



CANDIDATE
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0653/61

October/November 2023

1 hour

You must answer on the question paper.

No additional materials are needed.

- 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.

- The total mark for this paper is 40.
- The number of marks for each question or part question is shown in brackets [].

This document has **16** pages. Any blank pages are indicated.

- 1 A student investigates the effect of an enzyme used in the large-scale production of apple juice from apples.

(a) Procedure

The student:

- step 1** labels two test-tubes **E** and **W**
- step 2** uses a spatula to add apple puree (crushed apple) to each test-tube
- step 3** adds 10 cm^3 of the enzyme to the test-tube labelled **E**
- step 4** adds 10 cm^3 of distilled water to the test-tube labelled **W**
- step 5** stirs the contents of each test-tube using a clean glass rod
- step 6** puts both test-tubes in a beaker containing 250 cm^3 of water at an initial temperature of 40°C
- step 7** waits for 10 minutes and then measures the final temperature of the water in the beaker.

- (i) Fig. 1.1 shows the reading on the thermometer.

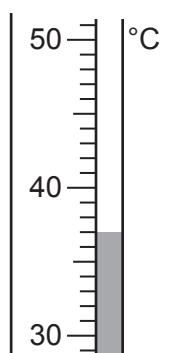


Fig. 1.1

Record the final temperature of the water.

final temperature of water = ... $^\circ\text{C}$ [1]

(ii) The student:

step 8 filters the contents of each test-tube as shown in Fig. 1.2

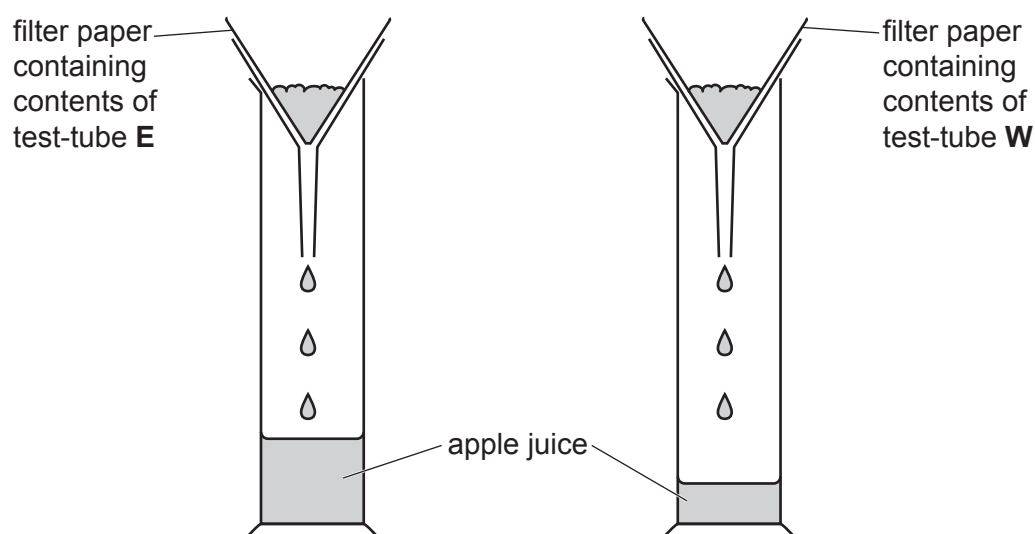


Fig. 1.2

step 9 collects the juice in a measuring cylinder for 5 minutes.

Fig. 1.3 shows the volume of juice collected in each measuring cylinder after 5 minutes.

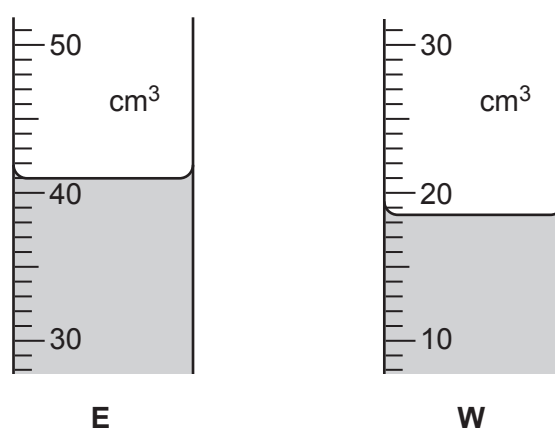


Fig. 1.3

Record in Table 1.1 the volume of apple juice collected from each test-tube to the nearest 0.5 cm^3 .

Table 1.1

test-tube	volume of apple juice collected / cm^3
E	
W	

[2]

- (iii) Use the results to suggest why this enzyme is used in the large-scale production of apple juice.

.....
 [1]

- (iv) Use your answer in (a)(i) to decide if temperature is a source of error in this investigation.

Tick (✓) the appropriate box and explain your decision.

☐ temperature is a source of error

☐ temperature is **not** a source of error

explanation

 [1]

- (v) Identify **one** source of error in **step 2**.

Suggest a suitable piece of apparatus to overcome this error.

error
 apparatus [1]

- (vi) Suggest why it is important to use a clean glass rod in **step 5**.

.....
 [1]

(b) Fig. 1.4 shows a section through an apple.



Fig. 1.4

In the box, make a large clear pencil drawing of the apple section shown in Fig. 1.4.

[3]

(c) Fig. 1.5 shows some cells in apple puree.

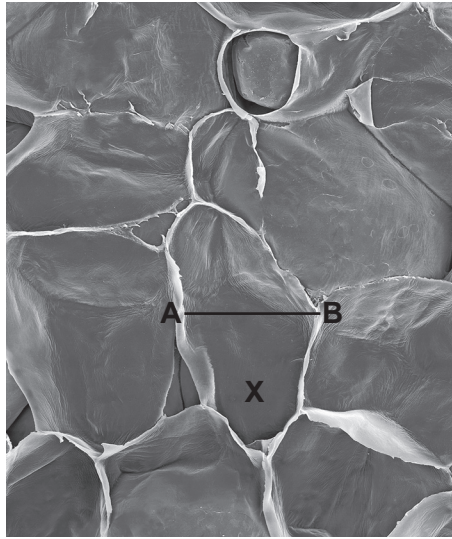


Fig. 1.5

- (i) Line **AB** represents the width of the apple cell labelled **X**.

Measure the length of line **AB**.

length of line **AB** = ... mm [1]

- (ii) The cells in Fig. 1.5 are magnified $\times 160$.

Calculate the actual width of the apple cell labelled **X**.

Use the equation shown.

$$\text{actual width of cell X} = \frac{\text{length of line AB}}{\text{magnification}}$$

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

actual width of cell **X** = ... mm [2]

[Total: 13]

- 2 (a) When magnesium ribbon is added to dilute hydrochloric acid, the mixture fizzes and makes hydrogen gas. The magnesium ribbon stays on the surface of the acid during the reaction. The reaction is complete when all the magnesium ribbon disappears and the fizzing stops.

State the test used to confirm the presence of hydrogen gas and give the observation for a positive result.

test

observation

[1]

- (b) A student investigates the rate of reaction between magnesium ribbon and dilute hydrochloric acid.

Procedure

The student:

- step 1** adds 25 cm^3 of dilute hydrochloric acid to a glass beaker
- step 2** puts a 5 mm length of magnesium ribbon into the dilute hydrochloric acid and immediately starts a stop-watch
- step 3** uses a glass rod to keep the magnesium ribbon under the surface of the dilute hydrochloric acid but **not** touching the bottom of the beaker
- step 4** stops the stop-watch when all the magnesium ribbon has reacted
- step 5** records in Table 2.1 the reaction time (the time it takes for all the magnesium ribbon to react) to the nearest second
- step 6** repeats **step 1** to **step 5** four more times using 10 mm, 15 mm, 20 mm and 25 mm lengths of magnesium ribbon instead of 5 mm.

- (i) In **step 1**, the student uses a measuring cylinder to measure 25 cm^3 of dilute hydrochloric acid.

Suggest **one** other piece of apparatus suitable for measuring 25 cm^3 accurately.

..... [1]

- (ii) Explain the importance of **step 3** in the procedure.

.....

..... [1]

- (iii) Suggest **one** source of uncertainty in the measurement of the reaction time.

.....

..... [1]

- (iv) Fig. 2.1 shows the stop-watch readings for 5 mm and 25 mm lengths of magnesium ribbon.

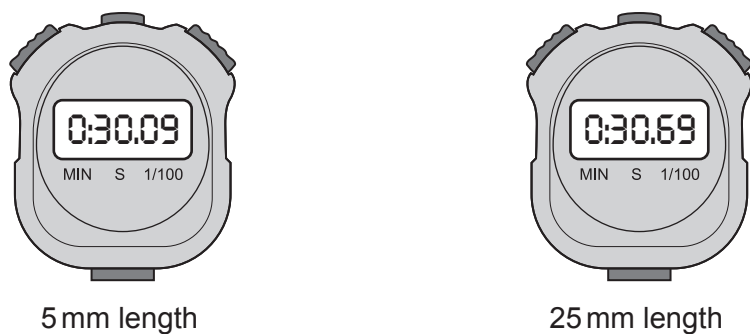


Fig. 2.1

Record in Table 2.1 the reaction times in Fig. 2.1 to the nearest second.

Table 2.1

length of magnesium ribbon /mm	reaction time /s	rate of reaction in mm/s
5		
10	31	0.32
15	29	0.52
20	30	0.67
25		

[2]

- (v) Calculate the rate of reaction for the 5 mm and 25 mm lengths of magnesium ribbon.

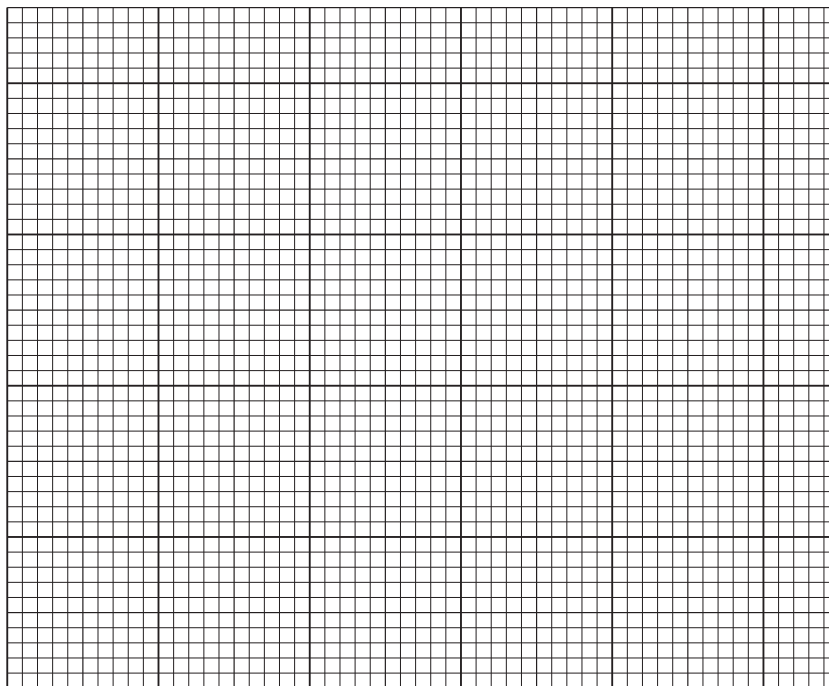
Use the equation shown.

$$\text{rate of reaction} = \frac{\text{length of magnesium ribbon}}{\text{reaction time}}$$

Record your values in Table 2.1.

[1]

- (vi) On the grid, plot a graph of the rate of reaction (vertical axis) against the length of magnesium ribbon.



[3]

- (vii) Draw the line of best fit. [1]

- (viii) Describe the relationship between the rate of reaction and the length of magnesium ribbon.

.....

..... [1]

- (c) The student repeats the procedure in (b) using a 100 mm length of magnesium ribbon.

The student concludes that the magnesium ribbon is in excess.

Suggest an observation the student makes to reach this conclusion.

.....

..... [1]

[Total: 13]

3 A student investigates the reflection of light by a plane mirror.

(a) Fig. 3.1 on page 11 shows a horizontal line **XZ**.

Line **NY** is the normal to line **XZ** at point **Y**.

Line **AY** meets line **XZ** at point **Y**.

The angle of incidence i is the angle between line **AY** and the normal, as shown in Fig. 3.1.

Measure the angle of incidence i in Fig. 3.1.

$i = \dots\dots\dots^\circ$ [1]

(b) **Procedure**

The student:

- puts the mirror along line **XZ** with the reflecting face of the mirror facing the letter **N** on Fig. 3.1
- places two pins, P_1 and P_2 , on line **AY** at least 5 cm apart.

(i) On Fig. 3.1, mark with crosses suitable positions for pins P_1 and P_2 .

Label the crosses P_1 and P_2 . [1]

(ii) **Procedure**

The student:

- looks into the mirror from the position of the eye shown in Fig. 3.1
- views the **images** of pins P_1 and P_2 in the mirror
- places two pins, P_3 and P_4 , to the right of the normal, so that pins P_3 and P_4 and the images of pins P_1 and P_2 all appear lined up, one behind the other.

The position of pin P_3 is already shown on Fig. 3.1.

Mark with a cross a suitable position for pin P_4 .

Label the cross P_4 . [1]

(c) Draw a straight line through the positions of pins P_3 and P_4 .

Continue the line until it meets line **XZ**.

Label the angle θ between line P_3P_4 and line **XZ**.

Measure angle θ .

$\theta = \dots\dots\dots^\circ$ [2]

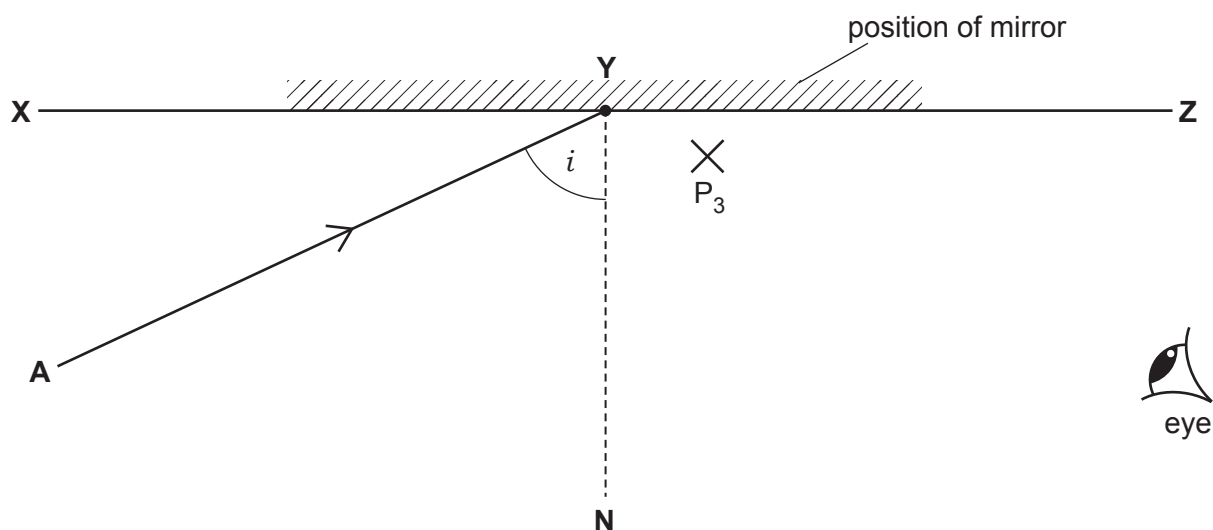


Fig. 3.1

(d) Procedure

The student:

- repeats the experiment for $i = 30^\circ$, 45° and 60°
- takes three readings of θ for each value of i
- records the results in Table 3.1.

Table 3.1

$i / ^\circ$	$\theta / ^\circ$		
	reading 1	reading 2	reading 3
30	61	59	29
45	46	47	45
60	31	28	30

The student notices that there is an anomalous reading in Table 3.1.

(i) Circle the anomalous reading. [1]

(ii) Suggest what the student does to improve the data.

.....

..... [1]

[Total: 7]

- 4 Plan an investigation to determine the relationship between the temperature of apple juice and the time it takes for ice cubes to melt when added to it.

You are provided with:

- ice cubes of different shapes and sizes
- a supply of apple juice
- beakers.

You may use any other common laboratory apparatus.

In your plan, include:

- any other apparatus you will need
- a brief description of the method, including what you will measure and how you will make sure your measurements are accurate
- the variables you will control
- a results table to record your measurements (you are not required to enter any readings in the table)
- how you will process your results to draw a conclusion.

You may include a labelled diagram if you wish.

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- 1 (a) A student investigates the effect of exercise on the heart rate of a fit and healthy person.

The heart rate is the number of heart beats per minute.

The student uses an electrocardiogram (ECG) to record the heart beats of the person.

Fig. 1.1 shows an ECG for one heart beat.

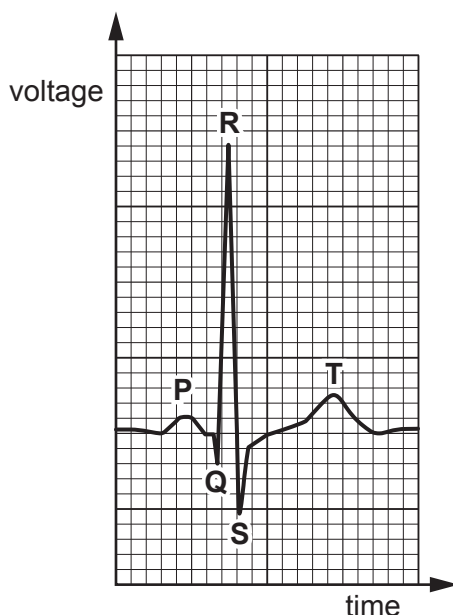


Fig. 1.1

The letters **P**, **Q**, **R**, **S** and **T** represent different stages of the heart beat.

Procedure

The student:

- records the number of heart beats in 5 seconds of the person at rest
- asks the person to run at a constant speed for a running time of 5 minutes
- records the number of heart beats in 5 seconds of the person at the end of this running time
- repeats the procedure for running times of 10, 15, 20 and 25 minutes.

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- (i) The ECG results for running times of 5 and 10 minutes are shown in Fig. 1.2.

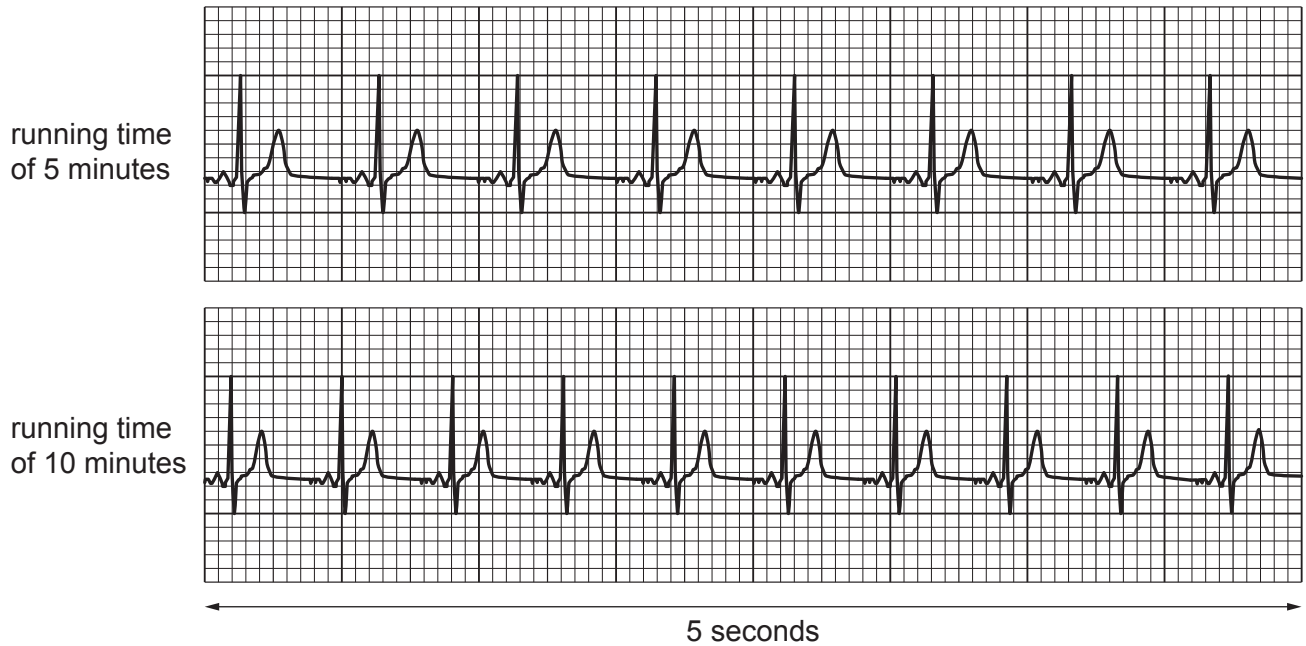


Fig. 1.2

Use Fig. 1.2 to count the number of heart beats in 5 seconds of the person at the end of running times of 5 minutes and 10 minutes.

Record these values in Table 1.1.

Table 1.1

running time /minutes	number of heart beats in 5 seconds	heart rate /bpm
0	5	60
5		
10		
15	12	144
20	12	144
25	12	144

[2]

- (ii) The heart rate is calculated as beats per minute (bpm).

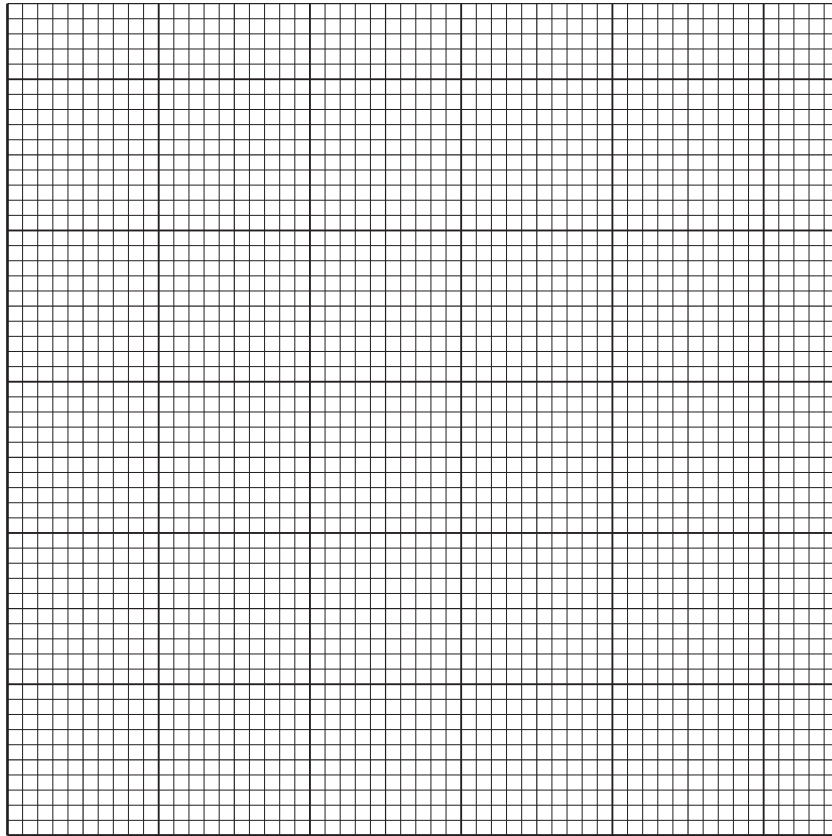
Complete Table 1.1 by calculating the heart rate of the person at the end of running times of 5 minutes and 10 minutes.

Use the equation shown.

$$\text{heart rate} = \text{number of heart beats in 5 seconds} \times 12$$

[1]

- (iii) On the grid, plot a graph of heart rate (vertical axis) against running time.



[3]

- (iv) Draw the best-fit curve.

[1]

- (v) Describe the relationship between running time and heart rate.

.....

.....

..... [1]

- (vi) The person is asked to run at a constant speed during the investigation.

Explain why this makes it a fair test.

.....

.....

..... [1]

(b) The ECG in Fig. 1.3 shows two heart beats.

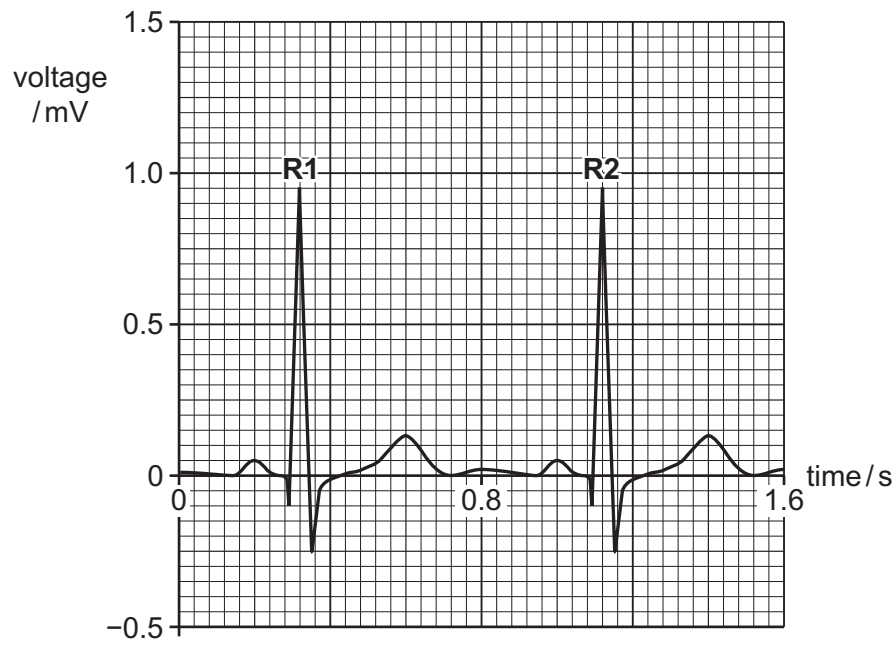


Fig. 1.3

Use Fig. 1.3 to determine the voltage at **R1** and the time between **R1** and **R2**.

voltage at **R1** = ... mV

time between **R1** and **R2** = ... s
[2]

(c) ECGs are used to diagnose heart problems.

Fig. 1.4 shows an ECG for a healthy person and an ECG for a person with a heart problem.

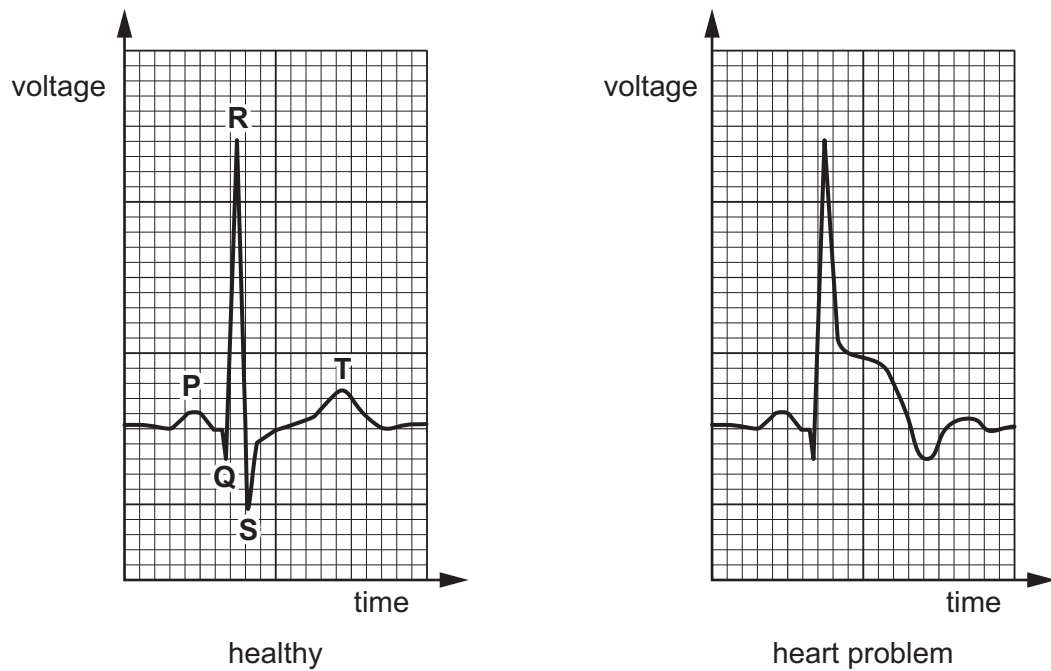


Fig. 1.4

Describe **one** similarity and **one** difference between the ECG for the healthy person and the ECG for the person with a heart problem.

similarity

.....

difference

.....

[2]

[Total: 13]

- 2 A student investigates the reaction between iron and a dilute acid.

At room temperature, this reaction is quite slow.

Procedure

The student:

- uses a measuring cylinder to add some dilute acid to a boiling tube
- adds excess iron powder to the dilute acid
- stirs the reaction mixture with a glass rod
- tests the gas produced with a lighted splint.

- (a) Fig. 2.1 shows the reading on the balance when the student measures the mass of iron powder.

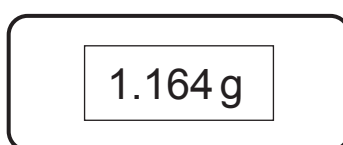


Fig. 2.1

Record the mass to **one** decimal place.

mass = ... g [1]

- (b) Suggest why the student mixes the reactants together by stirring during the procedure.

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

- (c) When the student tests the gas with a lighted splint, there is a squeaky pop.

Identify the gas produced in the reaction.

..... [1]

- (d) The reaction also produces a green solution. The student separates the green solution from the excess iron in the reaction mixture.

Draw a labelled diagram of the assembled apparatus that the student uses.

Label the residue and the filtrate.

[2]

- (e) The student tests the green solution to identify the ions it contains.

The tests and observations are shown in Table 2.1.

Table 2.1

test	observation
add dilute nitric acid and aqueous barium nitrate	white precipitate
add excess aqueous sodium hydroxide	green precipitate, insoluble in excess

- (i) State the name of the anion (negative ion) in the filtrate.

..... [1]

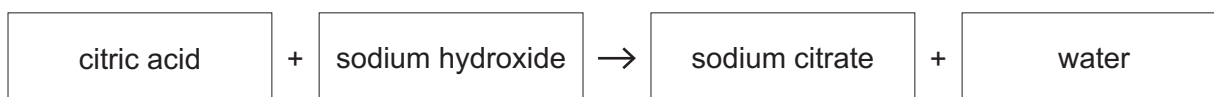
- (ii) State the name of the cation (positive ion) in the filtrate.

..... [1]

[Total: 7]

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- 3 Citric acid reacts with aqueous sodium hydroxide as shown in the word equation.



In the reaction, aqueous sodium hydroxide is neutralised by solid citric acid.

Sodium hydroxide is an alkali. When citric acid is added to aqueous sodium hydroxide, the pH decreases as the neutralisation reaction happens.

Plan an investigation to determine the relationship between the mass of citric acid added to aqueous sodium hydroxide and the pH of the solution obtained.

You are provided with:

- solid citric acid
- aqueous sodium hydroxide
- universal indicator and a pH colour chart.

You may use any common laboratory apparatus in your plan.

In your plan, include:

- the apparatus you will use
- a brief description of the method and an explanation of any safety precautions you will take
- what you will measure
- which variables you will keep constant
- how you will process your results to draw a conclusion.

You may include a labelled diagram if you wish.

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

- 4 A student compares the conducting properties of metal and glass.

The apparatus is shown in Fig. 4.1.

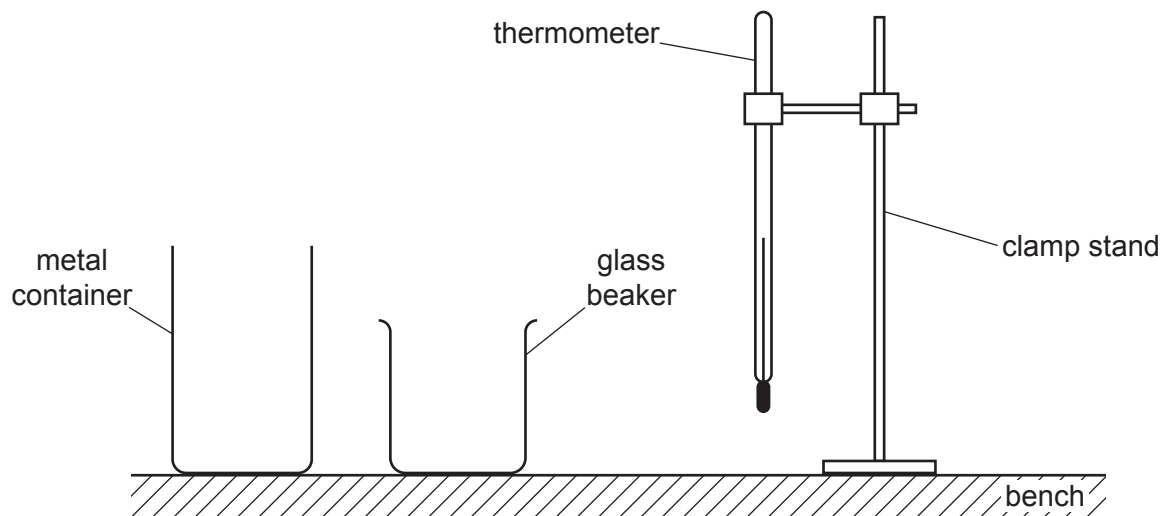


Fig. 4.1

Procedure

The student:

- step 1** measures the volume of some hot water using a measuring cylinder
- step 2** pours the hot water into the metal container
- step 3** places the thermometer into the hot water
- step 4** waits for half a minute
- step 5** records in Table 4.1 the temperature θ_M of the water in the metal container and at the same time starts a stop-watch
- step 6** records in Table 4.1 the temperature θ_M of the water in the metal container every minute for 6.0 minutes.

The student repeats the procedure using the glass beaker instead of the metal container and measures the temperature θ_G of the water in the glass beaker.

- (a) (i) Fig. 4.2 shows the hot water in the measuring cylinder.

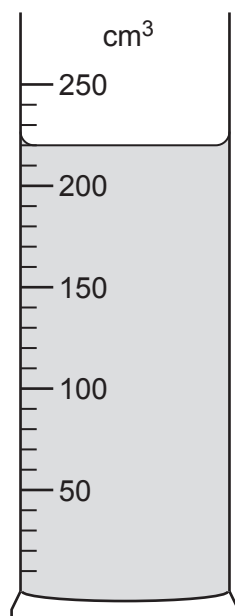


Fig. 4.2

Record the volume of hot water in the measuring cylinder.

volume = ... cm^3 [1]

- (ii) Describe how the student avoids a parallax error (line of sight error) when measuring the volume of hot water.

.....

..... [1]

- (b) (i) Fig. 4.3 shows the readings on the thermometers after one minute for the metal container and the glass beaker.

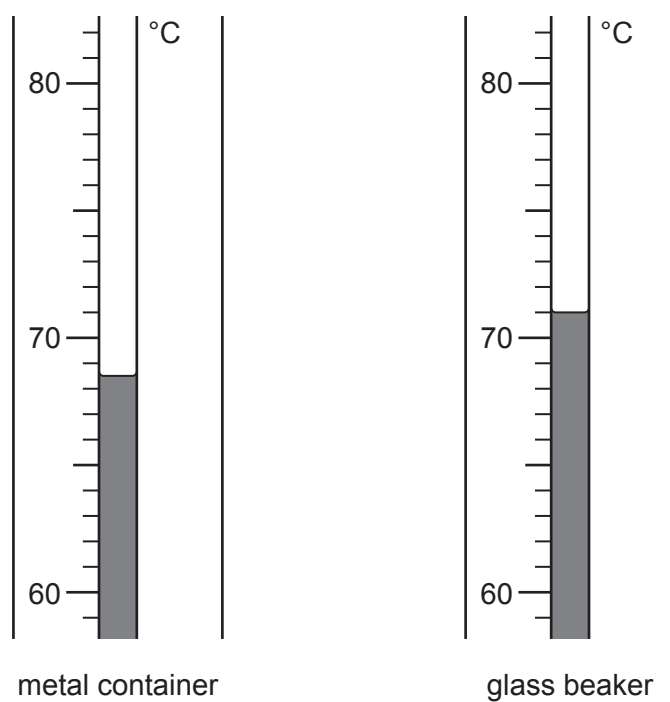


Fig. 4.3

Record in Table 4.1 the two temperature readings against time $t = 1.0$ min.

Table 4.1

t/min	$\theta_M/^\circ\text{C}$	$\theta_G/^\circ\text{C}$
0.0	71.5	73.5
1.0		
2.0	66.0	69.0
3.0	64.0	67.5
4.0	62.5	66.0
5.0	61.0	65.0
6.0	60.0	64.0

[2]

- (ii) Calculate the change in temperature $\Delta\theta_M$ for the metal container and $\Delta\theta_G$ for the glass beaker between $t = 0.0$ and $t = 6.0$ min.

$$\Delta\theta_M = \dots\dots\dots\text{ }^\circ\text{C}$$

$$\Delta\theta_G = \dots\dots\dots\text{ }^\circ\text{C}$$

[1]

- (iii) Calculate the average rate of cooling R_M for the water in the metal container and R_G for the water in the glass beaker.

Use the equations:

$$R_M = \frac{\Delta\theta_M}{\Delta t} \qquad R_G = \frac{\Delta\theta_G}{\Delta t}$$

where $\Delta t = 6.0$ min.

Record your answers to **two** significant figures.

Give the unit for the rate of cooling.

$$R_M = \dots\dots\dots$$

$$R_G = \dots\dots\dots$$

unit

[3]

- (iv) Two quantities are considered equal within the limits of experimental accuracy if the values are within 10% of each other.

Explain whether the rate of cooling in the metal container is equal to the rate of cooling in the glass beaker within the limits of experimental accuracy.

Include a calculation in your answer.

explanation

.....

[2]

- (c) (i) Explain why in **step 4** the student waits half a minute after adding the hot water before taking the first temperature reading.

.....

.....

..... [1]

- (ii) Suggest **two** improvements to the procedure to improve the accuracy of the results.

1

.....

2

.....

[2]

[Total: 13]

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- 1 A student investigates the effect of light on a plant.

The student uses a plant with variegated leaves that are green and white.

Fig. 1.1 shows one of the leaves on the plant.

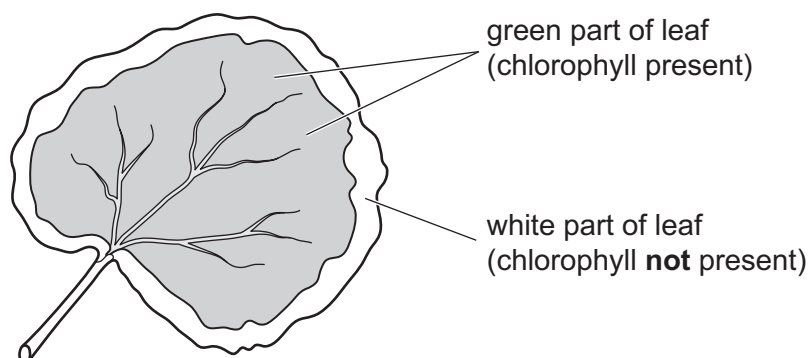


Fig. 1.1

(a) Procedure

The student:

- step 1** removes the starch from the leaves by placing the plant in a dark room for 2 days
- step 2** places a strip of black paper on the surface of one of the leaves of the plant, as shown in Fig. 1.2

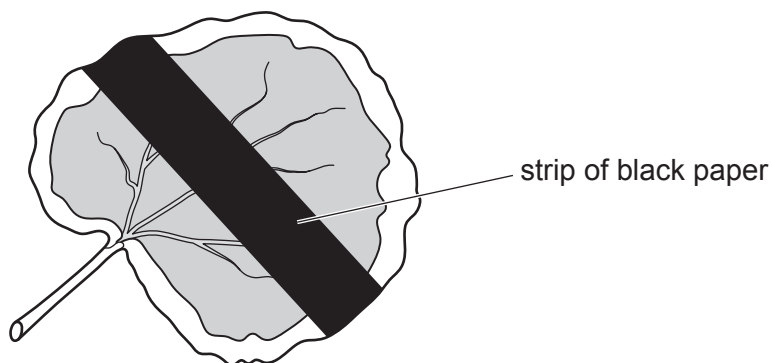


Fig. 1.2

- step 3** places the plant in bright light for 2 hours
- step 4** removes the strip of black paper
- step 5** removes the leaf from the plant
- step 6** places the leaf in boiling water for 5 minutes to remove the waxy cuticle
- step 7** places the leaf in hot ethanol for 5 minutes to remove the green colour (chlorophyll)
- step 8** places the leaf on a white tile and adds iodine solution.

Fig. 1.3 shows the leaf after iodine solution is added.

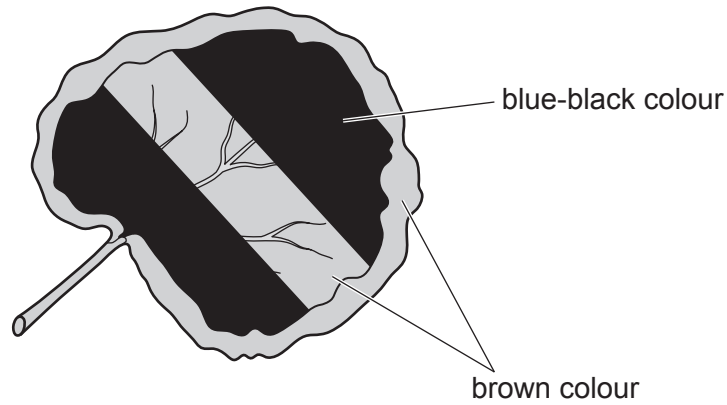


Fig. 1.3

- (i) A leaf produces starch as a result of photosynthesis.

Use Fig. 1.3 to determine which **two** factors are needed for photosynthesis.

Explain how the results in Fig. 1.3 provide evidence for your answers.

factor 1

explanation

.....

.....

factor 2

explanation

.....

.....

[4]

- (ii) Suggest why the green colour (chlorophyll) is removed in **step 7**.

.....

..... [1]

- (b) The student does a test to determine whether the leaf contains reducing sugar.

State the test the student uses. Include the observation for a positive result.

test

observation

[2]

[Total: 7]

- 2 Urease is an enzyme that breaks down urea in solution to form aqueous ammonia.

Urea in solution is almost neutral. The aqueous ammonia formed increases the pH of the solution.

Plan an investigation to determine the relationship between the concentration of urease and the pH of the solution formed.

You are provided with:

- urea solution
- 10% urease solution
- universal indicator solution and a pH colour chart.

You may use any common laboratory apparatus in your plan.

In your plan, include:

- the apparatus you will use
- a brief description of the method, explaining any safety precautions you will take
- what you will measure
- which variables you will keep constant
- how you will process your results to draw a conclusion.

You may include a labelled diagram if you wish.

You may include a results table if you wish (you do not need to include any results in the table).

3 A student investigates a white solid, **H**.

(a) **Procedure**

The student:

- dissolves some solid **H** in distilled water
- adds universal indicator to the solution
- compares the colour obtained with a pH colour chart.

The universal indicator turns a blue-green colour.

Fig. 3.1 shows a pH colour chart.

colour of universal indicator	red	orange	yellow	green	dark green	blue	purple
pH	1	4	6	7	8	10	14

Fig. 3.1

- (i) Use Fig. 3.1 to estimate the pH of the solution of **H**. [1]
- (ii) Suggest why this pH colour chart **cannot** give an exact value for the pH of the solution of **H**.

.....

..... [1]

(b) Procedure

The student:

- puts some dilute sulfuric acid into a test-tube
- adds some solid **H** to the dilute sulfuric acid
- tests the gas produced with limewater.

(i) The limewater turns milky.

State the name of the gas produced.

..... [1]

(ii) Tick (✓) the name of the anion (negative ion) present in **H**.

carbonate

☐

chloride

☐

nitrate

☐

sulfate

☐

[1]

(c) Procedure

The student:

- puts some aqueous sodium hydroxide into a test-tube
- adds some solid **H** to the aqueous sodium hydroxide
- warms the mixture
- tests the gas produced with damp red litmus paper.

(i) The damp red litmus paper turns blue.

State the name of the gas produced.

..... [1]

(ii) Tick (✓) the name of the cation (positive ion) present in **H**.

ammonium

☐

calcium

☐

copper

☐

zinc

☐

[1]

(d) Procedure

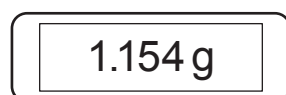
The student:

- step 1** puts 25.0 cm^3 of dilute sulfuric acid into a beaker
- step 2** uses a balance to find the mass of a sample of solid **H**
- step 3** adds the sample of solid **H** to the dilute sulfuric acid
- step 4** immediately starts a stop-watch
- step 5** stops the stop-watch when the mixture no longer fizzes.

- (i) State the name of a piece of apparatus suitable to measure 25.0 cm^3 of dilute sulfuric acid.

..... [1]

- (ii) Fig. 3.2 shows the reading on the balance in **step 2**.



mass of solid **H**

Fig. 3.2

Record the mass of solid **H** to **two** decimal places.

mass of solid **H** = ...g [1]

- (iii) Fig. 3.3 shows the reading on the stop-watch at **step 5**.



Fig. 3.3

Record this reaction time to the nearest second.

reaction time = ... s [1]

- (iv) Calculate the rate of reaction between solid **H** and dilute sulfuric acid.

Use the equation shown.

$$\text{rate of reaction} = \frac{\text{mass of solid H}}{\text{reaction time}}$$

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

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

- (v) Suggest **one** reason why it is difficult to measure the reaction time accurately using this procedure.

.....

..... [1]

- (vi) Suggest **one** improvement to the procedure that improves confidence in the rate of reaction calculated.

Explain your answer.

improvement

explanation

.....

[1]

[Total: 13]

- 4 A student investigates the magnification of a thin converging lens.

The student uses the apparatus shown in Fig. 4.1.

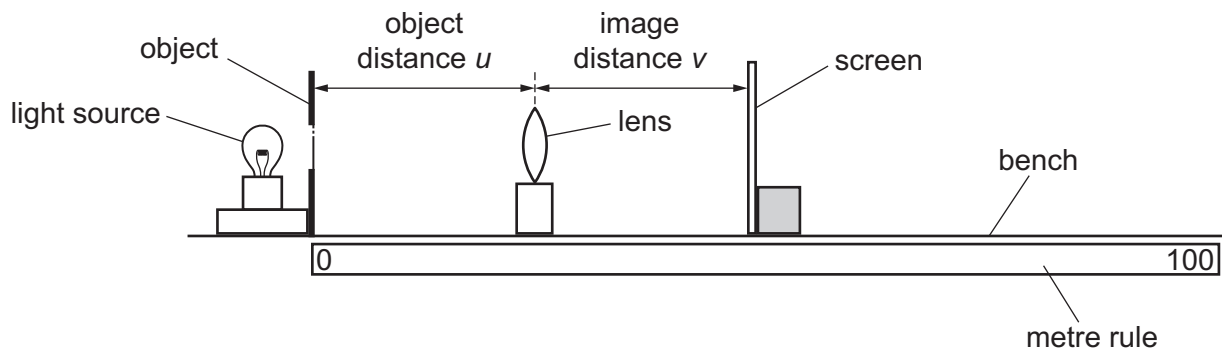


Fig. 4.1

Procedure

The student:

- records height h_o of the object
- places the object at the 0 cm mark on the metre rule
- places the lens at object distance u from the object
- changes image distance v so that a **sharp** image of the object is seen on the screen
- records height h_i of the image on the screen.

- (a) Fig. 4.2 shows the position of the lens on the metre rule.

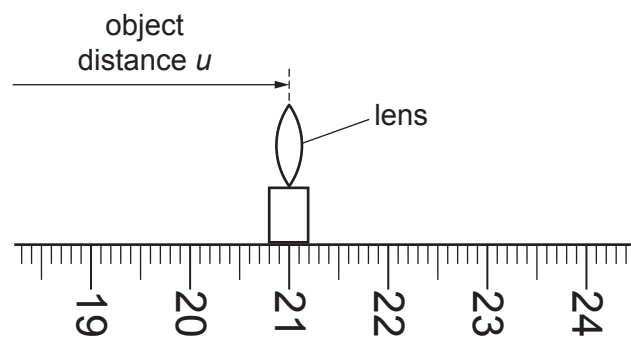


Fig. 4.2

Record object distance u .

$u = \dots\dots\dots$ cm [1]

- (b) (i) The student uses a triangular hole in a piece of cardboard as an object.

Fig. 4.3 shows the object, drawn to actual size.

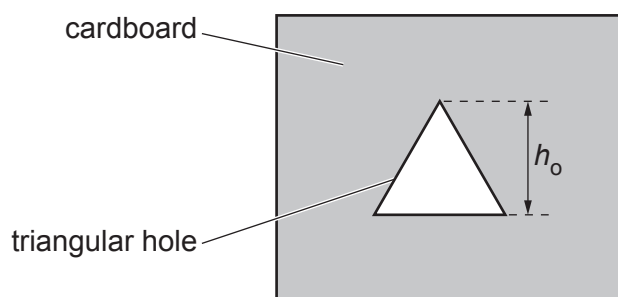


Fig. 4.3 (drawn to scale)

Use a ruler to measure h_o to the nearest 0.1 cm.

$$h_o = \dots\dots\dots \text{ cm [1]}$$

- (ii) Fig. 4.4 shows the outline of the image on the screen.

The image is inverted (upside-down).

The image is **not** actual size.

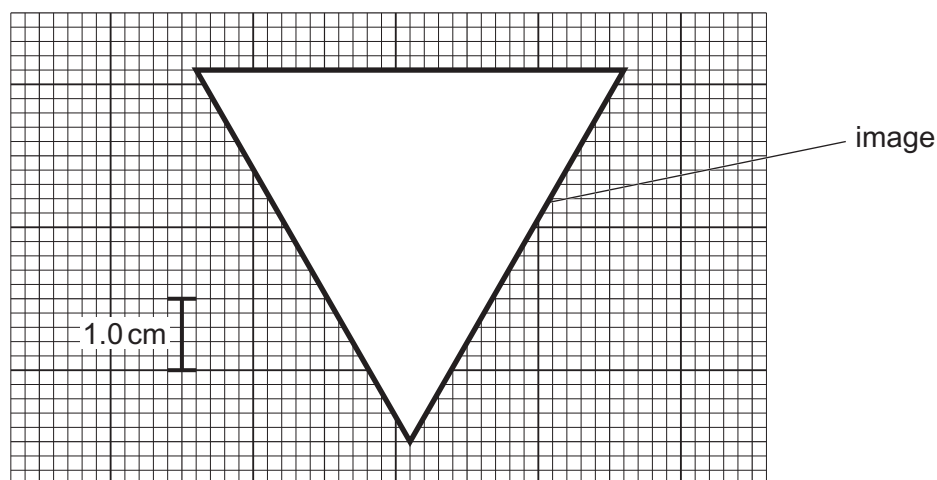


Fig. 4.4 (not to scale)

Use the scale on the screen to determine height h_i of the image.

$$h_i = \dots\dots\dots \text{ cm [1]}$$

- (c) The student repeats the procedure for values of $u = 25.0, 30.0, 35.0, 40.0$ and 45.0 cm.

Table 4.1 shows the results.

Table 4.1

object distance u /cm	image height h_i /cm	magnification M
25.0	2.5	1.7
30.0	1.7	1.1
35.0	1.2	0.8
40.0	0.9	0.6
45.0	0.8	

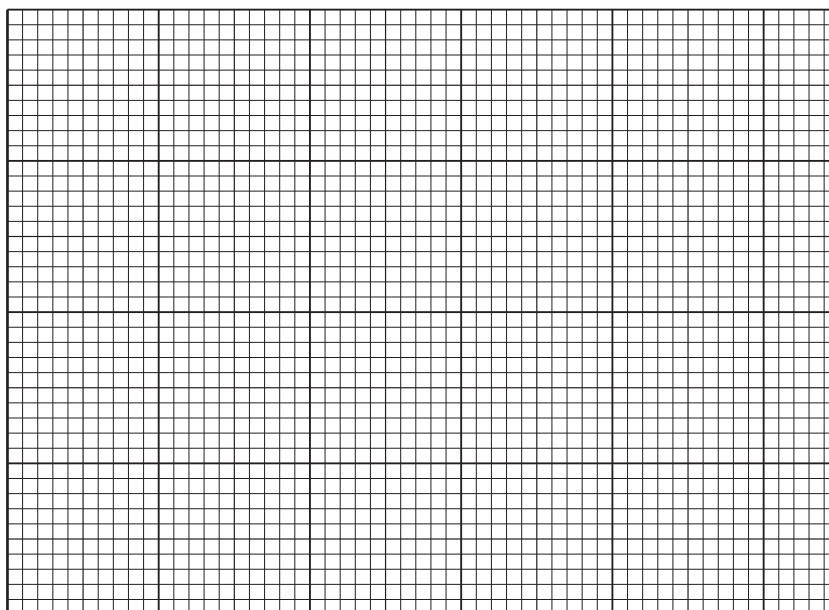
- (i) Complete Table 4.1 by calculating the magnification M at $u = 45.0$ cm.

Use the equation shown and your value of h_o from (b)(i).

$$M = \frac{h_i}{h_o}$$

[1]

- (ii) Use the data in Table 4.1 to plot a graph of magnification M (vertical axis) against object distance u .



[3]

- (iii) Draw the curve of best fit.

[1]

- (iv) Use your graph to determine the value of u when $M = 1.0$.

$u = \dots\dots\dots$ cm [1]

- (v) Calculate the focal length f of the lens.

Use your value from (c)(iv) and the equation shown.

$$f = \frac{u}{2}$$

$f = \dots\dots\dots$ cm [1]

- (d) (i) State **two** precautions the student must take to obtain a **sharp** image on the screen.

1

.....

2

.....

[2]

- (ii) Describe how the student avoids a parallax error (line-of-sight error) when measuring object distance u .

.....

..... [1]

[Total: 13]

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