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0653/61

May/June 2020

1 hour

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. Blank pages are indicated.

- 1 A student investigates the rate of diffusion in model cells.

Agar is a type of jelly that allows substances to diffuse (move) into it. Cubes of agar are used to represent cells of different sizes.

- (a) • Cubes of agar are stained with universal indicator.
• The student records the colour of the agar cubes.

colour of agar cubes = blue-green

Fig. 1.1 shows the pH chart for the universal indicator used.

pH	1	2	3	4	5	6	7	8	9	10	11	12	13	14
colour	red		orange			green			blue				purple	

Fig. 1.1

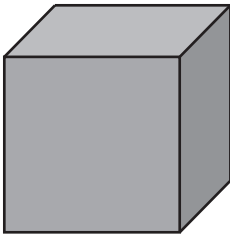
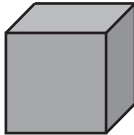
State the pH of the agar cubes.

.....

[1]

- (b) The student cuts three agar cubes so that they are different sizes. The sizes of the cubes are shown in Table 1.1.

Table 1.1

	cube A	cube B	cube C
description	 length 20 mm each side	 length 10 mm each side	 length 5 mm each side
surface area/mm ²	2400		
volume/mm ³	8000		
$\frac{\text{surface area}}{\text{volume}}/\text{mm}^{-1}$	0.3	0.6	1.2

- (i) Calculate the surface area for cube **B** and for cube **C**.

Use the equation shown and record your values in Table 1.1.

$$\text{surface area} = (\text{length})^2 \times 6$$

[1]

- (ii) Calculate the volume for cube **B** and for cube **C**.

Use the equation shown and record your values in Table 1.1.

$$\text{volume} = (\text{length})^3$$

[1]

- (c)
- Each cube is put into a separate beaker.
 - Sufficient dilute hydrochloric acid is added to cover each of the cubes.
 - The cubes gradually change colour from blue-green to red.
 - The time taken for the cubes to change to a red colour is measured.

The times displayed on the stop-clock for the three cubes are shown in Fig. 1.2.

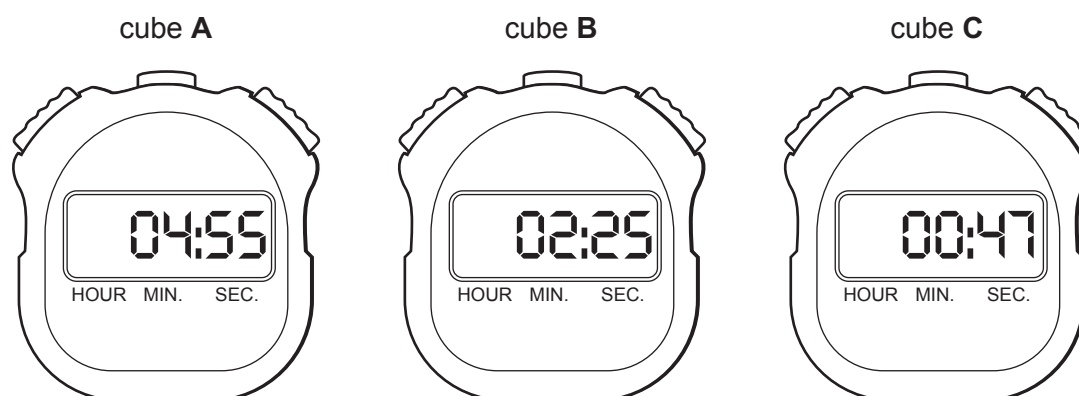


Fig. 1.2

- (i) Record in Table 1.2 these times in seconds.

[2]

- (ii) Complete the heading in Table 1.2.

Table 1.2

cube	$\frac{\text{surface area}}{\text{volume}} / \text{mm}^{-1}$	 /
A	0.3	295
B	0.6	
C	1.2	

[1]

- (iii) Describe the relationship between the value of $\frac{\text{surface area}}{\text{volume}}$ and the time taken for the agar to change colour.

.....
 [1]

- (iv) Explain why the cubes completely changed to a red colour.

.....

 [2]

- (v) State **one** safety hazard in this investigation and explain how the risk from this hazard is reduced.

safety hazard
 explanation
 [1]

- (d) The temperature of the acid affects its rate of diffusion through an agar cube.

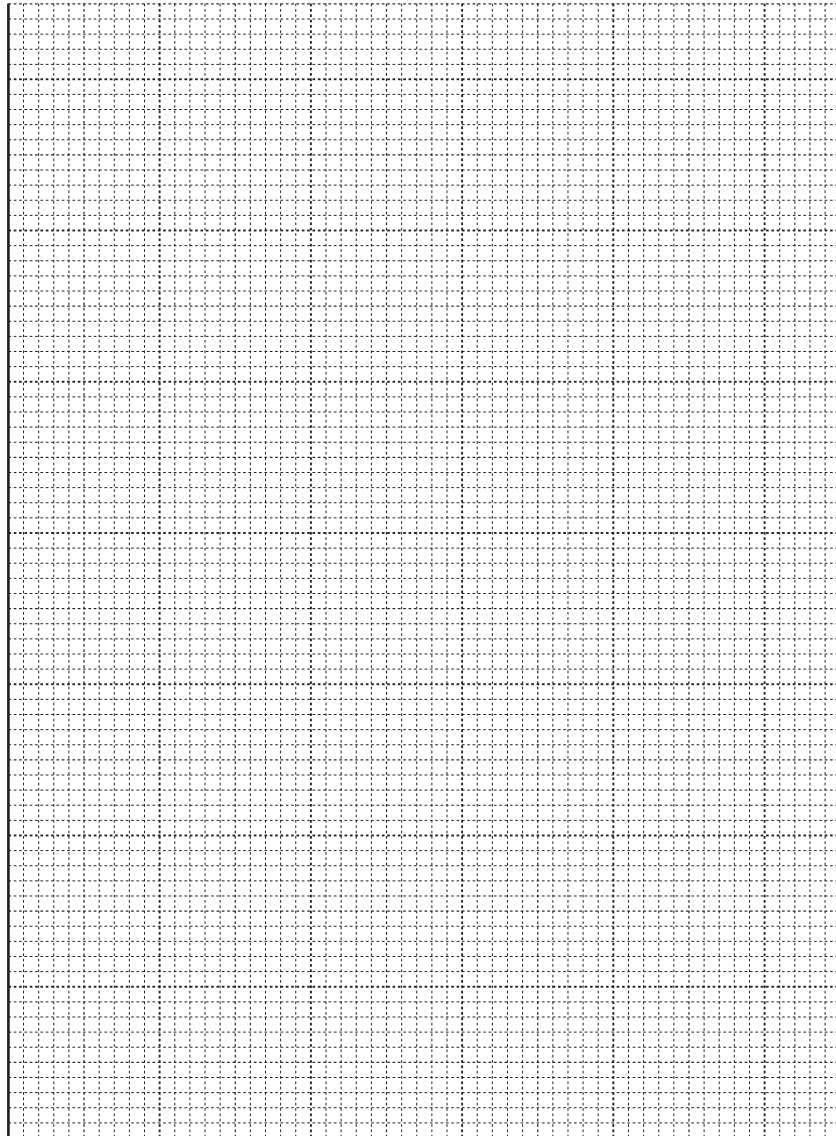
A student calculates the rate of diffusion of acid, through agar cubes of the same size, at different temperatures. The results are shown in Table 1.3.

Table 1.3

temperature / °C	rate of diffusion / mm per hour
10	10
20	18
30	25
40	29
50	33

- (i) On the grid, plot the rate of diffusion against temperature.

rate of diffusion
/mm per hour



temperature / °C

[2]

- (ii) Draw a curve of best fit.

[1]

[Total: 13]

- 2 A student investigates the reaction between aqueous sodium hydroxide and dilute hydrochloric acid.

The equation for this reaction is shown.



The student uses methyl orange indicator.

This indicator is:

- red in dilute hydrochloric acid
- yellow in aqueous sodium hydroxide
- orange in a neutral solution.

(a) Procedure

The student:

- measures 25 cm^3 of aqueous sodium hydroxide in a measuring cylinder
- pours this into a conical flask and adds the indicator
- fills a burette with dilute hydrochloric acid
- adds the dilute hydrochloric acid to the flask slowly until the indicator turns orange. If too much acid is added the indicator turns red
- records in Table 2.1 the colour of the solution at the end of the experiment and the volume of dilute hydrochloric acid added
- repeats the experiment three more times.

- (i) Name a piece of apparatus for measuring the 25 cm^3 of aqueous sodium hydroxide more accurately.

..... [1]

- (ii) Fig. 2.1 shows the burette readings for experiments 2 and 3.

Record these volumes in Table 2.1.

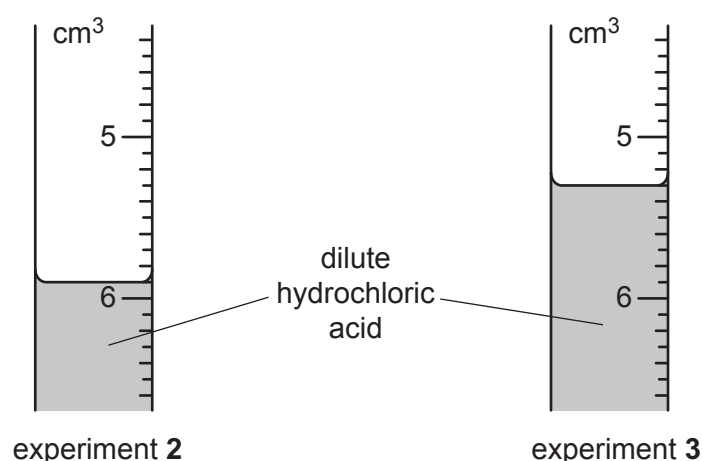


Fig. 2.1

Table 2.1

experiment	colour of indicator at end of experiment	volume of dilute hydrochloric acid added / cm ³
1	red	8.8
2	red	
3	orange	
4	orange	5.1

[2]

- (iii) The student wants to calculate the average volume of hydrochloric acid needed to just react completely with the aqueous sodium hydroxide.

Identify from Table 2.1 the volumes the student should use to calculate the average volume of dilute hydrochloric acid. Explain your choice.

volumes

explanation

[1]

- (iv) Use the volumes in (a)(iii) to calculate the average volume of dilute hydrochloric acid used.

average volume used = ... cm³ [1]

- (v) Predict the volume of dilute hydrochloric acid needed to just react completely with **75 cm³** of the same aqueous sodium hydroxide.

..... [1]

- (vi) State the type of reaction which occurs when dilute hydrochloric acid reacts with aqueous sodium hydroxide.

..... [1]

(b) Dilute hydrochloric acid and aqueous sodium hydroxide react in a 1:1 ratio.

- (i) Suggest whether the dilute hydrochloric acid or the aqueous sodium hydroxide is more concentrated. Explain your answer.

more concentrated solution

explanation

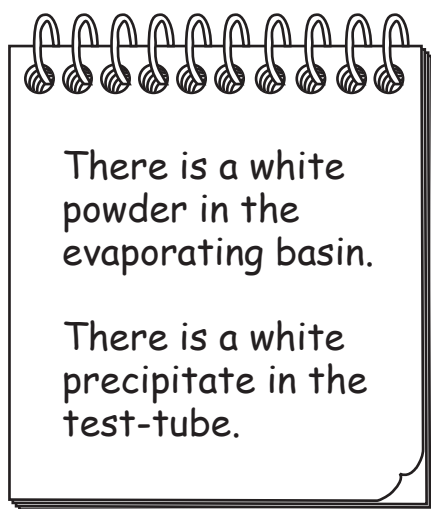
[1]

- (ii) Calculate how many times more concentrated the solution you chose in (b)(i) is than the other solution.

= times more concentrated [1]

(c) The student:

- adds some dilute hydrochloric acid to some aqueous sodium hydroxide
- places half of the mixture into a test-tube and the other half into an evaporating basin
- heats the mixture in the evaporating basin until all of the water has evaporated
- adds nitric acid and aqueous silver nitrate to the mixture in the test-tube
- records her observations.



- (i) Identify the anion that causes the white precipitate with aqueous silver nitrate.

..... [1]

- (ii) Identify the white powder in the evaporating basin.

..... [1]

- (iii) Draw the assembled apparatus used to evaporate the mixture.

Label your diagram.

[2]

[Total: 13]

3 A student investigates a ray of light travelling from glass into air.

- (a)
- She sets up the apparatus as shown in Fig. 3.1.
 - She shines the ray of light through the glass block along the normal (a line at 90° to the block at the middle of the straight edge).
 - The light emerges at 90° to the straight edge of the block.

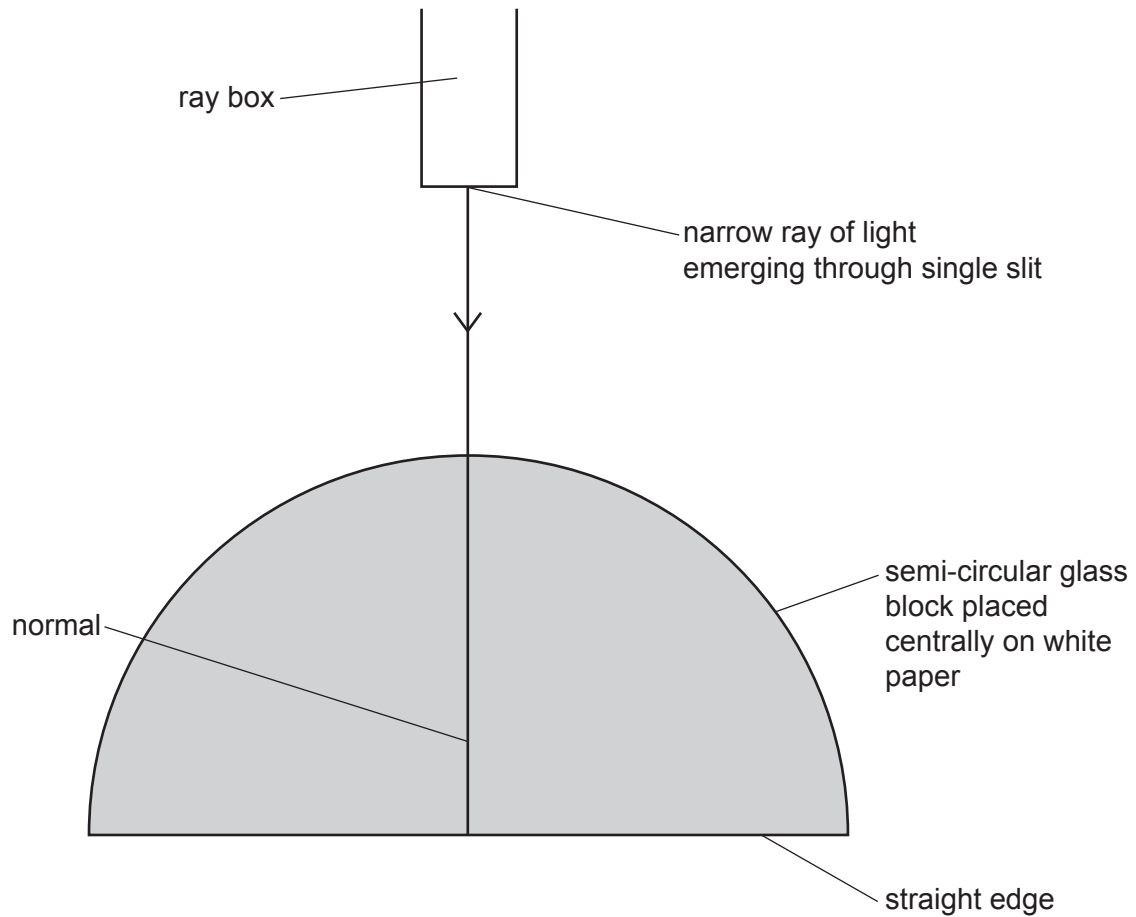


Fig. 3.1

- (i) Draw on Fig. 3.1 the ray of light as it emerges from the glass block. Label the line **X**. [1]

- (ii) • She varies the angle of incidence i of the light entering the glass block as shown in Fig. 3.2.

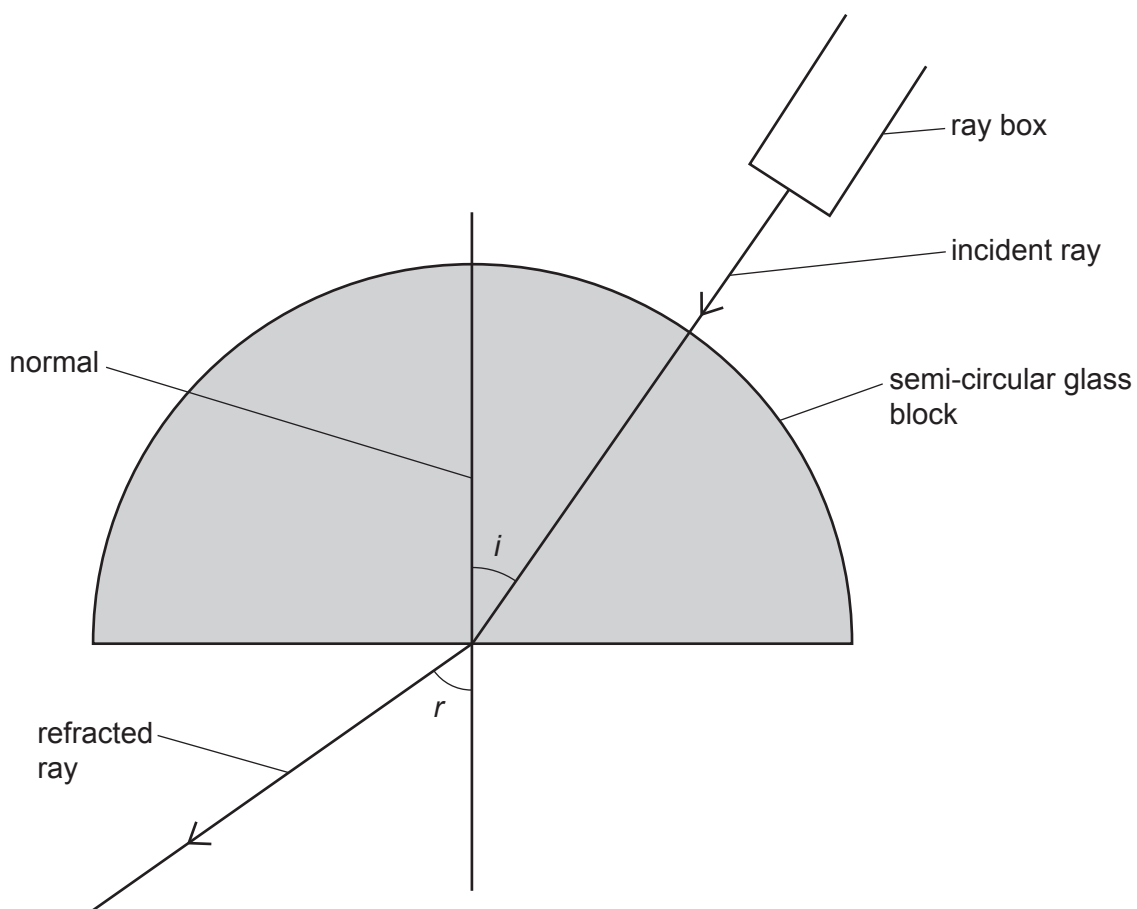


Fig. 3.2

- She measures and records the angle of refraction r for each angle of incidence i shown in Table 3.1.
- If no refracted ray emerges from the block she records this as **no refraction**.

Table 3.1

angle of incidence $i/^\circ$	angle of refraction $r/^\circ$
10	14
20	30
30	
40	74
50	no refraction
60	no refraction

Fig. 3.3 shows the refracted ray for the light with an angle of incidence $i = 30^\circ$.

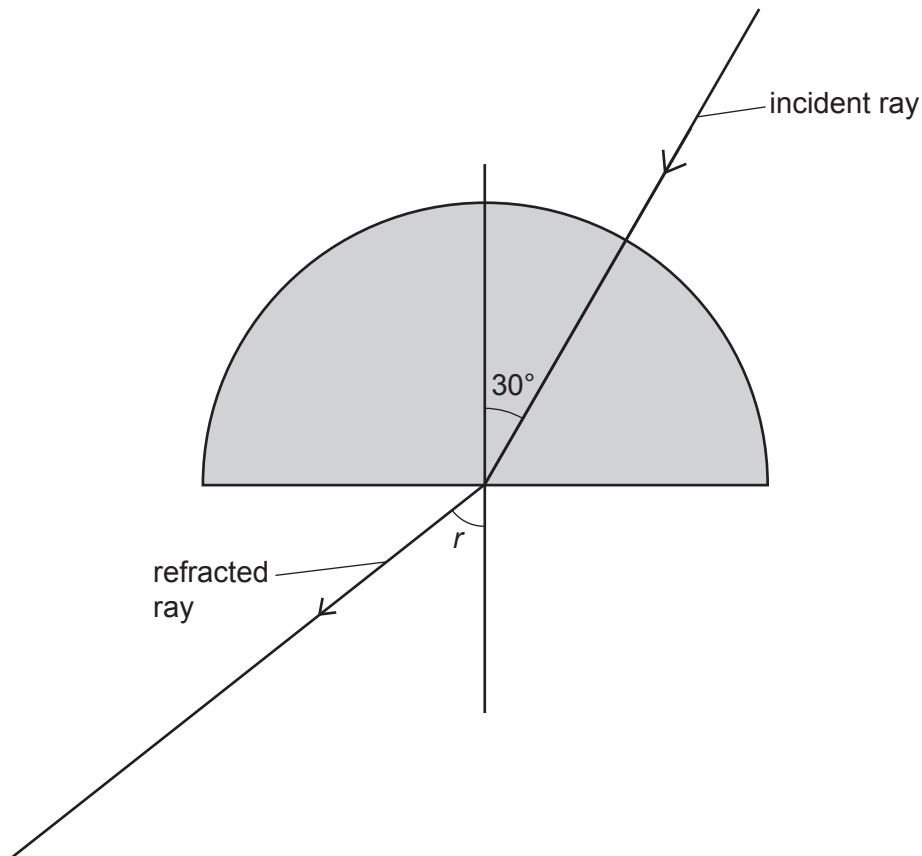


Fig. 3.3

Measure the angle of refraction r and record this value in Table 3.1.

[2]

- (b) Suggest **one** improvement that gives the student more confidence in her results.

.....
 [1]

- (c) A student predicts that doubling the angle of incidence i will always double the angle of refraction r .

Suggest whether the results in Table 3.1 support this prediction. Justify your answer with reference to the results in Table 3.1.

.....
 [1]

- (d) When no light emerges from the straight edge of the glass block, all the light has been reflected back inside the block.

The smallest angle of incidence at which all the light is reflected back inside the glass is called the critical angle.

Use your results in Table 3.1 to estimate a value for the critical angle.

estimate for critical angle = ... ° [1]

- (e) Suggest how this experiment could be improved to find a more accurate value for the critical angle.

.....

..... [1]

[Total: 7]

- 4 A student suggests that water waves will travel at different speeds in different depths of water.

Plan an investigation to find out how the speed of water waves varies with the depth of water they are travelling in.

You are provided with:

- a tank of length 50 cm × width 20 cm × depth 20 cm
- a supply of water
- a piece of wood that fits the width of the tank and can be dipped into the water to make water waves
- any other common laboratory apparatus that you need for the investigation.

In your plan, include:

- any additional apparatus
- a brief description of the method. You may include a labelled diagram if you wish.
- the values for any variables you will change
- the variables you will control
- the measurements you will make
- how you will process your results to draw a conclusion.

.....

.....

.....

.....



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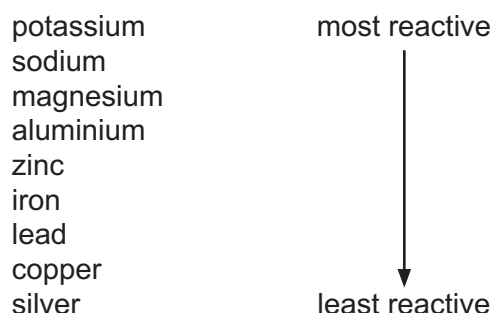
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- 1 A student investigates the reaction of some metals with dilute hydrochloric acid and with aqueous copper(II) sulfate.

The order of reactivity of some metals is shown.



(a) Procedure – reaction with dilute hydrochloric acid

The student:

- measures 10cm³ of dilute hydrochloric acid in a measuring cylinder and pours it into a large test-tube
- measures the temperature of the dilute hydrochloric acid and records it in Table 1.1
- adds 1 spatula of iron powder to the test-tube and stirs
- measures the final temperature of the mixture after 2 minutes and records it in Table 1.1.

She repeats the procedure using magnesium powder, zinc powder, lead powder and copper powder.

Table 1.1

metal	initial temperature /°C	final temperature /°C	change in temperature /°C
iron	19.5	38.0	
magnesium	21.0	78.0	57.0
zinc	21.5	56.5	
copper	21.0	21.0	0.0
lead			

- (i) The temperature readings for lead powder are shown in Fig. 1.1.

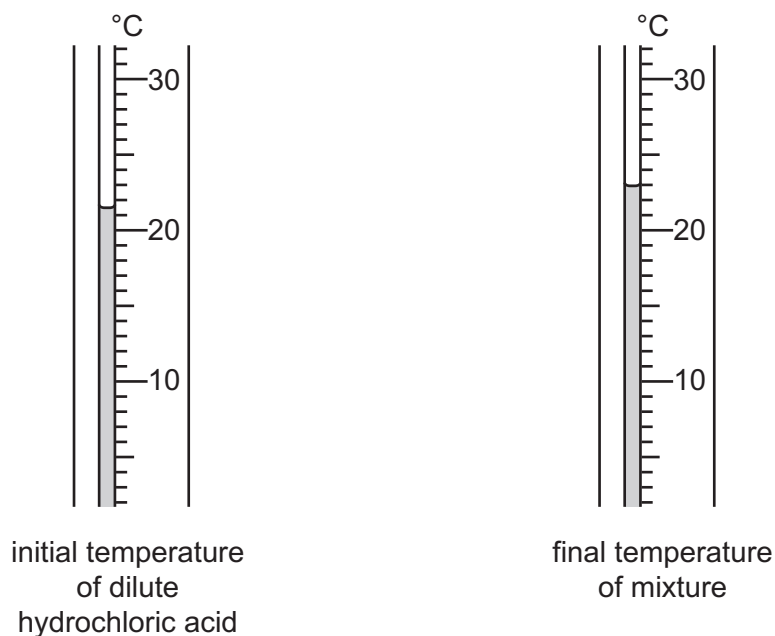


Fig. 1.1

Record in Table 1.1 these temperatures to the nearest 0.5 °C. [2]

- (ii) Calculate the change in temperature for iron, zinc and lead.
Record these changes in temperature in Table 1.1. [1]

- (iii) State which metal produces the **largest** change in temperature.
Suggest why this metal produces the largest change in temperature.

metal

suggestion

[1]

- (iv) Explain why the temperature does **not** change when copper is added to dilute hydrochloric acid.

..... [1]

- (v) Suggest **one** change to the **apparatus** which would improve the accuracy of the results.

.....

..... [1]

- (vi) Hydrogen gas is given off when magnesium reacts with dilute hydrochloric acid.

State a test for hydrogen gas and give the result of a positive test.

test

positive result

[1]

(b) Procedure – reaction with aqueous copper sulfate

The student:

- pours 10 cm³ of aqueous copper(II) sulfate into a test-tube
- measures the initial temperature of the aqueous copper(II) sulfate and records it in Table 1.2
- adds one spatula of magnesium powder to the test-tube and stirs the mixture
- measures the final temperature of the mixture after 2 minutes and records this in Table 1.2.

The student repeats the procedure using iron powder instead of magnesium powder.

Table 1.2

metal	initial temperature of aqueous copper(II) sulfate / °C	final temperature of mixture / °C	change in temperature / °C
magnesium	21.0		28.5
iron		34.0	13.0

- (i) Complete Table 1.2 by calculating the missing temperature readings. [2]

- (ii) Predict the change in temperature you would expect if zinc is added to aqueous copper(II) sulfate.
Explain your answer.

temperature change °C

explanation

.....

[1]

- (iii) Fig. 1.2 shows the observations the student makes during the reaction of magnesium powder and aqueous copper(II) sulfate.

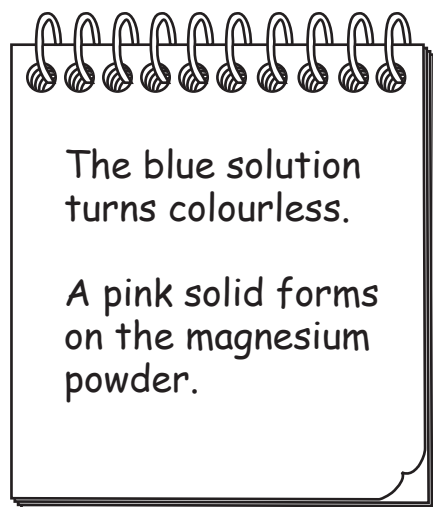


Fig. 1.2

Suggest the name of the pink solid and the salt present in the colourless solution.

name of pink solid

name of salt

[2]

- (iv) Explain the changes observed in (b)(iii).

.....

..... [1]

[Total: 13]

- 2 A student investigates the effect of substrate concentration on the rate of a reaction.

Catalase is an enzyme that breaks down the substrate, hydrogen peroxide, to release oxygen gas. The oxygen gas causes paper disks to rise in a solution of hydrogen peroxide.



- (a) The student is provided with catalase solution and five different percentage concentrations of hydrogen peroxide solution, **5%**, **4%**, **3%**, **2%** and **1%**.

Step 1 He dips five small paper disks into the catalase solution.

Step 2 He drops one of the soaked disks into a beaker containing 60 cm³ **5%** hydrogen peroxide solution.

Step 3 He starts a stop-clock.

Step 4 The disk sinks to the bottom of the beaker and then slowly rises to the surface as shown in Fig. 2.1.

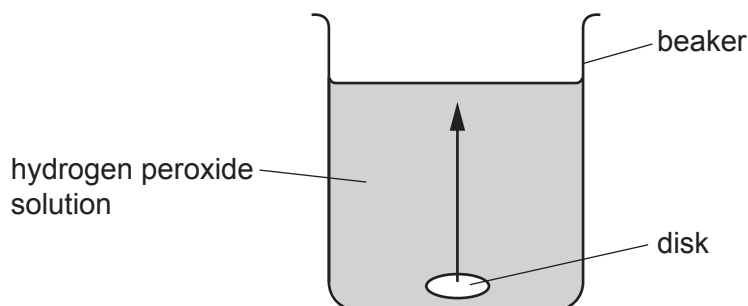


Fig. 2.1

Step 5 When the disk reaches the surface the student stops the stop-clock.

Step 6 He records the time in Table 2.1.

Step 7 He repeats step 2 to step 6 using **4%**, **3%**, **2%** and **1%** hydrogen peroxide.

The results for this first experiment are shown in Table 2.1.

Step 8 He then repeats the experiment.

Table 2.1

percentage concentration of hydrogen peroxide	time for the disk to rise to the surface/s		
	first experiment	repeat experiment	average
5	9	7	8
4	29	25	27
3	56		
2	101		
1	153	152	153

- (i) Name one piece of apparatus that would be suitable for measuring 60 cm^3 of hydrogen peroxide solution.

..... [1]

- (ii) Fig. 2.2 shows the readings on the stop-clocks for **3%** and **2%** hydrogen peroxide solutions for the repeat experiment.

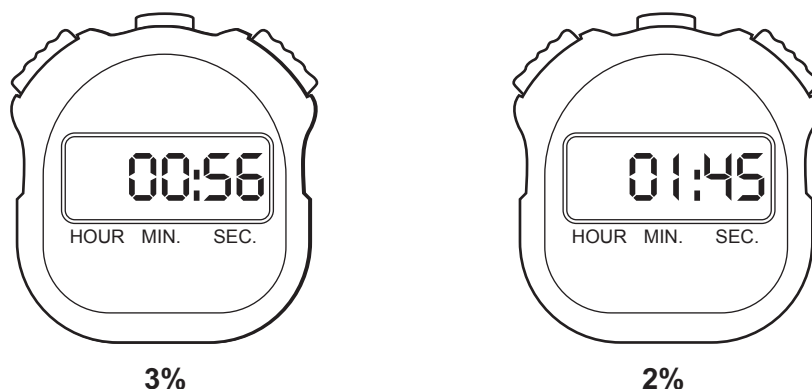


Fig. 2.2

Record in Table 2.1 the times shown in Fig. 2.2. [2]

- (iii) Calculate the average time for the **3%** and **2%** hydrogen peroxide concentrations. Record these values in Table 2.1. [1]

- (iv) Describe the relationship between the percentage concentration of hydrogen peroxide and the average time for the disks to rise to the surface.

..... [1]

- (v) Suggest why a repeat experiment is done.

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

- (vi) State **one** safety hazard associated with this investigation and explain how the risk from this hazard is reduced.

safety hazard

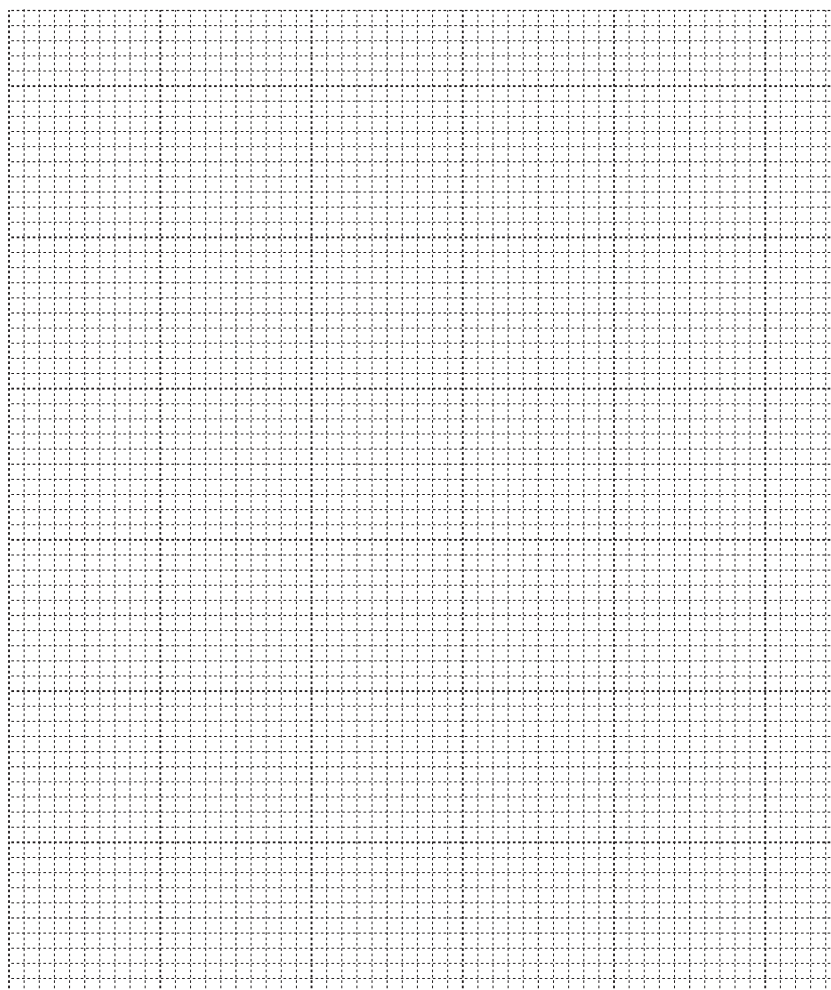
explanation

..... [1]

- (vii) Suggest **one** variable that the student should keep constant during this investigation.

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

- (b) (i) On the grid, plot a graph of the average time for the disks to rise (vertical axis) and the percentage concentration of hydrogen peroxide.



[3]

- (ii) Draw the curve of best fit. [1]
- (iii) Determine the average time for a disk to rise to the surface in a 3.7% hydrogen peroxide solution.

Show on your graph how you arrived at your answer.

average time = ... s [1]

[Total: 13]

3 A student investigates the resistance of a piece of wire.

- (a) Fig. 3.1 shows the circuit that he sets up to find the potential difference (p.d.) across the 100.0 cm length of wire and the current through the wire.

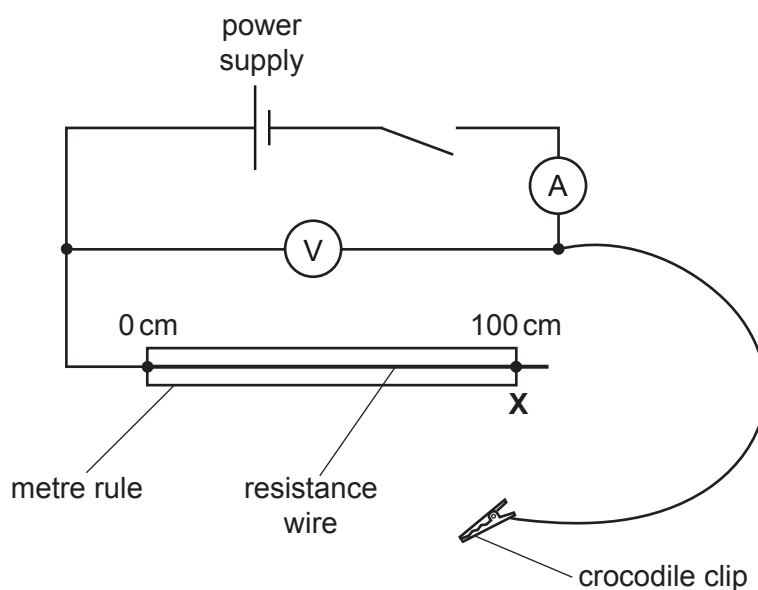


Fig. 3.1

- (i)
- The student connects the crocodile clip at **X** so that the length of resistance wire in the circuit is 100.0 cm.
 - He closes the switch.
 - He measures and records the potential difference (p.d.) across the wire and the current through the wire.
 - He opens the switch.

Fig. 3.2 shows the voltmeter and ammeter readings.

Read and record the p.d. and current.

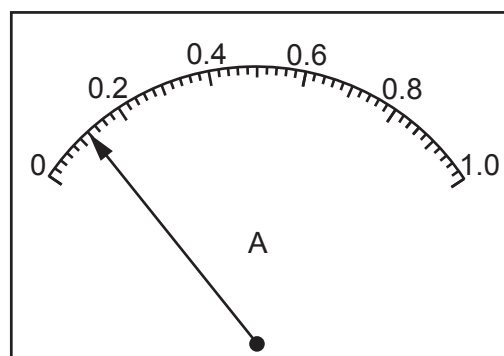
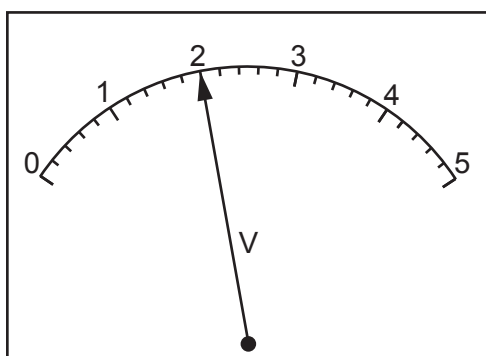


Fig. 3.2

p.d. = ... V

current = ... A
[2]

- (ii) Calculate the resistance R_1 of the 100.0 cm length of wire. Use the results in (a)(i) and the equation shown.

$$\text{resistance} = \frac{\text{p.d.}}{\text{current}}$$

$$R_1 = \dots\dots\dots \Omega \quad [1]$$

- (b)
- The student removes the crocodile clip and connects it so that the length of resistance wire in the circuit is 50.0 cm.
 - He closes the switch.
 - He measures and records the p.d. across the wire and the current through the wire.
 - He opens the switch.

Table 3.1 shows his results.

Table 3.1

p.d. /V	current /A
1.8	0.21

Calculate the resistance R_2 of the 50.0 cm length of wire. Give your answer to two significant figures.

$$R_2 = \dots\dots\dots \Omega \quad [1]$$

- (c) Another student suggests that the resistance of a 100.0 cm length of the wire should be double the resistance of a 50.0 cm length of the wire.

State whether the values of R_1 and R_2 support the student's suggestion. Justify your answer with reference to these values.

.....

..... [1]

- (d) Another student suggests that the resistance of a wire is proportional to its length.

- (i) Describe how the student can extend this experiment to test their suggestion.

.....

..... [1]

- (ii) Explain how the student can process the results to reach a conclusion.

.....

..... [1]

[Total: 7]

- 4 Fig. 4.1 shows an empty test-tube, floating in a measuring cylinder containing pure water.

If the same test-tube is put into a measuring cylinder containing a solution of salt and water it will float with a smaller length of the test-tube below the surface. This is because the salt solution has a greater density than pure water.

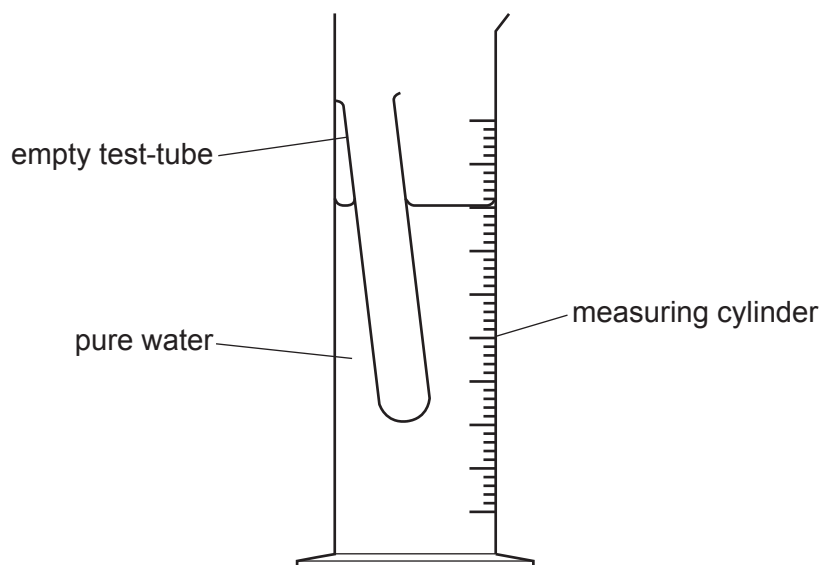


Fig. 4.1

The higher the concentration of salt in the solution the greater the density of the solution.

Five salt solutions of different, known concentrations are placed in beakers and labelled **A**, **B**, **C**, **D** and **E**. Another salt solution of unknown concentration is placed in another beaker and labelled **X**.

Plan an investigation to determine the concentration of salt solution **X** using the following apparatus:

- a measuring cylinder
- a test-tube
- a 30 cm ruler.

You may use any other common laboratory apparatus in your plan.

In your plan, include:

- a brief description of the method
- how you will ensure that your results are as accurate as possible
- how you will process your results
- how you will determine the concentration of **X**.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [7]

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- 1 A student investigates the effect of temperature on the uptake of water by a stem.

Water containing a blue stain moves up the xylem of a plant, staining the xylem blue.

Fig. 1.1 shows a cut section of the stem with stained xylem tubes.

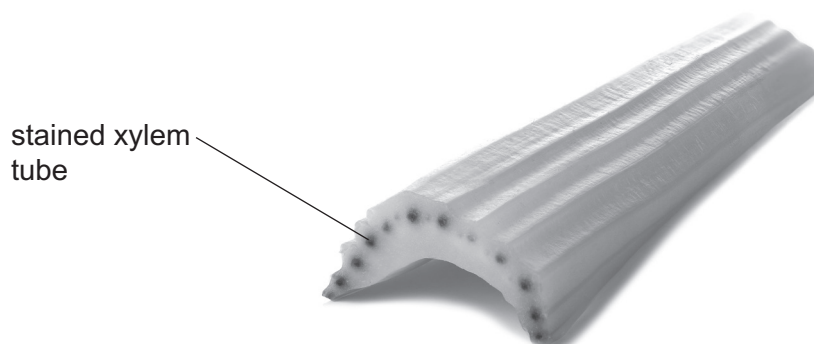


Fig. 1.1

(a) Procedure

- The student places one end of a freshly cut stem into water containing a blue stain at 20 °C.
- He leaves it in the blue stain for 60 minutes.
- He removes the stem.
- The student then cuts a 2 mm slice from the end of the stem that has been in the blue stain, as shown in Fig. 1.2.

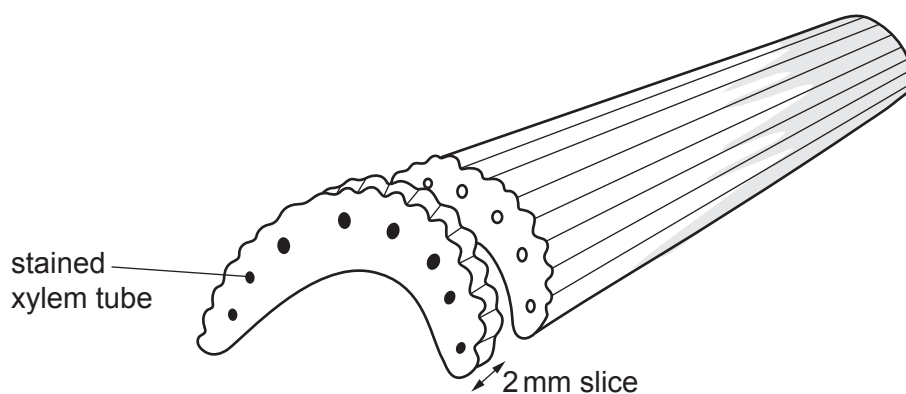


Fig. 1.2

- He observes the cut xylem tubes to see if they contain blue stain.
- If the xylem tubes contain the blue stain he takes another 2 mm slice and observes the new cut xylem tubes.
- The student repeats this until the xylem tubes are no longer stained blue.
- He then counts the number of slices cut to calculate how far the stain has travelled.
- He repeats the procedure at 25 °C, 30 °C, 35 °C and 40 °C.

Fig. 1.3 shows the cut stems at each temperature.

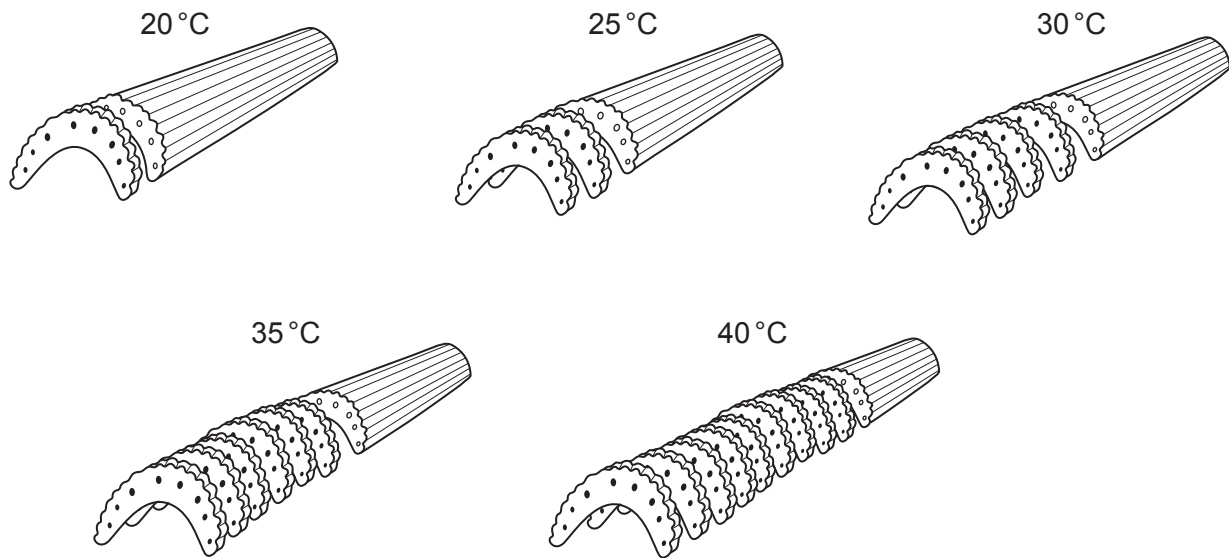


Fig. 1.3

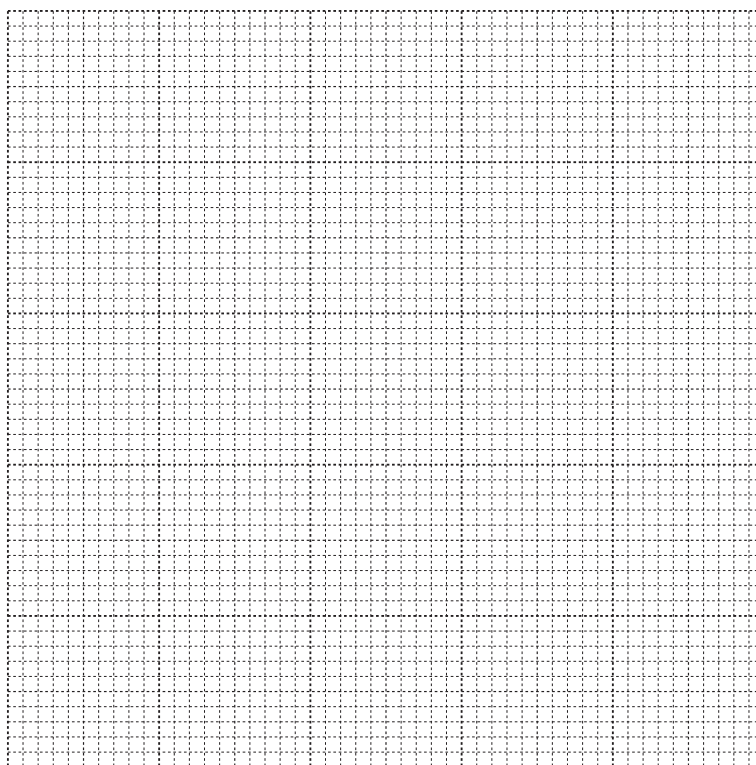
(i) Use Fig. 1.3 to complete Table 1.1.

Table 1.1

temperature/°C	number of slices	distance moved by stain/mm
20	1	2
25		
30	4	8
35		
40	9	18

[2]

- (ii) On the grid, plot a graph of the distance moved by the stain (vertical) against the temperature.



[3]

- (iii) Draw a curve of best fit. [1]

- (iv) Describe the relationship between the temperature and the distance moved by the stain.

.....
 [1]

- (v) State **one** variable that must be kept constant in this investigation.

.....
 [1]

- (vi) Suggest **one** possible source of error when calculating the distance moved by the stain.

.....
 [1]

- (vii) The student stated that there was a risk of cutting his hand when using the knife.

Describe **one** method of reducing this risk.

.....
 [1]

(b) Fig. 1.4 shows a close-up of the cut end of the stem.

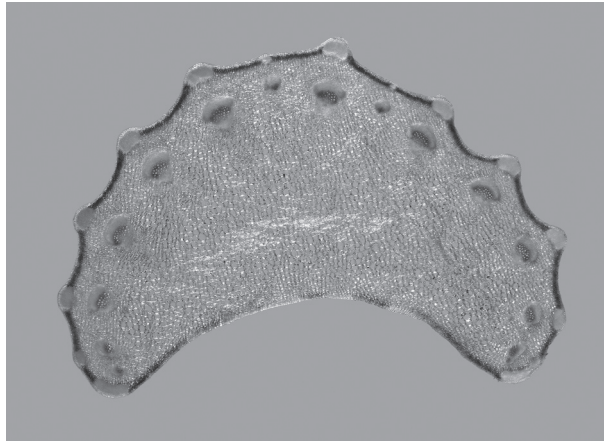


Fig. 1.4

Make an enlarged detailed drawing of the cut stem shown in Fig. 1.4.



[3]

[Total: 13]

- 2 A student performs an experiment to determine the volume of dilute hydrochloric acid needed to react completely with aqueous sodium hydroxide.

(a) The student uses the apparatus shown in Fig. 2.1.

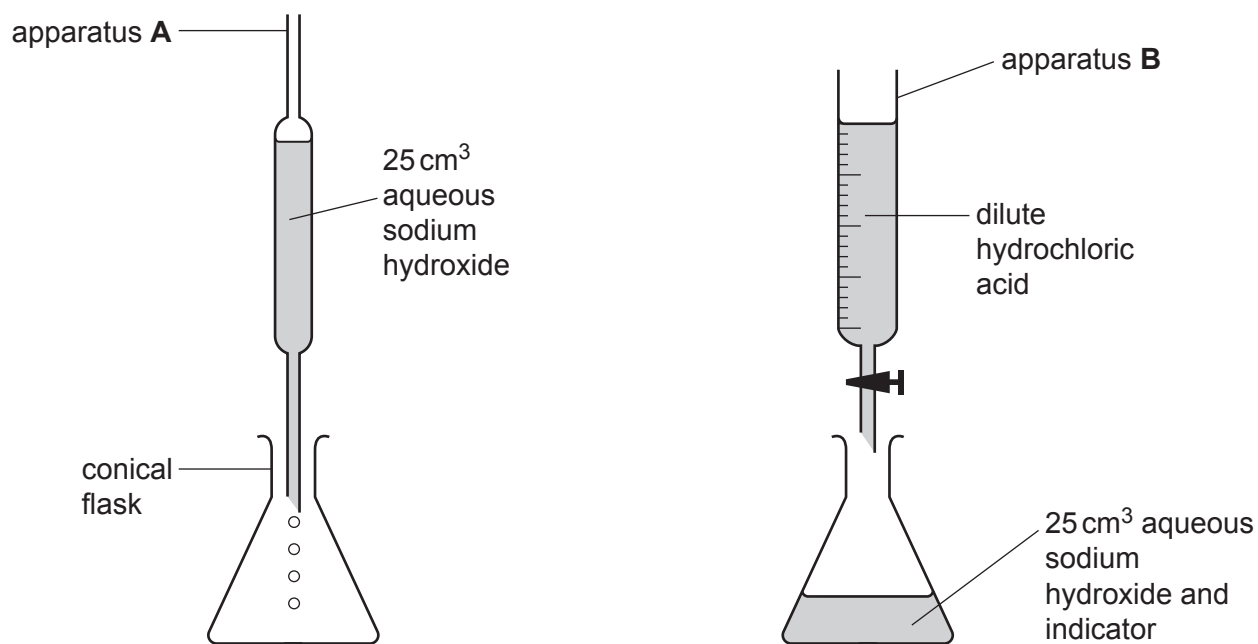


Fig. 2.1

Name apparatus **A** and **B**.

apparatus **A**

apparatus **B**

[2]

(b) Procedure

The student:

- places 25 cm³ aqueous sodium hydroxide into a conical flask using apparatus **A**
- adds a few drops of indicator
- fills apparatus **B** to 0.0 cm³ with dilute hydrochloric acid
- slowly adds the dilute hydrochloric acid until the reaction is complete
- measures the volume of dilute hydrochloric acid used
- records in Table 2.1 the volume of dilute hydrochloric acid used
- repeats the experiment three times.

Table 2.1

experiment number	volume of dilute hydrochloric acid / cm ³
1	
2	12.5
3	12.7
4	

- (i) Fig. 2.2 shows the volumes of dilute hydrochloric acid the student uses in experiments **1** and **4**.

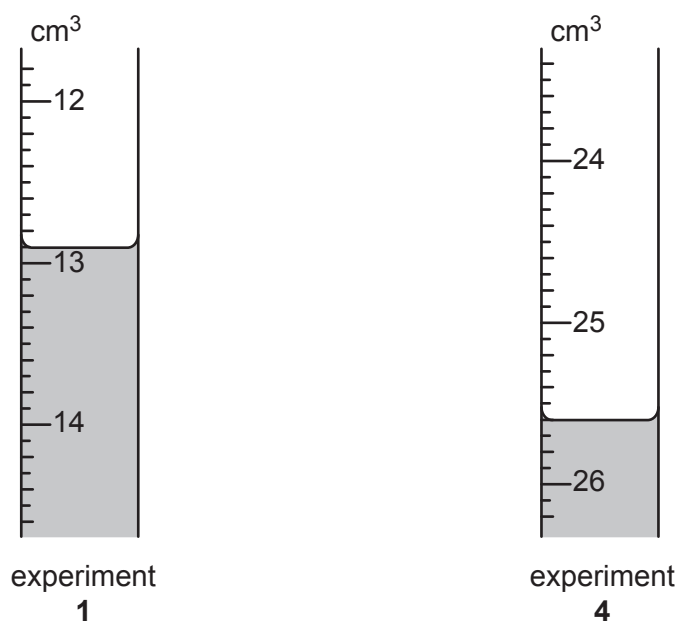


Fig. 2.2

Record in Table 2.1 these volumes to the nearest 0.1 cm³.

[2]

- (ii) Name a suitable indicator.

..... [1]

- (iii) Explain how the student knows when the reaction is complete.

..... [1]

- (iv) The student wants to calculate the average volume of dilute hydrochloric acid that just reacts completely with aqueous sodium hydroxide.

Select the volumes from Table 2.1 that should be used to calculate this average volume of dilute hydrochloric acid.

Explain your choice.

volumes cm^3

explanation

..... [1]

- (v) Use the volumes chosen in (b)(iv) to calculate the average volume of dilute hydrochloric acid used.

average volume = ... cm^3 [1]

- (vi) Predict what volume of dilute hydrochloric acid is needed to react completely with **75 cm^3** of aqueous sodium hydroxide.

..... [1]

- (vii) Identify which result in Table 2.1 is anomalous.

..... [1]

- (viii) Suggest what could have caused this anomaly.

..... [1]

- (c) Hydrochloric acid reacts with sodium hydroxide to make sodium chloride solution.

- (i) The student adds dilute nitric acid and aqueous silver nitrate to this sodium chloride solution.

Describe what the student observes in this test for a chloride ion.

..... [1]

- (ii) Describe how the student can make a dry sample of sodium chloride from the sodium chloride solution.

.....

..... [1]

[Total: 13]

- 3 A student investigates the stability of a plastic block.

He sets up the apparatus shown in Fig. 3.1.

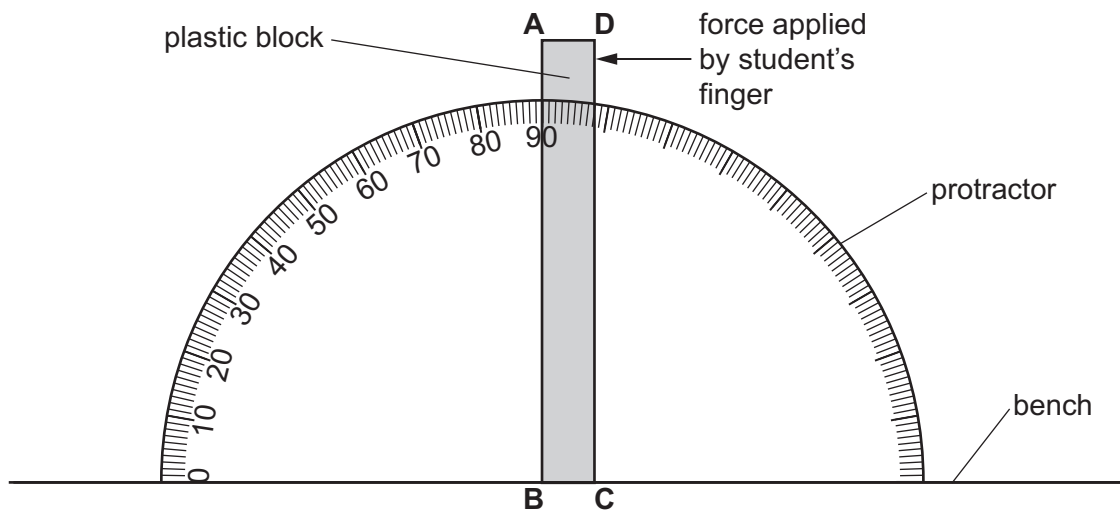


Fig. 3.1

Procedure

- The student gently pushes the top of the block until it just tips over (topples).
- He replaces the block and pushes it gently again.
- He measures the angle between the side of the block **AB** and the vertical at the point that the block just starts to topple.

- (a) Fig. 3.2 shows the position of the block as it just starts to topple.

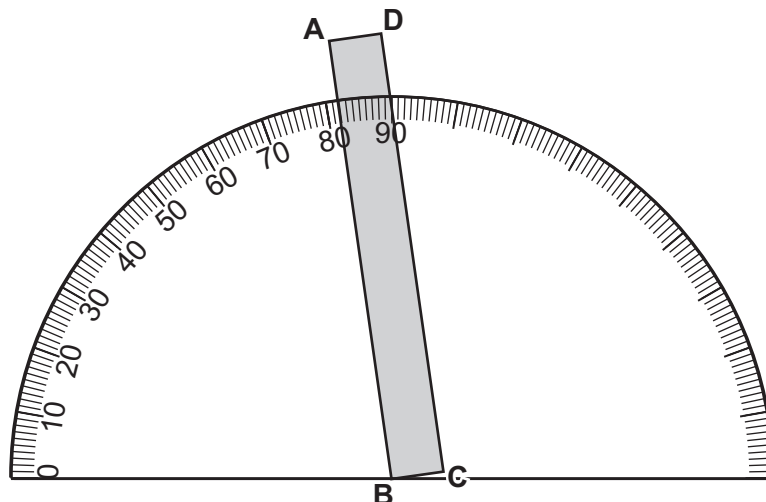


Fig. 3.2

- (i) Record the angle shown on the protractor by line **AB**.

angle shown on protractor = ...° [1]

- (ii) Use your value in (a)(i) to calculate the angle that **AB** makes with the vertical.

angle of **AB** with the vertical = ...° [1]

- (iii) The student repeats the procedure two more times. His results are shown in Fig. 3.3.

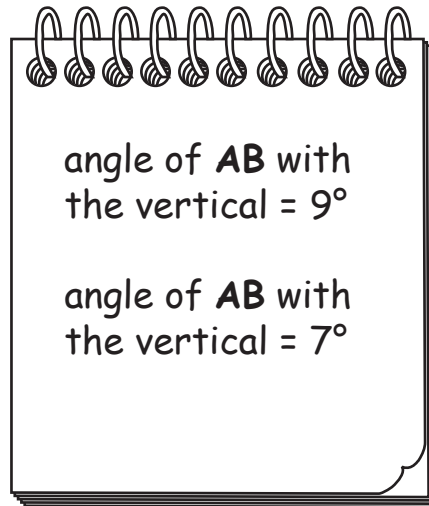


Fig. 3.3

The student carries out the test carefully on each occasion.

Suggest why his results for the angle are not identical in each experiment.

.....
 [1]

- (iv) Use the results in (a)(ii) and (a)(iii) to calculate the average angle of **AB** with the vertical when the block just starts to topple.

average angle = ... ° [1]

- (b) (i) Fig. 3.4 shows a face **ABCD** of the block.

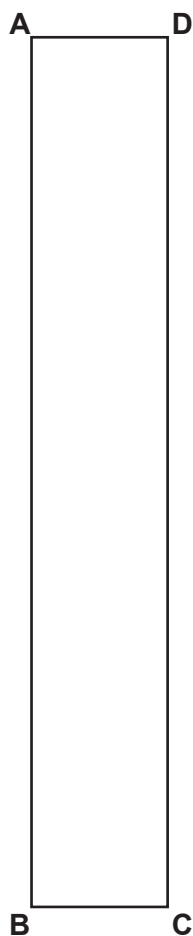


Fig. 3.4

Use a ruler to draw the diagonal line **AC**.

[1]

- (ii) On Fig. 3.4 use a protractor to measure the angle between lines **AC** and **CD** of the block. Record the size of this angle.

angle = ... ° [1]

- (c) A student suggests that the angle in (b)(ii) should be the same as the angle in (a)(iv).

State whether these two angles agree within the limits of experimental accuracy. Justify your answer with reference to the results.

.....

..... [1]

[Total: 7]

Question 4 begins on page 14

- 4 When a ball is released at the top of a ramp (slope) it will roll to the bottom of the ramp and then continue for some distance on a level surface before coming to rest.

A student predicts that the distance travelled by a ball from the bottom of the ramp will be proportional to the height of the top of the ramp above the bench.

Plan an investigation to test the student's prediction.

In your answer, include:

- the apparatus you will use. You may include a diagram
- a brief description of the method
- the variables which will be controlled
- the measurements you will make
- how you will ensure that your results are as accurate as possible
- how you will process your results to draw a conclusion.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [7]

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