Working Scientifically

The tables below show examples of the ways working scientifically could be assessed.
The column to the right gives examples of what students could be asked to do in an exam.

1 Development of scientific thinking

WS 1.1	Understand how scientific methods and theories develop over time.	Give examples to show how scientific methods and theories have changed over time. Explain, with an example, why new data from experiments or observations led to changes in models or theories. Decide whether or not given data supports a particular theory.
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.	Recognise/draw/interpret diagrams. Translate from data to a representation with a model. Use models in explanations, or match features of a model to the data from experiments or observations that the model describes or explains. Make predictions or calculate quantities based on the model or show its limitations. Give examples of ways in which a model can be tested by observation or experiment.
WS 1.3	Appreciate the power and limitations of science and consider any ethical issues which may arise.	Explain why data is needed to answer scientific questions, and why it may be uncertain, incomplete or not available. Outline a simple ethical argument about the rights and wrongs of a new technology.
WS 1.4	Explain every day and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments.	Describe and explain specified examples of the technological applications of science. Describe and evaluate, with the help of data, methods that can be used to tackle problems caused by human impacts on the environment.
WS 1.5	Evaluate risks both in practical science and the wider societal context, including perception of risk in relation to data and consequences.	Give examples to show that there are hazards associated with science-based technologies which have to be considered alongside the benefits. 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).
WS 1.6	Recognise the importance of peer review of results and of communicating results to a range of audiences.	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.

2 Experimental skills and strategies

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

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.
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.

4 Scientific vocabulary, quantities, units, symbols and nomenclature

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