Chemistry

Cambridge University Examinations

General Certificate of Education Ordinary Level
O – LEVEL 5070. Notes, P1, P2 and P4

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Chapter

The Mole Concepts

Work Sheet
Paper *4*

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Worksheet Paper 4

Moles

1

A student is given an impure sample of calcium hydroxide, $Ca(OH)_2$. The student attempts to determine the percentage, by mass, of calcium hydroxide in the sample.

(a) The sample is placed in a previously weighed beaker, which is then reweighed.

mass of beaker + sample = 51.23 g

mass of beaker = 49.86 g

Calculate the mass of the sample used in the experiment.

..... g [1]

(b) 25.0 cm^3 of 2.00 mol/dm^3 hydrochloric acid, HCl, (an excess) is added to the beaker using apparatus **A**. The contents of the beaker are stirred.

Calcium hydroxide reacts with hydrochloric acid.

$$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$$

The impurities dissolve but do not react with hydrochloric acid.

(i) Name apparatus **A**.

A

..... [1]

(ii) What is the safety item that should be used with apparatus **A**?

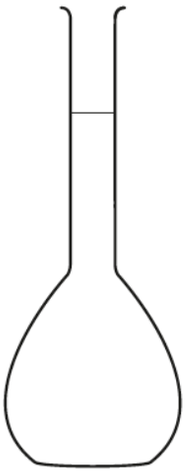
..... [1]

(iii) Why is the safety item used?

..... [1]

(c) The contents of the beaker are then transferred to apparatus **B**.

The student washes the beaker out twice with distilled water and transfers the washings to apparatus **B**. The student then makes up the solution to the 250 cm^3 mark with distilled water. This is solution **C**.



B

(i) Name apparatus **B**.

..... [1]

(ii) Why does the student wash out the beaker with distilled water and transfer the washings to apparatus **B**?

.....

..... [1]

(d) The student transfers 25.0 cm^3 of **C** into a conical flask using apparatus **A** and adds three drops of methyl orange indicator.

0.100 mol/dm^3 sodium hydroxide is put into a burette and run into the conical flask until the end-point is reached.

The sodium hydroxide reacts with the hydrochloric acid that remains after reaction with calcium hydroxide. The equation for the reaction is shown.

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

(i) Why does the student decide to use apparatus **A** and **not** a measuring cylinder to transfer 25.0 cm^3 of **C** into the conical flask?

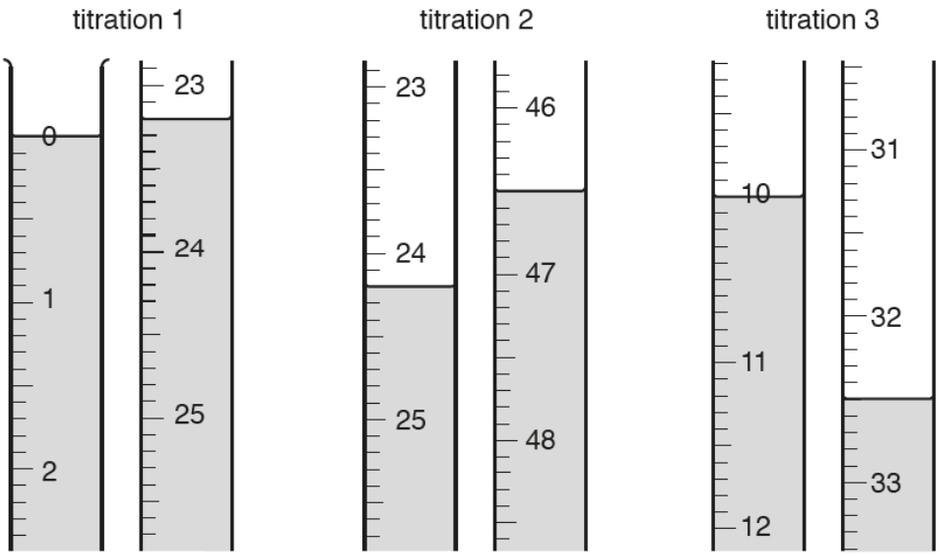
..... [1]

(ii) What is the colour change of the methyl orange indicator at the end-point?

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

(e) The student does three titrations.

The diagrams show parts of the burette with the liquid levels both at the beginning and at the end of each titration.



Use the diagrams to complete the 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 used/cm^3			
best titration results (✓)			

Summary

Tick (✓) the best titration results.

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

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

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

..... moles [1]

(g) Using your answer to **(f)** and the equation

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

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

..... moles [1]

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

..... moles [1]

(i) Calculate the number of moles of hydrochloric acid in 25.0 cm^3 of 2.00 mol/dm^3 hydrochloric acid.

..... moles [1]

(j) Using your answers to both **(h)** and **(i)**, calculate the number of moles of hydrochloric acid that react with the calcium hydroxide in the sample.

..... moles [1]

(k) Using your answer to **(j)** and the equation

$$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$$

calculate the number of moles of calcium hydroxide in the sample.

..... moles [1]

(l) Calculate the mass of calcium hydroxide in the sample.

[A_r: Ca, 40; O, 16; H, 1]

..... g [1]

(m) Using your answers to both **(a)** and **(l)**, calculate the percentage by mass of calcium hydroxide in the sample.

.....% [1]

(n) Another student carries out an experiment to determine the percentage, by mass, of calcium hydroxide in a sample. She uses the same technique but instead of using three drops of methyl orange indicator in the titration, she uses 3 cm^3. Methyl orange is a weak acid.

State and explain whether the average titration volume of sodium hydroxide would be smaller, larger or unchanged if 3 cm^3 of methyl orange indicator was used instead of three drops.

.....

.....

..... [2]

[Total: 22]

2 A student is given an impure sample of magnesium carbonate, $MgCO_3$. The student determines the percentage of magnesium carbonate by mass in the sample.

(a) The student adds a sample of the impure magnesium carbonate to a previously weighed beaker.

mass of beaker + sample = 53.28 g

mass of beaker = 52.86 g

Calculate the mass of the sample used in the experiment.

..... g [1]

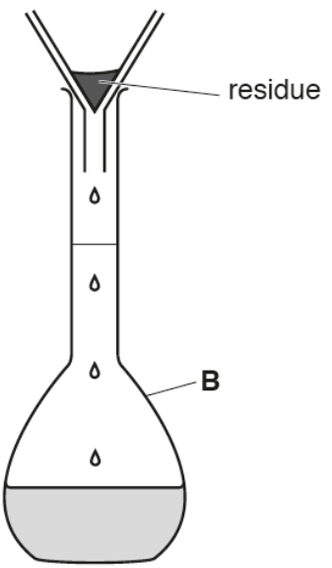
(b) 25.0 cm^3 of 1.00 mol/dm^3 hydrochloric acid, HCl, (an excess) is added to the beaker using a pipette. The contents of the beaker are stirred.

Magnesium carbonate reacts with hydrochloric acid.

$$MgCO_3 + 2HCl \rightarrow MgCl_2 + CO_2 + H_2O$$

The impurities do not react with hydrochloric acid and remain undissolved.

After reaction, the mixture is filtered into apparatus **B**. The student washes the residue on the filter paper with distilled water, which also passes into apparatus **B**.



The student then makes up the solution to the 250 cm^3 mark with distilled water. This is solution **C**.

(i) Name apparatus **B**.

..... [1]

(ii) Why does the student wash the residue with distilled water?

..... [1]

(c) The student transfers 25.0 cm^3 of **C** into a conical flask and adds three drops of methyl orange indicator.

A solution of 0.100 mol/dm^3 sodium hydroxide, NaOH, is put into a burette and run into the conical flask until the end-point is reached.

The sodium hydroxide reacts with the hydrochloric acid that remains after reaction with magnesium hydroxide. The equation for the reaction is shown.

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

What is the colour change of the methyl orange indicator at the end-point?

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

(d) The student does three titrations, using 25.0 cm^3 of **C** in each case.

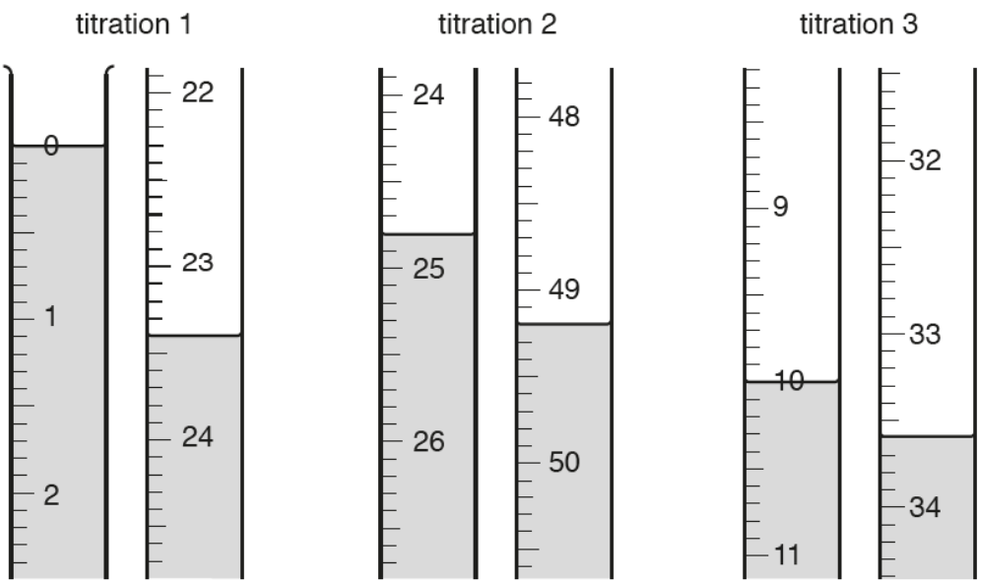
(i) Give two reasons why the student does three titrations using 25.0 cm^3 of **C**, rather than carrying out one titration using 250 cm^3 of **C**.

1 .....

2 .....

[2]

(ii) The diagrams show parts of the burette with the liquid levels both at the beginning and at the end of each titration.



Use the diagrams to complete the 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 used/cm^3			
best titration results (✓)			

Summary

Tick (✓) the best titration results.

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

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

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

..... moles [1]

(f) Using your answer to **(e)** and the equation

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

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

..... moles [1]

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

..... moles [1]

(h) Calculate the number of moles of hydrochloric acid in $25.0\,cm^3$ of $1.00\,mol/dm^3$ hydrochloric acid.

..... moles [1]

(i) Using your answers to both **(g)** and **(h)**, calculate the number of moles of hydrochloric acid that react with the magnesium carbonate in the sample.

..... moles [1]

(j) Using your answer to **(i)** and the equation

$$MgCO_3 + 2HCl \rightarrow MgCl_2 + CO_2 + H_2O$$

calculate the number of moles of magnesium carbonate in the sample.

..... moles [1]

(k) Calculate the mass of magnesium carbonate in the sample.

[A_r: Mg, 24; C, 12; O, 16]

..... g [1]

(l) Using your answers to **(a)** and **(k)**, calculate the percentage by mass of magnesium carbonate in the sample.

.....% [1]

(m) In the experiment the student uses a clean, dry flask for each titration.

Another student carries out the same experiment. This student uses one conical flask only. Between titrations, she washes the flask with water and does not dry it.

State whether the average titration volume of aqueous sodium hydroxide would be smaller, larger or unchanged, if the conical flask is washed with water and not dried between titrations. Explain your answer.

.....

.....

..... [2]

[Total: 20]

3 A student is asked to determine the percentage purity of a sample of impure magnesium carbonate.

(a) The sample is added to a previously weighed container, which is then reweighed.

mass of container + impure magnesium carbonate = 8.20 g
mass of container = 6.98 g

Calculate the mass of impure magnesium carbonate used in the experiment.

..... g [1]

(b) The sample is placed in a beaker and 50.0 cm^3 of 1.00 mol / dm^3 hydrochloric acid, an excess, is added.

The mixture is allowed to react. Carbon dioxide is produced.

What is observed in the flask as the reaction takes place?

.....[1]

(c) When the reaction has finished the solution is made up to 250 cm^3 with distilled water.

This is solution **V**.

(i) In which apparatus should **V** be prepared?

..... [1]

(ii) Using a pipette, 25.0 cm^3 of **V** is transferred into a conical flask.

Name a safety item that the student should attach to the pipette and suggest why it is used.

safety item .....

why it is used .....

.....
[2]

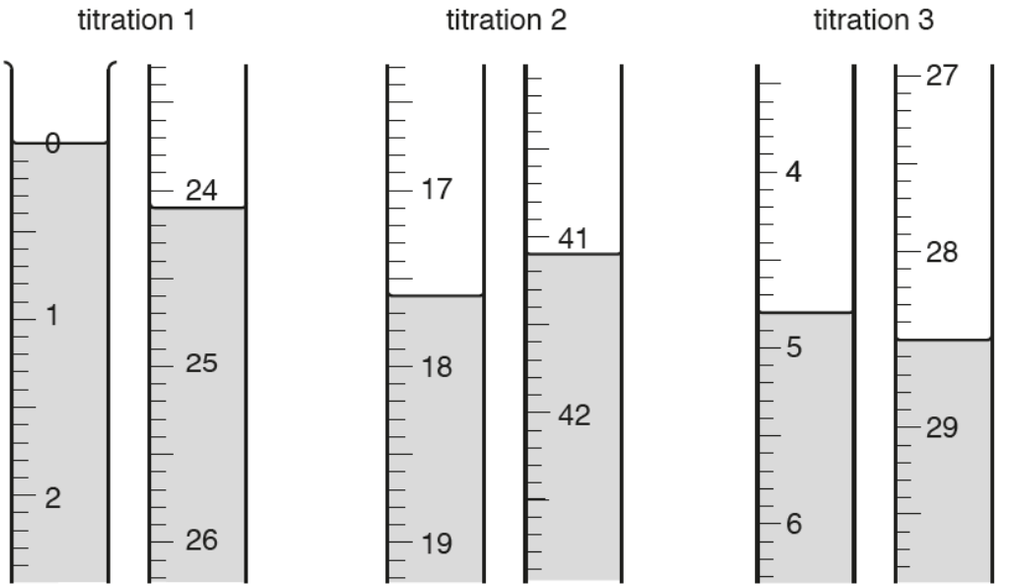
(d) A few drops of methyl orange indicator are added to the conical flask.

0.100 mol / dm^3 sodium hydroxide is added to the solution from a burette until an end-point is reached.

What is the colour change of the methyl orange at the end-point?

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

(e) The student does three titrations. The diagrams 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 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 required is

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

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

..... moles [1]

(g) Using the equation and your answer to **(f)**, deduce the number of moles of hydrochloric acid in 25.0 cm^3 of **V**.

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

..... moles [1]

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

..... moles [1]

(i) 50.0 cm^3 of 1.00 mol/dm^3 hydrochloric acid contains 0.0500 moles of hydrochloric acid.

Subtract your answer to **(h)** from 0.0500 to determine the number of moles of hydrochloric acid that react with the sample of magnesium carbonate.

..... moles [1]

(j) The equation for the reaction between magnesium carbonate and hydrochloric acid is shown.

$$MgCO_3 + 2HCl \rightarrow MgCl_2 + H_2O + CO_2$$

Using the equation and your answer to **(i)**, deduce the number of moles of magnesium carbonate in the sample.

..... moles [1]

(k) **(i)** Calculate the mass of magnesium carbonate in the sample.

[The relative formula mass of magnesium carbonate is 84.]

..... g [1]

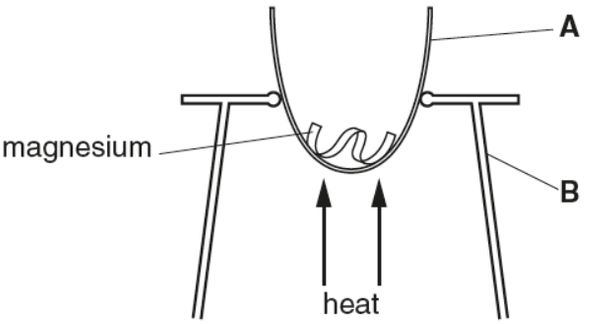
(ii) Using your answers to **(a)** and **(k)(i)**, calculate the percentage purity of the magnesium carbonate.

..... % [1]

[Total: 17]

4 A student does an experiment to convert magnesium into magnesium oxide, MgO.

A 0.36 g sample of magnesium is heated strongly for several minutes using the apparatus shown.



(a) Name apparatus **A** and **B**.

A .....

B ..... [2]

Magnesium is converted into a white powder, MgO. The expected mass of MgO is 0.60 g.

The student found that 0.55 g of MgO is produced in the experiment.

(b) Suggest one reason why the mass of MgO is lower than expected and suggest how the expected result may be achieved.

.....

.....

.....[2]

(c) The student does a similar experiment using 0.36 g of zinc instead of 0.36 g of magnesium.

Explain why he is wrong to expect that the mass of zinc oxide will also be 0.60 g.
[A_r: Mg, 24; Zn, 65]

.....

.....

.....[2]

(d) Suggest a safety item that the student should use when doing this experiment.

.....[1]

[Total: 7]

5 A student is given a sample of an organic acid, **V**, and asked to

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

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

mass of container + **V** = 8.38 g
mass of container = 6.92 g

(a) Calculate the mass of **V** used in the experiment.

..... g [1]

The student transfers the sample to a beaker and adds 50.0 cm^3 of 1.00 mol/dm^3 sodium hydroxide, an excess. The contents are allowed to react and are then transferred to a volumetric flask.

The solution is made up to 250 cm^3 with distilled water. This is solution **W**.

25.0 cm^3 of **W** is transferred into a conical flask. A few drops of thymolphthalein indicator are added to the conical flask. Thymolphthalein is colourless in acidic solution and blue in alkaline solution.

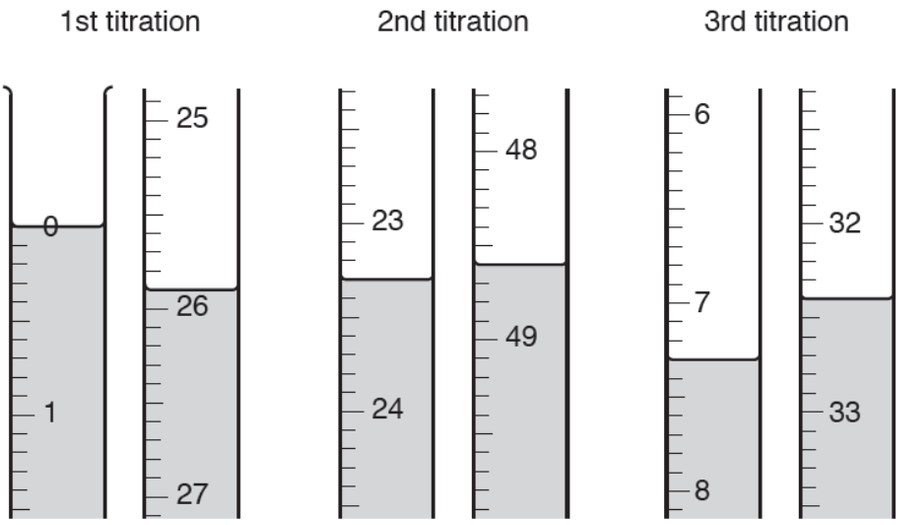
0.100 mol/dm^3 hydrochloric acid is put into a burette and added to the solution in the conical flask until an end-point is reached.

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

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

[1]

(c) The student does three titrations. The diagrams 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 hydrochloric acid used / cm^3			
best titration results (✓)			

Summary

Tick (✓) the best titration results.

Using these results, the average volume of 0.100 mol/dm^3 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 from **(c)**.

..... moles [1]

The equation for the reaction between hydrochloric acid and sodium hydroxide is shown.

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

(e) Using the equation and your answer from **(d)**, deduce the number of moles of sodium hydroxide in 25.0 cm^3 of **W**.

..... moles [1]

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

..... 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 that reacted with the original sample of the organic acid, **V**.

..... moles [1]

(i) **One** mole of **V** reacts with **two** moles of sodium hydroxide.
Deduce the number of moles of **V** in the sample.

..... moles [1]

(j) Using your answers from **(a)** and **(i)** calculate the relative molecular mass of the acid **V**.

.....[1]

(k) The acid **V** contains two carboxylic acid groups and has the molecular formula

$$HO_2CC_xH_yCO_2H$$

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

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

x .....

y .....
[2]

(l) Give the structure of the ester produced when **V** reacts with two molecules of ethanol under suitable conditions.

.....[1]

[Total: 16]

6 **(a)** When zinc is heated in air it reacts with oxygen to form an oxide.
A student does an experiment to find the formula of zinc oxide.

Some zinc is placed in a previously weighed crucible and reweighed.

mass of crucible + zinc = 7.04 g
mass of crucible = 5.74 g

(i) Calculate the mass of zinc used in the experiment.

..... g [1]

The crucible containing the zinc is heated and zinc oxide is produced. The crucible with zinc oxide is weighed.

mass of crucible + zinc oxide = 7.36 g

(ii) Calculate the mass of zinc oxide produced.

..... g [1]

(iii) Using your answers to **(i)** and **(ii)**, calculate the mass of oxygen that combines with the zinc.

..... g [1]

(iv) Using your answers to **(i)** and **(iii)**, calculate the formula of zinc oxide. Show all your working.
[A_r : Zn, 65; O, 16]

formula .....[2]

(b) When zinc reacts with dilute hydrochloric acid, a gas is produced.
Name the gas. Give a test and observation to identify the gas.

gas .....

test and observation .....
[2]

[Total: 7]

7 A student is given a sample of an organic acid and asked to

- determine its relative molecular mass,
- deduce its molecular formula.

The student titrates **R**, an aqueous solution containing $8.00\,g/dm^3$ of the organic acid, with **S**, an aqueous solution containing $0.100\,mol/dm^3$ of sodium hydroxide.

$25.0\,cm^3$ of **S** is transferred into a conical flask. A few drops of thymolphthalein indicator are added to the conical flask.

Thymolphthalein is colourless in acid solution and blue in alkaline solution.

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

(a) What is the colour in the conical flask

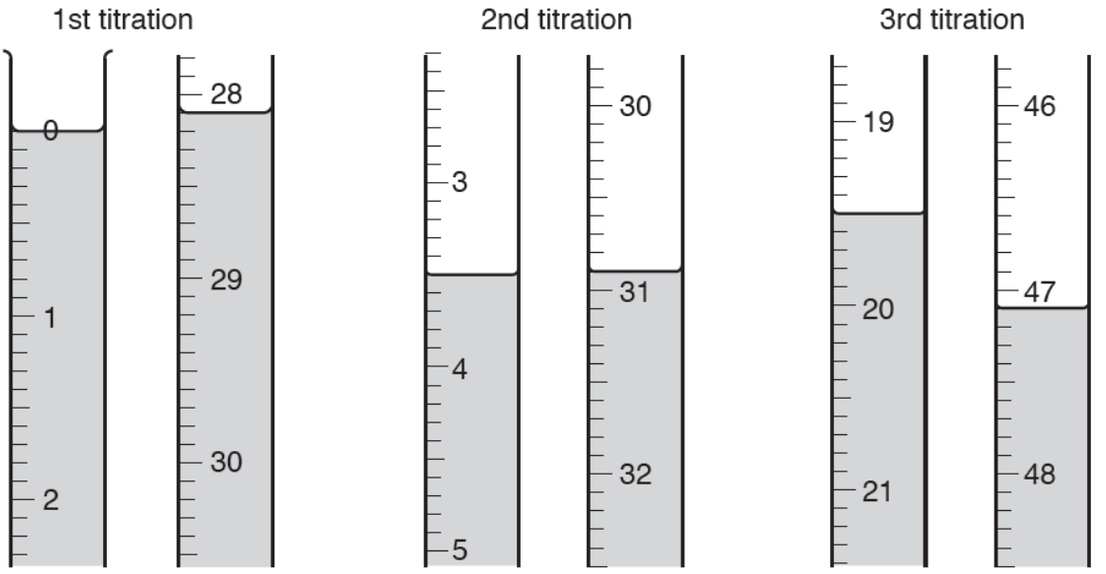
- before **R** is added,

  .....

- at the end-point?

  ..... [1]

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



Use these diagrams to complete the following table.

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

Summary
Tick (✓) the best titration results.
Using these results, the average volume of **R** used is ..... 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 in **(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 8.00 g/dm^3 of the acid, calculate the relative molecular mass of the acid.

.....[1]

(g) The organic acid has the formula

$$C_nH_{2n+1}CO_2H$$

where **n** is a whole number.

Using your answer to **(f)**, deduce the value of **n** and hence the molecular formula and the name for the organic acid.
[A_r: H, 1; C, 12; O, 16]

n = ...

molecular formula .....

name .....
[4]

[Total: 13]

8 A student does an experiment to determine the percentage by mass of copper in a sample of impure copper. The sample of impure copper is placed in a previously weighed container and reweighed.

mass of container + impure copper = 7.45 g

mass of empty container = 5.72 g

(a) Calculate the mass of impure copper used in the experiment.

..... g [1]

The student transfers the sample of impure copper to a beaker, adds excess concentrated nitric acid and stirs until all the solid has dissolved. The copper reacts with the nitric acid producing aqueous copper nitrate as shown in **equation 1**.

equation 1 $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

An excess of aqueous potassium iodide and an excess of dilute hydrochloric acid are then added to the beaker. A further reaction occurs as shown in **equation 2**.

equation 2 $2Cu(NO_3)_2 + 4KI + 4HCl \rightarrow 4KCl + 2CuI + 4HNO_3 + I_2$

The contents of the beaker are transferred to a suitable container and made up to 250 cm^3 with distilled water. This is solution **J**.

(b) Name the container in which solution **J** should be made.

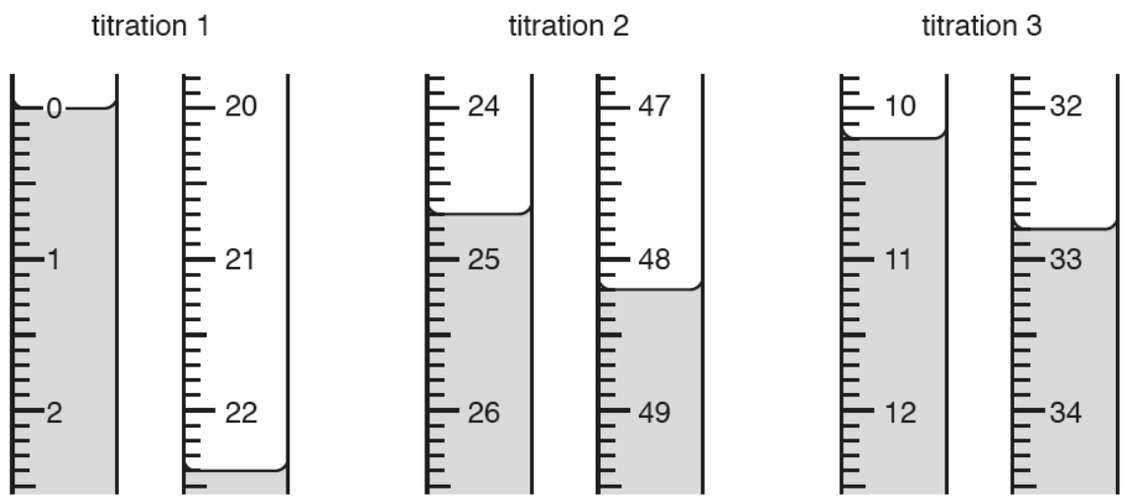
..... [1]

The student transfers 25.0 cm^3 of **J** to a conical flask and adds a few drops of a suitable indicator.

An aqueous solution of 0.100 mol/dm^3 sodium thiosulfate, $Na_2S_2O_3$, is put into a burette and run into the conical flask until the end-point is reached. The reaction between sodium thiosulfate, $Na_2S_2O_3$, and iodine, I_2, is shown in **equation 3**.

equation 3 $2Na_2S_2O_3 + I_2 \rightarrow 2NaI + Na_2S_4O_6$

(c) Three titrations are done. The diagrams 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 0.100 mol / dm^3 $Na_2S_2O_3$ / cm^3			
best titration results (✓)			

Summary

Tick (✓) the best titration results.

Using these results, the average volume of 0.100 mol / dm^3 $Na_2S_2O_3$ is

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

(d) Calculate the number of moles of $Na_2S_2O_3$ in the average volume of 0.100 mol / dm^3 $Na_2S_2O_3$.

..... moles [1]

(e) Use your answer to **(d)** and **equation 3** to calculate the number of moles of I_2 in 25.0 cm^3 of **J**.

equation 3 $2Na_2S_2O_3 + I_2 \rightarrow 2NaI + Na_2S_4O_6$

..... moles [1]

(f) Use your answer to **(e)** to calculate the number of moles of I_2 in 250 cm^3 of **J**.

..... moles [1]

(g) Use your answer to **(f)** and **equation 2** to calculate the number of moles of $Cu(NO_3)_2$ that produce the number of moles of I_2 calculated in **(f)**.

equation 2 $2Cu(NO_3)_2 + 4KI + 4HCl \rightarrow 4KCl + 2CuI + 4HNO_3 + I_2$

..... moles [1]

(h) Use your answer to **(g)** and **equation 1** to deduce the number of moles of Cu that produce the number of moles of $Cu(NO_3)_2$ calculated in **(g)**.

equation 1 $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

..... moles [1]

(i) Use your answer to **(h)** to calculate the mass of copper in the sample of impure copper.

[A_r: Cu, 63.5]

..... g [1]

(j) Use your answers to **(i)** and **(a)** to calculate the percentage by mass of copper in the sample of impure copper.

.....% [1]

[Total: 13]

9 A chemist plans an experiment to determine the concentration of acid in the juice of a lemon.

Making the solution

- Squeeze the juice out of a lemon.
- Using a measuring cylinder, transfer 10 cm^3 of the lemon juice into a 100 cm^3 volumetric flask.
- Make up to the 100 cm^3 mark with distilled water.
- Mix the solution thoroughly.

Titration

- Transfer 25.0 cm^3 of the diluted lemon juice into a conical flask.
- Add a few drops of a suitable indicator.
- Add 0.0500 mol/dm^3 sodium hydroxide, **R**, until the end-point is reached.
- Repeat the titration two more times.

(a) In the titration, state the name of the apparatus used to:

(i) transfer 25.0 cm^3 of the diluted lemon juice into the conical flask

..... [1]

(ii) add **R** to the diluted lemon juice in the conical flask.

..... [1]

(b) The results of the titrations are recorded in the table.

titration number	1	2	3
final reading/cm^3	15.6	30.8	45.8
initial reading/cm^3	0.0	15.6	30.8
volume of **R** used/cm^3			
best titration results (✓)			

(i) Complete the table by calculating the volumes of **R** used.

[1]

(ii) Tick (✓) the best titration results and explain why you have selected these values.

.....

.....

..... [1]

(iii) Use these best titration results to calculate the average volume of **R** used.

average volume of **R** used ..... cm^3
[1]

(c) **R** is 0.0500 mol/dm^3 sodium hydroxide, NaOH.

Calculate the number of moles of NaOH present in the average volume of **R** used.

..... moles [1]

(d) The acid in lemon juice is represented by the formula H**A**.

The equation for the reaction of H**A** with NaOH is shown.

$$NaOH + H\mathbf{A} \rightarrow Na\mathbf{A} + H_2O$$

Calculate the number of moles of H**A** that react with the NaOH in the average volume of **R** used.

..... moles [1]

(e) 25.0 cm^3 of diluted lemon juice is used in each titration.

Calculate the concentration, in mol/dm^3, of H**A** in the diluted lemon juice.

..... mol/dm^3 [1]

(f) **(i)** At the start of the experiment, distilled water was added to 10 cm^3 of lemon juice to make 100 cm^3 of diluted lemon juice.

Calculate the concentration, in mol/dm^3, of H**A** in the original lemon juice.

..... mol/dm^3 [1]

(ii) The actual concentration of acid in the lemon juice is different from your answer in **(f)(i)**.

Suggest the most likely source of error in the method for making the solution described at the start of the question.

.....

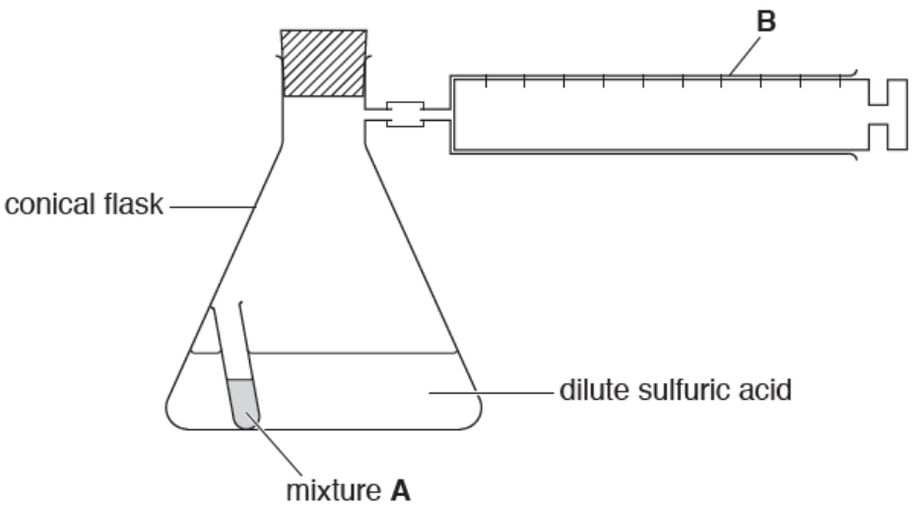
..... [1]

[Total: 10]

10 A student determines the mass of copper in mixture **A** which is composed of only copper and zinc.

Zinc reacts with dilute sulfuric acid. Copper does not.

Dilute sulfuric acid is mixed with **A** in the apparatus below. A gas is given off which is collected in **B**.



(a) Name apparatus **B**.

..... [1]

(b) **(i)** Name the gas collected in **B**. Give a test and observation to identify the gas.

name of gas .....

test and observation.....
[2]

(ii) Construct an equation for the reaction between zinc and dilute sulfuric acid.

..... [1]

(c) When all the zinc has reacted, the volume of gas collected in **B** is 96.0 cm^3 when measured at room temperature and pressure.
[1 mole of any gas occupies 24000 cm^3 at room temperature and pressure.]

(i) Calculate the number of moles of gas in 96.0 cm^3.

..... moles [1]

(ii) Using your answers to **(b)(ii)** and **(c)(i)** calculate the mass of zinc in **A**.
[A_r: Zn, 65]

..... g [1]

(iii) The mass of mixture **A** is 1.20 g. Calculate the mass of copper in mixture **A**.

..... g [1]

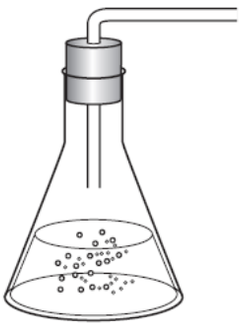
(d) When the reaction has finished, the student separates the copper from the solution remaining in the conical flask by filtration, using a previously weighed filter paper. As soon as the filtration finishes the student weighs the filter paper containing the copper residue and finds that its mass is greater than he expected. Explain why.

.....[1]

[Total: 8]

11 A student added 100 cm^3 of 0.10 mol/dm^3 hydrochloric acid to 0.5 g of calcium carbonate contained in a conical flask. The reaction produced carbon dioxide. The equation for the reaction is shown.

$$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$$



(a) Name the piece of apparatus which should be attached to the flask, for collecting and measuring the volume of carbon dioxide produced.

.....[1]

(b) Give a test to confirm the presence of carbon dioxide.

test and observation

.....[1]

(c) **(i)** Calculate the number of moles of calcium carbonate in 0.5 g.
[A_r: Ca, 40; C, 12; O, 16]

.....moles

(ii) Calculate the number of moles of hydrochloric acid in 100 cm^3 of 0.10 mol/dm^3.

.....moles

(iii) Was one of the reagents in excess?

Explain your answer.

.....[4]

(d) Using your answers in **(c)** calculate the volume of carbon dioxide produced when the reaction reached completion. (One mole of a gas occupies 24 dm^3 at room temperature and pressure).

.....dm^3 [1]

(e) The experiment was repeated using 0.5 g of magnesium carbonate instead of 0.5 g of calcium carbonate. Calculate the volume of carbon dioxide produced.
[A_r: Mg, 24; C, 12; O, 16]

.....dm^3 [2]

12 The student then repeated the experiment, this time adding 100 cm^3 of 0.25 mol/dm^3 sulphuric acid to an excess of zinc carbonate.

The equation for the reaction is

$$ZnCO_3 + H_2SO_4 \longrightarrow ZnSO_4 + CO_2 + H_2O$$

(e) Calculate the number of moles of sulphuric acid used in this experiment.

..... moles [1]

(f) Use your answer to **(e)** and the equation to calculate the mass of zinc sulphate produced.
[A_r: Zn, 65; S, 32; O, 16]

..... g [1]

(g) Calculate the volume of carbon dioxide produced during the reaction.
[One mole of a gas occupies 24 dm^3 at room temperature and pressure.]

..... dm^3 [1]

13 A student determines the percentage of iron in a powdered sample of impure iron by a titration method.

(a) The student adds the sample of impure iron to a previously weighed beaker which is then reweighed.

mass of beaker + impure iron = 39.36 g

mass of beaker = 37.52 g

Calculate the mass of impure iron used in the experiment.

..... g [1]

(b) An excess of dilute sulfuric acid is added to the beaker containing impure iron. The sulfuric acid reacts with the iron.

$$Fe(s) + 2H^+(aq) \rightarrow Fe^{2+}(aq) + H_2(g)$$

The impurities do not react with or dissolve in the sulfuric acid.

(i) What is meant by an *excess* of dilute sulfuric acid?

.....[1]

(ii) The student suggests that the beaker should be heated to make the iron react faster.

What safety precaution should be taken when heating the beaker? Explain your answer.

safety precaution .....

explanation .....

.....

[2]

(iii) What else could the student do to increase the rate of the reaction in the beaker?

.....[1]

(c) The insoluble impurities are separated from the aqueous solution. The aqueous solution is transferred from a beaker to a volumetric flask and made up to 250 cm^3 with water. This is solution **P**.

(i) Suggest a method of separating the insoluble impurities from the aqueous solution.

.....[1]

(ii) Suggest how the student should ensure that **all** the solution is transferred to the volumetric flask.

.....

.....[2]

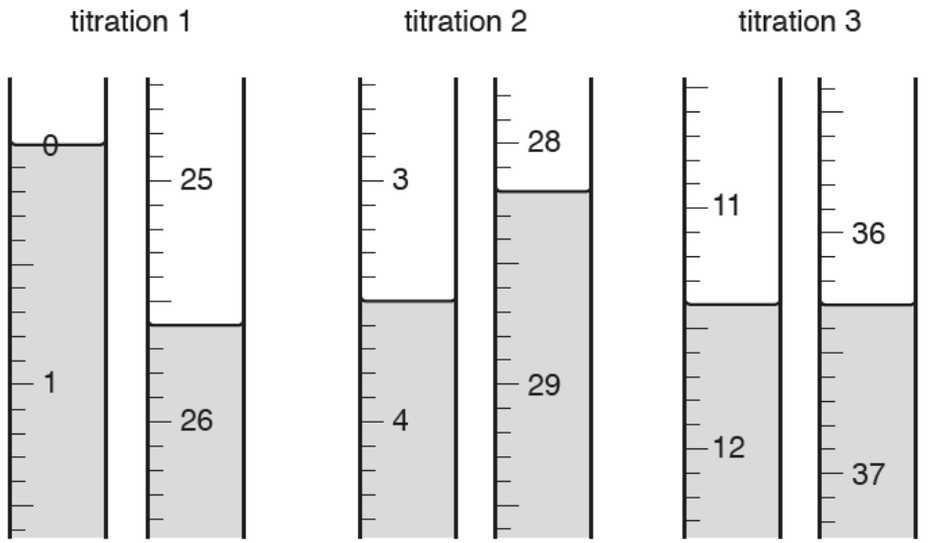
(d) The student transfers 25.0 cm^3 of **P** into a conical flask using a pipette.

Solution **Q** is 0.0200 mol/dm^3 potassium manganate(VII).

The student fills a burette with **Q** and runs it into the conical flask until the end-point is reached.

The student does three titrations.

(i) The diagrams show parts of the burette with the liquid levels both at the beginning and at the 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 **Q** / cm^3			
best titration results (✓)			

Summary

Tick (✓) the best titration results in the table.

Using these best results, the average volume of **Q** is

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

(ii) Give **two** reasons why the student does three titrations using 25.0 cm^3 of **P** in each, rather than carrying out one titration using 250 cm^3 of **P**.

reason 1 .....

reason 2 .....

[2]

(e) Calculate the number of moles of potassium manganate(VII) in the average volume of 0.0200 mol/dm^3 of aqueous potassium manganate(VII) in **(d)(i)**.

..... moles [1]

(f) **One** mole of potassium manganate(VII) reacts with **five** moles of Fe^{2+}.

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

..... moles [1]

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

..... moles [1]

(h) Calculate the mass of iron in 250 cm^3 of **P**.

[A_r: Fe, 56]

.....g [1]

(i) Using your answers to **(a)** and **(h)**, calculate the percentage by mass of iron in the impure iron.

.....% [1]

[Total: 19]