

2 The reaction between an acid and an alkali is exothermic. You will carry out a neutralisation experiment to determine the enthalpy change involved.

You will mix different volumes of an acid with a fixed volume of an alkali and measure the temperature rises that occur.

FB 4 is aqueous sodium hydroxide, NaOH.

FB 5 is 2.00 mol dm⁻³ hydrochloric acid, HCl.

(a) Method

- Use the thermometer to measure the initial temperature of **FB 4**. Record this initial temperature in the space for results.
- Support the cup in the 250 cm³ beaker.
- Fill one burette with **FB 5**. Label the burette **FB 5**.
- Fill the other burette with distilled water.

Experiment 1

- Use the 10 cm³ pipette to transfer 10.0 cm³ of **FB 4** into the cup.
- Add 9.00 cm³ of distilled water from the burette to the same cup.
- Add 1.00 cm³ of **FB 5** from the other burette to the same cup.
- Stir the mixture and use the thermometer to measure the maximum temperature. If necessary, tilt the cup so that the solution covers the bulb of the thermometer.
- Record the maximum temperature in Table 2.1.
- Empty, rinse and dry the cup ready for use in further experiments.

Further experiments

Repeat this method for Experiments 2–5, using 10.0 cm³ of **FB 4** and the volumes of water and **FB 5** shown in Table 2.1. In each case, measure and record the maximum temperature.

Carry out **two** further experiments, Experiments 6 and 7, which will enable you to determine more precisely the volume of **FB 5** that gives the largest maximum temperature. Record your measurements in Table 2.1.

Results

initial temperature of **FB 4** = °C

Table 2.1

experiment	volume of water /cm ³	volume of FB 5 /cm ³	maximum temperature /°C
1	9.00	1.00	
2	7.00	3.00	
3	5.00	5.00	
4	3.00	7.00	
5	1.00	9.00	
6			
7			

I	
II	
III	
IV	

[4]

(ii) Use the intersection on your graph in (b)(i) to determine the volume of **FB 5** required to neutralise 10.0 cm³ of **FB 4**.

volume of **FB 5** = cm³ [1]

(c) Calculations

(i) Calculate the amount, in mol, of hydrochloric acid in the volume of **FB 5** in (b)(ii).

(If you were unable to determine an answer to (b)(ii), use 5.10 cm³ as the volume of **FB 5**. This may **not** be the correct answer.)

amount of HCl = mol

Deduce the amount, in mol, of sodium hydroxide in 10.0 cm³ of **FB 4**.

amount of NaOH = mol [1]

(ii) Calculate the energy change, in J, when the amounts of reagents in (c)(i) neutralise each other. Show your working.

energy change = J [1]

(iii) Use your answer to (c)(ii) to calculate the enthalpy change, in kJ mol⁻¹, when one mole of **FB 4** is neutralised by one mole of **FB 5**.

enthalpy change = kJ mol⁻¹ [1]
sign value

[Total: 12]

Qualitative analysis

For each test you should record all your observations in the spaces provided.

Examples of observations include:

- colour changes seen
- the formation of any precipitate and its solubility (where appropriate) in an excess of the reagent added
- the formation of any gas and its identification (where appropriate) by a suitable test.

You should record clearly at what stage in a test an observation is made.

Where no change is observed, you should write 'no change'.

Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.

If any solution is warmed, a boiling tube must be used. If a solid is heated, a hard-glass test-tube must be used.

Rinse and reuse test-tubes and boiling tubes where possible.

No additional tests should be attempted.