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0653/61

May/June 2021

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. Any blank pages are indicated.

- 1 A student investigates an enzyme-catalysed reaction.

Hydrogen peroxide is broken down by catalase, an enzyme found in living cells such as the cells of potato tissue. Oxygen gas is released during the reaction.

(a) Procedure

The student:

Step 1 labels three test-tubes, **A**, **B** and **C**

Step 2 makes up three different concentrations of hydrogen peroxide solution by adding the volumes of 6% hydrogen peroxide solution and water as shown in Table 1.1.

Table 1.1

test-tube	volume of 6% hydrogen peroxide solution /cm ³	volume of water /cm ³	percentage concentration of hydrogen peroxide solution
A	2	4	2
B	4	2	
C	6	0	6

- (i) Calculate the percentage concentration of hydrogen peroxide solution for test-tube **B**.

Record your answer in Table 1.1 **and** Table 1.2.

[1]

- (ii) The student:

Step 3 cuts three 1 mm slices of potato from a potato cylinder as shown in Fig. 1.1.

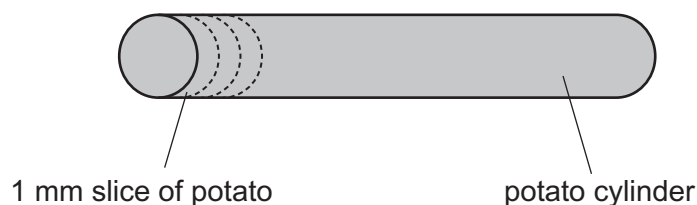


Fig. 1.1

Step 4 drops one potato slice into each labelled test-tube and starts the stop-watches

Step 5 records, in Table 1.2, the time taken for each potato slice to rise to the surface of the liquid.

The times for each potato slice are shown in Fig. 1.2.

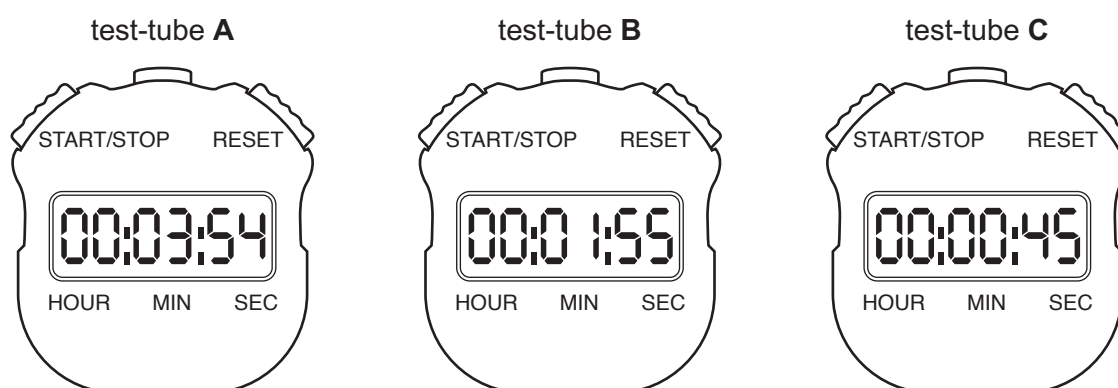


Fig. 1.2

Record in Table 1.2 the results shown in Fig. 1.2. Test-tube **B** has been completed for you.

Table 1.2

test-tube	percentage concentration of hydrogen peroxide solution	time taken for potato slice to rise to the surface /seconds
A	2	
B		115
C	6	

[2]

(iii) State a conclusion for these results.

.....
 [1]

(iv) State and explain **one** safety precaution taken when cutting the potato slices.

.....
 [1]

(v) Identify **two** variables that are controlled in this investigation.

1
 2 [2]

- (vi) Suggest why the experiment is **not** done using 20% concentration of hydrogen peroxide solution.

.....
 [1]

- (vii) Predict how the results will change if the potato slices are cut to a thickness of 2 mm instead of 1 mm. Explain your answer.

.....
 [1]

- (b) The student then adds the remaining potato cylinder to some iodine solution.
 State the nutrient tested for with iodine solution and state the observation for a positive result.

nutrient

observation

..... [2]

- (c) A student tests some potato with Benedict's solution by following the procedure shown in Fig. 1.3.

Step 1	put a piece of potato in a test-tube
Step 2	add 2 cm ³ Benedict's solution
Step 3	shake the test-tube to mix
Step 4	
Step 5	observe the colour after 3 minutes

Fig. 1.3

- (i) State the instruction for Step 4.

.....
 [1]

- (ii) State an observation for a positive result.

..... [1]

[Total: 13]

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2 A student is provided with five aqueous solutions, **F**, **G**, **H**, **J** and **K**.

- (a) The student puts three drops of Universal Indicator into test-tubes, each containing one of the solutions.

The results are shown in Table 2.1.

Table 2.1

solution	colour with Universal Indicator	pH of solution
F	red	
G	green	
H	blue-green	
J	purple	
K	red	

Use the pH colour chart to determine the pH of each solution.

colour with Universal Indicator	red	orange	yellow	green	blue-green	blue	purple
pH	0 – 3	4 – 5	6	7	8 – 9	10 – 11	12 – 14

Write your answers in Table 2.1.

[2]

- (b) (i) Put the solutions in order of decreasing acidity and increasing alkalinity.

most acidic

↓

most alkaline

[1]

- (ii) Explain why it is difficult to decide where to put **F** and **K** in the list in (b)(i).

.....

..... [1]

- (c) The student adds a small piece of magnesium to solution **F**.

The reaction mixture fizzes and produces hydrogen gas.

Describe a test for hydrogen gas and give the observation for a positive test.

test

observation

[2]

- (d) The student bubbles some carbon dioxide through solution **H**.

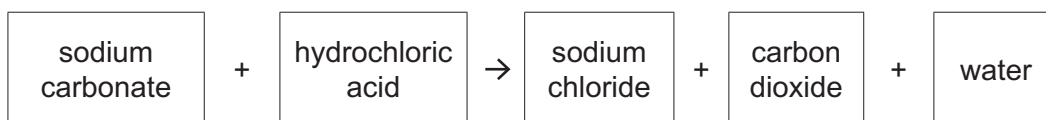
Solution **H** goes milky because it forms an insoluble white precipitate.

Name solution **H**.

..... [1]

[Total: 7]

- 3 Sodium carbonate is a white solid that reacts with dilute hydrochloric acid as shown in the word equation.



When sodium carbonate is added to dilute hydrochloric acid the reaction fizzes (bubbles). When the fizzing stops the reaction is complete.

The time it takes for the reaction to be completed is called the reaction time.

Plan an investigation to find out how the reaction time depends on the temperature of the hydrochloric acid.

You are provided with:

- sodium carbonate powder
- dilute hydrochloric acid

You may use any common laboratory apparatus in your plan.

In your plan, include:

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

You may include a labelled diagram if you wish.

You may include a table that can be used to record the results if you wish.

4 A student investigates how forces affect an elastic band.

Fig. 4.1 shows the elastic band before it is used by the student. It is drawn full-size. The elastic band has not yet been stretched with any forces.

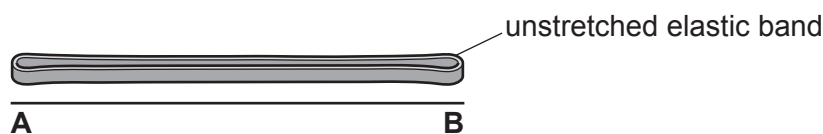


Fig. 4.1

Procedure

The student:

- suspends the elastic band from a nail and carefully places a 100 g mass hanger onto the elastic band as shown in Fig. 4.2

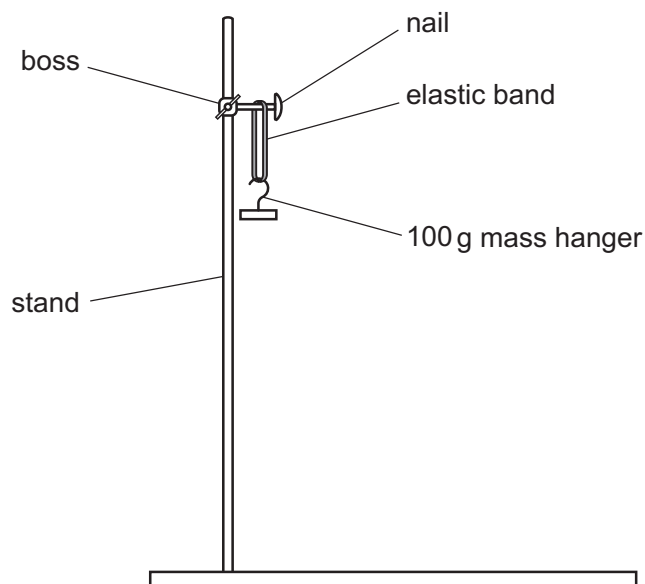


Fig. 4.2

- measures and records in Table 4.1 the stretched length of the elastic band
- without removing the mass hanger, carefully adds a 100 g mass to the hanger
- measures and records in Table 4.1 the stretched length of the elastic band
- continues adding 100 g masses one at a time until a total of 500 g is suspended from the elastic band, recording the length each time
- carefully removes the 100 g masses, one at a time
- after removing each 100 g mass, measures and records in Table 4.2 the stretched length of the elastic band
- measures the final length of the elastic band after the mass hanger has been removed.

- (a) Measure the unstretched length of the elastic band in Fig. 4.1 from point **A** to **B** to the nearest millimetre and record your result in Table 4.1.

Table 4.1

mass /g	force /N	length of elastic band /mm
0	0	
100	1.0	65
200	2.0	73
300	3.0	90
400	4.0	125
500	5.0	166

Table 4.2

mass /g	force /N	length of elastic band /mm
500	5.0	166
400	4.0	152
300	3.0	136
200	2.0	107
100	1.0	78
0	0	64

[1]

- (b) Explain why the student wears safety goggles during this experiment.

.....

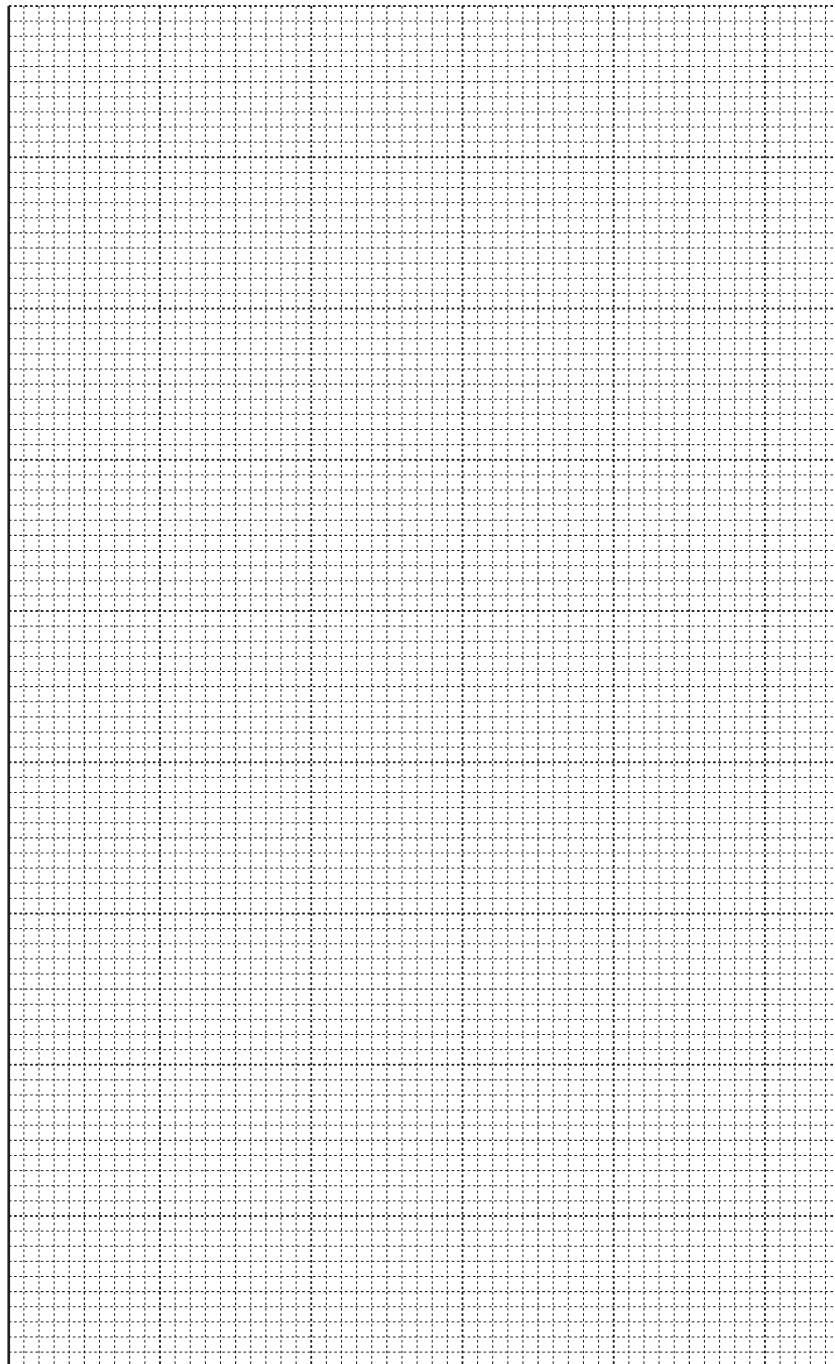
..... [1]

- (c) Use the information in Table 4.1 to deduce the force exerted by a 650g mass.

force = ... N [1]

- (d) (i) Use the results in Table 4.1 to plot a graph of the length of the elastic band (vertical axis) against force. Start your graph at (0,0).

length / mm



force / N

- (ii) Draw the best-fit curve. Label this curve “increasing force”. [2]
- (iii) Use your graph to estimate the length of the elastic band when a force of 2.5 N is applied to stretch it. [1]

length of elastic band when force is 2.5 N = ... mm [1]

- (iv) On the same axes, plot the results in Table 4.2. [1]
- (v) Draw the best-fit curve for the points plotted in (d)(iv). Label this curve “decreasing force”. [1]
- (e) Work is done as the elastic band is stretched. Elastic potential energy is stored in the stretched band.

When the stretching force is removed, some of the stored elastic potential energy is converted into thermal energy. This thermal energy is represented by the area between the two best-fit curves on the graph.

- (i) Estimate the area on the graph by counting the number of 1 cm^2 squares between your two best-fit curves from 0–5 N.
Show how you arrived at your answer.

area between the two best-fit curves = ... [2]

- (ii) Suggest how the student can improve the **experimental procedure** to get a more accurate estimate of the energy lost in the elastic band.

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

- (f) The area between the two best-fit curves can be used to calculate the energy lost.

A student does this experiment with a **different** elastic band.

The student calculates the area between their two best-fit curves as 150 N mm .

Calculate the energy lost when the student’s elastic band is stretched.

Use the equation shown.

$$\text{energy lost} = \text{area between the two best-fit lines} \times 0.001$$

energy lost = ... J [1]

[Total: 13]

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- 1 (a) A student investigates the rate of respiration in yeast cells.

Yeast is a single-celled organism similar to plant and animal cells.

The student uses methylene blue indicator. A solution of methylene blue loses its blue colour as the yeast cells respire.

Procedure

The student:

- puts 5 cm³ yeast suspension into each of three test-tubes labelled **A**, **B** and **C**
- adds the volumes of water, 5% glucose solution and methylene blue to test-tubes **A**, **B** and **C** as shown in Table 1.1

Table 1.1

test-tube	volume of water /cm ³	volume of 5% glucose solution /cm ³	volume of methylene blue /cm ³
A	5	0	1
B	4	1	1
C	0	5	1

- places the test-tubes in a water-bath at 40 °C
- records the time taken for the methylene blue to lose its blue colour in each test-tube
- if the time taken is longer than 5 minutes then the student records this value as **>300**
- repeats the procedure.

- (i) The student's results for test-tubes **B** and **C** for **trial 2** are shown in Fig. 1.1.

Record these values in Table 1.2.

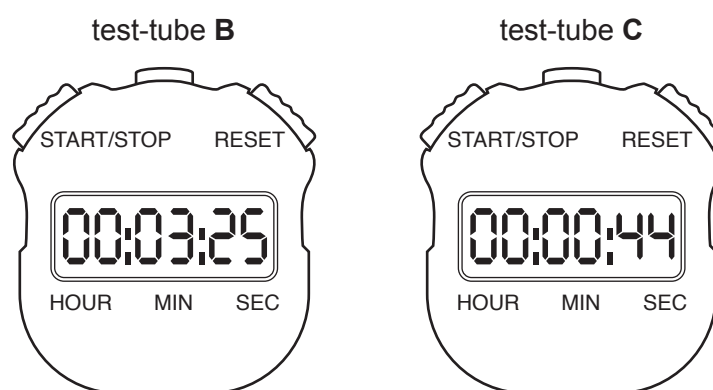


Fig. 1.1

Table 1.2

test-tube	volume of 5% glucose solution / cm ³	time taken to lose blue colour / seconds	
		trial 1	trial 2
A	0	>300	>300
B	1	187	
C	5	53	

[2]

(ii) State a conclusion for the results in Table 1.2.

.....
 [1]

(iii) Suggest why the student repeats the investigation.

.....
 [1]

(iv) Identify **one** variable that is kept constant during this investigation.

.....
 [1]

(v) The student wants to find out if all of the glucose in test-tube **C** has been used up.

Name the testing solution the student uses and give the colour observed for a **negative** result.

testing solution

colour for **negative** result

[1]

(b) The student thinks that carbon dioxide gas is given off when yeast cells respire.

State the test for carbon dioxide and include the observation for a positive result.

test

observation

[1]

- (c) Fig. 1.2 shows a yeast cell. The yeast cell has a cell wall and a large vacuole similar to a plant cell. The yeast cell is magnified 5000 times.

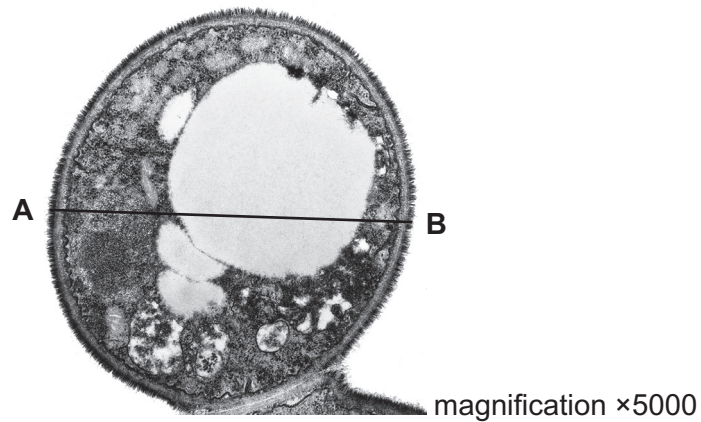


Fig. 1.2

- (i) Measure the length of the cell, line **AB**, on Fig. 1.2 in millimetres to the nearest millimetre.

length of line **AB** on Fig. 1.2 = ... mm [1]

- (ii) Calculate the actual length of the cell using the equation shown.

$$\text{actual length of cell} = \frac{\text{length of line } \mathbf{AB} \text{ on Fig. 1.2}}{\text{magnification}}$$

actual length of cell = ... mm [1]

- (iii) In the box provided, make a large, clear line drawing of the yeast cell in Fig. 1.2 showing the cell wall and vacuole.



[4]

[Total: 13]

2 A student investigates solid **F**.**(a) Procedure**

The student:

- adds some water to a test-tube
- measures the temperature of the water to the nearest 0.5°C
- adds two spatula loads of solid **F** to the water
- stirs the mixture until all of solid **F** dissolves
- measures the temperature of the solution to the nearest 0.5°C
- pours the solution into two test-tubes for use in **(b)** and **(c)**.

(i) Fig. 2.1 shows the two thermometer readings.

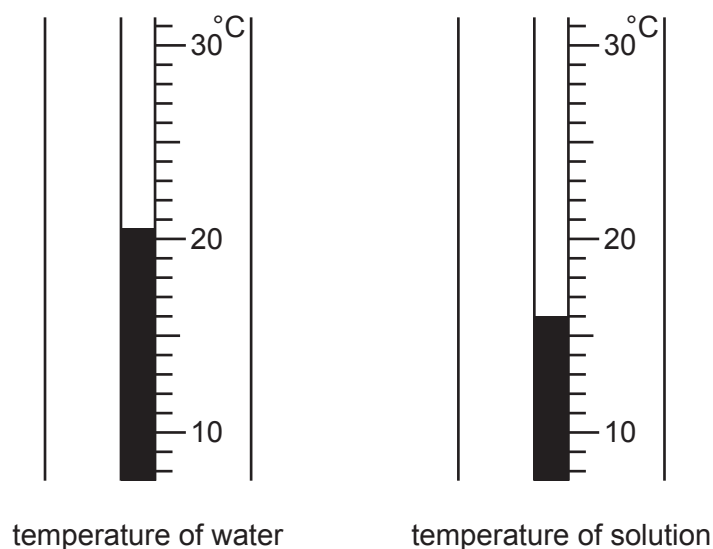


Fig. 2.1

Record in Table 2.1 these two temperatures to the nearest 0.5°C .

Table 2.1

temperature of water/ $^{\circ}\text{C}$	
temperature of solution/ $^{\circ}\text{C}$	

[2]

- (ii) In an endothermic process heat energy is taken in from the surroundings.

State if solid **F** dissolving in water is an endothermic process.

Explain your answer using the results in Table 2.1.

.....
 [1]

- (b) The student adds three drops of Universal Indicator solution to one of the test-tubes containing the solution of **F**.

The Universal Indicator turns red-orange.

Fig. 2.2 shows a pH colour chart.

red	orange	yellow	green	blue-green	blue	purple
1	4	6	7	8	10	14

Fig. 2.2

- (i) Use the pH colour chart in Fig. 2.2 to estimate the pH of the solution of **F**.

..... [1]

- (ii) Explain why using a pH colour chart does not give the student an accurate value for the pH of the solution of **F**.

.....
 [1]

- (c) The student adds an equal volume of aqueous sodium hydroxide to the other test-tube containing a solution of **F**.

The student warms the mixture carefully and tests the gas formed with damp red litmus paper. The student concludes that ammonia gas is formed.

- (i) Describe what happens to the piece of damp red litmus paper during the test for ammonia gas.

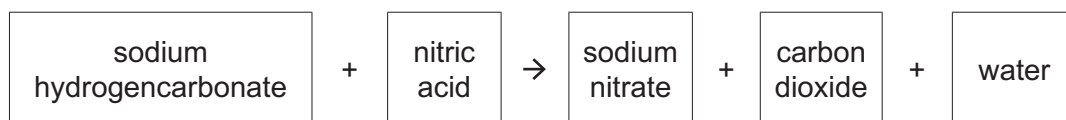
..... [1]

- (ii) Identify the positive ion present in the solution of **F**.

..... [1]

[Total: 7]

- 3 Sodium hydrogencarbonate is a white solid that reacts with dilute nitric acid as shown in the word equation.



When sodium hydrogencarbonate is added to dilute nitric acid the reaction mixture fizzes (bubbles). When the fizzing stops the reaction is complete.

The time it takes for the reaction to be completed is called the reaction time.

Plan an investigation to find out how the reaction time depends on the concentration of the dilute nitric acid.

You are provided with:

- sodium hydrogencarbonate powder
- dilute nitric acid
- distilled water

You may use any common laboratory apparatus in your plan.

In your plan, include:

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

You may include a labelled diagram if you wish.

You may include a table that can be used to record the results if you wish.

- 4 A student determines the cross-sectional area of a piece of resistance wire using measurements of current and voltage.

Fig. 4.1 shows the cross-sectional area of a wire.

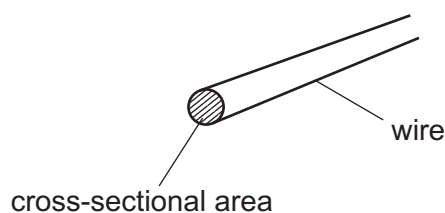


Fig. 4.1

(a) Procedure

The student:

- sets up the circuit shown in Fig. 4.2

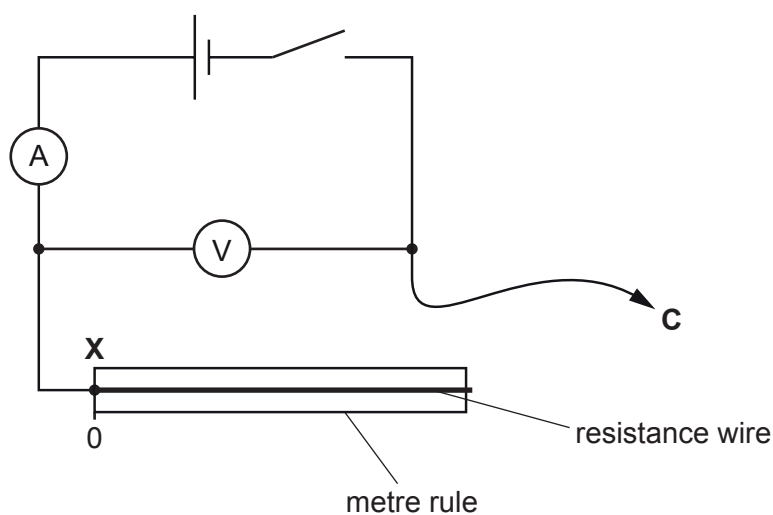


Fig. 4.2

- completes the circuit by connecting **C** to the resistance wire at length $l = 400\text{ mm}$ from point **X**, the zero end of the metre rule.
- closes the switch
- records in Table 4.1 the current I flowing in the circuit and the potential difference V between **X** and **C**
- opens the switch.

- (i) Fig. 4.3 shows the voltmeter and ammeter readings for $l = 400$ mm. Record these values in Table 4.1.

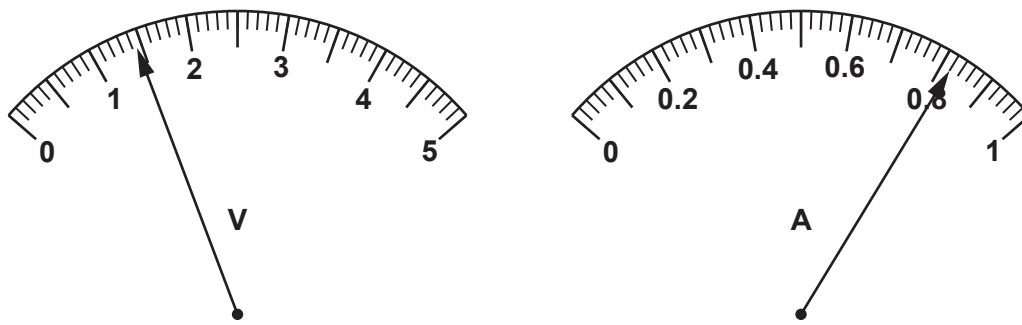


Fig. 4.3

Table 4.1

length, l /mm	potential difference, V /V	current, I /A	resistance, R / Ω
400			
500	1.60	0.73	2.2
700	1.85	0.59	3.1
800	1.90	0.54	3.5
900	1.95	0.50	3.9
1000	2.05	0.46	4.5

[2]

- (ii) The student repeats the procedure for lengths $l = 500$ mm, 700 mm, 800 mm, 900 mm and 1000 mm. The results are shown in Table 4.1.

Suggest why it is good experimental technique to open the switch between each reading.

.....
 [1]

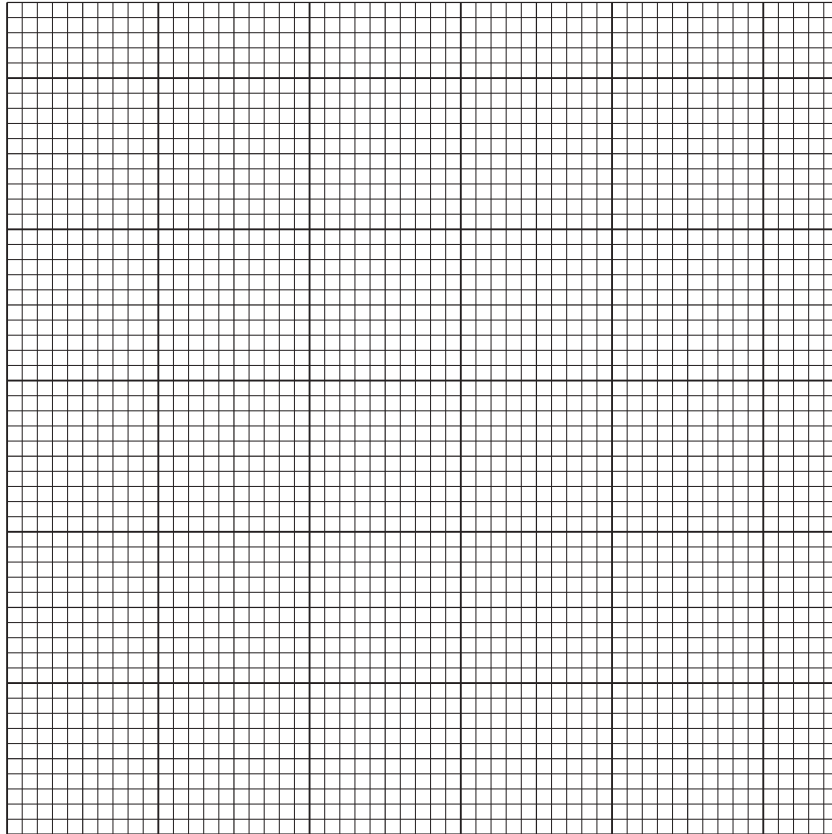
- (b) Calculate the resistance R of the 400 mm length of resistance wire. Use the equation shown.

$$R = \frac{V}{I}$$

Record the value of R in Table 4.1.

[2]

- (c) (i) Plot a graph of resistance R (vertical axis) against length of wire, l . Start your axes at (0,0).



[3]

- (ii) Draw the best-fit straight line.

[1]

- (iii) Use your graph to estimate the value of R at length $l = 600 \text{ mm}$.

$R = \dots\dots\dots \Omega$ [1]

- (iv) Calculate the gradient G of the line.
Indicate on your graph the points that you use to calculate the gradient.

$G = \dots\dots\dots$ [2]

- (d) Calculate the cross-sectional area A of the resistance wire. Use the equation shown.

$$A = \frac{0.00049}{G}$$

If you do not have a value for G in (c)(iv) use $G = 0.005$ here. This is **not** the correct value for G .

$A = \dots\dots\dots \text{mm}^2$ [1]

[Total: 13]

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- 1 A student investigates the effect of temperature on the activity of the enzyme pepsin.

Pepsin is an enzyme that breaks down proteins into amino acids as shown in Fig. 1.1.

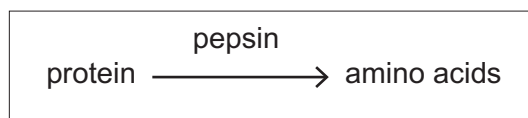


Fig. 1.1

Amino acids are acidic. They have a low pH.

Procedure

The student:

- sets up a water-bath at 10 °C
- puts 5 cm³ of protein solution into a test-tube and adds 1 cm³ of 1% pepsin solution
- puts 1 cm³ of Universal Indicator solution into the test-tube
- stirs the contents of the test-tube with a glass rod
- puts the test-tube into the water-bath
- starts the stop-clock
- records in Table 1.1 the time taken in seconds for the mixture in the test-tube to change from green to red.

The student repeats the procedure using water-baths at 20 °C, 30 °C, 40 °C, and 50 °C.

- (a) The student's results are shown in Table 1.1.

- (i) Add the units to the headings of Table 1.1.

Table 1.1

temperature /	time taken to change to red /
10	135
20	
30	32
40	32
50	

[1]

- (ii) The times taken for the colour to change from green to red at 20 °C and 50 °C are shown in Fig. 1.2.

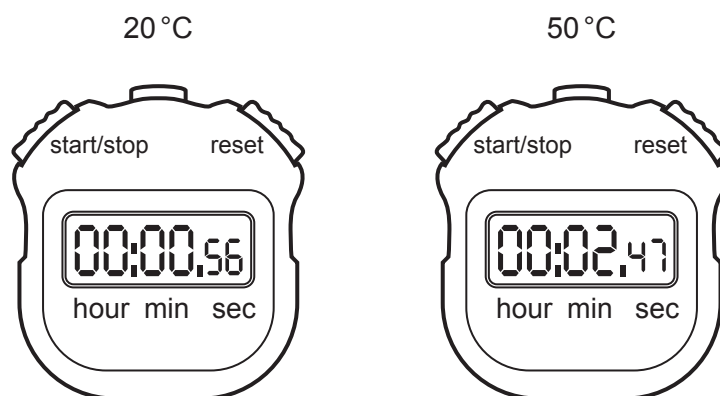


Fig. 1.2

Record these times in Table 1.1.

[2]

- (b) (i) Describe how the time taken for the Universal Indicator solution to turn red changes as the temperature increases.

.....

 [2]

- (ii) The student repeats the procedure at 35 °C. Predict the time taken for the Universal Indicator solution to change to red.

Explain your answer.

prediction

explanation

[2]

- (c) Fig. 1.3 shows the colour chart for the Universal Indicator solution used by the student.

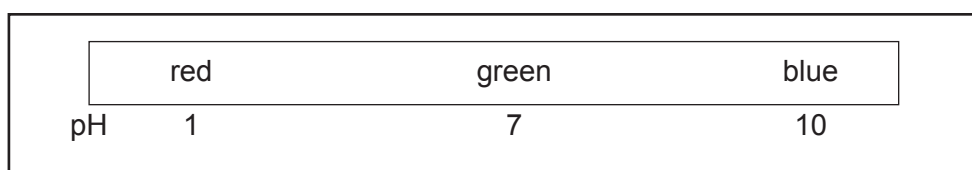


Fig. 1.3

State and explain why the colour of the Universal Indicator solution changes to red.

Use Fig. 1.1 and Fig. 1.3 to support your answer.

.....

.....

.....

..... [2]

- (d) The student stirs the contents of the test-tubes before putting them in the water-bath.

State why this is good experimental practice.

.....

..... [1]

- (e) State **one** variable that is kept constant during this investigation.

.....

..... [1]

- (f) Describe a test that confirms the presence of protein.

Include the colour for a positive result.

test

colour

[2]

[Total: 13]

- 2 Antacid tablets are used to reduce the symptoms of indigestion in the stomach caused by excess acid.

A student investigates the reaction of antacid tablets with dilute hydrochloric acid.

During the reaction carbon dioxide gas is made.

The student wants to find out if an increase in temperature increases the total volume of carbon dioxide made.

(a) The student:

- pours 25.0 cm^3 of dilute hydrochloric acid into a conical flask
- sets up the apparatus shown in Fig. 2.1
- removes the bung, quickly adds one antacid tablet, and replaces the bung
- collects the carbon dioxide in apparatus X.

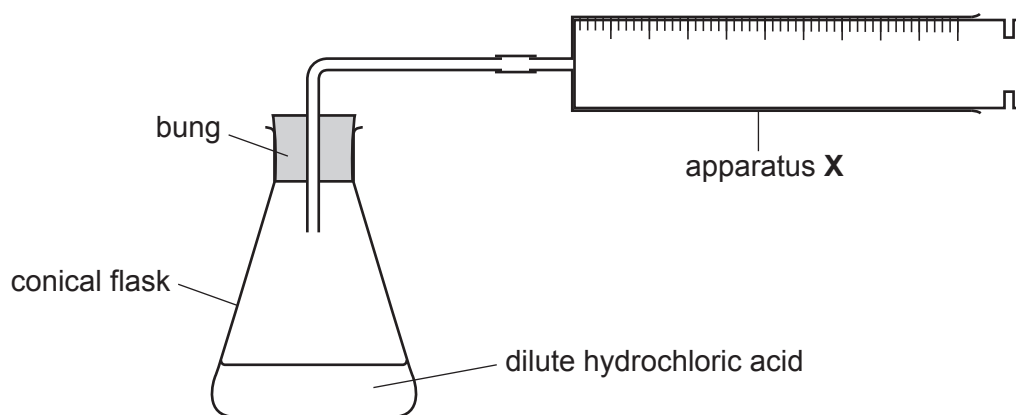


Fig. 2.1

(i) Name apparatus X.

..... [1]

- (ii) The student does the experiment with the dilute hydrochloric acid at 25 °C.

The student repeats the experiment with the dilute hydrochloric acid at 35 °C.

Fig. 2.2 shows the total volume of carbon dioxide collected in apparatus **X** at each temperature.

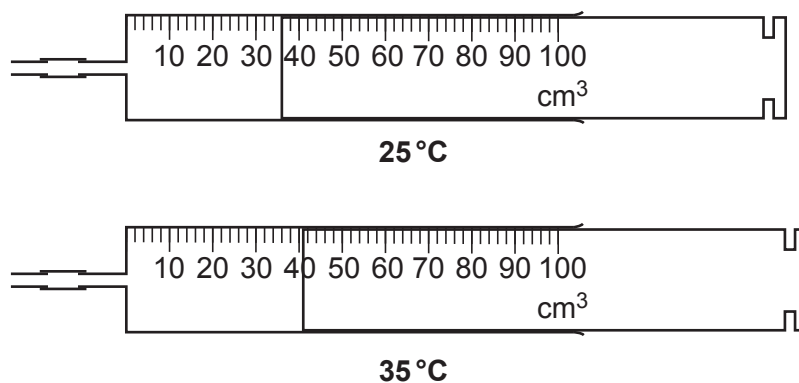


Fig. 2.2

Record these two volumes in Table 2.1.

Table 2.1

temperature / °C	total volume of carbon dioxide / cm ³
25	
35	

[2]

- (iii) Some of the gas made is **not** collected in apparatus **X**.

Use the information in the method to suggest why some of the gas is **not** collected.

.....
 [1]

- (iv) Describe a chemical test to confirm that the gas made is carbon dioxide.

Include an observation for a positive result.

test
 observation [1]

(b) Next, the student:

- dissolves an antacid tablet in water to make a solution
- adds three drops of Universal Indicator to this solution
- observes that the Universal Indicator turns green-blue.

Fig. 2.3 shows a pH colour chart.

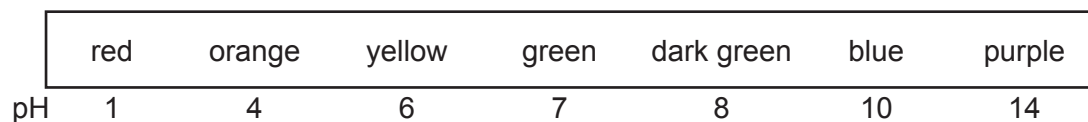


Fig. 2.3

(i) Use the pH colour chart in Fig. 2.3 to estimate the pH of the solution of the antacid.

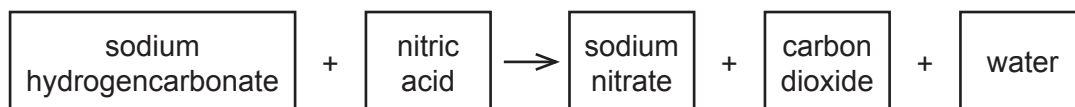
..... [1]

(ii) Explain why using a pH colour chart does **not** give the student an accurate value for the pH of the solution of antacid.

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

[Total: 7]

- 3 Sodium hydrogencarbonate is a white solid that reacts with dilute nitric acid as shown in the word equation.



The reaction is endothermic. This means that the temperature of the reaction mixture will decrease during the reaction.

Plan an investigation to find out how the temperature decrease of the reaction mixture depends on the mass of sodium hydrogencarbonate added to the dilute nitric acid.

You are provided with:

- sodium hydrogencarbonate powder
- dilute nitric acid

You may use any common laboratory apparatus in your plan.

In your plan, include:

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

You may include a labelled diagram if you wish.

You may include a table that can be used to record the results if you wish.

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- 4 A student measures the efficiency of an electric heating element in a circuit.

The student:

- sets up the apparatus shown in Fig. 4.1
- adds 100 cm^3 of water at room temperature to the beaker
- records in Table 4.1 the initial temperature of the water

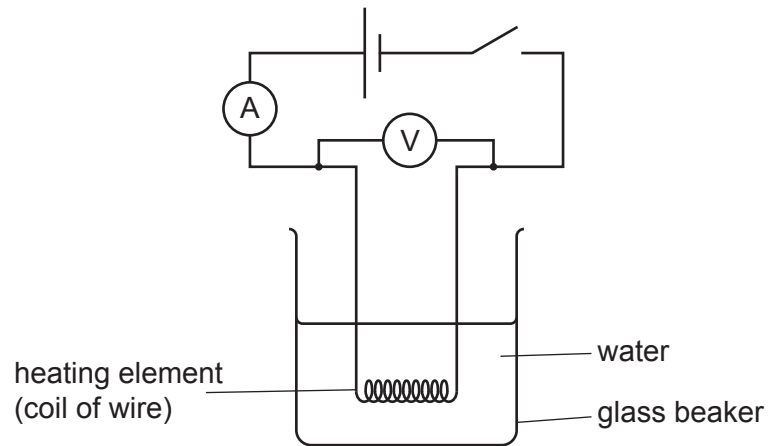


Fig. 4.1

- closes the switch and starts a stop-clock
- records in Table 4.1 the temperature of the water every 5 minutes for 30 minutes.

(a) Fig. 4.2 shows the thermometer reading at 5 minutes.

Record this temperature in Table 4.1.

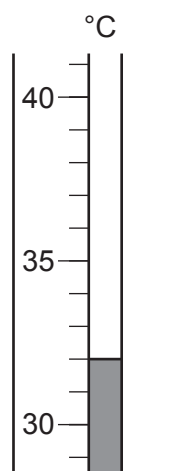


Fig. 4.2

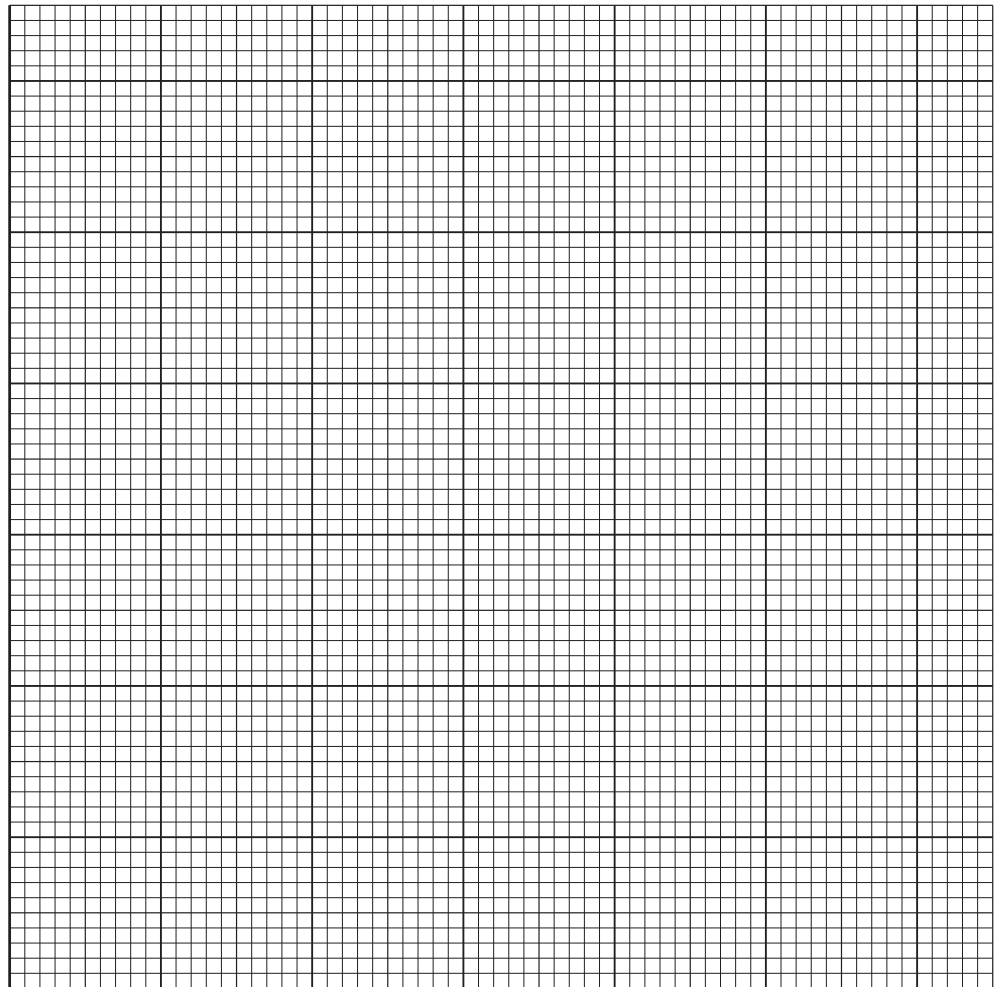
Table 4.1

time /min	temperature /°C
0	25.0
5	
10	38.0
15	42.0
20	
25	46.5
30	49.5

[1]

- (b) (i) Plot a graph of temperature against time. Do **not** start the temperature scale at 0.

temperature / °C



time / min

[2]

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

- (iii) The student did **not** record the temperature at 20 minutes. Use your graph to estimate this temperature reading.

estimate of temperature at 20 min = ... °C [1]

- (c) (i) Calculate the increase in temperature of the water after 30 minutes of heating.

temperature increase = ... °C [1]

- (ii) Calculate the thermal energy gained by the water in 30 minutes. Use your answer in (c)(i) and the equation shown.

$$\text{thermal energy} = 100 \times 4.2 \times \text{temperature increase}$$

Give your answer to an appropriate number of significant figures.

$$\text{thermal energy} = \dots\dots\dots \text{ J [2]}$$

- (d) (i) Fig. 4.3 shows the ammeter and voltmeter readings when the circuit is switched on.

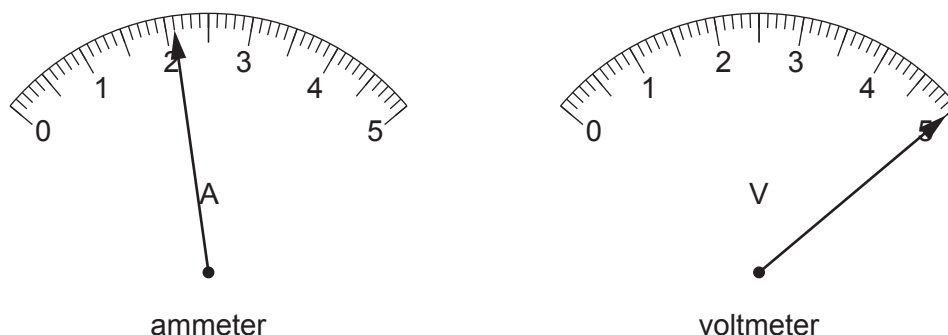


Fig. 4.3

Record the current I in the circuit and also the potential difference V across the coil of wire (heating element).

$$I = \dots\dots\dots \text{ A}$$

$$V = \dots\dots\dots \text{ V}$$

[2]

- (ii) Calculate the electrical energy supplied by the heating element in 30 minutes. Use your values in (d)(i) and the equation shown.

$$\text{electrical energy} = V \times I \times 1800$$

$$\text{electrical energy} = \dots\dots\dots \text{ J [1]}$$

- (e) Calculate the efficiency of the heating element. Use your answers in (c)(ii) and (d)(ii) and the equation shown.

$$\text{efficiency} = \frac{\text{thermal energy}}{\text{electrical energy}} \times 100$$

$$\text{efficiency} = \dots\dots\dots \% [1]$$

- (f) Suggest how the student can change the apparatus to improve the efficiency calculated in (e).

.....

..... [1]

[Total: 13]

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