GCSE Science: Support for practicals and maths

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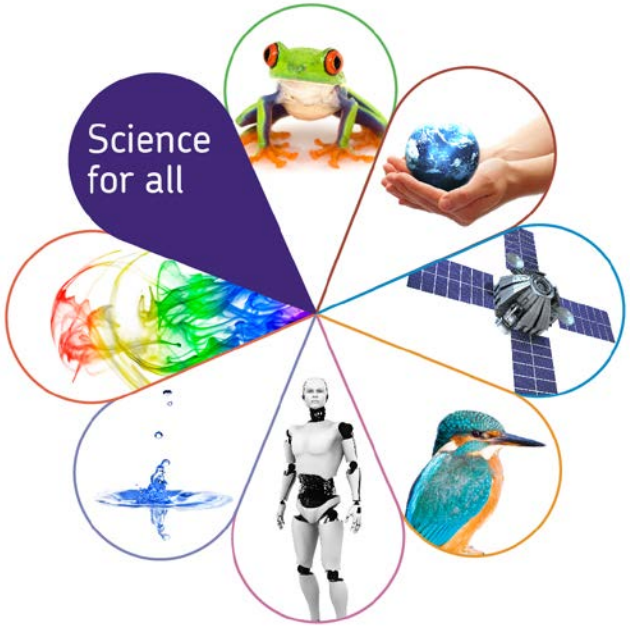

Agenda

- significance to teaching and learning of the changes to the assessment objectives
- the required practicals, and how they target the apparatus and techniques
- resources to support you and your students in developing their working scientifically skills
- sample of practical questions to gain a clearer understanding of how working scientifically will be assessed
- preview some of the materials to support you with the maths skills your students will need

Assessment objectives – significance to teaching and learning

The assessment objectives proposed by Ofqual are broadly similar to those for the current GCSEs but the inclusion of working scientifically will have a significant impact on teaching and learning.

	Assessment Objectives	Weighting
AO1	Demonstrate knowledge and understanding of: • scientific ideas • scientific techniques and procedures.	40% (current 37.5%)
AO2	Apply knowledge and understanding of: • scientific ideas • scientific enquiry, techniques and procedures.	40% (current 35%)
AO3	Analyse information and ideas to: • interpret and evaluate • make judgements and draw conclusions • develop and improve experimental procedures.	20% (current 27.5%)

GCSE Assessment objectives – what do they mean

	3 Key performance areas	GCSE Marks allocated
AO1 KNOW CONTENT	Knowing & showing understanding of what is in specification, this includes knowing practical procedures, apparatus & techniques	40%
AO2 APPLY	Applying and making sense of *observations* that can be unfamiliar includes processing data and enquiry approaches	40%
AO3 EEEs	Evaluating and drawing conclusions Evidence based decision making Refining enquiry approaches	20%

The common key performance areas across all phases = 60% of GCSE

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Integration of practical skills

3 components to practical skills:

- Working scientifically
- Apparatus and techniques
- Required practical activities

All of these components are intended to be integrated into teaching: they are not bolt-on sections of the specification.

Working scientifically

Working scientifically is the sum of all the activities that scientists do. We feel it is so important that we have woven it throughout our specification and written papers.
Our schemes of work will take this further for you and signpost a range of ways to navigate through this qualification so your students are engaged and enthused.

Sections within Working scientifically
Development of scientific thinking
Experimental skills and strategies
Analysis and evaluation
Scientific vocabulary, quantities, units, symbols and nomenclature

Working scientifically (2)

Students should be able to:	Examples of what students could be asked to do in an exam
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.

Draft Biology required practicals (resubmission)

	Required practical activities	Apparatus and technique ref
Biology & Combined	Use a light microscope to observe, draw and label a selection of plant and animal cells. A scale magnification must be included. (NEW)	1,7,
	Investigate the effect of a range of concentrations of salt or sugar solutions on the mass of plant tissue.	1,3,5
	Use qualitative reagents to test for a range of carbohydrates, lipids and proteins. To include: Benedict's test for sugars; iodine test for starch; and Biuret reagent for protein. (NEW)	2, 8 (Biology only)
	Investigate the effect of pH on the rate of reaction of amylase enzyme. Students should use a continuous sampling technique to determine the time taken to completely digest a starch solution at a range of pH values. Iodine reagent is to be used to test for starch every 30 seconds. Temperature must be controlled by use of a water bath or electric heater.	1,2,5,8
	Investigate the effect of light intensity on the rate of photosynthesis using an aquatic organism such as pondweed.	1,2,3,4,5
	Plan and carry out an investigation into the effect of a factor on human reaction time	1,3,4
	Measure the population size of a common species in a habitat. Use sampling techniques to investigate the effect of a factor on the distribution of this species.	1,3,4,6,8

Draft Biology only required practicals (resubmission)

	Required practical activities	Apparatus and technique ref
Biology only	Investigate the effect of antiseptics or antibiotics on bacterial growth using agar plates and measuring zones of inhibition.	1,3,4,8
	Investigate the effect of light or gravity on the growth of germinating seeds. Record results as both length measurements and as careful, labelled biological drawings to show the effects	1,3,4,7
	Investigate the effect of temperature on the rate of decay of fresh milk by measuring pH change	1,3,4,5

Draft Chemistry required practicals (resubmission)

	Required practical activities	Apparatus and technique ref
Chemistry & Combined	Preparation of a pure, dry sample of a soluble salt from an insoluble oxide or carbonate, using a Bunsen burner to heat dilute acid and a water bath or electric heater to evaporate the solution.	2,3,4,6
	Investigate what happens when aqueous solutions are electrolysed using inert electrodes. This should be an investigation involving developing a hypothesis	3,7 (chemistry only),8
	Investigate the variables that affect temperature changes in reacting solutions such as, eg acid plus metals, acid plus carbonates, neutralisations, displacement of metals. (new)	1,3,5,6
	Investigate how changes in concentration affect the rates of reactions by a method involving measuring the volume of a gas produced and a method involving a change in colour or turbidity. This should be an investigation involving developing a hypothesis.	1,3,5,6
	Investigate how paper chromatography can be used to separate and tell the difference between coloured substances. Students should calculate Rf values.	1,4
	Analysis and purification of water samples from different sources, including pH, dissolved solids and distillation.	2,3,4

Draft Chemistry required practicals (resubmission)

	Required practical activities	Apparatus and technique ref
Chemistry only	Determination of the reacting volumes of solutions of a strong acid and a strong alkali by titration. **Higher Tier only** Determination of the concentration of one of the solutions in mol/dm3 and g/dm3 from the reacting volumes and the known concentration of the other solution.	1,8
	Use of chemical tests to identify the ions in unknown single ionic compounds covering the ions in sections.	1,8

Draft Physics required practicals (resubmission)

	Required practical activities	Apparatus and technique ref
Physics & Combined	Investigation to determine the specific heat capacity of one or more materials. The investigation will involve linking the decrease of one energy store (or work done) to the increase in temperature and subsequent increase in thermal energy stored.	1,5
	Use circuit diagrams to set up an appropriate circuit to investigate a factor/the factors that affect the resistance of an electrical component. This should include how the length of a wire (at constant temperature) affects the resistance of the wire.	1,6,7
	Use circuit diagrams to construct appropriate circuits to investigate the V-I characteristics of variety of circuit elements including a filament lamp, a diode and a resistor at constant temperature.	6,7
	Use appropriate apparatus to make and record the measurements needed to determine the densities of regular and irregular solid objects and liquids. Volume should be determined from the dimensions of a regularly shaped object and by a displacement technique for irregularly shaped objects. Dimensions to be measured using appropriate apparatus such as a ruler, micrometre or Vernier callipers.	1

Draft Physics required practicals (resubmission)

	Required practical activities	Apparatus and technique ref
Physics & Combined	Investigate the relationship between force and extension for a spring.	1,2
	Investigate the effect of varying the force on the acceleration of an object of constant mass and the effect of varying the mass of an object on the acceleration produced by a constant force	1,2,3
	Make observations to identify the suitability of apparatus to measure the frequency, wavelength and speed of waves in a ripple tank and waves in a solid and take appropriate measurements. (NEW)	4
	Investigate how the amount of infra-red radiation absorbed or radiated by a surface depends on the nature of that surface. (NEW)	1,4
Physics only	Investigate the effectiveness of different materials as thermal insulators and the factors that may affect the thermal insulation properties of a material.(NEW)	1,5
	Investigate the reflection of light by different types of surface and the refraction of light by different substances.	4,8

Resources to support practical science

3 sections in the specification:

- Working scientifically
- Apparatus and techniques
- Required practical activities

- Resources: aqa.org.uk/resources/science/gcse/teach/practicals

- Required practicals summary
- Required practical activities
- Suggested Required practical apparatus list
- Practicals in exams
- Guide to improving practical work

Teachers' notes – required practicals activities

GCSE-level Biology required practical activity No. 1 – Microscopy

Teachers' notes

Required practical activity	Apparatus and techniques
Use a light microscope to observe, draw and label a selection of plant and animal cells. A scale magnification must be included.	AT 1, AT 7

Using a light microscope to observe, draw and label cells in an onion skin

Materials

In addition to access to general laboratory equipment, each student needs:

- a small piece of onion
- a knife or scalpel
- a white tile
- forceps
- a microscope slide
- a coverslip
- a microscope
- iodine solution in a dropping bottle.

Technical information

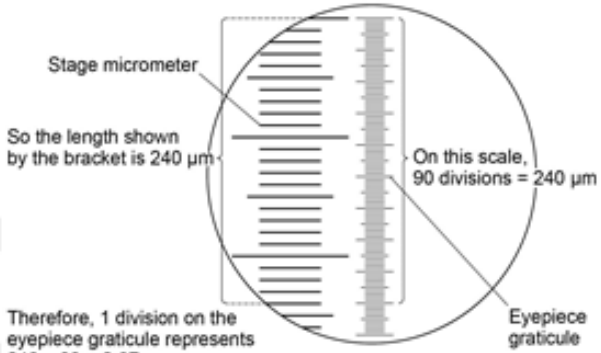
Iodine solution may be purchased ready-made or can be made up following the instructions on CLEAPSS recipe card number 50.

Additional information

The techniques involved should be demonstrated to the students. The students should be allowed time to practice the technique of preparing a wet slide.

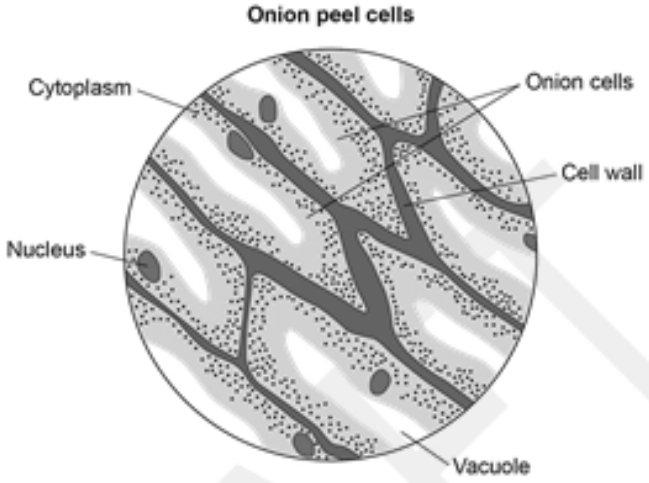
It is particularly important that they practise the technique of lowering the cover slip on to the slide so that no air bubbles are trapped.

Students should be familiar with the use of a microscope and how to use an eyepiece graticule.

Techniques requiring practice	Additional information
Lowering the coverslip on to the slide	
Using the microscope	Students should be given guidance in how to use an optical microscope, with particular reference to the coarse and fine focus controls.
Using an eyepiece graticule	Part of the stage micrometer viewed at x400 magnification  A simple eyepiece graticule, such as the one above, could be used. Students need to appreciate that with different objective lenses the distance between the lines on the graticule changes. Unless a stage micrometer is available, students will need to be told what each division on the graticule is worth for each different objective power.
Using a stage micrometer	If a stage micrometer is available students will need to be taught how to use it, using a diagram similar to the one above.

Teachers' notes continued

Students should be able to see the following using ×400 magnification.



Risk assessment

Risk assessment and risk management are the responsibility of the school or college.

- Care should be taken when using iodine solution to avoid staining and ingestion.
- Safety goggles should be used when handling iodine solution.

Trialling

The practical should be trialled before use with students.

Student sheet

GC SE-level Biology required practical activity No. 1 – Microscopy

Student sheet

Required practical activity	Apparatus and techniques
Use a light microscope to observe, draw and label a selection of plant and animal cells. A scale magnification must be included.	AT 1, AT 7

Using a light microscope to observe, draw and label cells in an onion skin

In this experiment you will prepare a microscope slide to show the cells and their contents in an onion leaf.

You will use an optical microscope to observe, draw and measure the cells in the onion skin. You will also need to identify structures within the cells.

Learning outcomes
1
2
Teachers to add these with particular reference to working scientifically

Method

You are provided with the following:

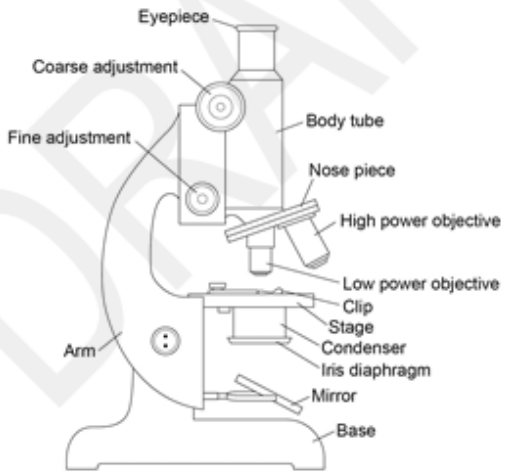
- a small piece of onion
- a knife or scalpel
- a white tile
- forceps
- a microscope slide
- a coverslip
- a microscope
- iodine solution in a dropping bottle.

You should read these instructions carefully before you start work.

1. Use a dropping pipette to put one drop of water onto a microscope slide.
2. Separate one of the thin layers of the onion.
3. Peel off a thin layer of epidermal tissue from the inner surface.
4. Use forceps to put this thin layer on to the drop of water that you have placed on the microscope slide.
5. Make sure that the layer of onion cells is flat on the slide.
6. Put two drops of iodine solution onto the onion tissue.
7. Carefully lower a coverslip onto the slide. Do this by placing one edge of the coverslip on the slide and then using a mounted needle to lower the other edge onto the slide.
8. Use a piece of filter paper to soak up any liquid from around the edge of the coverslip.
9. Put the slide on the microscope stage.

Using the microscope

The diagram shows a typical microscope.



This microscope has a mirror to reflect light up through the slide. Some microscopes have a built-in light instead of a mirror.

Student sheet continued

10. Turn the nosepiece to the lowest power objective lens.
11. Looking from the side (**not** through the eyepiece) turn the coarse adjustment knob so tha end of the objective lens is almost touching the slide.
12. Now looking through the eyepiece, turn the coarse adjustment knob in the direction to in the distance between the objective lens and the slide. Do this until the cells come into fo
13. Now rotate the nosepiece to use a higher power objective lens.
14. Slightly rotate the fine adjustment knob to bring the cells into a clear focus and use the lo power objective (×40 magnification) to look at the cells.
15. When you have found some cells, switch to a higher power (×100 or ×400 magnification)
16. In the space below make a clear, labelled drawing of some of these cells. Make sure tha draw and label any component parts of the cell.
17. Use an eyepiece graticule to measure the length of one of the epidermal cells that you h drawn. Remember to include the units.
18. Now measure the same cell in your drawing.
19. Calculate the magnification of your drawing, using the formula:

    magnification = length of drawing of cell/actual length of cell

20. Write the magnification underneath your drawing.

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Activity – enriching the learning during practical lessons

- The required practicals are straight forward, simple and traditional.
- consider as a department how you might rework one of the practicals to enrich the learning opportunity of the students.

  Things you might consider:
  - the context in which they are presented
  - a focus of working scientifically.

- Remember to look at the wording of the apparatus and techniques statement in the specification as this might influence your focus.
- What specific challenges do these practicals pose?
- How could they be overcome?
-

Monitoring arrangements for practicals

- Schools and colleges will be required to provide students with a reasonable opportunity to do the required practical activities.
- Awarding organisations must require each school or college to provide a practical science statement.
- This written statement will confirm that the school or college has taken reasonable steps to secure that each learner:

  (a) has completed the practical activities set by the awarding organisation

  (b) has made a contemporaneous record of:

  (i) the work which the learner has undertaken during those practical activities

  (ii) the knowledge, skills and understanding which the learner has derived from those practical activities.
- Ofqual have said failing to provide this declaration will be considered as malpractice.
- No endorsement or monitoring visits, unlike A-level.

How practical skills will be assessed on the paper

Papers will contain a number of different types of question which will assess students' practical skills and their understanding of practical techniques.

1. Questions that require a knowledge and understanding of a specific required practical activity procedure.
2. Questions that require a knowledge and understanding of apparatus and techniques from the list but do not relate to a specific required practical activity.
3. Questions set in a practical context where students require an understanding of the science rather than direct experience of the practical activity.

Resources - our exams explained (last section)
- Practicals in exams (extract)

Questions that require a knowledge and understanding of a specific required practical procedure

eg. Physics required practical 6

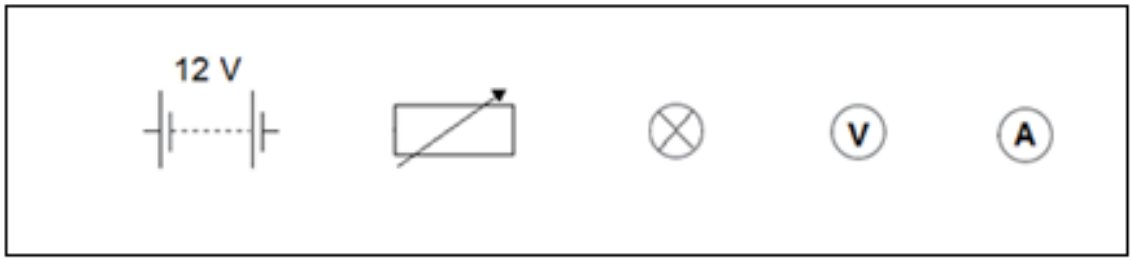
Investigate, using circuit diagrams to set up a circuit, the factor(s) that affect the resistance of an electrical component.

PHFP1 Question 3

0 3 A student wants to investigate how the current through a filament lamp affects its resistance.

0 3 . 1 Use the circuit symbols in the box to draw a circuit diagram that she could use.

[2 marks]



0 3 . 2 Describe how the student could use her circuit to investigate how the current through a filament lamp affects its resistance.

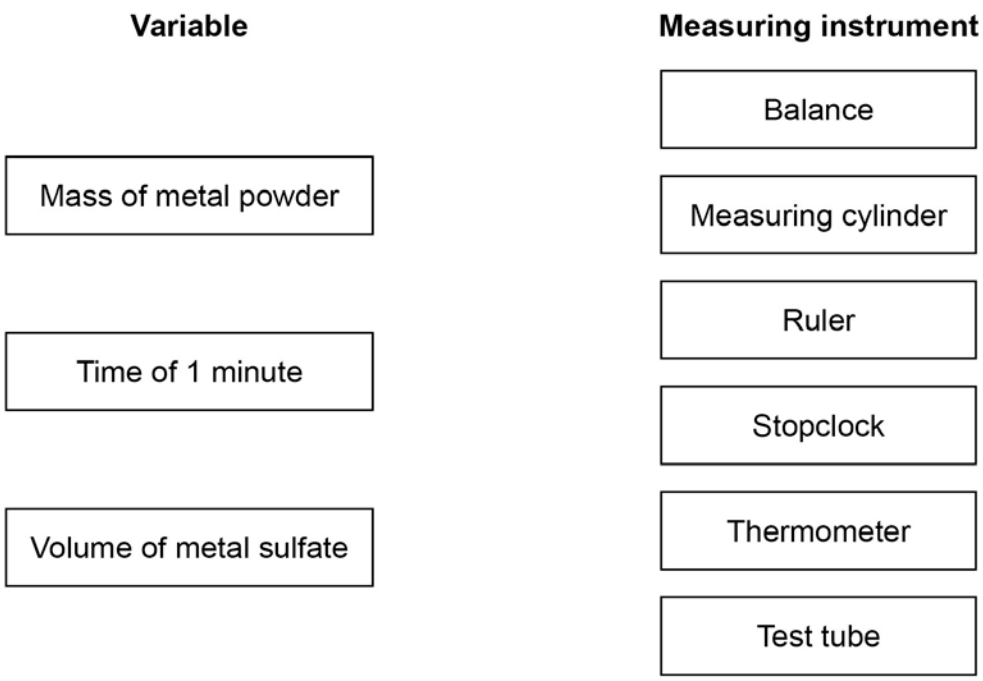
[4 marks]

Questions that require a knowledge and understanding of apparatus and techniques

0 2 . 2 The student used measuring instruments to measure some of the variables.

Draw **one** line from each variable to the measuring instrument used to measure the variable.

[3 marks]



Questions set in a practical context where students require an understanding of the science rather than direct experience of the practical activity

eg. Physics specification 4.4.5.1 Static charge

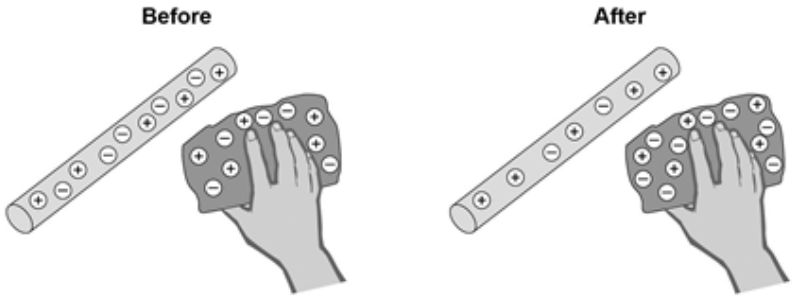
When certain insulating materials are rubbed against each other they become electrically charged. Negatively charged electrons are rubbed off one material and on to the other. The material that gains electrons becomes negatively charged. The material that loses electrons is left with an equal positive charge.

PHFP1 Question 6

0 6 A student rubs an acetate rod with a cloth.

Figure 8 shows the charges on the acetate rod and cloth before and after rubbing.

Figure 8



0 6 . 1 Explain how the friction between the acetate rod and the cloth causes the rod and cloth to become charged.

[3 marks]

Maths in GCSE Science

The challenge

- Combined: at least 20% of the marks must be for mathematical skills
- Ratio approximately 1:2:3 (in biology, chemistry and physics)
- Separates: Biology 10%, Chemistry 20% and Physics 30%
- In Foundation Tier papers, the level of maths is ‘not lower than that expected at Key Stage 3’
- In Higher Tier papers, the level of maths is ‘not lower than that of questions and tasks in assessments for the Foundation Tier in a GCSE Qualification in Mathematics’
- Maths criteria is specified by the DfE and stated in the specifications
- The criteria include arithmetic and numerical computation, handling data, algebra, graphs, geometry and trigonometry
- All criteria must be covered at all levels of ability over the lifetime of the specification, and for all subjects

Resources

- Science specific resource AQA and Teachit
- AQA GCSE Maths aqa.org.uk/subjects/mathematics
  all about maths allaboutmaths.aqa.org.uk
- ASE – ASE, The language of Mathematics (available in spring term 2016)
  ase.org.uk/resources/maths-in-science
- STEM stem.org.uk/

Support and contact details

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