Titrations

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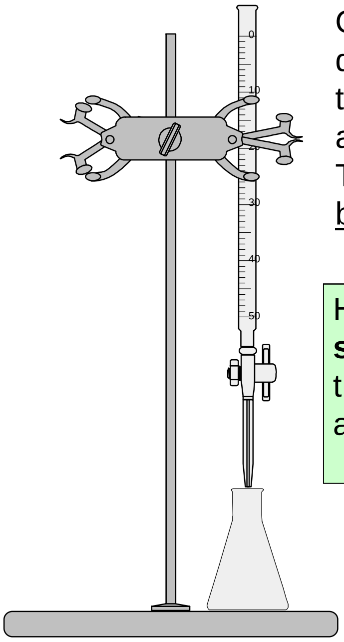
Titrations

Titrations are done often to find out the concentration of one substance by reacting it with another substance of known concentration.

They are often done with neutralisation reactions, but can be done with redox reactions.

Typical neutralisation reaction

$NaOH + HCl \rightarrow NaCl + H_2O$

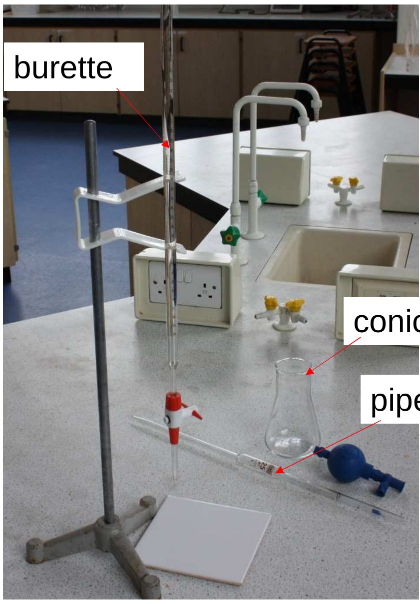


One substance (generally the one we don't know the concentration) is put in the <u>conical flask</u>. It is measured using a volumetric pipette.
The other substance is placed in the <u>burette</u>

However, the standard phrase: **titrate solution A with solution B** means that A should be in the conical flask and B should be in the burette.

Method for carrying out titration

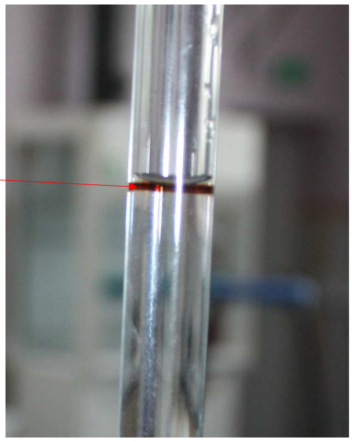
- **rinse equipment** (burette with acid, pipette with alkali, conical flask with distilled water)



Using the pipette

- **pipette 25 cm^3 of alkali into conical flask**
- **touch surface of alkali with pipette** (to ensure correct amount is added)

Make sure bottom of meniscus is on line on neck of pipette



Using the burette

Burette. Should be rinsed out with substance that will be put in it.

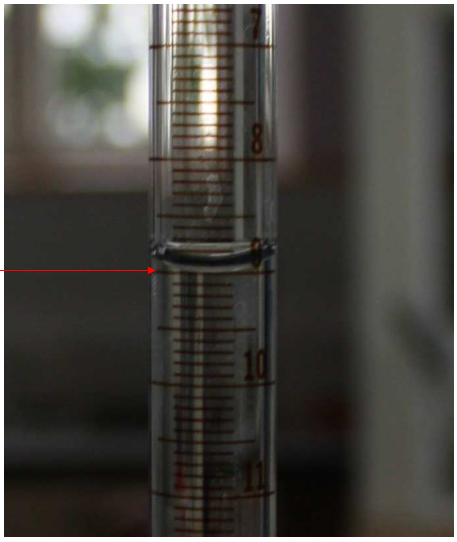
Don't leave the funnel in the burette.

Generally add acid solution from burette

- **make sure the jet space** in the burette **is filled** with acid

Reading the burette

Read the bottom of the meniscus on the burette



This is reading 9.00cm^3

The burette readings should always be given to 2dp

Adding indicator

- add **a few drops of indicator** and refer to colour change at end point
- phenolphthalein (pink to colourless: end point pink colour just disappears) [use if NaOH is used]

phenolphthalein Alkali colour

phenolphthalein acid colour

Methyl orange

Methyl orange is a suitable indicator for several neutralisation reactions and is red in acid and yellow in alkali. It is orange at the end point.

- use a white tile underneath the flask to help observe the colour change

Methyl orange Alkali colour

Methyl orange end point

Methyl orange acid colour

Titration

- add acid to alkali whilst **swirling the mixture** and **add acid dropwise at end point**
- **note burette reading** before and after addition of acid
- **repeats titration** until **at least 2 concordant results** are obtained- two readings within 0.1 of each other

Safety precautions

Acids and alkalis are corrosive
(at low concentrations acids are irritants)
Wear eye protection and gloves
If spilled immediately wash affected parts after spillage

If substance is unknown treat it as potentially toxic and wear gloves

Concordant results

Working out average titre results
Only make an average of the concordant titre results

Titration number	1	2	3
Initial burette reading (cm^3)	0.50	2.50	1.55
Final burette reading (cm^3)	24.50	27.00	25.95
Titre (cm^3)	24.00	24.50	24.40

Average titre = (24.50+ 24.40)/2 = 24.45

If **2 or 3 values are within 0.10cm^3** and therefore **concordant** or close then we can say results are accurate and **reproducible** and **the titration technique is good/ consistent**

Titrating mixtures
If titrating a mixture to work out the concentration of an active ingredient it is necessary to consider if the mixture contains other substances that have acid base properties. If they don't have acid base properties we can titrate with confidence.

Testing batches
In quality control it will be necessary to do titrations/testing on several samples as the amount/concentration of the chemical being tested may vary between samples

Titration calculations

A titration is normally done to find out the concentration of one substance by reacting it with another substance of known concentration.

The method is the same 3 step method for doing any calculation using a balanced equation

$aA + bB \rightarrow$ products

Volume & conc of $A_{(aq)}$ → Moles A → $\times \frac{b}{a}$ → Moles B → Conc of $B_{(aq)}$

Question. If 25 cm^3 of HCl is reacted with 22.4cm^3 of 2M NaOH, what would be the concentration of the HCl?

step 1: work out the number of moles of NaOH

Number of moles = conc x vol

Number of moles = 2 x 22.4/1000

moles of NaOH= 0.0448 mol

step2 :use the balanced equation to work out the moles of HCl

$NaOH + HCl \rightarrow NaCl + H_2O$

1 mole NaOH reacts with 1 mole HCl 1:1 ratio

So 0.0448 moles NaOH will react with 0.0448 moles HCl

Step 3: work out the conc of HCl

$$\textbf{concentration} = \frac{\textbf{moles}}{\textbf{volume (in dm}^3\textbf{)}} = \frac{0.0448}{(25/1000)} = 1.79\ M$$

$20cm^3$ of an unknown concentration of H_2SO_4 was titrated with 0.25M NaOH. $18.7cm^3$ of NaOH was required for neutralisation. What is the concentration of H_2SO_4 ?

step 1: work out the number of moles of NaOH

Number of moles = conc x vol

Number of moles = 0.25 x 0.0187

moles of NaOH= 4.68×10^{-3} mol

step2 :use the balanced equation to work out the moles of H_2SO_4

$H_2SO_4 + 2NaOH \rightarrow 2\ Na_2SO_4 + 2H_2O$

2 mole NaOH reacts with 1 mole H_2SO_4 2:1 ratio

So 4.68×10^{-3} moles NaOH will react with 2.34×10^{-3} moles H_2SO_4

Step 3: work out the conc of H_2SO_4

concentration = $\dfrac{\textbf{moles}}{\textbf{volume (in dm}^3\textbf{)}}$ $= \dfrac{0.00234}{(20/1000)}$ = 0.117 M

Exam Question

(a) 100 cm^3 of a standard solution of Na_2CO_3 was produced by dissolving 0.537 g of Na_2CO_3 in water in a volumetric flask. Calculate the concentration, in mol dm^{-3}, of the Na_2CO_3 solution.

(b) On titration, 25.00 cm^3 of the $Na_2CO_3(aq)$ solution from (a) required 23.75 cm^3 of hydrochloric acid for complete neutralisation. Calculate the concentration, in mol dm^{-3}, of the hydrochloric acid.

$Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$

Questions on errors

What effect would each of the errors described below have on the calculated value of the concentration of sodium hydroxide?

a The burette is not rinsed with the sodium hydroxide solution.

b The pipette is not rinsed with the potassium hydrogenphthalate solution.

c The tip of the burette is not filled before titration begins.

d The conical flask contains some distilled water before the addition of potassium hydrogenphthalate.

Reducing errors

To reduce the error in a burette reading it is necessary to make the titre a larger volume. This could be done by: increasing the volume and concentration of the substance in the conical flask or by decreasing the concentration of the substance in the burette.