GCSE
SCIENCE

Virtual communities

Resources booklet

Published: Autumn 2021

Contents

Working scientifically criteria

2 Experimental skills and strategies

Students should be able to:	Examples of what students could be asked to do in an exam
WS 2.1 Use scientific theories and explanations to develop hypotheses.	Suggest a hypothesis to explain given observations or data.
WS 2.2 Plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena.	Describe a practical procedure for a specified purpose. Explain why a given practical procedure is well designed for its specified purpose. Explain the need to manipulate and control variables. Identify in a given context: • the independent variable as the one that is changed or selected by the investigator • the dependent variable that is measured for each change in the independent variable • control variables and be able to explain why they are kept the same. Apply understanding of apparatus and techniques to suggest a procedure for a specified purpose.
WS 2.3 Apply a knowledge of a range of techniques, instruments, apparatus, and materials to select those appropriate to the experiment.	Describe/suggest/select the technique, instrument, apparatus or material that should be used for a particular purpose, and explain why.
WS 2.4 Carry out experiments appropriately having due regard for the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations.	Identify the main hazards in specified practical contexts. Suggest methods of reducing the risk of harm in practical contexts.
WS 2.5 Recognise when to apply a knowledge of sampling techniques to ensure any samples collected are representative.	Suggest and describe an appropriate sampling technique in a given context.
WS 2.6 Make and record observations and measurements using a range of apparatus and methods.	Read measurements off a scale in a practical context and record appropriately.
WS 2.7 Evaluate methods and suggest possible improvements and further investigations.	Assess whether sufficient, precise measurements have been taken in an experiment. Evaluate methods with a view to determining whether or not they are valid.

3 Analysis and evaluation

Apply the cycle of collecting, presenting and analysing data, including:

Students should be able to:	Examples of what students could be asked to do in an exam
WS 3.1 Presenting observations and other data using appropriate methods.	Construct and interpret frequency tables and diagrams, bar charts and histograms. Plot two variables from experimental or other data.
WS 3.2 Translating data from one form to another.	Translate data between graphical and numeric form.
WS 3.3 Carrying out and represent mathematical and statistical analysis.	For example: • use an appropriate number of significant figures • find the arithmetic mean and range of a set of data • construct and interpret frequency tables and diagrams, bar charts and histograms • make order of magnitude calculations • change the subject of an equation • substitute numerical values into algebraic equations using appropriate units for physical quantities • determine the slope and intercept of a linear graph • draw and use the slope of a tangent to a curve as a measure of rate of change • understand the physical significance of area between a curve and the x-axis and measure it by counting squares as appropriate.
WS 3.4 Representing distributions of results and make estimations of uncertainty.	Apply the idea that whenever a measurement is made, there is always some uncertainty about the result obtained. Use the range of a set of measurements about the mean as a measure of uncertainty.
WS 3.5 Interpreting observations and other data (presented in verbal, diagrammatic, graphical, symbolic or numerical form), including identifying patterns and trends, making inferences and drawing conclusions.	Use data to make predictions. Recognise or describe patterns and trends in data presented in a variety of tabular, graphical and other forms. Draw conclusions from given observations.

Students should be able to:	Examples of what students could be asked to do in an exam
WS 3.6 Presenting reasoned explanations including relating data to hypotheses.	Comment on the extent to which data is consistent with a given hypothesis. Identify which of two or more hypotheses provides a better explanation of data in a given context.
WS 3.7 Being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error.	Apply the following ideas to evaluate data to suggest improvements to procedures and techniques. • An accurate measurement is one that is close to the true value. • Measurements are precise if they cluster closely. • Measurements are repeatable when repetition, under the same conditions by the same investigator, gives similar results. • Measurements are reproducible if similar results are obtained by different investigators with different equipment. • Measurements are affected by random error due to results varying in unpredictable ways; these errors can be reduced by making more measurements and reporting a mean value. • Systematic error is due to measurement results differing from the true value by a consistent amount each time. • Any anomalous values should be examined to try to identify the cause and, if a product of a poor measurement, ignored.
WS 3.8 Communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions through paper-based and electronic reports and presentations using verbal, diagrammatic, graphical, numerical and symbolic forms.	Present coherent and logically structured responses, using the ideas in 2 Experimental skills and strategies and 3 Analysis and evaluation, applied to the required practicals, and other practical investigations given appropriate information.

Working scientifically 'hands-on' criteria

WS 2.4 Carry out experiments appropriately having due regard for the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations.	Identify the main hazards in specified practical contexts. Suggest methods of reducing the risk of harm in practical contexts.
WS 2.6 Make and record observations and measurements using a range of apparatus and methods.	Read measurements off a scale in a practical context and record appropriately.
WS 3.1 Presenting observations and other data using appropriate methods.	Construct and interpret frequency tables and diagrams, bar charts and histograms. Plot two variables from experimental or other data.
WS 3.2 Translating data from one form to another.	Translate data between graphical and numeric form.
WS 3.3 Carrying out and represent mathematical and statistical analysis.	For example: • use an appropriate number of significant figures • find the arithmetic mean and range of a set of data • construct and interpret frequency tables and diagrams, bar charts and histograms • make order of magnitude calculations • change the subject of an equation • substitute numerical values into algebraic equations using appropriate units for physical quantities • determine the slope and intercept of a linear graph • draw and use the slope of a tangent to a curve as a measure of rate of change • understand the physical significance of area between a curve and the x-axis and measure it by counting squares as appropriate.

Working scientifically 'minds-on' criteria

WS 2.1 Use scientific theories and explanations to develop hypotheses.	Suggest a hypothesis to explain given observations or data.
WS 2.2 Plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena.	Describe a practical procedure for a specified purpose. Explain why a given practical procedure is well designed for its specified purpose. Explain the need to manipulate and control variables. Identify in a given context: • the independent variable as the one that is changed or selected by the investigator • the dependent variable that is measured for each change in the independent variable • control variables and be able to explain why they are kept the same. Apply understanding of apparatus and techniques to suggest a procedure for a specified purpose.
WS 2.3 Apply a knowledge of a range of techniques, instruments, apparatus, and materials to select those appropriate to the experiment.	Describe/suggest/select the technique, instrument, apparatus or material that should be used for a particular purpose, and explain why.
WS 2.5 Recognise when to apply a knowledge of sampling techniques to ensure any samples collected are representative.	Suggest and describe an appropriate sampling technique in a given context.
WS 2.7 Evaluate methods and suggest possible improvements and further investigations.	Assess whether sufficient, precise measurements have been taken in an experiment. Evaluate methods with a view to determining whether or not they are valid.

WS 3.4 Representing distributions of results and make estimations of uncertainty.	Apply the idea that whenever a measurement is made, there is always some uncertainty about the result obtained. Use the range of a set of measurements about the mean as a measure of uncertainty.
WS 3.5 Interpreting observations and other data (presented in verbal, diagrammatic, graphical, symbolic or numerical form), including identifying patterns and trends, making inferences and drawing conclusions.	Use data to make predictions. Recognise or describe patterns and trends in data presented in a variety of tabular, graphical and other forms. Draw conclusions from given observations.
WS 3.6 Presenting reasoned explanations including relating data to hypotheses.	Comment on the extent to which data is consistent with a given hypothesis. Identify which of two or more hypotheses provides a better explanation of data in a given context.
WS 3.7 Being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error.	Apply the following ideas to evaluate data to suggest improvements to procedures and techniques. • An accurate measurement is one that is close to the true value. • Measurements are precise if they cluster closely. • Measurements are repeatable when repetition, under the same conditions by the same investigator, gives similar results. • Measurements are reproducible if similar results are obtained by different investigators with different equipment. • Measurements are affected by random error due to results varying in unpredictable ways; these errors can be reduced by making more measurements and reporting a mean value. • Systematic error is due to measurement results differing from the true value by a consistent amount each time. • Any anomalous values should be examined to try to identify the cause and, if a product of a poor measurement, ignored.
WS 3.8 Communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions through paper-based and electronic reports and presentations using verbal, diagrammatic, graphical, numerical and symbolic forms.	Present coherent and logically structured responses, using the ideas in 2 Experimental skills and strategies and 3 Analysis and evaluation, applied to the required practicals, and other practical investigations given appropriate information.

Activity 1

Example 1: Question 9, Biology Paper 1F, June 2019

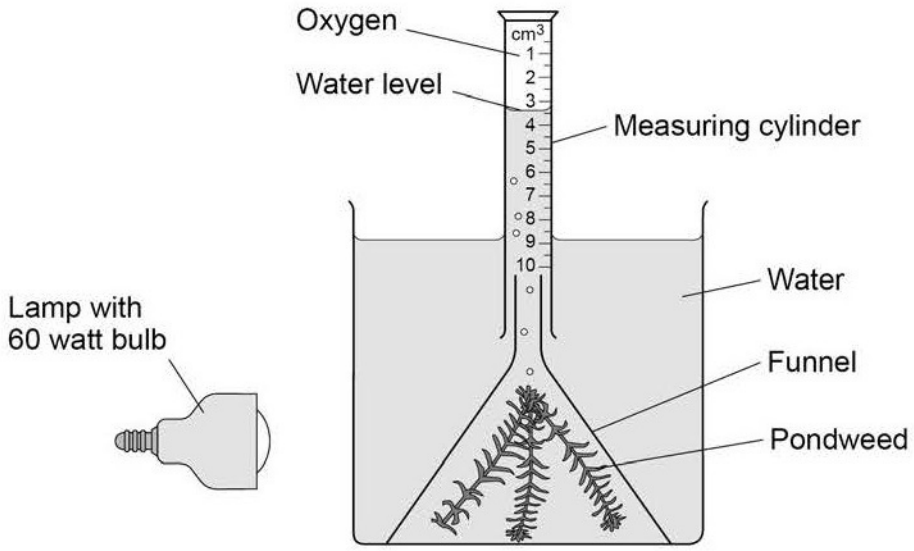
This is an investigation of the effect of light intensity on the rate of photosynthesis. It is a Required practical and students should be familiar with the set-up, or something very close to this.

What questions could you ask students about this method to progress their minds-on thinking?

A student investigated photosynthesis using pondweed.

Figure 14 shows the apparatus the student used.

Figure 14



This is the method used.

1. Set up the apparatus as shown in **Figure 14**.
2. Switch on the lamp.
3. After 20 minutes, record the volume of oxygen collected in the measuring cylinder.
4. Repeat steps 1–3 using bulbs of different power output.

Activity 2

Look at the investigations in examples 2, 3 and 4 (one Biology, one Chemistry and one Physics example).

Each investigation relates to a Required practical students should have done, but in a context or investigation different from what they are likely to have done in class.

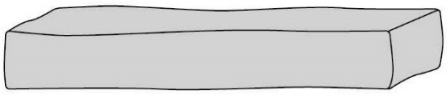
What extra questions might you add to your framework to help students with unfamiliar contexts?

Example 2: Question 7, Synergy Paper 2F, June 2018

A group of students investigated the effect of temperature on the rate of osmosis in potato cells. The students used five potato chips all cut to the same size.

Figure 9 shows one chip.

Figure 9



This is the method used.

1. Half fill a boiling tube with distilled water.
2. Heat the water to 25 °C
3. Place one potato chip in the boiling tube.
4. Keep the boiling tube and potato chip at 25 °C for 30 minutes.
5. Repeat steps 1–4 at four other temperatures.

In Biology RPA3 students will have carried out some sort of investigation into the effect of concentration of sugar or salt solutions on the mass of plant material (eg the change in mass of pieces of potato in different concentrations of sugar).

The introduction to this investigation clearly states that the students are studying a factor affecting rate of osmosis, so they should be able to relate this to the specification content. This investigation requires students to understand that what they have learned in their RPA can be applied to this situation, even though it is investigating something completely different which they haven't come across.

Example 3: Question 5, Trilogy Chemistry Paper 2F, June 2018

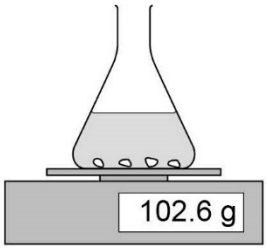
A student investigated the effect of the size of marble chips on the rate of the reaction between marble chips and hydrochloric acid.

This is the method used.

1. Add 10.0 g of marble chips into the flask.
2. Add 50 cm^3 of hydrochloric acid and start a timer.
3. Record the mass lost from the flask every 10 seconds.
4. Repeat steps 1 to 3 with different sizes of marble chips.

Figure 10 shows the apparatus.

Figure 10



Students will have carried out an experiment in the Chemistry RPA5 to investigate how changing the concentration of one of the reactants affects the rate of reaction (for example in a reaction between different concentrations of hydrochloric acid and magnesium ribbon). They should be familiar with the reaction and know how to measure the volume of gas given off.

This investigation is related in that it is looking at how a change in a variable affects the rate of reaction – in this case the size of marble chips. In this example, the method makes it clear that mass is lost, and the flask is open, so it is likely a gas is given off, which should point students to the area of content they should be thinking about. They are not being asked to measure the gas being given off, but simply to note the difference in mass as the reaction continues.

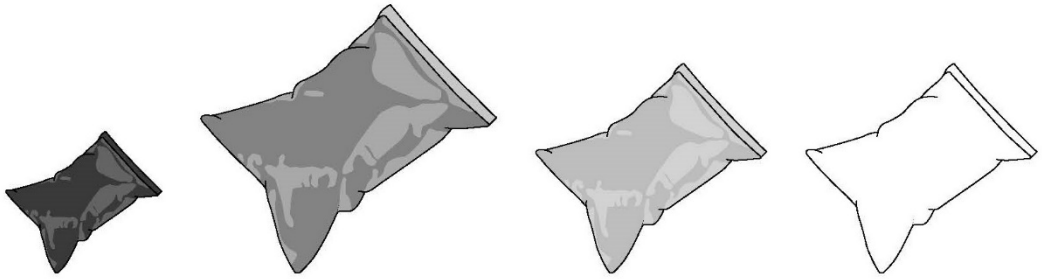
Example 4: Question 1, Synergy Paper 2H, June 2018

A solar water bag can be used to heat water for an outdoor swimming pool.

A student wanted to find out if the colour of the solar water bag affects the temperature increase of the water inside the bag.

Figure 1 shows some of the equipment used.

Figure 1



This is the method used.

1. Fill each bag with water.
2. Place the four bags on the ground outside.
3. After three hours, measure the temperature of the water inside each bag.
4. Repeat steps 1–3 on the next two days.

Students should be familiar with Physics RPA10, in which they investigate infrared radiation (most usually using some sort of Leslie cube), and will know that different surfaces affect the amount of infrared radiation absorbed.

Even though the context of this example will be unfamiliar, students should be able to recognise that this is what is happening here and apply the learning from the RPA – the different materials of the bags will have different effects on the amount of radiation absorbed and therefore the temperature of the water inside the bag.

Questions for interrogating an experimental method

Here are some suggestions for questions you could use with any given method (familiar or unfamiliar) and which you could adapt for the specific method or level of demand. You don't have to ask questions about every aspect of the practical – you could just use one or two to focus understanding.

Category of question	Questions that could be asked
Content being covered	• What is being investigated? • What is it in the wording that tells you this? • Does this method relate to a practical you have done? • Is it the same or is it slightly different? • How is it different from what you have done? • What topic you have studied is this practical about?
Hypotheses	• Is the student/scientist testing a hypothesis? • What hypothesis are they testing? • Suggest a hypothesis for this investigation. • Do the results support this hypothesis?
Variables	• Is the student changing any variables in this investigation? • What variables are they changing? • Why are they changing that variable? • What is the independent variable? • What is the dependent variable? • What variables to they need to keep the same?
Sampling/controls	• What would you use as a control sample in this experiment? • What would be a suitable range of measurements to use? • What other things could you measure? • How could you change the method to determine … ?
Measurements and types of error	• One of the results is anomalous. What could have caused this anomaly? • Give a reason why the measurement(s) may not be accurate. • The student made a mistake setting up the apparatus. What mistake did they make? What problem could this cause?
Accuracy/resolution	• What was the resolution of the [instrument used]? • What could the student do to make their results more accurate?
Results	• What results do you predict? Why? • What would getting results that don't match your prediction tell you?

	• Do the results confirm the hypothesis? If not, what **are** they showing? • Explain the result for [X] • One of the results is anomalous. How do you know which result is anomalous? What could have caused the anomalous result?
Evaluating methods/validity	• How could the student improve the method to get more valid results? • The method will produce qualitative results. How could you change the method to produce accurate, quantitative results? • How could the method be changed to ensure that results are repeatable? • What mistake did the student make when setting up the apparatus? • The student concludes that the results are valid. Is the student correct? Why?

Hub resources on the website

The following table lists the pdf resources available for the GCSE science Hub meetings, from Spring 2019 to Summer 2021. It also includes a brief description of what each document is about.

All resources can be downloaded from the science Hub pages on the AQA website. Usually only materials from the most recent three meetings are on this page, but all other materials (including pre-2019 materials) can be found on the Hub archive page.

Meeting session	Title of document	What it's about
Summer 2021	Presentation slides	• Supporting transition from KS3 to GCSE and from GCSE to A-level using a key transferrable maths skill in science (use of standard form) as an example • The requirements for the skill and how they are assessed at the different key stages • Ideas for how you can enable student progression AQA resources to aid this progression • Updates for arrangements for autumn 2021 and summer 2022
	Resource booklet	• Links to online resources • Example questions used in the activities • Starter activity flowchart • Example lesson activities • Information on progression in two other key maths skills not covered in the presentation
Spring 2021	Presentation slides	• Brief updates on the autumn 2020 series and what we know for summer 2021 • Supporting the learning gap – ideas and resources from STE • Understanding the requirements of some key command words in exam papers using student responses
	Support booklet	• Summaries of GCSE and A-level results for summer and autumn 2020 • Links to organisations and resources.

		• Definitions, what examiners are looking for and examples of student responses for the command words describe, explain, compare, evaluate.
	Commentaries booklet	Comments on the student responses regarding how they have, or have not, addressed the requirements of the command word.
Autumn 2020 (Virtual communities meetings)	Presentation slides	Focal points for group discussions.
	Supporting materials	• Reminder of situation for 2020/2021 as known at the time • Points to consider in breakout groups for discussions on practical work and importance of mock exams • Details of Apparatus and Techniques criteria covered in the Required Practical Activities for each GCSE science
Spring 2020	Presentation slides	• Reflections on mocks and brief reminder on how to use MERiT • How we assess maths skills in GCSE sciences at different levels of demand, using examples of student work • Discussion activity on ways of including opportunities for development of particular maths skills in schemes of work (using AQA schemes as examples) • Update on resources and draft plans for summer 2020 meetings
	Booklet 1	• Guidance on assessment of particular maths skills. • Student examples and commentaries for discussion in meeting and in school • Update on where to find resources
	Booklet 2	Extracts from AQA schemes of work for use in the exercise in the meeting.
	Booklet 3	Extracts from AQA specifications for use in the exercise in the meeting.
	Booklet 4	Guide to Hub resources on the website (now superseded by this table).

	Maths skills in science: Precision and decimal places	Link to Teachit resource referred to in meeting.
	Maths skills in science: Significant figures	Link to Teachit resource referred to in meeting.
	Mock analysis: Trilogy paper	Examples of how analysis of the Trilogy Paper 1 could be undertaken (repeated from Autumn 2019 meeting, by request).
Autumn 2019	Presentation slides	• Provisional national GCSE and A-level results from summer 2019 • GCSE entry patterns 2019 • Insight and examples of areas of weakness across all subjects; • Assessing equations at different demand levels • Using key questions for mock analysis to drive focused intervention
	Resource booklet	• AQA results statistics 2019 – GCSE and A-level • Example student responses in key areas of challenge in 2019 exams with commentaries • Assessing equations at different levels of demand
	Physics equations flashcards	An example of one of the free resources available from Teachit.
	Research update: 7402 A-level Biology essay	Background information on a number of areas related to the 7402 essay that haven't previously been looked at in detail and highlights to information already produced for this particular aspect of the assessment.
	A-level sciences endorsement Cycle 3 timeline	A printout of the timeline available on the website.
	Exampro MERiT timeline	Timeline of when data input and analysis for MERiT is available for the 2019/20 mocks.
	UAS flyer	Information on the AQA Unit Award Scheme.
	Mock analysis Paper 1 sheets	Examples of how analysis of the Trilogy Paper 1 could be undertaken.

Summer 2019	Presentation slides	• Feedback from spring meeting • How we assess AO3 at different levels of demand • Using legacy ISA materials as extra resource • Making the best use of ERA • Results day
	Booklet 1	• Examples from 2018 papers of questions that assess AO3 • Guide through ERA features • Update on resources
	Booklet 2	List of legacy ISAs, how they relate to the required practical, examples of data sheets and ideas on how could be incorporated into teaching.
	Booklet 3	Commentaries on the aspects of AO3 that each example assesses.
Spring 2019	Presentation slides	• Feedback on autumn 2018 meeting • Reflections on mocks • Marking extended response questions
	Booklet 1: Student examples and accompanying documents	• Example levels of response mark schemes • Example student responses from summer 2018 exams • Update on resources
	Booklet 2: Mark schemes	Mark schemes for the example responses.
	Booklet 3: Commentaries and marks awarded	Commentary on each example, explaining the marks awarded.

Additional resources

Below are the links to the resources mentioned in the presentation.

Planning resources for GCSE Biology

Project Calibrate homepage

Project Calibrate: Project information

Arrangements for VTQs in 2022

Arrangements for NEA in 2022

Ofqual consultation for summer 2022

Exampro

Teaching resources for GCSE Biology

Focus on success pack on disciplinary language

Teaching guide: exploring common misunderstandings

Decisions on NEA and fieldwork

Contact us

Our friendly team will be happy to support you between 8am and 5pm, Monday to Friday.

Tel: 01483 477 756
Email: gcsescience@aqa.org.uk
Twitter: @AQA

aqa.org.uk