AQA
Realising potential

Our exams explained

GCSE science exams from summer 2018

Version 1.1 October 2015

How we write straightforward questions that give students of all abilities the best opportunity to get the results they deserve.

- GCSE Combined Science: Trilogy (double award)
- GCSE Combined Science: Synergy (double award)
- GCSE Biology
- GCSE Chemistry
- GCSE Physics

See all our draft specimen question papers and mark schemes at **aqa.org.uk/gcse-science**

Contents

Structure of specimen assessment materials

Introduction

Our GCSE Science papers have been carefully designed to engage students so that they can show what they can do. The papers are deliberately flexible in terms of the mixture of question types and number of marks within each topic. This approach gives examiners the freedom to choose the best question style for the context and science content being assessed. It is also in line with the regulatory requirements.

The topics we're assessing are split across each paper so that you can prepare for examinations more easily. Each question assesses an assessment objective and in some cases more than one assessment objective.

We use a consistent range of question types:

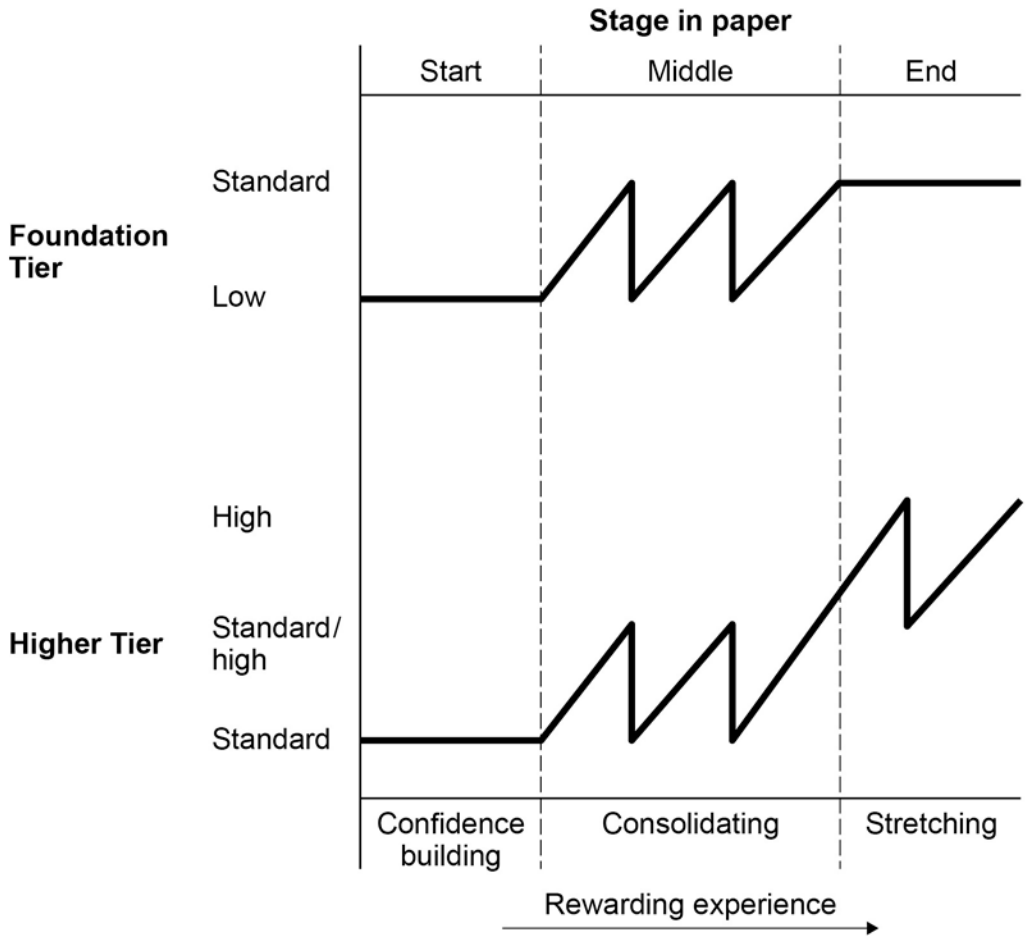
- closed: multiple-choice, link boxes, sentence completion, labelling diagrams
- open: labelling/drawing diagrams, short answer, calculations, extended response.

Our questions are structured. Within a whole question (eg question 01) there are several parts (eg 01.1, 01.2, 01.3 and 01.4) that link to a common theme/topic. We'll scaffold more questions in Foundation Tier papers and there will be a higher proportion of multiple-choice and short answer questions. In Higher Tier papers there will be more marks for open and extended response questions.

Ramping and level of demand

Ramping means that a question gets progressively more difficult as you work through it. Questions for any topic area will be ramped in terms of demand within the question as well as within the paper.

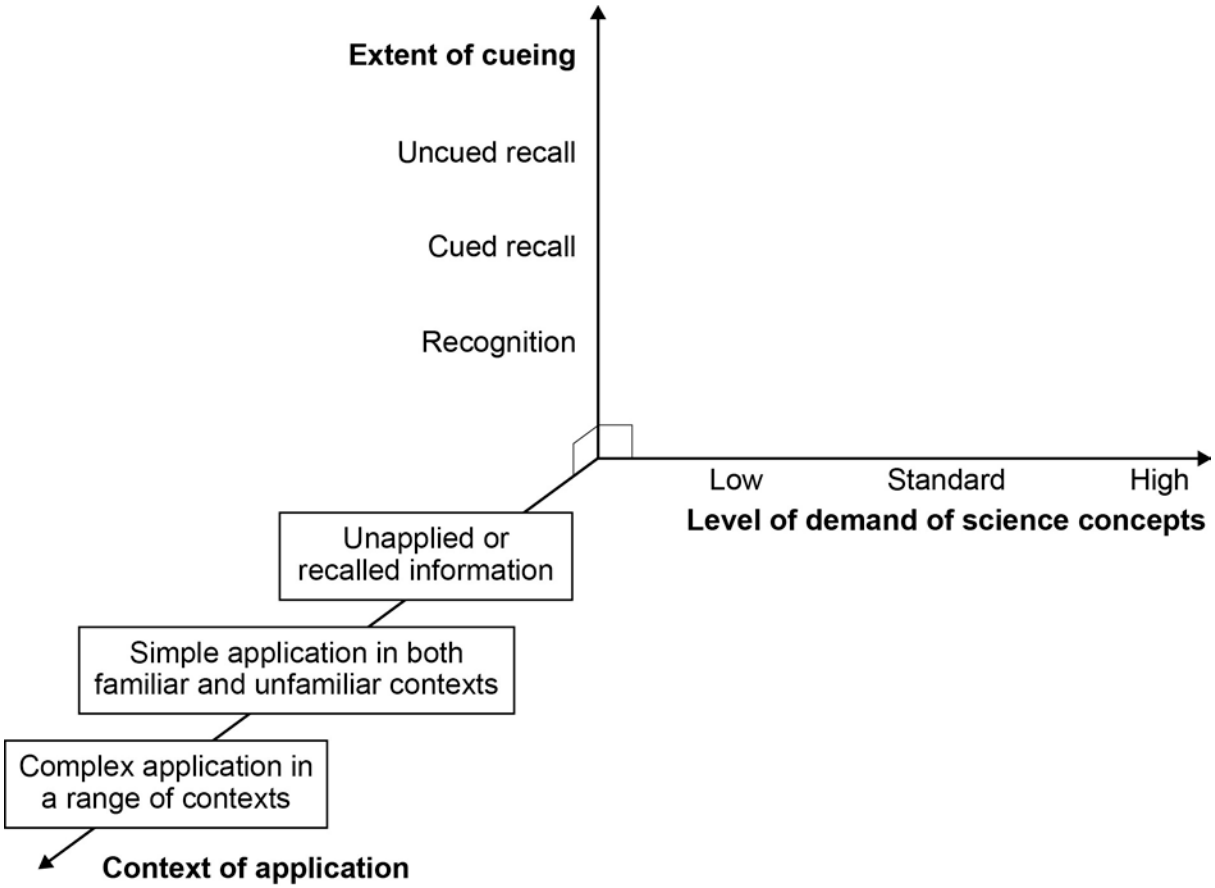
Some questions will step up in demand gradually, others quite sharply. This allows all students a fair chance of gaining some marks on each topic area throughout the paper. It also allows the demand of each paper to increase steadily through the paper.



The diagram illustrates the model we use to structure the ramping of Foundation Tier and Higher Tier question papers.

- Both tiers start with confidence-building questions set at the lowest demand for the paper: 'Low' for Foundation Tier; and 'Standard' for Higher Tier.
- The middle of each paper introduces ramping of each question up to the next level of demand. Within each question the demand increases, then the following question starts again at a lower demand.
- The end of the paper is where the students' ability is stretched the most. In the Foundation Tier this means questions are set at standard demand (common with the Higher Tier). In the Higher Tier the latter questions continue to ramp, but at a much higher level.

Level of demand is determined by factors such as: concept, context, content, the number of marks and the command word(s) used. The number of marks assigned to each level of demand within each paper is not precise (within a range) due to the complexity of these factors.



Foundation Tier papers are made up of low demand questions (aimed at grades 1–3); and standard demand questions (aimed at grades 4–5). A greater proportion of questions will be low demand.

Higher Tier papers are made up of: standard demand questions (aimed at grades 4–5); standard/high demand questions (aimed at grades 6–7); and high demand questions (aimed at grades 8–9).

Common questions

We will have a minimum of 30% of marks for common questions between Foundation and Higher Tier papers. This allows us to better align standards for grades 4–5. Common questions will be standard demand.

Working Scientifically

Working Scientifically† is a fundamental part of learning science. It is the sum off all the activities that scientists do and it's important to weave it throughout our papers. You will find many questions that reward student understanding of practical and enquiry skills as well as questions that require knowledge of how scientists know what they know.

Assessment Objectives

The exams will measure how students have achieved the following assessment objectives†.

AO1: Demonstrate knowledge and understanding of:

40% 1) scientific ideas

2) scientific techniques and procedures.

AO2: Apply knowledge and understanding of:

40% 1) scientific ideas

2) scientific enquiry, techniques and procedures.

AO3: Analyse information and ideas to:

20% 1a) interpret

1b) evaluate

2a) make judgements

2b) draw conclusions

3a) develop experimental procedures

3b) improve experimental procedures.

Linked questions

Some questions will test students' ability to link topics across different areas of the specification†. These questions that are 'linked' are more likely to be open, extended-response and marked using a levels of response mark scheme. They can also be several part questions underpinned by a common theme.

† indicates requirements set by the DfE and Ofqual.

Mathematical skills

† Mathematical skills will be tested at least to the standard of: Key Stage 3 Maths in Foundation Tier papers; and Level 1/Foundation Tier GCSE Maths in Higher Tier papers.

† A minimum of 10% of marks will test mathematical skills in biology; 20% in chemistry; and 30% in physics. For the two combined science qualifications mathematical skills will be in the ratio of 1:2:3.

Equations

There are two lists of physics equations:

1. Students must be able to recall and apply these equations.
2. Equations are given on a sheet inserted into the question papers; students must be able to select and apply these equations.

Accessibility

Clear language and layout of papers is important for **all** students. Our aim is to ensure students can understand what the question is asking and assess the science, not comprehension. This will give students the opportunity to gain the credit they deserve.

There are basic principles we work towards.

We:

- put command words at the beginning of a sentence, and use one per sentence
- use standard wording/instructions
- use direct questioning (eg what, why, how) where suitable
- add 'scaffolding' to questions to act as a guide
- ensure sentence length is less than 20 words
- use bullet points to clearly display specific strands of information
- embolden key bits of information
- ensure diagrams are relevant and clear
- only use italics for binomial names eg *S. mokarran*, and equations eg *E*p = *m g h*
- explain unfamiliar terms
- reduce repeated information
- include plenty of white space to improve readability.

† indicates requirements set by the DfE and Ofqual.

Sample questions with commentaries

Questions are from the draft specimen assessment materials submitted to Ofqual.

These may change in the final specimen papers but the types of question we use and our basic principles will remain.

Each example shows the specification reference, mathematical skill (MS), Working Scientifically (WS) reference and assessment objective (AO). Specific details on MS and WS can be found in section 3 of the relevant specification.

Question scaffolding

Throughout this booklet we have illustrated many ways on how we 'scaffold' questions to help students express their answer.

Answer line prompts are one type of scaffolding we often use. These are given to make the question more accessible by taking information already given in the question to help students structure their answer.

Biology – paper 1F, question 03.6

This question requires students to use a step-by-step process to estimate the size of a cheek cell. Students should be able to carry out calculations involving magnification, real size and image size.

The question is scaffolded into three steps of increasing difficulty. This is to make the calculation accessible to all students, particularly those who find calculations difficult.

The standard command word 'complete' and indicates the responses required. Each step uses a specific instruction:

- 'measure' to direct students to use a ruler
- 'use the equation to work out' to lead them correctly through the calculation
- 'convert' to answer with the appropriate SI units.

This question is designed to differentiate across the Foundation Tier attainment range. The final step is likely to be too difficult for some students.

Spec. ref.:	4.1.1.5	**MS:**	1c 2h 4a	**WS:**	3.2 3.3	**AO:**	AO2/2	**Demand:**	Low–standard

The cheek cell in **Figure 6** is magnified 250 times.

The width of the cell is shown by the line **D** to **E**.

Figure 6

0 3 . 6 Calculate the width of the cheek cell in micrometres (μm).

Complete the following steps.

[3 marks]

Measure the width of the cell using a ruler _____ mm

Use the equation to work out the real width of the cell in mm:

$$\text{real size} = \frac{\text{image size}}{\text{magnification}}$$

_____ mm

Convert mm to μm _____ μm

03.6		180 (μm) without working gains **3** marks		AO2/2 4.1.1.5
	45 (mm)		1	
	45 / 250 **or** 0.18 (mm)	allow ecf	1	
	180 (μm)		1	

Cheek cell © Ed Reschke/Getty Images

Multiple-choice questions (MCQs)

MCQs will feature in all papers. Often MCQs will appear at the beginning of questions to give students confidence. Including these questions allows us to test a greater breadth of content across our examinations. However, MCQs should not be considered as easy marks; some feature in Higher Tier papers at higher levels of demand.

MCQ types include:

- tick box
- linking boxes
- sentence completion.

Chemistry – paper 1H, question 08.6

Students need to calculate that the pH has changed by 10 pH units. Plus as it's a logarithmic scale this means a change in concentration of 10^{10}. This content is Higher Tier only.

Spec. ref.:	4.2.2.5	**MS:**	2h	**WS:**	n/a	**AO:**	AO2/1	**Demand:**	High

0 8 . 6 The student repeated the titration using a pH probe instead of an indicator.

The pH changed from pH 13 to pH 3.

By what factor did the hydrogen ion concentration change?

[1 mark]

Tick **one** box.

- 10 ☐
- 100 ☐
- 1 000 000 ☐
- 10 000 000 000 ☐

08.6	10 000 000 000		1	AO2/1 4.4.2.5

Biology – paper 1H, question 09.1

This question is an example of where a MCQ can be used to assess knowledge at high demand. It is expected that only high attaining students will have studied cell division in sufficient detail to answer correctly.

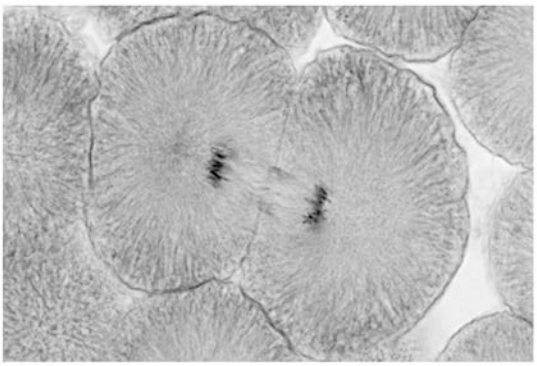
The question is worded simply to make it accessible and students are given three options from which to choose the correct answer. We try not to use negative questions but when we do we make it clear to students by emboldening the 'not'. The photographs are presented at a size whereby it's clear to students to distinguish between the three.

Spec. ref.:	4.1.2.2	**MS:**	n/a	**WS:**	3.5	**AO:**	AO2/1	**Demand:**	High

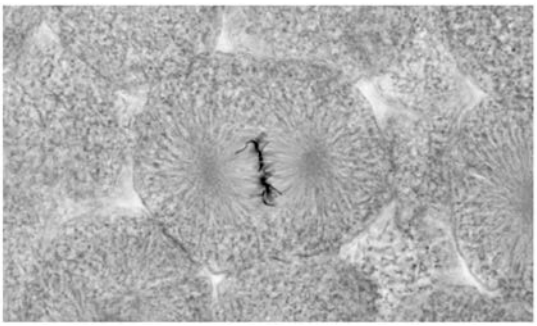
0 9 **Figure 7** shows photographs of some animal cells at different stages during the cell cycle.

Figure 7

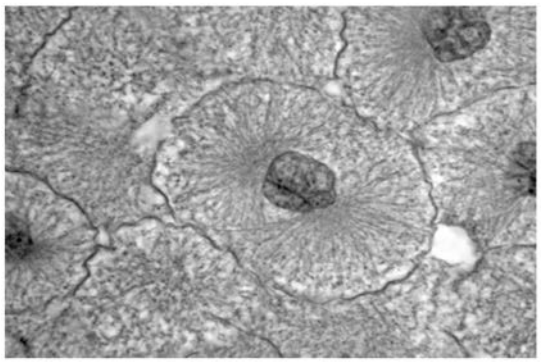
A



B



C



0 9 . 1 Which photograph in **Figure 7** shows a cell that is **not** going through mitosis?

[1 mark]

Tick **one** box.

A ☐ **B** ☐ **C** ☐

09.1	**C**		1	AO2/1 4.1.2.2

Telophase © Ed Reschke/Getty Images
Metapahse © Ed Reschke/Getty Images
Interphase © Ed Reschke/Getty Images

Link box

This type of question is useful for asking about multiple things that are linked, often definitions.

They are good at discriminating within a level of demand.

In terms of accessibility link box questions:

- are clear and straightforward
- reduce the amount of text required for a question
- introduce white space.

For link box questions we use a set direct style that is familiar to students:
‘Draw ***x*** line(s) from each ***y*** to ***z***’.

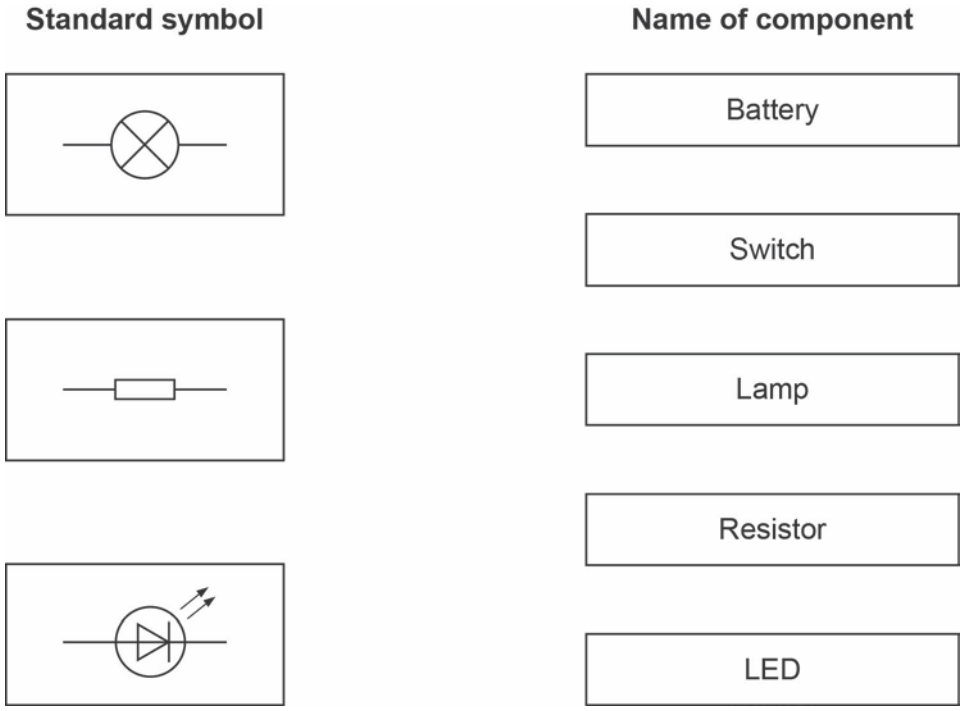
Combined Science: Synergy – paper 3F, question 05.1

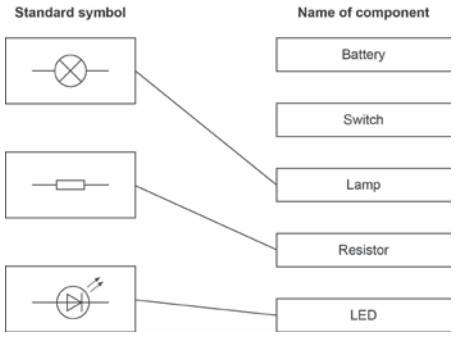
Students are required to recognise and use the standard symbols for common circuit elements.
Low attaining students can find drawing symbols and circuits daunting. This is a straightforward way of allowing students to demonstrate their knowledge without taxing their drawing skills.

Spec. ref.:	4.7.2.4	**MS:**	n/a	**WS:**	4.1	**AO:**	AO1/1	**Demand:**	Low

0 5 . 1 Draw **one** line from each symbol to the name of the component.

[3 marks]



05.1		extra lines from a symbol negate the mark	1 1 1	AO1/1 4.7.2.4

Sentence completion

These questions require students to complete sentences by either using prompts (words in a box) or without using prompts. As with link box questions, sentence completion questions are useful for asking about multiple things that are linked. The sentences are simple in terms of language construction and the gaps in the sentences are at the end of each sentence so that students do not need to refer back.

Biology – paper 2F, question 05.3

Students are expected to use their knowledge of deforestation to explain what effect this has upon the gases in the atmosphere.

The earlier parts of the question lead students into this low demand closed question. Students need to complete simple sentences using words from the box. There are six words to choose from for two marks. This question will differentiate well. The options pick up on common misconceptions encountered in this topic about the roles of photosynthesis and respiration.

Spec. ref.:	4.7.3.4	**MS:**	n/a	**WS:**	n/a	**AO:**	AO2/1	**Demand:**	Low

0 5 . 3 More forest was lost in 2012 than in 2009.

Use words from the box to complete the sentences.

[2 marks]

carbon dioxide	**excretion**	**nitrogen**
oxygen	**photosynthesis**	**respiration**

The increase in the area of forest lost has caused an increase

in the gas _____ .

The increase of this gas has been caused because less of the gas is being

absorbed by plants for the process of _____ .

05.3	carbon dioxide	in this order only	1	AO2/1 4.7.3.4
	photosynthesis		1	AO2/1 4.7.3.4

Short answer

Short answer questions will feature in all papers. Often they will be at the beginning of group of related questions to give students confidence. They are a good way to introduce students into an area of specification content before building up to extended response questions.

Combined Science: Trilogy – chemistry paper 2F, question 02.5

This question tests recall of a principle in a practical situation. Students have to apply the principle of using the boiling or melting point as a practical test for purity.

Spec. ref.:	5.8.1.1	**MS:**	n/a	**WS:**	2.2	**AO:**	AO1/1 AO2/1	**Demand:**	Standard

0 2 . 5 Describe how you could check if a liquid is pure.

[2 marks]

02.5	boiling or melting point at specific temperature		1 1	AO2/1 AO1/1 5.8.1.1

Combined Science: Synergy – paper 1H, question 09.4

The specification requires students to be able to describe evidence that it is the wave and not the water that moves. The question is based on a practical situation, presenting two contrasting statements and asking students to devise a way of working out which is correct.

The question is set at high demand. This is because of a combination of the following factors:

- It is not a required practical, and students may not have direct experience of the situation.
- It's in an open response format.
- Students need to take what they have learned in the abstract and apply it.

The command word 'suggest' recognises that this is a situation in which students may not be familiar and indicates that they should apply their knowledge.

The question is made accessible by:

- referring students back to the diagram
- giving each statement on a separate line
- using bold lettering to make the statements easily identifiable.

Spec. ref.:	4.1.4.1	**MS:**	n/a	**WS:**	2.2	**AO:**	AO2/2	**Demand:**	High

0 9 . 4 Some students investigated the properties of the waves generated in **Figure 8**.

Student **A** said 'the waves move water from one end of the tank to the other'.

Student **B** said 'that's wrong. Only the waves move, not the water'.

Suggest what the students could do to decide which of them is correct.

[2 marks]

09.4	place a floating object / plastic duck on the surface of the water it will stay in the same place **or** only bob up and down if the water doesn't move		1 1	AO2/2 4.1.4.1

Calculations

We have a set approach to the recall of equations and the level of demand of calculations. This consistency is to ensure students are rewarded fairly, across all subjects, for calculation questions.

For all calculation questions we use the 'error carried forward' principle so that students are only penalised for one error.

Low demand: equations will be given in the body of the question. This will allow students working at the lower grades to access AO2 calculation questions.

Should only be 'simple' equations with substitution of two numbers that are easy to manipulate. No transformation.

Standard demand: a prompt will be given with regard to the equation required eg 'Write down the equation which links distance, speed and time.'

Questions will involve substitution with something 'extra' (or be a more complex equation). The 'extra' could be: a transformation; change a quantity ie grams to kg; or obtaining data from somewhere eg from a graph or selecting appropriate data to use.

Standard/high demand: prompt given as for standard demand, with questions to involve a transformation and something 'extra'.

High demand: use of one of the equations that students have difficulty with (generally the given equations). Also, includes a transformation/something 'extra' or a multi-step calculation with no lead in or guidance given. If the question involves students needing to recall a required equation then a prompt for this is still given.

Transformations usually don't gain an additional mark. So for example, if calculating R using $V = I R$ then, as we do now, award two marks for the correct numerical answer. If these marks are not scored then allow one compensation mark for correct substitution or correct transformation and substitution.

The exceptions where transformation marks will be awarded are:

$E_k = ½ m v^2$ if v is required

$P = I^2 R$ if I is required

$V^2 – U^2 = 2 a s$ for any of the 4 quantities

$\frac{V_p}{V_s} = \frac{N_p}{N_s}$ for any quantity (provided V_s or N_s is not equal to 1)

This is due to the demand involved in rearranging these equations.

The nature of calculations means that there is often several strands of information and more than one command. So, for students to be able to take all of this information in, we split strands of information on separate lines. We also give prompts on the final answer line to reinforce what we're looking for in an answer.

Physics – paper 2F, question 01.2

This is a low demand calculation set in a wider context. The equation required has been provided (the equation will be required recall at least once in the lifetime of the specification). The command word 'calculate' is a standard command word indicating the type of response required.

The mark scheme allows students that show a correct method to gain credit even though the student may not be able to complete the arithmetic correctly. Two marks would be awarded if the correct final answer is found without any working been shown.

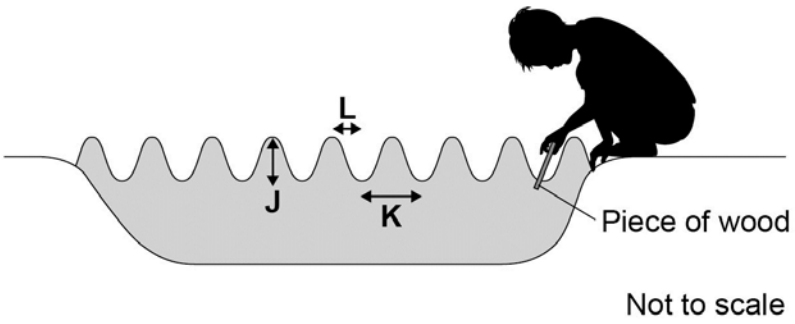
Spec. ref.:	4.3.1.2	**MS:**	3c	**WS:**	n/a	**AO:**	AO2/1	**Demand:**	Low

0 1 A child hits the surface of the water in a pond with a piece of wood.

This causes small water waves to move across the surface of the water.

Figure 1 shows a cross-section of the pond and water.

Figure 1



0 1 . 2 The waves produced have a wavelength of 0.12 m and a frequency of 3.0 Hz.

Use the following equation to calculate the speed of the waves.

wave speed = frequency × wavelength

[2 marks]

Wave speed = _____ m/s

01.2	speed = 3 × 0.12 speed = 0.36	 allow 0.36 with no working shown for the **2** calculation marks	1 1	AO2/1 4.3.1.2

Physics – paper 1F/1H, question 12.3/02.3

This question requires students to select and apply an equation from the Physics Equation sheet to this practical situation. They have to rearrange the specific heat capacity equation to calculate the mass of water used.

Students get one mark for a correct substitution of the numbers into the equation, and the second mark for the answer.

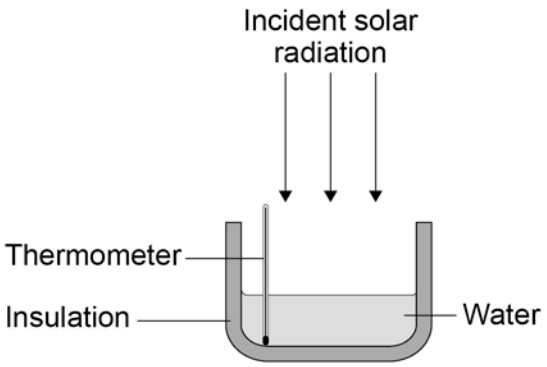
Spec. ref.:	4.2.1.4	**MS:**	3b 3c	**WS:**	n/a	**AO:**	AO2/2	**Demand:**	Standard

1 2 A student investigated how much energy from the Sun was incident on the Earth's surface at her location.

She put an insulated pan of water in direct sunlight and measured the time it took for the temperature of the water to increase by 10 °C.

The apparatus she used is shown in **Figure 16**.

Figure 16



The energy transferred to the water was 21 000 J.

The time taken for the water temperature to increase by 10 °C was 6000 seconds.

The specific heat capacity of water is 4200 J/kg °C.

1 2 . 3 Calculate the mass of water the student used in her investigation.

Use the correct equation from the Physics Equations Sheet.

[2 marks]

Mass = _____ kg

12.3	correct substitution ie 21 000 = m × 4200 × 10 mass = 0.5 (kg)	accept 0.5 (kg) with no working shown for the **2** calculation marks	1 1	AO2/2 4.2.1.4

Combined Science: Trilogy – chemistry paper 2H, question 04.3

Students are required to deduce the molecular formula of paracetamol from a given diagram.

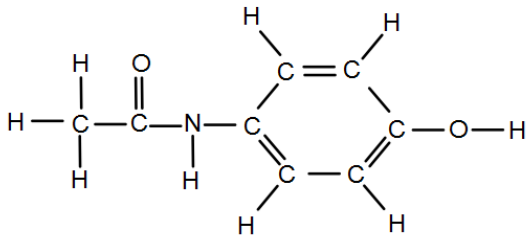
The command word 'calculate' makes it clear what is then required. The provision of the relative atomic masses in the question will reduce errors in reading values from the periodic table in the multi-step calculation.

Spec. ref.:	4.2.1.4	**MS:**	3a	**WS:**	1.2	**AO:**	AO2/1	**Demand:**	Standard/ high

0 4 . 3 The main ingredient in Aqamed is a painkiller called paracetamol.

Figure 8 represents a molecule of paracetamol.

Figure 8



Give the molecular formula of paracetamol.

Calculate its relative formula mass (M_r).

Relative atomic masses (A_r): H = 1; C = 12; N = 14; O = 16

[2 marks]

Molecular formula _____

Relative formula mass _____

_____

M_r = _____

04.3	$C_8H_9NO_2$	Any order of elements	1	AO2/1 5.2.1.4
	151		1	5.3.1.2

Combined Science: Trilogy – physics paper 1H, question 06.4

Students are required to recall the equation: density = mass × volume. The other four marks require students to apply this equation to the situation given to come up with an answer. They must then use this answer, select the appropriate equation from the equation sheet, perform another substitution and calculate the final answer.

The mark scheme clearly shows which mark is available for which part of the calculation. It also clarifies that there is no mark available for the selection of the equation from the equation sheet. There is a reminder in the wording that students must write down the equation used. An answer with no equation can only gain a maximum of four marks.

This is a very challenging multi-step calculation which will test the mathematics skills and physics understanding of the most able.

See how the first three lines of 06.4, which contain the strands of figures required, are on separate lines to improve readability.

Spec. ref.:	6.6.2.3	**MS:**	1b 3b 3c 3d	**WS:**	n/a	**AO:**	AO2/1	**Demand:**	High

Water vapour is a gas. Gases change state when they cool.

Figure 9 shows condensation on a cold bathroom mirror.

Figure 9

Bathroom mirror condensation © Dwight Eschliman/Getty Images

0 6 . 4 A volume of 2.5×10^{-5} m^3 of condensation forms on the mirror.

Density of water = 1000 kg/m^3

Specific latent heat of vaporisation of water = 2.26×10^6 J/kg.

Calculate the energy released when the condensation forms.

Write down the equations you use.

[5 marks]

Energy released = _____ J

06.4	Density = mass / volume		1	AO1/1
	m = $2.5 \times 10^{-5} \times 1000$		1	AO2/1
	m = 0.025 (kg)		1	AO2/1
	E = $0.025 \times 2\ 260\ 000$		1	AO2/1
	E = 56 500 (J)		1	AO2/1
		allow 56 500 (J) without working shown for the **4** calculation marks		6.6.2.3
		0 marks awarded for E = m × L		

Combined Science: Synergy – paper 4H, question 09.2

This question is intended to stretch the most able students. They must recall the equations for calculating gravitational potential and kinetic energy from the specification and apply them to the given situation. The instruction to write down any equations they use let students know they need to recall and use equations. They are told to make an assumption that will help them in the calculation.

Students need to go through a number of steps to produce the correct answer.

Students must:

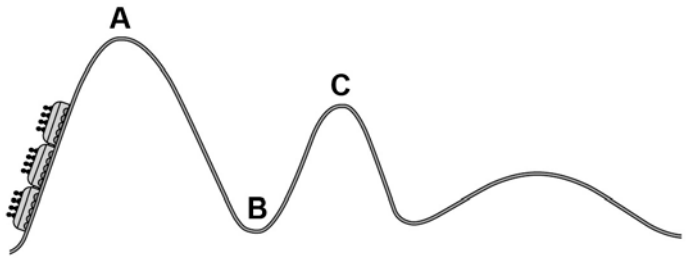
1. be able to recall and substitute into the equation to calculate the gravitational potential energy
2. understand that in this situation the gravitational potential energy is equal to the kinetic energy
3. recall the equation for calculating kinetic energy
4. rearrange the equation and substitute into it to calculate the correct answer (this is one of the equations where marks are awarded for rearrangement).

Students should show their working in all calculations. If they simply give an answer and it is wrong they will gain no marks, whereas they may achieve marks for correct working even if the final answer is incorrect. In this question, students who do not show their working but give the correct answer are assumed to have used the correct equations and will receive the four marks available for the calculation.

Spec. ref.:	4.6.1.5 4.7.1.9	**MS:**	3b 3c	**WS:**	3.3	**AO:**	AO1/1 AO2/1	**Demand:**	High

0 9 **Figure 6** shows a rollercoaster.

Figure 6



The rollercoaster is raised a vertical distance of 35 m to point **A** by the motor.

The motor takes 45 seconds to lift the rollercoaster to point **A**.

The mass of the rollercoaster is 600 kg.

The motor has a power rating of 8 kW.

0 9 . 2 The rollercoaster rolls from point **A** to point **B**, a drop of 35 m.

Calculate the speed of the roller coaster at point **B**.

Write down any equations you use.

Assume that air resistance is zero.

[6 marks]

Speed at point **B** = _____ m/s

09.2	gpe = 600 x 10 x 35 = 210 00	correct substitution into gpe = m g h	1	AO2/1 4.6.1.5
	gpe = KE		1	AO1/1
	KE = ½ m v^2		1	AO1/1
	$v = \sqrt{\frac{2 \times KE}{m}}$	correct rearrangement	1	AO2/1
	$= \sqrt{\frac{420\,000}{600}}$	correct substitution	1	AO2/1
	26.5 (m/s)	26.5 with no working shown gains the **4** calculation marks	1	AO2/1 4.7.1.9

Labelling and drawing diagrams

There are many types of questions centred around work on diagrams. They can be something as simple as using words from a box to label a diagram, all the way through to drawing and labelling a diagram as part of an extended response.

Chemistry – paper 2F/2H, question 09.3/02.3

This question is based on a required practical procedure that students can be expected to have carried out to distil salt solution. It draws on the basic knowledge of mixtures. Students are required to recall information directly from the specification. They must use their experience to complete and label a diagram to show how you would distil salt water.

Spec. ref.:	4.1.1.2 4.10.1.2	**MS:**	n/a	**WS:**	2.2 2.3	**AO:**	AO1/2	**Demand:**	Standard

0 9 . 3 Some countries make drinking water from sea water.

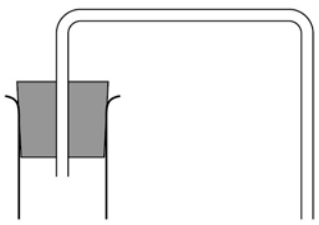
Complete **Figure 10** to show how you can distil salt solution to produce and collect pure water.

Label the following:

- pure water
- salt solution.

[3 marks]

Figure 10



09.3	(conical) flask containing salt solution test tube with pure water heat source		1 1 1	AO1/2 4.1.1.2 4.10.1.2

Biology – paper 2H, question 07.7

This is a five mark question with multiple steps of understanding needed to fully answer the question. The unscaffolded nature of the question and the unfamiliar context means the demand of this question is at standard/high. This question is far more open than a similar question, 09.5, on the Foundation Tier.

The question draws upon multiple skills based around being able to apply their understanding of genetic inheritance and genetic diagrams to draw a Punnett square. Then students need to analyse their Punnett square to give the probability of inheriting syndrome H.

The information is in three distinct 'chunks' so students can easily find what they need. Symbols are given to use for dominant and recessive alleles and there's ample space is given for the Punnett square.

Spec. ref.:	4.6.1.6	**MS:**	2e	**WS:**	3.2	**AO:**	AO2/2 AO3/3b	**Demand:**	Standard/ high

0 7 . 7 A recessive allele causes syndrome H.

A heterozygous woman and a homozygous recessive man want to have a child.

Draw a Punnett square diagram to find out the probability of the child having syndrome H.

Identify any children with syndrome H.

[5 marks]

Use the following symbols:

A = dominant allele

a = recessive allele

Probability = _____

07.7	mother / woman's gametes correct: A a		1	AO2/2 4.6.1.6
	father / man's gametes correct: a a		1	AO2/2 4.6.1.6
	correct derivation of offspring	ecf	1	AO2/2 4.6.1.6
	identification of child with syndrome H or genotype aa		1	AO2/2 4.6.1.6
	0.5	ecf allow 50% / 1/2 / 1 in 2 / 1:1 do **not** accept 1:2	1	AO3/3b 4.6.1.6

Graphs

We use a variety of graphs to test a range of skills covering all levels of demand. We have focused on making our graphs far clearer. For example, the amount of information displayed should be concise and relevant to the level being tested (ie graphs with two *y* axes are limited to the higher grades). Also, where applicable we use simpler gridlines instead of the standard 2 mm^2 grids. We want to assess students' ability to interpret information rather than bamboozling them by having to 'go searching in detail' for relevant information.

Combined Science: Trilogy – chemistry paper 2F, question 03.3

This is a simple one mark question requiring students to read information from a table and transfer it directly onto a bar graph.

Taking data and displaying it requires no manipulation or calculation. Therefore, this is low demand and is positioned near the beginning of the Foundation Tier paper to help build student confidence.

Spec. ref.:	5.10.1.2	**MS:**	4c	**WS:**	3.2	**AO:**	AO2/2	**Demand:**	Low

Table 3 shows the amounts of dissolved ions in a sample of drinking water.

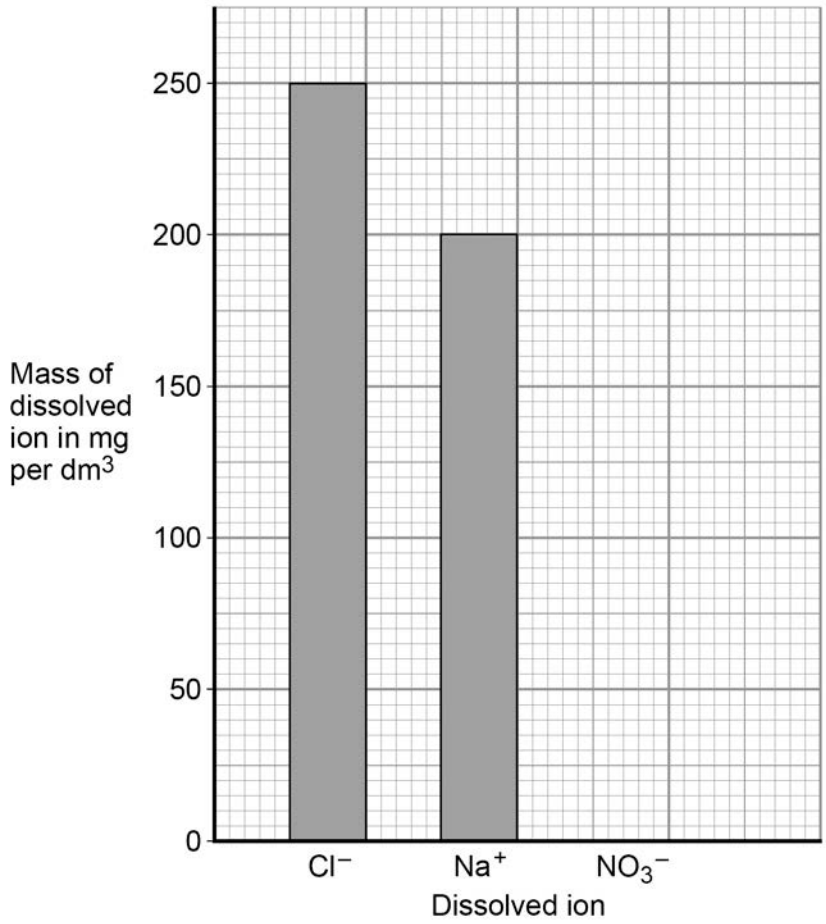
Table 3

Dissolved ion	**Mass in mg per dm^3**
Cl^-	250
Na^+	200
NO_3^-	40

0 3 . 3 Use the information in **Table 3** to complete the bar chart in **Figure 2**.

[1 mark]

Figure 2



03.3	correct bar for NO_3^-		1	AO2/2 5.10.1.2

Chemistry – paper 2F, question 05.5

Students have to plot a graph from given data. They need to then make a judgement from the data to reach a conclusion.

Students have been given the scale and labelled axes as scaffolding to the question. Also, the instructions for completing the graph are made clear by using a bullet list.

Spec. ref.:	5.10.1.2	**MS:**	4a 4c	**WS:**	3.5	**AO:**	AO2/2	**Demand:**	Low–standard

0 5 . 5 **Table 2** shows the student's results.

Table 2

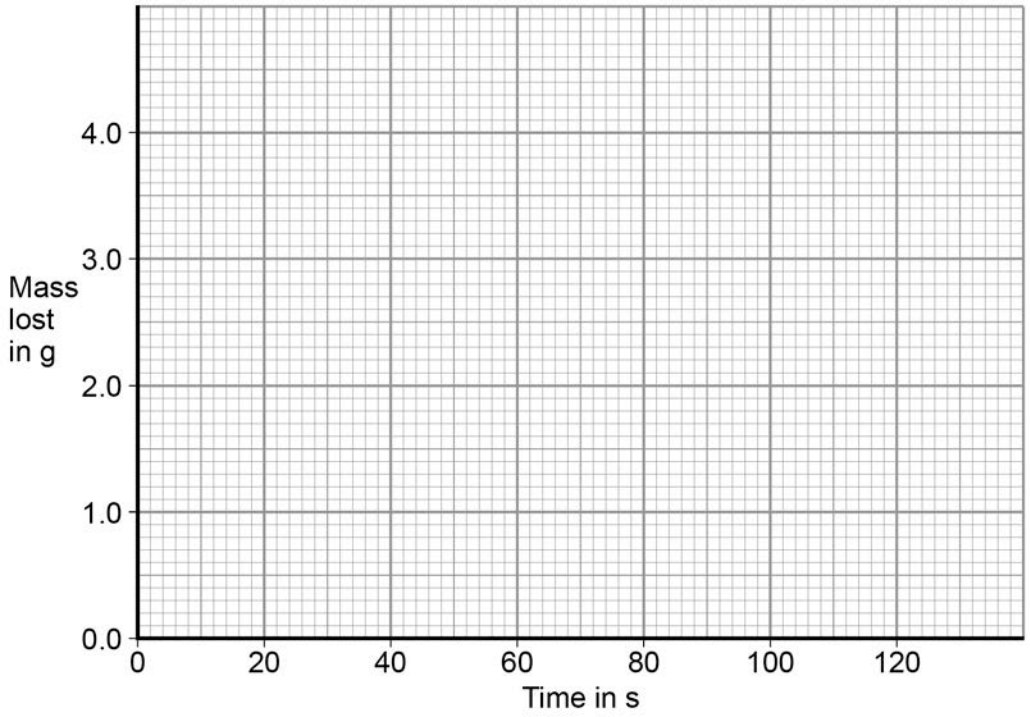
Time in s	Mass lost in g
0	0.0
20	1.6
40	2.6
60	2.9
80	3.7
100	4.0
120	4.0

On **Figure 6**:

- Plot these results on the grid.
- Draw a line of best fit.
- Draw a ring around the anomalous point.

[4 marks]

Figure 6



05.5	all points correct	± ½ small square ignore absence of plot at (0,0) allow **1** mark if 4 or 5 of the points from 20 s to 100 s are correct	2	AO2/2
	best fit line	must not deviate towards anomalous point	1	AO3/2a
	point at (60,2.9) circled		1	AO2/2 4.6.1.1 4.6.1.2

Combined Science: Trilogy – chemistry paper 1H, question 06.1

This question requires students to recall information directly from the specification. The complex nature of the topic being tested makes this more challenging.

Students are required to draw a reaction profile (energy level diagram) for an exothermic reaction. It needs to show the:

- relative energies of reactants and products
- activation energy
- overall energy change.

Again, the instructions are made clear by using a bullet list.

Spec. ref.:	5.5.1.2	**MS:**	n/a	**WS:**	1.2 4.1	**AO:**	AO1/1	**Demand:**	Standard–standard/ high

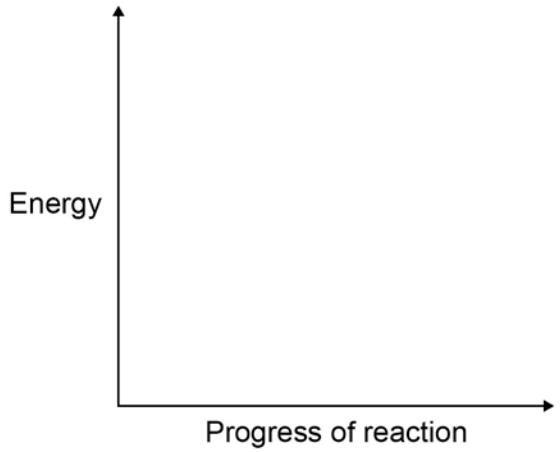
0 6 . 1 Draw a reaction profile for an exothermic reaction using the axes in **Figure 4**.

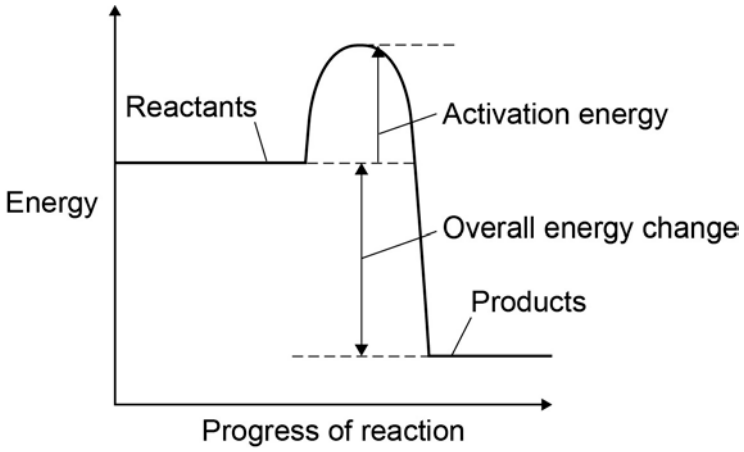
Show the:

- relative energies of the reactants and products
- activation energy
- overall energy change.

[3 marks]

Figure 4



06.1	the relative energies of the reactants and products the activation energy the overall energy change 	1 1 1	AO1/1 5.5.1.2

Combined Science: Synergy – paper 4H, question 10.3

This is a demanding graph plotting question. It uses negative numbers, which many students find difficult to handle, and a line of best fit that is a curve.

The demand ties in with GCSE Mathematics, where all levels of students need to be able to plot coordinates in all four quadrants. Students at this level are expected to understand that in science a line of best fit may be a curve.

Because of the difficulty of plotting negative numbers, for three marks students are expected only to plot the points, not complete the axes. They need to plot the points accurately, as the curve is used in a subsequent part of the question. Hence, the numbers given are straightforward considering the scale used.

The question should differentiate across the upper attainment range. Only the highest attaining students would be expected to get all three marks.

Spec. ref.:	4.7.2.2	**MS:**	4c	**WS:**	3.2	**AO:**	AO2/2	**Demand:**	Standard/ high–high

The student is given an electrical component in a sealed box.

She has to find out what the electrical component is by experiment.

The student records the current and the potential difference for the component.

Her results are shown in **Table 3**.

Table 3

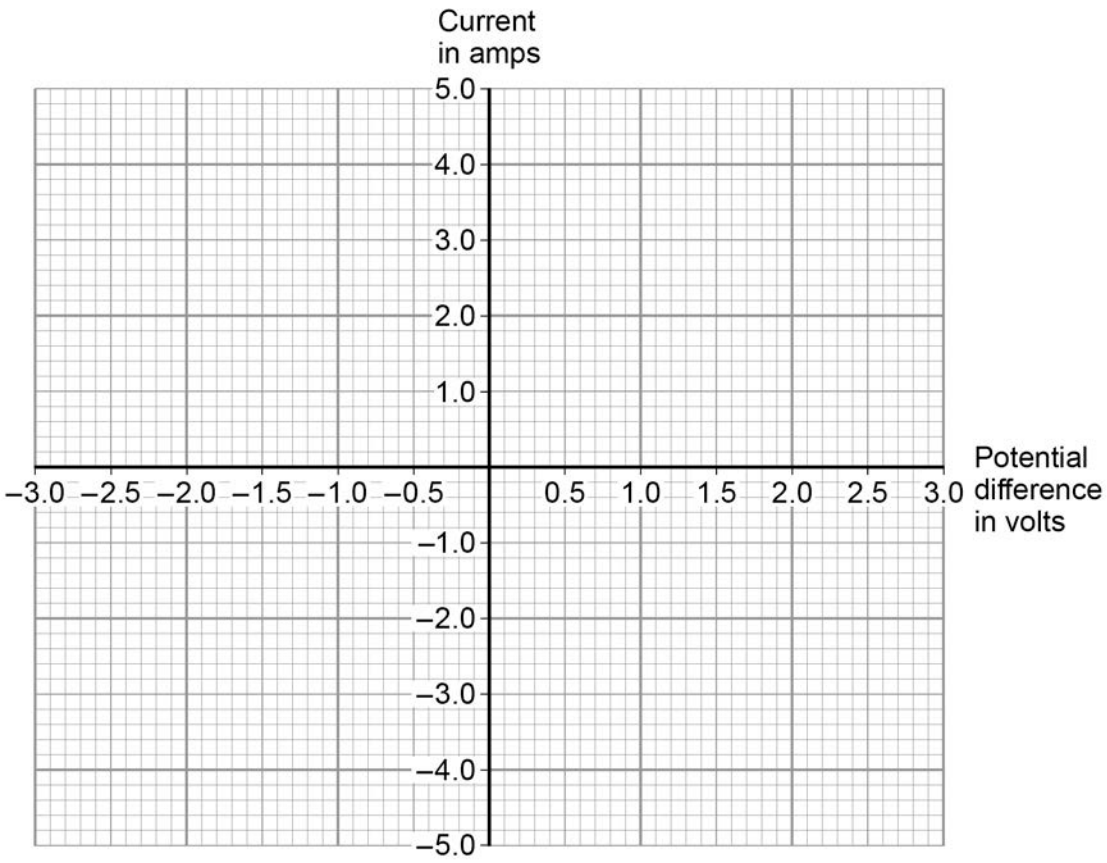
Potential difference in V	Current in A
–1.5	0.0
–1.0	0.0
–0.5	0.0
0.0	0.0
0.5	0.1
1.0	0.2
1.5	0.3
2.0	0.6
2.5	1.7
3.0	4.9

1 0 . 3 Use **Table 3** to plot a graph in **Figure 7**.

Draw a line of best fit.

[3 marks]

Figure 7



10.3	correct plotting of negative voltages correct plotting of positive voltages line of best fit		1 1 1	AO2/2 4.7.2.2

Chemical equations

It is expected that students are able to show their understanding of equations in all science disciplines. There are various levels of equations we ask ranging from: adding state symbols to an equation; completing a nuclear equation; and writing full balanced equations. We give more scaffolding to questions on the Foundation Tier.

Combined Science: Synergy – paper 1F/1H, question 09.1/02.1

This is a simple introduction to a longer question which is about a practical set in an unfamiliar context.

Students at all grades are required to know the word equation for respiration, and this is straightforward recall. One of the products is given, so students need to give the reactants for one mark and the other product for the second mark.

Although the question asks for a word equation, if students give the correct symbol equation they gain the marks.

Spec. ref.:	4.2.1.1	**MS:**	n/a	**WS:**	n/a	**AO:**	AO1/1	**Demand:**	Standard

0 9 . 1 Complete the word equation for respiration.

[2 marks]

_____ + _____ ⟶ _____ + water

09.1	glucose + oxygen carbon dioxide	allow $C_6H_{12}O_6 + 6O_2$ allow $6CO_2$	1 1	AO1/1 4.2.1.1

Combined Science: Synergy – paper 1H, question 11.3

Students should be able to use the names and symbols of common nuclei and particles to write balanced equations that show single alpha and beta decay. This is limited to balancing the atomic numbers and mass numbers.

The question tells students that lead is undergoing alpha decay, so they should recall that the missing product is $^{4}_{2}He$. They should then use this knowledge to deduce the rest of the numbers from the information already given.

The numbers given are straightforward. However, the calculation by deduction from the $^{4}_{2}He$ is not straightforward, so this question is set at standard/high demand. Again, for clarity, the equation text is enlarged to help students write their answer clearly.

Spec. ref.:	4.3.2.2	**MS:**	1c	**WS:**	n/a	**AO:**	AO2/1	**Demand:**	Standard/ high

1 1 . 3 Lead-210 is a radioactive isotope that decays to an isotope of mercury by alpha decay.

Complete the nuclear equation to show the alpha decay of lead-210.

[3 marks]

$$\_\_^{210}\_\_Pb \longrightarrow \_\_^{\_\_}_{80}Hg + \_\_^{\_\_}\_\_$$

11.3	$^{210}_{82}Pb \longrightarrow {}^{206}_{80}Hg + {}^{4}_{2}He$	one mark for each correct element in the equation	3	AO2/1 4.3.2.2

Chemistry – paper 1H, question 06.6

This question requires direct recall of the half equations for the reactions that occur in a hydrogen fuel cell. Higher Tier students are expected to be able to recall the equations for the reactions at the electrodes in a hydrogen fuel cell.

Previously recall of these half equations was at A-level A2 but now form part of the GCSE course under the new DfE criteria.

Spec. ref.:	4.5.2.2	**MS:**	n/a	**WS:**	1.4	**AO:**	AO1/1	**Demand:**	High

0 6 . 6 Write the **two** half equations for the reactions that occur at the electrodes in a hydrogen fuel cell.

[2 marks]

06.6	$H_2 \rightarrow 2H^+ + 2e^-$ $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$		1 1	AO1/1 4.5.2.2

Extended response

An extended-response question is an open response question worth four or more marks. In the GCSE science papers, extended response questions will be no greater than six marks.

Students are required to link ideas to produce a coherent, logical, structured answer. It also includes carrying out calculations where two or more steps are completed in the correct order.

There are two methods of marking extended-response questions:

- 'points marked' where the response matches the points listed on the mark scheme
- 'levels response' where a question can be answered in a number of ways, may require evaluative or decision-making skills and therefore some expert marker judgement is needed to award marks.

Combined Science: Synergy – paper 3F/3H, question 11.8/01.8

Students should be able to explain the mechanism of enzyme action: the 'lock and key' model. Students need to apply their knowledge to explain why amylase will not speed up all reactions. The instructions are clearly stated in two separate sentences: 'describe' instructs students to recall the process clearly; and 'explain' then indicates that they should give the reason. It is not marked using a levels of response mark scheme because there are four distinct marking points

Spec. ref.:	4.7.4.7	**MS:**	n/a	**WS:**	n/a	**AO:**	AO1/1 AO2/1	**Demand:**	Standard

1 1 . 8 An enzyme called amylase catalyses the reaction that breaks down starch to smaller molecules.

One model used to explain how enzymes affect reactions is called the lock and key model.

Describe the lock and key model of enzyme action.

Use the model to explain why amylase cannot be used to speed up **all** chemical reactions.

[4 marks]

11.8	enzymes have an active site		1	AO1/1
	which has a particular/specific shape or which only fits one type of molecule		1	AO1/1
	enzyme acts as the lock, the substrate is the key		1	AO1/1
	catalase will only fit with one molecule so won't work with other chemicals		1	AO2/1 4.7.4.7

Combined Science: Trilogy – biology paper 1H, question 08

This question provides an opportunity for an extended response at a high level of demand. Knowledge from two areas of the specification need to be linked. In this case, it requires some degree of lateral thinking to access full marks. Coupled with the difficult concept of active transport and unfamiliar context, this question is designed to stretch the most able of students.

This is an 'explain' question, so all points in the mark scheme have to be made in order to gain full marks. The first three marks are recall about active transport; the last two are for application of this knowledge. To ensure clarity of what we want students to write, the wording is kept concise and direct to avoid any confusion.

Spec. ref.:	4.1.3.3 4.4.2.1	**MS:**	n/a	**WS:**	1.2 3.6 4.1	**AO:**	AO1/1 AO2/1	**Demand:**	Standard/ high– high

0 8 Plants need nitrate ions in order to make proteins.

A plant is growing in soil flooded with water.

Explain why the plant cannot absorb enough nitrate ions.

[5 marks]

08	(nitrate) ions are absorbed by active transport		1	AO1/1 4.1.3.3
	(active transport) is the movement of ions against the concentration gradient		1	AO1/1 4.1.3.3
	(active transport) requires energy from respiration		1	AO1/1 4.1.3.3
	(respiration) requires oxygen		1	AO2/1 4.4.2.1
	no / little oxygen / air in water-logged soil		1	AO2/1 4.4.2.1

Chemistry – paper 1F, question 07.3

Students must draw on knowledge across the specification in order to 'compare' properties of transition metals with Group 1 elements. This question covers material that is detailed in our specification as 'Chemistry only'.

This question allows students to show their ability to write a sustained, logical, coherent response based on their knowledge of the periodic table.

This is a levels of response marked question.

The level is determined by:

- looking at the overall quality of the answer
- taking into account the chemistry content descriptor for each level
- using a 'best-fit' approach.

Once the level has been decided, the mark within the level is determined by the quality of the response at that level.

Spec. ref.:	4.1.2.5 4.1.3.1 4.1.3.2	**MS:**	n/a	**WS:**	n/a	**AO:**	AO1/1	**Demand:**	Standard

0 7 . 3 In the periodic table, Group 1 elements and the transition elements are metals.

Compare the chemical and physical properties of transition elements with Group 1 elements.

[6 marks]

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.3	**Level 3:** A number of properties of transition metals and Group 1 metals have been listed. There has been at least one comparison of properties made.		5–6	AO1/1 4.1.2.5 4.1.3.1 4.1.3.2
	Level 2: A number of chemical and physical properties are considered.		3–4	
	Level 1: One or more physical or chemical properties of transition metals or Group 1 metals.		1–2	
	Nothing written worthy of credit.		0	
	Indicative content Physical Transition metals • high melting points • high densities • strong • hard Group 1 • low melting points • low densities • soft Chemical Transition metals • low reactivity/react slowly (with water or oxygen) • used as catalysts • ions with different charges • coloured compounds Group 1 • very reactive/react (quickly) with water/non-metals • not used as catalysts • white/colourless compounds • only forms a +1 ion			

Combined Science: Synergy – paper 4H, question 08

This is a high level 'evaluate' question. Students must use the information given and their own knowledge of renewable and non-renewable energy resources. This is in the form of an argument for and against the use of wood chip as a renewable energy source.

The question specifies the issues that students should consider in their answer.

The open response format allows students to link ideas and develop a coherent response, demonstrating their scientific literacy. The question is marked using a levels of response mark scheme to allow for differentiation between levels of understanding. The level descriptors indicate the type of response expected and the amount of detail a student at each level is likely to give. Only the most able students are likely to give a Level 3 response.

Spec. ref.:	4.8.2.4	**MS:**	n/a	**WS:**	n/a	**AO:**	AO3/2a	**Demand:**	Standard/ high–high

0 8 It is claimed that burning wood chip is a renewable, carbon-neutral method of obtaining energy.

Read the statements about burning wood chips.

- It is estimated that the UK will burn 15–25 million tonnes of wood chip a year by 2017.
- Most of the wood chip burned in the UK comes from ancient hardwood forests in the USA, which have taken centuries to grow and are biodiverse.
- The wood chip is transported to the UK in bulk carrying ships, which burn fuel oil.
- Demand for wood chip is greater than supply.
- Exhaust gases from burning wood chip are at least as polluting as gases from burning coal.

Evaluate the economic, social, ethical and environmental issues associated with the use of wood chip as a renewable energy source.

[6 marks]

08	**Level 3:** The answer considers most of the statements and demonstrates a balance across all four areas specified in the question. The highest level of response gives an opinion that on this evidence wood chip is not an acceptable alternative to coal. It may question the validity of the statements since no references are given	5–6	AO3/2a 4.7.3.1
	Level 2: The answer will give an opinion of some sort, and considers most of the statements but may not be balanced. It may omit one of the areas specified in the question.	3–4	
	Level 1: The answer considers at least one of the areas specified in the question. The best answers at this level will consider more than one area. There may be an attempt at an opinion, but it may not be supported by the statements.	1–2	
	No relevant content	0	
	Indicative content Social • employment in the USA • loss of recreational resources when forests destroyed Environmental • destruction of habitats • atmospheric pollution caused by burning wood chip • atmospheric pollution caused by transport • not immediately carbon neutral • not immediately renewable Economic • cost of constructing power stations • cost of transporting wood chip Ethical • denying resources to future generations • potentially causing extinctions in the old forests • continual damage to the environment		

Practical skills

Questions on practicals will feature across papers with at least two required practicals featured in each series. The question types include all of those already contained within this booklet. There will be a minimum of 15% of marks† allocated to questions on practicals.

The specifications list the apparatus and techniques that the required practicals meet. Questions will reflect this list and include Working Scientifically sections 2 and 3.

Some questions will be on theoretical aspects of experimentation. For non-required practical contexts, all relevant information required to answer the questions will be given.

Questions based on practicals are very varied.

- Questions can be set in a practical context, but the question centres on the science, not the practical work.
- Some questions require specific aspects of a practical procedure to be understood in order to answer a question about the underlying science.
- Other questions require a thorough knowledge of the required practicals in order to answer the questions. This could be for planning or improving a method.

The following pages detail specific examples of types of practical questions we use, yet are not restricted to. They demonstrate the skills required through various stages of an investigation.

More detail, guidance and specific examples on the required practical questions will be given in the practical handbook for the GCSE sciences.

† indicates requirements set by the DfE and Ofqual.

Constructing hypotheses or finding evidence for a hypothesis
Physics – paper 2F, question 03.8

Students need to interpret and evaluate data in terms of a given hypothesis. Interpreting data is a procedure that students will have done in experiments. Students will also have experience of writing or testing a given hypothesis then testing to establish if the hypothesis is correct.

This question carries a single mark. The student should be able to evaluate the basic data to realise that the pattern does not support the hypothesis. The pattern and hypothesis are not complex and are easy to interpret and relate to each other.

Spec. ref.:	4.5.1	**MS:**	n/a	**WS:**	3.6	**AO:**	AO3/1b	**Demand:**	Low

0 3 . 8 Before starting the investigation the student wrote the following hypothesis:

'The bigger the area of a fridge magnet the stronger the magnet will be.'

The area of each magnet is given in **Table 1**.

Table 1

Fridge magnet	**Area of magnet in mm^2**
A	40
B	110
C	250
D	340
E	1350

Give **one** reason why the evidence from the investigation **does not** support the student's hypothesis.

[1 mark]

03.8	because the magnet with the biggest area was not the strongest	accept any correct reason that confirms the hypothesis is wrong	1	AO3/1b 4.5.1

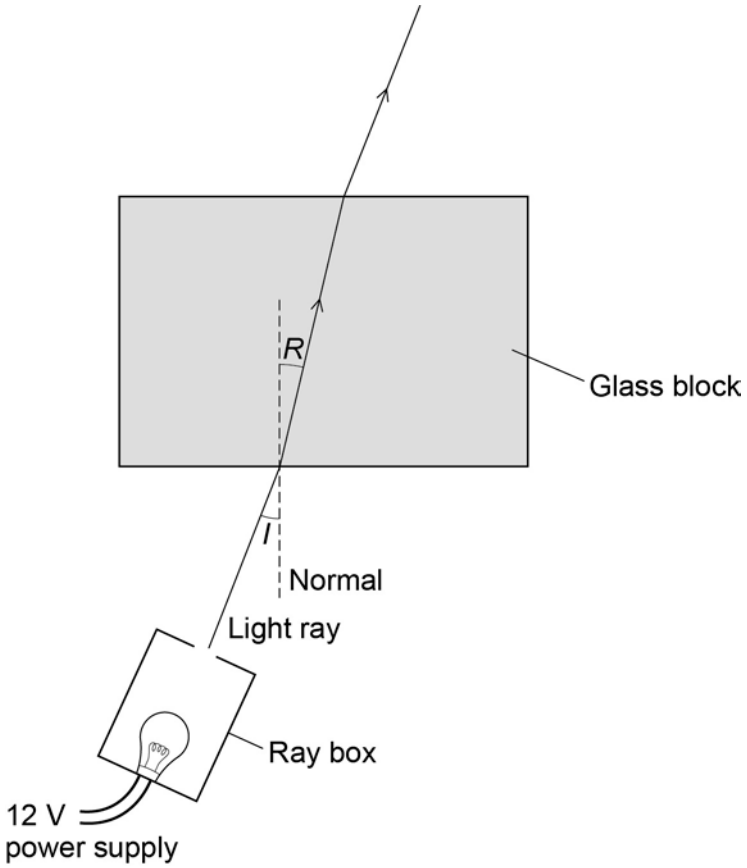
Plan a method
Physics – paper 2F/2H, question 13.2/03.1

This question is based on recall of one of the required practicals. By asking questions about the required practical experiments, the need to undertake all of the experiments is underlined. Asking the question in this way allows students to demonstrate their practical knowledge in the form of an extended response.

Spec. ref.:	4.3.2.2	**MS:**	n/a	**WS:**	n/a	**AO:**	AO1/2	**Demand:**	Standard

1 3 **Figure 24** shows the apparatus used to investigate how light changes direction when it enters a glass block.

Figure 24



The data given in **Table 6** was obtained by varying the angle ***I***.

Table 6

Angle *I*	**Angle *R***
20°	13°
30°	19°
40°	25°
50°	30°

1 3 . 2 Describe how the apparatus shown in **Figure 24** would be used to obtain the data given in **Table 6**.

[6 marks]

13.2	(place the glass block on a piece of paper,) draw around the block and then remove from the paper		1	AO1/2 4.3.2.2
	mark a normal line (at 90^o to the surface of the block). Use a protractor to measure and then draw a line at an angle of 20^o to the normal		1	
	replace the glass block and point the ray of light down the drawn line		1	
	mark the ray of light emerging from the block		1	
	remove the block and draw in the refracted ray		1	
	repeat the procedure for each of the other angles ***I***		1	

Safety considerations
Combined Science: Trilogy physics – paper 1F, question 03.3

Students need to recall possible safety precautions from one of the required practicals they will have undertaken during their study of the course.

This question also illustrates how we present detailed methods in question papers. We use:

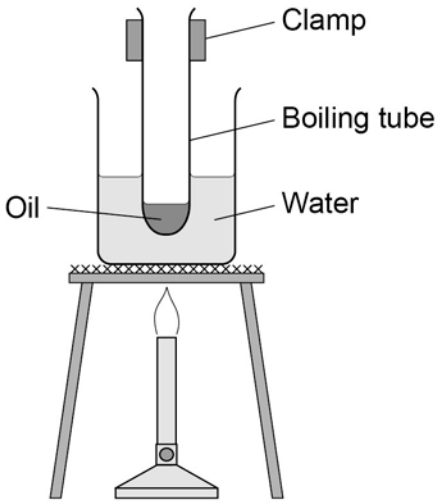
- direct wording to introduce the method: 'This is the method used'
- a numbered list to clearly show a sequence of events.

Spec. ref.:	6.2.1.4	**MS:**	n/a	**WS:**	2.4	**AO:**	AO1/2	**Demand:**	Low

0 3 A student investigated the change in temperature when oils of different specific heat capacities were heated.

She set up the apparatus shown in **Figure 5**.

Figure 5



This is the method used.

1. Put 25 g of oil into a boiling tube.
2. Pour 100 ml of water into a beaker and heat it with a Bunsen burner.
3. When the water is boiling, put the boiling tube into the beaker.
4. When the temperature of the oil reaches 30 °C heat for a further 30 seconds and record the rise in temperature.
5. Repeat with different oils.

0 3 . 3 Give **one** safety precaution the student should have taken.

[1 mark]

03.3	any **one** from: • wear safety goggles • oil not heated directly	accept any reasonable comment about not handling hot apparatus	1	AO1/2 6.2.1.4

Understanding variables
Physics – paper 2F, question 03.5

This question requires students to recognise the method given and identify that the thickness of the paper in this investigation is the control variable.

Spec. ref.:	4.5.1	**MS:**	n/a	**WS:**	2.2	**AO:**	AO3/1a	**Demand:**	Low

A student investigated the strength of fridge magnets.

The student put small sheets of paper between the magnet and the fridge door.

The student measured the maximum number of sheets of paper that each magnet was able to hold in place. The student tested five magnets, **A**, **B**, **C**, **D** and **E**.

0 3 . 5 Each sheet of paper used by the student had the same thickness.

What type of variable was the thickness of the paper?

[1 mark]

Tick **one** box.

- Control ☐
- Dependent ☐
- Independent ☐

03.5	control		1	AO3/1a 4.5.1

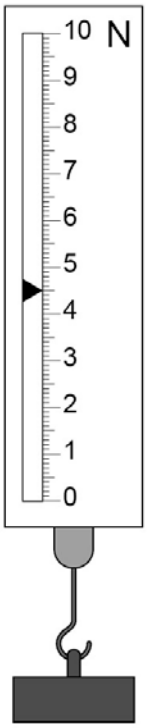
Reading scales
Combined Science: Synergy – paper 3F, question 01.3

Students need to take a reading from a newtonmeter. The use of a newtonmeter to measure weight is specified in the specification, so this is apparatus with which students should be familiar. In these types of question the diagram is clearly labelled, with a scale that is clear and easy to read. The diagram could be enlarged or given in a tactile format for visually impaired students. This mirrors the standard methods for making reasonable adjustments in practical work.

Spec. ref.:	4.6.1.4	**MS:**	4a	**WS:**	2.6	**AO:**	AO2/2	**Demand:**	Low

0 1 . 3 **Figure 1** shows a newtonmeter measuring the weight of an object.

Figure 1



What is the weight of the object?

[1 mark]

Weight = _____ N

01.3	4.5		1	AO2/2 4.6.1.4

Identifying errors
Combined Science: Synergy – paper 2F/2H, question 08.1/02.1

Students need to identify common mistakes in a practical set up and explain what effect the mistakes would have on the data obtained. The knowledge gained by doing this as one of the required practicals is underlined in this question.

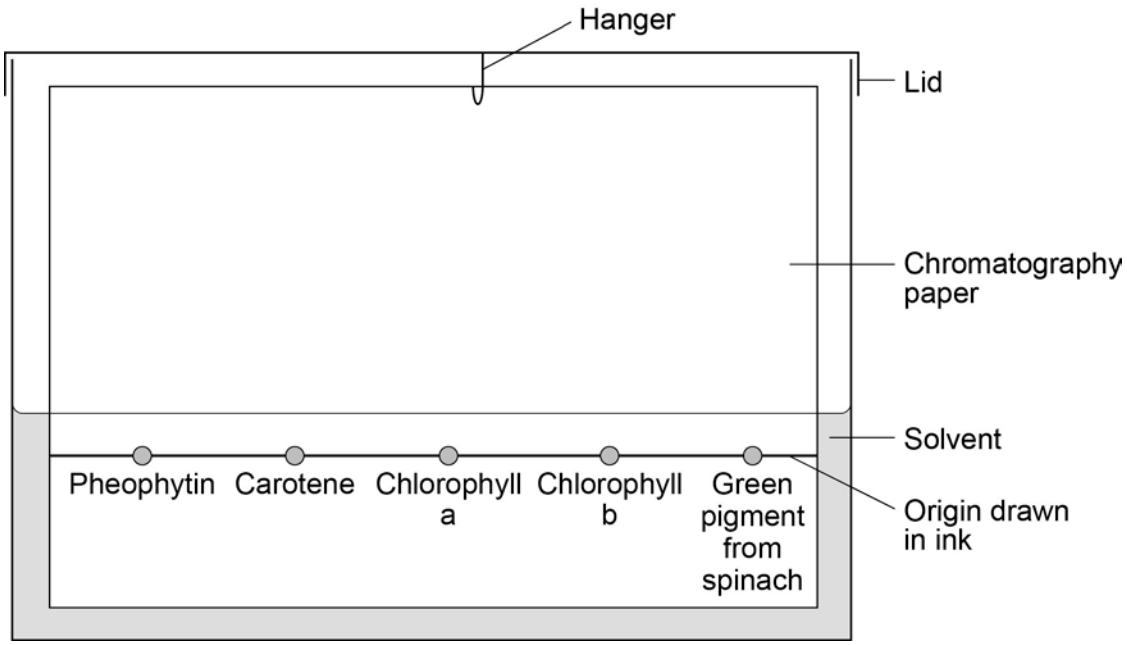
Spec. ref.:	4.2.2.4	**MS:**	n/a	**WS:**	2.7	**AO:**	AO3/3a	**Demand:**	Standard

0 8 A student used chromatography to identify the pigments in spinach leaves.

She compared a sample of pigment with some known pigments.

0 8 . 1 **Figure 11** shows the apparatus the student set up.

Figure 11



The student made **two** mistakes when she set up the apparatus.

Identify the **two** mistakes.

For each mistake, explain how the mistake would affect the results.

[4 marks]

08.1	origin line drawn in ink so it will run **or** dissolve in the solvent or split up spots under solvent **or** solvent above spots/origin line so they will mix with solvent **or** wash off paper **or** colour the solvent or dissolve in the solvent		1 1 1 1	AO3/3a 4.2.2.4

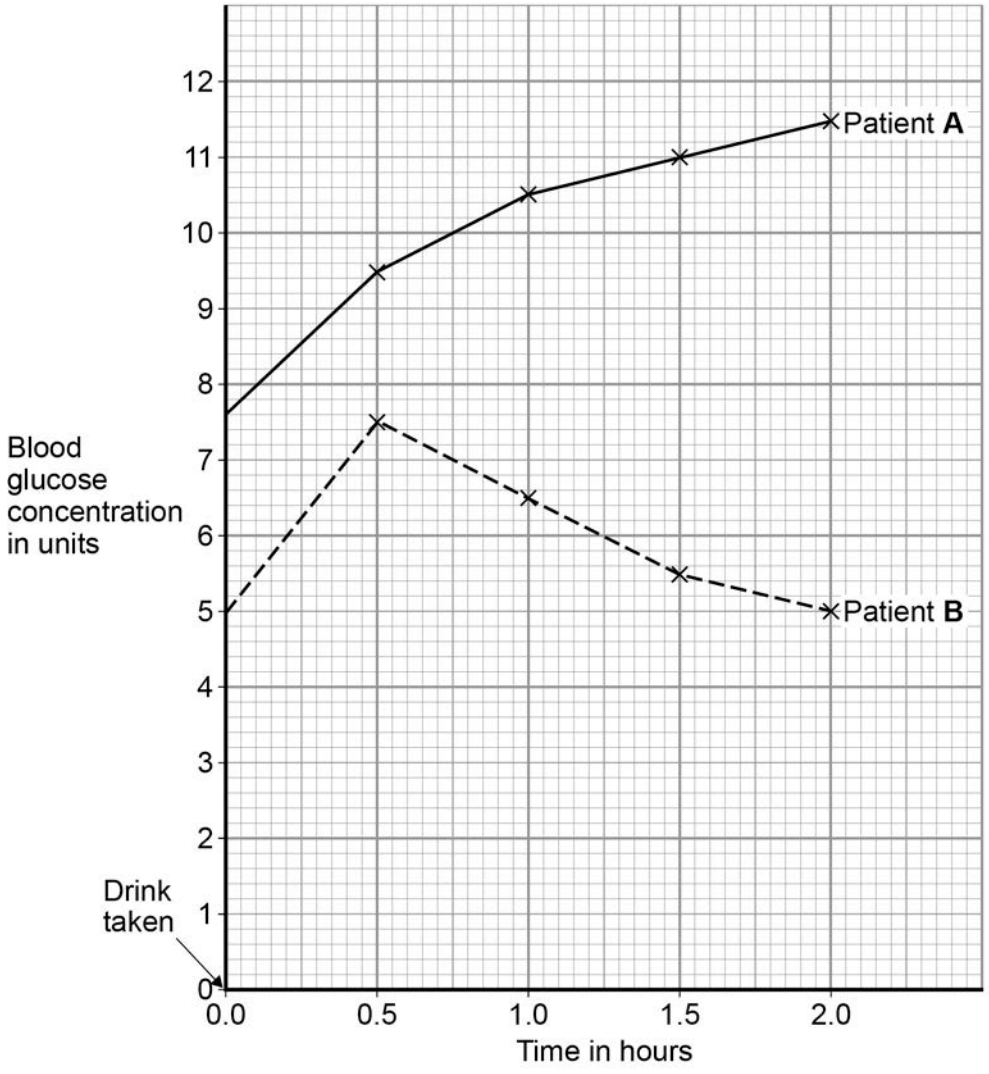
Data analysis
Biology – paper 2H, question 09.6

Students are required to analyse the graphical data by applying their knowledge of blood glucose concentration to identify which patient has diabetes. Also see how scaffolding is used to support their answer.

Spec. ref.:	4.5.3.2	**MS:**	n/a	**WS:**	n/a	**AO:**	AO3/2a	**Demand:**	Standard/ high

0 9 . 6 **Figure 11** shows the results of a glucose tolerance test for two patients, **A** and **B**.

Figure 11



Which patient has diabetes?

Justify your answer.

[2 marks]

Patient _____

Justification _____

_____

_____

_____

09.6	(patient **A**) glucose level much higher (than **B**) and remains high / does not fall	no mark for identifying **A**	 1 1	 AO3/2a 4.5.3.2 AO3/2a 4.5.3.2

Improvements
Combined Science: Trilogy – physics paper 1F, question 03.4

Students need to analyse the method and equipment presented and use this analysis and their practical experience to suggest an improvement.

Spec. ref.:	6.2.1.4	**MS:**	n/a	**WS:**	2.7	**AO:**	AO3/3b	**Demand:**	Low–standard

(The stem for this question can be found on page 62.)

0 3 . 4 Suggest **one** improvement to the student's method.

[2 marks]

03.4	repeat the experiment and calculate the mean temperature rise **OR** heat the oil for a longer period of time (1) to get a wider range of temperatures (1)		1 1	AO3/3b 6.2.1.4

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October 2015