Cambridge Assessment International Education

Skills for science

Interpreting and evaluating experimental observations and data

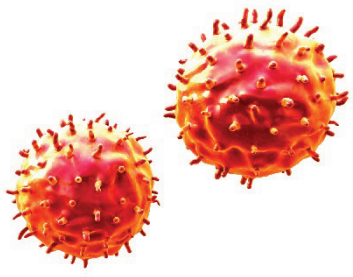
Cambridge IGCSE™

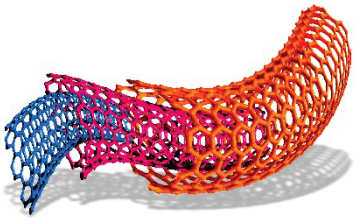
Biology 0610

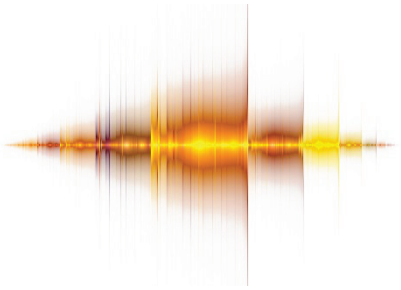
Chemistry 0620

Physics 0625

The activities and worksheets used in this booklet are suitable for use with other IGCSE, IGCSE (9–1) and O Level science syllabuses.







Version 1.0

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Contents

About this document

This document has been designed to help you to develop your learners' interpretation and evaluation skills as defined by assessment objective 3 (AO3) in the science syllabuses.

AO3 Experimental skills and investigations

Candidates should be able to:

- demonstrate knowledge of how to safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate)
- plan experiments and investigations
- make and record observations, measurements and estimates
- interpret and evaluate experimental observations and data
- evaluate methods and suggest possible improvements.

In AO3, learners are expected to be able to plan experiments and investigations. In this document, we will use the term 'experiments', but all of the skills, information and activities also apply to investigations.

The document is divided into **three** main sections:

1. Introduction

This describes the interpretation and evaluation skills required of our science syllabuses. It includes suggested questions that learners should ask themselves whilst examining experimental data. Help with starting classroom discussions on interpretation and evaluation in general terms are also provided.

2. Classroom activities

A set of generic worksheets are provided that can be used to increase learner confidence in interpretation and evaluation skills.

3. Example responses

Planning questions from past papers and the associated mark schemes are provided along with example responses. There is one example for each of the three IGCSE science subjects (Biology, Chemistry and Physics). A middle-level response is annotated with what was done well, what could be improved, and useful terminology. An improved response to the question is then annotated for comparison.

Introduction

Candidates may be required to do the following in either Paper 5 or Paper 6:

- *Interpret and evaluate observations and experimental data.*
- *Plot graphs and/or interpret graphical information.*
- *Complete tables of data, and process data, using a calculator where necessary.*
- *Draw an appropriate conclusion, justifying it by reference to the data and using an appropriate explanation.*

Scientifically, **interpretation** is making sense of the data obtained by an experiment. Interpretation uses several key scientific skills; learners may be asked to **describe** results and **explain** them using scientific knowledge; often, interpretation involves **drawing graphs** to represent data, performing **calculations** or manipulating the data so that it becomes easier to understand and hence form a conclusion.

Evaluation is another key scientific skill whereby a judgement is made about the results obtained from an experiment. Learners may be asked to **justify** their decisions.

Learners should be encouraged to:

- understand the command words **describe, explain, calculate** and **justify**
- draw a graph using data obtained from an experiment
- utilise information presented in graphical form
- utilise basic mathematical skills and scientific formulae to process data accurately.

A well-planned experiment will enable the learners to collect data easily. Learners need to ask themselves the following questions before interpreting and evaluating the data obtained:

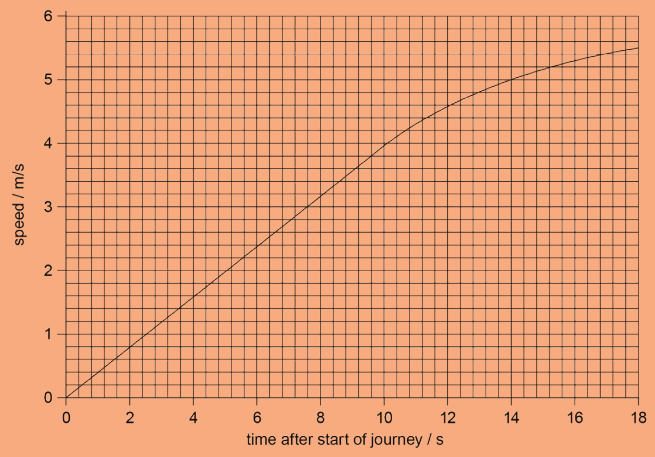
- Can I describe what the data is showing using appropriate scientific language?
- Can I explain what the data is showing using my scientific knowledge and using scientific language?
- Am I able to draw a graph of the data, remembering to include everything needed for my graph to make sense?
- Am I able to perform simple calculations to help with interpreting the data?
- Do the results of my calculations look ‘right’? Are the numbers roughly what I would expect?
- Can I make a personal judgement on the results obtained by an experiment and justify why I have made that decision?

Getting started

Before learners begin an experiment, encourage them to consider their interpretation skills by using the following activities.

Describing skills

Ask learners to form pairs, sitting back-to-back.
One learner has the graph shown below, and the other has a pencil and paper.



The learner with the graph has five minutes to describe it as accurately as possible to their partner.
After five minutes, the learners compare their graphs.
As a class compare the graphs they have drawn and make a list of what words and phrases were useful when describing the graph.

Graph drawing

Get learners to compile a list of 'how-to-draw the perfect graph'.
Compare with other members of the class.

Learners should think about:

- using a pencil and ruler
- which way around the axes go
- labelling axes
- scale
- plotting points
- drawing a line.

Predicting results

Get learners to sketch a graph showing the results they might expect to see for the following experiments. What would they put on each axis? What line (or bars) would they expect to see?

- The viscosity of oil as the temperature increases.
- The surface area of leaves found on trees in shady areas versus sunny areas.
- The distance travelled by an object travelling at a steady speed.

Classroom activities

The following worksheet activities can be used with your learners to help them improve their interpreting and evaluation skills. These worksheets are generic and can be used to develop interpreting and evaluation skills in general, not just for experiments.

- **Worksheet 1:** Match the statements
- **Worksheet 2:** A guide to using scientific language
- **Worksheet 3:** Drawing and using graphs
- **Worksheet 4:** Calculations
- **Worksheet 5:** Interpretation and evaluation scenario – biology
- **Worksheet 6:** Interpretation and evaluation scenario – biology
- **Worksheet 7:** Interpretation and evaluation scenario – chemistry
- **Worksheet 8:** Interpretation and evaluation scenario – chemistry
- **Worksheet 9:** Interpretation and evaluation scenario – physics
- **Worksheet 10:** Interpretation and evaluation scenario – physics

Worksheet 1: Match the statements

The list of statements in column **A** contains common command words used in science interpretation questions. Cut out the statements and stick them into column **A** on page 2 of the worksheet. The list of statements in column **B** are definitions of each of the command words given in column **A**. Cut out the statements and stick them in column **B,** matching them to the command word in column **A**.

The list of statements in column **C** contains examples of when the command words in column **A** might be used. Cut out the statements and stick them in column **C,** matching them to the command word in column **A** and definition in column **B**.

A	**B**	**C**
Describe	Use information in the question as well as a learner's own knowledge and understanding to make a judgement.	Waxy cuticle.
Calculate	Give an approximate value.	A covalent bond is where a shared pair of electrons holds two atoms together.
Explain	Use evidence from the information given to support an answer.	The data obtained was reliable because the experimenter repeated her results 5 times, but to make it more accurate she should have used a pipette instead of a measuring cylinder.
Define	Use given data or information to obtain an answer.	40 °C, because this is the temperature at which the enzyme reached its optimum activity.
Determine	Give the meaning of something.	pH 6.5
Estimate	Say what is seen from a table or graph, giving examples from the data where possible.	The temperature increased from 40 °C to 60 °C for the first 20 min.
Evaluate	Name or state.	Speed = distance / time
Identify	Use numbers given in the question to work out the answer.	Conduction happens in solids because the particles are tightly packed together.
Justify	State the reason for something happening using scientific knowledge and understanding.	2.5–3.1 g

Worksheet 1: Match the statements, continued

Put the command words in column **A** then match the definition for that command word in column **B** and the example in column **C**.

A	B	C

Worksheet 2: A guide to using scientific language

It is important to use the correct language when describing, explaining and evaluating scientific data. Learners need to avoid being 'vague' with language and use examples from the data wherever possible to support their written response.

Here are some set phrases that may be helpful to learners in writing a coherent scientific answer.

Type of question	What the learners need to do	Useful phrases to use		
Describing	Say what is seen from the data and give examples to support the answer.	Increases / increasing Decreases / decreasing Levels out / plateaus Maximum Minimum For example For instance An example of this is We can see this when Such as		
Explaining	Use scientific knowledge and vocabulary to say why something happens.	This... This evidence... This data... These results... This pattern... This trend... This relationship...	...suggests... ...proves... ...implies... ...demonstrates... ...show...	...that... ...the view that... ...the effect of...
Evaluating	Use scientific knowledge and information given in the question to make a judgement.	First... We can see that... It can be argued that... Alternatively ... In contrast...		

Worksheet 3: Drawing and using graphs

Drawing graphs is a key scientific skill, as is interpreting graphs to deduce information.

Below is a checklist for drawing graphs from experimental data. Also included is information on how to use graphs to extract information.

Drawing graphs

Always use a pencil and ruler to draw a graph. Axis labels may be written in pen, if preferred.

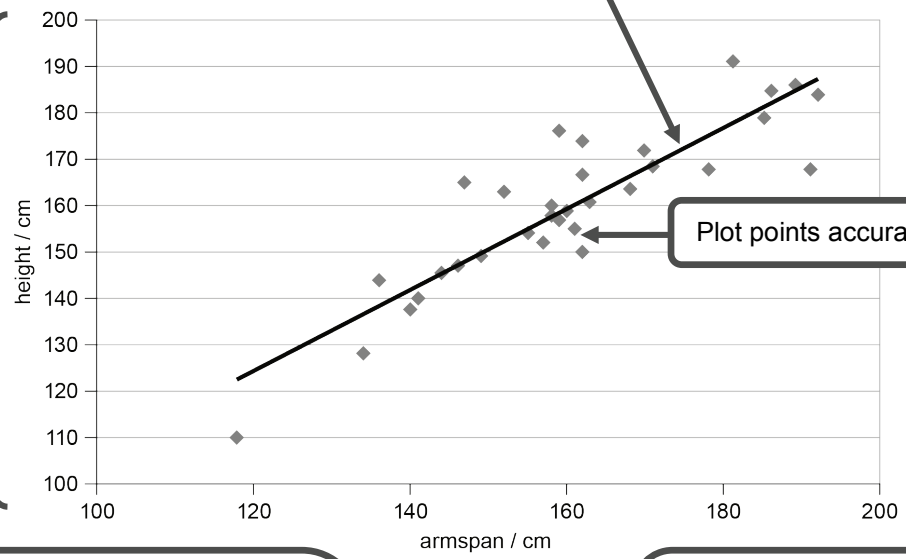
Bar chart or line graph?

As a rule, if both axes are numbers, then draw a **LINE GRAPH**.

If one axis is a number and the other one is words, then draw a **BAR CHART**.

Label the ***y*-axis** with your **dependent variable** (the thing that is measured in the experiment) – this is often column two of the results table. Give the units.

Line of best fit: equal number of points above and below the line.



Plot points accurately and correctly.

Scale:

- Values should increase by the same amount each time.
- Values should be separated by the same number of squares on the paper.
- Axes should fill over half the page.

Label the ***x*-axis** with the **independent variable** (the thing that is changed in the experiment) – this is often column 1 of the results table. Give the units.

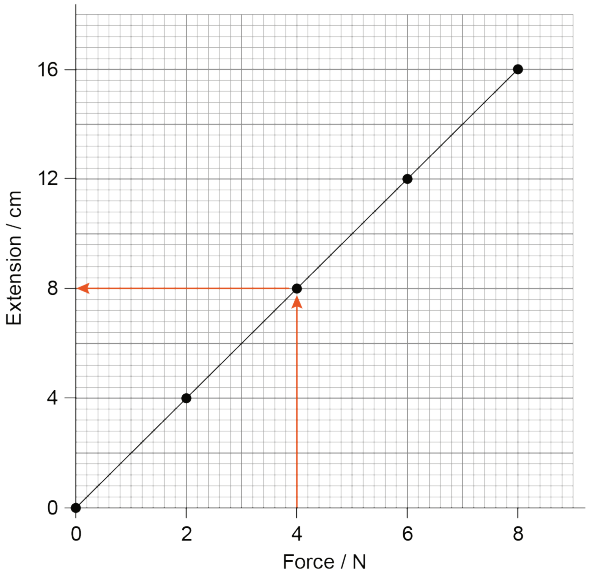
Worksheet 3: Drawing and using graphs, continued

Using graphs

1. Determining an unknown value

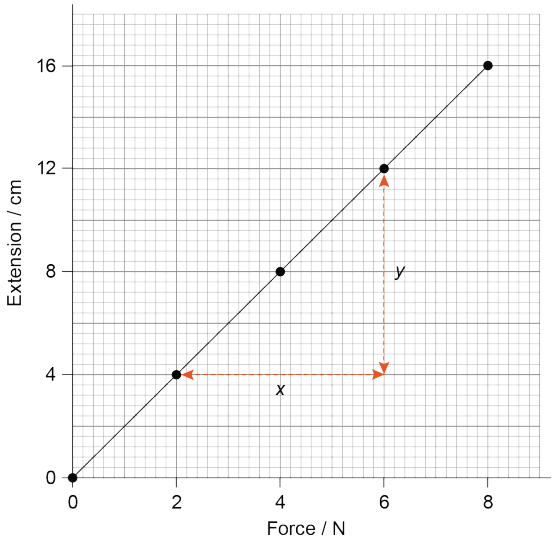
- Draw a vertical line using a ruler from the value on *x*-axis to the line on the graph
- Draw a horizontal line from the point at which the vertical line meets the line on the graph towards the *y*-axis.
- Read the scale on the *y*-axis at the point at which the horizontal line touches it. This is your unknown value.

Example: What is the extension of a spring if the force is 5N?
Drawing a vertical line up from 5N to where it meets the line, and then a horizontal line out to the y-axis gives a value of ***10cm***



2. Calculating the gradient

- Choose any two points on the line (for simplicity, try and choose points that fall along the squares of the graph paper to aid reading the values off the axes).
- Draw a right-angled triangle using the line of the graph as the hypotenuse.
- Use the scale on the *x*-axis to find the triangle's horizontal length.
- Use the scale on the *y*-axis to find the triangle's vertical length.
- Work out the gradient of the line by:



$$\text{gradient} = \frac{\text{vertical length } (y)}{\text{horizontal length } (x)}$$

Example: What is the gradient of line in the graph shown?

$$\text{gradient} = \frac{\text{vertical length } (y)}{\text{horizontal length } (x)} = \frac{8}{4} = \mathbf{0.5}$$

Worksheet 4: Calculations

You may be asked to perform simple mathematical calculations to process and interpret the data from an experiment.

In particular, you need to be competent in calculating / identifying the following:

- **Mean**: add the numbers together and divide by the total number of values.
- **Median**: the exact middle value. Put the numbers in order of size first. The median may lie in between 2 numbers.
- **Mode**: the value that occurs the most frequently in a set of data.
- **Range**: the spread of the values, i.e. the lowest value subtracted from the highest value.
- **Anomaly**: a value that does not follow the trend.

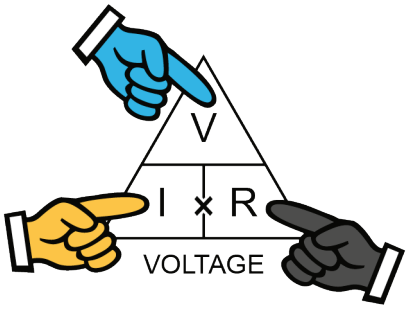
For each of the following sets of numbers:

1. crcle the anomaly
2. calculate the mean, median, mode and range **ignoring the anomaly**.

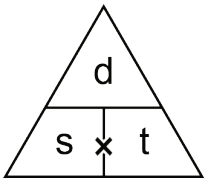
	Mean	Median	Mode	Range
2, 4, 4, 5, 7, 8, 14				
1.1, 2.4, 1.3, 1.4, 1.5, 1.2, 1.5, 1.6, 1.5				
43, 39, 45, 23, 48, 51, 48, 54, 42, 49				
17.1, 19.3, 19.4, 18.6, 28.2, 17.9				
110.1, 111.3, 109.7, 109.6, 114.2, 110.4, 110.8, 111.3				

Formula triangles

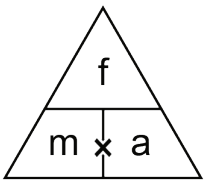
Formula triangles make recall and application of scientific formulae easier for learners. To use a formula triangle, cover with your finger what you want to find out. Commonly used formula triangles include:



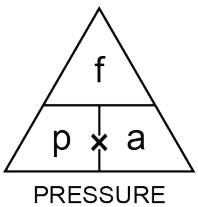
Voltage = Current × Resistance



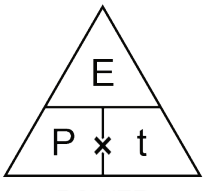
$\text{speed} = \frac{\text{distance}}{\text{time}}$



force = mass × acceleration



$\text{pressure} = \frac{\text{force}}{\text{area}}$



$\text{power} = \frac{\text{energy}}{\text{time}}$

Worksheet 5: Interpretation and evaluation scenario – biology

A group of students investigated the effect of two different exercises on the heart rate of ten male and ten female students.

Before the first exercise, the pulse rate at rest was measured and the group then jumped on the same spot for two minutes without moving their arms. Every two seconds an investigator shouted jump.

After two minutes the pulse rate was measured and the students were allowed ten minutes to rest.

Before the second exercise, the pulse rate at rest was measured again and the group was asked to do a different exercise.

The students jumped on the same spot for two minutes lifting their arms above their head as they jumped up and dropping their arms as they came down. Every two seconds an investigator shouted 'jump'.

Table 2.1 shows the results of this investigation.

Table 2.1

activity	average pulse rate / beats per minute		
	male students	female students	all students
resting	68	74	71
after jumping	96	92	
after jumping and moving arms	128	140	

Complete Table 2.1 by writing in the average pulse rate for all students after both forms of exercise.

Plot a bar chart of the data in Table 2.1, for both the male students and the female students

Worksheet 5: Interpretation and evaluation scenario (biology) – continued

State **one** similarity and **one** difference the effect of exercise has on males and females.

similarity .....

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difference .....

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Worksheet 6: Interpretation and evaluation scenario – biology

The table below shows the protein content of five foods.

Food	Protein content of food / g per 100 g
maize	3.2
rice	7.1
potato	2.0
yam	1.5
sorghum	11.3

(1) Plot a graph of the data shown in the table.

(2) It is recommended that a six-year-old child eats 20 g of protein a day.

Calculate the mass of sorghum a six-year-old child must eat each day to obtain 20 g of protein.

Show your working.

Give your answer to the nearest whole number.

Worksheet 7: Interpretation and evaluation scenario – chemistry

A learner investigated what happens when dilute hydrochloric acid and copper(II) sulfate solution react with different metals.

Five experiments were carried out:

Experiment 1:
A measuring cylinder was used to pour 10 cm^3 of dilute hydrochloric acid into a boiling tube.
The temperature of the hydrochloric acid was measured.
1 g of zinc was added to the boiling tube and the mixture stirred with a thermometer.
The maximum temperature reached by the mixture was measured.

Experiment 2:
Experiment 1 was repeated using 1 g of iron instead of zinc.

Experiment 3:
Experiment 1 was repeated using 1 g of magnesium instead of zinc.

Experiment 4:
A measuring cylinder was used to pour 10 cm^3 of copper(II) sulfate solution into a boiling tube.
The temperature of the solution was measured.
1 g of magnesium was added to the boiling tube and the mixture stirred with a thermometer.
The maximum temperature reached by the mixture was measured.

Experiment 5:
Experiment 4 was repeated using 1 g of iron instead of magnesium.
The observation was recorded below:

The solution turned colourless and a brown deposit formed.

Here are the results of the experiments:

Experiment	Initial temperature / °C	Final temperature / °C	Temperature rise / °C
1	22	25	3
2	21	23	2
3	24	61	37
4	21	46	15
5	24	29	5

Worksheet 7: Interpretation and evaluation scenario – chemistry, continued

(1) Draw a bar chart showing the results of experiments 1–5.

(2) Which experiment, **1**, **2** or **3**, produced the largest temperature rise?
Suggest why this experiment produced the largest temperature rise.

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(3) Explain the observation in experiment **5**.

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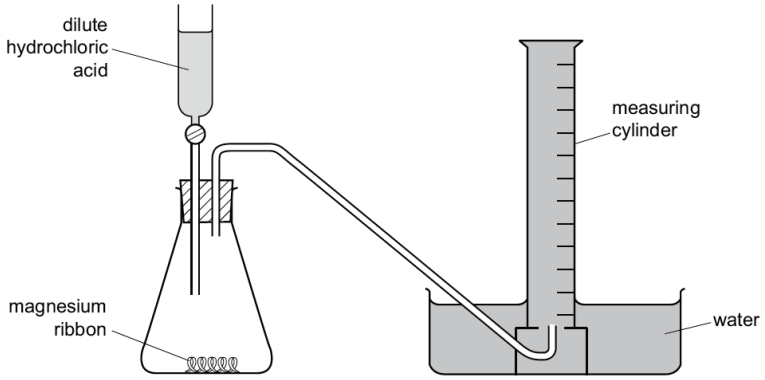
Worksheet 8: Interpretation and evaluation scenario – chemistry

A learner investigated the rate of reaction between dilute hydrochloric acid and excess magnesium at room temperature, using the following apparatus.



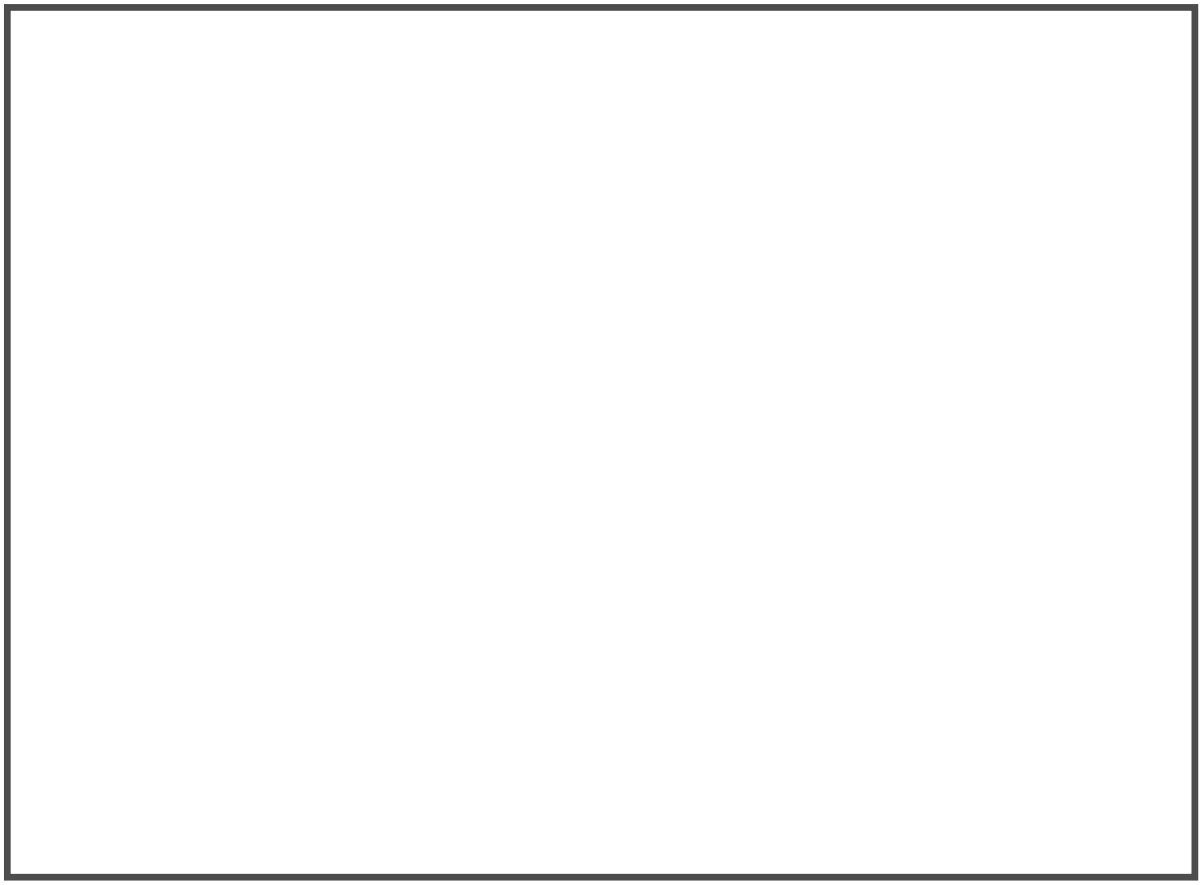
30 cm^3 of dilute hydrochloric acid was added to the conical flask containing magnesium ribbon. The timer was started and the volume of gas collected in the measuring cylinder was measured every 20 s for 180 s (3 min).

The results of this experiment are shown in the table below.

Time / s	Total volume of gas collected / cm^3
0	30
20	44
40	57
60	62
80	78
100	86
120	88
140	89
160	90
180	90

Worksheet 8: Interpretation and evaluation scenario – chemistry, continued

(1) Draw a smooth line graph showing the results in the table.



(2) Which result is anomalous? Suggest a reason for this anomalous result.

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(3) Use the graph to deduce the total amount of gas you would have expected to collect instead of this anomalous volume. Show on the graph how you worked out your answer.

(4) Explain why the total volume of gas collected does not increase after 160 seconds.

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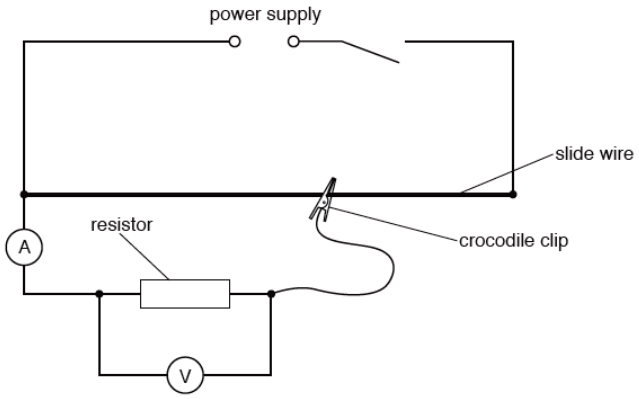
Worksheet 9: Interpretation and evaluation scenario – physics

Some learners are investigating the relationship between potential difference and current for a resistor. They are using the circuit shown below:



The crocodile clip is attached at various points along the slide wire, and the current and potential difference for the resistor were measured. The readings for potential difference *V and* current *I* for various positions of the crocodile clip are shown in the table below:

V **/ V**	***I*** **/ A**
0.4	0.08
0.8	0.17
1.2	0.25
1.6	0.34
2.0	0.41

Worksheet 9: Interpretation and evaluation scenario – physics, continued

(1) Plot a graph of V / V (y-axis) against I / A (x-axis).

(2) Determine the gradient of the graph, *G,* showing clearly how you obtained the necessary information.

(3) The resistance value *R* of the resistor is numerically equal to *G.* Give a value for *R*, to a suitable number of significant figures for this experiment. Include units.

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(4) A learner suggests that potential difference and current for this resistor should be proportional. State whether your graph supports this suggestion. Justify your statement by reference to your graph.

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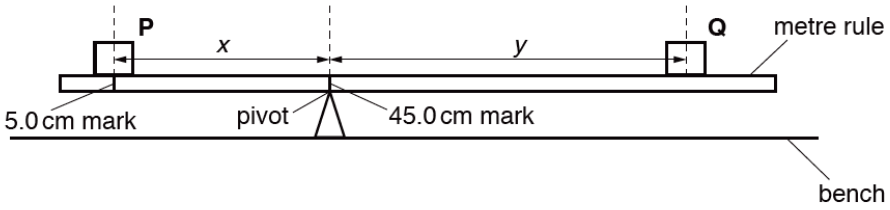
Worksheet 10: Interpretation and evaluation scenario – physics

A learner is determining the weight of a metre rule using a balancing method.

The apparatus is shown below:



The learner places load **P** on the metre rule at the 5.0 cm mark.

She places the metre rule on the pivot at the 45.0 cm mark.

She places load **Q** on the rule and adjusts its position so that the metre rule is a near as possible to being balanced.

She measures the distance *x* between the centre of load **P** and the pivot and the distance *y* from the centre of load **Q** and the pivot.

She repeats the procedure, placing load **P** at the 10.0 cm mark, at the 15.0 cm mark, at the 20.0 cm mark and at the 25.0 cm mark. The readings are shown in the table below:

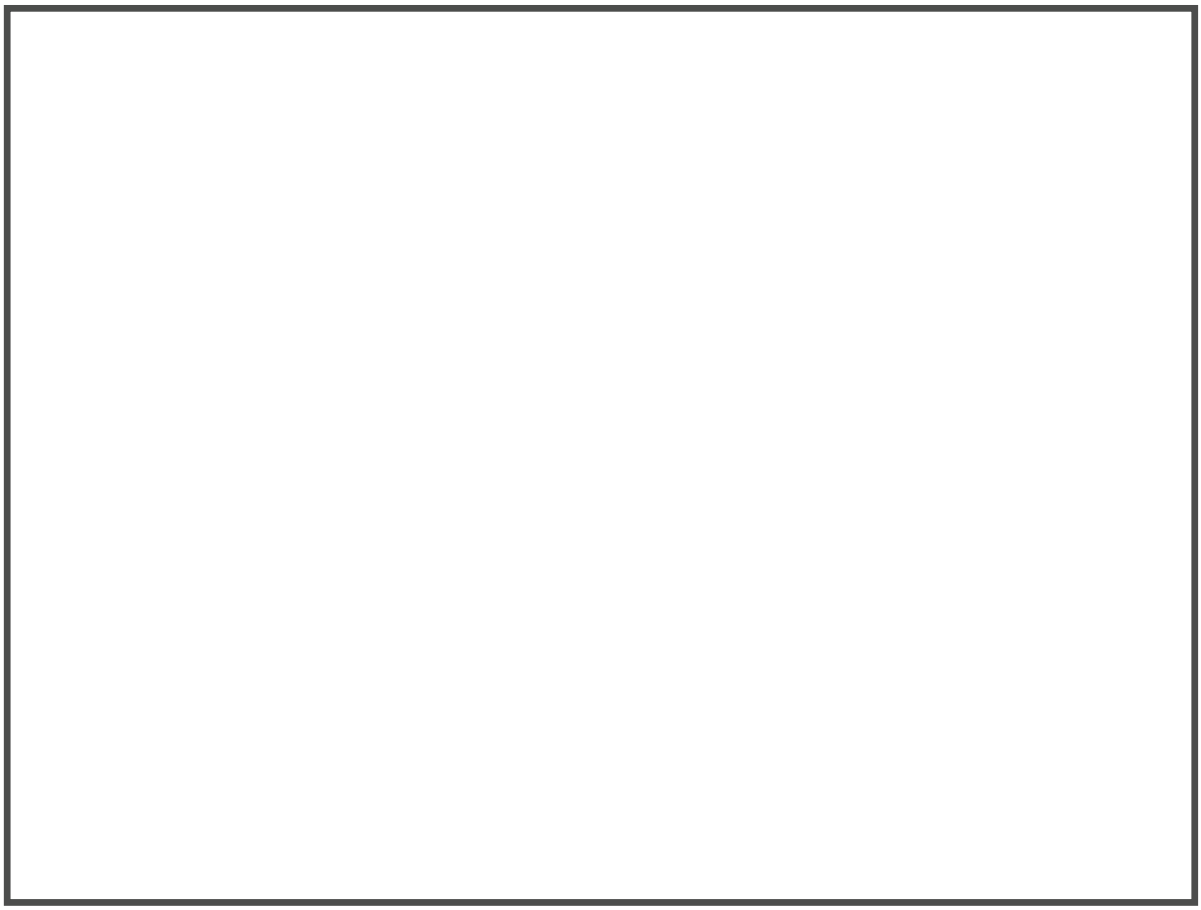
***x* / cm**	***y* / cm**	***A* / N cm**	***B* / N cm**
40.0	42.5		
35.0	36.0		
30.0	30.0		
25.0	24.0		
20.0	17.5.		

(1) For each value of *x,* calculate $A = Px$, where $P = 1.00$ N. Record the values in the table. *P* is the weight of load **P.**

(2) For each value of *y,* calculate $B = Qy$, where $Q = 0.80$ N. Record the values in the table. *Q* is the weight of load **Q.**

Worksheet 10: Interpretation and evaluation scenario – physics, continued

(3) Plot a graph of *A* / N cm (*y*-axis) against *B* / N cm (*x*-axis).



(4) Using the graph, determine the vertical intercept *Y* (the value of *A* when *B* = 0 N cm).
Show clearly on the graph how you obtained this value.

(5) Calculate the weight *W* of the metre rule using the equation

$W = \frac{Y}{z}$, where *z* = 5.0 cm.

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(6) The learner uses an accurate electronic balance to obtain a second value for the weight of the metre rule. Weight obtained on the balance = 1.24 N.
State and explain whether the two values for the weight agree within the limits of experimental accuracy.

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Example responses

This section includes a past paper question for each of the sciences. Example responses are shown with information on how the answers could be improved. Useful terminology and examples of improves answers are included to show how learner responses could be developed.

Interpretation and evaluation question – biology

In this question, learners are asked to interpret data collected from a study on alcohol and reaction times. They are asked to calculate the mean from given data, and plot an appropriate graph. Finally, they are asked to look at the data and state the range. Understanding of the terms 'mean' and 'range' are essential for success in this question, as are competent graph-drawing skills.

(f) In an investigation into the effects of alcohol on the nervous system, people were asked to carry out a test on their reaction time.

The person being tested looked at a coloured block on a computer screen.
As soon as the colour changed they pressed a button.
The time taken to press the button was recorded by the computer.
This was their reaction time.

Twenty people were tested before and after consuming a drink containing the same concentration of alcohol.

Table 1.2 shows the results of this investigation.

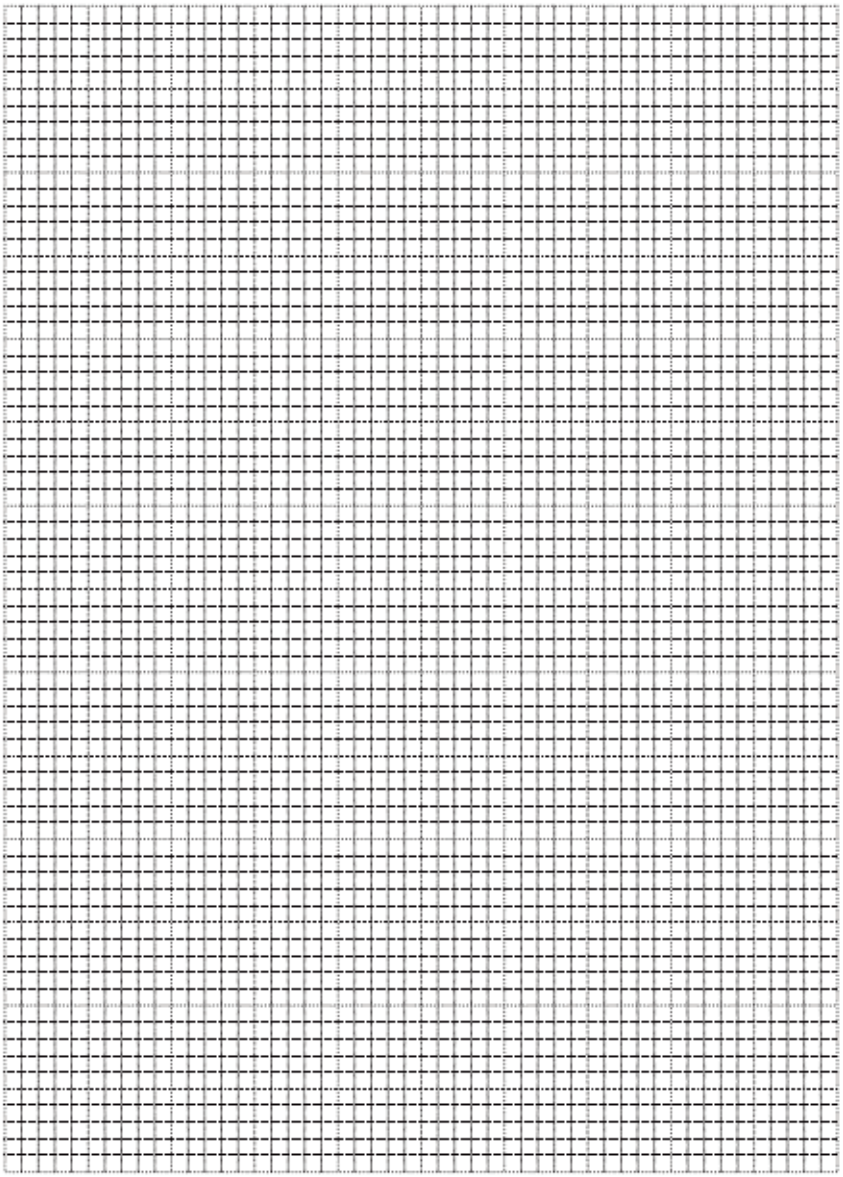
Table 1.2

test person	reaction time before consuming alcohol / milliseconds	reaction time after consuming alcohol / milliseconds
1	272	322
2	310	350
3	225	270
4	243	290
5	240	308
6	264	315
7	201	238
8	262	300
9	225	252
10	235	278
11	225	253
12	247	271
13	226	266
14	194	220
15	206	239
16	309	340
17	223	261
18	243	286
19	270	316
20	180	225
mean	240	

(i) Calculate the mean for the reaction time after consuming alcohol.

Write your answer in Table 1.2.

(ii) Plot a bar chart to show the **mean** reaction time of the people tested before and after consuming alcohol.



[3]

(iii) The range of reaction times recorded before consuming alcohol is 180–310 milliseconds.

Use Table 1.2 to identify the range of reaction times recorded after consuming alcohol.

..... milliseconds [1]

The mark scheme for this question is as follows:

Question	Mark scheme	Mark	Guidance
1 (f) (i)	280	[1]	
(ii)	**A** axes labelled; even scale; **P** **both** plots accurate ± ½ small square **C** columns not touching; of same width; columns at least half the grid on *y*-axis	[3]	*y*-axis: (mean) reaction time / ms *x*-axis: before drinking alcohol and after drinking alcohol / before and after / key given *x*-axis labels under each bar
(iii)	220–350 (milliseconds);	[1]	

Example response

This response would achieve the full mark. The learner clearly understands how to calculate the mean and has done so correctly.

(i) Calculate the mean for the reaction time after consuming alcohol.

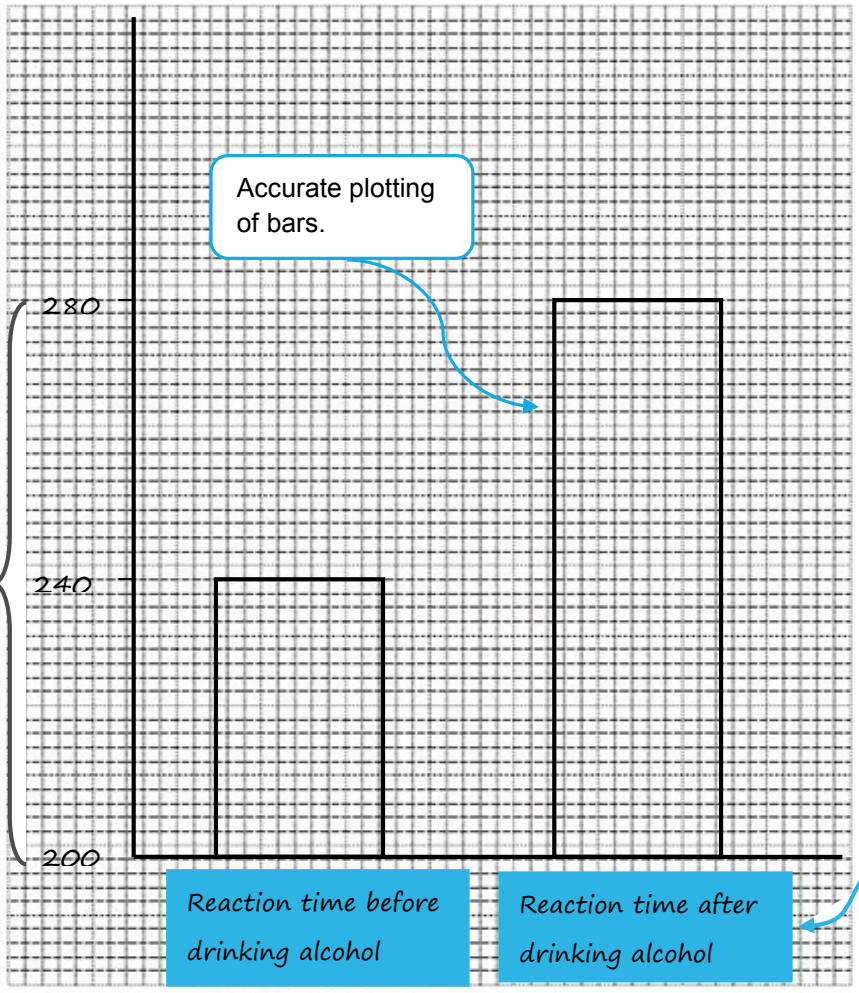
Write your answer in Table 1.2.

16	309	340
17	223	261
18	243	286
19	270	316
20	180	225
mean	240	280

Mean calculated correctly.

For drawing the graph, the candidate received 2 out of 3 marks. The *x*-axis was labelled correctly and the bars drawn were accurately plotted, of equal width and not touching. However, the *y*-axis scale was inaccurate and the labels absent.

(ii) Plot a bar chart to show the **mean** reaction time of the people tested before and after consuming alcohol.



y-axis scale is inaccurate and is not labelled.

Columns are of equal width and labelled correctly.

For the final part of the question, the candidate clearly understood the meaning of the term 'range' and gained a mark for identifying this from the data.

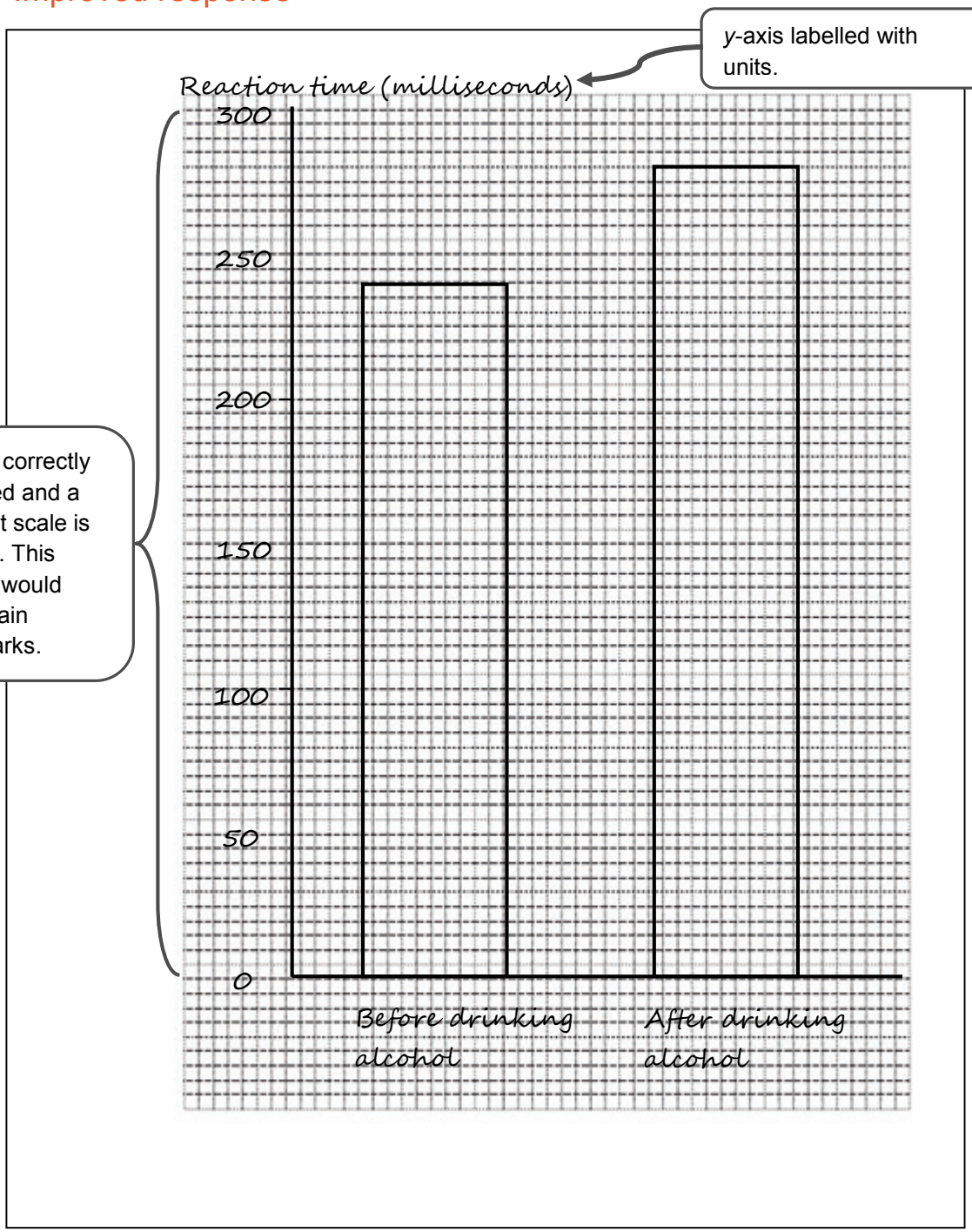
(iii) The range of reaction times recorded before consuming alcohol is 180–310 milliseconds.

Use Table 1.2 to identify the range of reaction times recorded after consuming alcohol.

220 - 350 ..... milliseconds [1]

Smallest and largest values identified from the data to give the range.

Improved response



y-axis labelled with units.

y-axis correctly labelled and a correct scale is drawn. This graph would now gain full marks.

Interpretation and evaluation question – chemistry

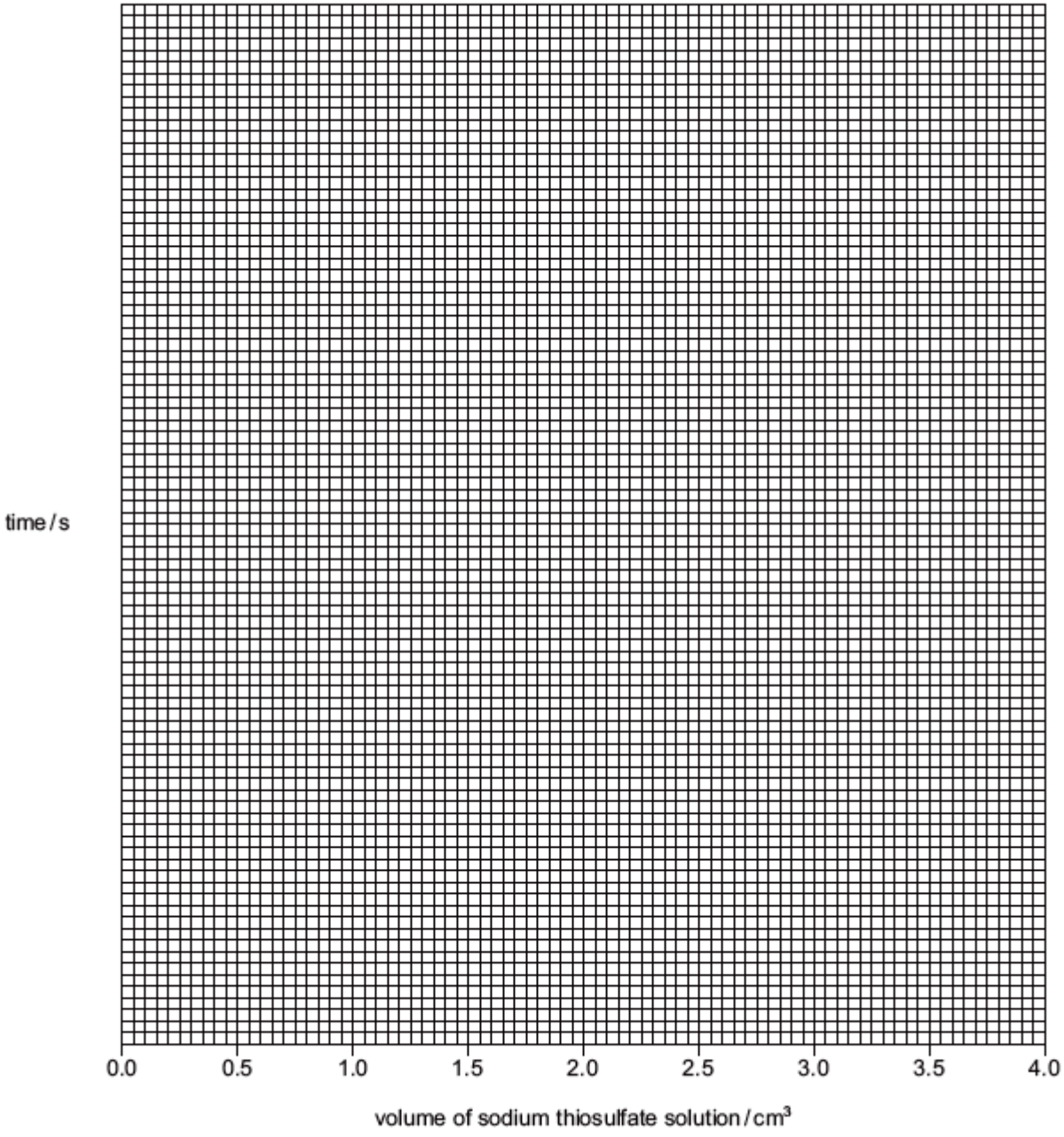
In this question learners are asked to look at an experiment that measures the rate of reaction by timing how long it takes for the colour of a solution to change from colourless to blue. They are asked to plot these data on a graph and draw a line of best fit. They then have to use the line of best fit to determine an unknown value. Learners need to be competent at graph drawing to succeed at this question. They also need to demonstrate their understanding of rates of reaction by sketching on the graph a line they might expect at a different temperature.

2 A student investigated the rate of reaction between hydrogen peroxide and aqueous potassium iodide. When these chemicals react they form iodine. Sodium thiosulfate solution reacts with iodine and can be used to show how fast the reaction proceeds.

(a) A burette was filled up to the 0.0 cm^3 mark with sodium thiosulfate solution.
Using a large measuring cylinder, 100 cm^3 of distilled water were poured into a conical flask.
Using a small measuring cylinder, 6 cm^3 of sulfuric acid, 1 cm^3 of starch solution and 4 cm^3 of aqueous potassium iodide were added to the flask.
0.5 cm^3 of sodium thiosulfate solution was added from the burette to the mixture in the flask and swirled to mix.
The reaction was then started by adding 3 cm^3 of hydrogen peroxide solution to the mixture, and the timer started.
The time taken for a blue colour to appear was noted.
A further 0.5 cm^3 of sodium thiosulfate solution was added to the mixture in the conical flask, swirled and the blue colour disappeared. The time when the blue colour reappeared was noted.
The experiment continued by adding further 0.5 cm^3 portions of sodium thiosulfate solution until a total of 3.0 cm^3 of sodium thiosulfate solution had been added, noting the times at which the blue colour reappeared.

Total volume of sodium thiosulfate solution added / cm^3	Time at which blue colour appeared / s
0.5	22
1	43
1.5	64
2	86
2.5	105
3	126

(b) Plot the results you have obtained on the grid and draw a best-fit straight-line graph.



[5]

(c) (i) **From your graph** deduce the time at which the blue colour would appear if a total of 4.0 cm^3 of sodium thiosulfate solution were added to the mixture in the conical flask. Show clearly **on the grid** how you worked out your answer.

..... [3]

(ii) Sketch **on the grid** the graph you would expect if the experiment was repeated at a higher temperature. [1]

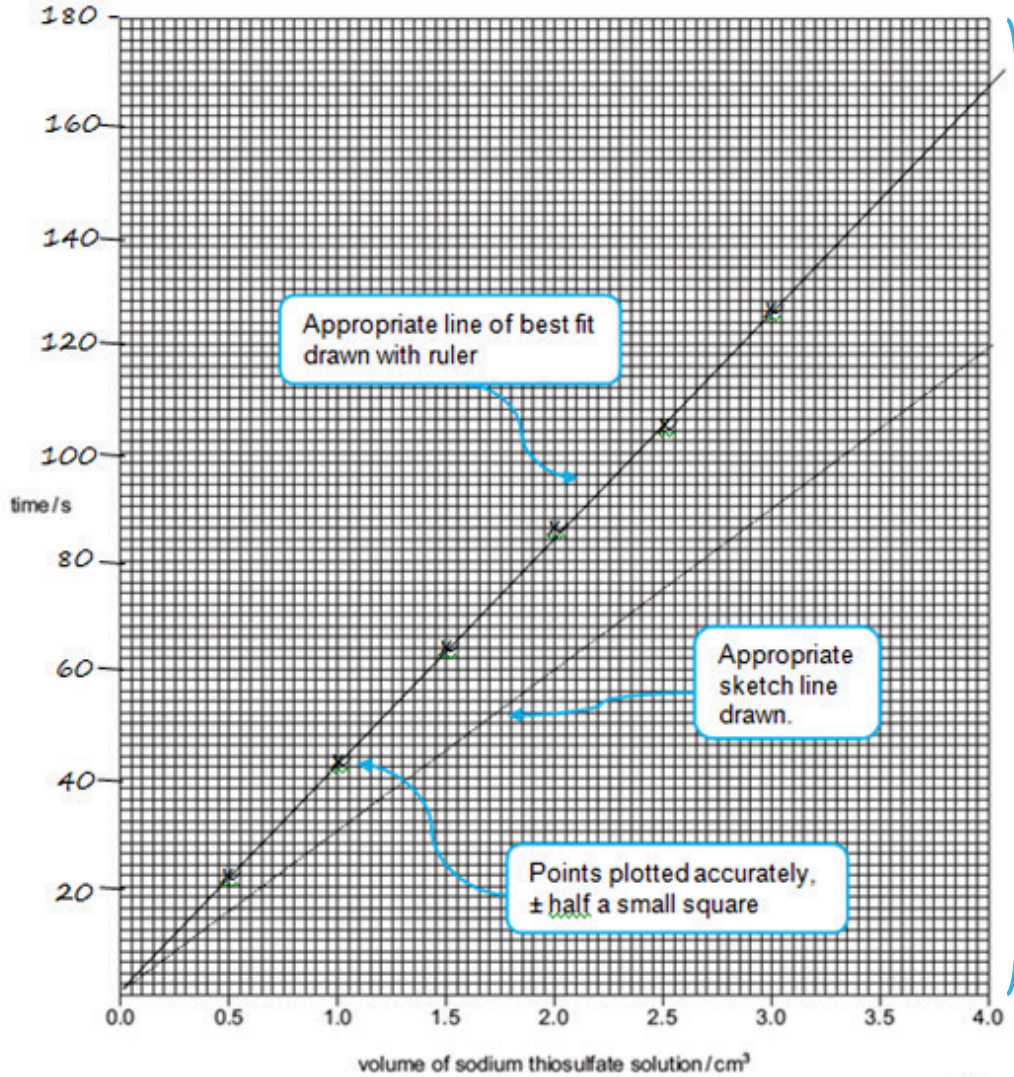
The mark scheme for this question is as follows:

Question	Mark scheme	Mark
2 (b)	Appropriate scale for y-axis / increasing at 20 s per large square; y-axis is a linear scale; all 6 points plotted correctly ± half a small square (2 marks); 5 points plotted correctly ± half a small square (1 mark); Best-fit straight-line graph;	1 1 2 1 [5]
(c)(i)	Value from graph ± half a small square (typically 167 – 170); Units / s; Extrapolation;	1 1 1 [3]
(c)(ii)	Sketch line below original line and diverging;	1

Example response

This is a mid-level response. The candidate has drawn an accurate graph, for which they receive full marks. They have used the graph to determine an unknown time correctly, however they have lacked attention to detail by not reading a value correctly from the y-axis, failing to include units or showing their working line on the grid, as instructed in the question.

(b) Plot the results you have obtained on the grid and draw a best-fit straight-line graph.



[5]

By plotting the points accurately and drawing a line of best fit, the candidate has gained the full 5 marks.

(c) (i) From your graph deduce the time at which the blue colour would appear if a total of 4.0 cm³ of sodium thiosulfate solution were added to the mixture in the conical flask. Show clearly on the grid how you worked out your answer.

163 [3]

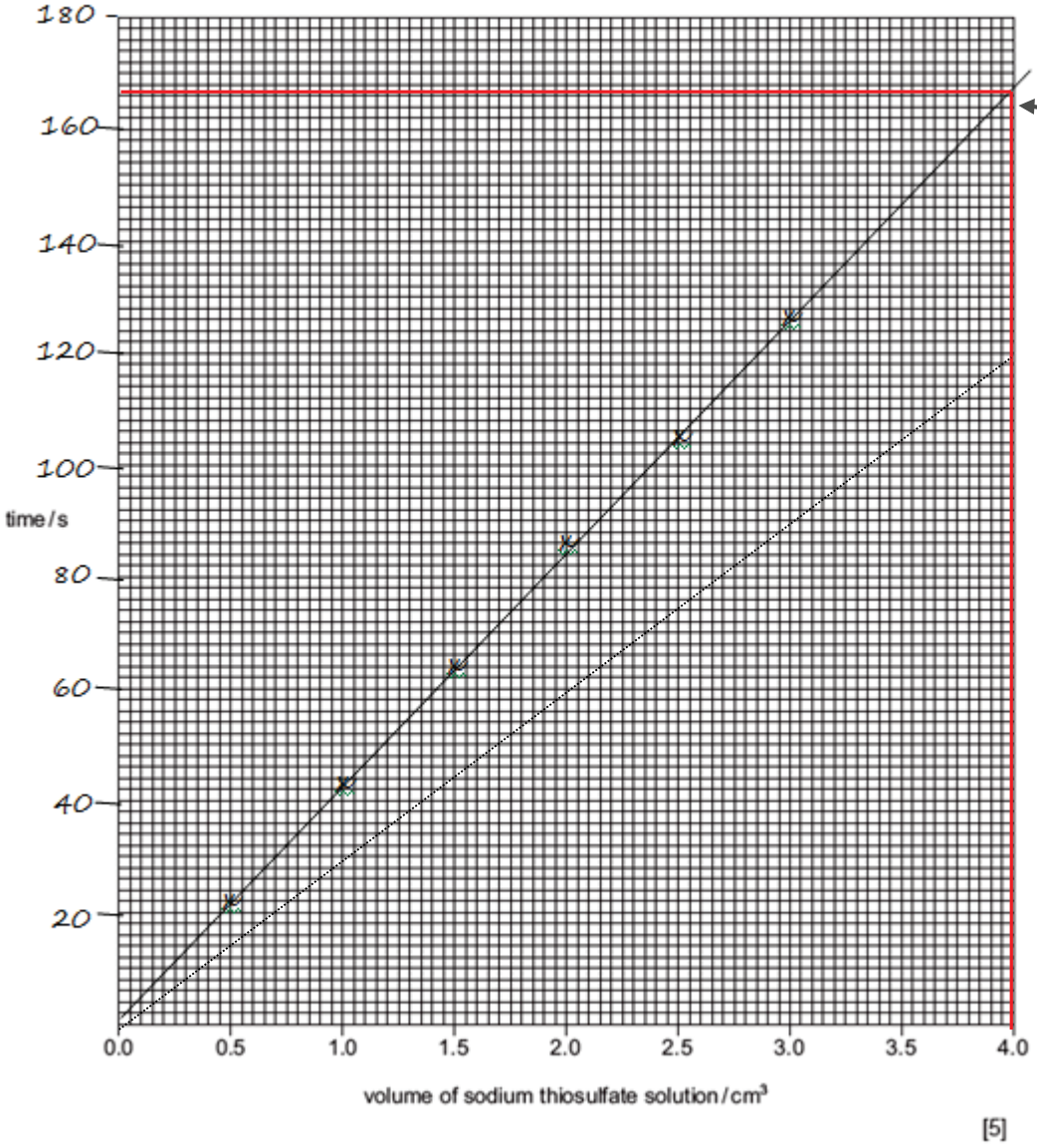
Value given is incorrect – it appears the candidate has misread the scale. Also, units are absent, as are marks on the grid to show how the answer is derived

(ii) Sketch on the grid the graph you would expect if the experiment was repeated at a higher temperature. [1]

Full marks given for identifying that the rate of reaction would happen quicker.

Improved response

(b) Plot the results you have obtained on the grid and draw a best-fit straight-line graph.



[5]

Marks on grid show how the learner arrived at the answer

Full marks are given as units are included and marks are present on the grid showing working out.

(c) (i) **From your graph** deduce the time at which the blue colour would appear if a total of 4.0 cm³ of sodium thiosulfate solution were added to the mixture in the conical flask. Show clearly **on the grid** how you worked out your answer.

167 seconds ..... [3]

Value has been correctly read from y-axis; units are now included.

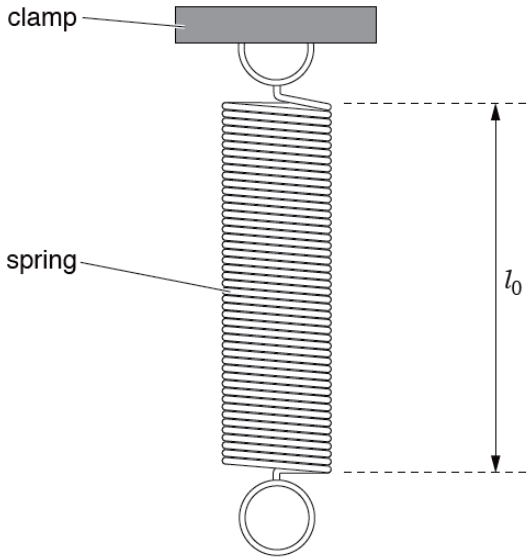
Sketch **on the grid** the graph you would expect if the experiment was repeated at a higher temperature. [1]

Interpretation and evaluation question – physics

In this question learners are asked to interpret data obtained from an experiment investigating the stretching of a spring. In addition to calculating the extension when increasing loads are added to the spring, learners have to plot a graph of the data and use the graph to predict an unknown value. To do well at this question, candidates need to be competent at drawing a graph and understand how to use the line of best fit to determine an unknown quantity.

1 A student is investigating the stretching of a spring.

The apparatus is shown in Fig. 1.1.



(a) On Fig. 1.1, measure the unstretched length l_0 of the spring. Record l_0 in the first row of Table 1.1. [1]

(b) The student hangs a load L of 1.0 N on the spring and measures the new length l of the spring. She repeats the measurements using loads of 2.0 N, 3.0 N, 4.0 N and 5.0 N. The readings are shown in Table 1.1.

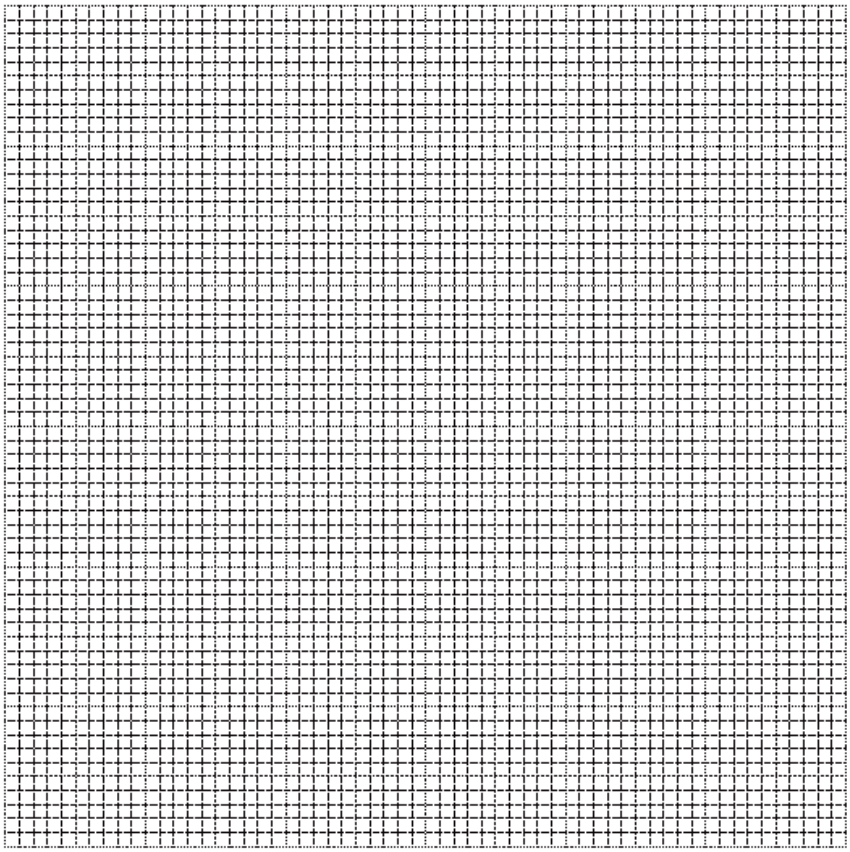
(i) For each set of readings, calculate the extension e of the spring using the equation $e = (l - l_0)$. Record the values of e in the table.

Table 1.1

L/N	l/mm	e/mm
0.0		0
1.0	59	
2.0	64	
3.0	69	
4.0	74	
5.0	78	

[1]

(c) Plot a graph of e/mm (y-axis) against L/N (x-axis).



[4]

(d) The student removes the load from the spring and hangs an unknown load **X** on the spring. She measures the length l of the spring.

l = 72 mm

(i) Calculate the extension e of the spring.

e = ... [1]

(ii) Use the graph to determine the weight W of the load **X**. Show clearly on the graph how you obtained the necessary information.

W = ... [2]

The mark scheme for this question is as follows:

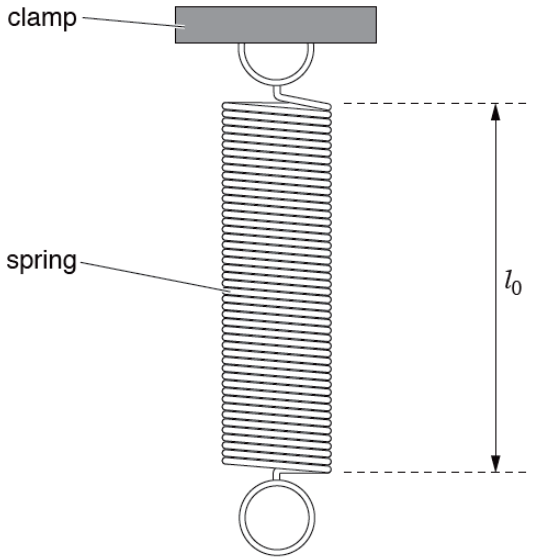
Question	Mark scheme	Mark
1 (a)	55 mm (correct answer only)	1
(b)(i)	4, 9, 14, 19, 23 (error carried forward from part (a))	1
(c)	Graph: Axes labelled correctly; Suitable scales; All plots correct to ½ small square; Good line judgement – thin continuous line, neat plots;	 1 1 1 1
(d)(i)	*e* = 17 (mm) (error carried forward from part (a))	1
(d)(ii)	Method clearly shown on graph *W* value 3.5-3.75; Unit N needed; (error not carried forward from (i))	1 1

Example response

This response gained 6 out of a possible 9 marks. The learner has demonstrated that they can use simple formulae to complete a data table. They are also competent at drawing a graph accurately. However, they failed to draw a line of best fit and did not understand how to use the line of best fit to find an unknown value.

1 A student is investigating the stretching of a spring.

The apparatus is shown in Fig. 1.1.



(a) On Fig. 1.1, measure the unstretched length l_0 of the spring. Record l_0 in the first row of Table 1.1. [1]

(b) The student hangs a load L of 1.0 N on the spring and measures the new length l of the spring. She repeats the measurements using loads of 2.0 N, 3.0 N, 4.0 N and 5.0 N. The readings are shown in Table 1.1.

(i) For each set of readings, calculate the extension e of the spring using the equation $e = (l - l_0)$. Record the values of e in the table.

l_0 correctly measured and recorded.

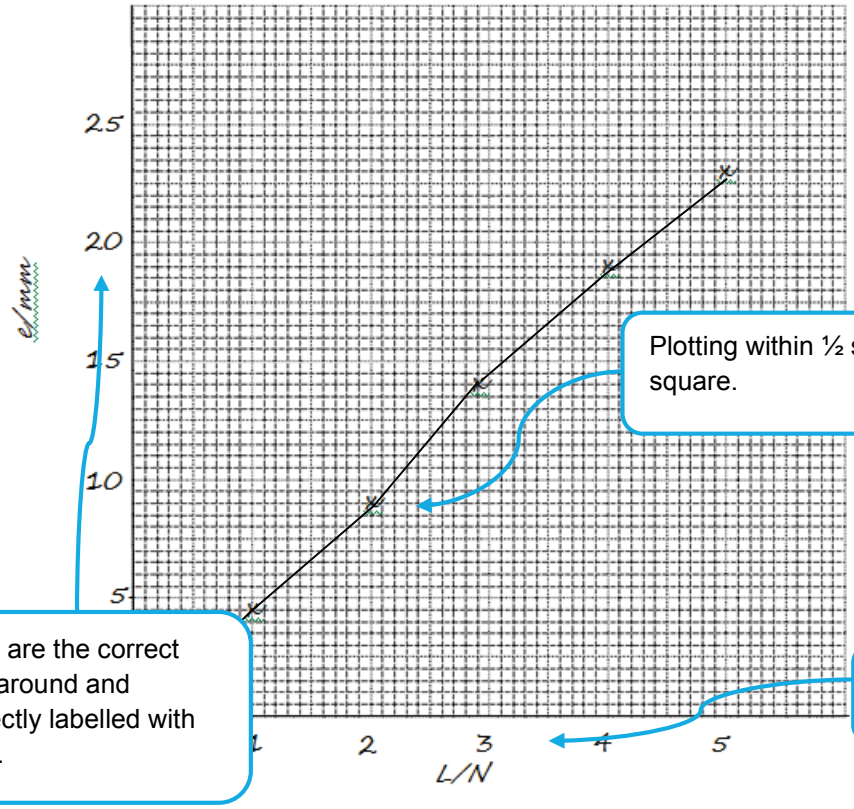
Table 1.1

L/N	l/mm	e/mm
0.0	55	0
1.0	59	4
2.0	64	9
3.0	69	14
4.0	74	19
5.0	78	23

All values calculated correctly by subtracting l from the starting length l_0.

[1]

(c) Plot a graph of e/mm (y-axis) against L/N (x-axis).



The graph is plotted accurately. However, the points have been joined together instead of a line of best fit being drawn.

Plotting within ½ small square.

Axes are the correct way around and correctly labelled with units.

Scale is suitable and accurate.

(d) The student removes the load from the spring and hangs an unknown load **X** on the spring. She measures the length l of the spring.

l = 72mm

(i) Calculate the extension e of the spring.

e = 17mm [1]

(ii) Use the graph to determine the weight W of the load **X**. Show clearly on the graph how you obtained the necessary information.

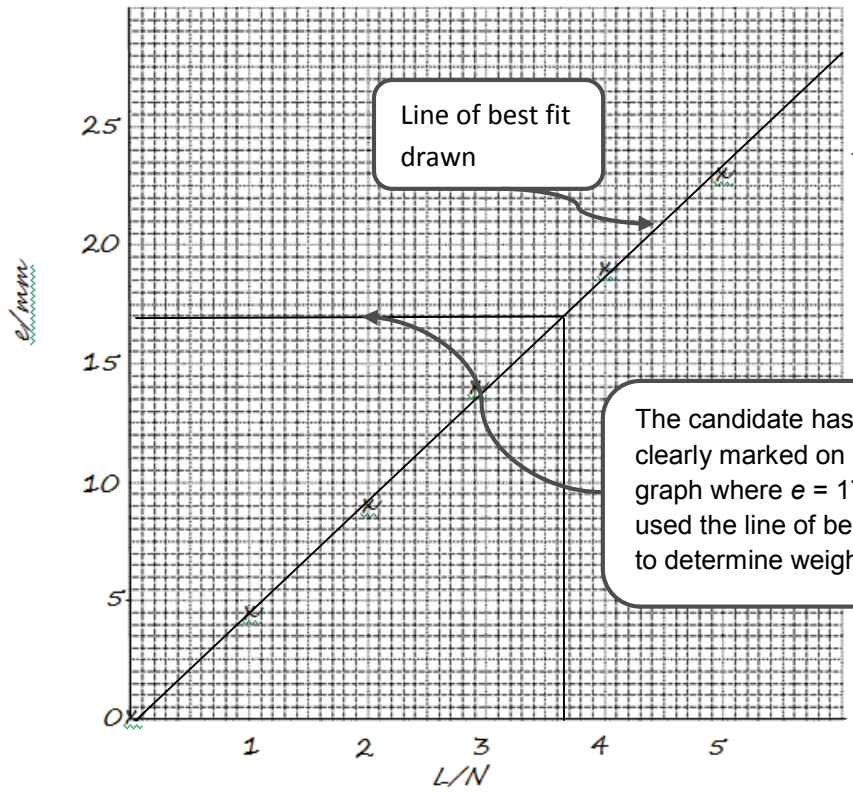
W = 14.6N [2]

Extension calculated correctly by subtracting l_0 (55 mm) from 72 mm.

The candidate has not taken a reading from the graph where e = 17. No marks given.

Improved response

(c) Plot a graph of e/mm (y-axis) against L/N (x-axis).



Graph plotted accurately and appropriate line of best fit drawn. Full marks given.

Line of best fit drawn

The candidate has clearly marked on graph where e = 17 and used the line of best fit to determine weight W.

(d) The student removes the load from the spring and hangs an unknown load **X** on the spring. She measures the length l of the spring.

l = 72mm

(i) Calculate the extension e of the spring.

e = 17mm [1]

(ii) Use the graph to determine the weight W of the load **X**. Show clearly on the graph how you obtained the necessary information.

W = 3.65N [2]

Line of best fit used to determine weight W. Full marks given.

Worksheet 1: suggested answers

A	B	C
Describe	Say what is seen from a table or graph, giving examples from the data where possible.	The temperature increased from 40 °C to 60 °C for the first 20 min.
Calculate	Use numbers given in the question to work out the answer.	Speed = distance / time
Explain	State the reason for something happening using scientific knowledge and understanding.	Conduction happens in solids because the particles are tightly packed together.
Define	Give the meaning of something.	A covalent bond is where a shared pair of electrons holds two atoms together.
Determine	Use given data or information to obtain an answer.	pH 6.5
Estimate	Give an approximate value.	2.5–3.1 g
Evaluate	Use information in the question as well as a learner's own knowledge and understanding to make a judgement.	The data obtained was reliable because the experimenter repeated her results five times, but to make it more accurate she should have used a pipette instead of a measuring cylinder.
Identify	Name or state.	Waxy cuticle.
Justify	Use evidence from the information given to support an answer.	40 °C, because this is the temperature at which the enzyme reached its optimum activity.

Worksheet 4: suggested answers

	Mean	Median	Mode	Range
2, 4, 4, 5, 7, 8, 14	5	4.5	4	6
1.1, 2.4, 1.3, 1.4, 1.5, 1.2, 1.5, 1.6, 1.5	1.4	1.5	1.5	0.5
43, 39, 45, 23, 48, 51, 48, 54, 42, 49	46.5	48	48	15
17.1, 19.3, 19.4, 18.6, 28.2, 17.9	18.5	18.6	—	2.3
110.1, 111.3, 109.7, 109.6, 114.2, 110.4, 110.8, 111.3	110.5	110.4	111.3	1.7

Worksheet 5: suggested answers

- 94; 134;

- Axes – labelled with units on *y*-axis;
  Scale – suitable even linear scale and plots to fill more than half of the printed grid;
  Plot – all points plotted accurately ± ½ square;
  Bars – have an equal gap between each component;

- Similarity – any 1 from:
  Exercise increases (average) pulse rate;
  (idea of) more intense the exercise the more increase in (average) pulse rate;

  Difference – any 1 from:
  Jumping produces greater increases in males than females;
  Jumping and moving arms produces greater increase in females than males;

Worksheet 6: suggested answers

(1) Axes labels with units
Even scale and plots to fill at least ½ grid in both directions
Plots accurate to ± ½ small square
Bars of equal width, not touching and with equal space in between

(2) 177

Worksheet 7: suggested answers

(1) *y*-axis scale linear and highest temperature change over half-way up *y*-axis;
All 5 bars at the correct height;
Bars clearly labelled;

(2) Experiment 3; magnesium is the most reactive metal;

(3) Copper formed; iron is more reactive / displacement reaction;

Worksheet 8: suggested answers

(1) All points correctly plotted; smooth line drawn

(2) Point at 60 s / 62 cm^3 / fourth point / measurement 4; misread measuring cylinder / read too early

(3) Value from graph (68–70) shown clearly

13 / 20 = 0.65 cm^3/s

(4) Steeper curve to same level

Air is displaced (when acid is added)

Worksheet 9: suggested answers

(1) Axes labelled with quantity AND unit;
Appropriate scales (plots occupying at least ½ grid);
Plots all correct;
Well-judged line AND thin, neat plots

(2) *G* present and triangle method seen using at least ½ line

(3) *R* in range 4.6 Ω to 4.9 Ω; to 2/3 significant figures and with correct unit

(4) Statement matching graph with reference to straight line; reference to passing through origin (within limits of experimental accuracy)

Worksheet 10: suggested answers

(1) A: 40.0, 35.0, 30.0, 25.0, 20.0

(2) B: 34.0, 28.8, 24.0, 19.2, 14.0

(3) Axes correctly labelled with quantity, right way around;
Appropriate scales starting at origin;
All plots correct to ½ small square;
Good line judgement, thin, continuous, single line through the plots with neat plots;

(4) Method shown on graph and Y correct to ½ mall square;

(5) W = 1.0–1.4;

(6) Agree; explanation includes idea of values being close enough.

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