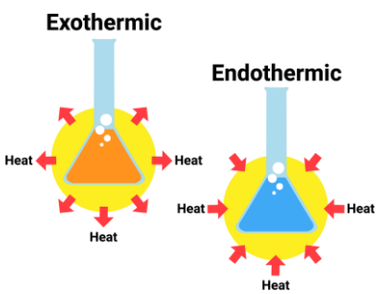
En 01. Exo and endothermic reactions.

- The law of **Conservation of Energy** states that the amount of energy at the end of a chemical reaction is the same as before the reaction takes place.
- If a reaction transfers energy to the surroundings, the product molecules must have less energy than the reactants, by the difference in energy transferred.



- An **Exothermic** reaction is one that transfers energy to the surroundings, so the temperature of the surroundings increases, e.g. **combustion** reactions, many **oxidation** reactions and **neutralisation**.
- An **Edothermic** reaction is one that takes energy from the surroundings, so the temperature of the surroundings decreases, e.g. **thermal decomposition** reactions.

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En 01. Exo and endothermic reactions (examples).

- A **hand warmer** works as result of an exothermic reaction. A supersaturated solution of sodium acetate transfers energy to the surroundings as it crystalises. If the hand warmer is heated in boiling water, the reaction reverses back to produce a supersaturated solution again.

- Sports injury 'cool packs' work when **citric acid** is reacted with **sodium hydrogencarbonate**. The reaction is so endothermic that it becomes cold (like iced water).

Thermal decomposition.

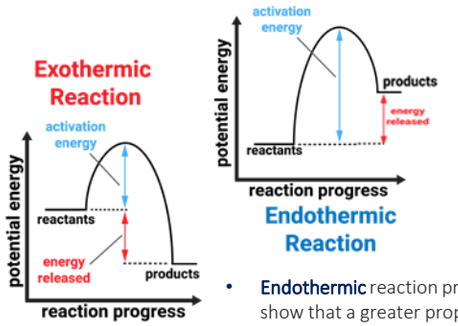
- Thermal decomposition reactions are **endothermic** because they are absorbing more energy than is being released from the formation of new products. For example:

copper carbonate ➔ copper oxide + carbon dioxide

Key Point

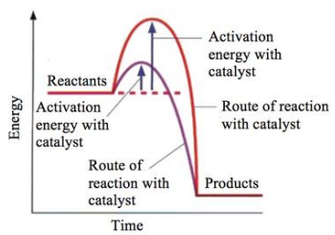
En 03. Reaction profiles.

- Chemical reactions can occur only when reacting particles **collide** with sufficient energy.
- The minimum amount of energy that particles must have to react is called the **activation energy**.
- A **reaction profile is** used to show the relative energies of the reactants and products, the activation energy and the overall energy change of a reaction.



- **Endothermic** reaction profiles show that a greater proportion of energy is absorbed by the reactants.

- **Exothermic** reaction profiles show that a greater proportion of energy is released to the surroundings from the formation of new products .



- If a **catalyst** is used in a reaction the **activation energy** and **pathway** of the reaction is altered. Catalysts can:

1. **Lower** the activation energy of a reaction.
2. Change the pathway of the reaction so that it proceeds at a **faster rate**.

En 04. Bond energies [HIGHER].

- The energy change in a reaction can be calculated using **bond energies**. A bond energy is the amount of **energy** needed to break one **mole** of a particular **covalent bond**.
- Different bonds have different bond energy values. NB. Theses are given to you in the exam when they are needed for a calculation.
- To calculate an energy change of a reaction:

1. add together the bond energies for all of the bonds in the **reactants**;
2. add together the bond energies for all of the bonds in the **products;**
3. **energy change = energy in – energy out**;
4. negative energy changes show that a reaction is **exothermic**.

- Two examples of bond energies are: H-H = 436 kJ/mol^{-1} and Cl-Cl = 243 kJ/mol^{-1}

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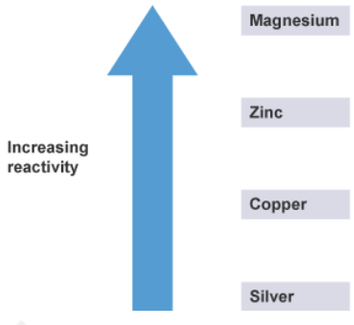
En 05. Chemical cells and batteries [CHEM ONLY].

- A **chemical cell** uses chemical reactions to transfer energy by electricity. The **voltage** of a cell depends upon a number of factors, including what the **electrodes** are made from and the substance used as the **electrolyte**.
- A simple cell can be made by connecting two different metals with **differing reactivity** with an electrolyte.
- In **non-rechargeable** cells, e.g. **alkaline cells**, a voltage is produced until one of the reactants is used up.
- In **rechargeable cells**, like the one used to power a mobile phone, the chemical reaction can be **reversed** by 'charging' the phone with an electric current.

What effects the voltage of a cell?

Here is a simple reactivity series:



- If different combinations of these metals are used to make a cell, we find that the voltage changes. In the ***table below**, the positive electrodes and what they are made from are listed along the top and negative electrodes along the side.
- The biggest voltage occurs when the difference in the **reactivity** of the two metals is greatest.

*	Magnesium	Zinc	Copper
Magnesium	0.00 V	1.61 V	+2.71 V
Zinc	-1.61 V	0.00 V	+1.10 V
Copper	-2.71 V	-1.10 V	0.00 V

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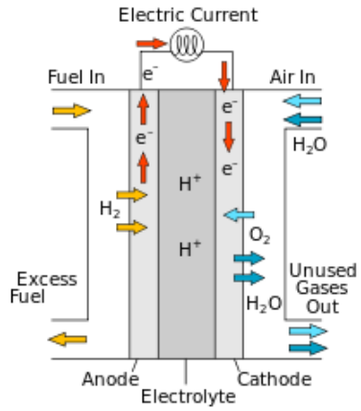
Key Point

En 06. Fuel Cells [CHEM ONLY/HIGHER]

- **Hydrogen-oxygen fuel cells** are an alternative to rechargeable chemical cells and batteries. In a hydrogen-oxygen fuel cell, hydrogen and oxygen are used to produce a voltage. Water is the only product. The overall reaction in a hydrogen-oxygen fuel cell is:

$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$



Electrode half equations – [HIGHER]
At the negative electrode:
$2H_2 + 4OH^- \rightarrow 4H_2O + 4e^-$

Electrode half equations – [HIGHER]
At the positive electrode:
$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

Evaluating fuel cells and chemical cells.

- Fuel cells and chemical cells have different strengths and weaknesses, depending on the intended use.
- Alkaline cells, rechargeable cells and hydrogen cells are the three main types of cell that you will need to evaluate.
- Don't forget to give your overall conclusion as to which is best!

Pros and cons of different types of cells:

- *Cost to manufacture*
- *Energy cost*
- *Safety*
- *Environmental impact*
- *Ease of maintenance*

Required Practical:

En 02. Energy Changes

Mathematical Skills:

- *[HIGHER] bond energy calculations.*
- *Calculating temperature changes.*
- *Plotting data, recognising standard form and converting decimal numbers.*

Relevant Modules:

AQA

- Bonding
- Quantitative Chemistry
- Chem Changes (electrolysis)

Useful YouTube links:

En 01. Exo/Endo | En 04 Bond energy | En 06. Hydrogen cells