Contents

Chapter 1 Titration

Finding Percentage Purity/Percentage Composition

8 **M** is a mixture of iron(II) sulfate and iron(III) sulfate.
A student determines the mass of iron(II) sulfate in the mixture using 0.0180 mol/dm^3 aqueous potassium manganate(VII), solution **S**.

(a) Potassium manganate(VII), which is purple, oxidises the iron(II) ions in the mixture.

Why does potassium manganate(VII) not react with iron(III) ions?

.....[1]

(b) A sample of **M** is added to a previously weighed container, which is then reweighed.

mass of container + **M** = 17.01 g
mass of container = 11.93 g

Calculate the mass of **M** used in the experiment.

..... g [1]

(c) The sample of **M** is placed in a flask, dissolved in 100 cm^3 of dilute sulfuric acid and mixed thoroughly. The solution is made up to 250 cm^3 with distilled water. This is solution **P**.

25.0 cm^3 of **P** is transferred into a conical flask.

What piece of apparatus should be used to transfer 25.0 cm^3 of **P**?

.....[1]

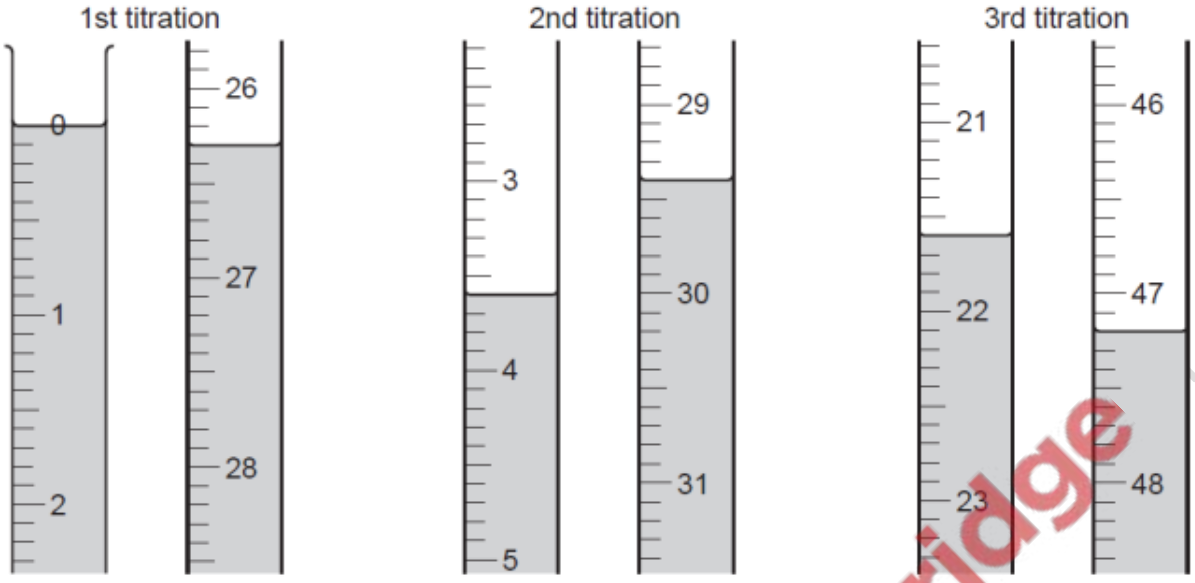
(d) Solution **S** is put into a burette and run into the conical flask containing **P** until the end-point is reached.

What is the colour of the solution in the conical flask

(i) before **S** is added, ...

(ii) at the end-point when **S** is just in excess? ..... [1]

(e) Three titrations are done. The diagrams below show parts of the burette with the liquid levels at the beginning and end of each titration.



Use the diagrams to complete the following table.

titration number	1	2	3
final burette reading / cm^3			
initial burette reading / cm^3			
volume of **S** used / cm^3			
best titration results (✓)			

Summary

Tick (✓) the best titration results.

Using these results, the average volume of **S** used is

..... cm^3. [4]

(f) **S** is 0.0180 mol/dm^3 potassium manganate(VII).

Calculate the number of moles of potassium manganate(VII) in the average volume of **S** in **(e)**.

..... moles [1]

(g) **One** mole of potassium manganate(VII) reacts with **five** moles of iron(II) sulfate.

Deduce the number of moles of iron(II) sulfate in 25.0 cm^3 of **P**.

..... moles [1]

(h) Calculate

(i) the number of moles of iron(II) sulfate in 250 cm^3 **P**,

..... moles [1]

(ii) the mass of iron(II) sulfate in 250 cm^3 of **P**.
[M_r: $FeSO_4$, 152]

..... g [1]

(i) Using your answers to **(b)** and **(h)(ii)**, calculate the mass of iron(II) sulfate in 1000 g of **M**.

..... g [1]

[Total: 13]

9 Substance **F** is a fertiliser containing ammonium sulfate.
A student determines the mass of ammonia produced from 1000 g of **F**.

(a) A sample of **F** is added to a previously weighed container which is then reweighed.

mass of container + **F**	=	9.22 g
mass of container	=	7.46 g

Calculate the mass of **F** used in the experiment.

..... g [1]

The sample of **F** is placed in a beaker and 50 cm^3 of 1.00 mol/dm^3 sodium hydroxide, an excess, is added.

The mixture is heated until all the ammonia gas has evolved.

$$(NH_4)_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O + 2NH_3$$

After cooling, the remaining mixture, which contains excess sodium hydroxide, is transferred to a graduated flask and made up to 250 cm^3 with distilled water. This is solution **G**.

25.0 cm^3 of **G** is transferred to a conical flask and a few drops of phenolphthalein indicator are added.

A burette is filled with 0.100 mol/dm^3 hydrochloric acid.

0.100 mol/dm^3 hydrochloric acid is added to **G** until an end-point is reached.

Phenolphthalein is colourless in acid solution and pink in alkaline solution.

(b) What is the colour of the solution in the conical flask

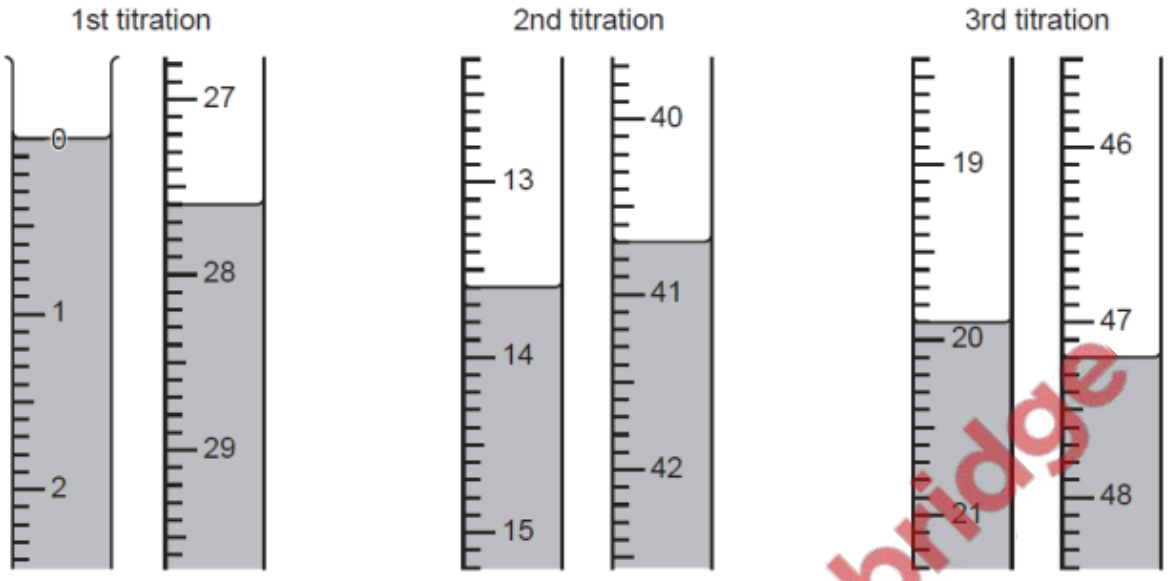
(i) before hydrochloric acid is added,

.....

(ii) at the end-point?

..... [1]

(c) Three titrations are done.
The diagrams below show parts of the burette with the liquid levels at the beginning and end of each titration.



Use the diagrams to complete the following table.

titration number	1	2	3
final reading / cm^3			
initial reading / cm^3			
volume of hydrochloric acid used / cm^3			
best titration results (✓)			

Summary:
Tick (✓) the best titration results.
Using these results, the average volume of hydrochloric acid used is

..... cm^3. [4]

(d) Calculate the number of moles of hydrochloric acid in the average volume of 0.100 mol / dm^3 hydrochloric acid in **(c)**.

..... moles [1]

(e) Using the equation

$$HCl + NaOH \rightarrow NaCl + H_2O$$

deduce the number of moles of sodium hydroxide in 25.0 cm^3 of **G**.

..... moles [1]

(f) Using your answer in **(e)** calculate the number of moles of sodium hydroxide in 250 cm^3 of **G**.

..... moles [1]

(g) Calculate the number of moles of sodium hydroxide in 50 cm^3 of 1.00 mol/dm^3 sodium hydroxide.

..... moles [1]

(h) By subtracting your answer in **(f)** from your answer in **(g)** calculate the number of moles of sodium hydroxide which reacts with the sample **F**.

..... moles [1]

(i) Given that 1 mole of sodium hydroxide produces 17 g of ammonia.
Calculate

(i) the mass of ammonia produced from the original sample of **F**,

..... g NH_3 [1]

(ii) the mass of ammonia produced from 1000 g of **F**.

..... g NH_3 / 1000 g fertiliser **F** [1]

(j) Like ammonium sulfate, ammonium nitrate NH_4NO_3, is a 'nitrogenous fertiliser' which is used to promote plant growth and increase crop yield.

Which two compounds will react together to form aqueous ammonium nitrate?

..... and ..... [1]

(k) Calculate the mass of nitrogen in 1000 g of ammonium nitrate.
[A_r : H,1; N,14; O,16]

..... g / 1000 g [1]

[Total: 15]

8 A student was given a bottle containing small pieces of scrap iron.

He was asked to find the purity of this sample of iron.

A small quantity of the iron was placed in a previously weighed container which was then reweighed.

mass of container + iron = 6.16 g
mass of container = 4.72 g

(a) Calculate the mass of iron.

..... g [1]

The iron was placed in a conical flask and excess dilute sulfuric acid was added to react completely with the iron. The flask was warmed and the iron reacted with the sulfuric acid to produce aqueous Fe^{2+} ions.

A gas was produced during this reaction.

(b) **(i)** Name this gas.

..... [1]

(ii) Give a test for this gas.

..... [1]

(iii) State the equation for the reaction between iron and sulfuric acid.

..... [1]

When all the iron had reacted the resulting solution was cooled and made up to 250 cm^3 with distilled water in a graduated flask. This was solution **S**.
Using a pipette, 25.0 cm^3 of **S** was transferred into a conical flask.
Solution **T** was 0.0200 mol/dm^3 potassium manganate(VII).
A burette was filled with **T**.
T was run into the conical flask until an end-point was reached.
Aqueous potassium manganate(VII) is purple.
Aqueous Fe^{2+} is pale green.

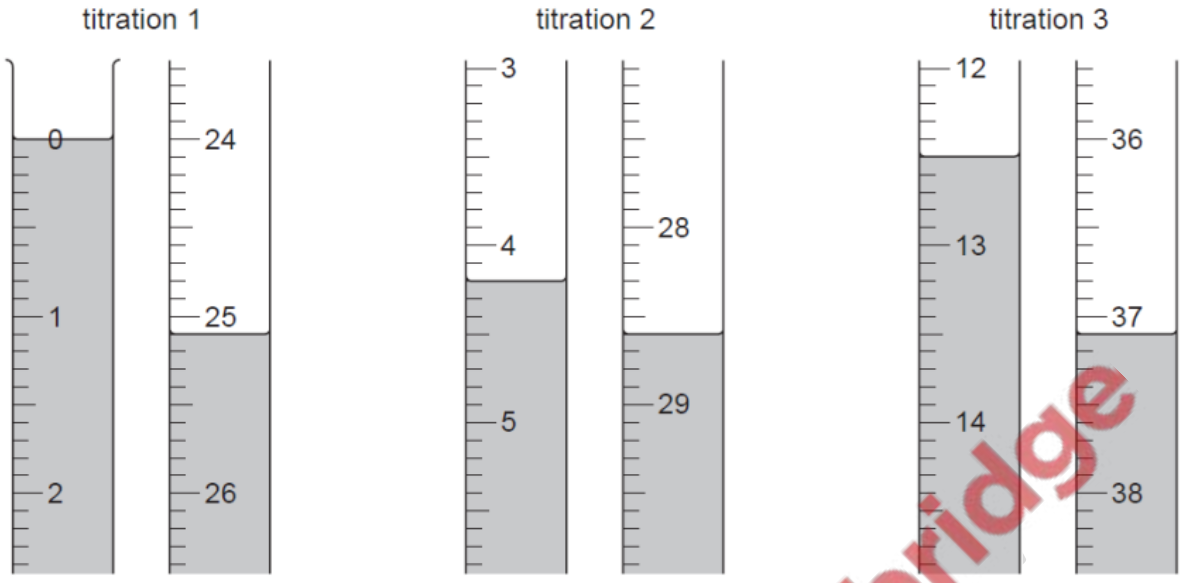
(c) What colour is the solution in the flask at the end-point?

Explain your answer.

.....

..... [2]

Three titrations were done. The diagrams below show parts of the burette with the liquid levels at the beginning and end of each titration.



(d) Use the diagrams to complete the results table.

titration number	1	2	3
final burette reading / cm^3			
initial burette reading / cm^3			
volume of **T** used / cm^3			
best titration results (✓)			

Summary

Tick (✓) the best titration results.

Using these results, the average volume of **T** was ..... cm^3. [4]

(e) Calculate the number of moles of potassium manganate(VII) in the average volume of **T** required in **(d)**.

T was 0.0200 mol/dm^3 potassium manganate(VII).

..... moles [1]

(f) Five moles of Fe^{2+} react with one mole of potassium manganate(VII).

Calculate the number of moles of Fe^{2+} in 25.0 cm^3 of **S**.

..... moles [1]

(g) Calculate the number of moles of Fe^{2+} in 250 cm^3 of **S**.

..... moles [1]

(h) Calculate the mass of Fe^{2+} in 250 cm^3 of **S**.

[A_r: Fe, 56]

..... g [1]

(i) Using your answers to **(a)** and **(h)**, calculate the percentage purity of the sample of iron.

..... % [1]

[Total: 15]

Finding Unknown Concentration

9 An experiment was done to find the concentration of an aqueous solution of ammonium chloride labelled **P**.

Q was 0.0800 mol/dm^3 hydrochloric acid.

A 25.0 cm^3 sample of **P** was measured into a flask followed by 25.0 cm^3 of 2.00 mol/dm^3 sodium hydroxide (an excess). Some of the sodium hydroxide reacted with the ammonium chloride to produce ammonia. The equation is given below.

$$NaOH + NH_4Cl \rightarrow NaCl + NH_3 + H_2O$$

(a) What apparatus should be used to measure out 25.0 cm^3 of a solution?

.....[1]

The flask was heated until no more ammonia was detected in the steam.

(b) Suggest a test to detect ammonia in the steam leaving the flask.

.....[1]

After cooling, the mixture was transferred to a volumetric flask and made up to 250 cm^3 with distilled water.
This was solution **R**.

25.0 cm^3 of **R** was transferred to a conical flask and a few drops of methyl orange indicator added.

(c) What colour was the methyl orange in the flask?

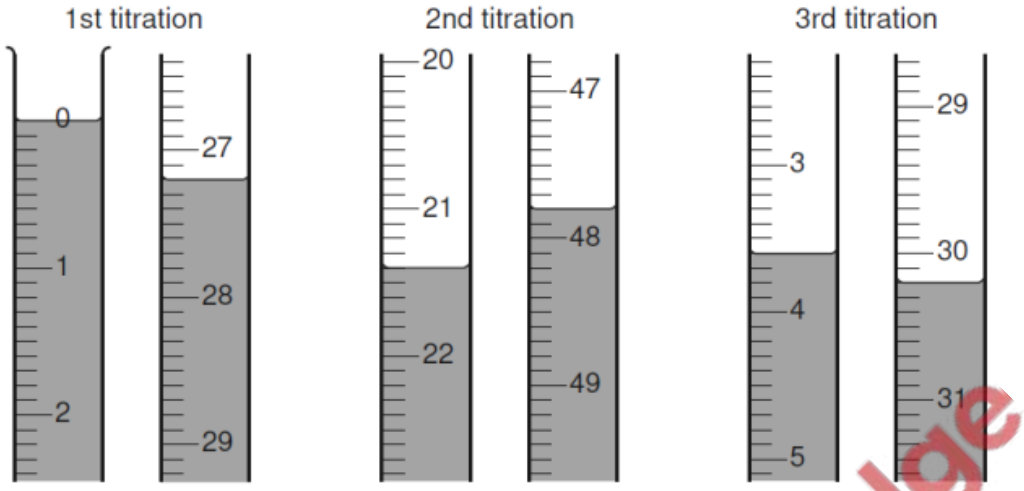
.....

A burette was filled with **Q**.
Q was run into the conical flask until an end-point was reached.

What was the colour of the methyl orange when the end-point was reached?

.....
[1]

Three titrations were done. The diagrams below show parts of the burette with the liquid levels at the beginning and end of each titration.



(d) Use the diagrams to complete the following table.

titration number	1	2	3
final burette reading /cm^3			
initial burette reading /cm^3			
volume of **Q** used /cm^3			
best titration results (✓)			

Summary:

Tick (✓) the best titration results.

Using these results the average volume of **Q** was .....cm^3. [4]

(e) **Q** was 0.0800 mol/dm^3 hydrochloric acid. Calculate the number of moles of hydrochloric acid in the average volume of **Q** calculated in **(d)**.

..... [1]

(f) Using the equation

$$NaOH + HCl \rightarrow NaCl + H_2O$$

and your answer to **(e)**, deduce the number of moles of sodium hydroxide in 25.0 cm^3 of **R**.

..... [1]

(g) Using your answer to **(f)** calculate the number of moles of sodium hydroxide in 250 cm^3 of **R**.

..... [1]

(h) Calculate the number of moles of sodium hydroxide present in 25.0 cm^3 of 2.00 mol/dm^3 aqueous sodium hydroxide which was added originally to 25.0 cm^3 of **P**.

..... [1]

(i) Using your answers to **(g)** and **(h)**, calculate the number of moles of sodium hydroxide that reacted with 25.0 cm^3 of **P**.

..... [1]

(j) Using the equation

$$NaOH + NH_4Cl \rightarrow NH_3 + NaCl + H_2O$$

and your answer to **(i)**,

(i) deduce the number of moles of ammonium chloride in 25.0 cm^3 of **P**,

..... [1]

(ii) calculate the concentration, in mol/dm^3, of **P**.

..... [1]

[Total: 14]

8 A student is given a sample of a metal carbonate, **R**CO_3.
She is asked to determine the relative atomic mass of **R** and suggest its identity.

(a) A sample of the metal carbonate is added to a previously weighed container which is then reweighed.

mass of container + **R**CO_3	=	12.01 g
mass of container	=	10.97 g

Calculate the mass of **R**CO_3 used in the experiment.

.....g [1]

(b) The student transfers the sample of **R**CO_3 to a beaker and adds 50.0 cm^3 of 1.00 mol/dm^3 hydrochloric acid (an excess).
All the solid reacts to form an aqueous solution.
When the reaction has finished, the contents of the beaker are transferred to a volumetric flask.
The solution is made up to 250 cm^3 with distilled water and mixed well.
This is solution **S**.

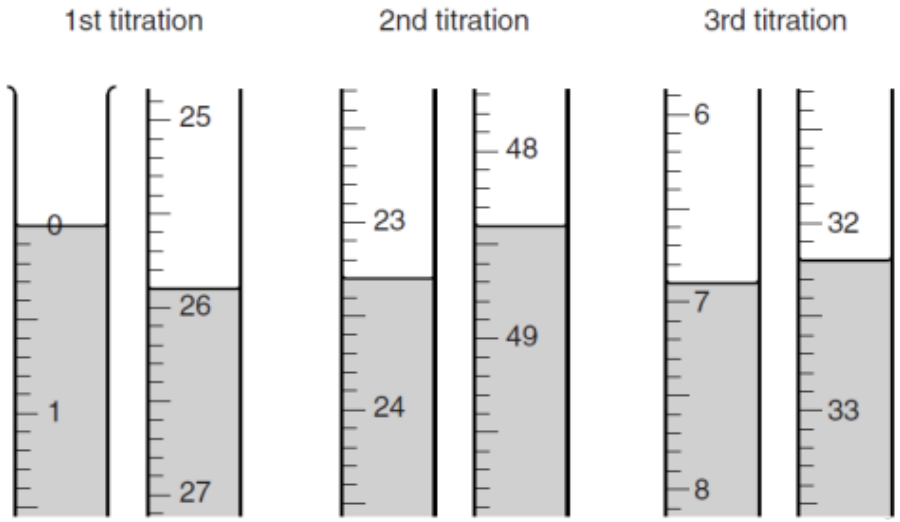
Using a pipette, 25.0 cm^3 of **S** is transferred to a conical flask and a few drops of methyl orange indicator are added.
A burette is filled with 0.100 mol/dm^3 aqueous sodium hydroxide which is added to the conical flask until an end-point is reached.

What is the colour of the solution in the conical flask

(i) before the alkali is added, ...

(ii) at the end-point? .....
[1]

(c) The student does three titrations. The diagrams below show parts of the burette with the liquid levels at the beginning and end of each titration.



Use the diagrams to complete the following table.

titration number	1	2	3
final burette reading / cm^3			
initial burette reading / cm^3			
volume of 0.100 mol/dm^3 sodium hydroxide / cm^3			
best titration results (✓)			

Summary:

Tick (✓) the best titration results.

Using these results, the average volume of 0.100 mol/dm^3 sodium hydroxide is

..... cm^3. [4]

(d) Calculate the number of moles of sodium hydroxide in the average volume of 0.100 mol/dm^3 sodium hydroxide.

..... moles [1]

(e) Using the equation

$$NaOH + HCl \rightarrow NaCl + H_2O$$

calculate the number of moles of hydrochloric acid in 25.0 cm^3 of **S**.

..... moles [1]

(f) Calculate the number of moles of hydrochloric acid in 250 cm^3 of **S**.

..... moles [1]

(g) Calculate the number of moles of hydrochloric acid in the original 50.0 cm^3 of 1.00 mol/dm^3 hydrochloric acid.

..... moles [1]

(h) By subtracting your answer in **(f)** from your answer in **(g)**, calculate the number of moles of hydrochloric acid that reacts with the sample of $\mathbf{R}CO_3$.

..... moles [1]

(i) Using the equation

$$\mathbf{R}CO_3 + 2HCl \rightarrow \mathbf{R}Cl_2 + H_2O + CO_2$$

calculate the number of moles of $\mathbf{R}CO_3$ that reacts with the number of moles of hydrochloric acid in your answer **(h)**.

..... moles [1]

(j) Using your answers to **(a)** and **(i)**, calculate the relative formula mass of $\mathbf{R}CO_3$ and hence the relative atomic mass of **R**.
[A_r: C, 12; O, 16]

relative formula mass of $\mathbf{R}CO_3$ = ...

relative atomic mass of **R** = ...
[2]

(k) **R** is less reactive than calcium but more reactive than zinc.
Suggest the identity of **R**.

R is ..... [1]

[Total: 15]

9 A student is given a sample of a metal hydroxide, **M**OH, and asked to determine the relative atomic mass of **M** by titrating an aqueous solution of **M**OH with 0.095 mol / dm^3 sulfuric acid, solution **S**.

(a) A sample of **M**OH is placed in a previously weighed container, which is then reweighed.

mass of container + **M**OH	=	11.58 g
mass of container	=	8.89 g

Calculate the mass of **M**OH used in the experiment.

.....g [1]

(b) The student transfers the sample of **M**OH to a beaker, adds about 100 cm^3 of distilled water and stirs the mixture until all the solid has dissolved. The contents of the beaker are then transferred to a volumetric flask.
The solution is made up to 250 cm^3 with distilled water.
This is solution **G**.
25.0 cm^3 of **G** is transferred to a conical flask.
A few drops of methyl orange indicator are added to the conical flask.

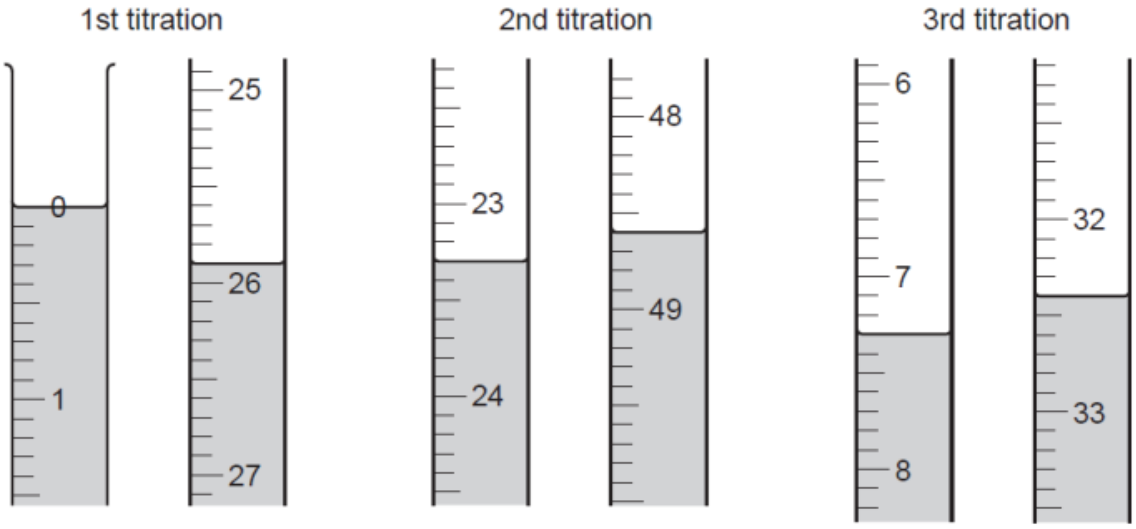
S is put into a burette and added to the solution in the conical flask until an end-point is reached.

What is the colour of the solution in the conical flask

(i) before **S** is added, ...

(ii) at the end-point? .....[1]

(c) The student does three titrations. The diagrams below show parts of the burette with the liquid levels at the beginning and end of each titration.



Use the diagrams to complete the following table.

titration	1	2	3
final burette reading / cm^3			
initial burette reading / cm^3			
volume of **S** used / cm^3			
best titration results (✓)			

Summary

Tick (✓) the best titration results.

Using these results the average volume of **S** is

..... cm^3 [4]

(d) Calculate the number of moles of sulfuric acid in the average volume of 0.095 mol/dm^3 sulfuric acid, **S**, from **(c)**.

..... moles [1]

(e) Using your answer to **(d)** and the equation, calculate the number of moles of **M**OH in 25.0 cm^3 of **G**.

$$2\mathbf{M}OH + H_2SO_4 \rightarrow \mathbf{M}_2SO_4 + 2H_2O$$

..... moles [1]

(f) Using your answer to **(e)** calculate the number of moles of **M**OH in 250 cm^3 of **G**.

..... moles [1]

(g) Using your answers to **(a)** and **(f)** calculate the mass of one mole of **M**OH.

..... [1]

(h) Using your answer to **(g)** calculate the relative atomic mass of **M**.
[A_r: H,1; O,16]

..... [1]

[Total: 11]

8 A student did an experiment to find the relative molecular mass of an organic acid. He titrated solution **R**, an aqueous solution containing 8.50 g/dm^3 of the organic acid, with solution **S**, containing 0.100 mol/dm^3 of sodium hydroxide.

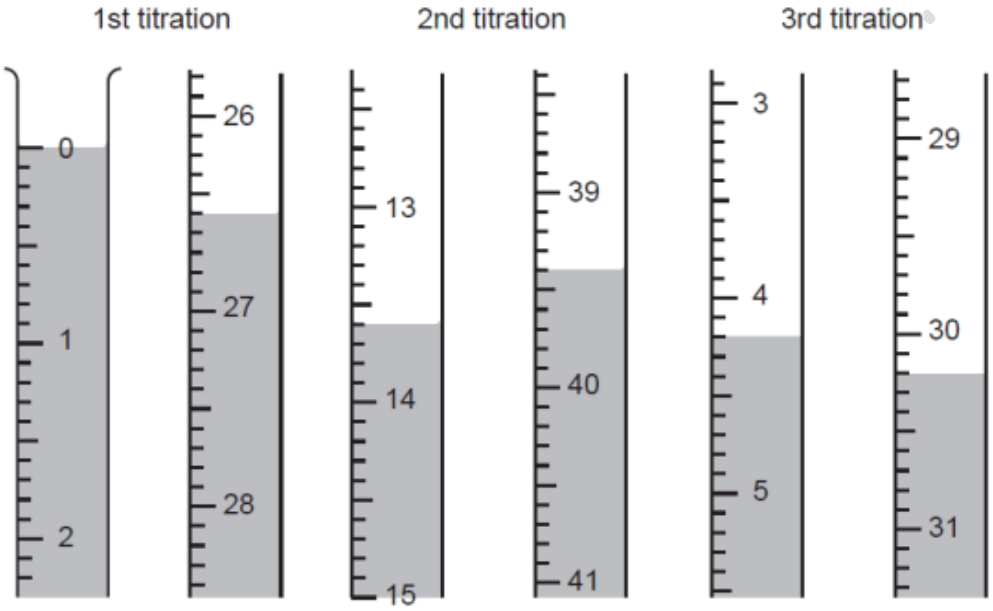
25.0 cm^3 of **S** was transferred into a conical flask and a few drops of phenolphthalein indicator were added. (Phenolphthalein is colourless in acid and pink in alkali.)

R was put into a burette and run into the conical flask containing **S** until the end-point was reached.

(a) What was the colour change at the end-point?

The colour changed from ..... to ..... [1]

Three titrations were done. The diagrams below show parts of the burette with the liquid levels at the beginning and end of each titration.



(b) Use these diagrams to complete the table of results.

titration number	1	2	3
final burette reading / cm^3			
initial burette reading / cm^3			
volume of **R** / cm^3			
best titration results (✓)			

Summary

Tick (✓) the best titration results.

Using these results, the average volume of **R** was ..... cm^3. [4]

(c) Calculate the number of moles of sodium hydroxide in 25.0 cm^3 of **S**.

..... moles [1]

(d) Given that 1 mol of acid neutralises 1 mol of sodium hydroxide, use your answer to **(c)** to deduce the number of moles of the organic acid in the average volume of **R**.

..... moles [1]

(e) Calculate the number of moles of the acid in 1.00 dm^3 of **R**.

..... moles [1]

(f) Using your answer to **(e)** and the information that **R** contains 8.50 g/dm^3 of the acid, calculate the relative molecular mass of the acid.

..... [1]

(g) **(i)** The general formula of an organic acid is $C_nH_{2n+1}CO_2H$.

Calculate the value of n in the formula for the organic acid in **R**.
[A_r: C, 12; O, 16; H, 1]

n = ... [1]

(ii) Deduce the formula for the organic acid in **R**.

The formula for the organic acid in **R** is ..... [1]

(h) A sample of the organic acid was reacted with an excess of ethanol, C_2H_5OH, in the presence of a small volume of concentrated sulfuric acid to give an organic product, **T**, and water.

(i) Suggest the formula for **T**.

The formula for **T** is .....[1]

(ii) To which homologous series does **T** belong?

.....[1]

[Total: 13]

8 A student was given a sample of an organic acid, **T**, and asked to

- determine its relative molecular mass, and
- suggest its molecular formula.

A sample of the acid was placed in a previously weighed container and reweighed.

mass of the container and the acid = 8.25 g
mass of container = 6.74 g

(a) Calculate the mass of the acid used in the experiment.

..... g [1]

The student transferred the sample to a beaker and added 50.0 cm^3 of 1.00 mol/dm^3 sodium hydroxide. The contents of the beaker were allowed to react and then transferred to a volumetric flask. The solution was made up to 250 cm^3 with distilled water. This was solution **S**.

25.0 cm^3 of **S** was transferred into a conical flask.

(b) What piece of apparatus was used to measure this volume of **S**?

.....[1]

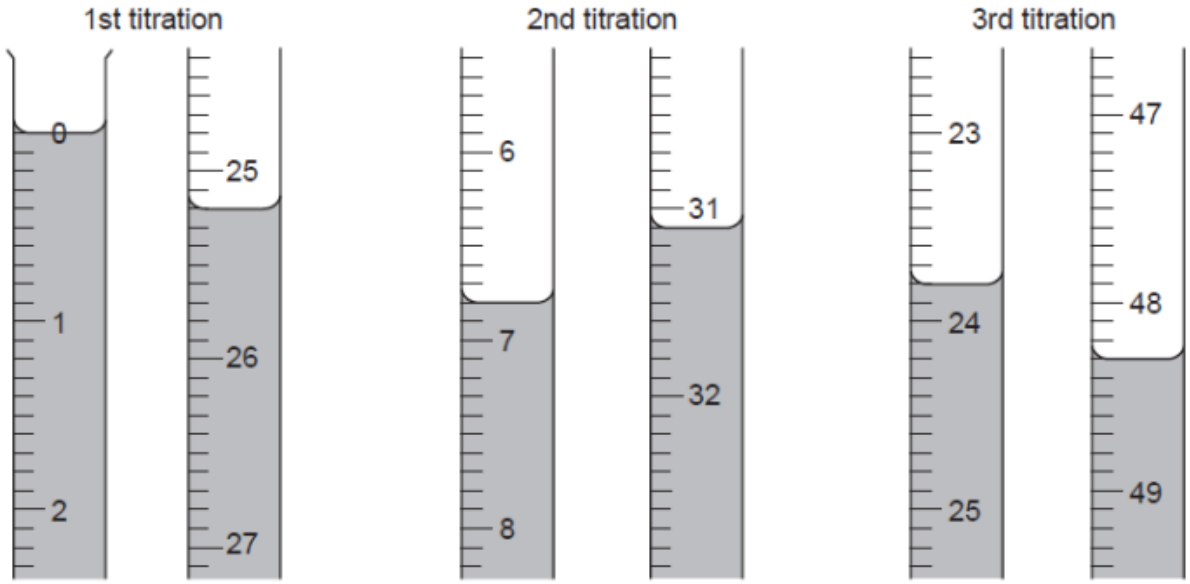
A few drops of phenolphthalein indicator were added to the conical flask.
0.100 mol/dm^3 hydrochloric acid was placed in a burette and added to the solution in the conical flask until an end-point was reached.
Phenolphthalein is colourless in acidic solution and pink in alkaline solution.

(c) What was the colour of the solution in the conical flask

- before the acid was added, ...
- at the end-point? .....

[1]

Three titrations were done. The diagrams below show parts of the burette with the liquid levels at the beginning and the end of each titration.



(d) Use the diagrams to complete the following table.

titration number	1	2	3
final reading / cm^3			
initial reading / cm^3			
volume of hydrochloric acid used / cm^3			
best titration results (✓)			

Summary

Tick (✓) the best titration results.

Using these results, the average volume of hydrochloric acid required was ..... cm^3. [4]

(e) Calculate the number of moles of hydrochloric acid in the average volume of 0.100 mol /dm^3 hydrochloric acid calculated in **(d)**.

..... moles [1]

(f) Hydrochloric acid reacts with sodium hydroxide according to the following equation.

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

Deduce the number of moles of sodium hydroxide present in 25.0 cm^3 of solution **S**.

..... moles [1]

(g) Using your answer in **(f)**, calculate the number of moles of sodium hydroxide in 250 cm^3 of solution **S**.

..... moles [1]

(h) Calculate the number of moles of sodium hydroxide in 50.0 cm^3 of 1.00 mol/dm^3 sodium hydroxide.

..... moles [1]

(i) By subtracting your answer in **(g)** from your answer in **(h)**, calculate the number of moles of sodium hydroxide that reacted with the original sample of the organic acid, **T**.

..... moles [1]

(j) Given that **one** mole of **T** reacted with **two** moles of sodium hydroxide, calculate the number of moles of **T** in the sample.

..... moles [1]

(k) Using your answers to **(a)** and **(j)** calculate the relative molecular mass of the acid **T**.

.....[1]

The acid **T** contains two carboxylic acid groups and has the formula

$$HOOCC_xH_yCOOH$$

where **x** and **y** are whole numbers.

(l) Deduce the values of **x** and **y** in the formula.
[A_r: C, 12; O, 16; H, 1]

x .....

y .....
[2]

(m) A sample of the acid **T** was reacted with an excess of ethanol in the presence of a small volume of sulphuric acid.

(i) Give the formula of the organic product.

.....[1]

(ii) To which group of compounds does the product belong?

..... [1]
[Total: 18]

Redox

9 **R** is a mixture of iron(II) sulphate and iron(III) sulphate.

A student determined the percentage of iron(II) sulphate in the mixture using 0.0200 mol/dm^3 aqueous potassium manganate(VII), solution **S**.

Potassium manganate(VII), which is purple, oxidises the iron(II) ions in the mixture.

(a) Suggest why potassium manganate(VII) does not react with iron(III) ions.

..... [1]

A sample of **R** was added to a previously weighed container, which was then reweighed.

mass of container + **R** = 18.04 g
mass of container = 11.96 g

(b) Calculate the mass of **R** used in the experiment.

..... g [1]

The sample of **R** was placed in a flask, dissolved in 100 cm^3 of dilute sulphuric acid and the solution made up to 250 cm^3 with distilled water. This was solution **T**.

25.0 cm^3 of **T** was transferred into a conical flask.

(c) What piece of apparatus should be used to transfer this volume of **T**?

..... [1]

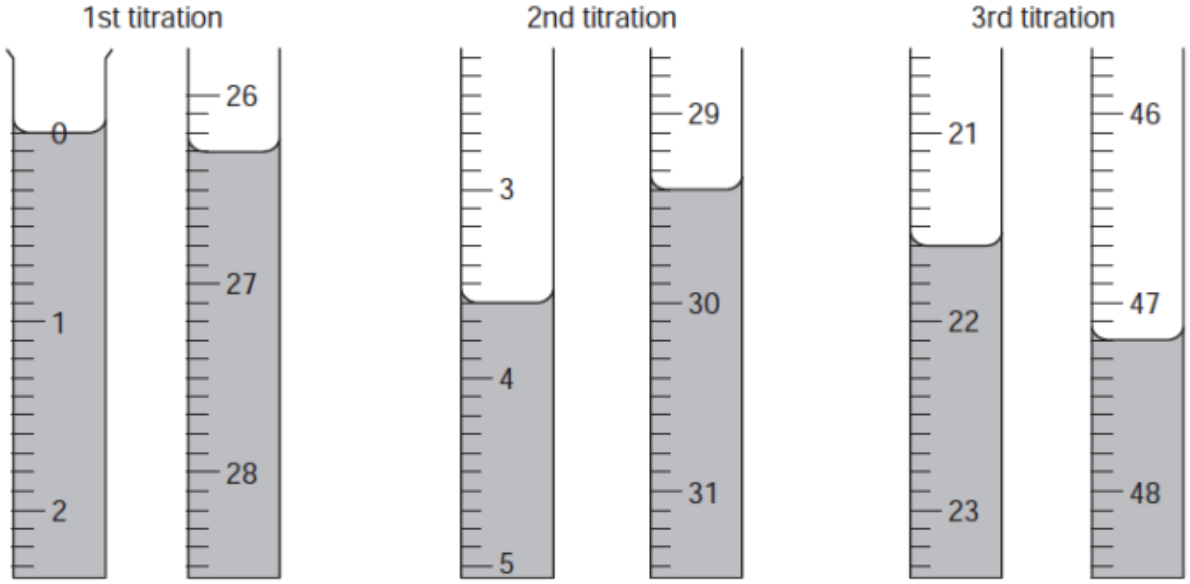
Solution **S** was put into a burette and run into the conical flask containing **T**.

(d) What was the colour of the solution in the conical flask

(i) before **S** was added, ...

(ii) at the end-point? .....
[2]

Three titrations were done. The diagrams below show parts of the burette with the liquid levels at the beginning and end of each titration.



(e) Use the diagrams to complete the following table.

titration number	1	2	3
final burette reading / cm^3			
initial burette reading / cm^3			
volume of **S** used / cm^3			
best titration results (✓)			

Summary

Tick (✓) the best titration results.

Using these results the average volume of **S** used was ..... cm^3. [4]

S is 0.0200 mol/dm^3 potassium manganate(VII).

(f) Calculate the number of moles of potassium manganate(VII) present in the average volume of **S** in **(e)**.

..... moles [1]

One mole of potassium manganate(VII) reacts with **five** moles of iron(II) sulphate.

(g) Calculate the number of moles of iron(II) sulphate in 25.0 cm^3 of **T**.

..... moles [1]

(h) Calculate the number of moles of iron(II) sulphate in 250 cm^3 of **T**.

..... moles [1]

(i) Using your answer to **(h)**, calculate the mass of iron(II) sulphate present in solution **T**.
[M_r: $FeSO_4$, 152]

..... g [1]

(j) Using your answers to **(b)** and **(i)**, calculate the percentage of iron(II) sulphate in the sample of **R**.

..... % [1]

Salt.xH$_2$O type questions

8 Iron(II) sulfate crystals have the formula $FeSO_4.xH_2O$, where **x** is a whole number.

A student determines the value of **x** using aqueous 0.0200 mol/dm^3 potassium manganate(VII), **F**.

Potassium manganate(VII), which is purple, oxidises iron(II) ions to iron(III) ions.

(a) A sample of iron(II) sulfate crystals is added to a previously weighed container which is then reweighed.

mass of container + crystals = 10.94 g
mass of container = 5.98 g

Calculate the mass of iron(II) sulfate crystals used in the experiment.

..... g [1]

(b) The student transfers the sample of iron(II) sulfate crystals to a beaker and adds 100 cm^3 of dilute sulfuric acid. The solution is made up to 250 cm^3 with distilled water and mixed well.

This is solution **G**.

Using a pipette, 25.0 cm^3 of **G** is measured into a conical flask.

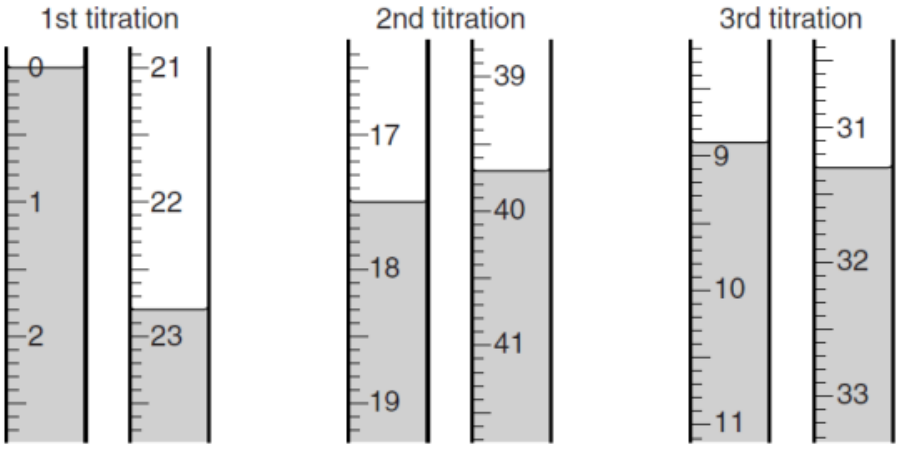
F is put into a burette and run into the conical flask containing **G**.

What is the colour of the solution in the flask

(i) before **F** is added, ...

(ii) at the end-point? ..... [1]

(c) The student does three titrations. The diagrams below show parts of the burette with the liquid levels at the beginning and end of each titration.



Use the diagrams to complete the results table.

titration number	1	2	3
final burette reading / cm^3			
initial burette reading / cm^3			
volume of **F** added / cm^3			
best titration results (✓)			

Summary

Tick (✓) the best titration results.
Using these results, the average volume of **F** is ..... cm^3. [4]

F is 0.0200 mol/dm^3 potassium manganate(VII), $KMnO_4$.

(d) Calculate the number of moles of $KMnO_4$ present in the average volume of **F**.

..... moles [1]

(e) Five moles of $FeSO_4$ react with one mole of $KMnO_4$.
Calculate the number of moles of $FeSO_4$ present in 25.0 cm^3 of **G**.

..... moles [1]

(f) Calculate the number of moles of $FeSO_4$ present in 250 cm^3 of **G**.

..... moles [1]

(g) Using your answer to **(f)**, calculate the mass of $FeSO_4$ in the original sample of $FeSO_4.\mathbf{x}H_2O$.
[A_r: O, 16; S, 32; Fe, 56]

..... g [1]

(h) Using your answers to **(a)** and **(g)**, calculate the mass of water in the sample of $FeSO_4.\mathbf{x}H_2O$.

..... g [1]

(i) Using your answer to **(h)**, calculate the number of moles of water in the sample of $FeSO_4.\mathbf{x}H_2O$.
[A_r: H, 1; O, 16]

..... moles [1]

(j) Using your answers to **(f)** and **(i)**, calculate the number of moles of water combined with one mole of $FeSO_4$.

..... moles [1]

(k) State the value of **x** in the formula of $FeSO_4.\mathbf{x}H_2O$.

.....[1]

(l) When iron(II) sulfate crystals are left to stand in air a yellow solid forms on the surface of the crystals.

(i) Suggest the identity of the yellow solid.

.....[1]

(ii) Why is it formed?

.....[1]

(iii) The yellow solid is dissolved in water. Aqueous sodium hydroxide is added.
What is seen?

.....[1]

[Total: 17]

10 Washing soda is hydrated sodium carbonate, $Na_2CO_3.xH_2O$, where **x** is a whole number.

A student determines the value of **x** in the formula by titration with 0.100 mol / dm^3 hydrochloric acid, solution **S**.

(a) A sample of $Na_2CO_3.xH_2O$ is placed in a previously weighed container which is then reweighed.

mass of container + $Na_2CO_3.xH_2O$	= 8.31 g
mass of container	= 4.79 g

Calculate the mass of $Na_2CO_3.xH_2O$.

.....g [1]

(b) The student transfers the sample of $Na_2CO_3.xH_2O$ to a beaker, adds about 100 cm^3 of distilled water and stirs the mixture until all the solid has dissolved. The contents of the beaker are then transferred to a volumetric flask.
The solution is made up to 250 cm^3 with distilled water.
This is solution **T**.
25.0 cm^3 of **T** is transferred into a conical flask.

Name the apparatus used to transfer this volume of **T**.

.....[1]

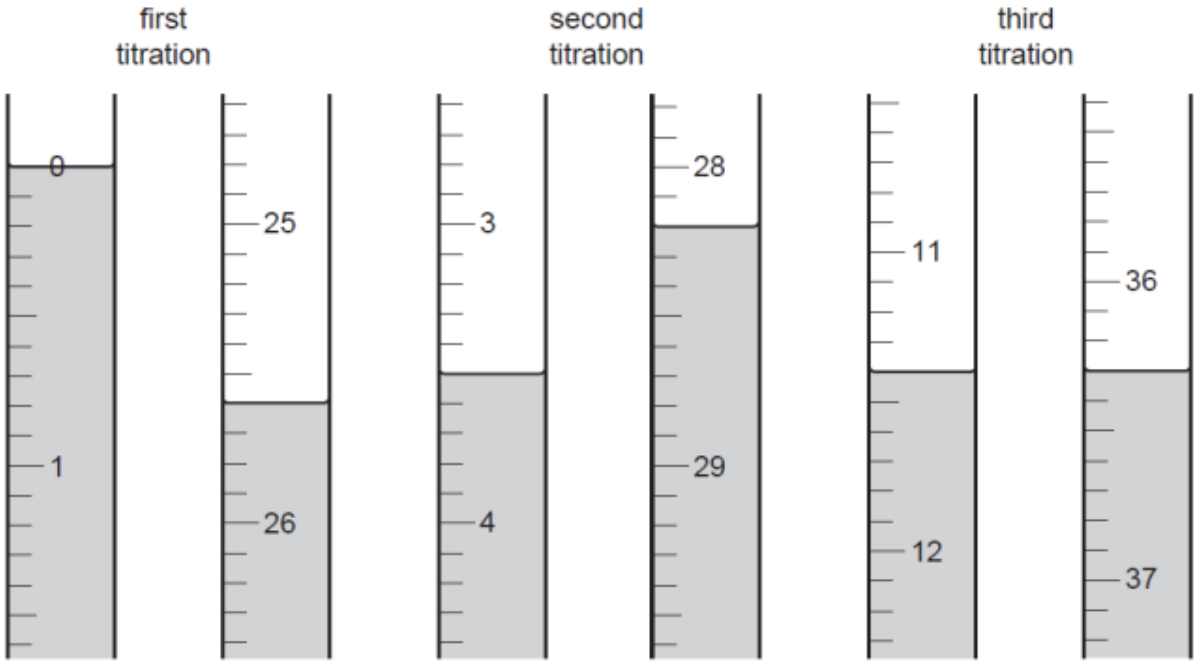
(c) A few drops of methyl orange indicator are added to the conical flask. **S** is put into a burette and added to the solution in the conical flask until an end-point is reached.

What is the colour of the solution in the flask

(i) before **S** is added, ...

(ii) at the end-point? ..... [1]

(d) The student does three titrations. The diagrams below show parts of the burette with the liquid levels at the beginning and end of each titration.



Use the diagrams to complete the following table.

titration number	1	2	3
final burette reading / cm^3			
initial burette reading / cm^3			
volume of **S** / cm^3			
best titration results (✓)			

Summary

Tick (✓) the best titration results.

Using these results, the average volume of **S** is

..... cm^3 [4]

(e) **S** is 0.100 mol / dm^3 hydrochloric acid.

Calculate the number of moles of hydrochloric acid in the average volume of **S** from **(d)**.

..... moles [1]

(f) One mole of sodium carbonate reacts with two moles of hydrochloric acid.

Deduce the number of moles of sodium carbonate which reacts with the number of moles of hydrochloric acid from **(e)**.

..... moles [1]

(g) Using your answer to **(f)**, calculate the number of moles of sodium carbonate in 250 cm^3 of **T**.

..... moles [1]

(h) Calculate the relative formula mass of sodium carbonate, Na_2CO_3.
[A_r: C, 12; O, 16; Na, 23]

..... [1]

(i) Using your answers to **(g)** and **(h)**, calculate the mass of sodium carbonate, Na_2CO_3, in 250 cm^3 of **T**.

..... g [1]

(j) By subtracting your answer in **(i)** from your answer in **(a)**, calculate the mass of water in the original sample of hydrated sodium carbonate.

..... g [1]

(k) Using your answers to **(h)**, **(i)** and **(j)** in the following formula, calculate the value of **x** and write the formula for hydrated sodium carbonate.

$$\mathbf{x} = \frac{\text{answer to (h)} \times \text{answer to (j)}}{18 \times \text{answer to (i)}}$$

x = ...

formula for hydrated sodium carbonate ..... . [2]

[Total: 15]

9 The formula for iron(II) sulphate crystals is $FeSO_4.xH_2O$ where x is a whole number.
A student determined the value of x using 0.0200 mol/dm^3 potassium manganate(VII). This was solution **G**.

(a) A sample of iron(II) sulphate crystals was added to a previously weighed container, which was then reweighed.

Calculate the mass of iron(II) sulphate crystals used in the experiment.

Mass of container + crystals = 12.38 g
Mass of empty container = 5.42 g

Mass of iron(II) sulphate crystals = ... g

[1]

(b) The sample was dissolved in 100 cm^3 of dilute sulphuric acid and the solution was made up to 250 cm^3 with distilled water. This was solution **H**.

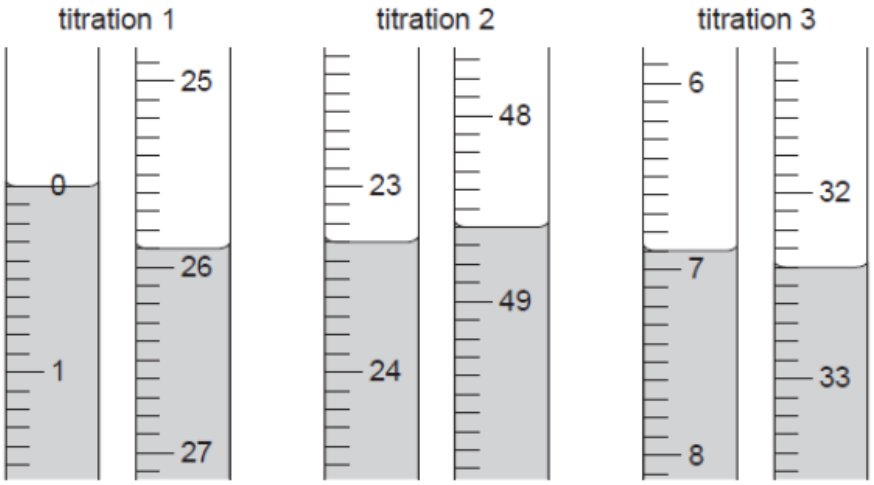
A 25.0 cm^3 sample of **H** was measured into a titration flask.

Solution **G** was run from a burette into the flask containing **H** until an end-point was reached. Potassium manganate(VII) is purple.

What was the colour change at the end-point?

from .....to .....[1]

(c) Three titrations were done. The diagrams below show parts of the burette before and after each titration.



Use these diagrams to complete the table of results.

titration number	1	2	3
final reading/cm^3			
first reading/cm^3			
volume of solution **G**/cm^3			
best titration results (✔)			

Summary.

Tick (✔) the best titration results. Using these results, the average volume of **G** was ..... cm^3. [4]

(d) **G** is 0.0200 mol/dm^3 potassium manganate (VII).
Calculate how many moles of $KMnO_4$ were present in the titrated volume of **G** calculated in **(c)**.

.....moles [1]

(e) Five moles of $FeSO_4$ react with one mole of $KMnO_4$.
Calculate how many moles of $FeSO_4$were present in 25.0 cm^3 of **H**.

.....moles [1]

(f) Calculate how many moles of $FeSO_4$ were present in the 250 cm^3 of **H**.

.....moles [1]

(g) Using your answers to **(f)**, calculate the mass of $FeSO_4$ in the original sample of $FeSO_4.xH_2O$. [M_r: $FeSO_4$, 152.]

.....g [1]

(h) Using your answer to **(a)** and **(g)** calculate the mass of water in the sample of $FeSO_4.xH_2O$.

.....g [1]

(i) Using our answer to **(h)** calculate the number of moles of water in the sample of $FeSO_4.xH_2O$.
[A_r:H,1; O, 16]

.....moles [1]

(j) Using your answers to **(f)** and **(i)** calculate the value of x in $FeSO_4.xH_2O$.

.....[1]

H_xA type Questions

8 A student was required to determine the value of x in the formula of the acid H_x**A**, by titrating an aqueous solution of the acid **S** with aqueous sodium hydroxide **T**.

S is 0.0450 mol/dm^3 aqueous acid, H_x**A**.

T is 0.0800 mol/dm^3 aqueous sodium hydroxide.

(a) 25.0 cm^3 of **T** was transferred into a conical flask.

Which piece of apparatus was used for this measurement?

.....

[1]

(b) A few drops of methyl orange indicator were added.

What was the colour of the solution in the conical flask?

.....

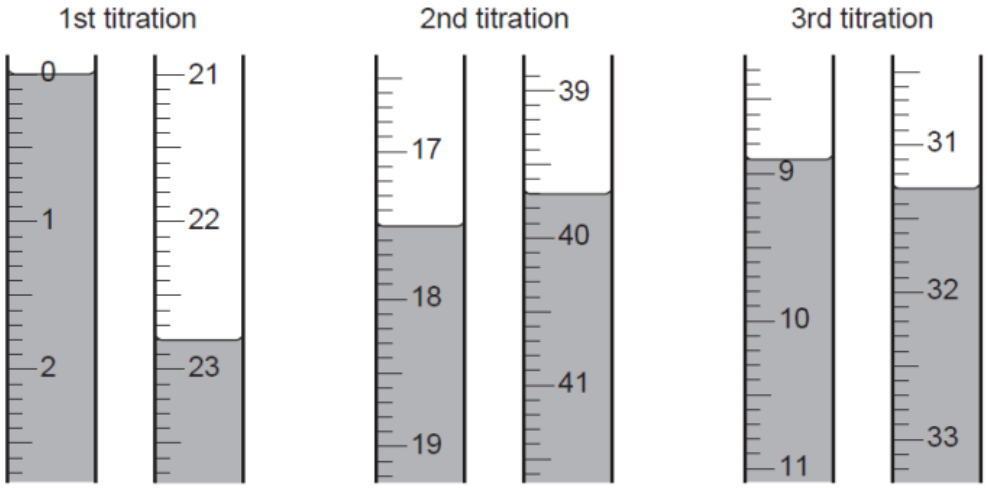
A burette was filled with **S**, which was run into the conical flask until an end-point was reached.

What was the colour of the solution in the flask when the end-point was reached?

.....

[1]

Three titrations were done. The diagrams below show parts of the burette with the liquid levels at the beginning and end of each titration.



(c) Use the diagrams to complete the following table.

titration number	1	2	3
final burette reading / cm^3			
initial burette reading / cm^3			
volume of **S** / cm^3			
best titration results (✓)			

Summary

Tick (✓) the best titration results.
Using these results, the average volume of **S** was

..... cm^3. [4]

(d) **S** is 0.0450 mol/dm^3 H_x**A**.
Using your answer to **(c)** calculate the number of moles of acid H_x**A** in the average volume of **S**.

..... moles [1]

(e) **T** is 0.0800 mol/dm^3 sodium hydroxide.
Calculate the number of moles of sodium hydroxide in 25.0 cm^3 of **T**.

..... moles [1]

(f) Using your answers to **(d)** and **(e)** calculate the number of moles of sodium hydroxide which react with one mole of H_x**A**.

..... moles [1]

(g) Using your answer to **(f)**, deduce the value of x in the formula H_x**A**.

..... [1]

(h) **(i)** Using your answer to **(g)**, suggest the chemical formula of an acid represented by H_x**A**.

..... [1]

(ii) Write an equation for the reaction between the acid suggested in **(h)(i)** and sodium hydroxide.

[1]

[Total: 12]

9 The formula of an acid is written as H_xA.

A student tried to find the value of x in the formula of the acid by titrating its aqueous solution with aqueous sodium hydroxide.

S is a 0.0450 mol/dm^3 aqueous solution of acid H_xA.

T is 0.120 mol/dm^3 sodium hydroxide.

A burette was filled with **S**.

A 25.0 cm^3 portion of **T** was measured into a conical flask.

(a) Which piece of apparatus was used for this measurement?

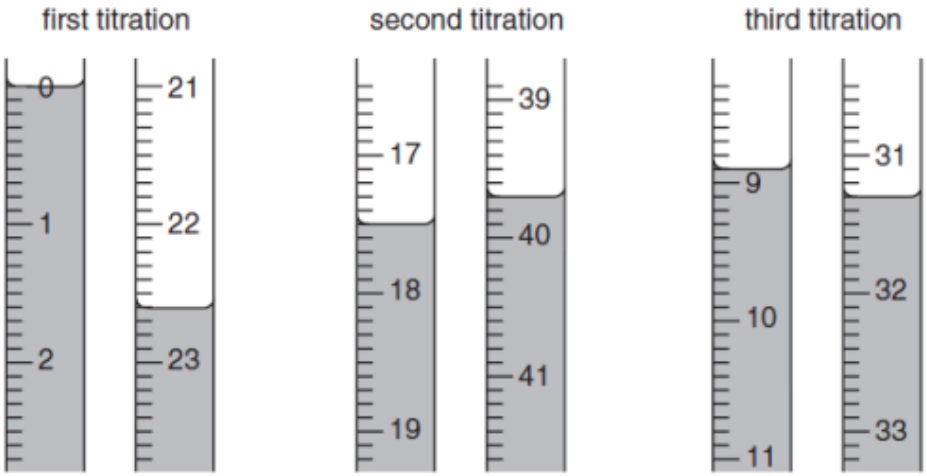
.....[1]

A few drops of methyl orange indicator were added.

(b) What colour change was seen at the end-point?

The indicator changed from ..... to ..... [1]

(c) The diagrams below show parts of the burette with the liquid levels before and after each titration. Use them to complete the results table and summary.



Results

titration number	1	2	3
final burette reading/cm^3			
first burette reading/cm^3			
volume of **S** required/cm^3			

Summary.

Tick the best titration results. Using these results, the average volume of solution **S** was ..... cm^3. [4]

(d) **T** is 0.120 mol/dm^3 sodium hydroxide.
Calculate how many moles of sodium hydroxide are present in 25.0 cm^3 of solution **T**.

..... moles [1]

(e) **S** is 0.0450 mol/dm^3 H_xA.
Calculate how many moles of acid H_xA are present in your average volume of **S**.

..... moles [1]

(f) Using your answers to **(d)** and **(e)** deduce how many moles of sodium hydroxide react with one mole of H_xA.

..... moles [1]

(g) Using your answer to **(f)** deduce the value of x in the formula H_xA.

..... [1]

(h) Using your answers to **(f)** and **(g)** write an equation for the reaction between sodium hydroxide and H_xA.

.....[2]