The content on this sheet is assessed on paper 2 only.

Topic 7b—Heat energy changes in chemical reactions

* Indicates that these are some examples only: you could be asked about any substance / reaction.

7.9—Heat energy changes in reactions

a—salts dissolving in water

When salts dissolve in water, the ionic lattice breaks down to form free moving ions. Sometimes, salts dissolving result in the temperature increase, and sometimes the temperature goes down: it depends on the salt that is dissolving.

b—neutralisation reactions

In a neutralisation reaction, an acid reacts with a base to produce a salt and water. These reactions always lead to a temperature increase, and so are exothermic.

c—displacement reactions

In a displacement reaction, a more reactive element (a metal or halogen, for example) replaces a less reactive element in a solution of its salt. These reactions tend to release energy, and so are exothermic.

d—precipitation reactions

In a precipitation reaction, an insoluble solid is formed in the reaction between two solutions. Some precipitation reactions lead to a temperature increase and so are exothermic. However, some cause the temperature to decrease, and energy is taken in overall. These changes are described as being endothermic.

All of the reactions above can make use of measuring the temperature change to calculate the energy change in the reaction, using the equation energy change (J) = mass of substance heated (kg) x specific heat capacity (J kg^{-1} $°C^{-1}$) x temperature change (°C).

7.10—Exothermic reactions

Exothermic reactions are reactions in which heat is given out to the surroundings. This leads to an increase in temperature, and so exothermic reactions feel warm/hot.

7.11—Endothermic reactions

Endothermic reactions are reactions in which heat is taken in from the surroundings. This leads to a decrease in ________________, and so endothermic reactions feel cool/cold.

7.12—Bond breaking and making

In every chemical reaction, the bonds in the reactant(s) first need to be broken, before new bonds are made.

Breaking bonds is an endothermic process: that is, energy must be taken in from the surroundings.

Conversely, bond making is an exothermic process, and energy is given out to the surroundings.

7.13—Overall heat energy changes

a—Exothermic reactions

A reaction will be exothermic overall when more energy is given out during bond making, than is taken in during bond breaking.

b—Endothermic reactions

A reaction will be endothermic when more energy is taken in during bond making than is given out during bond breaking.

7.14—Calculating bond energy changes (HT only)*

We can calculate the overall energy change in a reaction by calculating the changes in bond energy. The equation required is:

Energy change = Σ energy of bonds broken - Σ energy of bonds made.

A shorthand way to remember this is "BREAK TAKE MAKE".

You will be provided the bond energies that are relevant to the equation you are considering.

Step 1: calculate the total sum of **all** of the bond energies in **all** of the reactants (energy of bonds broken). *It may be worthwhile drawing out the bonds in the molecule(s)*.

NB. You can 'cancel out' any identical bonds at this step: for example, if there are 3 C-H bonds on both sides, you don't need to include these in your calculation.

Step 2: calculate the total sum of **all** of the bond energies in **all** of the products (energy of bonds made). *It may be worthwhile drawing out the bonds in the molecule(s)*.

Step 3: Energy change = Σ energy of bonds broken - Σ energy of bonds made.

Example: calculate the total energy change for the following reaction:

$$H_2 + Cl_2 \longrightarrow 2\,HCl$$

Bond energies (kJ mol^{-1}): H-H = 436, Cl-Cl = 242, H-Cl = 431.

H-H + Cl-Cl → 2 H-Cl

Step 1:

H-H + Cl-Cl = 436 + 242 = 678 (kJ mol^{-1})

Step 2:

2 x H-Cl = 2 x 431 = 862 (kJ mol^{-1})

Step 3:

678—862 = -184 kJ mol^{-1}

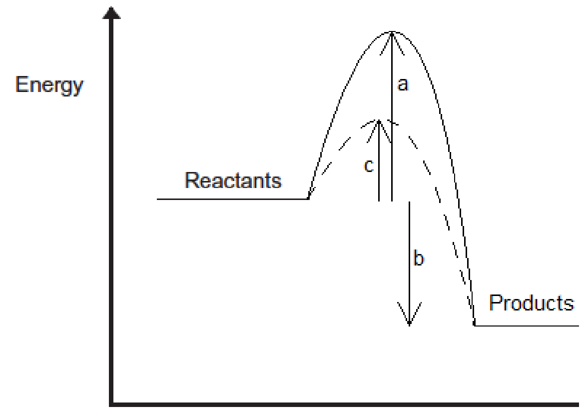
NB. A negative energy change value indicates an exothermic reaction

7.15—Activation energy

The activation energy is the minimum amount of energy that particles must have in order that they can react when they collide with one another. It is the amount of energy needed to break bonds.

7.16—Reaction profile diagrams

Exothermic reaction

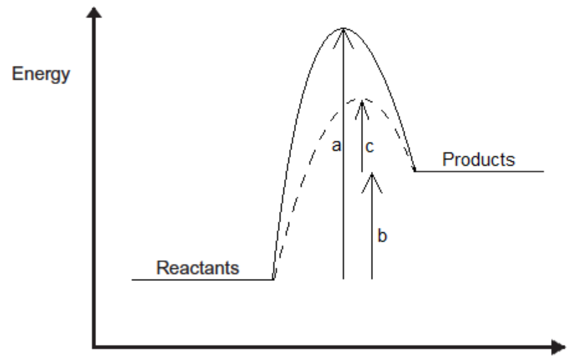


a) this arrow represents the activation energy of the reaction (energy has to be taken in for this step, as it involves bond breaking).

b) this arrow represents the overall energy change for the reaction (energy has been given out overall, so it is exothermic.

c) this arrow represents the catalysed reaction (the activation energy is smaller than the 'uncatalysed' reaction.

Endothermic reaction



a) this arrow represents...the activation energy of the reaction (energy has to be taken in for this step, as it involves bond breaking).

b) this arrow represents...the overall energy change for the reaction (energy has been taken in overall, so it is endothermic.

c) this arrow represents...the catalysed reaction (the activation energy is smaller than the 'uncatalysed' reaction.