Chemical Energy

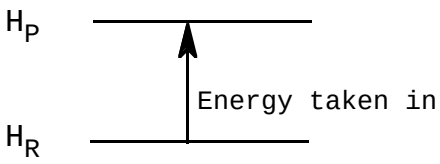
One mole of every substance has a characteristic quantity of chemical potential energy called its **Enthalpy, H**.

The change in energy during a chemical reaction is known as the **Enthalpy change**, **ΔH**.

ΔH = Enthalpy of products (H_P) - Enthalpy of reactants (H_R)

Endothermic Reactions

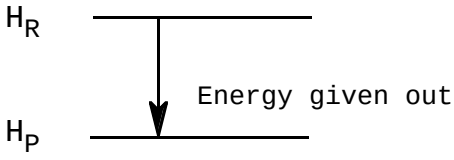
When $H_P > H_R$ then **energy is taken in** during the reaction and **ΔH is positive**.



The energy is taken from the surroundings which therefore lose heat.

Exothermic Reactions

When $H_R > H_P$ then **energy is given out** during the reaction and **ΔH is negative**.



The energy is given out into the surroundings which therefore gain heat.

Some Standard Enthalpy Changes

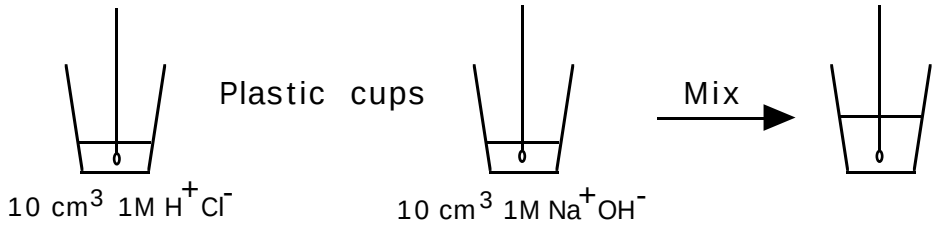
1. Enthalpy of Neutralisation

The heat of neutralisation is the heat given out when 1 mole of H^+ reacts with 1 mole of a base e.g.

$H^+NO_3^-$ + Na^+OH^- -> $Na^+NO_3^-$ + H_2O ΔH = - 57.4 kJ

Finding the Enthalpy of Neutralisation by experiment :

Method: reaction of 10 cm^3 1M H^+Cl^- with 10 cm^3 1M Na^+OH^-



We assume that all the heat given out goes into the 20 cm^3 aqueous solution formed.

Result: Maximum rise in temperature = 6.6 C^0

Heat req.to raise temp.of 1kg of water by 1 C^0 = 4.18 kJ

= specific heat, c

=>Heat req.to raise temp.of m kg of water by ΔT C^0 = $cm\Delta T$

=>Heat req.to raise temp.of 0.02 kg of water by 6.6 C^0 = 4.18 x 0.02 x 6.6

= 0.552 kJ

=>Heat given out in forming 0.01 moles H_2O = 0.552 kJ

=>Heat given out in forming 1 mole H_2O = 55.2 kJ

i.e. Enthalpy of neutralisation = $\underline{- 55.2 \text{ kJ mol}^{-1}}$

(Should be - 57.4 kJ mol^{-1})

2. Enthalpy of Combustion

The enthalpy of combustion of a substance is the enthalpy change when 1 mole of the substance burns completely in Oxygen.
e.g. the heat of combustion of Ethane is - 1560 kJ mol^{-1}

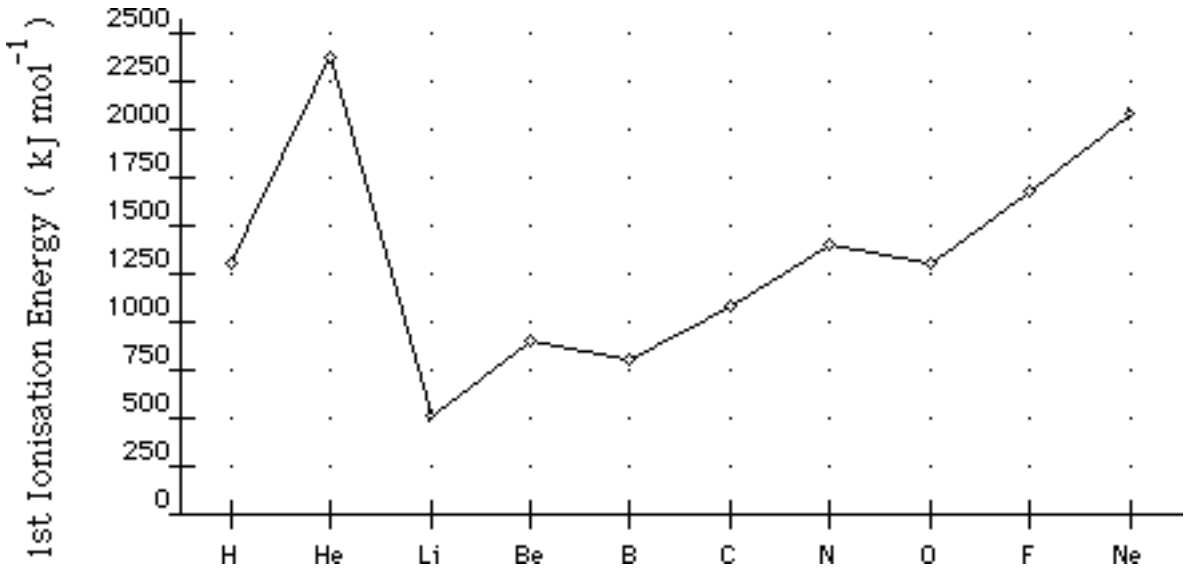
C_2H_6 + 7/2 O_2 -> 2 CO_2 + 3 H_2O ΔH = - 1560 kJ

3. Ionisation energy (I.E.)

The ionisation energy is the energy required to remove 1 mole of electrons from 1 mole of atoms or ions in the gaseous state. Electrons are held to the atom by the attraction of the positive nucleus. The ionisation energy therefore increases as the nuclear charge increases (across a period L->R).

Although the nuclear charge also increases down a group (T->B) the ionisation energy actually decreases ! This is because the outer electrons are entering increasingly higher energy levels. As the electrons get further from the nucleus the attraction of the nucleus is reduced. Also, the increasing number of electrons between the outer electrons and the nucleus screens the nuclear charge and reduces it.

A completely filled outer energy level is particulary stable ; electrons in a completely filled outer energy level are thus difficult to remove. The inert gases have particularly high I.E.'s.



Once an electron has been removed the energy required to remove subsequent electrons becomes increasingly higher due to the attraction afforded by the increasing positive charge on the ion.

e.g. 1st I.E. of Sodium = 502 kJ mol^{-1}

$Na(g) \rightarrow Na^{+}(g) + e \quad \Delta H = 502\ kJ$

2nd I.E. of Sodium = 4560 kJ mol^{-1}

$Na^{+}(g) \rightarrow Na^{2+}(g) + e \quad \Delta H = 4560\ kJ$

3rd I.E. of Sodium = 6920 kJ mol^{-1}

$Na^{2+}(g) \rightarrow Na^{3+}(g) + e \quad \Delta H = 6920\ kJ$

etc

Notice that the second I.E. of Sodium is **very much higher** than the first. The first electron is removed from the third energy level :

$Na(g)\ 2)8)1 \rightarrow Na^{+}(g)\ 2)8 + e \quad \Delta H = 502\ kJ$

The second must be taken from the second level, nearer the positive nucleus :

$Na^{+}(g)\ 2)8 \rightarrow Na^{2+}(g)\ 2)7 + e \quad \Delta H = 4560\ kJ$

This requires much more energy.

4. Enthalpy of Solution

The heat of solution is the energy change when 1 mole of solute is dissolved in excess water e.g.

$K^{+}Cl^{-}(s) \rightarrow K^{+}(aq) + Cl^{-}(aq) \qquad \Delta H = +12\ kJ$

When an electrovalent substance dissolves in Water energy is first taken in to overcome the attractive forces between the ions (Lattice Energy) then energy is given out when the Water molecules cluster round the ions (Enthalpy of hydration):