

Bond Energies

- **Energy is essential for reactions.** In order for a chemical reaction to occur, energy is needed. The minimum amount of energy, the **activation energy**, is supplied to break the **reactant bonds**.

Bonds in Endothermic reaction :

- **Bonds are broken in reactants.** In order for particles to react, existing bonds must be **broken** to release the atoms, so they are free to make new bonds.
- **Bond breaking is endothermic.** When bonds are broken, this process is **endothermic**. Energy is taken in from the surroundings in order to break old bonds.

Bonds in Exothermic Reactions:

- **Bonds are formed in products.** When a reaction has taken place, bonds are **formed** between atoms to create products. Energy is released when new bonds are made.
- **Bond formation is exothermic.** When new bonds are formed, this process is **exothermic**. Energy is released to the surroundings through the formation of new bonds.

Reaction profile diagrams

- There are two simple ways of showing the energy changes that take place in a chemical reaction:
 - an energy level diagram
 - a reaction profile

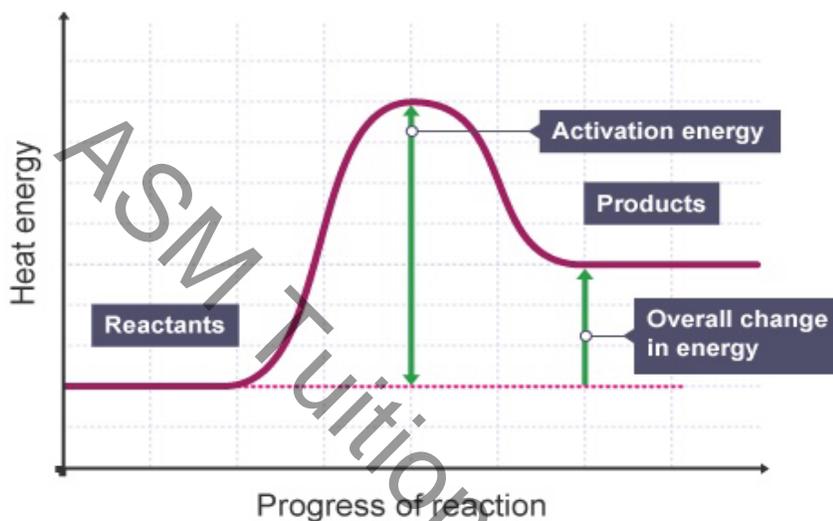
Reaction profiles

- A reaction profile shows how the energy of the reactants and products changes during a reaction. It includes the **activation energy - the minimum energy needed for a reaction to start**. The activation energy is shown as a 'hump' in the line which:
 - starts at the energy of the reactants
 - is equal to the difference in energy between the top of the **'hump'** and the reactants

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

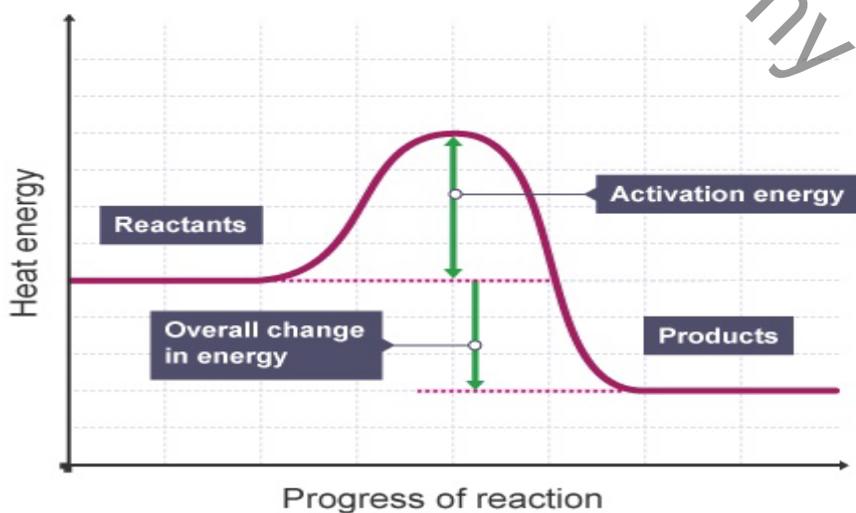
Endothermic reaction profile:

- ▶ In an endothermic reaction, the energy change is **positive**. This is because the products have more energy than the reactants and the arrow showing the overall change in energy points upwards.



Endothermic Reaction Profile:

- ▶ In an exothermic reaction, the energy change is **negative**. This is because the products have less energy than the reactants and the arrow showing the overall change in energy points downwards.



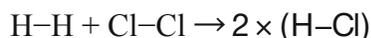
Energy change calculations

- ▶ 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 energies. These are given when they are needed for calculations.
- ▶ To calculate an energy change for a reaction:
 - add together the bond energies for all the bonds broken in the reactants - this is the **'energy in'**
 - add together the bond energies for all the bonds formed in the products - this is the **'energy out'**
- ▶ The **'energy in' is an endothermic change**, as the energy is being used to break bonds.
- ▶ The **'energy out' is an exothermic change**, as the energy is released as new bonds are formed. Therefore the energy change is:

$$\text{energy change} = \text{energy in} - \text{energy out}$$

Example 1:

Hydrogen and chlorine react to form hydrogen chloride gas:



Use the bond energies in the table to calculate the energy change for this reaction.

Bond	Energy
H-H	436 kJ mol ⁻¹
Cl-Cl	242 kJ mol ⁻¹
H-Cl	431 kJ mol ⁻¹

$$\text{Energy in} = 436 + 242 = 678 \text{ kJ mol}^{-1}$$

$$\text{Energy out} = (2 \times 431) = 862 \text{ kJ mol}^{-1}$$

$$\text{Energy change} = \text{in} - \text{out}$$

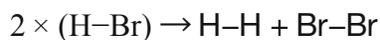
$$= 678 - 862$$

$$= -184 \text{ kJ mol}^{-1}$$

The energy change is **negative**. This shows that the reaction is **exothermic**, as the 'energy out' is larger than the 'energy in'.

Example 2:

1. Hydrogen bromide decomposes to form hydrogen and bromine:



2. Use the bond energies in the table to calculate the energy change for this reaction.

Bond	Energy
H-Br	366 kJ mol ⁻¹
H-H	436 kJ mol ⁻¹
Br-Br	193 kJ mol ⁻¹

$$\text{Energy in} = 2 \times 366 = 732 \text{ kJ mol}^{-1}$$

$$\text{Energy out} = 436 + 193 = 629 \text{ kJ mol}^{-1}$$

$$\text{Energy change} = \text{in} - \text{out}$$

$$= 732 - 629$$

$$= +103 \text{ kJ mol}^{-1}$$

3. The energy change is **positive**. This shows that the reaction is **endothermic, as the 'energy out' is smaller than the 'energy in'**.