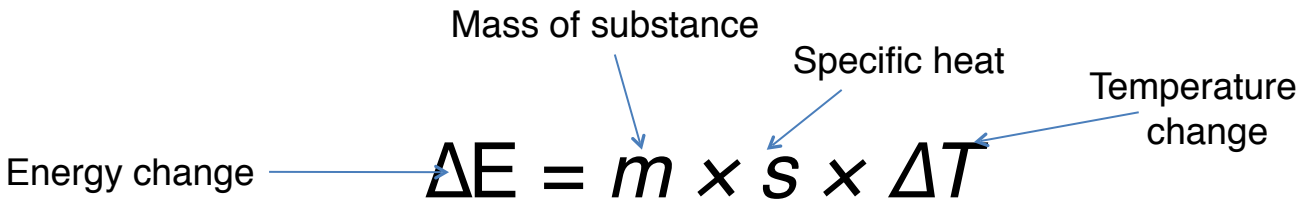
Chemistry 2.4 Structure, bonding and Thermodynamics

Specific heat energy and bond enthalpy

Specific heat *(s)*

- The specific heat energy (J g^{-1} $^oC^{-1}$) of the substance is the energy required to increase one ^oC in one gram of substance.



- Water is the common substance used to measure heat change
- It has a specific heat energy of 4.18 J g^{-1} $^oC^{-1}$

Example

A laboratory technician adds 43.1 mL of 11.6 mol L^{-1} hydrochloric acid to water to form 500 mL of solution. The temperature of the solution rises 2.6 °C.

Calculate the energy change for the reaction, hence calculate the enthalpy of the reaction

$c = 4.18 \text{ J g}^{-1} \text{ °C}^{-1}$

Example cont.

Volume of water is 500 mL

Since the density of water is 1 gmL^{-1}

(one gram per mini-litre)

Mass of water (m) = 500 g

Specific heat (s) = 4.18 J g^{-1} $^oC^{-1}$

Change of temperature (T) = 2.6 ^oC

E = 500 g x 4.18 J g^{-1} $^oC^{-1}$ x 2.6 ^oC = 5434 J

5434 J = 5.434 kJ

Example cont.

5.434 kJ when 43.1 mL of 11.6 mol L^{-1} HCl added to water

The amount of HCl is 11.6 molL^{-1} x 0.0431 L = 0.49996 mol of HCl

The enthalpy is

5.434 kJ ÷ 0.49996 mol = <u>10.9 kJmol^{-1}</u>

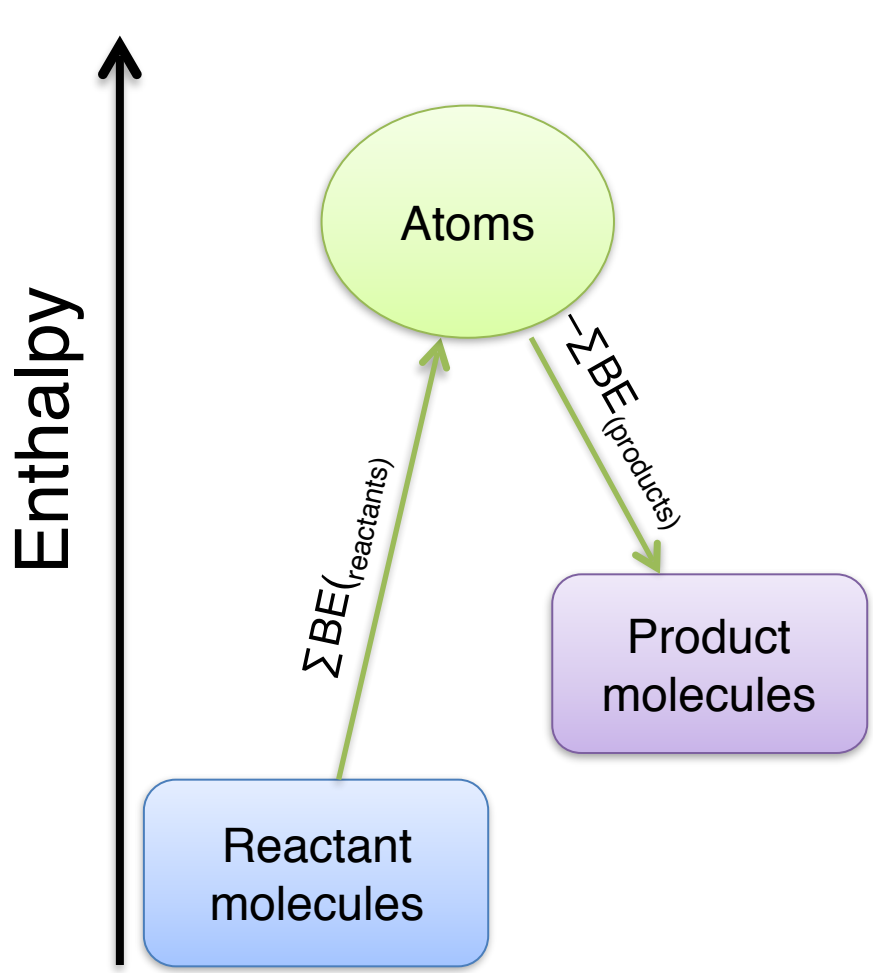
Bond energy in calculation

- Chemical reactions involve in
  - Breaking bonds in the reactants ($\Delta H = +$)
  - Forming bonds in the products ($\Delta H = -$)
- Therefore the overall enthalpy change is

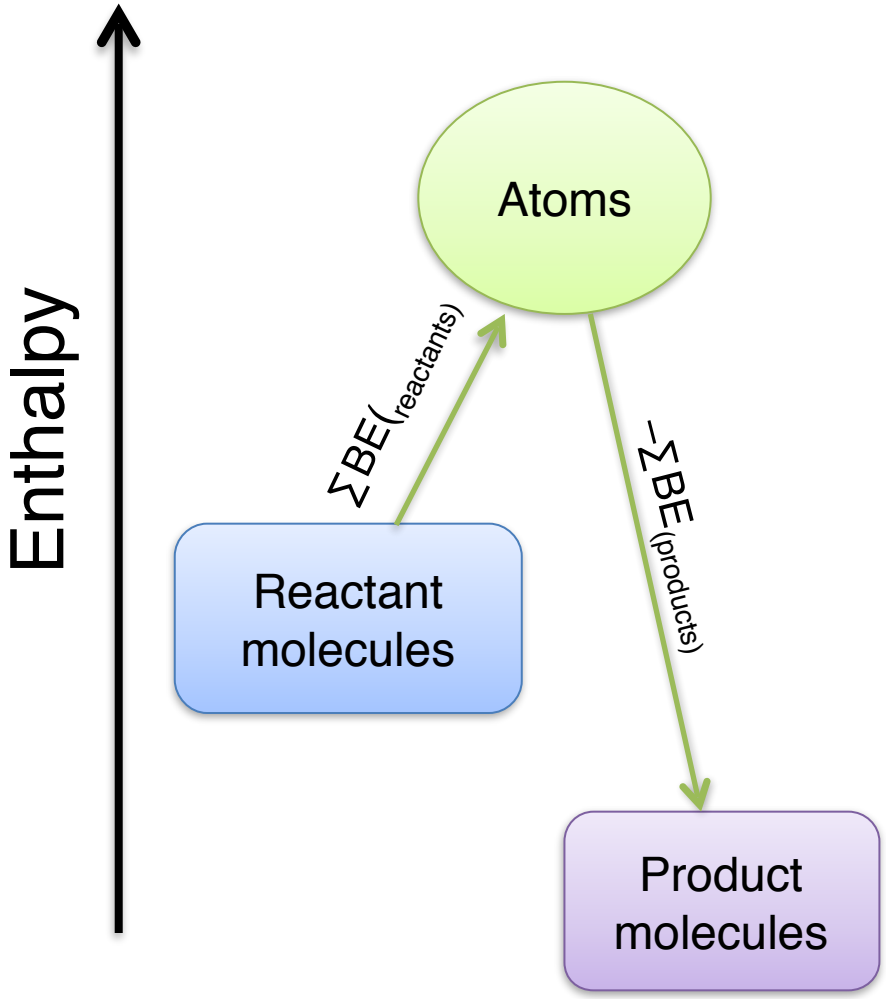
$$\Delta H = \sum BE_{(reactants)} - \sum BE_{(products)}$$

BE = Bond Energy

Overall picture



Endothermic



Exothermic

Example #1

Enthalpy change for the combustion of hydrogen gas

H-H = 436.4 kJ mol^{-1}

O=O = 498.7 kJ mol^{-1}

O-H = 460.0 kJ mol^{-1}

$$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O$$

$\sum BE_{(reactants)}$ = 2 × 436.4 kJ mol^{-1} + 498.7 kJ mol^{-1}

= 1371.5 kJ mol^{-1}

$\sum BE_{(products)}$ = 4 × 460.0 kJ mol^{-1}

= 1840.0 kJ mol^{-1}

$\Delta H^o = \sum BE_{(reactants)} - \sum BE_{(products)}$

= 1371.5 kJ mol^{-1} – 1840.0 kJ mol^{-1}

= -468.5 kJ mol^{-1}