DFD

Cambridge Assessment International Education

Cambridge IGCSE™

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CO-ORDINATED SCIENCES **0654/63**

Paper 6 Alternative to Practical **October/November 2025**

1 hour 30 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS
- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION
- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [ ].
- Notes for use in qualitative analysis are provided in the question paper.

This document has **24** pages.

[Turn over

Question 1 starts on page 3.

1 A student investigates the uptake of water by a plant.

(a) Fig. 1.1 shows the apparatus used to measure water uptake in a shoot of a plant.
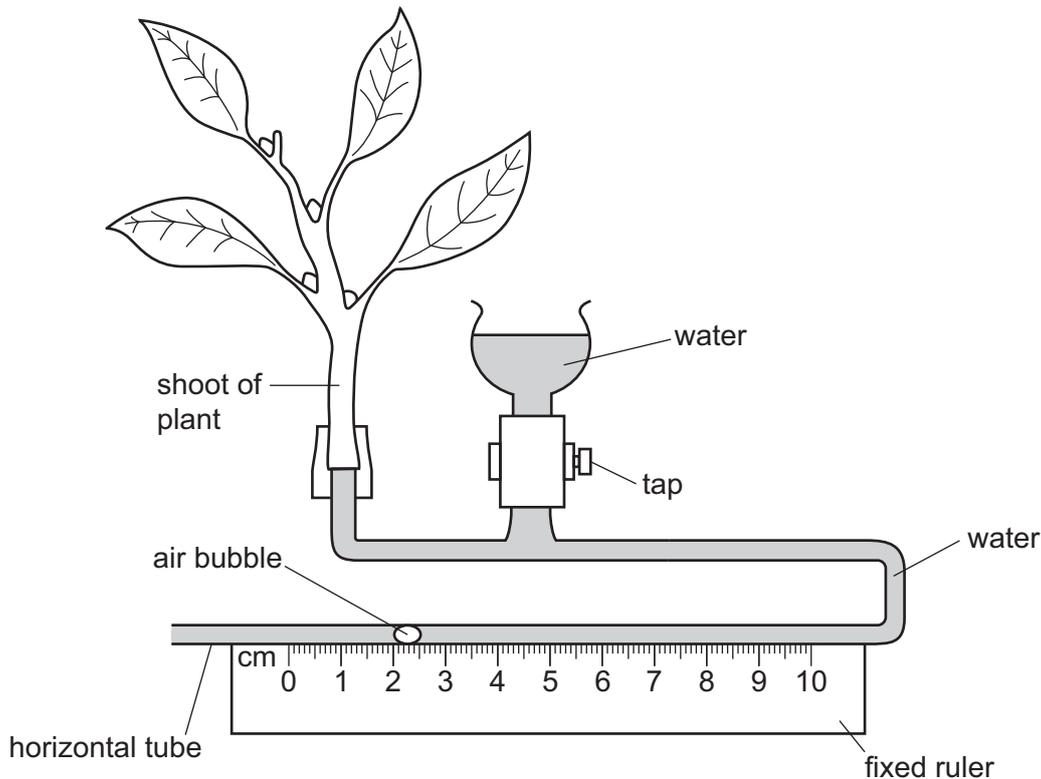

Fig. 1.1

The cut end of a leafy shoot of a plant is inserted into the apparatus.

As water is lost from the leaves, water moves into the plant shoot to replace it.

This causes the air bubble to move towards the shoot.

(i) The student assembles the apparatus and waits five minutes before taking their initial measurement of the position of the air bubble.

Suggest why the student waits 5 minutes.

....

.... [1]

(ii) The student records the initial position of the left edge of the air bubble and then records the position of the left edge of the bubble every 2 minutes for 10 minutes.

Some of the student's results are shown in Table 1.1.

Table 1.1

time / min	position of left edge of air bubble / cm
0	0.6
2	2.1
4	
6	
8	7.0
10	8.7

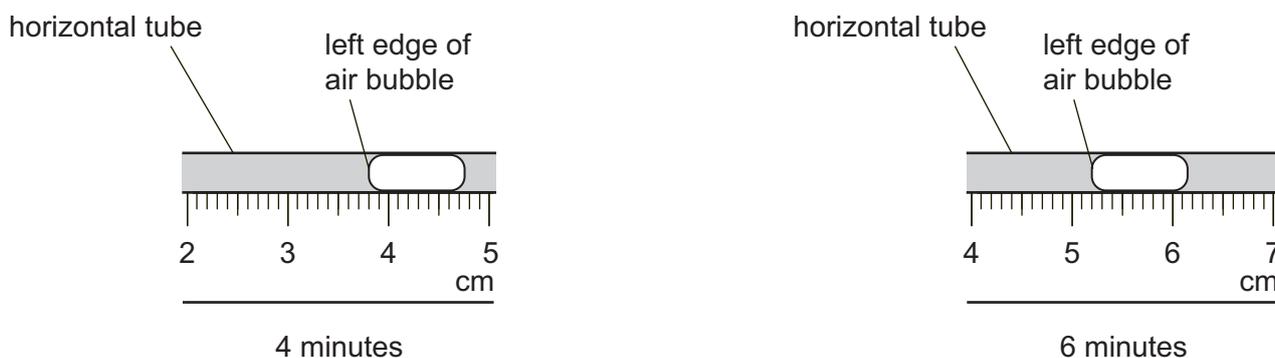Fig. 1.2 shows the position of the air bubble at 4 and 6 minutes.

Fig. 1.2

Measure the position of the bubble at 4 minutes and 6 minutes.

Read your measurements from the **left edge** of the bubble.

Record these values in Table 1.1. [2]

(b) (i) On the grid, plot position of air bubble (vertical axis) against time.

You will be asked to extend the graph.

Your vertical axis needs to include the value 10.

Your horizontal axis needs to include the value 12.
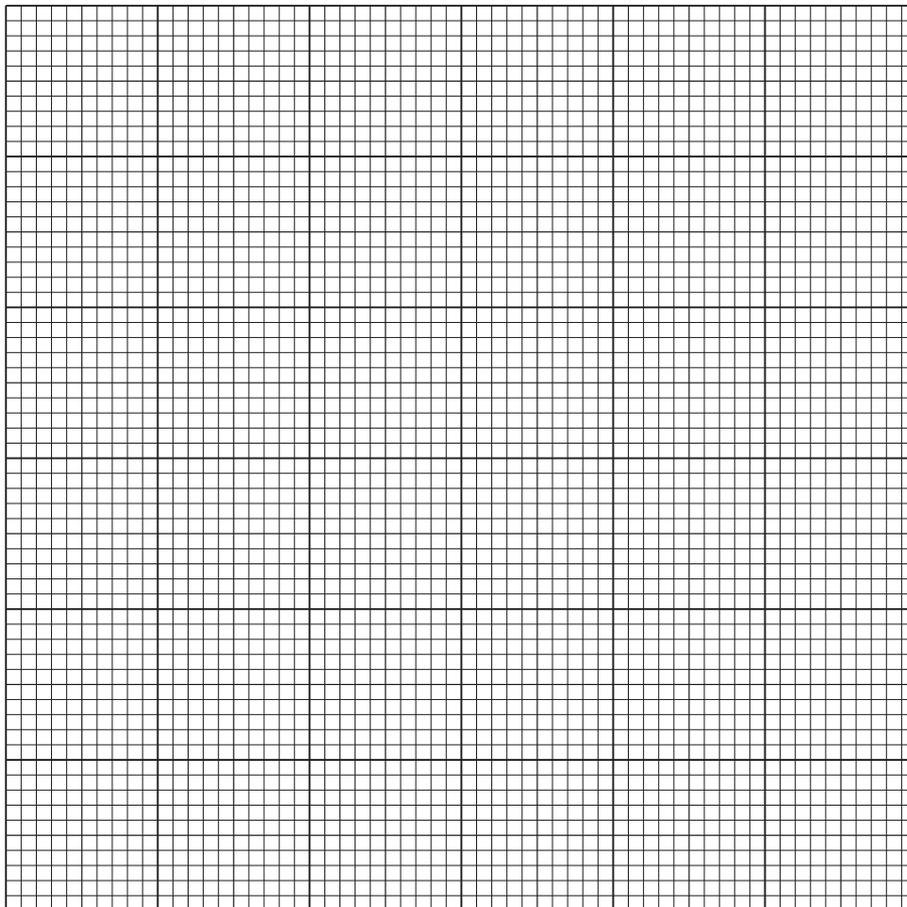
[3]

(ii) Draw the best-fit straight line. [1]

(iii) Use your graph to estimate the time at which the left edge of the bubble reaches the 9.5 cm position.

Show your working on the graph.

time = ... min [2]

(iv) Determine the gradient of the graph.

Show your working on the graph.

gradient = ... [2]

(v) The gradient of the graph is a measure of the rate of movement of the air bubble.

State the unit of this rate.

.... [1]

(c) Explain why it is important to measure to the same part of the bubble each time.

....

.... [1]

[Total: 13]

Question 2 starts on page 8.
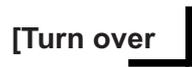
2 *Daphnia* are transparent aquatic animals that live in ponds.

They are viewed using a microscope allowing their heart rate to be measured and recorded.

Fig. 2.1 shows a *Daphnia* viewed using a microscope.

Fig. 2.1

(a) A student investigates the effect of some solutions on the heart rate of *Daphnia*.

A *Daphnia* is placed in a solution and observed under a microscope.

The student's results are shown in Table 2.1.

Table 2.1

solution	heart rate in beats per minute			
	trial 1	trial 2	trial 3	average
pond water	213	312	300	275
cola	374	389	365	376
coffee **X**	387	408	402	399
coffee **Y**	338	335	332	335

(i) Circle the anomalous result in Table 2.1. [1]

(ii) Calculate the correct average for the solution with an anomalous result.

average = ... beats per minute [1]

(b) Suggest why the student needs data for the pond water as well as the other solutions.

....

.... [1]

(c) (i) Cola and coffee contain a chemical called caffeine.

Suggest the effect that caffeine has on the heart rate of *Daphnia*.

Use the data in Table 2.1 to support your answer.

....

....

.... [1]

(ii) The manufacturers of coffee **Y** claim that **all** the caffeine has been removed.

Suggest and explain if the manufacturer's claims are supported by the data in Table 2.1.

Explain your answer.

suggestion ....

explanation ....

....

....
[2]

(iii) Suggest **one** reason why a different *Daphnia* is used for each trial in each solution.

....

.... [1]

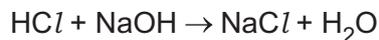[Total: 7]

3 A student investigates the neutralisation reaction between dilute hydrochloric acid and aqueous sodium hydroxide.

The solutions react in a 1:1 ratio.

hydrochloric acid + sodium hydroxide → sodium chloride + water

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

Bromothymol blue is an indicator. It turns yellow in acid solutions, blue in alkali solutions and green in neutral solutions.

(a) Procedure

The student:

- puts dilute hydrochloric acid into a burette
- records in Table 3.1 the initial reading on the burette
- puts 25.0 cm^3 of aqueous sodium hydroxide into a conical flask
- adds bromothymol blue indicator to the conical flask, the indicator turns blue
- slowly adds dilute hydrochloric acid from the burette to the aqueous sodium hydroxide and swirls the flask
- stops adding when the indicator just turns green
- records in Table 3.1 the final reading on the burette.

The student repeats the experiment three more times.

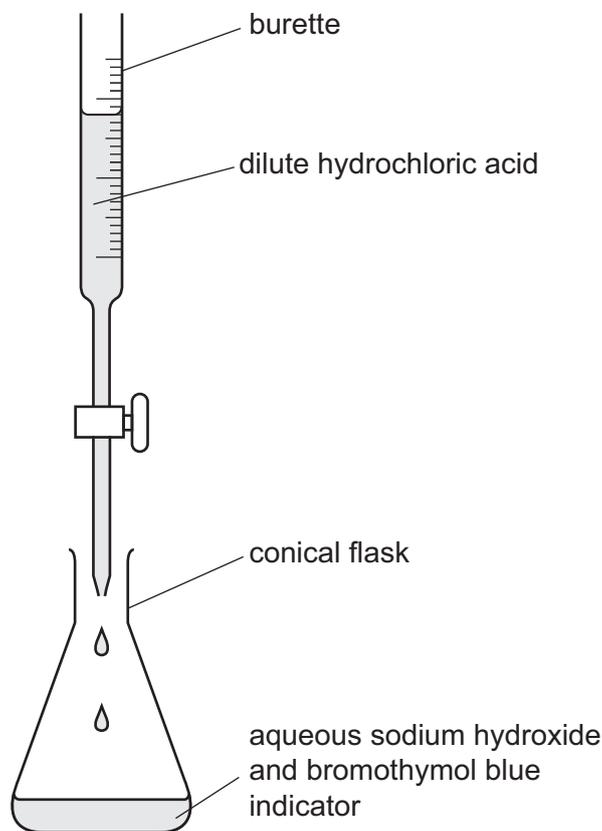Fig. 3.1 shows the apparatus the student uses.

burette

dilute hydrochloric acid

conical flask

aqueous sodium hydroxide and bromothymol blue indicator

Fig. 3.1

Table 3.1

	trial 1	trial 2	trial 3	trial 4
initial reading on burette / cm^3		1.25	3.45	2.20
final reading on burette / cm^3		13.75	16.00	14.65
volume of dilute hydrochloric acid added / cm^3		12.50	12.55	12.45

(i) Fig. 3.2 shows the initial and final volumes of dilute hydrochloric acid in the burette for trial 1.

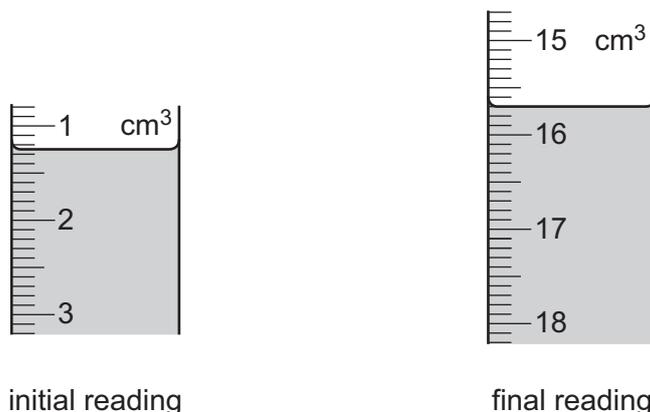initial reading   final reading

Fig. 3.2

Record in Table 3.1 these burette readings to the nearest 0.05 cm^3. [2]

(ii) Calculate the volume of dilute hydrochloric acid added in trial 1.

Record your value in Table 3.1. [1]

(iii) Calculate the average volume of dilute hydrochloric acid added.

Show your working.

volume = ... cm^3 [2]

(iv) Explain why it is good experimental practice to repeat experiments.

....

.... [1]

(v) State the name of the piece of apparatus used to measure the 25.0 cm^3 of aqueous sodium hydroxide.

.... [1]

(b) Concentration is measured in a unit called M.

A 3 M solution is three times more concentrated than a 1 M solution.

The concentration of the dilute hydrochloric acid used in the experiment is 2 M.

Estimate the concentration of the aqueous sodium hydroxide.

Show your working.

concentration = ... M

working ....

....

[2]

(c) The student:

- repeats the experiment one more time
- adds more dilute hydrochloric acid than is needed to neutralise the aqueous sodium hydroxide.

State the final colour of the indicator in this experiment.

.... [1]

(d) The student:

- adds the amount of dilute hydrochloric acid needed to neutralise the aqueous sodium hydroxide without adding any indicator
- puts the aqueous sodium chloride formed into an evaporating basin
- puts the evaporating basin on a tripod and gauze
- heats the aqueous sodium chloride to dryness.

Draw a labelled diagram to show the assembled apparatus the student uses to obtain dry sodium chloride from the aqueous sodium chloride.

[3]

[Total: 13]

4 Solid **X** dissolves in water and the solution it forms is acidic.

Plan an experiment to find the relationship between the mass of **X** dissolved in water and the pH of the solution formed.

You are provided with solid **X**.

You may use any common laboratory apparatus.

Include in your plan:

- the apparatus you will need
- a brief description of the method
- the measurements you will make
- the variables you will control
- how you will process your results to draw a conclusion.

You may include a results table if you wish, you are not required to enter any readings in the table.

You may include a labelled diagram if you wish.

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.... [7]

5 A student determines the mass of a metal ball using a balancing method.

(a) Fig. 5.1 shows the assembled apparatus the student uses.

not to scale

Fig. 5.1

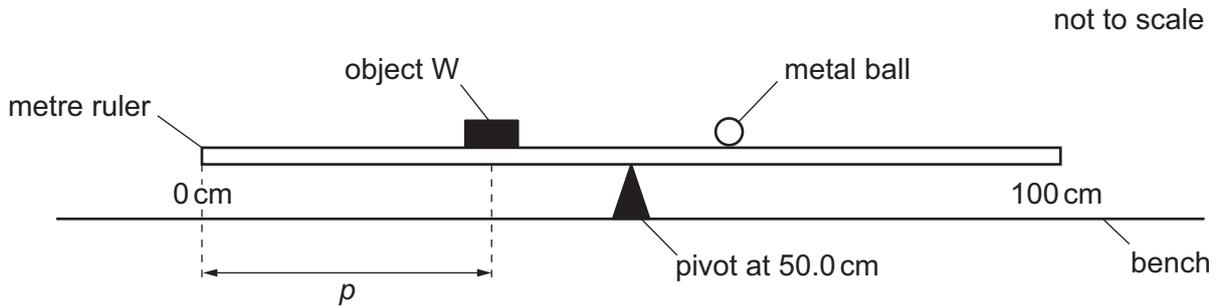**Procedure**

The student:

- places object W at a distance p from the 0 cm end of the metre ruler
- moves the metal ball on the ruler until the metre ruler just balances.

(i) The student determines the distance p when the metre ruler is balanced.
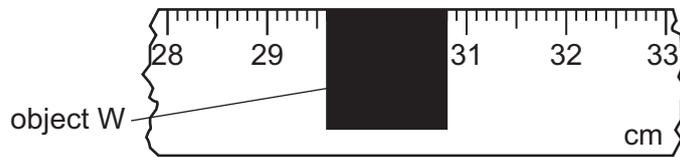
Fig. 5.2 shows object W on the metre ruler as seen from above.

Fig. 5.2

The student records the reading at each side of object W from the 0 cm end of the metre ruler.

Record the reading at each side of object W.

reading 1 .... cm

reading 2 .... cm

[1]

(ii) Calculate the distance *p* from the 0 cm end of the metre ruler to the centre of object W.

p = ... cm [1]

(iii) Calculate the mass *m* of the metal ball.

Use the equation shown.

$$m = \frac{1550}{p}$$

m = ... g [1]

(iv) Suggest **one** difficulty the student has when balancing the ruler.

....

.... [1]

(b) (i) The student uses a digital balance to measure the mass of the metal ball.

Fig. 5.3 shows the reading on the balance.

metal ball

54.68   g
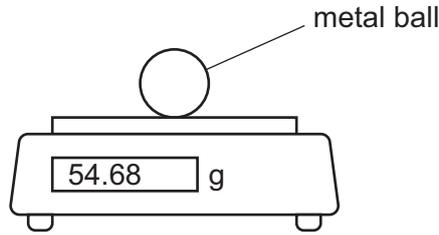
Fig. 5.3

Record this reading in g to the nearest 0.1 g.

mass = ... g [1]

(ii) Two values are considered to be equal within the limits of experimental error if the difference between them is less than 10%.

Explain if your values of mass from **(a)(iii)** and **(b)(i)** are considered equal within the limits of experimental error.

Justify your answer with a calculation.

....

.... [2]

(c) (i) Another student does a different balancing experiment.

Procedure

The student:

- fixes an object to one end of the ruler
- places a mass of 20 g onto the opposite end of the ruler
- moves the mass towards the pivot until the ruler just balances
- measures the distance of the mass from the pivot.

The student repeats the procedure using the masses in Table 5.1.

Table 5.1

mass /g	distance of the mass from the pivot/cm
20	24.0
40	12.0
60	8.0
80	6.0

The results show that mass is inversely proportional to the distance of the mass from the pivot.

Explain how the results in Table 5.1 support this relationship.

....

.... [1]

(ii) Suggest how confidence in the relationship is increased.

Do **not** include repeating the procedure with masses of 20, 40, 60 or 80 g in your answer.

....

.... [1]

[Total: 9]

6 A student investigates how the surface area of hot water exposed to the air affects the decrease in temperature of the hot water.

(a) Procedure

The student:

step 1　pours $100 \, cm^3$ of hot water into a beaker
step 2　stirs the hot water and assembles the apparatus shown in Fig. 6.1
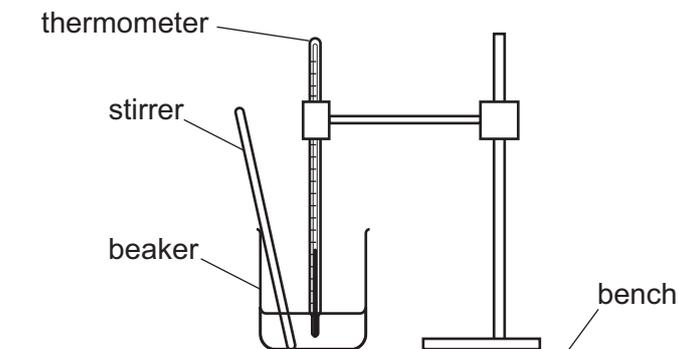
Fig. 6.1

step 3　waits until the initial temperature T_1 of the water is 95.0 °C
step 4　starts a stop-clock and waits for 1 minute
step 5　stops the stop-clock, stirs the water and records the final temperature T_2 of the water.

The student repeats the procedure 5 times with beakers of different size.

Table 6.1 shows the student's results.

Table 6.1

surface area of hot water exposed to the air / cm^2	T_1 / °C	T_2 / °C	decrease in temperature / °C
11	95.0		
19	95.0	92.0	3.0
32	95.0		
41	95.0	80.5	14.5
53	95.0	64.5	30.5
	95.0	43.5	51.5

(i) The diameter of hot water exposed to the air in the final experiment is 9.3 cm.

Calculate the surface area of the hot water exposed to the air.

Use the equation shown.

$$area = 0.785 \times (diameter)^2$$

Record your answer in Table 6.1.

Give your answer to **two** significant figures. [2]

(ii) Fig. 6.2 shows T_2 for surface areas of the hot water exposed to the air of 11 cm^2 and 32 cm^2.
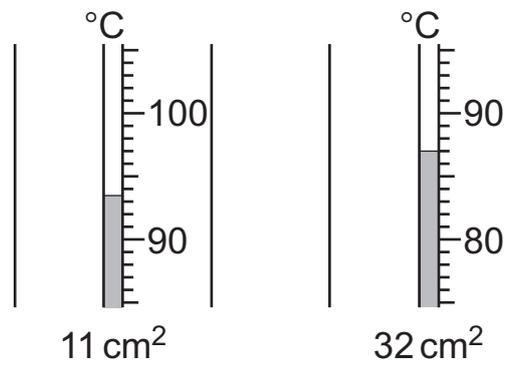

Fig. 6.2

Record in Table 6.1, these values in °C to the nearest 0.5 °C. [2]

(iii) Complete Table 6.1 by calculating the decrease in temperature for surface areas of 11 cm^2 and 32 cm^2. [1]

(iv) Describe, in detail, the relationship between the surface area of hot water exposed to the air and the decrease in temperature of the hot water.

Use the results in Table 6.1.

....

....

.... [2]

(v) Explain why it is important that the student stirs the hot water in step 5.

....

.... [1]

(vi) The beaker and thermometer for the final experiment is shown in Fig. 6.3.
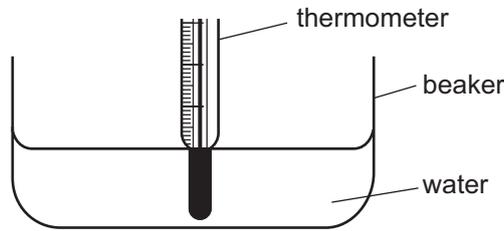
Fig. 6.3

The student repeats the procedure using a beaker with a larger diameter than that shown in Fig. 6.3.

Suggest why the temperature measured is **not** accurate.

....

.... [1]

(b) The student says the procedure in **(a)** is **not** valid.

The student repeats the procedure in **(a)** and insulates the sides of the beakers.

Explain how this change makes the procedure more valid.

....

.... [1]

(c) The rate of cooling of hot water increases when the temperature difference between the hot water and the room temperature increases.

The student repeats the procedure in **(a)** in a warmer room.

Suggest what happens to the values of T_2 in this experiment.

Explain your answer.

....

.... [1]

[Total: 11]

NOTES FOR USE IN QUALITATIVE ANALYSIS

Tests for anions

anion	test	test result
carbonate, CO_3^{2-}	add dilute acid, then test for carbon dioxide gas	effervescence, carbon dioxide produced
chloride, Cl^- [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt.
bromide, Br^- [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	cream ppt.
iodide, I^- [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	yellow ppt.
nitrate, NO_3^- [in solution]	add aqueous sodium hydroxide, then aluminium foil; warm carefully	ammonia produced
sulfate, SO_4^{2-} [in solution]	acidify with dilute nitric acid, then add aqueous barium nitrate	white ppt.

Tests for aqueous cations

cation	effect of aqueous sodium hydroxide	effect of aqueous ammonia
ammonium, NH_4^+	ammonia produced on warming	–
calcium, Ca^{2+}	white ppt., insoluble in excess	no ppt. or very slight white ppt.
copper(II), Cu^{2+}	light blue ppt., insoluble in excess	light blue ppt., soluble in excess, giving a dark blue solution
iron(II), Fe^{2+}	green ppt., insoluble in excess, ppt. turns brown near surface on standing	green ppt., insoluble in excess, ppt. turns brown near surface on standing
iron(III), Fe^{3+}	red-brown ppt., insoluble in excess	red-brown ppt., insoluble in excess
zinc, Zn^{2+}	white ppt., soluble in excess, giving a colourless solution	white ppt., soluble in excess, giving a colourless solution

Tests for gases

gas	test and test result
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	turns limewater milky
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	'pops' with a lighted splint
oxygen, O_2	relights a glowing splint

Flame tests for metal ions

metal ion	flame colour
lithium, Li^+	red
sodium, Na^+	yellow
potassium, K^+	lilac
copper(II), Cu^{2+}	blue-green