Chapter 7: Energy changes

Knowledge organiser

Energy changes

During a chemical reaction, energy transfers occur.

Energy can be transferred:

- to the surroundings – **exothermic**
- from the surroundings – **endothermic**

This energy transfer can cause a temperature change.

Energy is always conserved in chemical reactions.

This means that there is the same amount of energy in the Universe at the start of a chemical reaction as at the end of the chemical reaction.

The surroundings

When chemists say energy is transferred from or to "the *surroundings*" they mean "everything that isn't the reaction".

For example, imagine you have a reaction mixture in a test tube. If you measure the temperature in the test tube using a thermometer, the thermometer is then part of the surroundings.

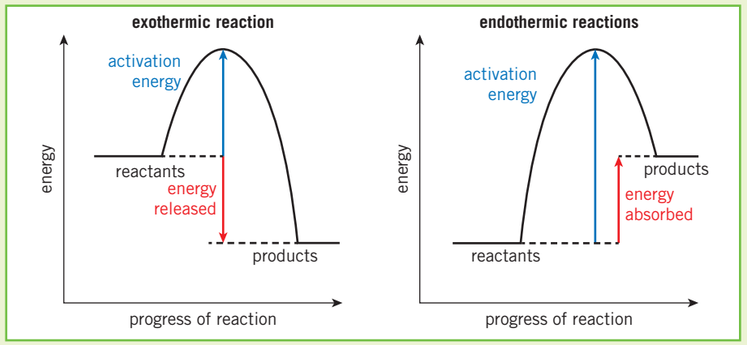
- If the thermometer records an increase in temperature, the reaction in the test tube is exothermic.
- If the thermometer records a decrease in temperature, the reaction in the test tube is endothermic.

Reaction	Energy transfer	Temperature change	Example	Everyday use	Bonds
exothermic	to the surroundings	temperature of the surroundings increases	• **oxidation** • **combustion** • **neutralisation**	• self-heating cans • hand warmers	more energy released when making bonds than required to break bonds
endothermic	from the surroundings	temperature of the surroundings decreases	• **thermal decomposition** • citric acid and sodium hydrogen carbonate	• sports injury packs	less energy released when making bonds than required to break bonds

Reaction profiles

A **reaction profile** shows whether a reaction is exothermic or endothermic.

The **activation energy** is the minimum amount of energy that particles must have to react when they collide.



Bonds (HT only)

Atoms are held together by strong chemical bonds. In a reaction, those bonds are broken and new ones are made between different atoms.

- Breaking a bond requires energy so is endothermic.
- Making a bond releases energy so is exothermic.

Breaking bonds

If a lot of energy is released when making the bonds and only a little energy is required to break them, then overall energy is released and the reaction as a whole is exothermic.

Making bonds

If a little energy is released when making the bonds and a lot is required to break them, then overall energy is taken in and the reaction as a whole is endothermic.

Bond calculations

Different bonds require different amounts of energy to be broken (their **bond energies**). To work out the overall energy change of a reaction, you need to:

1. work out how much energy is required to break all the bonds in the reactants
2. work out how much energy is released when making all the bonds in the products.

overall energy transferred = energy required to break bonds – energy required to make bonds

- A positive number means an endothermic reaction.
- A negative number means an exothermic number.

Chemical cells

In a metal displacement reaction, one metal is oxidised – it loses electrons. These electrons are transferred to another metal, which gains the electrons and so is reduced.

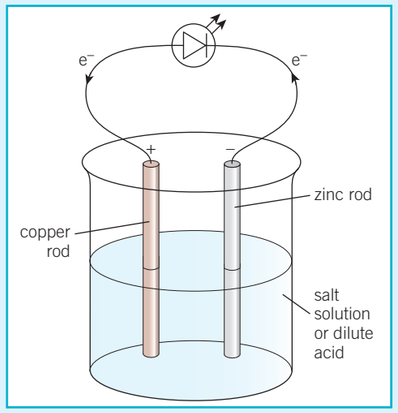
By using a **chemical cell** to conduct this reaction, the electron's movement generates a current.

In the cell shown, the zinc atoms from the electrode lose electrons, turn into ions, and move into the solution.

The electrons travel through the circuit to the copper electrode, causing the LED to light up.

Once at the copper electrode, a metal ion *from the solution* will pick the electrons up and become a metal atom.

The greater the difference in reactivity between the two metals in the cell, the greater the potential difference produced.



Batteries

A **battery** is formed of two or more cells connected in series.

- Some batteries are **rechargeable**. An external electric current is applied, which reverses the reaction.
- Some batteries, like alkaline batteries, are not rechargeable because the reaction is not reversible. Once the reactants are used up, the chemical reaction stops and no more potential differences are released.

Hydrogen fuel cells

Fuel cells use a fuel and oxygen from the air to generate a potential difference.

Hydrogen fuel cells generate electricity from hydrogen and oxygen. The overall reaction is:

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$$

The hydrogen is oxidised to produce water.

There are different types of hydrogen fuel cell. In alkaline fuel cells, the half equations are below:

- $2H_2(g) + 4OH^-(aq) \rightarrow 4H_2O(l) + 4e^-$
- $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$

Advantages

- the only waste is water
- do not need to be electrically recharged

Disadvantages

- hydrogen is highly flammable and difficult to store
- hydrogen is often produced from non-renewable resources

Key terms

Make sure you can write a definition for these key terms.

activation energy, battery, bond energy, chemical cell, combustion, endothermic, exothermic, fuel cell, neutralisation, oxidation, reaction profile, rechargeable, thermal decomposition

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Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	C7 questions	Answers
1	What is an exothermic energy transfer?	transfer to the surroundings
2	What is an endothermic energy transfer?	transfer from the surroundings
3	What is a reaction profile?	diagram showing how the energy changes in a reaction
4	What is the activation energy?	minimum amount of energy required before a collision will result in a reaction
5	What is bond energy?	the energy required to break a bond or the energy released when a bond is formed
6	In terms of bond breaking and making, what is an exothermic reaction?	less energy is required to break the bonds than is released when making the bonds
7	In terms of bond breaking and making, what is an endothermic reaction?	more energy is required to break the bonds than is released when making the bonds
8	How are chemical cells made?	connect two different metals (electrodes) in a solution (electrolyte)
9	What is a battery?	two or more chemical cells connected in series
10	How does the potential difference of a cell depend on the metals that the electrodes are made of?	the bigger the difference in reactivity, the greater the potential difference
11	How can some cells be recharged?	by applying an external current
12	Why can some cells not be recharged?	the reaction cannot be reversed
13	What is a fuel cell?	cell that uses a fuel and oxygen to generate electricity
14	In the hydrogen fuel cell, what is the overall reaction?	$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$
15	In the alkaline hydrogen fuel cells, what are the half equations?	$2H_2(g) + 4OH^-(aq) \rightarrow 4H_2O(l) + 4e^-$ $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$
16	Give an advantage of the hydrogen fuel cell.	only product is water, do not need to be electrically recharged
17	Give a disadvantage of the hydrogen fuel cell.	hydrogen is flammable, difficult to store and is often produced from non-renewable sources

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