Skills

The ways in which chemistry investigation skills are expressed are set out in the following table on intended student learning.

Key Ideas	Intended Student Learning
Students should know and understand the following:	*Students should provide evidence that they are able to do the following:*
Purposes of Investigations	
Investigations and experiments have a clearly defined purpose.	State the purpose of the investigation or experiment.
Investigations are based on existing information or issues.	For a given topic, state the key ideas or issues relevant to the information required, and identify the type of resource that might provide the information.
Before searching for information it is necessary to have a clear idea of the information required, the level of detail needed, and the appropriate facilities for extracting the information.	
Before undertaking an information search it is necessary to be familiar with search techniques, the way in which the information is structured, and the means of retrieving the information.	Identify key search words and phrases for a given topic. Use an information source (e.g. library catalogue, CD-ROM, or the Internet) to obtain information about a topic.
Questions and Hypotheses	
Investigable questions guide investigations on chemistry issues.	Formulate a question for an investigation based on a chemistry issue.
Investigations are often designed to explore questions and to develop possible solutions to those questions.	Suggest possible investigations to test the question.
Experiments may be used to test hypotheses.	State a testable hypothesis, where appropriate.
Designing Investigations	
Design	
Scientific inquiry involves designing procedures, including investigations based on the scientific method or observations made in the field, to investigate questions. Designing an investigation involves identifying: • what needs to be observed • the measurements that need to be taken • the techniques that need to be used • the apparatus or measuring instruments needed.	Design procedures to investigate posed questions or hypotheses. Design and carry out investigations to explore a chemistry issue. Design and carry out experiments, using the scientific method. Record and analyse observations.
Every step in a practical or issues investigation serves a purpose.	Describe the steps of an investigation. Draw or interpret diagrams of the apparatus used in an experiment.

Key Ideas	Intended Student Learning
Students should know and understand the following:	*Students should provide evidence that they are able to do the following:*
Variables	
Many practical investigations involve deliberately changing one quantity and determining the effect on another quantity. These quantities are referred to as 'variables'.	Identify the variables in a practical investigation.
The quantity being deliberately changed is called the 'independent variable'. The quantity that changes as a result, and is measured, is called the 'dependent variable'.	Classify appropriate variables in a practical investigation as independent or dependent.
Other variables are held constant, if possible, throughout a practical investigation.	Identify any variables that are deliberately held constant throughout a practical investigation.
Conducting Investigations	
Procedures	
Practical investigations require a particular set of actions to be carried out in a well-defined order.	Follow instructions accurately and safely.
Appropriate apparatus is selected to undertake: • measurement of mass, volume, temperature, and pH	Select appropriate apparatus for the measurement of mass, volume, temperature, and pH.
• volumetric analysis	Prepare standard solutions, carry out dilutions, and undertake titrations.
• construction of electrochemical cells	
• preparation of simple organic compounds.	Construct galvanic and electrochemical cells.
	Prepare organic compounds, using distillation, reflux, and liquid–liquid extraction.
Safety and Ethics	
Ethical practices must be followed when conducting investigations.	Maintain confidentiality, report accurately, and acknowledge the work of other people.
Safety must be considered when conducting investigations.	Recognise hazards and work safely during a practical investigation.
Many investigations involve the collaborative efforts of a team.	Negotiate procedures with the other members of a team. Define the role of each member.
Members of a team work together.	Perform the role of a team member.
Errors in Measurements	
Measurements are affected by random and/or systematic errors.	Identify sources of errors and uncertainty that may occur in a practical investigation.
Random errors are present when there is scatter in the measured values. Systematic errors are present when measured values differ consistently from the true value.	Distinguish between random and systematic errors.

Key Ideas	Intended Student Learning
Students should know and understand the following:	*Students should provide evidence that they are able to do the following:*
Where applicable, increasing the number of samples minimises the effects of random errors and improves the reliability of the data.	Explain the importance of increasing the number of samples in a practical investigation.
Systematic errors can be identified and results verified by repeating an experiment using an alternative source of equipment and materials.	Explain the importance of repeating a practical investigation where feasible.
Precision, Reliability, and Accuracy	
The reliability/precision of data collection is related to the reproducibility of the measurements.	Where possible, collect data using measurements that can be reproduced consistently.
Measurements are more reliable/precise when there is less scatter in the results.	Determine which of two or more measuring instruments or sets of measurements is most reliable/precise.
Reliability/precision depends on the extent to which random errors are minimised.	Use averages or graphing as a means of detecting or minimising the effects of random errors.
The accuracy of an experimental value indicates how close the result is to the true value and depends on the extent to which systematic errors are minimised.	State which result of two or more experiments is most accurate, given the true value.
The resolution of a measuring instrument is the smallest increment measurable by the measuring instrument.	Select an instrument of appropriate resolution for a measurement.
The number of significant figures for a measurement is determined by the reproducibility of the measurement and the resolution of the measuring instrument.	Record and use measurements to an appropriate number of significant figures.
Information and Data	
Valid conclusions depend on gathering appropriate evidence.	In investigations, make and record careful and honest observations and measurements.
Practical investigations involve observations, which may be quantitative or qualitative.	Distinguish between qualitative and quantitative evidence.
Data can be more easily interpreted if presented in a well-structured table.	Present data in an appropriate tabular form. Include a title, column headings showing the quantities measured and the units used, and the values observed or researched.
Graphs are a useful way of displaying some forms of data. When a graph is plotted, the independent variable (or a quantity derived from it) is plotted horizontally and the dependent variable (or a quantity derived from it) is plotted vertically.	Plot a graph of dependent variable versus independent variable. Include a title, labelled axes, and appropriate scales and units.
A line of best fit can show relationships between variables in an experiment.	Draw a line of best fit through a series of points on a graph such that the plotted points are scattered evenly above and below the line of best fit.

Key Ideas	Intended Student Learning
Students should know and understand the following:	*Students should provide evidence that they are able to do the following:*
Understanding of a topic, issue, or question is enhanced, using information from different sources.	Obtain information from different sources. Limit investigations to a manageable size and identify available sources of relevant information.
Evidence obtained should be critically examined for accuracy and its suitability for the purpose for which it was sought.	Evaluate evidence for bias, credibility, accuracy, and suitability.
The source of information must be recorded so that the information is accessible to others.	List the sources of information, using an appropriate format.
Interpretation and Evaluation	
Careful observation in a practical investigation is essential for analysis and for comparison with other experiments.	Describe a pattern observed in the results of an experiment.
The scatter of data points above and below the line of best fit is probably due to random errors.	Using the scatter in the graphs of data from similar investigations, compare the random errors.
Subsequent investigations can be improved by the critical evaluation of the procedure and results.	Analyse and evaluate information from a series of observations or an investigation, and suggest improvements or indicate the additional information needed.
A conclusion should be written at the end of each investigation.	Write a conclusion that is based on the results of an investigation and related to the question posed and the purpose of, or the hypothesis for, the investigation.
Alternative Views	
The evidence collected through investigations may be interpreted in a variety of ways.	Describe a range of alternative interpretations or points of view based on evidence, and state reasons for the selection of the preferred interpretation.
Arguments can be presented for and against an issue on the basis of information selected from different sources.	Construct for-and-against arguments on an issue, based on information gathered from different credible sources.
Personal views must be substantiated by the evidence collected through an investigation.	Present a justification of, or evidence for, a personal view.
Communication	
Communication in chemistry uses specific terminology, conventions, and symbols.	Use chemistry terminology, conventions, and symbols that are appropriate for the purpose of the communication.
Chemical reactions can often be described by means of a chemical equation.	Write appropriate chemical equations.
Communication for different audiences requires the use of a format suitable for the purpose.	Select the appropriate format for a particular audience.

Key Ideas	Intended Student Learning
Students should know and understand the following:	*Students should provide evidence that they are able to do the following:*
All communication needs to be well structured, well organised, and clearly presented.	Present communications (oral, written, and multimedia) clearly and logically, using chemistry concepts appropriate for the audience.
Written reports should state what was done and why, the results, the analysis and interpretation of the results, and the conclusions drawn from the results. Sufficient information should be included to enable the procedure to be repeated by others.	Write a report of an investigation that includes a description of its purpose and experimental procedure (if designed by the student), results, analysis, interpretation, and conclusions.
Multimedia presentations use minimal language and a variety of graphics to present information.	Use concise language and graphics to present information.