

Heat, enthalpy and Hess's law

AP Chemistry · Lab

Name: _____ Date: _____ Class: _____

Can you find the enthalpy change of a reaction you cannot measure directly? Here you use Hess's law with two reactions that are easy to measure: sodium hydroxide dissolving in water and sodium hydroxide reacting with acid. The difference gives the enthalpy of neutralisation, which you compare with the accepted value.

Level: AP Chemistry · **Curriculum:** AP Chem Unit 6

Aim

Determine ΔH for $\text{NaOH(aq)} + \text{HCl(aq)} \rightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)}$ by measuring ΔH_1 (NaOH(s) dissolving in water) and ΔH_2 (NaOH(s) reacting with HCl(aq)).

Equipment

- Polystyrene cups with lids, thermometer (0.1 °C), 100 cm³ measuring cylinder, balance
- NaOH pellets (2.00 g per run), 0.500 M hydrochloric acid, distilled water
- Stopwatch and stirring rod

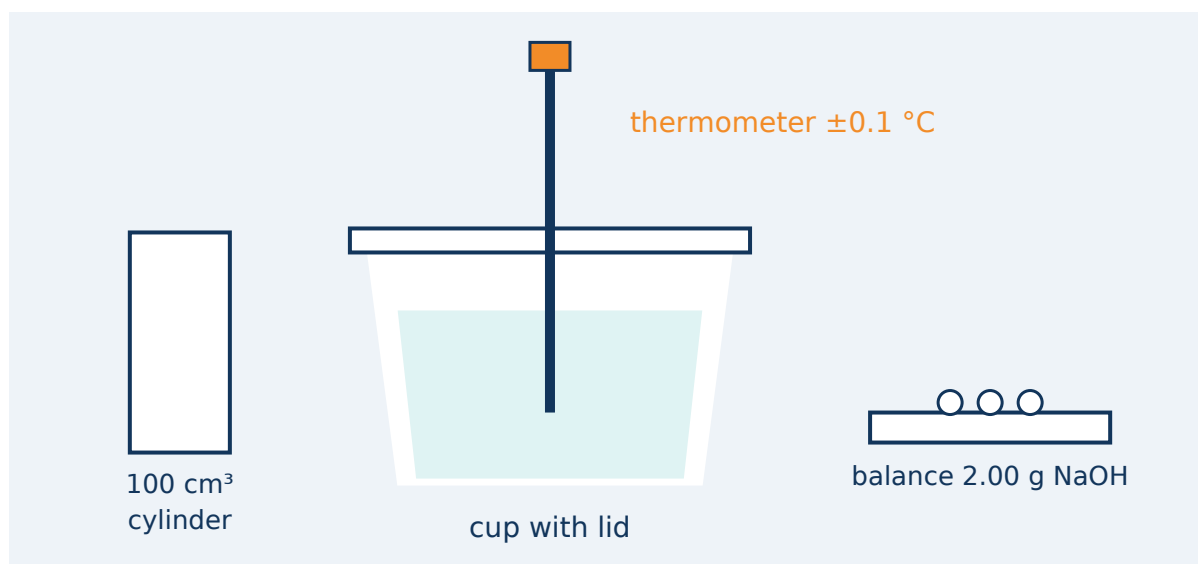
Safety

Safety

Sodium hydroxide is corrosive and the solution gets hot: wear eye protection and gloves, never touch pellets with bare hands, and wash spills at once with plenty of water. Hydrochloric acid at 0.5 M may irritate. Stir with the stirring rod, not the thermometer.

Method

1. Place 100.0 cm³ of water in the cup and measure the temperature for 2 minutes.
2. Add 2.00 g of NaOH, replace the lid and stir gently.
3. Record the highest temperature reached.
4. Repeat with 100.0 cm³ of 0.500 M HCl instead of water.
5. Use the same mass of NaOH and fresh solutions each time.



Set-up: the cup is insulated and covered so the temperature rise measures the heat released.

Results

Experiment	Initial temperature (°C)	Highest temperature (°C)
1: NaOH(s) in water	21.0	26.2
2: NaOH(s) in HCl(aq)	21.0	32.8

Take the solution mass as 102.0 g in both runs and $c = 4.18 \text{ J/(g } ^\circ\text{C)}$. $M(\text{NaOH}) = 40.00 \text{ g/mol}$.

Analysis questions

Question 1 Fair test

Explain why both runs use the same mass of NaOH and the same volume of liquid.

Question 2 Dissolving

Calculate q for run 1 and ΔH_1 in kJ/mol of NaOH.

Question 3 Reaction with acid

Calculate q for run 2 and ΔH_2 in kJ/mol of NaOH. Show that the moles of acid equal the moles of NaOH.

Question 4 Hess's law

Draw the energy cycle and calculate ΔH_3 for $\text{NaOH(aq)} + \text{HCl(aq)} \rightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)}$.

Question 5 Comparison

The accepted value is -57.3 kJ/mol. Calculate the percentage difference.

Question 6 Direction of errors

Explain the effect of heat loss to the room on the magnitude of the result and name one other source of error.

Question 7 Improvement

Suggest two changes that would improve the accuracy.