15th June

Success Criteria:

- **I know how titrations are carried out.**
- **I can identify a pipette, burette and pipette filler.**
- **I know what concordant results are.**
- **I can carry out a titration calculation.**

This week's videos on titrations are available here:

Carrying out a titration: https://www.youtube.com/watch?v=FDQ1aLh5FiY

Titration calculations: https://youtu.be/Wh8Vf3gv_go

This document contains:

1. Homework answers – please mark your work
2. Notes – please copy into your notes jotter (or print and glue)
3. Self check – please complete in class jotter
4. Self check answers – please mark your work
5. Homework – complete in homework jotter

Then complete this week's form:

https://forms.office.com/Pages/ResponsePage.aspx?id=oyzTzM4Wj0KVQTctawUZKWuHxssNNghPm8XlfK7Z5UxUOTVDMFI2VkJaQ1kzNk9LOVkyWlYwMVJVSS4u

Please mark last week's homework

Mole calculations 26

1. What is the concentration of the following solutions?

(a) 0.1 mole of substance dissolved in 200 cm^3 of solution

n = 0.1 mol
c = ?
v = 200 cm^3 / 1000 = 0.2 l

c = n/v
= 0.1 mol /0.2 l
= **0.5 mol l^{-1}**

(b) 0.2 mole of substance dissolved in 200 cm^3 of solution

n = 0.2 mol
c = ?
v = 200 cm^3 / 1000 = 0.2 l

c = n/v
= 0.2 mol/0.2 l
= **1 mol l^{-1}**

(c) 0.15 mole of substance dissolved in 75 cm^3 of solution

n = 0.15 mol
c = ?
v = 75 cm^3 / 1000 = 0.075 l

c = n/v
= 0.15 mol/0.075 l
= **2 mol l^{-1}**

2. How many moles of substance are dissolved in the following solutions?

(a) 250 cm^3 of 2 mol l^{-1}

n = c x v
= 2 mol l^{-1} x 0.25 cm^3
= 0.5 mol

(b) 300 cm^3 of 1 mol l^{-1}

n = c x v
= 1 mol l^{-1} x 0.3 cm^3
= 0.3 mol

(c) 500 cm^3 of 0.5 mol l^{-1}

n = c x v
= 0.5 mol l^{-1} x 0.5 cm^3
= 0.25 mol

(d) 400 cm^3 of 2 mol l^{-1}

n = c x v
= 2 mol l^{-1} x 0.4 cm^3
= 0.8 mol

3. A pupil prepares 20 cm^3 of an 0·5 mol l^{-1} solution of calcium hydroxide {$Ca(OH)_2$}.

(a) What is the mass of 1 mole of calcium hydroxide?
$Ca(OH)_2$ = (1 x Ca) + (2 x O) + (2 x H) = 40 g + 32 g + 2 g = **74 g**

(b) How many moles of calcium hydroxide are present in the solution?
n = c x v = 0·5 mol l^{-1} x 0.02 l = **0.01 mol**

(c) What mass of calcium hydroxide is present in the solution?
m = n x GFM = 0.01 mol x 74 g = **0.74 g**

4. Kirsty added magnesium to hydrochloric acid. She found that 2·45g of magnesium reacted with 100 cm^3 of 2 mol l^{-1} acid.

(a) How many moles of hydrochloric acid did she use?
n = c x v = 2 mol l^{-1} x 0.1 l **= 0.2 mol**

(b) How many moles of magnesium did she use?
n = m / GFM = 2.45 g / 24.5g **= 0.1 mol**

5. A beaker contains 50 cm^3 of a 0·4 mol l^{-1} solution of sodium carbonate (Na_2CO_3).

(a) What is the mass of one mole of sodium carbonate?
Na_2CO_3 = (2 x Na) + (1 x C) + (3 x O) = 46 g + 12 g = 48 g = **106 g**

(b) How many moles of sodium carbonate is present in the solution?
n = c x v = 0.4 mol/l x 0.05 l = **0.02 moles**

(c) What mass of sodium carbonate is present in the solution?
M = n x GFM = 0.02 moles x 106 g = **2.12 g**

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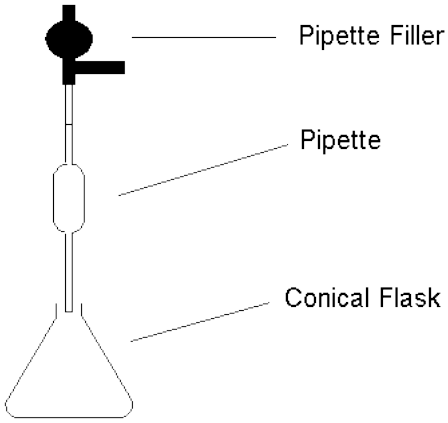
Titration

Titration is an analytical technique used to determine the accurate volumes involved in chemical reactions such as neutralisation. The technique involves the use of an indicator which changes colour when the alkali has been neutralised by the acid. This is called the end-point of the reaction.

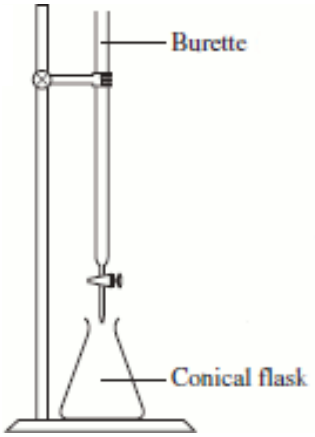
Titration can also be used to produce a soluble salt. Once the volumes of acid and alkali have been noted, the reaction can be repeated without the indicator to produce an uncontaminated salt solution. The salt solution can then be evaporated to dryness.

Method

Step 1:



Step 2:



1. A pipette is filled using a pipette filler to provide an accurately known volume of a solution.

2. Indicator is then added to the conical flask so the end-point of the reaction can be seen.

3. A solution of accurately known concentration is then added slowly using the burette until the end-point is reached.

Results

Titration	Start volume (cm^3)	Final volume (cm^3)	Volume added (cm^3)
~~Rough~~	~~0.0~~	~~15.4~~	~~15.4~~
First	15.4	30.4	15.0
second	30.4	45.4	15.0

A rough titration is always carried out first. Titrations are repeated until the results are concordant (values are within ±0.2 cm^3). Only concordant results are used in the calculation (±0.2 cm^3). The volume of solution used in the rough titre is not used to calculate the average volume of solution used in the reaction.

For these results the average volume of solution used in this titration is 15 cm^3.

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Titration calculations

Titration is commonly used in neutralisation reactions to calculate an unknown concentration (of either the acid or alkali).

Example

Q: What is the concentration of NaOH if 20 cm^3 is required to neutralise 50 cm^3 of HNO_3 with a concentration of 1 mol l^{-1}? The balanced equation for the reaction is:

$$NaOH + HNO_3 \rightarrow NaNO_3 + H_2O$$

Step 1: We are given the volume and concentration of HNO_3 so can work out the number of moles.

n = ?

c = 1 mol l^{-1}

v = 50 cm^3 / 1000 = 0.05 l

n = c x v

= 1 mol l^{-1} x 0.05 l

= 0.05 moles

Step 2: Use the balanced equation to find the mole ratio of HNO_3:NaOH and calculate how many moles of NaOH would react.

1 mole of HNO_3: 1 mole of NaOH

Therefore, 0.05 moles HNO_3: 0.05 mole of NaOH

Step 3: We now have the number of moles and the volume of NaOH so can work out the concentration.

n = 0.05 moles

c = ?

v = 20 cm^3 / 1000 = 0.02 l

c = n / v

= 0.05 moles / 0.02 l

= 2.5 mol l^{-1}

Or the calculation can also be set out in a table:

	HNO_3 (known)	NaOH (unknown)
Mole ratio	1 → (x 1)	→ 1
Number of moles - n (mol)	n = c x v = 1 mol l^{-1} x 0.05 l = 0.05 mol → (x 1)	→ 0.05 mol
Concentration - c (mol l^{-1})	1 mol l^{-1}	C =n/v = 0.05 mol / 0.02 l **= 2.5 mol l^{-1}**
Volume - v (l)	50 cm^3 / 1000 = 0.05 l	20 cm^3/1000 = 0.02 l

Complete in Classwork jotter

Self-Check

1. Nitric acid reacts with sodium hydroxide according to the equation:

$$HNO_3 + NaOH \text{ ---> } NaNO_3 + H_2O$$

What volume of 0·1 mol l^{-1} nitric acid is needed to neutralise 100 cm^3 of a 0·2 mol l^{-1} solution of sodium hydroxide?

2. Hydrochloric acid reacts with calcium hydroxide according to the equation:

$$2HCl + Ca(OH)_2 \text{ ---> } CaCl2 + H_2O$$

50 cm^3 of a 0·5 mol l^{-1} solution of hydrochloric acid was neutralised by 100$cm^3$of calcium hydroxide solution. What was the **concentration of the calcium hydroxide solution**?

3. Sodium hydroxide reacts with sulphuric acid according to the equation:

$$2NaOH + H_2SO_4 \text{ ---> } Na_2SO_4 + 2H_2O$$

40 cm^3 of a solution of sodium hydroxide was neutralised by 100 cm^3 of a 0·5 mol l^{-1} solution of sulphuric acid. What was the **concentration of the sodium hydroxide?**

Mark your Self-Check

Self-Check Answers

1.

	NaOH (known)	HNO_3 (unknown)
MR	1 → (x 1) →	1
n (mol)	n = c x v = 0.2 mol l^{-1} x 0.1 l = 0.02mol → (x 1) →	0.02 mol
c (mol l^{-1})	0.2 mol l^{-1}	0.1 mol l^{-1}
v (l)	100 cm^3 / 1000 = 0.1 l	V = n/c = 0.02 mol / 0.1 mol l^{-1} **= 0.2 l**

2.

	HCl	$Ca(OH)_2$
MR	2 → (x 0.5) →	1
n (mol)	n = c x v = 0.5 mol l^{-1} x 0.05 l = 0.025mol → (x 0.5) →	0.0125 mol
c (mol l^{-1})	0.5 mol l^{-1}	C =n/v = 0.0125 mol / 0.1 l **= 0.125 mol l^{-1}**
v (l)	50 cm^3 / 1000 = 0.05 l	100 cm^3 / 1000 = 0.1 l

3.

	H_2SO_4	NaOH
MR	1 → (x 2) →	2
n (mol)	n = c x v = 0.5 mol l^{-1} x 0.1 l = 0.05mol → (x 2) →	0.1 mol
c (mol l^{-1})	0.5 mol l^{-1}	C =n/v = 0.1 mol / 0.04 l **= 2.5 mol l^{-1}**
v (l)	100 cm^3 / 1000 = 0.1 l	40 cm^3 / 1000 = 0.04 l

Complete homework in homework jotter.

Mole calculations and Titration calculations 27

1. What is the concentration of the following solutions?

   (a) 0.1 mole of substance dissolved in 200 cm^3 of solution
   (b) 0.2 mole of substance dissolved in 200 cm^3 of solution
   (c) 0.15 mole of substance dissolved in 75 cm^3 of solution

2. How many moles of substance are dissolved in the following solutions?

   (a) 250 cm^3 of 2 mol l^{-1} (b) 300 cm^3 of 1 mol l^{-1}
   (c) 500 cm^3 of 0.5 mol l^{-1} (d) 400 cm^3 of 2 mol l^{-1}

3. Hydrochloric acid reacts with potassium hydroxide according to the equation:

   $HCl + KOH \rightarrow KCl + H_2O$

   What is the concentration of a solution of hydrochloric acid if 12·5 cm^3 of hydrochloric acid is neutralised by 20 cm^3 of a 0·1 mol l^{-1} solution of potassium hydroxide?

4. Sodium hydroxide reacts with sulphuric acid according to the equation:

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

   What is the concentration of sulphuric acid if 20 cm^3 of a solution of the acid is neutralised by 25 cm^3 of a 0·5 mol l^{-1} solution of sodium hydroxide?

5. 1mole of oxalic acid neutralises 2 moles of sodium hydroxide.
   What volume of a 0·5 mol l^{-1} solution of oxalic acid neutralises 100 cm^3 of a 2 mol l^{-1} solution of sodium hydroxide?