2.4 Chemical Reactions and Energy

Introduction:

- Almost every chemical reaction is accompanied by an **energy change**.
- When a chemical reaction happens, energy is transferred to or from the surroundings.
- Energy changes can be explained by examining the **changes in chemical bonding** during a reaction.
- Energy changes are used to classify reactions as **exothermic** or **endothermic**.

Exothermic Reactions:

- An exothermic reaction happens when energy is **transferred to** the surroundings.
- During an exothermic reaction, the **temperature of the surroundings increases**.
- Combustion, neutralisation and oxidation reactions are all exothermic.
- Exothermic reactions are used in self-heating food cans and outdoor hand warmers.

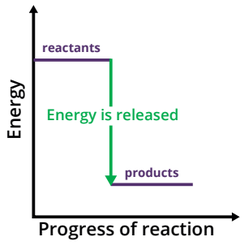
Endothermic Reactions:

- An endothermic reaction happens when energy is **taken in** from the surroundings.
- During an endothermic reaction, the **temperature of the surroundings decreases**.
- Thermal decomposition and electrolysis reactions are all endothermic.
- Endothermic reactions are used in instant ice packs used to treat injuries.

Energy Profiles:

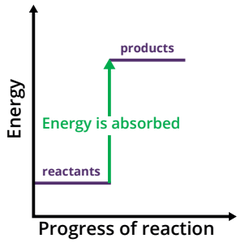
- An energy level diagram shows whether a reaction is exothermic or endothermic.
- The diagram shows the energy in the reactants and products, and the difference in energy between them.

Exothermic reactions:



- » The **products are at a lower energy level than the reactants**.
- » Energy is **given out** to the surroundings.
- » The **downwards arrow** shows that energy is given out.

Endothermic reactions:



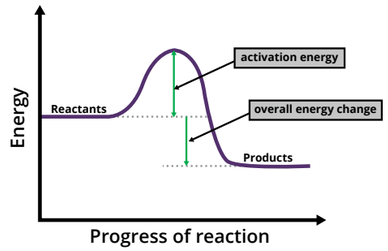
- » The **products are at a higher energy level than the reactants**.
- » Energy is **taken in** from the surroundings.
- » The **upwards arrow** shows that energy is taken in.

Reaction Profiles:

- A **reaction profile** shows how the **energy of the chemicals changes** during a reaction.
- A reaction profile also includes the **activation energy** - the minimum energy needed to start a reaction.
- The activation energy is shown as a 'hump' in the line.

The activation energy:

- » starts at the energy of the reactants
- » is equal to the difference in energy between the top of the 'hump' and the reactant.



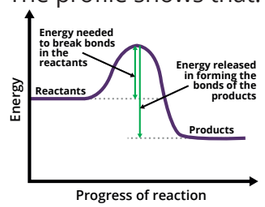
- The overall **change in energy** in a reaction is still the **difference between** the energy of the reactants and the energy of the products.

Breaking and Making Bonds:

- During a chemical reaction:
  - » **energy is needed** to **break the bonds** in the **reactants**
  - » **energy is released** when the **bonds in the products** are **formed**
  - » the difference between the energy needed to break bonds and the energy released when forming bonds determines the type of reaction.

Exothermic reactions:

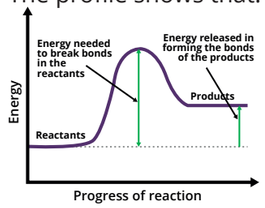
The profile shows that:



- » **more energy is released** when new bonds are made than is needed to break existing bonds
- » the overall energy change is **negative** – meaning that **energy is given out** to the surroundings.

Endothermic reactions:

The profile shows that:



- » **more energy is taken in** when the existing bonds are broken than is released in making new bonds
- » the overall energy change is **positive** – meaning that **energy is taken in** from the surroundings.

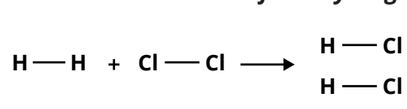
Calculating bond energies:

- 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 covalent bonds of a given type.

> ***To calculate the energy change for a reaction:***
> 1. Add together the bond energies for **all the bonds in the reactants** - this is the **'energy in'**.
> 2. Add together the bond energies for **all the bonds in the products** - this is the **'energy out'**.
> 3. Overall energy change = energy in – energy out.

Example

Hydrogen and chlorine react to form hydrogen chloride.



Bond	Bond energy (kJ/mol)
H — H	436
Cl — Cl	243
H — Cl	432

Energy in = 436 + 243 = **679 kJ/mol**
Energy out = (2 × 432) = **864 kJ/mol**
Energy change = in – out = 679 – 864 = **–185 kJ/mol**

The energy change is **negative**. More energy is given out than is taken in and the reaction is **exothermic**.

Note - positive energy change = endothermic reaction!