45. Thermometric titration

Topic

Titration, neutralisation, energy changes and salt formation.

Timing

60 min.

Description

Students titrate sodium hydroxide with hydrochloric acid. The temperature is measured each time a portion of acid is added. The highest temperature indicates the endpoint of the reaction and this is used to estimate the molarity of the hydrochloric acid.

Apparatus and equipment (per group)

- Thermometer (0–100 °C) supported at its upper end (in a cork) in a clampstand
- Polystyrene cup
- Burette and burette stand
- Measuring cylinder (>15 cm$^3$).

Chemicals (per group)

- Hydrochloric acid 1.5 mol dm$^{-3}$ (concentration not indicated on bottle)
- Sodium hydroxide 2 mol dm$^{-3}$ (Corrosive) (concentration indicated on bottle).

Teaching tips

The main concern in this experiment is the heat loss. With more able or older students, it is possible to discuss the extrapolation of the cooling curve. To reinforce the point an indicator could also be used to show that the end point really was at the highest temperature. If possible a lid should be used.

Teachers may wish to develop the theory of titration further using this experiment.

A temperature sensor attached to a computer can be used here in place of the thermometer. Data logging software will show the temperature change as acid is added to alkali. Adding a pH sensor to the experiment helps to show that after the equivalence point is reached, the temperature stops rising.

Background theory

- Neutralisation reactions
- Energy changes in chemical reactions
- Moles and solutions
- Graph plotting skills.

Safety

Wear eye protection.
The aim of this experiment is to measure the maximum temperature reached during the reaction between hydrochloric acid and sodium hydroxide solution. The solutions of acid and alkali do not have the same concentration. The volumes that have reacted at the highest temperature reached, represent the ‘end point’ of the titration.

What to record

Record your results in a table.

<table>
<thead>
<tr>
<th>Volume of acid added/cm³</th>
<th>Temperature/°C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What to do

1. Using a measuring cylinder, place 15 cm³ of sodium hydroxide (Corrosive) into the polystyrene cup and measure the temperature.
2. Using the burette add a small portion (3–5 cm³) of dilute hydrochloric acid to the solution in the polystyrene cup. Swirl the solution and measure the highest temperature reached.
3. Immediately add a second small portion of the dilute hydrochloric acid, swirl and again measure the highest temperature.
4. Continue in this way until there are enough readings to decide the highest temperature for the experiment.

Safety

Wear eye protection.

Questions

1. What is the highest temperature reached in this reaction?
2. Draw a graph of your results.