

# Fuel Cells

You must be able to:

- HT Recall energy is released when new bonds are made
- HT Calculate the energy transferred in reactions and use it to deduce whether a reaction is exothermic or endothermic
- Understand how simple cells can be made
- Explain how hydrogen fuel cells work and why they are so useful
- HT Write half equations for the electrode reactions in the hydrogen fuel cell.

## HT Energy Change of Reactions

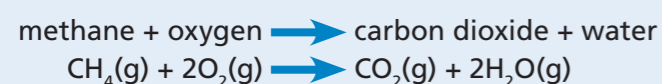
- In a chemical reaction, new substances are produced:
  - The bonds in the reactants are broken.
  - New bonds are made to form the products.
- Breaking a chemical bond requires energy – it is an **endothermic** process.
- When a new chemical bond is formed, energy is given out – it is an **exothermic** process.
- If more energy is required to break bonds than is released when bonds are formed, the reaction must be endothermic.
- If more energy is released when bonds are formed than is needed to break bonds, the reaction must be exothermic.

## Measuring Energy Changes

- The amount of energy produced in a chemical reaction in solution can be measured by mixing the reactants in an insulated container.
- This enables the temperature change to be measured before heat is lost to the surroundings.
- This method would be suitable for neutralisation reactions and reactions involving solids, e.g. zinc and acid reactions.

## Energy Calculations

Calculate the energy transferred in the following reaction:



The bond energies needed for this are:

C–H is 412kJ/mol, O = O is 496kJ/mol

C=O is 805kJ/mol, H–O is 463kJ/mol

Energy used to break bonds is:      Energy given out by making bonds:

4 C–H = 4 × 412 = 1648kJ

2 C=O = 2 × 805 = 1610kJ

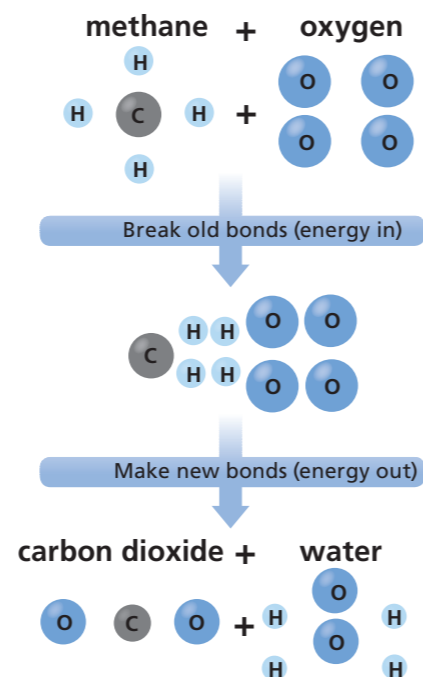
2 O=O = 2 × 496 = 992kJ

4 H–O = 4 × 463 = 1852kJ

Total = 1648kJ + 992kJ = 2640kJ      Total = 1610kJ + 1852kJ = 3462kJ

energy change = energy used to break bonds – energy given out by making bonds

$$= 2640\text{kJ} - 3462\text{kJ} = -822\text{kJ}$$



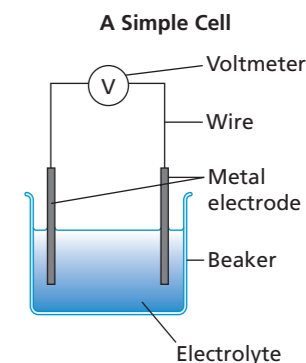
### Key Point

**Endothermic:**  
energy required to break old bonds > energy released when new bonds are formed

**Exothermic:**  
energy required to break old bonds < energy released when new bonds are formed

## Cells and Batteries

- The chemicals in **cells** react together to release electricity.
- A simple cell can be made by placing two different metals into a beaker containing an electrolyte.
- Batteries are made when two or more cells are connected together.
- Cells can be joined in series to produce a higher voltage, e.g. if two 3.0V cells are joined in series, the total voltage produced by the battery is 6.0V.



## Fuel Cells

- **Fuel cells** are a very efficient way of producing electrical energy.
- Most fuel cells use hydrogen, but other fuels can be used.
- In a hydrogen fuel cell:
  - Hydrogen and oxygen are supplied to the fuel cell.
  - The fuel is oxidised to produce a potential difference (voltage).
  - Overall, the hydrogen is oxidised to form water.

HT Hydrogen is added at the anode.

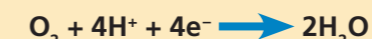
HT The hydrogen molecules lose electrons to form hydrogen ions.



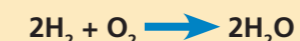
HT Oxygen is added at the cathode.

HT The hydrogen ions formed at the anode travel through the electrolyte to the cathode.

HT At the cathode, the hydrogen ions react with oxygen molecules to form water.



HT The overall equation for the reaction in the hydrogen fuel cell is found by adding the two half equations together:



- Traditional methods of producing electricity involve many stages and are less efficient and more polluting than fuel cells.
- Fuel cells have lots of advantages:
  - Hydrogen fuel cells produce water, which is non-polluting.
  - They are lightweight and small.
  - They have no moving parts so are very unlikely to breakdown.

### Quick Test

1. HT A chemical reaction gives out more energy when bonds are made than it takes in to break bonds. What sort of reaction is it?
2. List **four** advantages of hydrogen fuel cells over traditional ways of producing electricity.
3. HT Give the equation for the chemical reaction which takes place at:
  - a) the anode of a hydrogen fuel cell
  - b) the cathode of a hydrogen fuel cell.

## Revise

### Key Point

Fuel cells are a very efficient way of producing electrical energy.

The fuel is oxidised electrochemically to produce a potential difference or voltage.

### Key Words

HT **endothermic**  
HT **exothermic**  
**cell**  
**fuel cells**