Energy changes in reactions

Energy changes in reactions

During a chemical reaction, there is always an energy change.

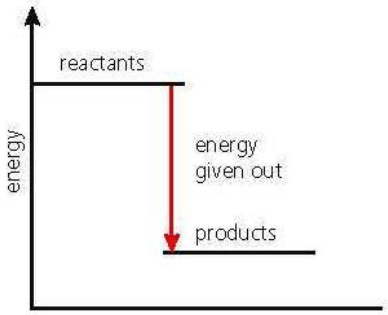
Exothermic reactions

Exothermic reactions give out energy.

These reactions can be described as:

reactants + products = energy

The total energy is the same on each side of the arrow, in a reaction. So in exothermic reactions, the products have lower energy than the reactants. This is shown on the **energy level diagram** on the right.



▲ An energy level diagram for an exothermic reaction. The products have lower energy than the reactants.

Other examples of exothermic reactions

All these are exothermic:

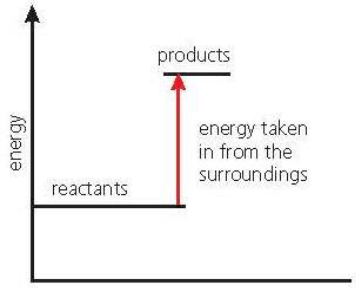
- the neutralisation of acids by alkalis.
- the combustion of fuels.

Endothermic reactions

Endothermic reactions take in energy from their surroundings.

Other examples of endothermic reactions

- reactions that take place in cooking.
- photosynthesis.



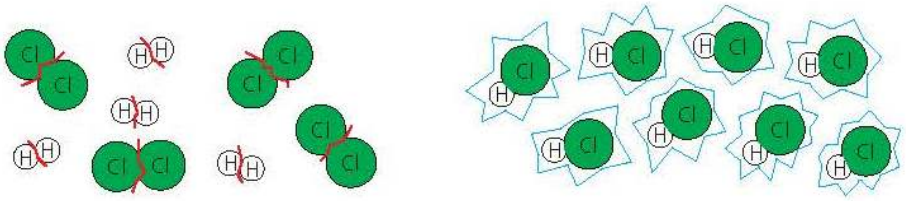
▲ An energy level diagram for an endothermic reaction. The products have higher energy than the reactants.

1 Is it exothermic or endothermic?
   a the burning of a candle
   b the reaction between sodium and water
   c the change from raw egg to fried egg
2 Which unit is used to measure energy changes?
3 $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$
   The energy change for this reaction is − 822.4 kJ.
   What can you conclude about the reaction?
4 Draw an energy level diagram for:
   a an endothermic reaction b an exothermic reaction

Explaining energy changes

Making and breaking bonds

In a chemical reaction, bonds must first be broken. Then new bonds form. *Breaking bonds takes in energy. Making bonds releases energy.*



If the energy taken in to break bonds is *less than* the energy released in making bonds, the reaction is exothermic.

If the energy taken in to break bonds is *greater than* the Energy released in making bonds, the reaction is endothermic.

Bond energy (kJ / mole)	
H–H	436
Cl–Cl	242
H–Cl	431
C–C	346
C=C	612
C–O	358
C–H	413
O=O	498
O–H	464
N≡N	946
N–H	391

Calculating the energy changes in reactions

So let's calculate the energy change for those reactions on page 116.

Calculating energy changes
The calculation is always:
energy in – energy out

1 The exothermic reaction between hydrogen and chlorine

$H—H + Cl—Cl \longrightarrow 2\,H—Cl$

Energy in to break each mole of bonds:

1 × H—H	436 kJ
1 × Cl—Cl	242 kJ
Total energy in	678 kJ

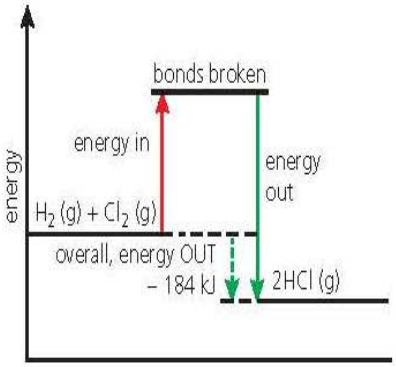
Energy out from the two moles of bonds forming:

2 × H—Cl 2 × 431 = 862 kJ

Energy in − energy out = 678 kJ − 862 kJ = −184 kJ

So the reaction gives out **184 kJ** of energy, overall.

Its energy level diagram is shown on the right.



▲ For the hydrogen/chlorine reaction.

2 The endothermic decomposition of ammonia

Combustion of Methane

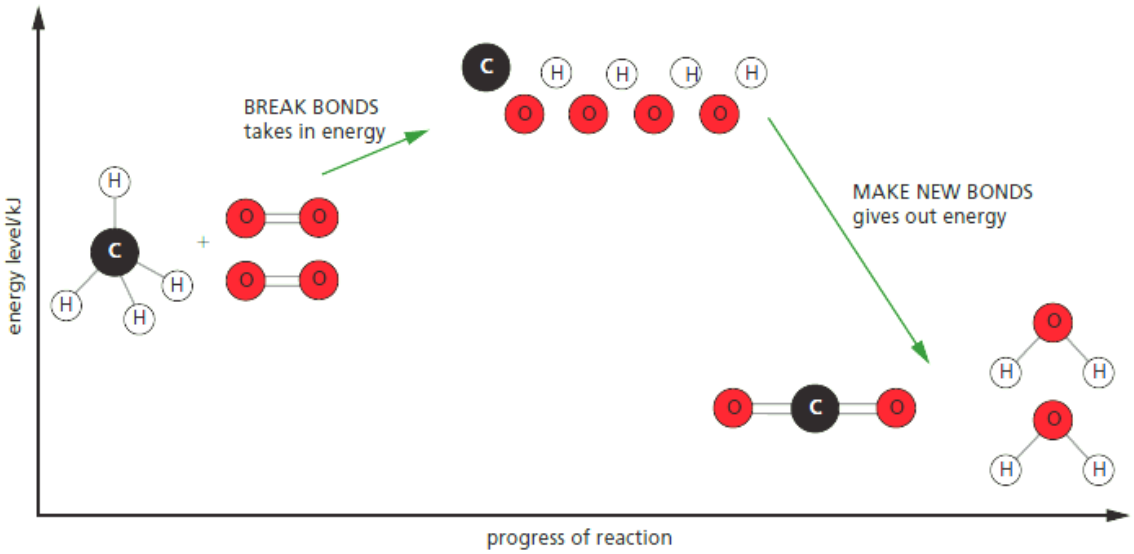


Figure 6.19 Breaking and forming bonds during the combustion of methane.

- Calculate the energy change for the combustion of Methane. Use the table from the previous page and (C=O):803 KJ/mol

- Calculate the Heat change for the formation of (i) Water (ii) Ammonia

Activation Energy

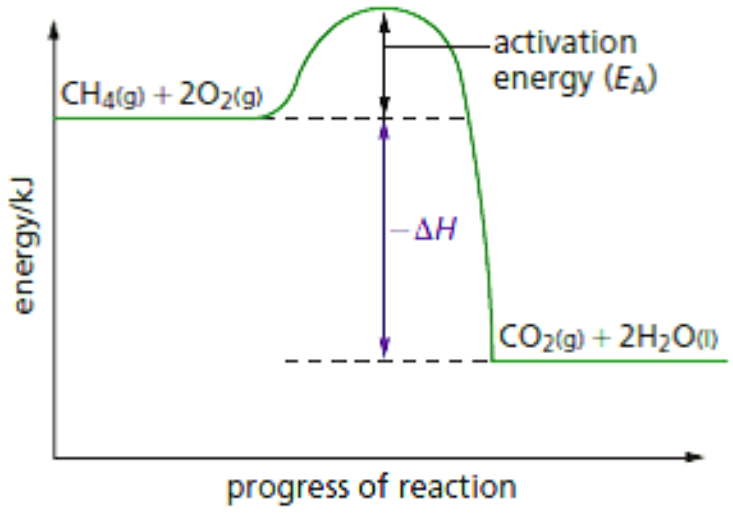


Figure 6.20 Energy level diagram for methane/oxygen.

The minimum energy needed for a reaction to take place is called the *Activation Energy.*

Energy from fuels

A fuel is any substance we use to provide energy.

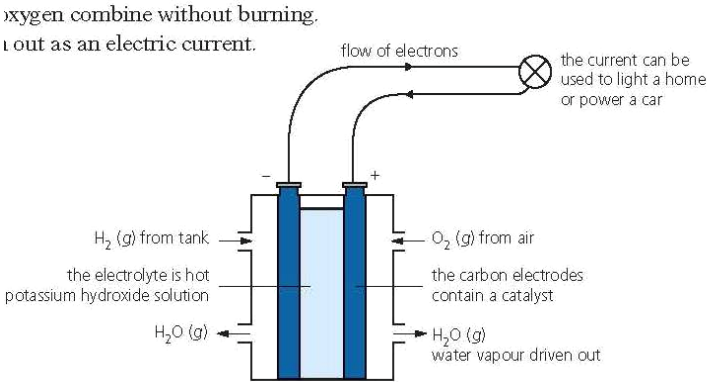
The fossil fuels

The fossil fuels - coal, petroleum (oil), and natural gas (methane) - are the main fuels used around the world. We burn them to release heat.

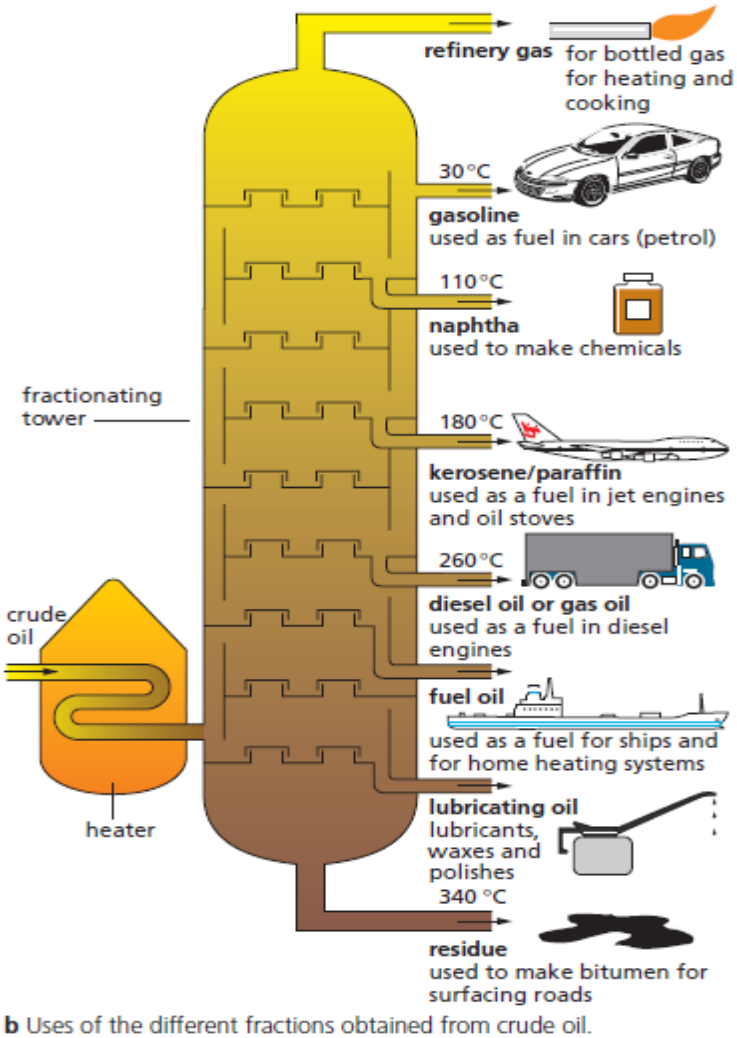
The hydrogen fuel cell

In the hydrogen fuel cell, hydrogen and oxygen combine without burning.

It is a redox reaction. The energy is given out as an electric current.



Fractions from the fractional distillation of Crude oil



b Uses of the different fractions obtained from crude oil.

Photosynthesis

- **Photosynthesis** is the reaction between carbon dioxide and water, in the presence of chlorophyll and sunlight, to produce glucose:

$$6CO_2(g) + 6H_2O(l) \xrightarrow{\text{light, chlorophyll}} C_6H_{12}O_6(aq) + 6O_2(g)$$

carbon dioxide + water → glucose + oxygen