

## 4.5 Revision Checklist : Energy

### Conservation of Energy

Energy is conserved in chemical reactions. The amount of energy in the universe 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 amount transferred.

An **exothermic reaction** is one that transfers energy to the surroundings so the **temperature** of the surroundings **increases**.

Exothermic reactions include combustion, many oxidation reactions and neutralisation.

Everyday uses of exothermic reactions include self-heating cans and hand warmers.

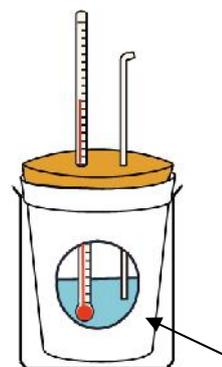
An **endothermic reaction** is one that takes in energy from the surroundings so the **temperature** of the surroundings **decreases**.

Endothermic reactions include thermal decompositions and the reaction of citric acid and sodium hydrogencarbonate.

Some sports injury packs are based on endothermic reactions

### Required practical: measuring energy change: General method

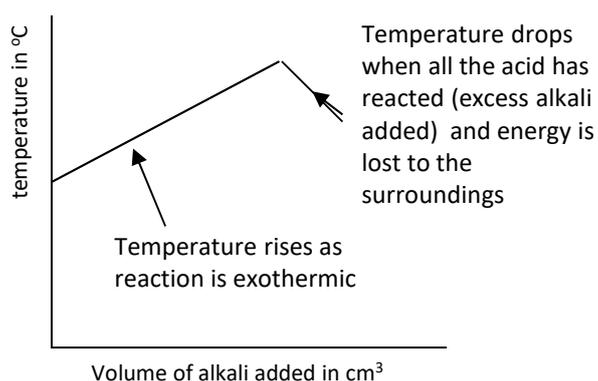
- put polystyrene cup in a beaker for insulation and support
- measure required volumes of solution with measuring cylinder/pipette
- clamp thermometer into place making sure the thermometer bulb is immersed in liquid
- measure the initial temperatures of the solution or both solutions if 2 are used
- transfers reagents to cup. If a solid reagent is used then add the solution to the cup first and then add the solid weighed out on a balance.
- stirs mixture
- measures final temperature



polystyrene cup in a beaker

### Required practical: measuring energy change: neutralisation

1. put polystyrene cup in a beaker for insulation and support
2. measure required volume of hydrochloric acid with measuring cylinder/pipette
3. clamp thermometer into place making sure the thermometer bulb is immersed in liquid
4. measure the initial temperature of the acid
5. add 5cm<sup>3</sup> of sodium hydroxide.
6. stirs mixture and measure temperature
7. repeat steps 5 and 6 until 40cm<sup>3</sup> of NaOH added



### Activation Energy

Chemical reactions can occur only when reacting particles collide with each other and with sufficient energy. The **minimum amount of energy** that particles must have to **react** is called the activation energy.

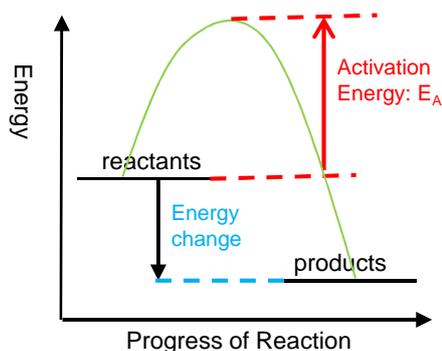
## Reaction profiles

Reaction profiles can be used to show the relative energies of reactants and products, the activation energy and the overall energy change of a reaction.

A reaction profile for an exothermic reaction can be drawn in the following form on the right:

### Exothermic

The energy level diagram shows that in an exothermic reaction the **products are lower in energy** than the reactants

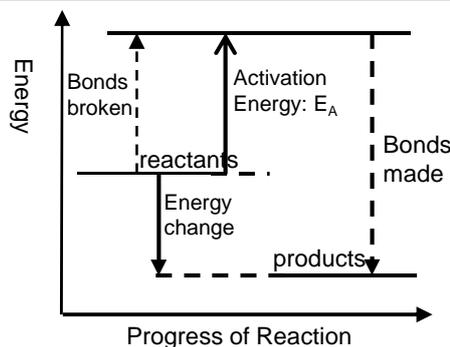


During a chemical reaction:

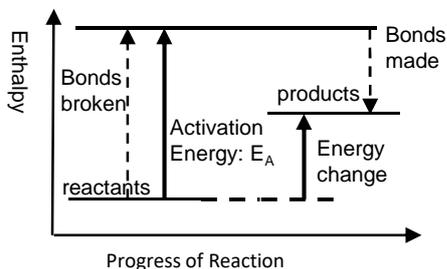
- energy must be supplied to break bonds in the reactants
- energy is released when bonds in the products are formed.

### Exothermic reaction

In an **exothermic reaction**, the **energy** released from **forming** new bonds is **greater** than the energy needed **to break** existing bonds.

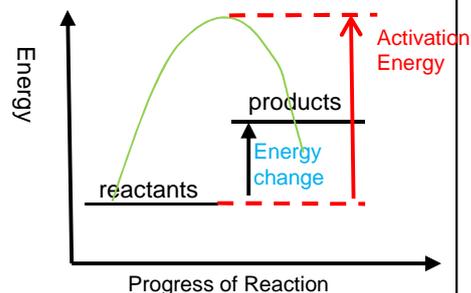


### Endothermic reaction



The energy level diagram shows that the **products are higher in energy** than the reactants

In an **endothermic reaction**, the **energy** needed to **break** existing bonds is **greater** than the energy **released from forming** new bonds.



## Bond energies

The energy needed to break bonds and the energy released when bonds are formed can be calculated from bond energies.

The difference between the sum of the energy needed to break bonds in the reactants and the sum of the energy released when bonds in the products are formed is the overall energy change of the reaction.

$$\text{Energy change of reaction} = \text{sum of bonds energies broken} - \text{sum of bonds energies made}$$

Example . Using the following mean bond energy data to calculate the energy change for this reaction



$$\begin{aligned} \text{Energy change} &= \text{Sum of bond energies broken} - \text{Sum of bond energies made} \\ &= (2 \times \text{H-H} + 1 \times \text{O=O}) - (4 \times \text{O-H}) \\ &= (2 \times 436 + 498) - (4 \times 464) \\ &= -486 \text{ kJ/mol} \end{aligned}$$

| Bond | Bond energy (kJ/mol) |
|------|----------------------|
| H-H  | 436                  |
| O-H  | 464                  |
| O=O  | 498                  |

## Cells and Batteries

Chemistry only

Cells contain chemicals which react to produce electricity. The voltage produced by a cell is dependent upon a number of factors including the **type of electrode** and **electrolyte**.

**Batteries** consist of two or more cells connected together in series to provide a greater voltage

A simple cell can be made by **connecting two different metals** in contact with an electrolyte.

*The bigger the difference in reactivity between the two metals the larger the voltage*

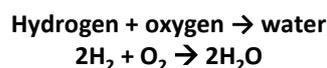
In **non-rechargeable** cells and batteries the chemical reactions stop when one of the **reactants has been used up**. Alkaline batteries are non-rechargeable.

**Rechargeable** cells and batteries can be recharged because the **chemical reactions are reversed** when an **external electrical current** is supplied.

### Fuel Cells

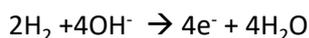
Fuel cells are supplied by an external source of fuel (eg hydrogen) and oxygen or air. The fuel is oxidised electrochemically within the fuel cell to produce a potential difference.

The overall reaction in a hydrogen fuel cell involves the oxidation of hydrogen to produce water.

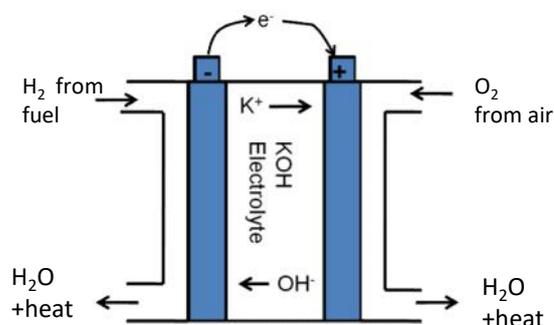
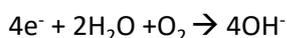


### Half equations for the electrode reactions in the hydrogen fuel cell.

At the negative electrode the hydrogen gas reacts with hydroxide ions to produce water. This produces electrons.



At the positive electrode oxygen gas reacts with water to produce hydroxide ions. This uses up electrons.



Hydrogen fuel cells offer a potential alternative to rechargeable cells and batteries.

#### Advantages of Hydrogen fuel Cells

- No pollutants produced -only water
- Do not need recharging- quicker to refuel than to recharge a rechargeable cell
- Can travel further before refuelling in comparison to rechargeable cells
- No toxic chemicals to dispose of at end of the cell's life
- Hydrogen can be renewable if made by electrolysis using renewable energy

#### Disadvantages of Hydrogen fuel Cells

- Hydrogen is highly flammable/explosive
- Hydrogen is difficult to store/takes up a lot of space
- Hydrogen not renewable if produced using fossil fuels
- Not many hydrogen filling stations