**Aim**

You are going to find the concentration of a solution of sodium hydroxide solution using a solution of sulfuric acid of known concentration.

\[ 2 \text{NaOH(aq)} + \text{H}_2\text{SO}_4(aq) \rightarrow \text{Na}_2\text{SO}_4(aq) + 2 \text{H}_2\text{O(l)} \]

You will place 25.0 cm\(^3\) of the sodium hydroxide solution in a conical flask and find the volume of sulfuric acid from a burette needed to neutralise the sodium hydroxide.

**Safety**

- The acid and alkali are irritants.
- Be careful not to allow solution to enter the pipette filler.

**Method**

1. Collect some sulfuric acid in a labelled, clean, dry 100 cm\(^3\) beaker.
2. Using a funnel, pour about 25 cm\(^3\) of the sulfuric acid into a burette. Use it to rinse out the burette with the acid. To do this, allow a small amount of the acid to drain out of the burette tap down the sink, while the rest of the acid is emptied out of the other end down the sink while rotating the burette to ensure that it is well rinsed.
3. Place the rinsed burette in a burette holder on a stand.
4. Fill the burette with some more of the acid so that it is on the 0.0 cm\(^3\) line (read at the bottom of the meniscus).
5. Rinse out a conical flask with water.
6. Collect some sodium hydroxide solution in a second labelled, clean, dry 100 cm\(^3\) beaker.
7. Using a pipette filler, fill a 25.0 cm\(^3\) pipette with the sodium hydroxide solution, and then empty it down the sink which will rinse out the pipette.
8. Now measure out exactly 25.0 cm\(^3\) of the sodium hydroxide solution with the pipette and allow it to drain naturally into the conical flask. Touch the pipette under the surface of the solution a couple of times (this removes some of the remaining sodium hydroxide – note that there should still be some left in the pipette even after this).
9. Place the conical flask on a white tile.
10. Add 4 drops of phenol red indicator into the sodium hydroxide in the conical flask.
11. Add acid from the burette to the conical flask until the indicator changes colour from purple to orange. If you add too much acid, it will go yellow.
12. Record the final reading.
13. You are now going to repeat the titration several times. To do this:
   - rinse out the conical flask with water
   - re-fill the burette with acid and record the start reading
   - add another 25.0 cm\(^3\) of sodium hydroxide solution from the pipette into the conical flask and add 4 drops of indicator
   - add acid from the burette to the conical flask until you are close to the point where it changes colour, and then start adding the acid drop by drop to get a more accurate end point; as you approach the end point rinse down the insides of the flask with deionised water from a wash bottle
   - record the final reading
13. When you have done enough titrations (your teacher will guide you), rinse out all the glassware with water. To rinse the burette, pour water from a beaker through the burette. For the pipette, use a pipette filler to fill and drain the pipette with water.
### Results table

#### Questions

1. Did you get any anomalous results? Identify them or state that there are none, and explain your answer.

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2. Calculate the mean volume of acid needed to neutralise the sodium hydroxide solution. Do not include any anomalous results. Show your working.

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3. Calculate the concentration of the sodium hydroxide solution in mol/dm$^3$. Show your working and give your answer to 3 significant figures.

   \[ 2 \text{NaOH(aq)} + \text{H}_2\text{SO}_4(aq) \rightarrow \text{Na}_2\text{SO}_4(aq) + 2 \text{H}_2\text{O(l)} \]

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4 Calculate the concentration of the sodium hydroxide solution in g/dm³. Show your working and give your answer to 3 significant figures.

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5 Your teacher will give you the correct value for the concentration of the sodium hydroxide solution. State and explain if your results were accurate.

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6 Look at your titration results and then state and explain if your results were repeatable.

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7 You did not get the same results in each titration due to random errors. What is meant by the term random error?

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8 Record the results for five other people’s mean volume from their titration.

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9 Look at the results in question 8 and then state and explain if the results were reproducible.

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Another student did this same experiment. His titres were about 1 cm$^3$ greater than everyone else’s. This was because he rinsed the conical flask with some sodium hydroxide solution before adding the 25.0 cm$^3$ from the pipette in each titration. What is the name given to an error like this that is repeated each time?

Look back at your titration volumes. Excluding any anomalous results, state the mean volume with an estimation of the uncertainty (for example, 24.4 ± 0.3 cm$^3$). Explain how you found the uncertainty.

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**ASSESSMENT GRID**

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