Titrating sodium hydroxide with hydrochloric acid

Learning objectives

1 Set up and carry out a neutralisation reaction by titration.
2 Calculate the concentration of hydrochloric acid using experimental results.
3 Produce a pure sample of sodium chloride crystals from sodium chloride solution.
4 Accurately record experimental observations and data.
5 Calculate the percentage yield of sodium chloride (challenge).

Introduction

Table salt is used in cooking. It is also added to our food to make it taste better. The chemical name for table salt is sodium chloride.

Sodium chloride solution can be made in a neutralisation reaction by reacting sodium hydroxide with dilute hydrochloric acid.

Your challenge is to produce a pure sample of sodium chloride crystals, starting with a sample of sodium hydroxide solution and dilute hydrochloric acid.

Equipment

Apparatus

- Safey glasses
- Burette, 30 or 50 cm^3
- Conical flask, 100 cm^3
- Beaker, 100 cm^3
- Pipette, 20 or 25 cm^3, with pipette filler
- Stirring rod
- Small (filter) funnel, about 4 cm diameter
- Burette stand and clamp
- White tile or sheet of white paper
- Bunsen burner
- Tripod
- Pipe clay triangle
- Evaporating basin, at least 50 cm^3 capacity
- Crystallising dish
- Microscope or hand lens suitable for examining crystals in the crystallising dish

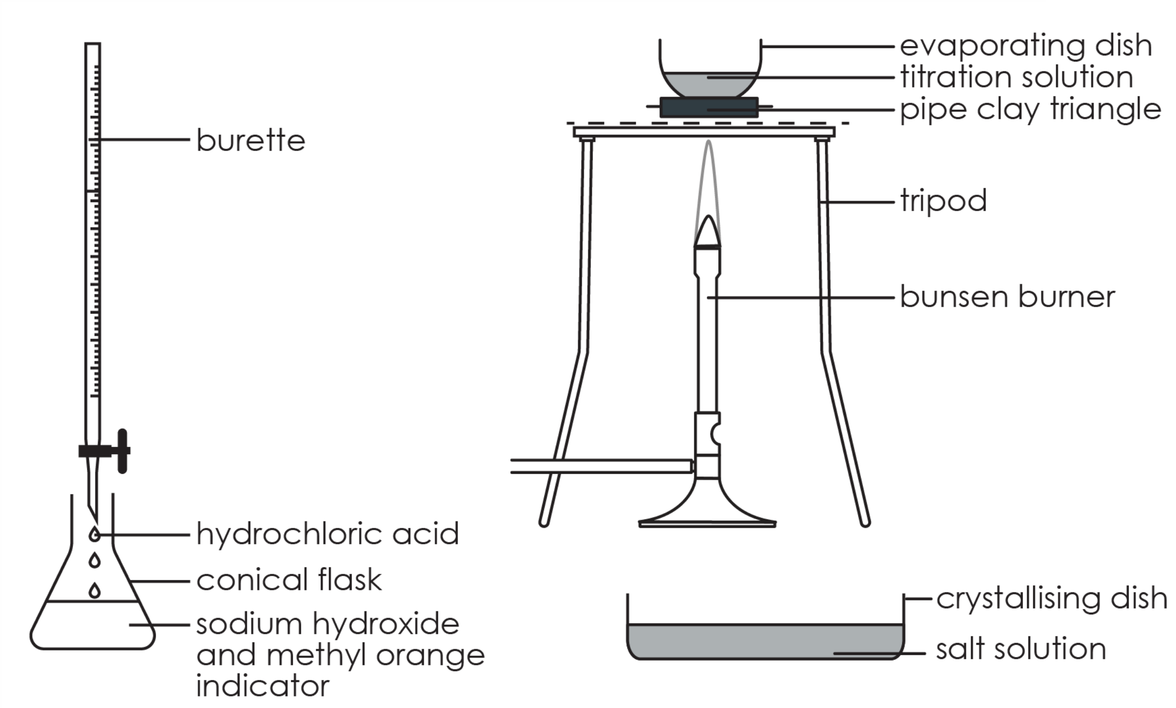
Chemicals

- Sodium hydroxide solution, 0.4 M (IRRITANT)
- Dilute hydrochloric acid, 0.4 M
- Methyl orange indicator solution

Health and safety

- Wear eye protection throughout

Diagram



Method

Stage 1

1. Using a small funnel, pour a few cubic centimetres of 0.4 M hydrochloric acid into the burette, with the tap open and a beaker under the open tap. Once the tip of the burette is full of solution, close the tap and add more solution up to the zero mark. (Do not reuse the acid in the beaker – this should be rinsed down the sink.)
2. Use a pipette with pipette filler to transfer 25 (or 20) cm^3 of 0.4 M sodium hydroxide solution to the conical flask and add two drops of methyl orange indicator. Swirl gently to mix. Place the flask on a white tile or piece of clean white paper under the burette tap.
3. Add the hydrochloric acid to the sodium hydroxide solution in small volumes, swirling gently after each addition. Continue until the solution just turns from yellow–orange to red and record the reading on the burette. Rinse this coloured solution down the sink.

Stage 2

1. Refill the burette to the zero mark.
2. Carefully add the same volume of fresh hydrochloric acid as you used in stage 1, step 3, to a fresh 25 (or 20) cm^3 of sodium hydroxide solution, to produce a neutral solution, but this time without any indicator.

Stage 3

1. Pour this solution into an evaporating basin. Reduce the volume of the solution to about half by heating on a pipe clay triangle or ceramic gauze over a low to medium Bunsen burner flame. The solution spits near the end and you get fewer crystals. Do not boil dry. You may need to evaporate the solution in, say, 20 cm^3 portions to avoid overfilling the evaporating basin. Do not attempt to lift the hot basin off the tripod – allow to cool first and then pour into a crystallising dish.
2. Leave the concentrated solution to evaporate further in the crystallising dish. This should produce a white crystalline solid in one or two days.
3. Record the mass of the sodium chloride crystals.
4. Examine the crystals under a microscope.

Questions

Stage 1

1. Name the products formed in this reaction.

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2. Write a word equation for this reaction.

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3. Write a symbol equation for this reaction.

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4. Explain why methyl orange was added to the conical flask.

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5. State the volume of hydrochloric acid needed to neutralise the sodium hydroxide.

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6. Use the information below and your answers from questions 3 and 5 to calculate the concentration of the hydrochloride acid.

$$\text{concentration (mol/dm}^3) = \frac{\text{number of moles}}{\text{volume (dm}^3)}$$

Volume of NaOH $= 25\ \text{cm}^3$
Concentration of NaOH $= 0.4\ \text{mol/dm}^3$

Stage 2

1. Explain why you must use another 25 cm^3 of sodium hydroxide solution to make your crystals, rather than making your crystals from the solution in stage 1.

2. Explain why an indicator was not used in stage 2 of the process.

3. Explain why it is good practice to repeat stage 1 and work out the average reading.

4. Describe how you could test to see if all the hydrochloric acid had been neutralised without contaminating the product.

Stage 3

1. Explain what was happening when the titration solution was being heated in the evaporation basin.

2. Record the mass of your crystals.

3. Sketch what you see when you look at the salt crystals under the microscope.

4. Describe the shape of the crystals.

5. Use your knowledge of ionic bonding to explain the shape of the crystals. Include a lattice diagram in your answer.

Challenge question

Calculate the percentage yield of sodium chloride.

$$\%\ \text{yield} = \frac{\text{actual mass}}{\text{theoretical mass}} \times 100$$

To determine the actual mass, you will need to measure the mass of your crystals on a mass balance.

To calculate the theoretical mass, you will need to use:

- A_r Na = 23, A_r Cl = 35.5
- the balanced equation for the reaction
- the starting concentrations and volumes used in stage 1 of the practical

Show all your working. You may wish to tabulate your data in the space below.