# Core practical 3: Find the concentration of a solution of hydrochloric acid

## Objective

- To find the concentration of a solution of hydrochloric acid

## Safety

- Wear eye protection.
- Phenolphthalein solution is flammable and toxic.
- Bench hydrochloric acid is an irritant.
- Ensure burettes are filled when the top of the burette is below eye level.

## Specification links

- Practical techniques 1, 4, 5, 6, 11
- CPAC 1a, 2a, 2b, 3a, 3b, 4a, 4b

## Procedure

1. Wash out the 250 $cm^3$ volumetric flask with distilled water.
2. Use the pipette to transfer 25.0 $cm^3$ of the hydrochloric acid solution into the volumetric flask. Make the solution up to the mark with deionised water.
3. Prepare your apparatus for the titration. The burette should contain the sodium hydroxide solution and the conical flask should contain the dilute hydrochloric acid solution.
4. Pour a 25.0 $cm^3$ aliquot of the diluted hydrochloric acid into the conical flask. Add two drops of phenolphthalein indicator.
5. Titrate the contents of the flask against the sodium hydroxide solution (previously standardised). All burette readings should be recorded to the nearest 0.05 $cm^3$.
6. The end point of this titration is indicated by the contents of the flask becoming pale pink. Continued swirling will cause the pink colour to fade and disappear – if the pink colour persists for 5 seconds or more, then the end point has been reached.
7. Continue to conduct titrations until you have two concordant titres.
8. Record your results in a table similar to the following:

| | Rough | Trial 1 | Trial 2 | Trial 3 | Trial 4 |
|---|---|---|---|---|---|
| **Final burette reading/$cm^3$** | | | | | |
| **Initial burette reading/$cm^3$** | | | | | |
| **Titre/$cm^3$** | | | | | |

## Notes on procedure

- The students will need instructions on how to prepare glassware for a titration.
- Phenolphthalein will become colourless again after the end point has been reached and it has turned pink as it reacts with carbon dioxide in the air.

## Answers to questions

1. $HCl + NaOH \rightarrow NaCl + H_2O$
2. 
   (a) $2NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$
   (b)
      (i) Decrease
      (ii) The volume of sodium hydroxide solution will not change because the sodium carbonate made will also react with the hydrochloric acid. Two moles of sodium carbonate react to make one mole of sodium hydroxide which will react with two moles of hydrochloric acid, the same number of moles of hydrochloric acid that the sodium hydroxide would have reacted with.
3. The percentage error will be larger, the smaller the titre.

## Sample data

| | Trial 1 | Trial 2 | Trial 3 | Trial 4 |
|---|---|---|---|---|
| **Final burette reading/$cm^3$** | 30.55 | 32.10 | 30.65 | 33.40 |
| **Initial burette reading/$cm^3$** | 0.45 | 2.15 | 0.60 | 3.15 |
| **Titre/$cm^3$** | 30.10 | 29.85 | 30.05 | 30.25 |

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## All the maths you need

- Recognise and make use of appropriate units in calculations.
- Recognise and use expressions in decimal and ordinary form.
- Use an appropriate number of significant figures.
- Find arithmetic means.
- Understand and use the symbols: =, <, <<, >>, >, $\propto$, ~ and $\rightleftharpoons$.
- Change the subject of an equation.
- Substitute numerical values into algebraic equations, using appropriate units for physical quantities.

## Equipment

- burette, clamp and stand
- sodium hydroxide solution (previously standardised)
- bench hydrochloric acid (approximately 1 mol $dm^{-3}$)
- phenolphthalein
- 250 $cm^3$ conical flask
- 25 $cm^3$ volumetric pipette plus safety filler
- 100 $cm^3$ beakers for transfer of solutions
- funnel for filling burette
- 250 $cm^3$ beaker
- 250 $cm^3$ volumetric flask

## Procedure

1. Wash out the 250 $cm^3$ volumetric flask with distilled water.
2. Use the pipette to transfer 25.0 $cm^3$ of the hydrochloric acid solution into the volumetric flask. Make the solution up to the mark with deionised water.
3. Prepare your apparatus for the titration. The burette should contain the sodium hydroxide solution and the conical flask should contain the dilute hydrochloric acid solution.
4. Pour a 25.0 $cm^3$ aliquot of the diluted hydrochloric acid into the conical flask. Add two drops of phenolphthalein indicator.
5. Titrate the contents of the flask against the sodium hydroxide solution (previously standardised). All burette readings should be recorded to the nearest 0.05 $cm^3$.
6. The end point of this titration is indicated by the contents of the flask becoming pale pink. Continued swirling will cause the pink colour to fade and disappear – if the pink colour persists for 5 seconds or more, then the end point has been reached.

7. Continue to conduct titrations until you have two concordant titres.
8. Record your results in a table similar to the following:

| | Rough | Trial 1 | Trial 2 | Trial 3 | Trial 4 |
|---|---|---|---|---|---|
| **Final burette reading/cm$^3$** | | | | | |
| **Initial burette reading/cm$^3$** | | | | | |
| **Titre/cm$^3$** | | | | | |

## Analysis of results

1. Calculate the mean titre using your two concordant results.
2. Calculate the number of moles of sodium hydroxide that were contained in your mean titre.
3. Calculate the number of moles of hydrochloric acid that were contained in the full 250 cm$^3$ of diluted hydrochloric acid.
4. Calculate the concentration of the original solution of hydrochloric acid.

## Learning tips

- Do not include your rough titration when calculating your mean.
- Give all burette readings to the nearest 0.05 cm$^3$

## Questions

1. Write a chemical equation for the reaction of hydrochloric acid with sodium hydroxide.
2. The pink colour seen at the end point fades because the excess sodium hydroxide reacts with carbon dioxide in the air. This reaction makes sodium carbonate.
   (a) Write an equation for the reaction of sodium hydroxide with carbon dioxide.
   (b) When sodium hydroxide solution is stored, it reacts with carbon dioxide in the air.
      (i) How will this change the concentration of the sodium hydroxide solution?
      (ii) How will this affect the volume of sodium hydroxide solution required to reach the end point in the titration? Explain your answer.
3. Explain why it is better to have a titre of around 25 cm$^3$ than of around 10 cm$^3$.

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| Equipment per student/group | Notes on equipment |
|---|---|
| burette, clamp and stand | |
| sodium hydroxide solution (previously standardised) | If this is not available, a solution of approximately 0.08 mol $dm^{-3}$ can be provided. Label the solution with its concentration. |
| bench hydrochloric acid (approximately 1 mol $dm^{-3}$) | Just over 25 $cm^3$ per student. Label the solution 'unknown concentration'. |
| phenolphthalein | |
| 250 $cm^3$ conical flask | |
| 25 $cm^3$ volumetric pipette plus safety filler | |
| 100 $cm^3$ beakers for transfer of solutions | |
| funnel for filling burette | |
| 250 $cm^3$ beaker | |
| 250 $cm^3$ volumetric flask | |
| distilled water | |
| deionised water | |

## Notes