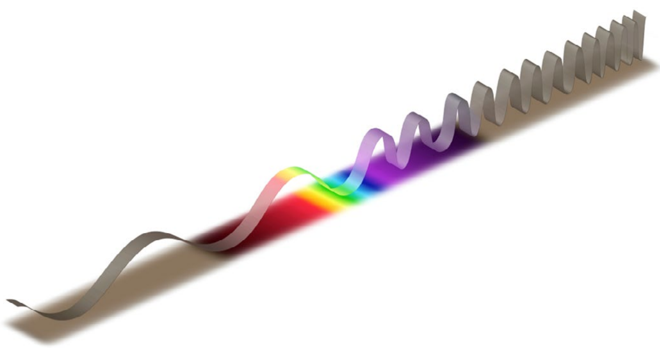
Cambridge Assessment International Education

Example Responses – Paper 3

Cambridge O Level Physics 5054

For examination from 2023



Cambridge Pathway

Contents

Introduction

The main aim of this booklet is to exemplify standards for those teaching Cambridge O Level Physics 5054.

This booklet contains responses to all questions from June 2023 Paper 32, which have been written by a Cambridge examiner. Responses are accompanied by a brief commentary highlighting common errors and misconceptions where they are relevant.

The question papers and mark schemes are available to download from the School Support Hub

5054 June 2023 Question Paper 32

5054 June 2023 Mark Scheme 32

5054 June 2023 Instructions 32

Past exam resources and other teaching and learning resources are available from the School Support Hub

Question 1

1 In this experiment you will measure the capacity of a drinks cup by three different methods.

The capacity of a cup is the maximum volume of liquid that it can hold.

You are provided with:

- a drinks cup with a capacity of approximately 200 cm^3
- a 30 cm ruler
- a metre rule
- approximately 80 cm of thin string
- a 250 cm^3 measuring cylinder
- a supply of water.

(a) method 1

Fig. 1.1 shows the measurements to be taken.

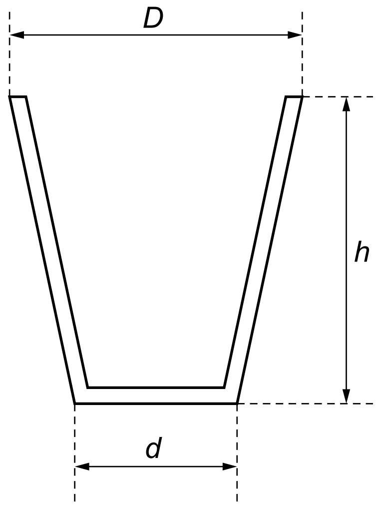


Fig. 1.1

(i) Measure the height *h*, the diameter *D* and the diameter *d* of the cup provided.

h = 8.3 cm

D = 7.2 cm

d = 5.3 cm

[2]

Examiner comment

- For the first mark, candidates needed to write *h*, *D* and *d* to the nearest millimetre (0.1 cm), not just to the nearest centimetre (which would be too inaccurate). It would be unrealistic to attempt to measure these values to a higher degree of accuracy.
- The second mark was awarded for the correct trend for a tapered cup.

(ii) Calculate the average diameter d_A of the cup using your readings from **(a)(i)** and the equation:

$$d_A = \frac{(D + d)}{2} \qquad d_A = \frac{(7.2 + 5.3)}{2}$$

d_A = ...6.25...... cm [1]

(iii) Calculate a value for the capacity V_1 of the cup using the equation:

$$V_1 = \frac{\pi d_A^2 h}{4} \qquad V_1 = \frac{[\pi \times (6.3)^2 \times 8.3]}{4}$$

V_1 = ...259...... cm^3 [1]

Examiner comment

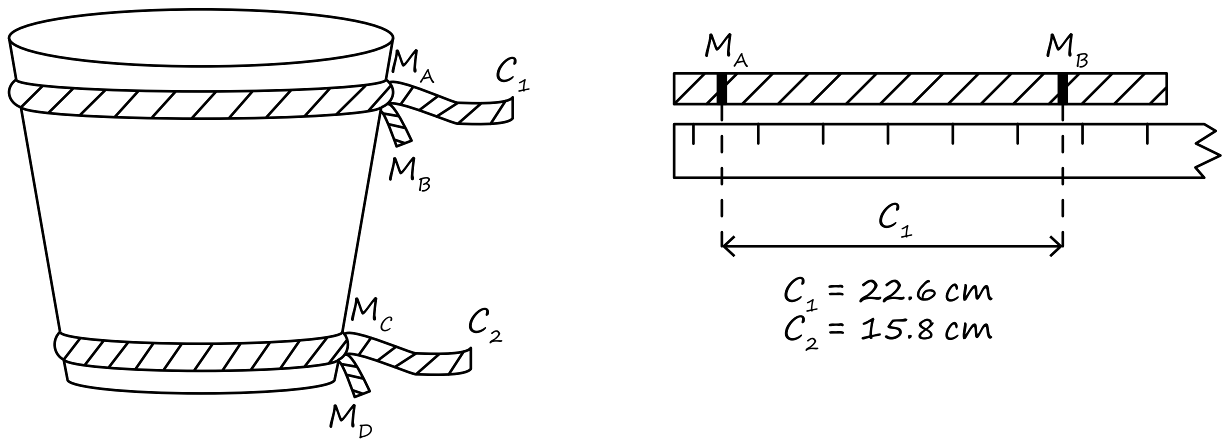
- The calculation should have been correct and with correct rounding of numbers. Allowance was made for some variation in the final response due to the various approximations of π, or the value built into different calculators. For this paper, when there was no specific demand for an answer to be given to a number of significant figures, then it is advisable to write numbers to several significant figures and then round off the final answer, usually to 2 or 3 significant figures.
- Candidates needed to recognise whether the answers to their calculations were realistic by developing the skill of making rough estimates of quantities. The cups used should have had volumes of about 250 cm^3 and an average circumference in the region of 18 to 25 cm. Calculated values which were very different from these values (for example, twice as much or one or more powers of ten different) should suggest to the candidate that they should check their measurements and calculations, and also check whether they used the correct units or wrapped the string an extra time around the cup.

(b) method 2

Use the string and the metre rule to determine the average circumference *C* of the cup.

(i) Describe the method you use and show your working.

You may draw a diagram, if you wish.



Make a mark close to one end of the string and hold the marked point against the edge of the cup. Wrap the string firmly around the edge of the cup and mark where the string reaches the first mark. Use the rule to measure the distance between the marks. Do this for the top edge and the lower edge and calculate the average value.

Ctop = 22.6 cm, Clower = 15.8 cm

$C = \frac{(22.6 + 15.8)}{2} = 19.2\text{ cm}$

C = 19.2 cm [2]

Examiner comment

- As an alternative method, the middle of the cup could be located, and the string marked then wrapped at least three times around the cup. Then it could be marked where it meets the first mark and the length of the string measured. The circumference would then be obtained by dividing the length by the number of times the string had been wrapped around the cup.
- Some candidates incorrectly measured the diameter, found the radius and then calculated the circumference, but this was inaccurate. Another incorrect method was to wrap the string across the top of the cup, down one side, across the base and up the other side.
- Some candidates confused 'string' and 'spring'. 'String' is a thread-like substance usually more than 1 millimetre thick and made from plant or synthetic fibres such as nylon. 'Springs' are usually made from twisted or coiled metal.

(ii) Calculate a value for the capacity V_2 of the cup using the equation:

$$V_2 = \frac{C^2 h}{4\pi}$$

$$V_2 = \frac{[(19.2)2 \times 8.3]}{4\pi} = 243$$

V_2 = ...243.......... cm^3 [1]

Examiner comment

The mark was awarded if V_2 was within the range +/- 10% of V_1, so this was a good measure of how accurate the candidate's practical work had been and whether they had used the formulae correctly.

(c) method 3

Pour water into the measuring cylinder up to a level that is greater than 200 cm^3 and record the volume. This is reading R_1.

Pour water from the measuring cylinder into the cup until it is full and record the volume of water left in the measuring cylinder. This is reading R_2.

Determine the volume of water V_3 in the cup. Show your working.

$R_1 = 242\ cm^3$, $R_2 = 20\ cm^3$,

$V_3 = (242 - 20)$

$= 222\ cm^3$

R_1 = ...242.......... cm^3

R_2 = ...20.......... cm^3

V_3 = ...222.......... cm^3

[1]

(d) All three methods of determining the capacity of the drinks cup give values which are approximate.

State **one** reason why the volume calculated in **method 2** and **one** reason why the volume calculated in **method 3** are **not** accurate.

method 2 *the string measures the external circumference of the cup so the calculated volume includes the volume of the cup itself and not just the volume that the cup can hold*

method 3 *some water may have been left on the sides of the measuring cylinder above R_2*

[2]

Examiner comment

- Candidates only needed to give one reason for each method.
- Alternative responses for method 2 included 'the string is slightly stretchy', 'it has thickness', 'it may have slipped as it was wrapped round the cup', or 'there may have been some overlap of the loops'.
- Alternative responses for method 3 included that the cup may have been slightly underfilled or overfilled as there was no line marking the level where the cup was deemed to be full. Water could have been spilled while being transferred from one vessel to the other. There could have been water left in the cup. There could have been a parallax error if volume readings were not taken at right angles to the reading on the scale.

Question 2

2 In this experiment you will investigate the effective resistance of different combinations of resistors and lamps in circuits.

You are provided with:

- power source
- a switch
- an ammeter
- a voltmeter
- three identical resistors
- three identical lamps
- one additional connecting lead.

The supervisor has set up the apparatus as shown in Fig. 2.1.

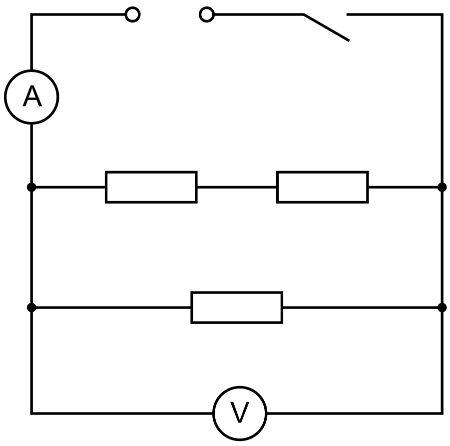


Fig. 2.1

(a) **(i)** Close the switch.

Record the potential difference V_1 across the resistors, and the current I_1 in the circuit.

Open the switch.

V_1 = ...2.75............ V

I_1 = ...0.40............ A
[1]

(ii) Calculate the effective resistance R_1 of the combination of resistors using the equation:

$$R_1 = \frac{V_1}{I_1}$$

$R_1 = \frac{2.75}{0.40} = 6.88$

R_1 = ...6.88.......... Ω [1]

(iii) Suggest why the switch is opened after the readings of potential difference and current have been taken.

to prevent the resistors from overheating

.... [1]

(b) Rearrange the circuit so that the resistors are connected as shown in Fig. 2.2.

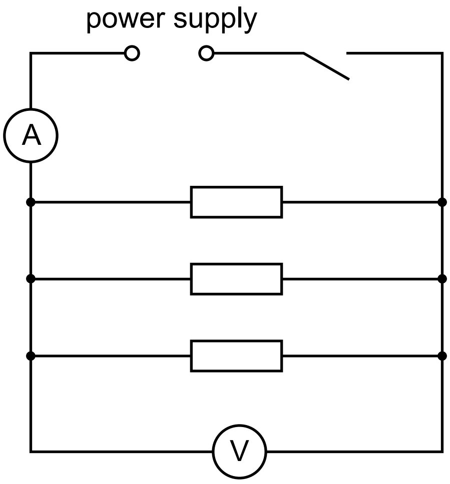


Fig. 2.2

(i) Close the switch.

Record the potential difference V_2 across the resistors and the current I_2 in the circuit.

Open the switch.

V_2 = ...2.52.......... V

I_2 = ...0.74.......... A

[1]

Examiner comment

I_2 will be larger than I_1 if the circuit has been constructed correctly.

(ii) Calculate the effective resistance R_2 of the combination of resistors using the equation:

$$R_2 = \frac{V_2}{I_2}$$

Record your answer on the answer line.

Write down the value of $2R_2$

$$R_2 = \frac{2.52}{0.74} = 3.41$$

$$2R_2 = 2 \times 3.41 = 6.82$$

R_2 = ...3.41........ Ω

$2R_2$ = ...6.82........ Ω

[1]

(c) If the resistors are identical, theory suggests that $R_1 = 2R_2$.

Two quantities can be considered to be equal within the limits of experimental accuracy if their values are within 10% of each other.

State whether your results indicate that the resistors are identical. Support your statement with a calculation.

calculation

$$\%\ \text{difference} = 100 \times \frac{(6.88 - 6.82)}{6.88}$$

$$= 0.87\%\ \text{(which is less than 10\%).}$$

statement yes, the resistors can be considered identical because the difference between them is less than 10 %

[2]

Examiner comment

- It was essential for candidates to show an appropriate calculation, with a comparison of the percentage difference between the two values and with the 10 % difference between the two values.
- Alternative valid calculation:

  'the larger value is 6.88 Ohms

  10 % of 6.88 is 0.688

  upper limit of experimental accuracy is 6.88 + 0.688 = 7.568

  lower limit of experimental accuracy is 6.88 – 0.688 = 6.192

  the smaller value, 6.82, lies between these limits

  (6.192 < 6.82 < 6.88 < 7.568)

  Statement: the two resistors can be considered to be identical because 6.82 is within 10 % of 6.88'.

(d) Set up the circuit shown in Fig. 2.1 on page 6, replacing the resistors with the lamps.

Close the switch.

Calculate the effective resistance R_3 of the combination of lamps.

Record any readings you take and show your working.

V_3 = 2.67 V, I_3 = 0.55 A

$$R_3 = \frac{V_3}{I_3} = 4.85 \text{ Ohms}$$

R_3 = ...4.85.......... Ω [1]

(e) Rearrange the circuit as shown in Fig. 2.2 on page 7, replacing the resistors with the lamps.

Close the switch.

Calculate the effective resistance R_4 of the combination of lamps.

Record any readings you take and show your working.

V_4 = 2.37 V, I_4 = 0.90 A

$$R_4 = \frac{V_4}{I_4} = \frac{2.37}{0.90} = 2.63 \text{ Ohms}$$

R_4 = ...2.63.......... Ω [1]

Examiner comment

R_4 should have been smaller than R_3 if the circuit had been constructed correctly.

(f) The teacher explains that the resistance of the lamp filaments changes due to a heating effect and therefore R_3 is not equal to $2R_4$.

Describe **one** observation that you made while doing the experiment that supports the teacher's explanation.

the lamps were much brighter in the circuit where all the lamps were in parallel [1]

Examiner comment

All that was required here was a simple statement of what the candidate saw, for example 'the lamps were much brighter in the fourth circuit.' No explanation was required, but the lamps were brighter because they were hotter. The heating effect was much lower when resistors were used, so R_1 and $2R_2$ should have been almost equal, but when the resistors were replaced by lamps there was a much greater heating effect and in the fourth circuit the lamps became much hotter so they glowed much brighter (and R_3 should have been considerably less than $2R_4$).

Question 3

3 In this experiment you will investigate the image formed by a converging lens.

You are provided with:

- a converging lens in a lens holder
- a metre rule
- a 30 cm ruler
- a white screen
- a triangular object in a piece of white card
- a lamp with a power supply to illuminate the triangular object.

Set up the apparatus as shown in Fig. 3.1.

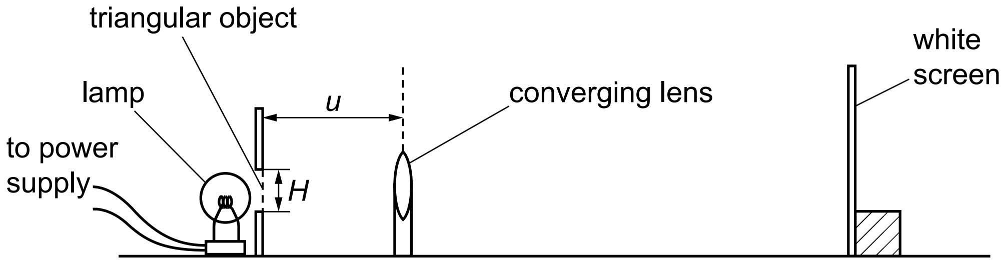


Fig. 3.1

(a) Measure and record the height H of the triangular object provided.

H = ...2.6.......... cm [1]

Examiner comment

H was the vertical distance from the middle of the base to the apex. Some candidates incorrectly wrote down the length of one side of the triangle.

(b) Switch on the lamp and place the lens a distance u = 20.0 cm from the triangular object.

Adjust the position of the screen until a sharp, focussed image of the triangular object is formed on the screen.

(i) Measure the height h of the image on the screen.

h = ...6.5.......... [1]

Examiner comment

h was the vertical height of the image. No unit was given, so candidates could have written it in centimetres or millimetres and they could have given the unit, but this was not essential.

(ii) Calculate the value of $\frac{1}{h}$.

Give your answer to 2 significant figures.

$\frac{1}{h}$ = ...0.15 cm^{-1}.......... [1]

Examiner comment

$\frac{1}{h}$ was the reciprocal of the vertical height of the image. No unit was given, so it could have been written in 1 / centimetres, cm^{-1}, 1 / millimetres or mm^{-1} and the unit should have been written in, but this was not essential.

(c) Repeat **(b)** for values of u between u = 25.0 cm and u = 50.0 cm.

Record all your readings and calculations in Table 3.1. Include your readings from **(b)**.

Add appropriate headings with units to each column.

Table 3.1

u / cm	h / cm	$\frac{1}{h}$ / 1 / cm
20.0	6.5	0.15
25.0	3.5	0.29
30.0	2.4	0.42
40.0	1.5	0.67
50.0	1.1	0.91

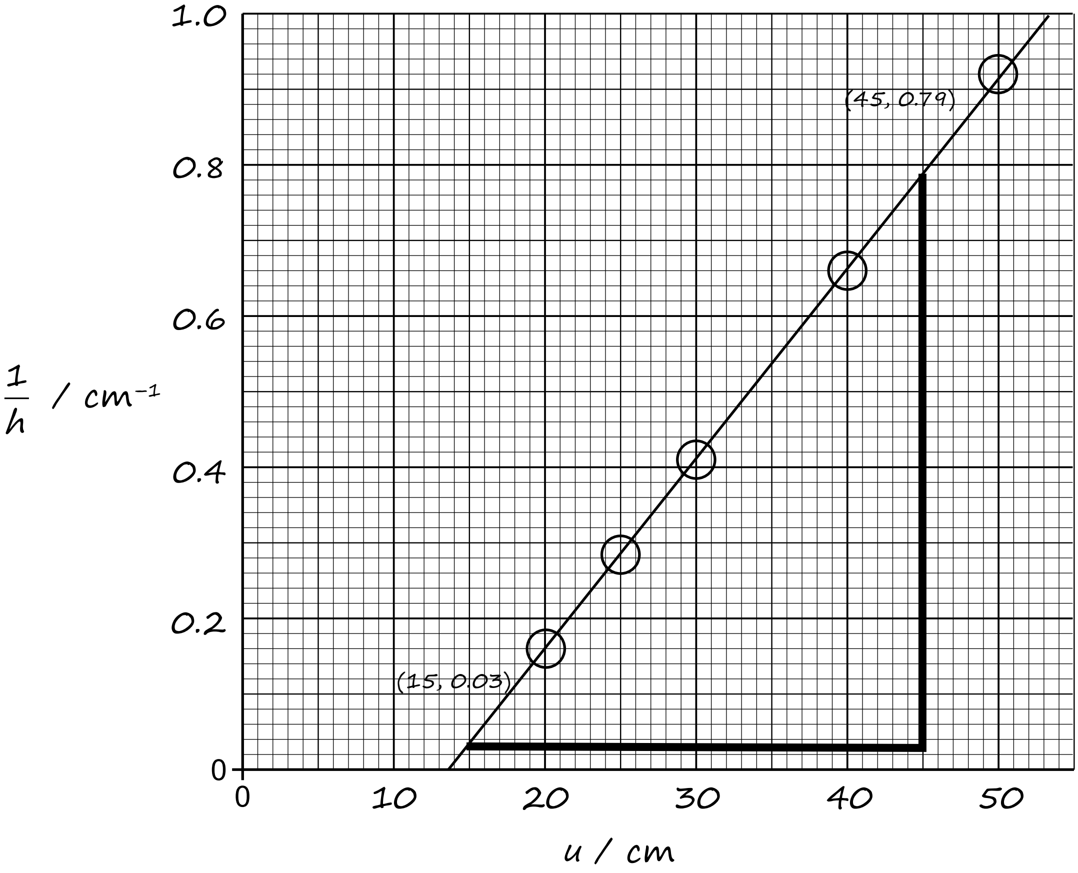
[3]

Examiner comment

The units were an essential part of the headers to the table in order for the first mark to be awarded for the headings to each column of the table. The second mark was awarded for u values being spread across the range of 20 to 50 cm and h decreasing as u increased. The third mark was awarded for values of h and $\frac{1}{h}$ having been recorded to consistent and appropriate levels of precision down each column of results.

(d) On the grid provided, plot a graph of $\frac{1}{h}$ on the *y*-axis against *u* on the *x*-axis.

Start both axes from the origin (0, 0). Draw the straight line of best fit.



[4]

Examiner comment

- Candidates needed to label the axes with the quantity and the unit. Scales needed to be linear, start from the origin (because this was given in the instructions and was marked on the grid), but also easy to use (e.g. based on 2, 5 or 10 units represented by 1 cm).
- Accurately plotted points needed to be indicated with fine marks (dots or crosses) and a thin neat, single, best-fit straight line drawn.

(e) **(i)** Calculate the gradient *m* of your line. Show all working and indicate on the graph the values you use.

Points chosen: (15, 0.03) and (45.0, 0.79)

$$M = \frac{(0.79 - 0.03)}{(45 - 15)}$$

$$= \frac{0.76}{30}$$

$$= 0.02533$$

m = ...0.02533........ [2]

Examiner comment

Candidates should not have used points from the table. They needed to clearly indicate the selected points, and the best way to do this was to draw a 'gradient triangle' as shown on the graph.

(ii) Calculate the focal length *f* of the lens. Use your value of *H* from **(a)** and the equation:

$$f = \frac{1}{mH}$$

$$f = \frac{1}{(0.0253 \times 2.6)}$$

$= 15.202$

f = ...15.202.................. cm [1]

Examiner comment

The actual focal length, f, should have been 15 cm. This was a particularly successful set of results by a candidate. The mark was awarded for a range of values indicating a good level of practical work with a correct calculation.

(f) When measuring the height of the image on the screen, your hand and the ruler may obstruct the light from the object and prevent it from reaching the screen.

Suggest **one** improvement to the apparatus provided to overcome this problem.

make pencil marks on the screen at the top and bottom of the image......

and then measure the vertical distance between them and this is the [1]

height of the image

Examiner comment

Candidates could also have stated that a calibrated screen could have been used, or that a piece of graph paper or a scale could have been fixed to the screen, or a translucent screen could have been used and the measurements made on the back of it.

Question 4

4 A student investigates the time taken for ice cubes to melt when they are placed in a beaker of hot water.

Plan an experiment to investigate how the thickness of the cardboard insulation around a beaker affects the time taken for the ice cubes in the beaker to melt.

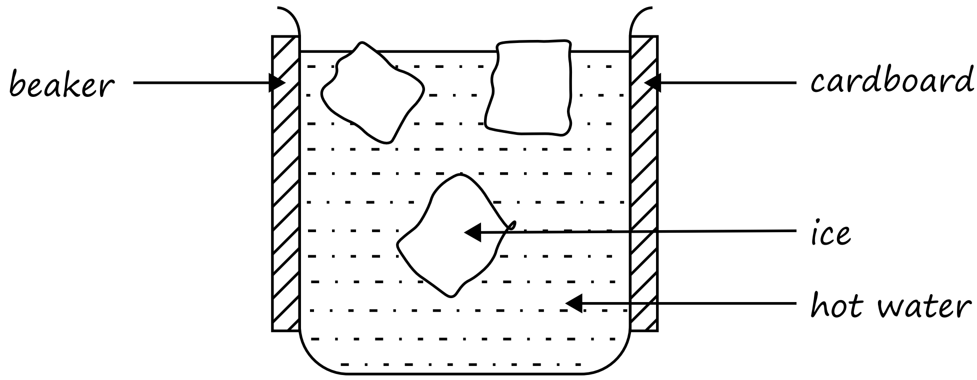
You are **not** required to do this experiment.

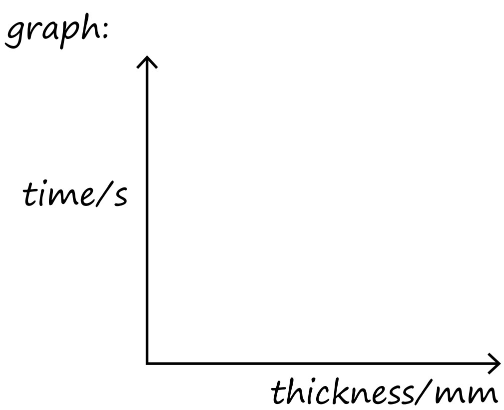
The following apparatus is available:

250 cm^3 beaker
supply of hot water
supply of ice cubes
thermometer
stopwatch
supply of 2 mm thick cardboard sheets.

In your plan you should:

- explain briefly how to carry out the investigation
- state the key variables to keep constant
- draw a table with column headings to show how to display the readings
- explain how to use your readings to reach a conclusion.





Wrap the beaker with one sheet of 2 mm thick cardboard and secure it in place. Pour a measured amount of hot water into the beaker and measure the temperature of the water. When the water has cooled to the chosen starting temperature add the ice cubes and at the same time start the stopwatch. Stop the stopwatch as soon as all the ice has melted. Record the time taken for the ice to melt and the thickness of the cardboard. Repeat the experiment using an extra layer of cardboard each time until 5 layers of cardboard have been added. Use the same starting temperature and volume of water, the same mass of ice cubes and the same beaker used each time. The room temperature should also be constant.

Record the results in a table:

Number of cardboard layers	Thickness / mm	Time / s
1	2	
2	4	
3	6	
4	8	
5	10	

Compare the times taken for the ice to melt for different thicknesses of cardboard and plot a graph of time (y-axis) against thickness (x-axis) to see if there is a relationship between the time and the thickness of the cardboard.

Examiner comment

- Marking point 1 was awarded for text or a good, correctly labelled diagram describing hot water and ice inside a beaker that has been wrapped around the outside with cardboard.
- A common misconception was to draw or describe how the cardboard was placed inside the beaker.
- Marking point 2 was awarded if candidates showed that the timing started when the ice was put into the hot water and stopped exactly when the last piece of ice had melted.
- Many candidates incorrectly thought that the temperature had to be measured at regular intervals or that the timing stopped when the temperature began to rise, but these timings would have led to inaccurate results. The thermometer was only used to check the initial temperature(s).
- Marking point 3 was awarded if there was evidence that a set of data for a total of 5 or more different thicknesses of cardboard were to be collected. This was in line with guidance on plotting graphs that a minimum of 5 points should be plotted. Some candidates described measuring the time for melting with or without cardboard, but this did not answer the question 'how the thickness of the cardboard insulation around a beaker affects the time taken.'
- To be awarded marking point 4, candidates needed to specifically mention at least one appropriate quantity that was going to be kept constant for each run of the experiment. The question did not specify how many variables to list so more than one could and should have been listed. The most important variables have been listed in this example response.

- To be awarded marking point 5, the table needed to be in two columns, one for the number of sheets of cardboard (or thickness of cardboard, with a correct unit) and one for the time (with a correct unit). A common misconception by candidates was to replace 'thickness' by 'amount of insulation' or just 'insulation' but these two terms are not the name of the physical quantity being measured. The best responses were those which had columns for thickness (mm) and time (s) so that there was suitable data to plot a line graph. A line graph would usually be preferable to a bar chart.
- For marking point 6, a line graph was the best method of showing any relationship between the time and the thickness of cardboard, whereas a bar graph would be plotted for the relationship between the time and the number of sheets. If candidates didn't mention a graph, then they needed to include a sentence instead indicating that the times for different thicknesses would be compared to see if the time for the ice to melt was affected by the thickness of the cardboard.
- Candidates should not use predictions as the conclusion. In this experiment, an expected prediction would be for the melting time to increase as the thickness of the cardboard increased. Suitable wording to change it from a prediction to an acceptable response would be, 'compare the results in the table to see if the melting time increased as the thickness increased'. It may have been of help to the candidate to imagine that it was not known whether the thickness affected the melting time and how they could make a decision on whether there was a link between the two quantities if this was the first time it had ever been investigated.
- Marking points 3 and 6 were the least frequently awarded marks.

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