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| Chemical Experiments |
| Enthalpy of Reaction |
| Pupil’s Guide |



This reaction can be applied to curriculum for excellence.

**Higher Chemistry**

Chemical energy

**Introduction**

The investigation of energy changes in chemical reactions is an important part of chemistry. It is carried out using a calorimeter. Purpose built devices are expensive and not commonly found in schools.

This particular version is a microscale version. The reaction vessel is a small 7 cm3 ‘bijou’ with holes in the lid to allow in a digital thermometer and a Pasteur pipette.

This is seated in a beaker full of cotton wool for extra insulation.

**Health & Safety**

2 mol l-1 hydrochloric acid is of no significant hazard but

2 mol l-1 sodium hydroxide is corrosive to skin and eyes.

The quantities are small which makes things safer but eye protection should be worn when handling the NaOH solution.

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**You will need**

|  |  |
| --- | --- |
| 1 x beaker and cotton wool | 1 x ‘bijou’ with pierced lid |
| Digital thermometer | 2 x 3 cm3 Pasteur pipettes |
| 2 mol l-1 hydrochloric acid  | 2 mol l-1 sodium hydroxide [corrosive] |

**To do**

1. Set up your apparatus with the thermometer inserted through the hole in the lid, reaching to the bottom.

The results will be better if you have your bijou wrapped in cotton wool (or something similar) as insulation.

It will also be a good idea to use a clamp to hold the thermometer otherwise the apparatus will spill over.

1. Add 2.5 cm3 of sodium hydroxide to the bijou, let it stand for a minute or so until the temperature settles.
2. Record the start temperature.
3. Add 0.5 cm3 of hydrochloric acid and start the timer. Quickly shake to mix.
4. Monitor the temperature as it rises and record the maximum temperature reached.
5. Empty out and rinse your bijou. Then, using this or a clean one, repeat the experiment with the quantities in the table overleaf.

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| --- | --- | --- | --- | --- | --- |
| Experiment | 1 | 2 | 3 | 4\* | 5\* |
| Volume of 2 Mol l-1 NaOH (aq) (cm3) | 2.5 | 2.0 | 1.5 | 1.0 | 0.5 |
| Volume of 2 Mol l-1 HCl (aq) (cm3) | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 |
| Temperature rise (°C) |  |  |  |  |  |

\* For experiments 4 & 5 it is best to add the acid first so the larger volume will allow a more accurate initial temperature reading.

****Plot your results on a graph like the one below

**Calculations**

You should get a graph shaped something like this one

Draw straight lines along the two sides of the graph – as has been done here

From the graph take the temperature rise from where the lines cross.

Here are specimen calculations for this graph of the neutralisation of 1 mol l-1 NaOH by 1 mol l-1 HCl.

The maximum change in temperature can be seen to be 5.8oC.

The volume of alkali added at this maximum temperature change is 15cm3

The volume of acid added = 30-15 = 15 cm3

No of moles of HCl = C x V

 = 1 x 0.015

 = 0.015 moles

Stoichiometry of the reaction is:

 1 HCl : 1 NaOH

0.015 HCl : 0.015 NaOH

Energy = ∆H = - cm ∆ T

Where c = specific heat capacity of water – 4.18 joules per g per °C

M = mass of water in g (30 g in this case – 30 cm3 but we can assume a density of 1.0)

ΔT = change in temperature in °C (5.8°C in this case)

 = -4.18 x 30 x5.8

 = - 727.32 J

Enthalpy of neutralisation:

0.015 moles 🡪 727.32 J

1 mol 🡪 727.32/0.015

 = -48.488 kJ/mol