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Thursday 16 May 2019 – Morning

GCSE (9−1) Chemistry B (Twenty First Century Science)

J258/03 Breadth in Chemistry (Higher Tier)

Time allowed: 1 hour 45 minutes

You must have:
- the Data Sheet (for GCSE Chemistry B (inserted))
- a ruler (cm/mm)

You may use:
- a scientific or graphical calculator
- an HB pencil

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Answer **all** the questions.
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- Write your answer to each question in the space provided. If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.

INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- This document consists of **24** pages.

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Answer **all** the questions.

1 Diamond and graphite are two forms of carbon.

(a) **(i)** Fig. 1.1 shows the structure of diamond:

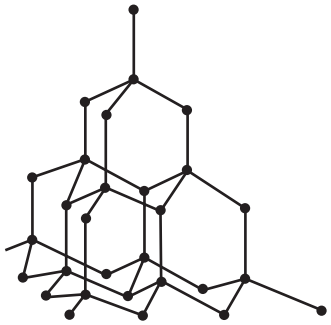

Fig. 1.1

Explain why diamond has a high melting point.

.....

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

(ii) **Fig. 1.2** shows the structure of graphite.

Graphite also has a high melting point.

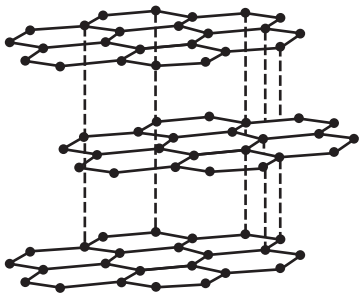

Fig. 1.2

Describe and explain **two** other properties of graphite.

Use the structure shown in **Fig. 1.2** to help explain your answers.

Property 1 .....

Explanation .....

.....

Property 2 .....

Explanation .....

.....

[2]

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(b) Diamond has a high density.

1.0 g of diamond has a volume of 0.29 cm^3.

Calculate the mass of 1.0 cm^3 of diamond.

Give your answer to **2** significant figures.

Mass = ... g **[2]**

(c) 12 g of diamond produces 44 g of CO_2 when it is burned completely.

(i) Calculate the mass of CO_2 produced when 1.0×10^{-3} g of diamond is burned completely.

Give your answer to **2** significant figures.

Mass of CO_2 = ... g **[2]**

(ii) Jane makes some statements about graphite and diamond:

1 'Complete combustion of 12 g of graphite produces less than 44 g of CO_2.'

2 'This is because atoms in graphite are further apart than in diamond.'

Do you agree with Jane's statements?

Explain your answer.

.....

.....

.....

..... **[2]**

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2 Ben uses chromatography to investigate a solid black food dye.

(a) Ben tests the solubility of the dye in three solvents.

Here are his results:

Solvent	Result
water	insoluble
ethanol	insoluble
propanone	soluble

(i) Which of the three solvents are **non-aqueous**?

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

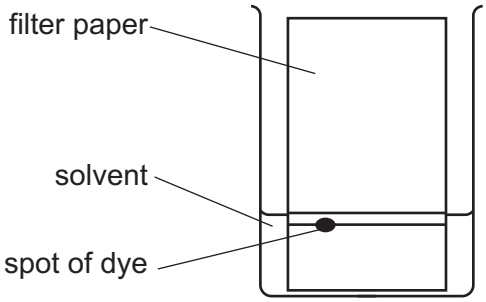
(ii) Ben uses paper chromatography to investigate the dye.

Which of the three solvents should Ben use in his investigation?

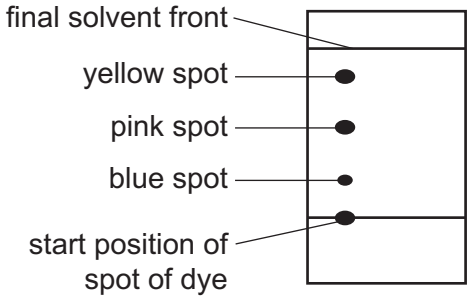
..... **[1]**

(b) Here is some information about the experiment:

chromatogram at the start



chromatogram at the end



(i) Name the stationary phase.

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

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(ii) What is wrong with the way Ben set up his experiment?

Explain your answer.

.....

.....

..... **[2]**

(iii) Which spot has the greatest R_f value in the chromatogram at the end?

Explain your answer.

.....

.....

..... **[2]**

(c) Ben thinks the dye is a pure substance. Kareem, another student, disagrees.

Who do you agree with?

Explain your answer.

.....

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

(d) Ben measures the melting point of the dye.

Describe what Ben would see if the dye is pure.

.....

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

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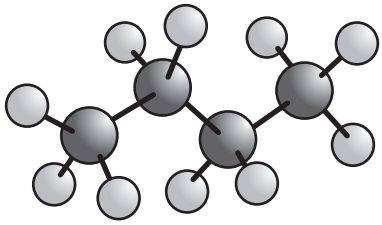
3 'Camping gas' contains butane.

This is a 'ball and stick' model of a butane molecule:



(a) **(i)** Butane is a hydrocarbon.

Draw a 'dot and cross' diagram for a butane molecule.

[1]

(ii) Chemists use 'ball and stick' models and 'dot and cross' diagrams.

Give **one** advantage of using each model.

'ball and stick'

.....

.....

'dot-and cross'

.....

.....

[2]

(b) The molecular formula of butane is C_4H_{10}.

Calculate the percentage of carbon by mass in butane.

Give your answer to **2** significant figures.

Percentage of carbon = ... % **[3]**

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(c) Propane is another hydrocarbon.

Butane, C_4H_{10}, boils at 0 °C.

Propane, C_3H_8, boils at −42 °C.

Explain this difference in boiling point.

Use ideas about intermolecular forces in your answer.

.....

.....

.....

..... **[2]**

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4 This question is about the efficiency of LED light-bulbs in 2015 compared to 2011.

The table shows part of a life-cycle assessment for the two light-bulbs. The numbers in the table compare the energy used to give the same amount of light in a certain time.

Stage in life cycle	2011 light (MJ)	2015 light (MJ)
Manufacture	343	132
Transport	3	2
Use	3540	1630

(a) In total, 2015 LED lights use less energy than 2011 LED lights.

Calculate the percentage decrease in energy use at 'manufacture' stage from 2011 to 2015.

Give your answer to **2** significant figures.

Percentage decrease = ... % **[2]**

(b) The data in the table does not cover the whole life-cycle assessment.

Describe in detail the **final** stage of the life-cycle assessment.

.....

.....

..... **[2]**

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5 Mendeleev left gaps when he constructed his Periodic Table. He thought elements would be discovered to fill these gaps.

(a) Mendeleev left a gap below aluminium.

Later gallium was discovered and fitted this gap.

Give **two** reasons why gallium fitted this gap.

1 .....

2 .....

[2]

(b) When Mendeleev made his Periodic Table he also put some elements 'out of order'.

Which later discovery proved that he was right to do this?

Tick (✓) **one** box.

More properties of the elements were discovered.	☐
Atomic numbers were measured.	☐
Most atoms contain neutrons.	☐
More elements were discovered.	☐

[1]

(c) Gallium forms an oxide, Ga_2O_3.

Draw a 'dot and cross' diagram for the **ions** in Ga_2O_3.

Show outer electron shells only.

[3]

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6 Some cars use hydrogen fuel cells instead of petrol.

This is the reaction that happens in the hydrogen fuel cell:

$2H_2 + O_2 \rightarrow 2H_2O$

(a) Suggest **one** advantage and **one** disadvantage of using fuel cells instead of petrol.

Advantage

.....

.....

Disadvantage

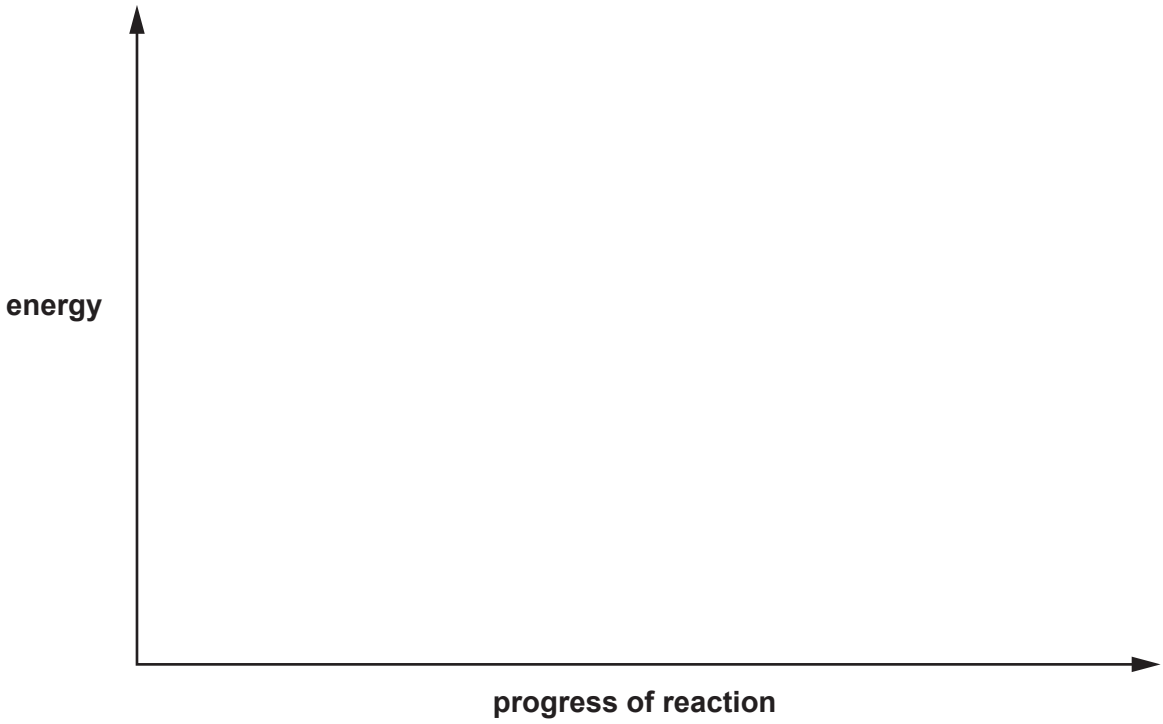
.....

.....

[2]

(b) Complete a reaction profile for the above reaction of hydrogen with oxygen.

On the profile, show:
- the formulae of reactants and products
- the activation energy.



[3]

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(c) Burning 10 g of hydrogen gives out 1200 kJ of energy.

How much energy is given out when 1.0 mole of H_2 burns?

Use the formula: number of moles = $\frac{\text{mass of substance}}{\text{relative formula mass}}$

Energy = ... kJ **[2]**

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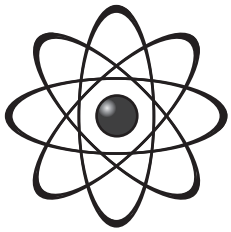
7 This question is about Rutherford's model of the atom.



Rutherford's model describes:
- a small positive nucleus
- the nucleus surrounded by empty space
- electrons orbiting in this empty space.

(a) Thomson's 'plum pudding' atom was an earlier model of the atom.

Describe **one** way in which Thomson's model of the atom was different from Rutherford's.

.....

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

(b) Rutherford asked Hans Geiger and Ernest Marsden to do an experiment to test his model.

They fired positive particles at a piece of gold foil.

What did they see that surprised them?

Tick (✓) **one** box.

All the positive particles went straight through. ☐

Some positive particles lost their charge. ☐

Many positive particles 'bounced back'. ☐

Very few positive particles 'bounced back'. ☐

[1]

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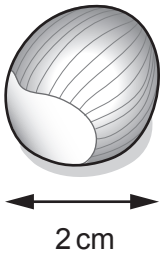
(c) A nut has an average diameter of 2 cm.



The diameter of an atom is on average 50 000 times bigger than the diameter of its nucleus.

Estimate the diameter of the nucleus if the atom is as big as the nut.

Give your answer in metres **and** in standard form.

Diameter = ... m **[2]**

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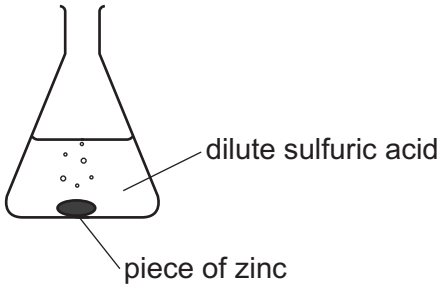
8 Sundip reacts zinc with dilute sulfuric acid.



This is the equation for the reaction:

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

(a) Sundip drops a **piece** of zinc into some dilute sulfuric acid.

She then drops some zinc **powder** into the dilute sulfuric acid.

Which reaction is faster?

Explain your answer.

.....

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

(b) Sundip adds some blue copper sulfate solution to the sulfuric acid. She then drops in a piece of zinc.

Sundip thinks copper sulfate is a catalyst.

Describe **two** things that Sundip would observe if copper sulfate is a catalyst.

1 .....

.....

2 .....

.....
[2]

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(c) **(i)** Sundip uses 6.5 g of zinc and excess acid. All the zinc reacts.

Calculate the **volume** of hydrogen is made at room temperature and pressure.

Use the formula: number of moles of gas = $\frac{\text{volume of gas in sample}}{24}$

Give your answer to **2** significant figures.

One mole of gas at room temperature and pressure has a volume of 24 dm^3.

Volume of hydrogen = ... dm^3 **[2]**

(ii) Sundip repeats **(c)(i)** with a catalyst present.

How does the volume of hydrogen compare with the volume calculated in part **(c)(i)**?

Give **one** reason for your answer.

.....

.....

..... **[2]**

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9 Some countries do not have enough drinkable water.

(a) Chlorine is added to water to make it fit to drink.

The test for chlorine gas relies on two properties of chlorine.

Put a (ring) around the **two** correct answers.

acidic

bleaching action

green gas

reacts with metals

toxic

[2]

(b) **(i)** Explain why chlorine is added to drinking water.

.....

.....

..... **[2]**

(ii) Give **one** risk of adding chlorine to drinking water.

.....

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

(c) Beth adds a solution of sodium bromide to a sample of water.

(i) What colour does she see if the water contains dissolved chlorine?

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

(ii) Write an **ionic** equation for this reaction.

.....

..... **[2]**

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10 Ammonia and its compounds are used world-wide as fertilisers.

Ammonia is made by the Haber process.

This is an equation for the reaction:

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

The forward reaction is exothermic.

(a) The $\rightleftharpoons$ sign shows that the reaction is 'in equilibrium'.

Which two statements are correct for this reaction at equilibrium?

Tick (✓) **two** boxes.

The reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ has stopped. ☐

There is a mixture of N_2, H_2 and NH_3. ☐

The reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ is going in both directions. ☐

The reaction $2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$ does not happen. ☐

[2]

(b) Which two statements about the Haber Process are correct?

Tick (✓) **two** boxes.

Nitrogen is the most expensive raw material. ☐

Hydrogen is made from natural gas and steam. ☐

Ammonia is separated and the nitrogen and hydrogen are recycled. ☐

The reaction is faster at low pressures. ☐

[2]

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(c) In the Haber process a temperature of 450 °C is often used.

Nina says,

'The Haber process should be run at a lower temperature. More ammonia is produced per day at a lower temperature.'

Discuss Nina's statement.

.....

.....

.....

..... **[3]**

(d) Jamal, another student, says,

'Fertilisers that contain ammonium compounds should be banned.'

Give **one** argument for and **one** argument against these types of fertilisers being banned.

.....

.....

.....

.....

..... **[2]**

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11 Mia has three metals, **A**, **B** and **C**, that she reacts with water.

This is what she sees:

Metal **A** Fizzes and reacts quickly.

Metal **B** A few bubbles appear after some time.

Metal **C** Slow fizzing.

(a) **(i)** Which metal forms positive ions most easily?

Give **one** reason for your answer.

.....

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

(ii) Metal **A** reacts with water to form $\mathbf{A^{2+}}$ ions.

Write the **half** equation for this reaction.

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

(iii) Explain whether metal **A** is being reduced or oxidised.

.....

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

(b) Metal **C** goes brown when put in copper sulfate solution, $CuSO_4$.

Metal **C** forms a compound that contains $\mathbf{C^{2+}}$ ions.

Write a balanced symbol equation for this reaction. Include state symbols.

..... **[2]**

(c) Metals conduct electricity.

Describe how the bonding in metals explains this.

.....

.....

.....

..... **[2]**

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12 'Tumsoothe' is a medicine that cures indigestion.

Tumsoothe is a solution of 'sodium bicarbonate', $NaHCO_3$.

Layla puts some Tumsoothe in a beaker and places it on a balance.

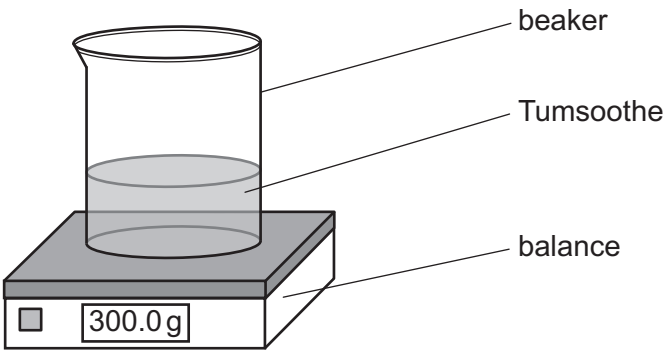

Fig. 12.1

She adds dilute hydrochloric acid to the contents of the beaker. CO_2 is given off.

(a) Layla records the mass of the beaker and its contents every 10 seconds up to 60 seconds.

This is a graph of her results:

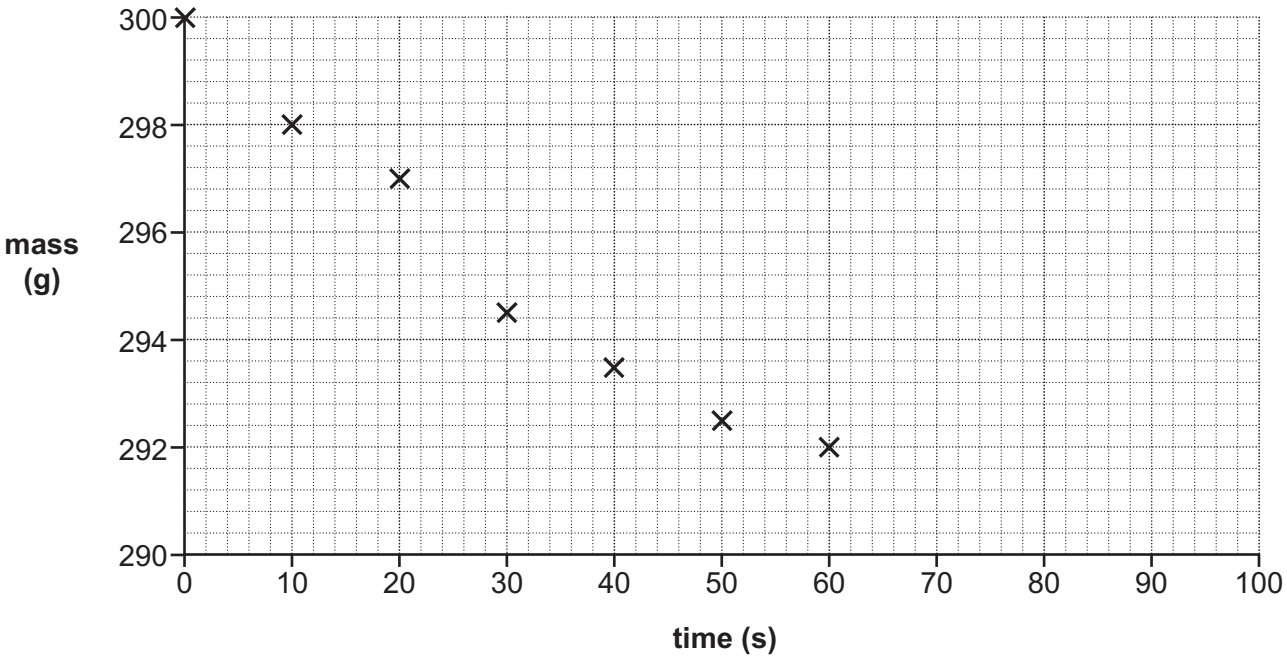

Fig. 12.2

(i) Draw a curve of best fit on the graph in **Fig 12.2**. **[1]**

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(ii) Use **Fig. 12.2** to calculate the **initial** rate of reaction.

Initial rate of reaction = ... g/s **[2]**

(iii) Describe how the rate of reaction changes with time.

.....

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

(iv) Use **Fig. 12.2** to estimate the **total** mass loss in the reaction after 100 seconds has passed.

Explain how you obtained your answer.

.....

.....

.....

Total mass loss = ... g **[2]**

(b) Layla does her experiment a second time. She uses an excess of acid and a different volume of Tumsoothe.

8 g of CO_2 is given off.

(i) Calculate the number of moles of CO_2 given off.

Use the formula: number of moles = $\frac{\text{mass of substance}}{\text{relative formula mass}}$

Give your answer to **2** significant figures.

Number of moles of CO_2 = ... mol **[2]**

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(ii) This is an equation for the reaction:

$NaHCO_3(aq) + HCl(aq) \rightarrow CO_2(g) + NaCl(aq) + H_2O(l)$

Calculate the **mass** of $NaHCO_3$ that reacts.

Use the formula: number of moles = $\frac{\text{mass of substance}}{\text{relative formula mass}}$

Give your answer to **2** significant figures.

Use your answer to **(b)(i)** to help you.

Mass of $NaHCO_3$ = ... g **[2]**

(c) Layla wants to measure the concentration of $NaHCO_3$ in Tumsoothe.

She titrates her Tumsoothe solution with hydrochloric acid.

(i) Layla measures out 25.0 cm^3 of Tumsoothe.

What piece of apparatus should Layla use to measure out this volume?

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

(ii) Layla repeats her titration three times. Her results are shown.

Repeat	**1**	**2**	**3**
Volume of acid added to neutralise $NaHCO_3$ (cm^3)	20.10	20.20	20.60

What can Layla do to improve the quality of her results?

.....

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

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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