Energy Flow

Energy and chemical compounds

Compounds have **internal energy**. It is the sum of the potential energy and kinetic energy of particles that make up the compound. In biological compounds these particles are usually molecules. The potential energy results from interactions between atoms in the molecule (electrostatic interactions between electrons and protons). Kinetic energy results from bonds in molecules vibrating and rotating. If the compound is a liquid or a gas, the molecules also have kinetic energy as a result of their movement in space (translational kinetic energy).

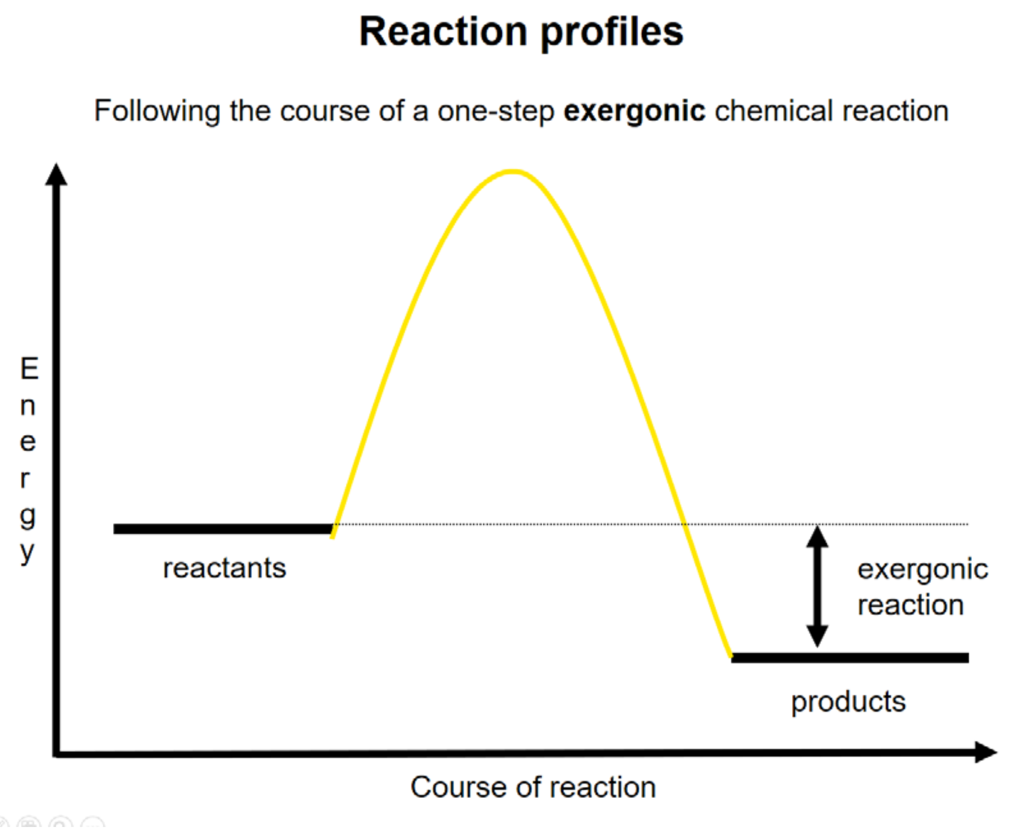
Atoms are held together in molecules by covalent bonds. Energy is needed to break bonds. Energy is released when bonds form.

When a reaction takes place we can consider that the bonds in the reactant are broken. Energy must be added to do this. This can be shown on as plot of energy versus course of reaction (a reaction profile). When the product is formed energy is released. There are two possible situations:

1. **The internal energy of the products is less than the internal energy of the reactants**

   The height of the peak from the reactants side is a measure of the strength of the bonds in the reactants and the height of the peak from the products is a measure of the strength of the bonds in the product. Thus we can consider the bonds in the product to be stronger than the bonds in the reactants.

   Energy is released to the surroundings in the reaction - it is an exergonic reaction.



2. **The internal energy of the products is more than the internal energy of the reactants.**

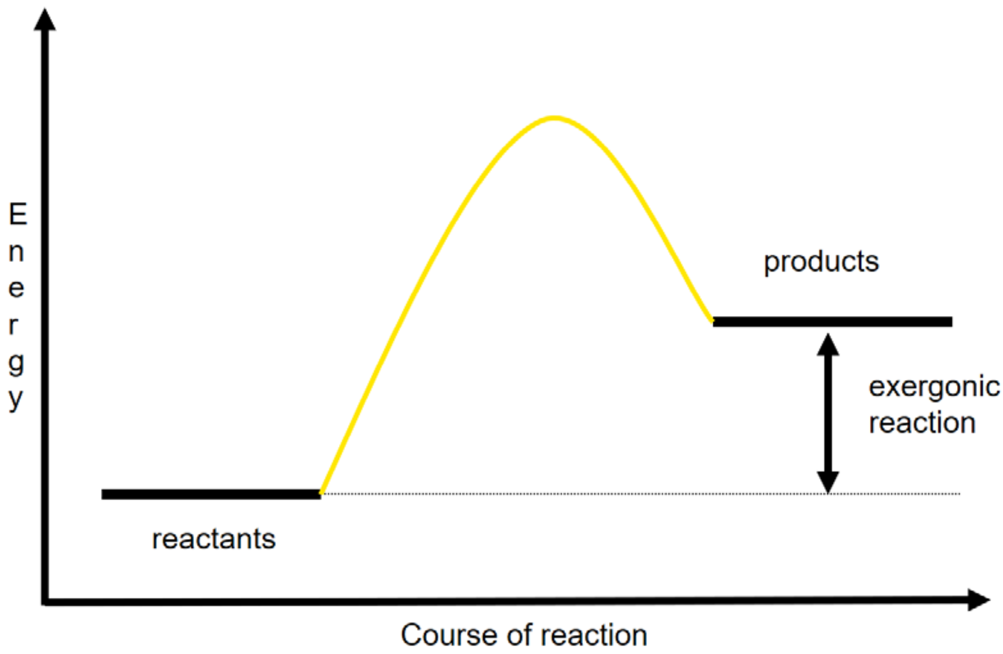
   In this case we can consider the bonds in the product to be weaker than the bonds in the reactants.

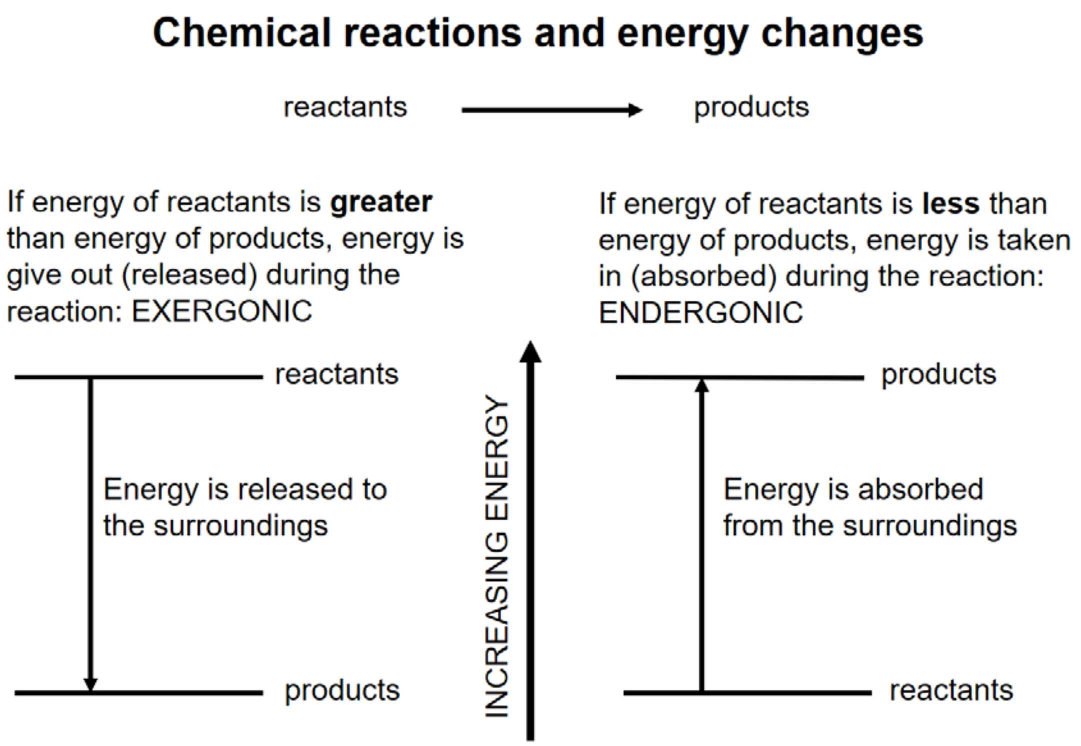
   Energy is taken in from the surroundings in the reaction - it is an endergonic reaction.

(You may wonder why such endergonic reactions occur at all. The answer lies in the fact that other factors are involved - such as temperature and change in disorder, or entropy. The controlling factor is the change in another energy function - the Gibbs Free Energy - which combines these).

Reaction profiles

Following the course of a one-step **endergonic** chemical reaction





Energy is often released or absorbed in the form of heat, leading to a temperature change. In such cases the terms used are **exothermic** and **endothermic**.

Photosynthesis

Green plants contain chlorophyll. They use energy from sunlight to synthesise glucose from carbon dioxide and water. Oxygen is also formed. This is called **photosynthesis** and may be summarised by the word equation:

$$\text{carbon dioxide + water} \xrightarrow[\text{chlorophyll}]{\text{sunlight}} \text{glucose + oxygen}$$

> See the topic about Photosynthesis

Chlorophyll plays a vital role by absorbing sunlight of a range of wavelengths, primarily blue and red. It is a **catalyst** for photosynthesis - increasing the speed of the reaction by taking part in it but remaining unchanged at the end.

Glucose is a source of energy for the body. It is also the building block for polysaccharides (giant carbohydrates), though this takes up usually less than 4% of the glucose produced by photosynthesis. Polysaccharides such as starch and cellulose make up the **biomass**. Starch is used by plants to 'store' energy, while animals use glycogen (also a polymer of glucose) to 'store' energy.

Productivity is the rate at which a system absorbs light energy. The units are kilojoules per square metre per year (kJ m^{-2} yr^{-1}). **Gross primary production** is the rate at which light energy is converted into biomass. Subtracting the energy needed for respiration gives the **net primary production**, and this is the rate at which energy is made available for consumers.

Find out more by looking at:

> Enzymes
> Photosynthesis
> Carbohydrates

Cycles

Energy cycles

Energy stored in plant carbohydrates is transferred through ecosystems in cycles that regenerate the reactants in photosynthesis (carbon dioxide and water). It is sometimes said that the energy flows through the system.

The carbon cycle

The balance between photosynthesis, respiration and combustion maintains a relatively constant concentration of carbon dioxide in the atmosphere.

The water cycle

The balance between photosynthesis and respiration, in a cycle where energy is used to convert water from the liquid to the gas phase, maintains the concentration of water in the atmosphere. This concentration varies widely with location.

The nitrogen cycle

This is a more complicated cycle. It involves nitrogen fixation, nitrification and decomposition and ammonification. A balance between atmospheric nitrogen and nitrates available for plant growth is maintained. It is largely driven by energy stored from photosynthesis.

Information on all the cycles at www.biozone.co.uk/biolinks/ECOLOGY.html

Test your knowledge

Take quiz on *Energy flow*