Limiting & Excess Method

2 Silver iodide may be made by the reaction between aqueous potassium iodide and aqueous silver nitrate.

A student added $50\,cm^3$ of $1.0\,mol/dm^3$ potassium iodide to $30\,cm^3$ of $2.0\,mol/dm^3$ silver nitrate.

$$KI(aq) + AgNO_3(aq) \longrightarrow KNO_3(aq) + AgI(s)$$

(a) (i) Describe what was seen during the reaction.

....

(ii) How could the silver iodide be removed from the mixture?

.... [3]

(b) (i) Which of the reagents potassium iodide or silver nitrate was in excess? Explain your answer.

answer ....

explanation ....

....

....

(ii) Calculate the mass of silver iodide formed (A_r: Ag, 108; I, 127.)

.... [5]

(c) The student did another experiment to make silver chloride by adding $50\,cm^3$ of $1.0\,mol/dm^3$ potassium chloride to $30\,cm^3$ of $2.0\,mol/dm^3$ silver nitrate,

(i) Describe the appearance of the silver chloride

on forming, ...

on standing for a few minutes. ....

....

(ii) Was the mass of silver chloride more than, the same or less than the mass of silver iodide in **(b)(ii)**? Explain your answer. (A_r: Ag, 108; Cl, 35.5.)

answer ....

explanation ....

....
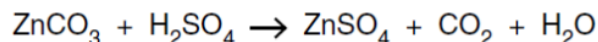
.... [4]

Question 2

4 A student makes zinc sulfate by adding powdered zinc carbonate to a beaker half-filled with dilute sulfuric acid.
The equation for the reaction is

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

(a) Give a test for carbon dioxide.

test ....

observation .... [1]

(b) (i) If the acid is in excess how will the student know when the reaction has stopped?

....

.... [1]

(ii) If the zinc carbonate is in excess what additional observation will the student make when the reaction has stopped?

....

.... [1]

(c) To ensure that all the acid is neutralised, the student adds excess zinc carbonate. The mixture is well stirred.

How is the unreacted zinc carbonate removed from the mixture?

....

.... [1]

(d) The student repeats the experiment, this time adding excess zinc carbonate to $100\,cm^3$ of $0.5\,mol/dm^3$ sulfuric acid.

Calculate the number of moles of sulfuric acid used in the experiment.

.... moles [1]

(e) Using your answer to **(d)** and the equation, calculate

    (i) the mass of zinc sulfate which is produced,
       $[A_r: O, 16; S, 32; Zn, 65]$

.... g [2]

    (ii) the volume of carbon dioxide evolved.
        [One mole of a gas occupies $24\,dm^3$ at room temperature and pressure.]

.... cm^3 [1]

[Total: 8]

w/12/qp41

1 The apparatus below contains $0.100\,mol/dm^3$ sulfuric acid.

cm³
—50
—40
—30
—20
—10
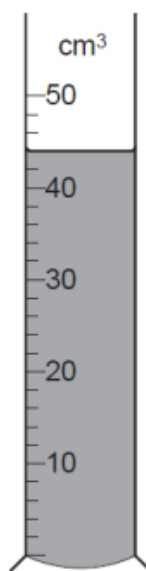
(a) (i) Name the apparatus.

.... [1]

(ii) What is the volume of $0.100\,mol/dm^3$ sulfuric acid?

.... cm³ [1]

(iii) Using your answer to **(a)(ii)**, calculate the number of moles of $0.100\,mol/dm^3$ sulfuric acid.

.... moles [1]

(b) (i) The sulfuric acid was poured into a beaker and 0.12g of magnesium was added. The magnesium reacted with the sulfuric acid and hydrogen was produced.

How many moles of magnesium were added?
[A_r: Mg, 24]

.... moles [1]

(ii) Write the equation for the reaction between magnesium and sulfuric acid.

.... [1]

(iii) Using your answers to **(a)(iii)**, **(b)(i)** and **(b)(ii)**, suggest which reagent was in excess, magnesium or sulfuric acid?
Explain your answer.

.... [1]

(c) (i) Give a positive test for hydrogen gas.

test ....

observation .... [1]

(ii) Calculate the volume of hydrogen gas produced in this reaction.
[1 mol of a gas measured at 25 °C occupies a volume of 24 dm^3.]

.... dm^3 [1]

[Total: 8]

w/10/qp42/43

Water of Crystallization (Salt.xH2O Type Questions)

Question 4

3 A student heats a sample of hydrated sodium carbonate, $Na_2CO_3.xH_2O$, in a crucible until all the water of crystallisation is removed. The purpose of the experiment is to determine the value of **x** in the formula $Na_2CO_3.xH_2O$.
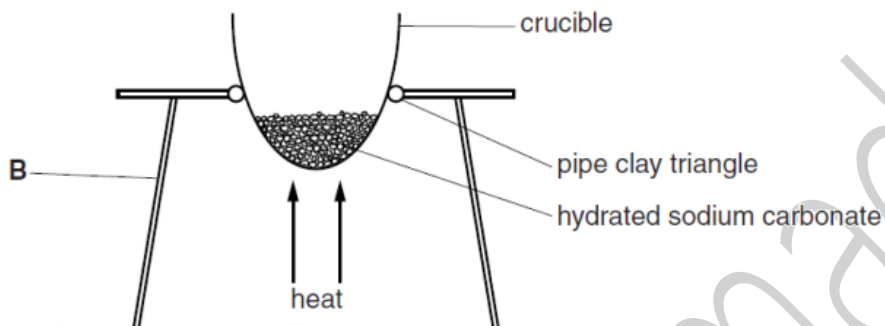
(a) Name the apparatus **B**.

....[1]

(b) How can the student be sure that all the water of crystallisation has been removed?

....[1]

(c) After heating 0.715 g of the hydrated salt, $Na_2CO_3.xH_2O$, 0.265 g of the anhydrous salt, Na_2CO_3, remained.

(i) Calculate the mass of water of crystallisation removed.

.... g [1]

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

....

Calculate the relative formula mass of water, H_2O.
[A_r: H, 1; O, 16]

....
[1]

(iii) Calculate the number of moles of Na_2CO_3 in 0.265 g.

.... moles of Na_2CO_3

Calculate the number of moles of H_2O in your answer to **(c)(i)**.

.... moles of H_2O
[1]

(d) Using your answers to **(c)(iii)**, calculate the value of **x** in the formula $Na_2CO_3.xH_2O$.

x = ...[1]

[Total: 6]

w/14/qp41

1 Iron(II) sulfate crystals have the formula $FeSO_4.xH_2O$, where **x** is a whole number. A student is asked to find the value of **x**.

The crystals are placed in a previously weighed crucible which is then reweighed.

(a) What colour are iron(II) sulfate crystals?

....[1]

(b) Mass of crucible + iron(II) sulfate crystals = 9.01 g
Mass of crucible = 5.97 g

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

....g [1]

(c) The crystals are gently heated until no more water is given off.
The crucible and contents are cooled and reweighed.

Mass of crucible and iron(II) sulfate after heating = 7.66 g

(i) Calculate the mass of iron(II) sulfate which remains after heating.

....g [1]

(ii) Calculate the mass of water lost from the crystals.

....g [1]

(iii) Calculate the number of moles of iron(II) sulfate that remain after heating.
[M_r: $FeSO_4$, 152]

.... moles [1]

(iv) Calculate the number of moles of water which are lost on heating.
[M_r: H_2O, 18]

.... moles [1]

(d) (i) Using your answers to **(c)(iii)** and **(c)(iv)** calculate the number of moles of water combined with one mole of iron(II) sulfate.

.... moles [1]

(ii) What is the value of **x** in the formula $FeSO_4.xH_2O$?

x = ...[1]

[Total: 8]

2 Calcium sulfate crystals have the formula $CaSO_4.xH_2O$ where x is a whole number.

(a) A student places some calcium sulfate crystals in a previously weighed crucible.

mass of crucible + crystals   =   11.20g
mass of crucible   =   5.80g

Calculate the mass of crystals used in the experiment.

.... g [1]

(b) The crucible is heated to remove all the water from the crystals.
The crucible and contents are allowed to cool and are then reweighed.

mass of crucible and contents after heating =   10.07g

(i) Calculate the mass of calcium sulfate after heating.

.... g [1]

(ii) Calculate the mass of water removed by heating.

.... g [1]

(c) Calculate

(i) the formula mass, M_r, of $CaSO_4$,

(ii) the formula mass, M_r, of water H_2O.
[A_r: H,1; O,16; S, 32; Ca, 40]

$CaSO_4$ ....

H_2O ....   [1]

(d) In the formula $CaSO_4.xH_2O$, **x** is a whole number.
Use the equation below to calculate the value of **x**.

$$x = \frac{\text{answer (b)(ii)} \times M_r\ CaSO_4}{\text{answer (b)(i)} \times M_r\ H_2O}$$

x = ... [1]

(e) What general name is given to compounds that have lost all their water of crystallisation?

.... [1]

[Total: 6]

2 A student was given some hydrated sodium carbonate crystals, $Na_2CO_3.xH_2O$, where x is a whole number. They were placed in a previously weighed container, which was reweighed.

mass of container + sodium carbonate crystals   = 9.87 g
mass of container   = 5.83 g

(a) Calculate the mass of sodium carbonate crystals used in the experiment.

....g [1]

The container and crystals were heated to remove the water of crystallisation and then reweighed. This process was repeated until there was no further change in mass.

(b) Describe the appearance of the sodium carbonate crystals after heating.

....

....[2]

mass of container + sodium carbonate after heating = 7.35 g

(c) **(i)** Calculate the mass of sodium carbonate which remained after heating.

....g [1]

(ii) Calculate the mass of water which was lost from the crystals.

....g [1]

(d) (i) Calculate the relative formula mass of sodium carbonate, Na_2CO_3, and the relative formula mass of water.
[A_r: Na, 23; C, 12; O, 16; H, 1]

relative formula mass of sodium carbonate ....

relative formula mass of water ....

[1]

(e) Using your answers to **(c)** and **(d)**, calculate

(i) the number of moles of sodium carbonate which remained after heating,

.... [1]

(ii) the number of moles of water which were lost on heating.

.... [1]

(f) Using your answers to **(e)** calculate the value of x in the formula $Na_2CO_3.xH_2O$.

x = ... [2]

[Total: 10]

Question 8

3 A student was given some hydrated iron(II) sulfate crystals, $FeSO_4.xH_2O$. They were placed in a previously weighed crucible which was reweighed.

Mass of crucible + iron(II) sulfate crystals = 10.45 g
Mass of crucible = 6.60 g

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

.... g [1]

(b) The crystals were gently heated until no more water vapour was given off.

(i) What word describes the iron(II) sulfate now that it has lost all of its water of crystallisation?

.... [1]

The crucible and contents were reweighed.

Mass of crucible + iron(II) sulfate after heating = 8.90 g

(ii) Calculate the mass of iron(II) sulfate which remained after heating.

.... g [1]

(iii) Calculate the mass of water lost from the crystals.

.... g [1]

(c) (i) Calculate the relative formula mass of iron(II) sulfate, $FeSO_4$.

[A_r: Fe, 56; S, 32; O, 16]

....

(ii) Calculate the relative formula mass of water.

[A_r: H, 1; O, 16]

....

[1]

(d) Using your answers to **(b)(ii)** and **(iii)**, and **(c)(i)** and **(ii)**, calculate

   (i) how many moles of iron(II) sulfate remained after heating,

   .... [1]

   (ii) how many moles of water were lost during heating.

   .... [1]

(e) The value of **x** in the formula $FeSO_4.xH_2O$ can be found using the following formula.

$$x = \frac{\text{answer to (d)(ii)}}{\text{answer to (d)(i)}}$$

Calculate the value of **x** and hence write the formula of hydrated iron(II) sulfate.

   x = ... [1]

The formula of hydrated iron(II) sulfate is .... [1]

[Total: 9]

1 Iron(II) sulfate crystals have the formula $FeSO_4.xH_2O$, where **x** is a whole number. A student is asked to find the value of **x**.

The crystals are placed in a previously weighed crucible which is then reweighed.

(a) What colour are iron(II) sulfate crystals?

....[1]

(b) Mass of crucible + iron(II) sulfate crystals = 9.01 g
Mass of crucible   = 5.97 g

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

....g [1]

(c) The crystals are gently heated until no more water is given off.
The crucible and contents are cooled and reweighed.

Mass of crucible and iron(II) sulfate after heating = 7.66 g

(i) Calculate the mass of iron(II) sulfate which remains after heating.

....g [1]

(ii) Calculate the mass of water lost from the crystals.

....g [1]

(iii) Calculate the number of moles of iron(II) sulfate that remain after heating.
[M_r: $FeSO_4$, 152]

.... moles [1]

(iv) Calculate the number of moles of water which are lost on heating.
[M_r: H_2O, 18]

.... moles [1]

(d) (i) Using your answers to **(c)(iii)** and **(c)(iv)** calculate the number of moles of water combined with one mole of iron(II) sulfate.

.... moles [1]

(ii) What is the value of **x** in the formula $FeSO_4.xH_2O$?

x = ...[1]

[Total: 8]

s/14/qp42

3 A student heats 0.336 g of a metal carbonate, MCO_3. The sample decomposes according to the equation shown.

$$MCO_3 \rightarrow MO + CO_2$$

0.176 g of carbon dioxide is produced.

(a) Describe a test for carbon dioxide gas.

....[1]

(b) How can the student be sure that **all** the MCO_3 decomposes?

....

....[1]

(c) (i) Calculate the mass of MO produced.

.... g [1]

(ii) Calculate the number of moles in 0.176 g of carbon dioxide.
[A_r: C, 12; O, 16]

.... moles [1]

(iii) Use the equation

$$MCO_3 \rightarrow MO + CO_2$$

and your answer to (c)(ii) to deduce the number of moles of MO produced.

.... moles [1]

(iv) Using your answers to (c)(i) and (c)(iii), calculate the relative formula mass of MO.

relative formula mass .... [1]

(v) Calculate the relative atomic mass of M.
[A_r: O, 16]

....[1]

[Total: 7]

Question 11

2 When copper is heated in air it reacts with oxygen to form an oxide.

A student does an experiment to find the formula of copper oxide.

(a) Describe the appearance of copper.

....[1]

(b) Some copper is placed in a previously weighed crucible and reweighed.

mass of crucible + copper = 5.92 g
mass of crucible = 4.65 g

Calculate the mass of copper used in the experiment.

....g [1]

(c) The crucible containing the copper is heated and copper oxide is produced. The crucible with copper oxide is weighed.

mass of crucible + copper oxide = 6.24 g

Calculate the mass of copper oxide produced.

....g [1]

(d) Using your answers to **(b)** and **(c)** calculate the mass of oxygen that combines with the copper.

....g [1]

(e) Using your answers to **(b)** and **(d)** calculate the formula of copper oxide. Show your working.
[A_r : O, 16; Cu, 64]

....[2]

[Total: 6]

s/12/qp41

1   A student did the following experiment to find the formula of magnesium oxide.

A 10 cm length of magnesium ribbon was loosely coiled and placed in a previously weighed crucible which was then reweighed.

mass of crucible + magnesium = 13.08 g
mass of crucible   = 12.72 g

(a) Calculate the mass of magnesium.

.... g [1]

The crucible was placed on a pipe clay triangle and heated strongly for several minutes. During the heating the crucible lid was lifted and replaced several times. The magnesium was converted into magnesium oxide.
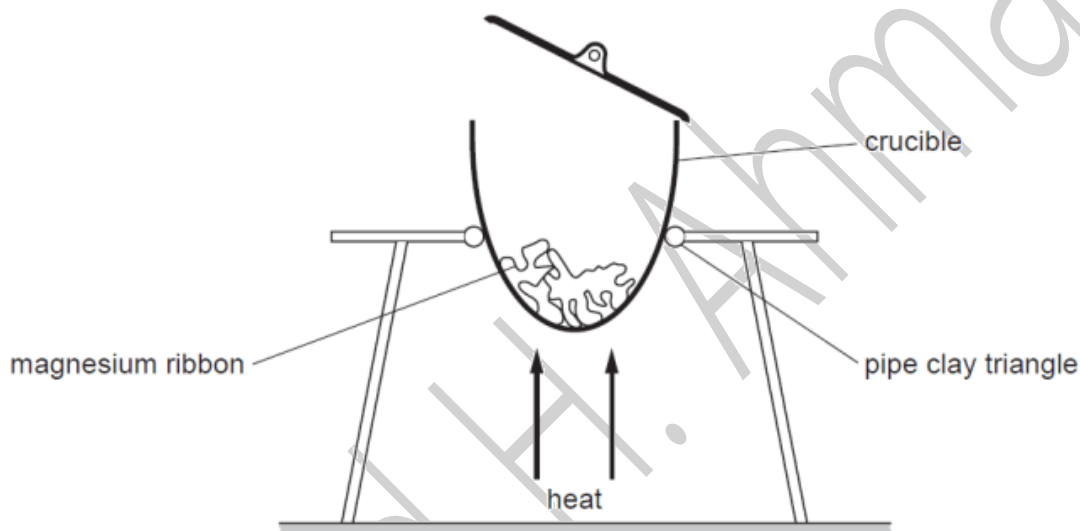
(b) (i)   Why was it necessary for a lid to be placed on the crucible during heating?

.... [1]

(ii)   Why was the lid lifted during heating?

.... [1]

(c) Describe the appearance of

(i) magnesium,

.... [1]

(ii)   magnesium oxide.

.... [1]

After cooling, the crucible was weighed. It was then reheated, cooled and reweighed.

final mass of crucible + magnesium oxide = 13.32 g

(d) Why was the crucible re-heated?

.... [1]

(e) (i) Calculate the mass of magnesium oxide.

.... g [1]

(ii) Calculate the mass of oxygen that reacted with the magnesium.

.... g [1]

(f) Using your answers to **(a)** and **(e)(ii)**, calculate the formula of magnesium oxide.

[A_r: Mg, 24; O, 16]

.... [2]

[Total: 10]

Question 13

(iv) 1 mole of the hydrocarbon reacts with 1 mole of bromine.
In this experiment 4.2g of the hydrocarbon reacted with 16g of bromine. Calculate the formula of the hydrocarbon and state its name.
[A_r: C, 12; H, 1; Br, 80]

formula of the hydrocarbon ....

name of the hydrocarbon ....

[2]

s/07/qp4

Question 14

8 A student does an experiment to determine the numerical value of **x** in the compound KIO_x.
A sample of KIO_x is placed in a previously weighed container and reweighed.

mass of container + KIO_x = 7.25g

mass of empty container = 6.44g

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

....g [1]

The student transfers the sample of KIO_x 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 250 cm^3 volumetric flask. The solution is made up to 250 cm^3 with distilled water. This is solution **J**.

A 25.0 cm^3 portion of **J** is transferred to a conical flask. A few grams of potassium iodide and 10 cm^3 of dilute hydrochloric acid are added to the conical flask. All the iodine in KIO_x is converted into iodine molecules, I_2. A few drops of a suitable indicator are added.

1 mole of KIO_x reacts with KI and produces 3 moles of iodine molecules, I_2.

(b) What apparatus should be used to transfer 25.0 cm^3 of **J** to the conical flask?

....[1]

(c) $0.100 \, mol/dm^3$ aqueous sodium thiosulfate, $Na_2S_2O_3$, is put into a burette and run into the conical flask.

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

first titration	second titration	third titration
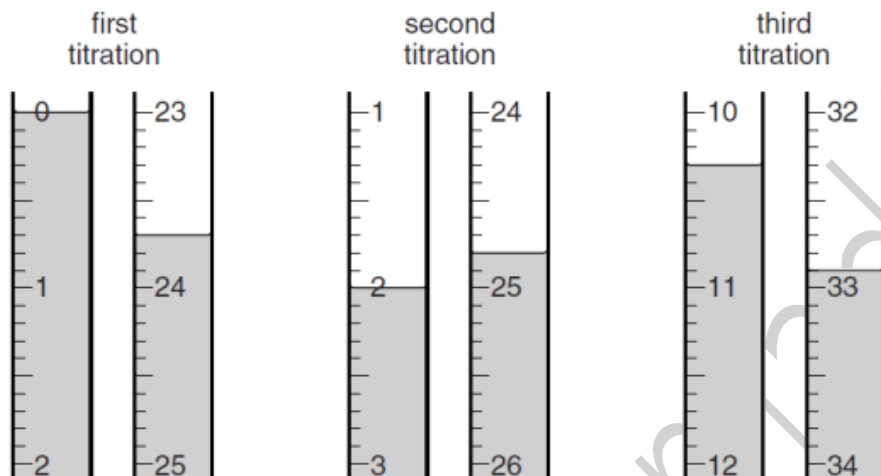
Use the diagrams to complete the results table.

titration number	1	2	3
final burette reading/cm³			
initial burette reading/cm³			
volume of 0.100 mol/dm³ sodium thiosulfate/cm³			
best titration results (✓)			

Summary

Tick (✓) the best titration results.

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

....cm³.

[4]

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

.... moles [1]

(e) 2 moles of $Na_2S_2O_3$ react with 1 mole of I_2.

Calculate the number of moles of iodine, I_2, present in 25.0 cm^3 of the solution titrated.

.... moles [1]

(f) 1 mole of KIO_x produces 3 moles of I_2.

Using your answer to **(e)** calculate the number of moles of KIO_x in 25.0 cm^3 of solution **J**.

.... moles [1]

(g) Using your answer to **(f)** calculate the number of moles of KIO_x in 250 cm^3 of solution **J**.

.... moles [1]

(h) Using your answers to **(a)** and **(g)** calculate the relative formula mass of KIO_x.

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

(i) Using your answer to **(h)** calculate the value of **x** in the formula KIO_x.
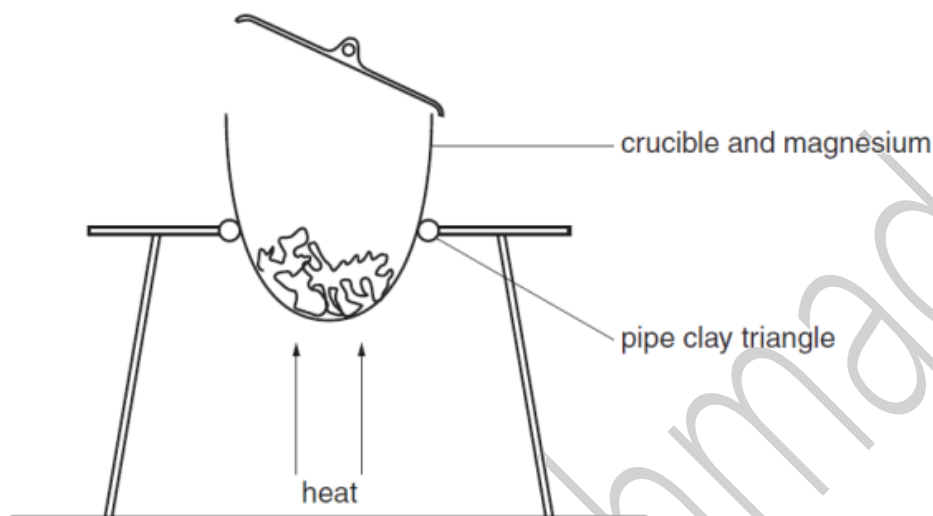[A_r: O, 16; K, 39; I, 127]

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

[Total: 12]

3 A student does an experiment to find the formula of magnesium oxide.
A 10 cm length of magnesium is loosely coiled and placed in a weighed crucible.

The crucible is heated for several minutes during which the crucible lid is raised from time to time. The magnesium changes to magnesium oxide.

(a) mass of crucible + magnesium = 14.33 g
mass of crucible = 13.85 g

Calculate the mass of magnesium.

.... g [1]

(b) Describe the appearance of

 (i) magnesium,

 ....

 (ii) magnesium oxide.

 .... [2]

(c) After cooling, the crucible is weighed.
It is reheated, cooled and reweighed.
Why is this done?

.... [1]

(d) Final mass of crucible + magnesium oxide = 14.65 g

Calculate

(i) the mass of magnesium oxide,

.... g

(ii) the mass of oxygen which reacts with the magnesium.

.... g [2]

(e) Using your answers to **(a)** and **(d)(ii)**, calculate the formula of magnesium oxide.
[A_r: O,16; Mg, 24]

.... [2]

(f) **(i)** Give an equation for a reaction in which magnesium oxide reacts with an acid.

.... [1]

(ii) By referring to your equation, state whether magnesium oxide can be classed as an acidic, basic or amphoteric oxide.

.... [1]
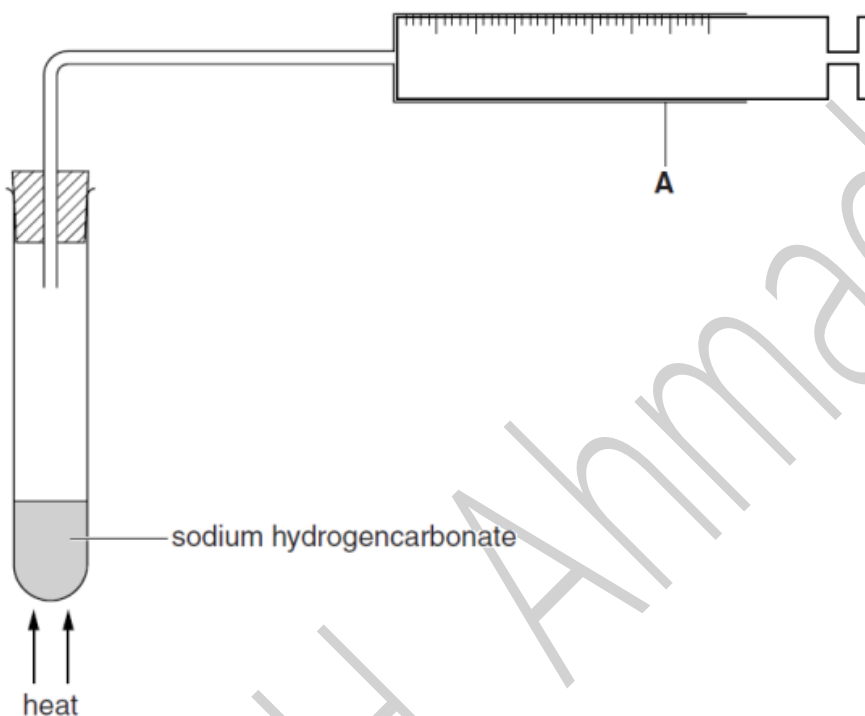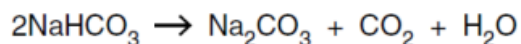
[Total: 10]

General Question on Moles

Question 17

1   A student heats some sodium hydrogencarbonate in the apparatus shown below. The reaction produces carbon dioxide.
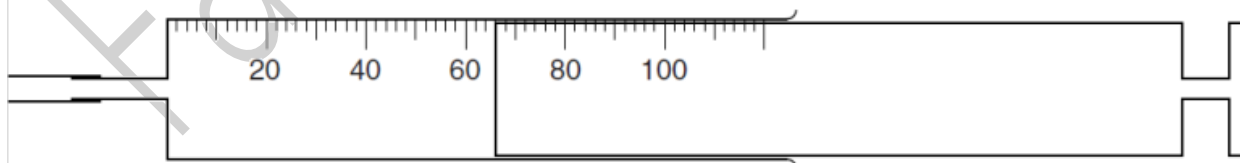
$$2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$$

A

sodium hydrogencarbonate

heat

(a) Name apparatus **A**.

....   [1]

(b) Give a test for carbon dioxide.

....[1]

(c) The diagram below shows apparatus **A** at the completion of the reaction. The carbon dioxide collected is at room temperature and pressure.

What volume of carbon dioxide is collected?

....cm^3 [1]

(d) Using your answer to **(c)**, calculate the number of moles of carbon dioxide collected, measured at room temperature and pressure.
(One mole of a gas occupies $24\,000\,cm^3$ at room temperature and pressure.)

.... moles [1]

(e) (i) Using the equation for the reaction and your answer to **(d)** calculate the number of moles of sodium hydrogencarbonate used in the experiment.

.... moles [1]

(ii) Calculate the relative formula mass of sodium hydrogencarbonate.
[A_r: H,1; C,12; O,16; Na, 23]

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

(iii) Using your answers to **(e)(i)** and **(e)(ii)** calculate the mass of sodium hydrogencarbonate used in the experiment.

.... g [1]

[Total: 7]

3 A student adds $50\,cm^3$ of $1.50\,mol/dm^3$ barium nitrate to $100\,cm^3$ of $1.00\,mol/dm^3$ sodium sulfate.

Barium sulfate is produced.

(a) (i) Describe the appearance of barium sulfate in the resulting mixture.
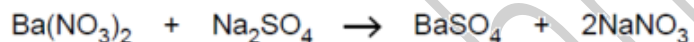
....[1]

(ii) How does the student produce a pure sample of barium sulfate from the original mixture?

....

....

....[3]

(b) The equation for the reaction is

$$Ba(NO_3)_2 \;+\; Na_2SO_4 \;\longrightarrow\; BaSO_4 \;+\; 2NaNO_3$$

(i) Calculate the number of moles of barium nitrate present in $50\,cm^3$ of $1.50\,mol/dm^3$ solution.

.... moles [1]

(ii) Calculate the number of moles of sodium sulfate in $100\,cm^3$ of $1.00\,mol/dm^3$ solution.

.... moles [1]

(iii) Deduce the number of moles of barium sulfate produced.

.... moles [1]

(iv) Calculate the mass of barium sulfate produced.
[A_r: O,16; S,32; Ba,137]

....g [2]

[Total: 9]

1 A student adds hydrochloric acid to calcium carbonate to produce carbon dioxide.

calcium
carbonate

$50 \, cm^3$ of $0.20 \, mol/dm^3$
hydrochloric acid
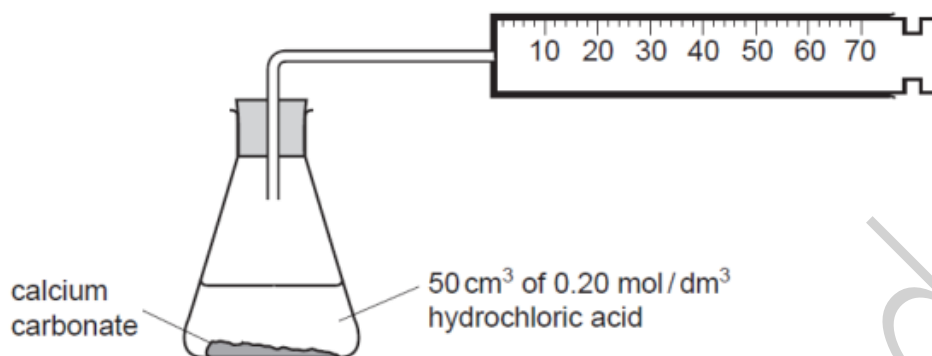
The diagram below shows the gas syringe containing the volume of carbon dioxide collected in one minute.
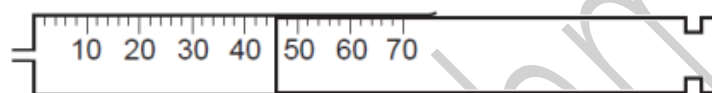
(a) What volume of carbon dioxide is collected in one minute?

....cm^3 [1]

(b) Will the volume collected during the second minute be less than, the same, or more than the volume collected during the first minute? Explain your answer.

....

....

....[2]

The equation for the reaction is

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

(c) $50 \, cm^3$ of $0.20 \, mol/dm^3$ hydrochloric acid is added to an excess of calcium carbonate.

(i) Calculate the number of moles in $50 \, cm^3$ of $0.20 \, mol/dm^3$ hydrochloric acid.

.... moles [1]

(ii) Calculate the relative formula mass of calcium carbonate.
[A_r: C,12; O,16; Ca, 40.]

....[1]

(iii) Using your answers to **(c)(i)** and **(c)(ii)** and the equation for the reaction, calculate the mass of calcium carbonate required to completely react with $50\,cm^3$ of $0.20\,mol/dm^3$ hydrochloric acid.

.... cm^3 [1]

(iv) Calculate the maximum volume of carbon dioxide that is produced when $50\,cm^3$ of $0.20\,mol/dm^3$ of hydrochloric acid reacts completely with the excess calcium carbonate.

[1 mole of a gas occupies a volume of $24\,dm^3$ at room temperature and pressure.]

.... cm^3 [1]

(d) Suggest how the speed of this reaction can be **increased** by changing

(i) the particle size of calcium carbonate,

....[1]

(ii) the concentration of hydrochloric acid.

....[1]

(e) Suggest another way in which the student can increase the speed of the reaction.

....[1]
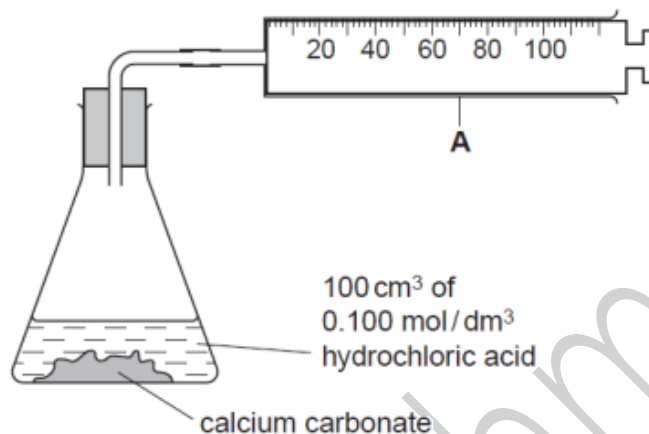
[Total: 10]

s/11/qp42

1 A student added $100\,cm^3$ of $0.100\,mol/dm^3$ hydrochloric acid (an excess) to a known mass of calcium carbonate contained in a conical flask. The reaction produced carbon dioxide according to the following equation.

$$CaCO_3 \;+\; 2HCl \;\rightarrow\; CaCl_2 \;+\; H_2O \;+\; CO_2$$
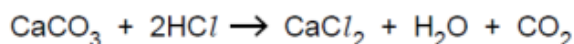
The apparatus is shown below.

A

$100\,cm^3$ of
$0.100\,mol/dm^3$
hydrochloric acid

calcium carbonate

(a) Name the apparatus labelled **A**.

.... [1]

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

test ....

observation .... [1]

(c) The diagram below shows apparatus **A** at the completion of the reaction.
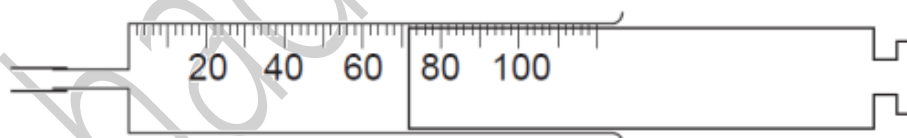
apparatus **A**

What volume of carbon dioxide was collected?

.... cm^3 [1]

(d) Using your answer to **(c)**, calculate the number of moles of carbon dioxide produced in the reaction.
[One mole of a gas occupies $24\,000\,cm^3$ at room temperature and pressure.]

.... moles [1]

(e) (i) Using the equation for the reaction and your answer to **(d)**, suggest the number of moles of calcium carbonate that reacted with 0.100 mol/dm^3 hydrochloric acid.

.... moles **[1]**

(ii) Calculate the relative formula mass of calcium carbonate, $CaCO_3$.
[A_r: Ca, 40; C, 12; O, 16]

.... **[1]**

(iii) Using your answers to **(e)(i)** and **(ii)**, calculate the mass of calcium carbonate that reacted with 0.100 mol/dm^3 hydrochloric acid.

.... g **[1]**

(f) The experiment was repeated using magnesium carbonate instead of calcium carbonate. The mass of magnesium carbonate used was identical to the mass of calcium carbonate in the previous experiment.
Calculate the volume of carbon dioxide collected.
[A_r: Mg, 24; C, 12; O, 16]

.... cm^3 **[2]**

[Total: 9]

The student then repeated the experiment, this time adding 100 cm³ of 0.25 mol/dm³ 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 dm³ at room temperature and pressure.]

.... dm³ [1]

3 A student added $30\,cm^3$ of $1.5\,mol/dm^3$ aqueous silver nitrate to a beaker containing $50\,cm^3$ of $1.0\,mol/dm^3$ aqueous sodium bromide.

A precipitate of silver bromide was produced.

(a) (i) What colour was the precipitate?

....

(ii) Name the method by which this precipitate was separated from the mixture.

....

[2]

(b) (i) Calculate the number of moles of silver nitrate contained in $30\,cm^3$ of $1.5\,mol/dm^3$ aqueous silver nitrate.

.... moles

(ii) Calculate the number of moles of sodium bromide contained in $50\,cm^3$ of $1.0\,mol/dm^3$ aqueous sodium bromide.

.... moles

[2]

Sodium bromide reacts with silver nitrate according to the equation below.

$$AgNO_3 + NaBr \longrightarrow AgBr + NaNO_3$$

(c) Using this equation and your answers to **(b)**, calculate the mass of silver bromide produced in this experiment.

[A_r: Ag, 108; Br, 80]

.... g [2]

(d) The student repeated the experiment using $40\,cm^3$ of $1.5\,mol/dm^3$ aqueous silver nitrate with $50\,cm^3$ of $1.0\,mol/dm^3$ sodium bromide.
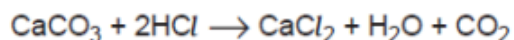
Calculate the mass of silver bromide produced in this experiment.

.... g [2]

3   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.
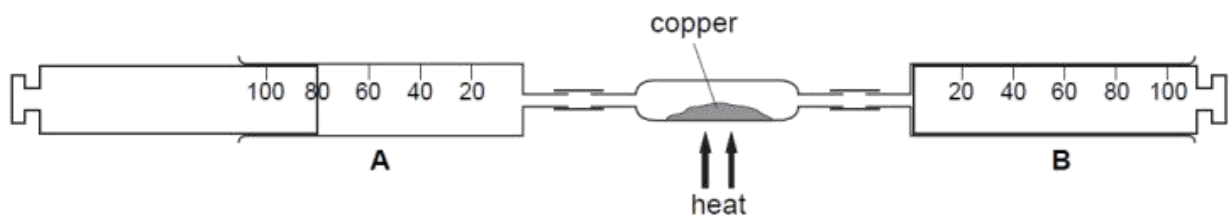[A_r: Mg, 24; C, 12; O, 16]

....dm^3 [2]

s/04/qp4

Question 24

1   A student found the composition of air using the apparatus shown below.

Syringe **A** contained 80 cm³ of air. The air was forced over heated copper into syringe **B**. The air was then forced back into syringe **A**.

The process was repeated several times until the volume of gas forced back into syringe **A** was constant.

The diagram below shows the volume of gas in syringe **A** after the experiment was finished.
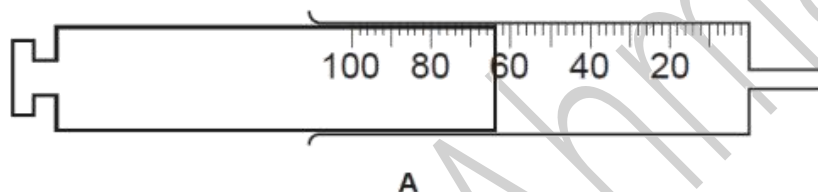
(a) **(i)**   Name the major component of the gas remaining in syringe **A**.

....[1]

  (ii)   What is the volume of gas remaining in syringe **A**?

....[1]

  (iii)   Calculate the percentage of oxygen in the original sample of air.

....[1]

(b)   The copper reacted with oxygen in the air to produce copper(II) oxide.

  (i)   Write the equation for this reaction.

....[1]

  (ii)   What colour is copper(II) oxide?

....[1]

(c) In another experiment 0.16 g of copper was placed in the tube.

    (i) Calculate the number of moles of copper in the tube.
[A_r: Cu, 64]

....[1]

    (ii) Using your equation in **(b)(i)** deduce the number of moles of oxygen required to react with 0.16 g of copper.

....[1]

    (iii) Using your answer to **(c)(ii)** calculate the volume of oxygen required to react with 0.16 g of copper.
[1 mol of a gas measured at 25 °C occupies a volume of 24 dm^3.]

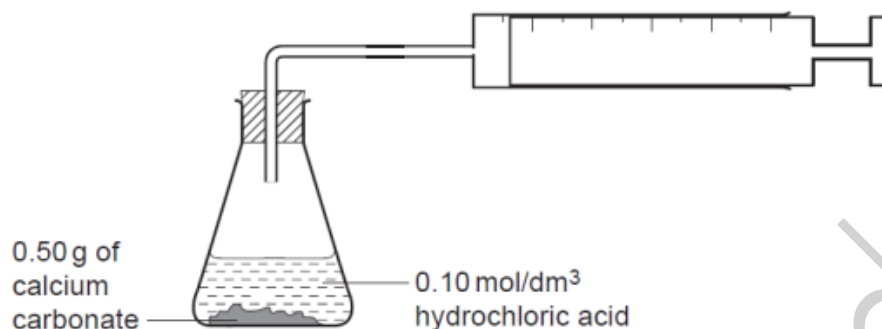...cm^3 [1]

    (iv) Using your answers to **(a)(iii)** and **(c)(iii)** calculate the volume of air required to react with 0.16 g of copper.

....cm^3 [1]
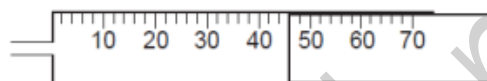
[Total: 9]

1 A student added hydrochloric acid to calcium carbonate to produce carbon dioxide using the apparatus shown below.

0.50 g of
calcium
carbonate

0.10 mol/dm³
hydrochloric acid

(a) The diagram below shows the volume of carbon dioxide collected after one minute.

What volume of carbon dioxide was collected after one minute?
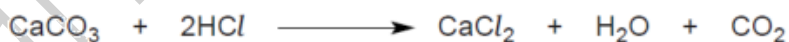
....cm³ [1]

(b) Would the volume of carbon dioxide collected during the second minute be less than, the same, or more than the volume collected during the first minute? Explain your answer.

....

....

....[2]

(c) The equation for the reaction is

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

0.10 mol/dm³ hydrochloric acid was added to 0.50g of calcium carbonate until no more carbon dioxide was produced.

(i) Calculate the number of moles of calcium carbonate used in the experiment.
    [A_r; C, 12; O, 16; Ca, 40]

....moles

(ii) Using your answer to **(c)(i)** calculate the minimum volume of 0.10 mol/dm^3 hydrochloric acid that was required to react with 0.50 g of calcium carbonate.

....cm^3

(iii) Calculate the maximum volume of carbon dioxide produced. 1 mole of a gas measured at 25 °C has a volume of 24 dm^3.

....cm^3
[3]

w/05/qp4

Question 26

(c) (i) Calculate the mass of nitrogen contained in 160 g of ammonium nitrate, NH_4NO_3 (A_r: N, 14; H, 1; O, 16.)

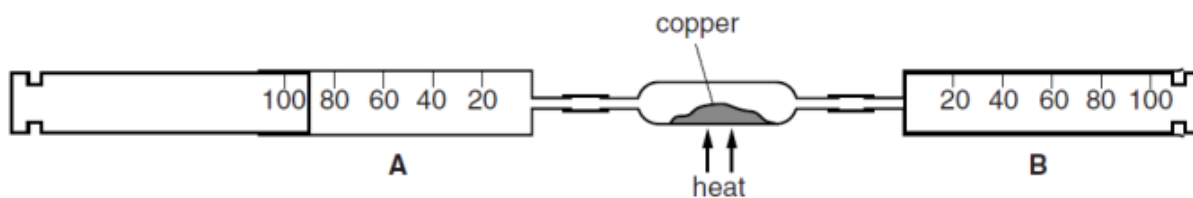... g

(ii) What is the volume of this mass of nitrogen at r.t.p.? (One mole of a gas occupies 24 dm^3 at r.t.p.)

.... dm^3

s/02/qp4

1   A student determines the oxygen content of air using the apparatus shown.

copper

A   heat   B

Syringe **A** contains 90 cm^3 of air. The air is forced over heated copper into syringe **B**. The air is then forced back over the heated copper into syringe **A**.

The process is repeated several times until the volume of gas forced back into syringe **A** is constant. The apparatus is allowed to cool to room temperature.

The diagram below shows the volume of gas in syringe **A** after the experiment is finished.

A
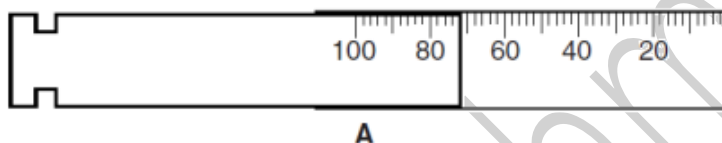
(a) Copper reacts with oxygen in the air to produce copper(II) oxide.

(i) Construct the equation for this reaction.

....[1]

(ii) What colour is copper(II) oxide?

....[1]

(b) (i) What is the volume of gas remaining in syringe **A**?

.... cm^3 [1]

(ii) Name the major component of the gas remaining in syringe **A**.

....[1]

(iii) Calculate the volume of oxygen that reacts with the copper.

.... cm^3 [1]

(iv) Using your answer to **(b)(iii)**, calculate the number of moles of oxygen that react with the copper.
[One mole of a gas occupies 24 000 cm^3 at room temperature and pressure.]

.... moles [1]

(v) Using your equation in **(a)(i)** and your answer to **(b)(iv)** calculate the mass of copper that reacts with the oxygen.
[A_r: Cu, 64]

....g [1]

(c) In another experiment $60\,cm^3$ of oxygen is required to react with all the copper. Calculate the volume of air required to provide this volume of oxygen.
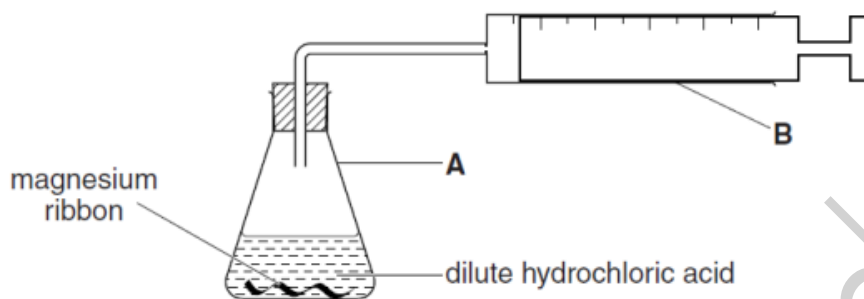
.... cm^3 [1]

[Total: 8]

Question 28

1 A student adds a known mass of magnesium ribbon to $100\,cm^3$ of dilute hydrochloric acid (an excess) in the apparatus shown below. Hydrogen gas is evolved. The time taken to collect $48\,cm^3$ of gas at room temperature and pressure is measured.

(a) (i) Name apparatus **A**.

....[1]

(ii) Name apparatus **B**.

....[1]

(b) (i) Calculate the number of moles of hydrogen in the $48\,cm^3$ of gas.

[1 mole of any gas occupies $24\,000\,cm^3$ at room temperature and pressure.]

.... moles [1]

(ii) Use the equation below to deduce the mass of magnesium used in the experiment to produce $48\,cm^3$ of hydrogen at room temperature and pressure.

$[A_r: Mg, 24]$

$$Mg \ + \ 2HCl \ \rightarrow \ MgCl_2 \ + \ H_2$$
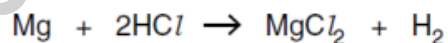
.....................................g [1]

(c) Give a test for hydrogen gas.

....[1]

w/13/qp41

1 **(a)** A student pours aqueous silver nitrate into a measuring cylinder.
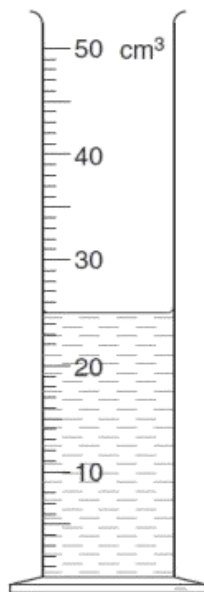
What is the volume of aqueous silver nitrate in the measuring cylinder?

.... cm^3 [1]

(b) The student transfers the aqueous silver nitrate into a beaker containing excess aqueous potassium iodide. A precipitate of silver iodide is formed.
What colour is silver iodide?

.... [1]

(c) The student separates the silver iodide precipitate from the solution.
Name the separation process.

.... [1]

(d) The student dries and weighs the silver iodide.

mass of silver iodide = 4.70 g

Calculate the number of moles of silver iodide in this mass.
[A_r: Ag, 108; I, 127]

.... moles [1]

(e) The concentration of aqueous potassium iodide used is 1.00 mol/dm^3. It reacts with aqueous silver nitrate according to the following equation.

$$AgNO_3 \ + \ KI \ \rightarrow \ AgI \ + \ KNO_3$$
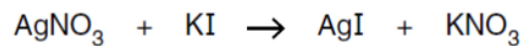
Using your answer from **(d)**, deduce the number of moles of silver nitrate used in the reaction.

.... moles [1]

(f) Using your answers to **(a)** and **(e)** calculate the concentration of the aqueous silver nitrate.

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

[Total: 6]

w/12/qp42

Question 30

4   A student heats solid sodium hydrogencarbonate in the apparatus shown below. The carbon dioxide gas produced is collected in apparatus **D**.

$$2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$$
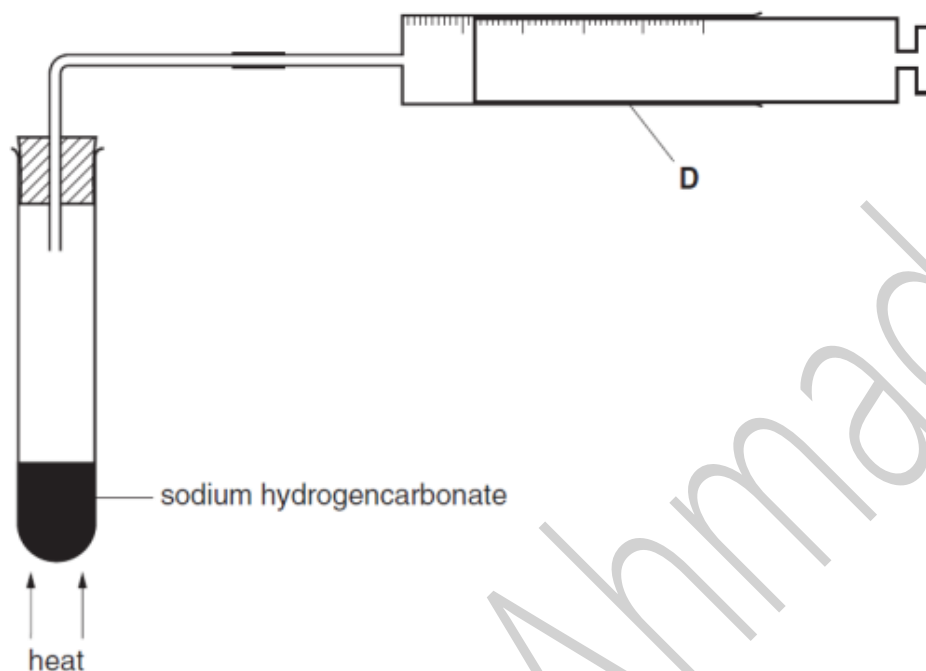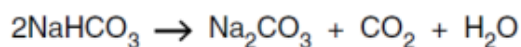
(a) Name apparatus **D**.

.... [1]

(b) Give a test for carbon dioxide.

test ....

observation .... [1]

(c) On heating the sample of sodium hydrogencarbonate, $120\,cm^3$ of carbon dioxide is evolved. The gas is measured at room temperature and pressure.

(i) Calculate the number of moles of carbon dioxide evolved.
[1 mole of a gas occupies $24\,dm^3$ at room temperature and pressure.]

.... moles [1]

(ii) Using your answer to **(c)(i)** and the equation for the reaction, deduce the number of moles of sodium hydrogencarbonate decomposed.

.... moles [1]

(iii) Using your answer to **(c)(ii)**, calculate the mass of sodium hydrogencarbonate decomposed.

$[A_r: H,1; C,12; O,16; Na, 23]$

.... g [1]

[Total: 5]

w/11/qp42

2 A student produced zinc oxide by heating zinc nitrate.

Some zinc nitrate was placed in a previously weighed crucible which was then reweighed.

mass of crucible + zinc nitrate = 11.79 g
mass of crucible = 9.90 g

(a) Calculate the mass of zinc nitrate.

.... g [1]

The solid zinc nitrate was heated in a fume cupboard. The following reaction took place.

$$2Zn(NO_3)_2(s) \rightarrow 2ZnO(s) + 4NO_2(g) + O_2(g)$$
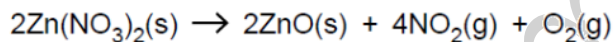
(b) Describe the appearance of zinc oxide.

.... [1]

(c) Why was the heating done in a fume cupboard?

.... [1]

(d) Using your answer to **(a)** calculate the number of moles of zinc nitrate used in the reaction.

[A_r: Zn, 65; N, 14; O, 16]

.... moles [1]

(e) Using the equation for the reaction and your answer to **(d)** calculate the total volume of each gas produced from the reaction.

[1 mole of a gas occupies a volume of 24 dm³ at room temperature and pressure.]

volume of NO$_2$ .... cm³

volume of O$_2$ .... cm³

[2]

(f) Name a compound that will react with zinc oxide to make zinc nitrate.

.... [1]

[Total: 7]

w/09/qp4

Percentage Yield

3 A student used magnesium oxide to prepare magnesium nitrate.
The magnesium nitrate was then heated to re-form magnesium oxide.
The object of the experiment was to determine whether the mass of magnesium oxide produced was the same as the amount used initially.

Some magnesium oxide was put into a weighed evaporating dish.
The dish was reweighed.

Mass of dish + magnesium oxide   = 14.70 g
Mass of dish   =   8.90 g

(a) Calculate the mass of magnesium oxide used.

The mass of magnesium oxide = ... g   [1]

(b) An acid was slowly added until all the magnesium oxide had dissolved. Magnesium nitrate was produced.

Name the acid.

....[1]

(c) The solution was evaporated to dryness and the resulting solid was heated in a fume cupboard. The following reaction took place.

$$2Mg(NO_3)_2(s) \longrightarrow 2MgO(s) + 4NO_2(g) + O_2(g)$$
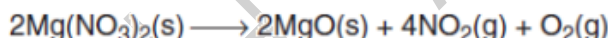
After cooling, the dish was weighed. It was then heated again, cooled and reweighed. The final mass of the dish and contents was 14.40 g.

(i) Why was the heating done in a fume cupboard?

....[1]

(ii) Why was the dish reweighed?

....[1]

(iii) Calculate the mass of magnesium oxide obtained.

.... g [1]

(d) Using your answers to (a) and (c)(iii) calculate the percentage yield of magnesium oxide.

....% [1]

(e) Suggest one reason why the experiment did not produce the same amount of magnesium oxide as was used at the beginning of the experiment.

....[1]

Question 33

4 A student was asked to make a sample of barium sulphate, $BaSO_4$. She added $100\,cm^3$ of $0.20\,mol/dm^3$ sulphuric acid to $60\,cm^3$ of $0.25\,mol/dm^3$ barium nitrate.
The equation for the reaction is

$$Ba(NO_3)_2 + H_2SO_4 \longrightarrow BaSO_4 + 2HNO_3$$

(a) Describe the appearance of barium sulphate in the resulting mixture.

....[1]

(b) Calculate

(i) the number of moles of sulphuric acid used in the experiment,

.... moles [1]

(ii) the number of moles of barium nitrate used in the experiment.

.... moles [1]

(c) Using your answers to **(b)(i)** and **(ii)** calculate the maximum mass of barium sulphate that could be produced in the reaction.
[A_r: Ba, 137; S, 32; O, 16]

.... g [1]

The barium sulphate was removed from the solution by filtration. It was dried and weighed.

(d) The mass of barium sulphate obtained was 3.35 g. Calculate the percentage yield of barium sulphate.

.... % [1]

Another student, doing the same experiment and using the same quantities of barium nitrate and sulphuric acid, obtained 3.60 g of product.

(e) Suggest a reason for this increased mass of product.

....[1]

(f) Suggest a different barium salt that could have been used instead of barium nitrate to produce barium sulphate.

....[1]

[Total: 7]

w/07/qp4

Percentage Composition

Question 34

2 A student investigated the properties of dilute aqueous ammonia.

(a) A few drops of litmus solution were added to $5\,cm^3$ of aqueous ammonia.

What was the colour of the mixture?

....[1]

(b) Aqueous sodium hydroxide was added to the aqueous ammonia and the solution was warmed. A gas was evolved.

Name this gas and give a test and result to confirm its presence.

gas ....

test ....

result ....[3]

The fertiliser ammonium phosphate, which is made from ammonia, has the formula $(NH_4)_3PO_4$. It contains phosphorus, one of three essential elements for the growth of plants.

(c) (i) Which other essential element is found in ammonium phosphate?

....

(ii) Calculate the mass of phosphorus contained in 1 kg of ammonium phosphate. (A_r: N, 14; H, 1; P, 31; O, 16)

....[3]

s/03/qp4

2 The fertiliser ammonium nitrate is a source of nitrogen.
It has the formula NH_4NO_3.
It can be made by adding an acid to aqueous ammonia.

(a) Name and give the formula of this acid.

name ....

formula .... [1]

(b) Describe briefly how crystals of ammonium nitrate can be made from aqueous ammonium nitrate.

....

....

....[3]

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

....g [2]

(ii) What volume would the mass of nitrogen calculated in **(i)** occupy in the gaseous state at room temperature and pressure?
[One mole of a gas occupies 24 dm^3 at room temperature and pressure.]

.... dm^3 [1]

(d) Name and give the formula of another ammonium salt which may be used as a fertiliser.

name ....

formula .... [1]

(e) Give both the formula and a test for the ammonium ion.

formula ....

test ....

observation ....[3]

[Total: 11]

Question 36

(e) The original mixture of 100 g of hexane, C_6H_{14}, and heptane, C_7H_{16}, contained 40 g of hexane.

Calculate the amount, in moles, of both hexane and heptane and hence the percentage by moles of hexane in the mixture.

[A_r: C,12; H,1]

moles of hexane ....

moles of heptane ....

[1]

percentage by moles of hexane .... [1]

[Total: 12]

Question 37

(c) The fertiliser ammonium phosphate, $(NH_4)_3PO_4$, contains nitrogen, one of the essential elements for the growth of plants.

  (i) Which other essential element is found in ammonium phosphate?

  .... [1]

  (ii) Given an aqueous solution of ammonium phosphate, describe a test to confirm the presence of the ammonium ion.

  ....

  ....

  ....

  .... [3]

  (iii) Calculate the mass of nitrogen contained in 1 kg of ammonium phosphate.

  $[A_r: N, 14; H, 1; P, 31; O, 16]$

  .... g [2]

  [Total: 10]

w/09/qp4