Chemistry Knowledge Organiser
C7 - Energy changes

Energy in Reactions

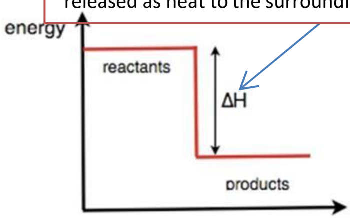
Energy is conserved in chemical reactions. The amount of energy in the **universe at the end** of a chemical reaction **is the same as before the reaction** takes place. In a chemical reaction, bond breaking and bond making occur. To break a chemical bond you need to overcome the force of attraction in the bond, this process requires energy therefore it is **endothermic.** The process of bond formation is **exothermic,** energy is released when bonds form. In a chemical reaction the difference between the energy required to break the bonds and the energy gained from making the bonds will decide whether a reaction is exothermic or endothermic.
Chemical reactions can therefore be divided into exothermic and endothermic chemical reactions.

	What happens?	Why?	Example
Exothermic	Heat energy is transferred to the surroundings.	The energy required to break chemical bonds is less than the energy gained from making chemical bonds. Therefore the excess is given off as heat to the surroundings.	Combustion reaction, reactions used in hand warmers
Endothermic	Heat energy is taken in from the surroundings	The energy required to break chemical bonds is more than the energy gained from making chemical bonds. Therefore heat is taken in from the surroundings.	The reaction of citric acid and sodium hydrogencarbonate, the reactions used in ice packs

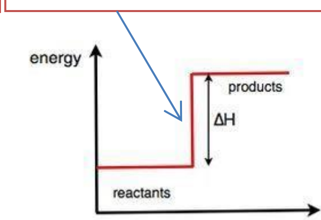
Reaction Profiles

Reminder from topic 15: 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** can be used to show the relative energies of reactants and products, the activation energy and the overall energy change of a reaction.

This is the reaction profile of an **exothermic reaction,** the energy of the products is lower than that of the reactants. The difference in energy is released as heat to the surroundings.



This is the reaction profile of an **endothermic reaction,** the energy of the products is higher than that of the reactants. The difference in energy is taken in from the surroundings.

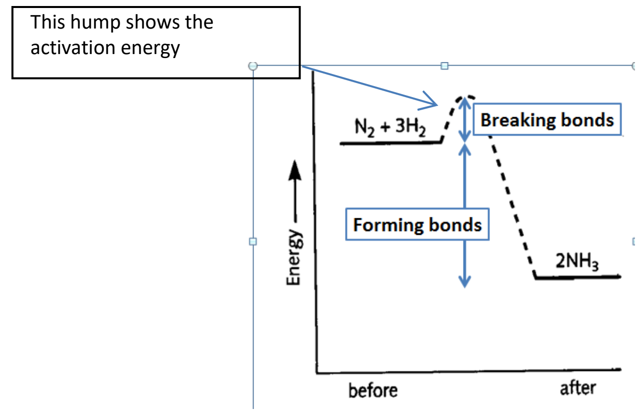


Key Terms	Definitions
Reaction Profile	A graph which shows the energies of the products and reactants in a chemical reaction
Exothermic	A reaction that gives out heat to the surroundings
Endothermic	A reaction that takes heat in from the surroundings

Reaction Profiles- In more detail

The profile below shows the reaction which makes ammonia from nitrogen and hydrogen. The equation is given below:

$$N_2 + 3H_2 \rightarrow 2\ NH_3$$



There are some key features to highlight on this graph ,firstly the curved section represents the **activation energy** for this reaction, this hump shows how much energy is required to break the bonds in the reactants. To overcome the activation energy we often need to heat our reactants. The products are lower in energy than the reactants, this means it is an **exothermic reaction.** As the excess energy is given out to the surroundings. as heat **energy.**

Calculating bond energies -higher tier.

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.
For example consider the reaction:

$$N_2 + 3H_2 \rightarrow 2\ NH_3$$

To work out the overall energy change you will need to subtract, the energy gained from forming the bonds in ammonia, from the energy required to break the nitrogen and hydrogen bonds. This will give you the overall energy change, if the value is negative then the reaction is exothermic, if the value is positive the reaction is endothermic

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Bond Energies continued- Higher Tier

You can calculate the energy change in a reaction from bond energies given to you in a question. For example consider the reaction below:

$$2\,H-O-O-H \rightarrow 2\,H-O-H + O=O$$

This shows that hydrogen peroxide breaks down to make water and oxygen. We can use bond energies to work out the energy change in the reaction.

Bond	Bond energy in kJ per mole
H – O	464
O – O	146
O = O	498

The energy required to break the reactant bonds is:

2 H – O – O – H

2 x464 (for the O-H bonds) = 928 + 146 (for the O-O bond)=1074 however as there is a 2 in the equation this number needs to be doubled.

2 x 1074 = 2148 klj/mol

The energy gained from making the product bonds is:

2 H – O – H   O = O

2x464= 928 but there is a 2 in the equation so this doubled to 1856 and we also need to add the 498 for the double bond in O_2

1856+498=2354 kj/mol

Therefore we do energy required to break reactant bonds- energy gained from making product bonds:

2184-2354=-170kj/mole

If the value is negative then the reaction is **exothermic**
If the value is positive the reaction is **endothermic.**

Key Terms	Definitions
Equilibrium	A reaction that is reversible
Le Chatelier's principle	A principle which states, "If a system is at equilibrium and a change is made to any of the conditions, then the system responds to **counteract the change"**
Dynamic Equilibrium	An equilibrium where the forward and backward reactions are happening at the same rate

Equilibrium

Some chemical reactions are reversible, this means they can happen in both the **forward and reverse directions.** The symbol we use to represent an equilibrium reaction is shown in the equation below:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

In a dynamic equilibrium reaction, the forward and reverse reactions are happening at the **same rate.**

A dynamic equilibrium has to occur in a **closed system**, where no reactants and products are allowed to escape.

If the equilibrium lies to the left, it means that there is a **greater concentration of reactants than products**
If the equilibrium lies to the right it means there is a **greater concentration of products than reactants.**

Most equilibrium reactions are endothermic in one direction and exothermic in another direction. A good example is the hydration and dehydration of copper sulphate. It is exothermic when water is added to the copper sulphate, it is endothermic when water is removed.