Cambridge Assessment International Education

Skills for science

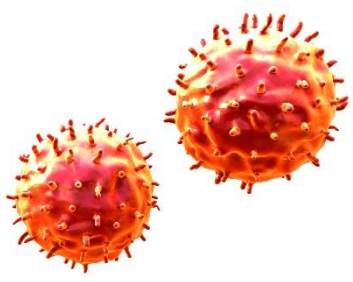
Evaluating methods and suggesting improvements

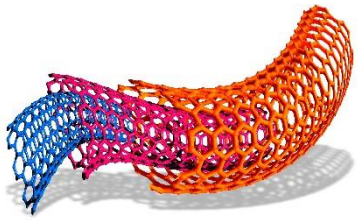
Cambridge International O Level

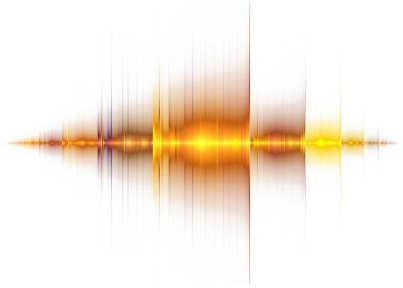
Biology 5090

Chemistry 5070

Physics 5054







Version 1.0

Cambridge Pathway

In order to help us develop the highest quality resources, we are undertaking a continuous programme of review; not only to measure the success of our resources but also to highlight areas for improvement and to identify new development needs.

We invite you to complete our survey by visiting the website below. Your comments on the quality and relevance of our resources are very important to us.

www.surveymonkey.co.uk/r/GL6ZNJB

Would you like to become a Cambridge International consultant and help us develop support materials?

Please follow the link below to register your interest.

www.cambridgeinternational.org/cambridge-for/teachers/teacherconsultants/

Contents

About this document

This document has been designed to help you to develop your learners' 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 evaluate methods and suggest possible improvements. 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 importance of evaluating scientific methods within the context of our science syllabuses. It includes suggested questions that learners should ask themselves whilst evaluating experiments and suggesting how an experiment could be improved. Help with starting classroom discussions on evaluating methods and suggesting improvements 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 evaluating methods and suggesting improvements.

3. Example responses

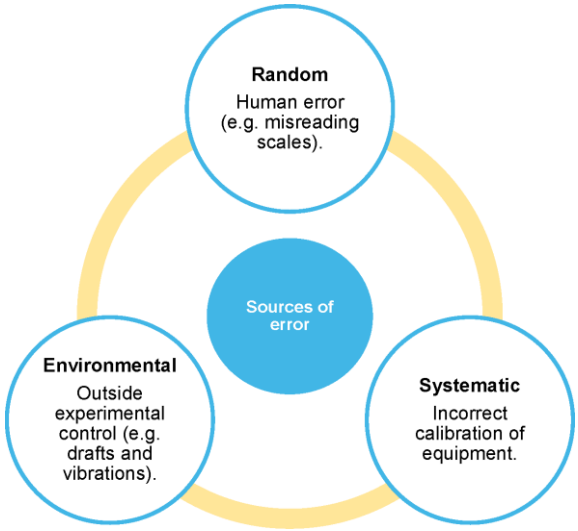
Questions from past papers and the associated mark schemes are provided along with example responses. There is one example for each of the three science subjects (biology, chemistry and physics). A middle-level response is annotated with what was done well, what could be improved, and useful terminology.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

Introduction

Candidates may be required to do the following in either Paper 3 or Paper 4:

- *Identify sources of error and suggest possible improvements in procedures*

All scientific experiments contain **sources of error** that need to be minimised to obtain results that are **accurate** and **reliable**. Sources of error may be **random**, **systematic** or **environmental**.



Learners should be encouraged to:

- understand what is meant by the terms *reliable* and *accurate* for the data gathered during an experiment
- consider how to adjust a procedure in order to make the data gathered more accurate and reliable
- look objectively at a method, identifying sources of random, systematic and environmental errors, and suggest appropriate improvements for each.

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

- What data is being collected?
- Is the apparatus arranged so that accurate measurements can be taken?
- Is the equipment used appropriate for the experiment?
- Will the equipment allow for the collection of accurate data?
- Is the experiment designed in a such a way as to collect reliable data?

Getting started

Encourage learners to consider how to evaluate a method and suggest improvements by doing the tasks below.

Selecting the correct equipment

Discuss which equipment a learner might use to do the following scientific procedures.

- Measuring 30 cm^3 of hydrochloric acid.
- Measuring the time taken for a trolley to run down a 1 m ramp.
- Measuring 3 drops of iodine.
- Measuring 7.6 cm^3 of sodium hydroxide.
- Measuring the length of an extended spring.
- Measuring the volume of gas produced when an acid reacts with a metal.

Identifying the correct method

For each of the following experiments, ask the learners to decide how they could ensure that the data gathered is as accurate and reliable as possible. They should consider:

- the type of equipment used to gather the data
- how they should position themselves or the equipment in order to gather the data
- how many times the experiment needs to be carried out
- are there any factors out of the experimenter's control that may affect the data gathered.

Measuring the rate of photosynthesis
A learner measured the rate at which the leaves of a pond plant produced bubbles of oxygen gas when exposed to different intensities of light. They changed the light intensity by positioning a lamp 20 cm, 40 cm, 60 cm, 80 cm and 100 cm away from a beaker containing the pond plant. The number of bubbles of oxygen produced by the plant in 1 min was measured for each position of the lamp.

The reaction of iron with copper(II) sulfate
A learner measured 25 cm^3 of aqueous copper(II) sulfate into a beaker. The temperature of the solution was recorded initially, at 30 s and again at 60 s. At 60 s, a piece of iron was added to the copper(II) sulfate and the mixture stirred continuously. The temperature was recorded every 30 s until 300 s.

Measuring the rate of cooling of two different-sized beakers of hot water
A learner wished to investigate if the size of the surface area of water exposed to the air affects the rate at which it cools. They used two different-sized beakers, A and B. Beaker B is bigger than beaker A. 75 cm^3 of hot water was poured into both beakers. A stopwatch was immediately started, and the temperature of the water in each beaker was recorded every 30 s for 300 s.

Classroom activities

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

- **Worksheet 1:** Match the statements
- **Worksheet 2:** Types of error
- **Worksheet 3:** Common errors and improvements
- **Worksheet 4:** Accuracy in experiments
- **Worksheet 5:** Suggesting improvements scenario – biology
- **Worksheet 6:** Suggesting improvements scenario – biology
- **Worksheet 7:** Suggesting improvements scenario – chemistry
- **Worksheet 8:** Suggesting improvements scenario – chemistry
- **Worksheet 9:** Suggesting improvements scenario – physics
- **Worksheet 10:** Suggesting improvements scenario – physics

Worksheet 1: Match the statements

Accuracy is dependent upon the equipment used and the skill of the scientist.

Reliability is how close the data are to each other; reliable data have very little variation in their values.

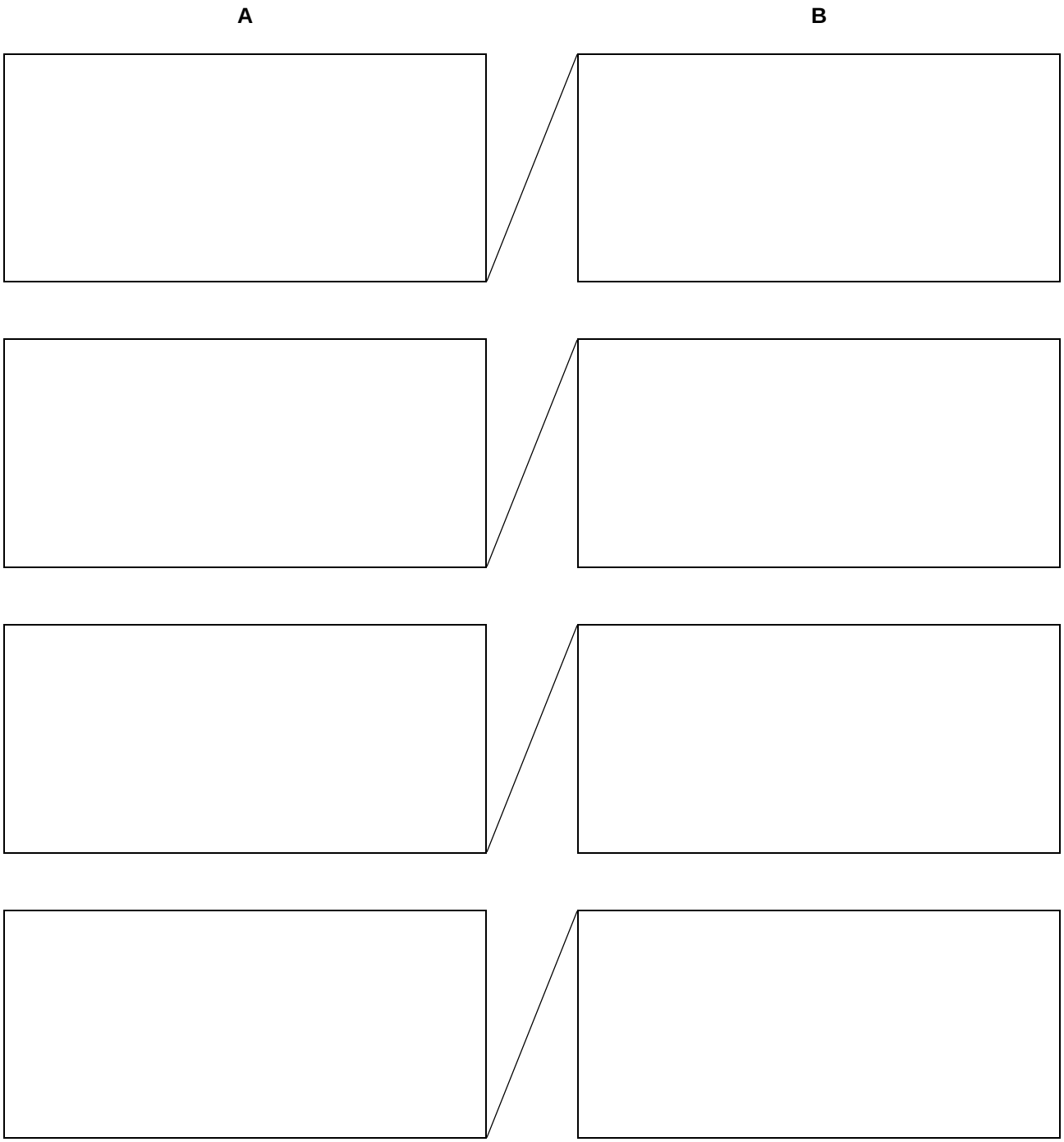
The list of statements in column **A** contains methods used when collecting data in an experiment. Cut out the statements and stick them into column **A** on page 2 of the worksheet.

The list of statements in column **B** describes whether a method is accurate and/or reliable. Cut out the statements and stick them in column **B,** matching them to the type of method in column **A**.

A	**B**
Sophia counts in her head and repeats the experiment five times.	Accurate Not reliable
Alice counts using a stopwatch and does not repeat the experiment.	Not accurate Reliable
Amir counts in his head and does not repeat the experiment.	Accurate Reliable
Hong counts using a stopwatch and repeats the experiment five times.	Not accurate Not reliable

Worksheet 1: Match the statements, continued

Put the types of method in column **A** and match it to whether that method is accurate and / or reliable in column **B**.



Worksheet 2: Types of error

For each of the following scenarios, decide whether the error is **random**, **systematic** or **environmental.**

Scenario	Random, systematic or environmental error?
The scale was misread on the measuring cylinder.	
The timer was started just after the acid was added to the flask.	
The gas tap was turned off during an experiment.	
The thermometer was read at the wrong angle.	
The ammeter reading was 0.2 A when no current was flowing through it.	
The battery in the stopwatch ran out during the experiment.	
The wires in the circuit had poor connections.	
The bubbles were too small and moving too quickly to count.	
The temperature of the room increased during the course of the experiment.	
Three drops were added to the test-tube instead of one.	
A draft was coming through the window whilst measuring the temperature of a boiling tube.	

Worksheet 3: Common errors and improvements

Below is a list of common errors encountered in science experiments. For each, consider how this error could affect the data collected and how this error could be improved.

Error	How this affects the data collected	Improvement
Misreading the meniscus on a measuring cylinder.		
Using two different balances to conduct two different readings.		
Adding too many drops of a chemical.		
Balance does not return to 0.0 g after another person has used it.		
Contamination from dirty glassware.		
The experiment was set up in such a way that it was difficult to take a reading.		
Running out of time.		
The ammeter is showing a reading despite no current flowing.		
The results gathered do not show a pattern.		
The person gathering the data switches to another person halfway through the experiment.		

Worksheet 4: Accuracy in experiments

For each of the following scientific procedures, state how you would do this as accurately as possible. Consider equipment used and positioning of the experiment.

Procedure	How to ensure accuracy
Measuring 100 cm^3 of acid.	
Taking the temperature of a solution.	
Measuring the length of a spring.	
Adding 1.5 cm^3 of a liquid.	
Weighing 2.7 g of a powder.	
Timing one oscillation of a pendulum.	
Measuring the rate of photosynthesis by counting bubbles of oxygen.	
Timing how long it takes for a solution to change colour.	

Worksheet 5: Improvement scenario – biology

A learner wished to test three food supplements, **P**, **Q** and **R** for vitamin C.

Only **two** of the food supplements contain a high amount of vitamin C.

When iodine solution is mixed with starch a blue-black colour is observed. Vitamin C stops the blue-black colour from forming.

Step 1 Label a test-tube **P** and add 3 cm^3 of food supplement **P** to the test-tube.

Step 2 Add 1 cm^3 of starch solution to test-tube **P**.

Step 3 Add iodine solution to test-tube **P**, one drop at a time. Count the drops as you add them. Gently shake the test-tube from side to side after adding each drop. Stop adding drops when a blue-black colour remains **or** when you have added 20 drops of iodine solution.

Step 4 Record the number of drops added in Table 1.2.

Step 5 Repeat steps **1** to **4** with food supplements **Q** and **R**.

Table 1.1 shows how the number of drops of iodine solution added relates to the vitamin C content of the food supplement.

Table 1.1

number of drops of iodine solution added	vitamin C content
1	none
2–3	low
4 or more	high

1 There is a source of error in **step 3** of the vitamin C test.
Identify this source of error.

……

2 Suggest why it is a source of error.

……..

……..

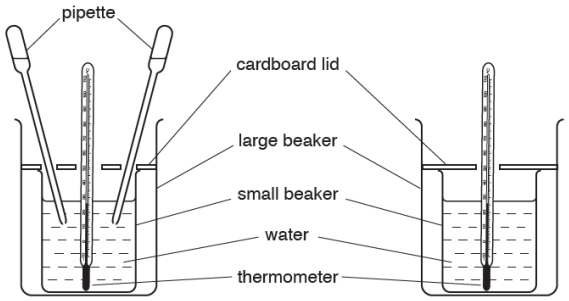
3 How could you improve this experiment in order to overcome this source of error?

……

……

Worksheet 6: Improvement scenario – biology

A learner was investigating how an elephant controls its body temperature by heat loss through its ears. When an elephant is too hot, increasing blood flow to the surface of the skin in the ears helps cool it down. The learner set up a model of what happens in the elephant's ears as shown in the diagram below.



They placed hot water in two small beakers and stood each one in a large beaker. One beaker had 'ears' and one beaker did not. The 'ears' are represented by two small dropping pipettes. The pipettes were continuously squeezed and released throughout the experiment so that water continuously moves out of and into the pipettes.

The starting temperature of the water in each beaker was recorded, and the temperature measured in each beaker every minute for 8 minutes.

1 What sources of error are there in this experiment?

……

……

2 Suggest why these are sources of error.

……

……

……

3 How could the learner improve this experiment in order to overcome these sources of error?

……

……

……

Worksheet 7: Improvement scenario – chemistry

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

Three 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.

1 Identify **two** sources of error in this investigation.

……

……

2 Suggest why these are sources of error.

……

……

……

3 How could the learner improve this experiment in order to overcome these sources of error?

……

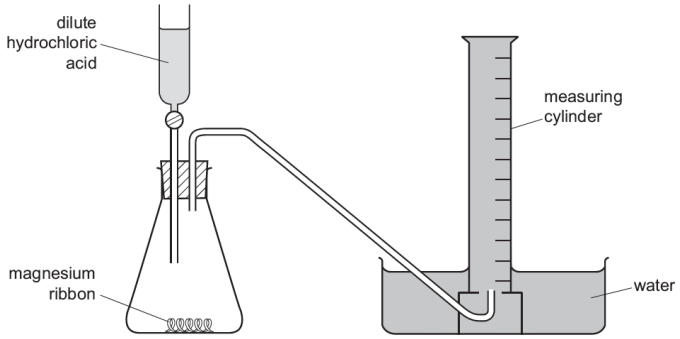
……

……

……

Worksheet 8: Improvement 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).

1 Identify **two** sources of error in this experiment.

……

……

2 Suggest why these are sources of error.

……

……

……

3 How could the learner improve this experiment in order to overcome these sources of error?

……

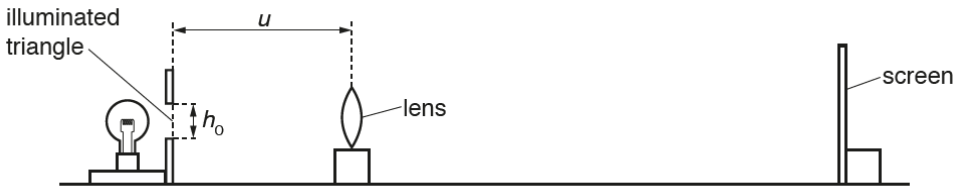
……

……

Worksheet 9: Improvement scenario – physics

A learner is investigating the magnification produced by a converging lens.

They set-up their apparatus as shown in the diagram.



The learner set the distance *u* between the illuminated triangle and the lens to 20.0 cm.

They placed the screen near the lens and moved it until a sharp image of the triangle is seen on the screen.

They measured and recorded the height of the image formed on the screen.

The learner repeated the procedure for distances of *u* of 25.0 cm, 35.0 cm, 45.0 cm and 55.0 cm.

1 What are the sources of error in this experiment?

……

……

2 Suggest why these are sources of error.

……

……

……

3 How could the learner improve this experiment in order to overcome these sources of error?

……

……

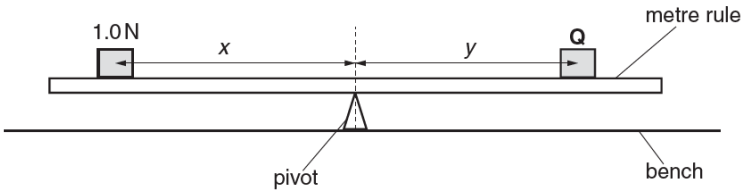
……

Worksheet 10: Improvement scenario – Physics

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

They placed a metre rule on a pivot and adjusted its position so that the metre rule is as near as possible to being balanced. The metre rule remained in this position throughout the experiment.

The scale reading of the metre rule at the point at which it balances on the pivot was recorded.



A 1.0 N load was placed on the metre rule so that its centre was at the 20.0 cm mark. The distance *x* between the 20.0 cm mark and the pivot was recorded. Load **Q** was placed on the metre rule and its position adjusted so that the metre rule is as near as possible to being balanced. The distance *y* between the centre of load **Q** and the pivot was recorded.

The weight *W* of load **Q** was calculated using the equation $W = kx$, where $k = 1.0$ N.

1 What are the sources of error in this experiment?

……

……

2 Suggest why these are sources of error.

……

……

……

3 How could the learner improve this experiment in order to overcome these sources of error?

……

……

……

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 improved answers are included to show how learner responses could be developed.

Evaluating methods and suggesting improvements question – biology

In this question, learners are asked to comment upon **sources of error** in an experiment and suggest a suitable **control**. To do this well, learners need to read the method and examine any diagrams carefully. They need to consider what measurements are being taken and how this can be done accurately. They also need to look at experimental set-up and consider where there are possible errors that could affect the measurements taken. Finally, the learners need to consider what could be used as a control to validate any data collected. A good way to do this is to think about what is being changed in the experiment (the independent variable) and consider how to alter this to form a reference value.

1 Metabolic reactions in cells produce toxic chemicals which can be converted to harmless or less toxic chemicals.

Hydrogen peroxide is broken down using the enzyme catalase which is found in most cells.

Fig. 1.1 shows this reaction.

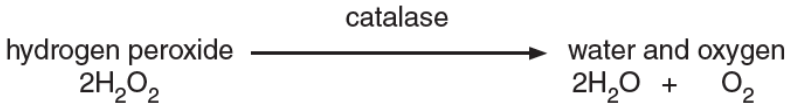


Fig. 1.1

A student investigated the effect of alcohol (ethanol) on the activity of catalase found in potato, using three pieces of potato cut to the same size.

Fig. 1.2 shows these pieces of potato.

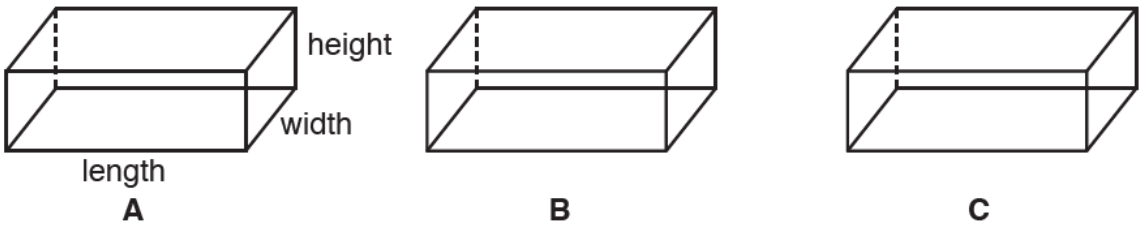


Fig. 1.2

Step 1 The student labelled six test-tubes, **1**, **2**, **3**, **4**, **5**, and **6** and used a syringe to add 10 cm^3 of hydrogen peroxide solution to each of the test-tubes.

Step 2 They cut potato piece **A** to obtain two slices of similar size.

Step 3 The student placed the free end of a delivery tube into a large test-tube containing water.

Step 4 They placed one of the slices of potato piece **A** into the hydrogen peroxide solution in test-tube **1**.

Step 5 The student immediately placed the rubber bung attached to the delivery tube into test-tube **1** and pushed it in as tightly as possible, as shown in Fig. 1.3.

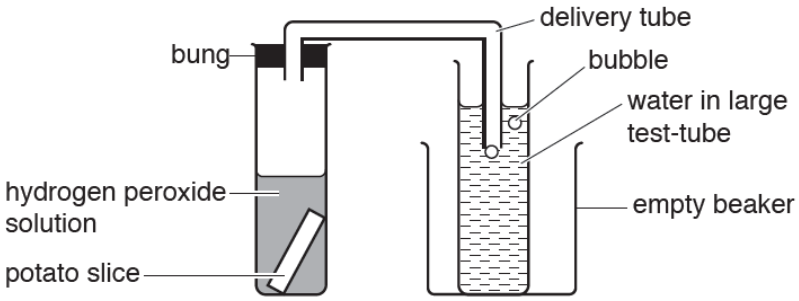


Fig. 1.3

Step 6 They counted the number of bubbles released from the delivery tube in 3 minutes.

Step 7 The student repeated steps **4–6** for the second slice of potato piece **A** using test-tube **2**.

Step 8 They repeated steps **2–7** for potato piece **B** using test-tubes **3** and **4**.

Step 9 They repeated steps **2–7** for potato piece **C** using test-tubes **5** and **6**.

The student used a tally to count the number of bubbles.

(ii) The method of measuring the oxygen gas produced is a source of error.

State **one** reason why this method is a source of error.

.....

.....

Suggest how to improve the method to minimise this error.

.....

.....

.....

[2]

(iii) Identify the source of error in step **2**. State why this is a source of error.

source of error .....

.....

reason .....

.....

.....

[2]

(iv) Describe a control experiment that the student could carry out for this investigation.

.....

.....

.....

.....

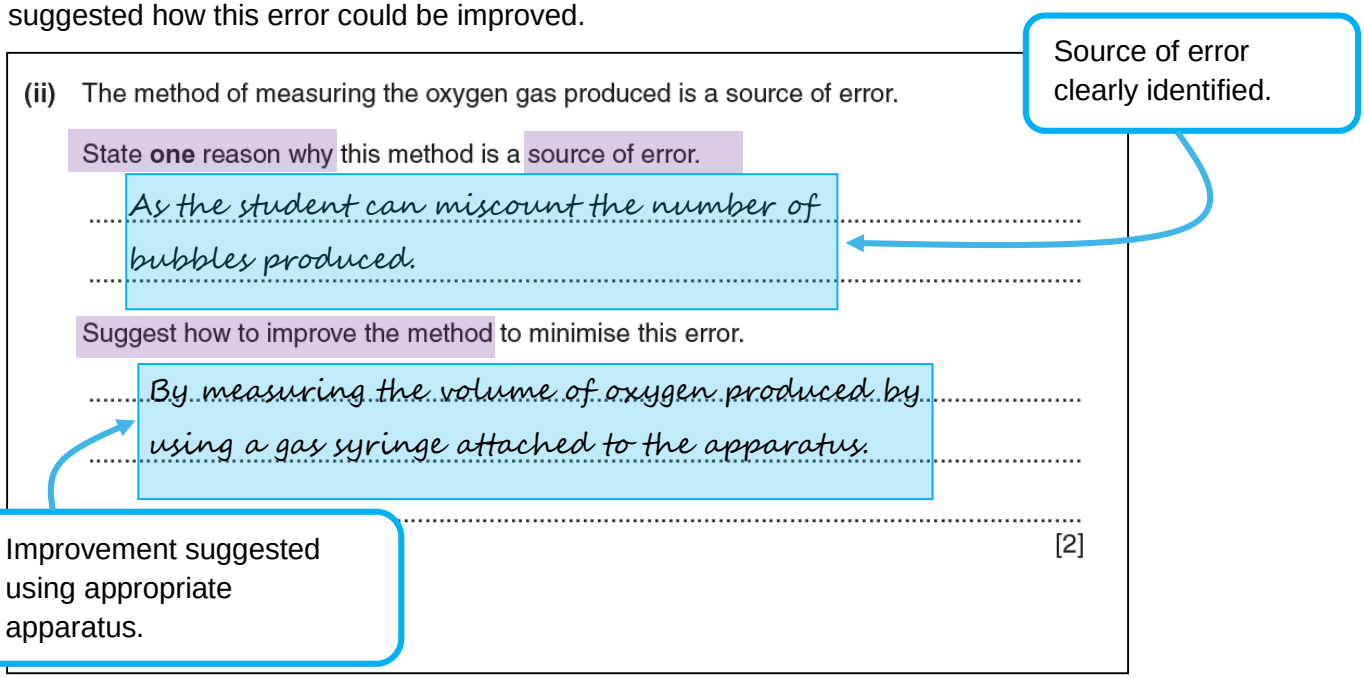
.....[2]

The mark scheme for this question is as follows:

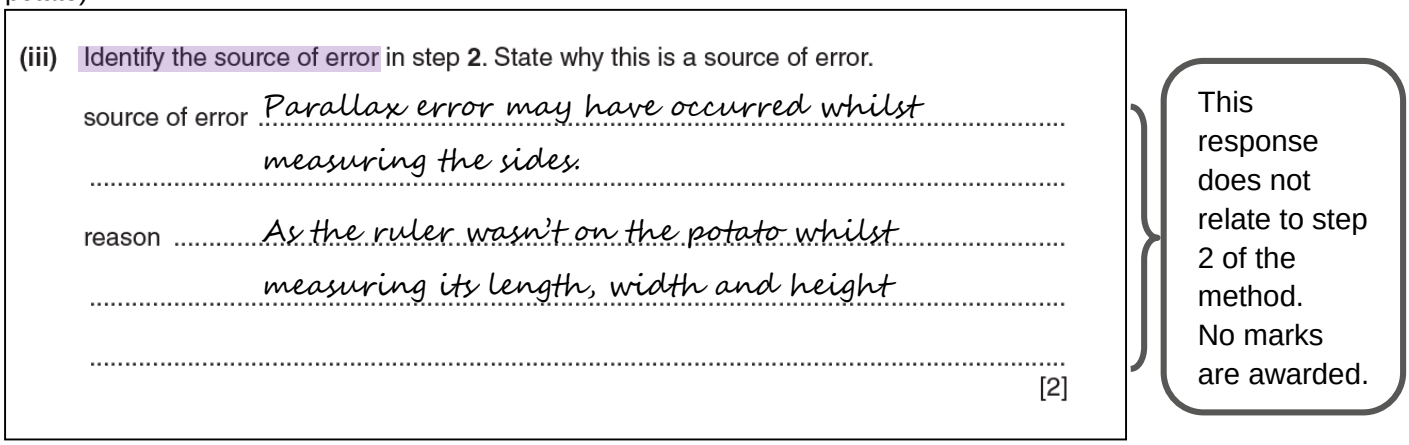
Question	Mark scheme	Guidance	Mark
d (ii)	*source of error* / *method of reducing error* Bubbles are all different sizes; / Measure the volume / use a gas syringe / collect in a measuring cylinder; Bubbles are difficult to count; / Use a (tally) counter / method of collecting the gas / measure the volume / use 2 people / repeat for reliability; Setting up and starting time; / Use 2 people;	Method must match the mark; 1 mark for error, 1 mark for method.	1 + 1 [max 2]
(iii)	size / mass / volume of the slices or type / age of potato, may not be equal surface area is different / quantity of available catalase is different		[2]
(iv)	Use exactly the same method / repeat / description of original method Except soak potato in water (and not ethanol) / use 0% alcohol / without alcohol / use untreated potato	IGNORE: Use boiled potato / boiled catalase / repeat without potato / use water instead of hydrogen peroxide / use liver or yeast / use glass beads	[2]

Example response

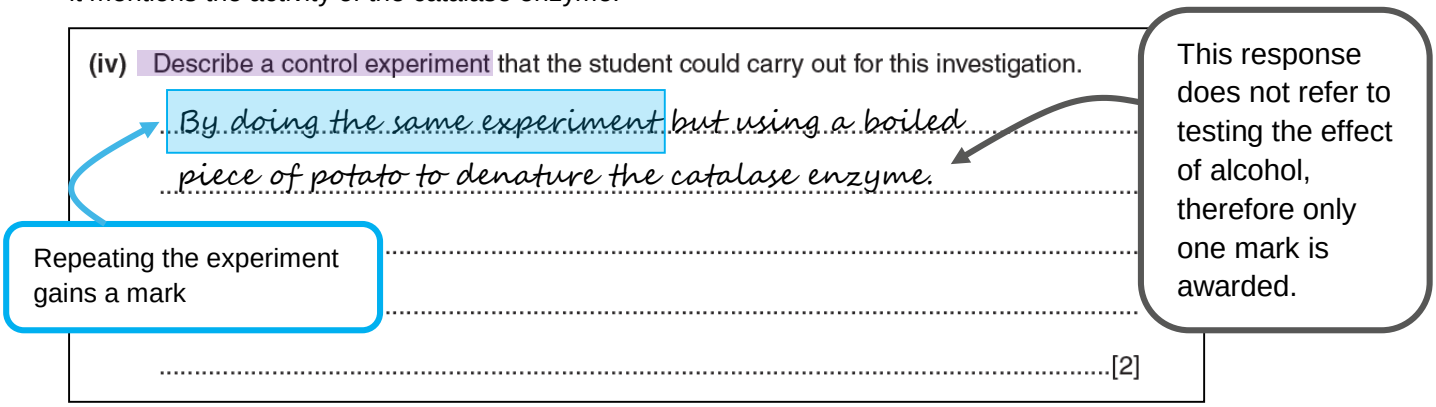
This response would achieve the full mark. The learner has clearly identified a source of error and suggested how this error could be improved.



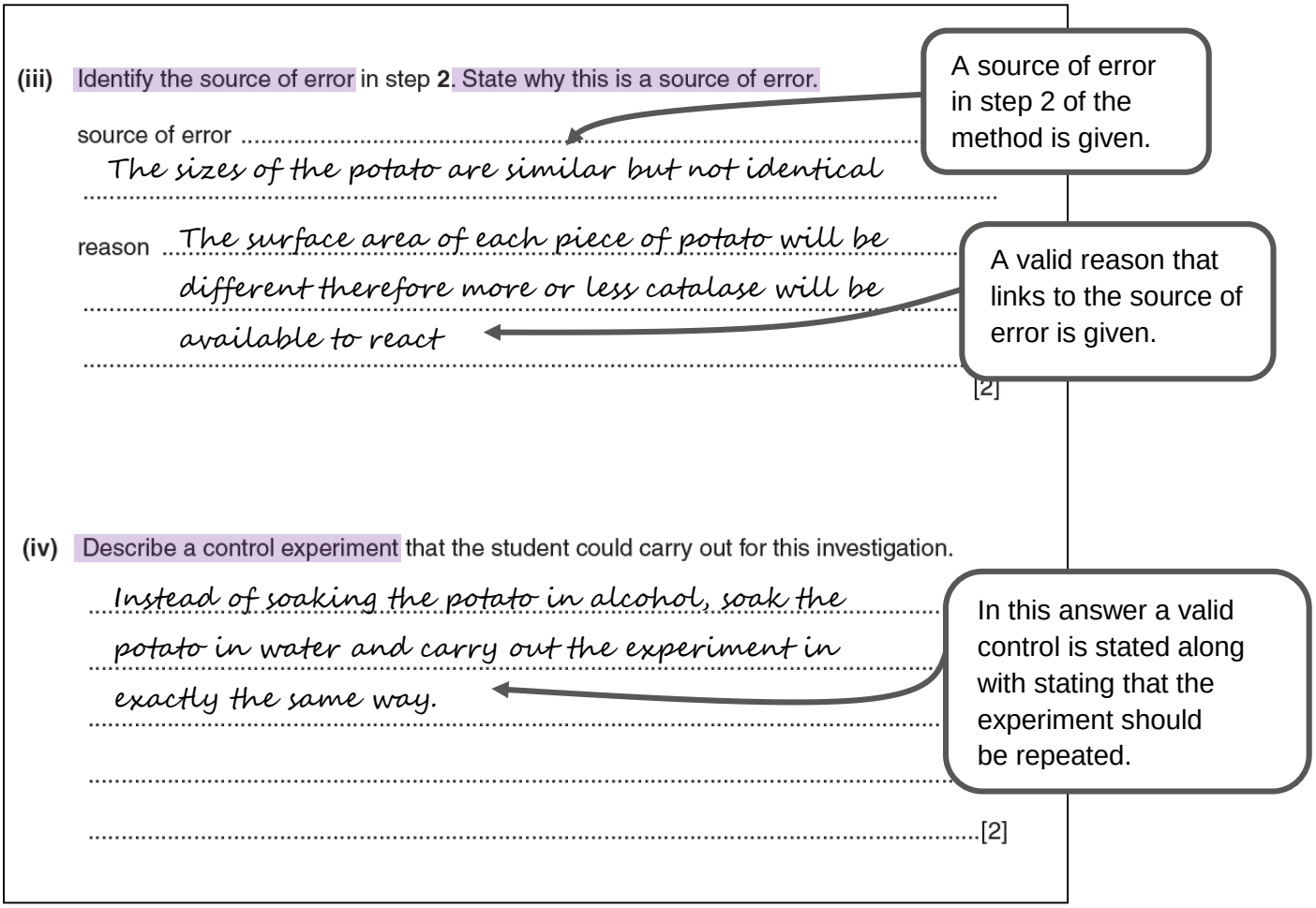
For the third part of the question, the learner did not gain any marks. They have clearly misinterpreted the question as their answer does not relate to step 2 of the method (where no ruler was used in cutting the potato).



This is a mid-level response, gaining one out of two possible marks. The learner has stated they would repeat the experiment but their response does not refer to the variable being changed (alcohol concentration); instead it mentions the activity of the catalase enzyme.



Improved response



Evaluating methods and suggesting improvements question – chemistry

In this question learners are asked to look at and label a piece of apparatus. They are then asked to identify a mistake in the apparatus and suggest why an electrical heater is used rather than a Bunsen burner. This is a straightforward question to answer providing learners understand the principle of distillation.

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

Five experiments were carried out.

(a) *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.

(b) The gas produced in experiment 3 was tested with a lighted splint and the result recorded below.

test ...lighted splint.....

result ...popped.....

(c) *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.....

(g) Suggest why potassium was **not** used as one of the metals in these experiments.

..... [1]

(h) Give **one** advantage of using a measuring cylinder to add the hydrochloric acid to the boiling tube.

..... [1]

(i) Suggest and explain **one** improvement to increase the accuracy of these experiments.

.....

.....

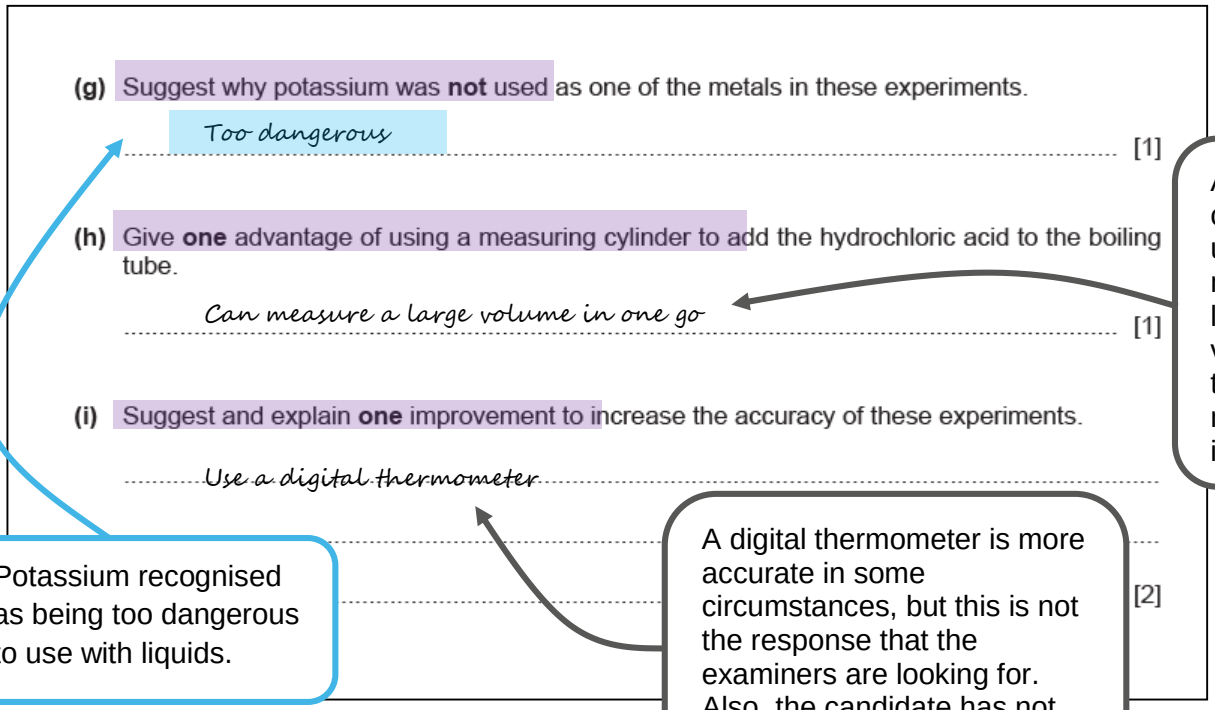
..... [2]

The mark scheme for this question is as follows:

Question	Mark scheme	Mark
2 (g)	Potassium is too reactive / dangerous;	1
(h)	Quick / easy to use	1
(i)	Insulate / lag tube / use a lid; To reduce heat losses; OR Use a pipette / burette; Instead of measuring cylinder / more accurate;	1 1 1 1 [2]

Example response

This is a low to mid-level response. The learner has correctly identified that potassium is too dangerous to use in an experiment involving liquids. However, they are too vague in their reasoning as to why pieces of equipment are used. They also do not give a valid improvement to the experiment and explain it coherently.



(g) Suggest why potassium was **not** used as one of the metals in these experiments.

Too dangerous [1]

(h) Give **one** advantage of using a measuring cylinder to add the hydrochloric acid to the boiling tube.

Can measure a large volume in one go [1]

(i) Suggest and explain **one** improvement to increase the accuracy of these experiments.

Use a digital thermometer

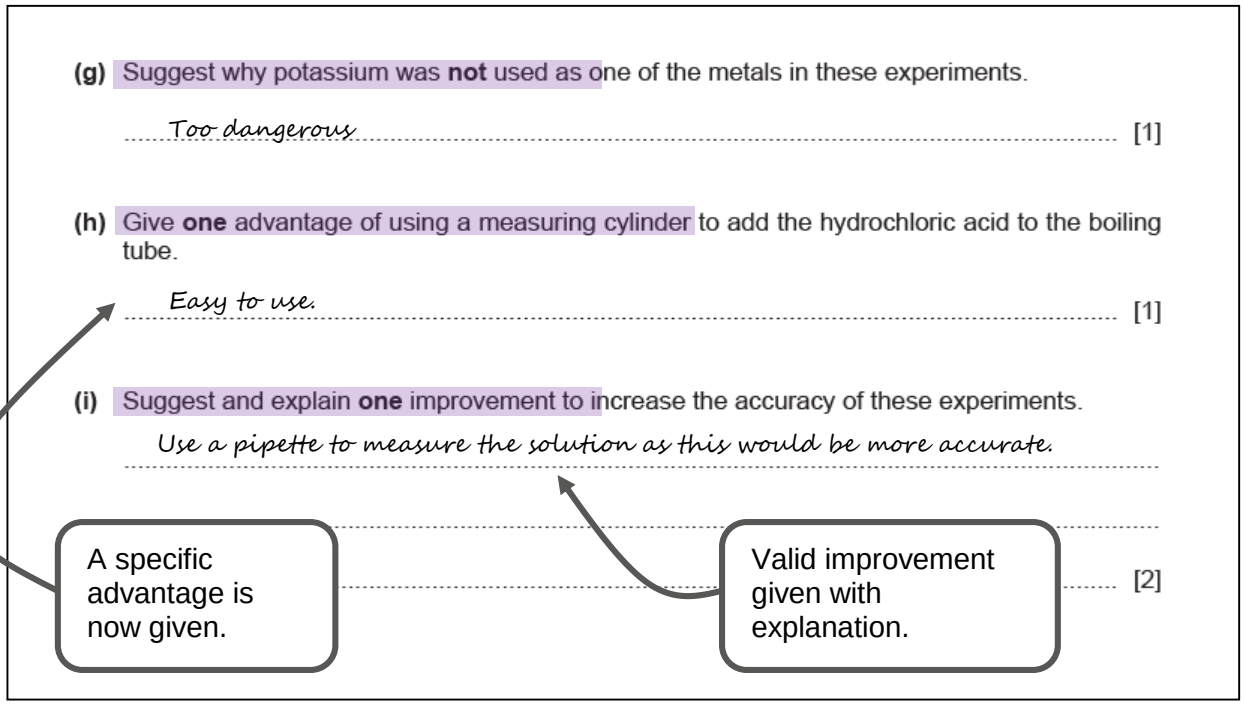
[2]

A measuring cylinder is used for measuring large volumes, but this is not the reason why it is used in this

Potassium recognised as being too dangerous to use with liquids.

A digital thermometer is more accurate in some circumstances, but this is not the response that the examiners are looking for. Also, the candidate has not explained the improvement.

Improved response



(g) Suggest why potassium was **not** used as one of the metals in these experiments.

Too dangerous [1]

(h) Give **one** advantage of using a measuring cylinder to add the hydrochloric acid to the boiling tube.

Easy to use. [1]

(i) Suggest and explain **one** improvement to increase the accuracy of these experiments.

Use a pipette to measure the solution as this would be more accurate.

[2]

A specific advantage is now given.

Valid improvement given with explanation.

Evaluating methods and suggesting improvements question – physics

In this question learners are asked to look at an experiment using a pendulum to calculate the acceleration of free fall *g,* and how this experiment could be improved. To answer this question well, learners need to consider how to improve the accuracy and reliability of the results obtained.

1 A student uses a pendulum to determine a value for the acceleration of free fall *g*.

Figs. 1.1 and 1.2 show the apparatus.

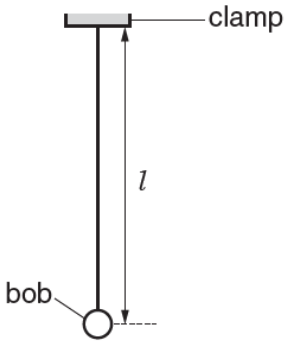


Fig. 1.1

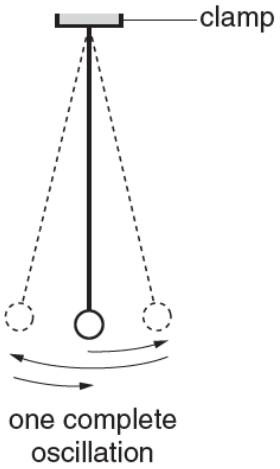


Fig. 1.2

(d) The student checks the value of the acceleration of free fall *g* in a text book. The value in the book is 9.8 m/s^2.

(i) Suggest a practical reason why the result obtained from the experiment may be different.

.....

.....

.....[1]

(ii) Suggest **two** improvements to the experiment.

1. .....

.....

2. .....

.....

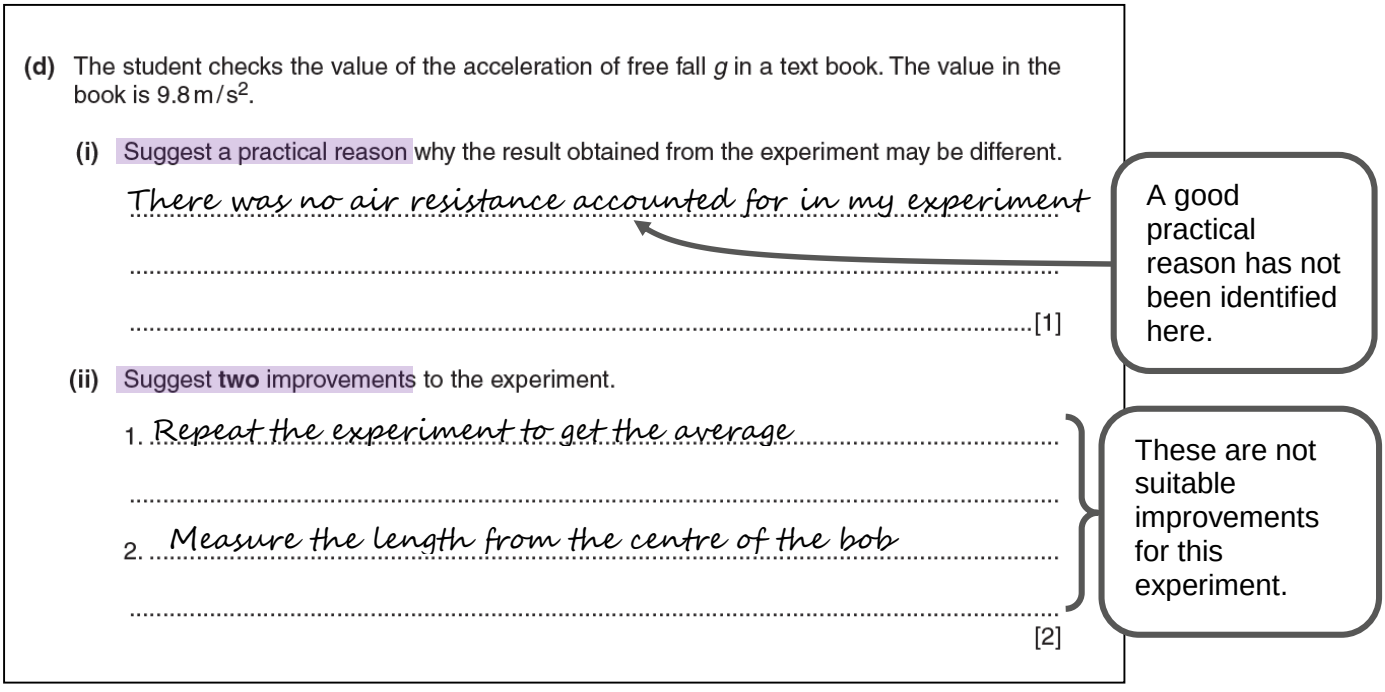
[2]

The mark scheme for this question is as follows:

Question	Mark scheme	Mark
1 (d) (i)	Explanation of cause of inaccuracy in measuring *t* or *l* e.g. learner did not react quickly enough when starting/stopping stopwatch OR difficulty in measuring accurately to centre of bob	1
1 (d) (ii)	Any two from: Use different lengths Repeat timing Use of a fiducial mark Increased number of oscillations Plot a graph using length and time or time^2	2

Example response

This answer did not receive any marks. First, the learner did not give a valid practical reason as to why the results may have differed. Second, the improvements suggested are vague and not appropriate.



(d) The student checks the value of the acceleration of free fall *g* in a text book. The value in the book is 9.8 m/s^2.

(i) Suggest a practical reason why the result obtained from the experiment may be different.

There was no air resistance accounted for in my experiment

.....

.....[1]

(ii) Suggest **two** improvements to the experiment.

1. Repeat the experiment to get the average .....

.....

2. Measure the length from the centre of the bob .....

.....

[2]

A good practical reason has not been identified here.

These are not suitable improvements for this experiment.

Improved response

(d) The student checks the value of the acceleration of free fall *g* in a text book. The value in the book is 9.8 m/s^2.

(i) Suggest a practical reason why the result obtained from the experiment may be different.

The learner may not have started the stopwatch exactly as the pendulum was let go – timing an oscillation may be inaccurate

[1]

(ii) Suggest **two** improvements to the experiment.

1. Repeat the timings several times

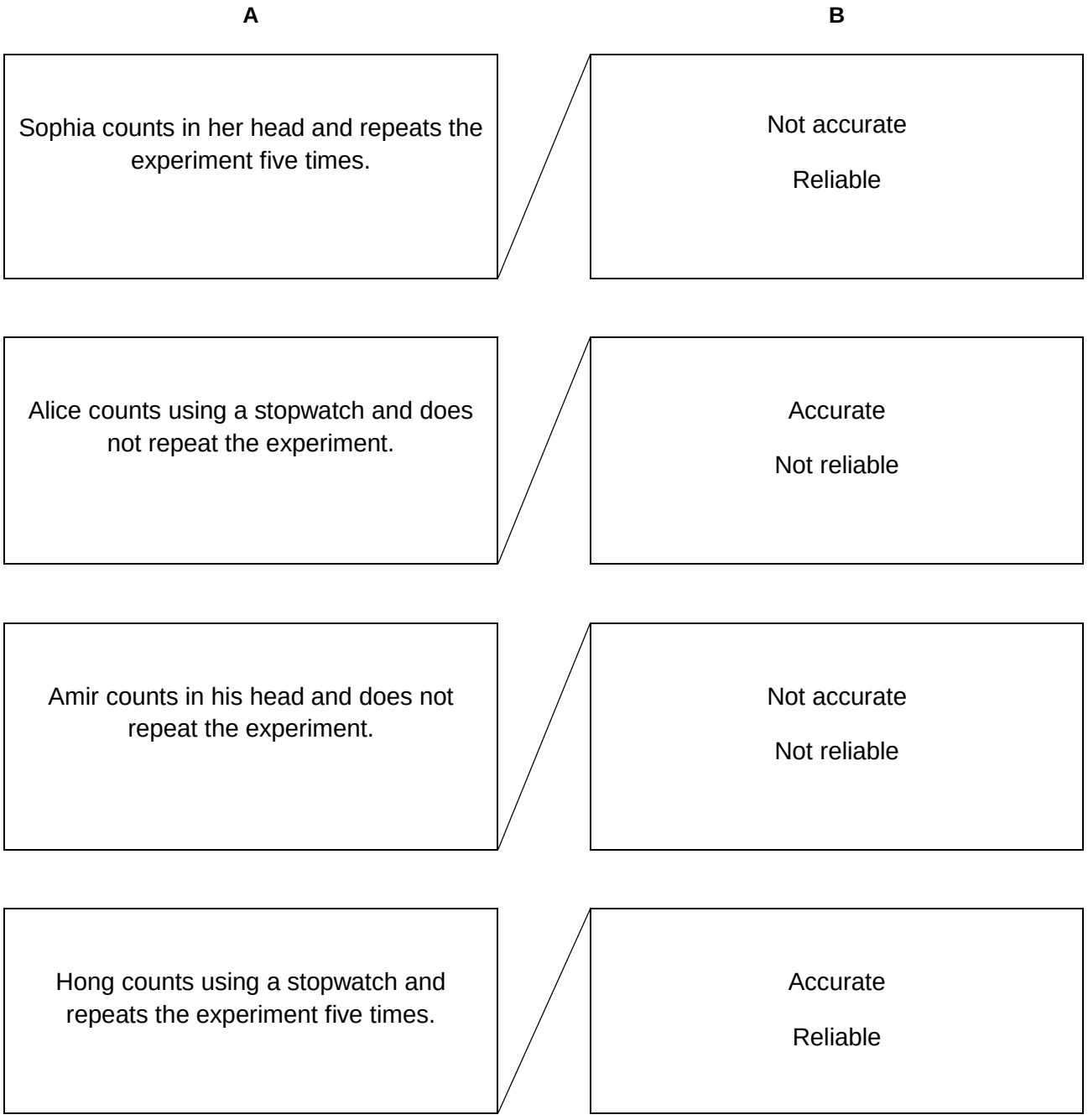
2. Use different lengths of pendulum to check results are consistent

[2]

A valid reason is given why the result may have been different.

Two appropriate improvements have been suggested.

Worksheet 1: suggested answers



Worksheet 2: suggested answers

Scenario	Random, systematic or environmental error?
The gas taps stopped working during an experiment.	Random
The scale was misread on the measuring cylinder.	Random
The timer was started just after the acid was added to the flask.	Systematic
The gas tap was turned off during an experiment.	Random
The thermometer was read at the wrong angle.	Random
The ammeter reading was 0.2 A when no current was flowing through it.	Systematic
The battery in the stopwatch ran out during the experiment.	Random
The wires in the circuit had poor connections.	Random
The bubbles were too small and moving too quickly to count.	Systematic
The temperature of the room increased during the course of the experiment.	Environmental
Three drops were added to the test-tube instead of one.	Random
There was a draft coming through the window whilst measuring the temperature of a boiling tube.	Environmental

Worksheet 3: suggested answers

Error	How this affects the data collected	Improvement
Misreading the meniscus on a measuring cylinder.	Incorrect volumes added – may alter results of experiment.	Ensure experimenter is at eye level with the measuring cylinder whilst measuring volume.
Using two different balances to conduct two different readings.	Potential for zero error; one balance may read differently to another.	Use the same balance for all readings.
Adding too many drops of a chemical.	Incorrect volumes added – may alter results of experiment.	Use a syringe or micro pipette to add drops; release drops slowly and carefully.
Balance does not return to 0.0 g after another person has used it.	Potential for zero error – wrong amounts of substance measured.	Use a different balance; ensure balance returns to zero before measuring.
Contamination from dirty glassware.	Other substances may enter experiment and alter results.	Ensure all glassware clean before use.
The experiment was set up in such a way that it was difficult to take a reading.	Difficulty in taking accurate readings.	Alter set up in order that accurate readings are taken; move experimenter in order that accurate readings are taken.
Running out of time.	Cannot obtain complete set of data.	Read method thoroughly before beginning experiment to effectively plan time available.
The ammeter is showing a reading despite no current flowing.	Systematic error – all results affected.	Use a different ammeter and ensure it is at zero when no current is flowing.
The results gathered do not show a pattern.	Inconclusive results.	Repeat the experiment; ignore anomalous results.
The person gathering the data switches to a different person halfway through the experiment.	Results may not follow a trend.	Use same person to record data throughout experiment.

Worksheet 4: suggested answers

Procedure	How to ensure accuracy
Measuring 100 cm^3 of acid.	• use a measuring cylinder • ensure you are at eye level to meniscus
Taking the temperature of a solution.	• use a thermometer • ensure you are at eye level to temperature scale
Measuring the length of a spring.	• use a ruler with millimetre scale • ensure you are at eye level to spring and ruler • ensure readings are taken from the same point • repeat readings to gather consistent data
Adding 1.5 cm^3 of a liquid.	• use a syringe or micropipette • ensure no air bubbles are present in syringe
Weighing 2.7 g of a powder.	• ensure balance is at zero • tare balance with weigh boat before adding powder
Timing one oscillation of a pendulum.	• use a stopwatch • ensure stopwatch is at zero before starting • use two scientists (one to time and one to hold pendulum) • repeat readings to gather consistent data
Measuring the rate of photosynthesis by counting bubbles of oxygen.	• use a tally counter • if too many bubbles measure volume of gas produced by attaching apparatus to a gas syringe
Timing how long it takes for a solution to change colour.	• use a stopwatch • ensure stopwatch is at zero before starting • use colour standards to compare colour of solution with to ensure objectivity

Worksheet 5: suggested answers

1 Using drops of / a dropper for iodine solution

OR

Drops dribble down the side of the test-tube

2 Each drop will be a different amount / volume

OR

Not all iodine reaches the liquid in the bottom of the tube

3 Use a syringe or micro-pipette that dispenses liquid in accurate volumes

OR

Add iodine directly into liquid at bottom of tube
Agitate tube gently after iodine added to ensure contents evenly distributed

Worksheet 6: suggested answers

1 Lid may not fit snugly on the beaker / holes made in cardboard / more holes in the lid with ears
Water volume is not measured
Squeeze rate not measured or defined
Difficult to measure both times and temperatures on both beakers simultaneously

2 Heat may be lost through gaps / more heat lost from lid with more holes
Bigger volumes of water retain heat for longer
Greater squeezing rate would equate to greater heat loss
Inaccuracies in reading temperatures and times

3 Improve insulation of beaker; same volume of water in each beaker; starting temperatures of each beaker the same; measure rate of squeezing / force of squeezing; use a digital thermometer (easier to read); tape up holes to reduce heat loss; repeat the experiment.

Worksheet 7: suggested answers

1 No lid on boiling tube / no insulation
Using a measuring cylinder to measure small volumes of acid may be inaccurate

2 Heat lost through top and sides of boiling tube – inaccurate temperatures recorded
More / less acid available to react with metal may lead to smaller / greater temperatures recorded

3 Use a lid / insulate the boiling tube
Use a pipette / burette to measure acid (more accurate than measuring cylinder)

Worksheet 8: suggested answers

1 Measurement of acid may be inaccurate
Acid added to flask gradually
Results may be inaccurate / unreliable

2 More or less acid added to the flask therefore greater or less reaction with magnesium; more or less gas produced
Reaction may not begin until a certain volume of acid is present therefore initial measurements may be inaccurate
Unable to confirm that results are consistent / reliable

3 Use a burette / pipette to measure volume of acid
Use a cotton thread to hold a tube containing acid inside the flask
Repeat the experiment to obtain more readings and calculate a mean

Worksheet 9: suggested answers

1 Difficulty measuring of height of image: objects (hand / ruler) in front of image / image measured from angle
Difficulty in visualising image
Difficulty in determining if measurements are reliable

2 Inaccurate measurements taken
Inaccurate measurements taken
Results may not follow a trend / pattern

3 Use translucent screen and view from behind; attach ruler to screen before starting experiment
Ensure room is dark
Repeat the experiment in order to calculate a mean

Worksheet 10: suggested answers

1 Difficulty judging when rule is balanced
Centre of mass of the rule maintained over the centre of the pivot throughout experiment
Loads obscure scale on rule
Difficulty judging position of centre of load

2 Inaccurate measurement of centre of balance of rule
Centre of balance could alter and affect subsequent readings
Inaccurate readings taken
Inaccurate readings taken

3 Measure height from surface at each end of rule to check they are equal; comparison to known balanced line
Check position of centre of rule at all times throughout experiment / repeat experiment
Measure scale either side of load; use additional rule on top of load to measure
Measure scale on either side of load and calculate centre of load from these values

Cambridge Assessment International Education
1 Hills Road, Cambridge, CB1 2EU, United Kingdom
t: +44 1223 553554 f: +44 1223 553558
e: info@cambridgeinternational.org www.cambridgeinternational.org