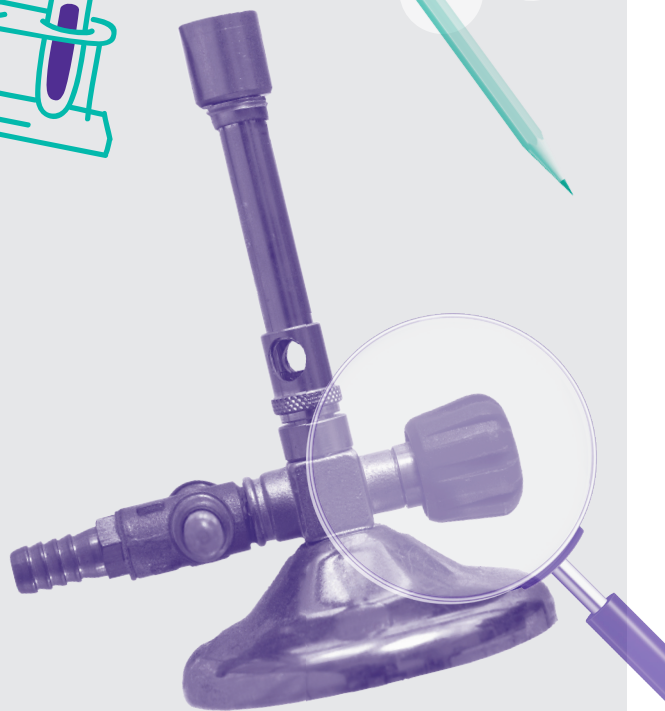
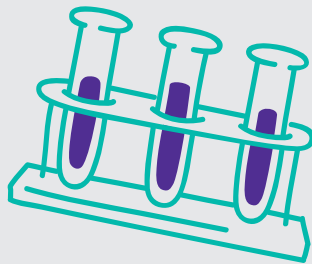


Focus on success: GCSE science

Practical questions

Build on your students' assessment performance using our self-guided, modular training pack

Activities
booklet



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Activity 1

Identifying the elements within a Required Practical (RP) question

Prior to carrying out this activity, the group should have had a discussion to identify the different elements that make up practical work based questions.

Slides 4–5 of the guidance presentation can act as an aid to help the understanding that students can be assessed on a number of different things under the heading of practical skills in a number of ways.

To illustrate this holistic approach to assessment, in small groups or pairs, look at the three questions from the 2018 papers on pages 10–16. For each item indicate which of the following elements it is assessing:

- Assessment Objective (AO)
- science content
- Working Scientifically (WS)
- maths skills.

The WS criteria are available for reference on pages 5–9.

Working Scientifically

1 Development of scientific thinking

Students should be able to:	Examples of what students could be asked to do in an exam
WS 1.1 Understand how scientific methods and theories develop over time.	<p>Give examples to show how scientific methods and theories have changed over time.</p> <p>Explain, with an example, why new data from experiments or observations led to changes in models or theories.</p> <p>Decide whether or not given data supports a particular theory.</p>
WS 1.2 Use a variety of models such as representational, spatial, descriptive, computational and mathematical to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts.	<p>Recognise/draw/interpret diagrams.</p> <p>Translate from data to a representation with a model.</p> <p>Use models in explanations, or match features of a model to the data from experiments or observations that the model describes or explains.</p> <p>Give examples of ways in which a model can be tested by observation or experiment.</p>
WS 1.3 Appreciate the power and limitations of science and consider any ethical issues which may arise.	<p>Explain why data is needed to answer scientific questions, and why it may be uncertain, incomplete or not available.</p> <p>Outline a simple ethical argument about the rights and wrongs of a new technology.</p>
WS 1.4 Explain everyday and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments.	<p>Describe and explain specified examples of the technological applications of science.</p> <p>Describe and evaluate, with the help of data, methods that can be used to tackle problems caused by human impacts on the environment.</p>
WS 1.5 Evaluate risks both in practical science and the wider societal context, including perception of risk in relation to data and consequences.	<p>Give examples to show that there are hazards associated with science-based technologies which have to be considered alongside the benefits.</p> <p>Suggest reasons why the perception of risk is often very different from the measured risk (eg voluntary vs imposed risks, familiar vs unfamiliar risks, visible vs invisible hazards).</p>

<p>WS 1.6</p> <p>Recognise the importance of peer review of results and of communicating results to a range of audiences.</p>	<p>Explain that the process of peer review helps to detect false claims and to establish a consensus about which claims should be regarded as valid. Explain that reports of scientific developments in the popular media are not subject to peer review and may be oversimplified, inaccurate or biased.</p>
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2 Experimental skills and strategies

Students should be able to:	Examples of what students could be asked to do in an exam
<p>WS 2.1</p> <p>Use scientific theories and explanations to develop hypotheses.</p>	<p>Suggest a hypothesis to explain given observations or data.</p>
<p>WS 2.2</p> <p>Plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena.</p>	<p>Describe a practical procedure for a specified purpose.</p> <p>Explain why a given practical procedure is well designed for its specified purpose.</p> <p>Explain the need to manipulate and control variables.</p> <p>Identify in a given context:</p> <ul style="list-style-type: none"> 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. <p>Apply understanding of apparatus and techniques to suggest a procedure for a specified purpose.</p>
<p>WS 2.3</p> <p>Apply a knowledge of a range of techniques, instruments, apparatus, and materials to select those appropriate to the experiment.</p>	<p>Describe/suggest/select the technique, instrument, apparatus or material that should be used for a particular purpose, and explain why.</p>
<p>WS 2.4</p> <p>Carry out experiments appropriately having due regard for the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations.</p>	<p>Identify the main hazards in specified practical contexts.</p> <p>Suggest methods of reducing the risk of harm in practical contexts.</p>
<p>WS 2.5</p> <p>Recognise when to apply a knowledge of sampling techniques to ensure any samples collected are representative.</p>	<p>Suggest and describe an appropriate sampling technique in a given context.</p>
<p>WS 2.6</p> <p>Make and record observations and measurements using a range of apparatus and methods.</p>	<p>Read measurements off a scale in a practical context and record appropriately.</p>

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: <ul style="list-style-type: none"> • 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.

<p>WS 3.6</p> <p>Presenting reasoned explanations including relating data to hypotheses.</p>	<p>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.</p>
<p>WS 3.7</p> <p>Being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error.</p>	<p>Apply the following ideas to evaluate data to suggest improvements to procedures and techniques.</p> <ul style="list-style-type: none"> • 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.
<p>WS 3.8</p> <p>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.</p>	<p>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.</p>

4 Scientific vocabulary, quantities, units, symbols and nomenclature

Students should be able to:	Examples of what students could be asked to do in an exam
<p>WS 4.1 Use scientific vocabulary, terminology and definitions.</p> <p>WS 4.2 Recognise the importance of scientific quantities and understand how they are determined.</p> <p>WS 4.3 Use SI units (eg kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate.</p> <p>WS 4.4 Use prefixes and powers of ten for orders of magnitude (eg tera, giga, mega, kilo, centi, milli, micro and nano).</p> <p>WS 4.5 Interconvert units.</p> <p>WS 4.6 Use an appropriate number of significant figures in calculation.</p>	<p>The knowledge and skills in this section apply across the specification, including the required practicals.</p>

Combined biology, Foundation and Higher tier, Paper 2

☐ ☐ Many biotic and abiotic factors can affect the growth of plants.

☐ ☐ . ☐ Are the factors in **Table 1** biotic or abiotic?

[2 marks]

Tick **one** box for each factor.

Table 1

Factor	Biotic	Abiotic
Diseases		
Herbivores		
Temperature		
Water		

Two students investigated the effect of light intensity on the distribution of small plants.

The plants are growing under a tree in a park.

The students made the following hypothesis:

‘As you move outwards from a tree there will be more plant growth.’

☐ ☐ . ☐ Explain why the students thought their hypothesis would be correct.

[3 marks]

0 1 . 3 The students used two pieces of equipment.

Give the scientific name of each piece of equipment.

[2 marks]

A square frame measuring $0.5\text{ m} \times 0.5\text{ m}$

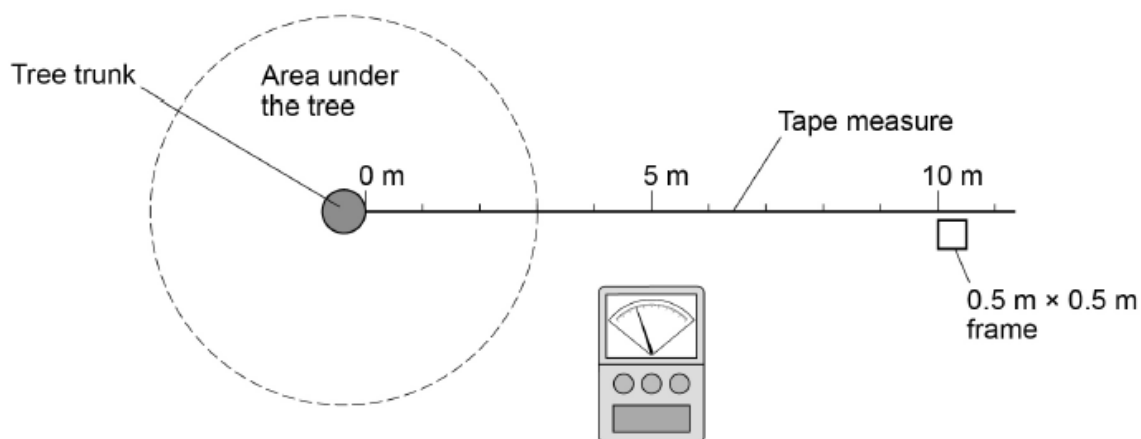
An electronic device to measure light intensity

This is the method used.

1. Fix one end of a tape measure at the base of the tree.
2. Fix the other end of the tape measure 11 metres from the tree.
3. At 0 metres put the square frame on the ground.
4. Identify all the plant species growing inside the frame.
5. Estimate and record the percentage cover of each plant species.
6. Measure the light intensity inside the frame.
7. Put the square frame on the ground every 2 metres along the tape to 10 metres.
8. Repeat steps 4 – 6 in every frame.

Figure 1 shows the equipment in this investigation.

Figure 1



0 1 . 4 Calculate the total area sampled.

[1 mark]

0 1 . 5 The whole investigation was done as quickly as possible on the same day.

Suggest **one** reason why.

[1 mark]

0 1 . 6 Give **one** way the investigation could be improved.

[1 mark]

Chemistry, Higher tier, Paper 1

0 5

A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

Table 2 shows the student's results.

Table 2

Metal	Temperature increase in °C
Copper	0
Iron	13
Magnesium	43
Zinc	17

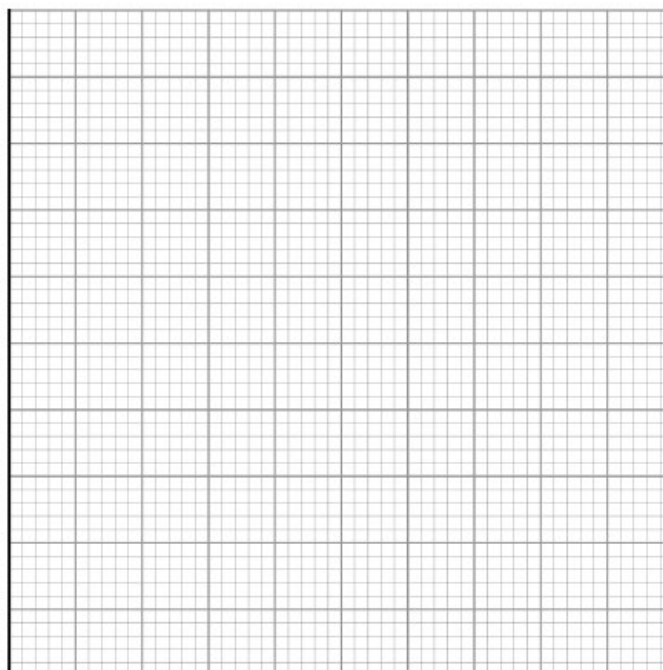
0 5 . 1

Plot the data from **Table 2** on **Figure 4** as a bar chart.

[2 marks]

Figure 4

Temperature
increase
in °C



Metal

- 0 5 . 2 The student concluded that the reactions between the metals and copper sulfate solution are endothermic.

Give **one** reason why this conclusion is **not** correct.

[1 mark]

- 0 5 . 3 The temperature change depends on the reactivity of the metal.

The student's results are used to place copper, iron, magnesium and zinc in order of their reactivity.

Describe a method to find the position of an unknown metal in this reactivity series.

Your method should give valid results.

[4 marks]

- 0 5 . 4 Draw a fully labelled reaction profile for the reaction between zinc and copper sulfate solution on **Figure 5**.

[3 marks]

Figure 5

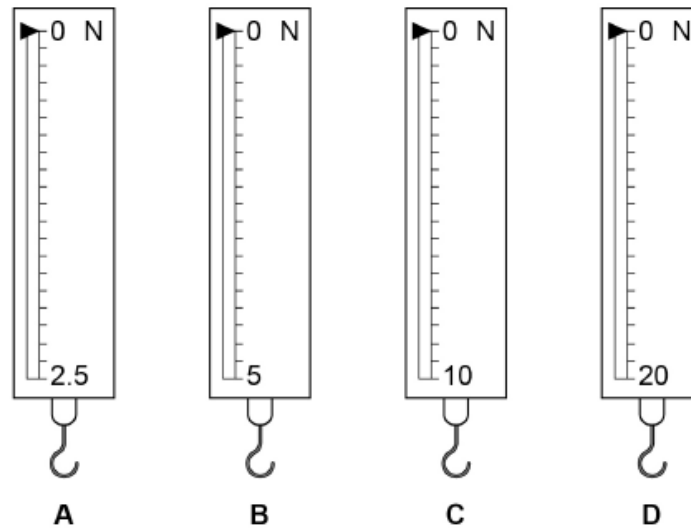


Combined physics, Higher tier, Paper 2

0 4 . 1 Figure 6 shows four newtonmeters.

Each newtonmeter contains a spring.

Figure 6



Which newtonmeter has the spring with the greatest spring constant?

Give a reason for your answer.

[2 marks]

Newtonmeter _____

Reason _____

0 4 . 2 The newtonmeter in **Figure 7** will give an error when used to make a measurement.

Figure 7



Name the type of error.

Describe how this error can be corrected.

[2 marks]

Type of error _____

Correction _____

0 4 . 3 A student hangs a weight on a newtonmeter.

The energy now stored in the spring in the newtonmeter is 4.5×10^{-2} J

The student then increases the weight on the newtonmeter by 2.0 N

Calculate the total extension of the spring.

Spring constant = 400 N/m

[6 marks]

Activity 2

The similarities and differences of apparatus and techniques (ATs)

ATs are key assessment criteria that the Required Practicals (RPs) have to address.

As a group, look at the following tables. Discuss what the (big picture) similarities and differences are between the ATs for the different sciences.

You may need to consider what some of the ATs mean and which aspects of them are appropriate for different RPs.

Biology

	Apparatus and techniques
AT1	Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, temperature, volume of liquids and gases, and pH (links to A-level AT a).
AT2	Safe use of appropriate heating devices and techniques including use of a Bunsen burner and a water bath or electric heater (links to A-level AT a).
AT3	Use of appropriate apparatus and techniques for the observation and measurement of biological changes and/or processes.
AT4	Safe and ethical use of living organisms (plants or animals) to measure physiological functions and responses to the environment (links to A-level AT h).
AT5	Measurements of rates of reaction by a variety of methods including production of gas, uptake of water and colour change of indicator.
AT6	Application of appropriate sampling techniques to investigate the distribution and abundance of organisms in an ecosystem via direct use in the field (links to A-level AT k).
AT7	Use of apparatus, techniques and magnification, including microscopes, to make observations of biological specimens and produce labelled scientific drawings (links to A-level AT d and e).

Chemistry

	Apparatus and techniques
AT1	Use of appropriate apparatus to make and record a range of measurements accurately, including mass, time, temperature and volume of liquids and gases (links to A-level AT a).
AT2	Safe use of appropriate heating devices and techniques including use of a Bunsen burner and a water bath or electric heater (links to A-level AT a).
AT3	Use of appropriate apparatus and techniques for conducting and monitoring chemical reactions, including appropriate reagents and/or techniques for the measurement of pH in different situations (links to A-level AT a and d).
AT4	Safe use of a range of equipment to purify and/or separate chemical mixtures including evaporation, filtration, crystallisation, chromatography and distillation (links to A-level AT d and g).
AT5	Making and recording of appropriate observations during chemical reactions including changes in temperature and the measurement of rates of reaction by a variety of methods such as production of gas and colour change (links to A-level AT a and l).
AT6	Safe use and careful handling of gases, liquids and solids, including careful mixing of reagents under controlled conditions, using appropriate apparatus to explore chemical changes and/or products (links to A-level AT a and k).
AT7	Use of appropriate apparatus and techniques to draw, set up and use electrochemical cells for separation and production of elements and compounds (links to A-level AT d and j).

Physics

	Apparatus and techniques
AT1	Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, volume and temperature. Use of such measurements to determine densities of solid and liquid objects (links to A-level AT a and b).
AT2	Use of appropriate apparatus to measure and observe the effects of forces including the extension of springs (links to A-level AT a).
AT3	Use of appropriate apparatus and techniques for measuring motion, including determination of speed and rate of change of speed (acceleration/deceleration) (links to A-level AT a, b and d).
AT4	Making observations of waves in fluids and solids to identify the suitability of apparatus to measure speed/frequency/wavelength. Making observations of the effects of the interaction of electromagnetic waves with matter (links to A-level AT i and j).
AT5	Safe use of appropriate apparatus in a range of contexts to measure energy changes/transfers and associated values such as work done (links to A-level AT a and b).
AT6	Use of appropriate apparatus to measure current, potential difference (voltage) and resistance, and to explore the characteristics of a variety of circuit elements (links to A-level AT f).
AT7	Use of circuit diagrams to construct and check series and parallel circuits including a variety of common circuit elements (links to A-level AT g).

Activity 3

Reviewing the coverage of ATs in RP lessons

In small groups, choose the lesson plans or equivalent that you work from when teaching one of the RPs. Review them to see if the ATs are sufficiently and explicitly covered in these lessons so that students understand that aspect of the AT.

A modelled, edited scheme of work for biology RP1 is on pages 20–21 for your reference.

Refer to the tables on pages 22–29 showing the ATs that are assigned to each RP.

Discuss whether

- your lesson plans explicitly cover the ATs adequately or if further work is needed on this
- your KS3 course provides a good introduction to AT1 'use appropriate apparatus to make and record a range of measurements accurately'.

Biology RP1 scheme of work

Spec ref	Summary of the specification content	Learning outcomes What most students should be able to do	Suggested timing (hours)	Opportunities to develop scientific communication skills	Opportunities to develop and apply practical and enquiry skills	Self/peer assessment Opportunities and resources Reference to past questions that indicate success
4.1.1.5	<p>Microscopy</p> <p>Required Practical: Microscopy</p> <p>Use a light microscope to observe, draw and label a selection of plant and animal cells. A magnification scale must be included.</p> <p>AT skills covered by this practical activity: Biology AT7.</p>	<p>An electron microscope has much higher magnification and resolving power than a light microscope. This means that it can be used to study cells in much finer detail. This has enabled biologists to see and understand many more sub-cellular structures.</p> <p>Limited to the differences in magnification and resolution.</p> <div> <ul style="list-style-type: none"> Describe how to use a microscope to clearly see a plant cell. Draw a labelled diagram of what you see. Calculate the magnification. </div>	1	<p>View projected images of various different cells: The Cell: An image library</p> <p>Ask pupils how big they are on the screen. Determine that cells are magnified so we can see them and that a scale is used.</p> <p>Show various images with scale bars: Red blood cells Columnar epithelial cells Plant cell Nematode</p> <div> <p>In pairs, explain how you could adjust the microscope to:</p> <ul style="list-style-type: none"> increase the magnification of your image improve the resolution. </div>	<p>Pupils can draw scale diagrams of simple shapes onto squared paper and label them with scale bars: Scale drawing grid Scale drawing image</p> <div> <p>Using the worksheet in the practical handbook students use a microscope to focus a prepared slide and then attempt to draw the image they see.</p> <p>Discuss with students how to use the microscope correctly to:</p> <ul style="list-style-type: none"> avoid breaking the slide understand why there are different lenses focus the image. </div>	<p>Students exchange scale diagrams and determine the size of the original object using the scale.</p> <div> <p>In groups, create some 'top tips' for using a microscope to see your skin cells and know how small they are.</p> </div>

				<p>Discuss why it's important to work out the magnification of images and how you do this.</p> <p>Carry out calculations involving magnification, real size and image size using the formula:</p> $\text{magnification} = \frac{\text{size of image}}{\text{size of real object}}$ <p>HW: Describe how electron microscopy has increased understanding of subcellular structures in terms of magnification and resolution.</p>		
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Biology AT criteria

Students who do the methods suggested in the practical handbook will have the opportunity to access the following aspects of the Ofqual criteria. Teachers should ensure that all of the AT criteria are covered for each student.

Individual practical activities will not cover all aspects of a criterion. It is only by doing all of the RPs that all aspects of each AT criterion will be covered. Some of the AT criteria are very specific, and will be addressed only by doing a particular activity.

		Required Practical activity									
		Microscopy	Microbiology (biology only)	Osmosis	Food tests	Enzymes	Photosynthesis	Reaction time	Plant responses (biology only)	Field investigations	Decay (biology only)
AT1 Use of appropriate apparatus to make and record a range of measurements accurately, including:	length		✓	✓			✓	✓	✓	✓	
	area		✓							✓	
	mass			✓							
	time					✓	✓		✓		
	temperature					✓					✓
	volume of liquids			✓		✓					
	volume of gases										
	pH					✓					✓

AT2 Safe use of appropriate heating devices and techniques including Bunsen burner and water bath or electric heater.					✓	✓					
AT3 Use of appropriate apparatus and techniques for the observation and measurement of biological changes and/or processes.			✓	✓			✓	✓	✓		✓
AT4 Safe and ethical use of living organisms (plants or animals) to measure physiological functions and responses to the environment.	physiological functions							✓			✓
	response to environment		✓				✓		✓	✓	
AT5 Measurement of rates of reaction by a variety of methods including:	production of gas						✓				
	uptake of water			✓							
	colour change of indicator					✓					✓
AT6 Application of appropriate sampling techniques to investigate the distribution and abundance of organisms in an ecosystem via direct use in the field.										✓	

AT7 Use of appropriate apparatus, techniques and magnification, including microscopes, to make observations of biological specimens and produce labelled scientific drawings.		✓							✓		
AT8 (biology only) Use appropriate techniques and qualitative reagents to identify biological molecules and processes in more complex and problem-solving contexts including continuous sampling in an investigation.			✓								

Chemistry AT criteria

Students who do the methods suggested in the Practical Handbook will have the opportunity to access the following aspects of the Ofqual criteria. Teachers should ensure that all of the AT criteria are covered for each student.

Individual practical activities will not cover all aspects of a criterion. It is only by doing all of the RPs that all aspects of each AT criterion will be covered. Some of the AT criteria are very specific, and will be addressed only by doing a particular activity.

		Required Practical activity							
		Making salts	Neutralisation (chemistry only)	Electrolysis	Temperature change	Rates of reaction	Chromatography	Identifying ions (chemistry only)	Water purification
AT1 Use of appropriate apparatus to make and record a range of measurements accurately, including:	mass				✓	✓			✓
	time					✓			
	temperature				✓	✓			
	volume of liquids		✓		✓	✓			
	volume of gases					✓			
AT2 Safe use of appropriate heating devices and techniques including use of a Bunsen burner and water bath or electric heater.		✓						✓	✓

AT3 Use of appropriate apparatus and techniques for conducting and monitoring chemical reactions, including appropriate reagents and/or techniques for the measurement of pH in different situations.				✓		✓			✓
AT4 Safe use of a range of equipment to purify and/or separate chemical mixtures including:	evaporation	✓							✓
	filtration	✓							
	crystallisation	✓							
	chromatography						✓		
	distillation								✓
AT5 Making and recording of appropriate observations during chemical reactions including changes in temperature and the measurement of rates of reaction by a variety of methods such as production of gas and colour change.	temperature change				✓				
	production of gas					✓			
	colour change					✓			
AT6 Safe use and careful handling of gases, liquids and solids, including careful mixing of reagents under controlled conditions, using appropriate apparatus to explore chemical changes and/or products.		✓			✓	✓			
AT7 Use of appropriate apparatus and techniques to draw, set up and use electrochemical cells for separation and production of elements and compounds.				✓					

AT8 (chemistry only) Use of appropriate qualitative reagents and techniques to analyse and identify unknown samples or products including:	gas tests							✓	
	flame tests							✓	
	precipitation reactions							✓	
	determination of concentration		✓						

Physics AT criteria

Students who do the methods suggested in the Practical Handbook will have the opportunity to access the following aspects of the Ofqual criteria. Teachers should ensure that all of the AT criteria are covered for each student.

Individual practical activities will not cover all aspects of a criterion. It is only by doing all of the RPs that all aspects of each AT criterion will be covered. Some of the AT criteria are very specific, and will be addressed only by doing a particular activity.

		Required Practical activity									
		Specific heat capacity	Thermal insulation (physics only)	Resistance	I-V characteristics	Density	Force and extension	Acceleration	Waves	Light (physics only)	Radiation and absorption
AT1 Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, volume and temperature. Use of such measurements to determine densities of solid and liquid objects.	length			✓		✓	✓	✓			
	area										
	mass	✓				✓		✓			
	time	✓	✓					✓			
	temperature	✓	✓								✓
	volume		✓			✓					
AT2 Use of appropriate apparatus to measure and observe the effects of forces including the extension of springs.							✓	✓			

AT3 Use of appropriate apparatus and techniques for measuring motion, including determination of speed and rate of change of speed (acceleration/deceleration).								✓			
AT4 Making observations of waves in fluids and solids to identify the suitability of apparatus to measure speed/frequency/wavelength. Making observations of the effects of the interaction of electromagnetic waves with matter.									✓	✓	✓
AT5 Safe use of appropriate apparatus in a range of contexts to measure energy changes/transfers and associated values such as work done.		✓	✓								
AT6 Use of appropriate apparatus to measure current, potential difference (voltage) and resistance, and to explore the characteristics of a variety of circuit elements.				✓	✓						
AT7 Use of circuit diagrams to construct and check series and parallel circuits including a variety of common circuit elements.				✓	✓					✓	

Activity 4

Development and progression from KS3

Using one of the RPs as a theme, in groups consider and discuss the following questions:

- What is the new learning at KS4 around this RP?
- How are you developing particular WS skills you have identified as appropriate for this topic?

Use the physics RP 'Force and extension' model on page 31 to assist.

Suggested progression of enquiry skills from KS3 to KS4 can be found on pages 32–35.

Discuss:

- Which, if any, of the WS skills do your students find most challenging?
- What resources do you have to focus on improving these?
- How can you organise the coverage of these skills across the three sciences at GCSE to make best use of your teaching time?

Force and extension Required Practical

Extension of a spring	ATs	New learning from KS3	WS progression
<p>Investigate the relationship between force and extension for a spring.</p> <p>Trilogy 6.5.3 Synergy 4.6.1.6 Physics 4.5.3</p>	<p>AT1 Use appropriate apparatus to make and record a range of measurements accurately including length.</p> <p>AT2 Use appropriate apparatus to measure and observe the effect of forces including the extension of springs.</p>	<p>Explain why to change the shape of an object (by stretching, bending or compression), more than one force has to be applied – this is limited to stationary objects only.</p> <p>Describe the difference between elastic deformation and inelastic deformation caused by stretching forces.</p> <p>The relationship between force, spring constant and either extension or compression $F = k \times e$ (directly proportional, provided that the limit of proportionality is not exceeded) .</p> <p>Explain what happens when a spring is stretched or compressed in terms of work done and elastic potential energy providing the spring is not inelastically deformed.</p> <p>From the resulting data/graph describe the relationship (linear/nonlinear).</p> <p>Calculate a spring constant in linear case.</p> <p>Calculate work done using elastic potential energy = $0.5 \times \text{spring constant} \times (\text{extension})^2$</p>	<p>3.1 Constructing their own graph (choosing scale, labelling axis and plotting accurately).</p> <p>Explain why it's a straight line.</p> <p>3.5 Describing with comparative values the pattern and relationship shown by the graph.</p> <p>Understanding directly proportional.</p> <p>3.7 What is meant by accuracy.</p> <p>What to do to ensure readings are accurate.</p> <p>What types of errors happen when taking the measurements (systematic).</p>

Progression of enquiry skills from KS3 to KS4

As the KS3 POS states, 'Working Scientifically is described at the beginning of the POS, but must always be taught through and clearly related to substantive science content in the POS', the same is true at KS4. Working Scientifically needs to be integrated into practical lessons as well as content-focused lessons to reflect how scientists really work.

All the enquiry skills taught at KS3 continue into KS4 where a deeper understanding of them is required. These threads then continue to be developed at KS5 through the RPs and the practical science endorsement to prepare students effectively for science at degree level.

KS3 POS	DfE criteria Section 3 of specification	KS4
Enquiry skill	Working Scientifically	Examples of new learning and how ideas may progress
Pay attention to objectivity and concern for accuracy, precision, repeatability and reproducibility	3.7 1.6	<ul style="list-style-type: none"> Understand the difference between the terms. Understand what needs to be done or what needs improving in an investigation to ensure readings are accurate and or precise. This could be linked to the choice of apparatus to improve accuracy. Understand why scientists do repeats. Understand why measurements need to be reproducible. Understand what peer review is and why it is important to avoid bias and maintain objectivity. Understand that some claims and reports in popular media are not subject to peer review and may be oversimplified, inaccurate or biased.
Understand scientific methods and theories develop as earlier explanations are modified	1.1	<ul style="list-style-type: none"> Name examples in the specification, eg development of electron microscopes, organisation of the periodic table, plum pudding theory. Use information on unfamiliar theories to explain how theories may develop, eg Synergy 2018, 4H, Q7.4. Acceptance that ideas and theories change and develop – science never stands still. Changes need to be evidence based.

Evaluate risks	1.5 2.4	<ul style="list-style-type: none"> Specific risks in an investigation exemplified by chemical hazards and health and safety. For example corrosive nature of acids, using a fume cupboard when working with poisonous gases (eg chlorine), safe precautions taken when using radioactive sources, heating things and using scalpels in biology etc.
Identifying independent, dependent and control variables	2.2	<ul style="list-style-type: none"> Understand what is meant by the three types of variables and so what the difference is between them. Identify the variables in experiments they might not have done in class or have done slightly differently in class (eg using different type of acid or metals in a chemical reaction), using a computer programme to test for reaction rates. Why there is a need to control variables or the converse, what would be the effect of not controlling some variables?
Use appropriate techniques, apparatus and materials	2.3 ATs assigned to RPs	<ul style="list-style-type: none"> Correct names of apparatus. Why they chose that particular piece of apparatus, eg why a burette rather than a measuring cylinder, why a water bath rather than a Bunsen burner, why use a ruler with a mm scale rather than a cm scale? Why they are carrying out the steps in the method.
Make and record observations and measurements	2.6 4.3,4.4,4.5,4.6	<ul style="list-style-type: none"> Construct a results table with correct headings and organise data in it correctly. Using correct SI units. Understand resolution range and interval. Converting units, eg dm^3 and cm^3. What is meant by precision. What is meant by accurate.

Evaluate the reliability of methods and suggest possible improvements	2.7	<ul style="list-style-type: none"> Understand the difference between repeatable and reproducible. Suggest sources of error and what effect that error might have had on the results. Suggest improvements to method, eg repeats and calculating the mean or using a measuring device with greater resolution.
Apply sampling techniques	2.5	<ul style="list-style-type: none"> How you carry out a valid investigation when using people as your sample population on, for example, does smoking effect heart rate during exercise? How do you select your sample, what variables do you control, eg age, gender etc. Carrying out a line transect (RP). How to estimate a population using sampling techniques, eg a quadrat (RP).
Mathematical concepts and calculate results	3.3 4.3 , 4.4, 4.5, 4.6	Integrating any appropriate maths skill (section 7 of the specification) into practical lessons.
Present observations and data using appropriate methods, including tables and graphs	3.1 3.2 4.3	<ul style="list-style-type: none"> Constructing tables correctly. Understanding simple pie charts. Understand which type of graph to choose for different types of data. Knowing how to choose an appropriate scale. Understanding where the labels for the X and Y axis come from. Practise plotting points accurately (including the 0,0 if given). Drawing lines of best fit based on what the data is showing. Constructing graphs with negative numbers, eg biology – osmosis. Constructing graph with two lines, eg chemistry – using graphs with more than one variable (Higher demand).
Interpret observations and data, including identifying patterns and using observations, measurements and data to draw conclusions	3.4 3.5 4.3	<ul style="list-style-type: none"> Calculations using data from graphs, eg % change. Illustrate points with comparative figures. Use of correct scientific language to describe patterns and trends. Using data to support or counter a given conclusion. Estimate intermediate values in tables, eg estimate the missing value. Understand what is meant by uncertainty and how to work out uncertainty.

Present reasoned explanations	3.6	<ul style="list-style-type: none"> • Using the appropriate scientific knowledge from the specification to explain the conclusion. • Comment on the extent to which the data is consistent with the hypothesis. • If two different hypotheses have been made, which provides a better explanation of the data in a given context?
Evaluate data, showing awareness of potential sources of random and systematic error	3.7	<ul style="list-style-type: none"> • Understand what is meant by random error, systematic error and zero error. • Identify what type of error has occurred in a given situation: eg reading from the wrong part of the meniscus. • Consistent parallax error (term not required), eg measuring an object with a ruler or reading from a meter with a needle but not looking directly over it. • Effect of tiredness on human reaction time, eg stopwatch. Reaction time might be a random error, but if you are tired you would probably be consistently slower than if you weren't, but that's not really a zero error. • If your apparatus isn't properly calibrated, eg a Newtonmeter might show increments of 1N but actually be going up by increments of 0.9N each time if the spring was too warm. • For each RP identify the obvious errors that could occur and what type they are. State how you might correct the error. • Understand when it's appropriate to do more repeats, ie to remove random error – making more measures, removing anomalous results and calculate a new mean.

Activity 5

Identifying your department's next steps

Practical assessment involves a number of interwoven skills which need to be developed by the student during both KS3 and KS4. Slide 14 of the guidance presentation summarises these.

Development time is limited so it is important to identify the areas that are priorities for you and your students. Ensure these are doable in the time frame you have available.

Some of these elements are covered in other training modules and some support is available for others.

Challenges with practical assessment:

- understanding and using subject specific language
- identifying and integrating the science behind the practical
- practicals broader than RP (AO2) – identifying classic practicals in your subject
- applying maths skills in a practical context
- map coverage of these skills across the three sciences
- teacher challenges – time and technician support.

In groups, consider which elements, if any, you can look at this year. Consider if one of the strands in this training is more important to prioritise.

Resources and support

Resources to support activity 5

Understanding and using subject-specific language

Summer 2020 Hub materials

Subject-specific vocabulary aqa.org.uk/subjects/science/gcse

Practicals broader than the RP

Focus on success: GCSE science – AO2 module aqa.org.uk/focus-on-success-science

AO3 analyse, interpret and evaluate information

Summer 2019 Hub materials

Focus on success: GCSE science – AO3 module (spring 2020) aqa.org.uk/focus-on-success-science

Applying maths skills in a practical context

Focus on success: GCSE science – Maths in science module (summer 2020) aqa.org.uk/focus-on-success-science
teachitscience.co.uk

Mapping coverage of skills across all three sciences

Required Practical coverage table – Focus on success: GCSE science – Practical questions module aqa.org.uk/focus-on-success-science

Identifying and integrating the science behind the practical

Specification for relevant science aqa.org.uk/subjects/science/gcse

Further resources

The language of measurement, Boohan R, Campbell P

The language of maths in science, Boohan R, Needham, R

exampro.co.uk

ase.org.uk/mathsinscience

science.cleapss.org.uk

stem.org.uk

gatsby.org.uk

Our practical handbooks offer teacher and technician notes and student worksheets for a **suggested method** to help teachers plan purposeful practical work. This is to develop both practical and investigative skills and encourages the thinking behind the doing. If students are asked for a method in the exam question, any suitable method that gives the correct outcomes will be credited.

The Required practical handbooks available on the teach tab of your subject on aqa.org.uk/subjects/science/gcse offer teacher and technician notes and student worksheets for a suggested method to help teachers plan purposeful practical work. This develops both practical and investigative skills and encourages the thinking behind the doing. If students are asked for a method in an exam question, any suitable method that gives the correct outcomes will be credited.

[GCSE Biology](#)

[GCSE Chemistry](#)

[GCSE Physics](#)

[GCSE Combined Science Synergy and Trilogy](#)

Teachers are encouraged to provide other opportunities for practical work throughout the course. This is clearly stated in the AO2 criteria 'scientific enquiry, techniques and procedures encompasses, but is **broader than**, knowledge and understanding of the core practical activities (RPs)'.

Opportunities for further practical skills development are signposted in the right-hand column of the content section of each specification. Each SOW should provide ideas and suggestions for practical activities and all approved textbooks cover additional practicals beyond the RPs.

In exam papers, a question is made up of items, meaning that any question will often cover more than one AO and will assess content as well as practical and maths skills. For this reason, you will see that there are few questions that focus solely on a RP, rather, whole questions assess a number of different aspects.

Due to this, only parts of questions have been used in some of the examples with their accompanying mark schemes.

Personal action plan

Following your training session and results of your post-session health check, use this action plan to help continue your development in specific areas.

Knowledge/competency area	Development notes

Personal development aim/target:
What do I need to achieve?
Actions:
Support required:
Measure(s) of success:
Review date(s):
Achievement date:

Group action plan

Following the group reflection on the session, complete this action plan to support the department's continued development.

Department goal:
Where is the knowledge and expertise?
Actions: Who has ownership of each area?
Support required: How will we work together? How will we hold each other to account?
Measure(s) of success: How will we evidence achievements?
Review date(s):
Achievement date:

Notes

Contact us

T: 01483 477756

E: gcsescience@aqa.org.uk

aqa.org.uk