General comments approved by the VCAA (page 1)

Rubrics and poster templates

At their sessions in Term 2 the VCAA provided a detailed rubric that could be simplified and adapted for each investigation and a template for the poster. Please find copies of them on the CEA website. VCAA will release more template suggestions soon.

VCAA Advice to Teachers

The VCAA has released *Advice to Teachers for Units 1 and 2*. Significant details are provided for all aspects of a scientific investigation. (Appendix 1 page 30), including detailed examples of research and practical investigations. They have given ideas on how to plan and carry out these investigations.

Finding shared resources

On the CEA website under *VCE Chemistry/New Study Design* materials which can be shared are uploaded. Teacher can email their examples for sharing to the project officer who will upload them in this space.

Thoughts for your consideration

Remember in Year 11 there is more flexibility. The Year 11 investigations are useful for developing the skills needed for the final assessment in Year 12. The research investigation helps the development of skills required for critical thinking, evaluation and presentation. While the practical investigation provides skill development in areas such as writing a viable question and hypothesis, identifying variables (page 36 of *Advice to teachers for Units 1 and 2*), developing appropriate practical activities, further analysis and evaluation as well as creative writing and referencing skills.

The requirement of logbooks will assist with authentication. You can't stop the students talking out of class, obviously, but what they write and how they explain their results should be individual. As you do now, you would need to look out for plagiarism and make it clear that both students would be penalised if it occurs. This will reduce the chance of a good student being prepared to share.

A way of approach with the topic choices for the investigations is:

- In Unit 1, the Research Investigation is on the same area of the content, but you can use different research topics for each student.
- In Unit 2 and for the Year 12 Unit 3 or 4 Practical Investigations, students could analyse different substances/ aspects of the same area of the content, such as how does the Vitamin C content compare to the label.

Because the topics for the Research Investigation are not dependent on content taught in class, you can position this according to your own timetable. Whether you complete it in one week or over several weeks is entirely your decision.

VCAA Units 1–4: Key science skills

The development of a set of key science skills is a core component of the study of VCE Chemistry and applies across Units 1 to 4 in all areas of study. In designing teaching and learning programs and in assessing student learning for each unit, teachers should ensure that students are given the opportunity to develop, use and demonstrate these skills in a variety of contexts when undertaking their own investigations and when evaluating the research of others. As the complexity of key knowledge increases from Units 1 to 4 and as opportunities are provided to undertake investigations, students should aim to demonstrate the key science skills at a progressively higher level.

Key science skill	VCE Chemistry Units 1–4
Develop aims and questions, formulate hypotheses and make predictions	• determine aims, hypotheses, questions and predictions that can be tested • identify independent, dependent and controlled variables
Plan and undertake investigations	• determine appropriate type of investigation: experiments (including use of controls and calibration curves); solving a scientific or technological problem; simulations; access to secondary data, including data sourced through the internet that would otherwise be difficult to source as raw or primary data through a laboratory or a classroom • select and use equipment, materials and procedures appropriate to the investigation, taking into account potential sources of error and uncertainty
Comply with safety and ethical guidelines	• apply ethical principles when undertaking and reporting investigations • apply relevant occupational health and safety guidelines while undertaking practical investigations, including following recommended protocols from safety data sheets
Conduct investigations to collect and record data	• work independently and collaboratively as appropriate and within identified research constraints • systematically generate, collect, record and summarise both qualitative and quantitative data
Analyse and evaluate data, methods and scientific models	• process quantitative data using appropriate mathematical relationships, units and number of significant figures • organise, present and interpret data using schematic diagrams and flow charts, balanced chemical equations, tables, graphs, percentages and calculations of mean • take a qualitative approach when identifying and analysing experimental data with reference to accuracy, precision, reliability, validity, uncertainty and errors (random and systematic) • explain the merit of replicating procedures and the effects of sample sizes in obtaining reliable data • evaluate investigative procedures and possible sources of bias, and suggest improvements • explain how models are used to organise and understand observed phenomena and concepts related to chemistry, identifying limitations of the models
Draw evidence-based conclusions	• determine to what extent evidence from an investigation supports the purpose of the investigation, and make recommendations, as appropriate, for modifying or extending the investigation • draw conclusions consistent with evidence and relevant to the question under investigation • identify, describe and explain the limitations of conclusions, including identification of further evidence required • critically evaluate various types of information related to chemistry from journal articles, mass media and opinions presented in the public domain • discuss the implications of research findings and proposals
Communicate and explain scientific ideas	• use appropriate chemical terminology, representations and conventions, including standard abbreviations, graphing conventions and units of measurement • discuss relevant chemical information, ideas, concepts, theories and models and the connections between them • identify and explain formal chemical terminology about investigations and concepts • use clear, coherent and concise expression • acknowledge sources of information and use standard scientific referencing conventions

Year 11 Research investigation Unit 1

This is a Year 11 research assessment task that presents independent findings. This could be presented as a scientific digital poster, oral communication or written report.

See Chapter 11 in new 5th Edition Pearson Heinemann Chemistry 1 for information of how to develop of the necessary skills and ideas to complete this investigation in 4-6 hours. Skills practice is provided here as well as suggested timelines.

VCAA

The task is to apply and extend knowledge and skills developed in Unit 1 when investigating one aspect of the discoveries and research that have underpinned the development, use and modification of useful materials or chemicals. Students need to complete this task within a given time frame of 4-6 hours of classroom time.

Skills

The following skills are useful for the Year 12 Practical Investigation. Students need to

- apply critical and creative thinking skills to summarise and evaluate data
- use science inquiry skills to determine relevance of material
- use communication skills to clearly and concisely present information

In learning the refining these skills, they will conduct and present the findings of an independent investigation.

VCAA Key Knowledge

- the characteristics of effective science communication: accuracy of chemical information; clarity of explanation of chemical concepts, ideas and models; contextual clarity with reference to importance and implications of findings; conciseness and coherence
- the chemical concepts specific to the investigation: definitions of key terms; use of appropriate chemical terminology, conventions, units and representations
- the use of data representations, models and theories in organising and explaining observed phenomena and chemical concepts, and their limitations
- the nature of evidence and information: distinction between weak and strong evidence, and scientific and nonscientific ideas; and validity, reliability and authority of data including sources of possible errors or bias
- the influence of social, economic, environmental and ethical factors relevant to the selected chemical investigation.

Suggested Topics

These are available in the VCAA Study Design. There are 10 overall topics with many possible aspects suggested that a student could choose to investigate.

Suggestions and ideas from the Developmental Workshops

1. **Suggestion timing**
    a. Because of the nature of research, teachers could consider implementing little research tasks/ research throughout the term/semester. See Chapter 11 *Heinemann Chemistry 1* for suggestions.
    b. Run in the two weeks before Term 1 holidays or
    c. Run after exams in June before Term 2 holidays.
2. **Possibly present as 2 parts**
    a. In Part 1: students develop their research question, hypothesis and methodology and this is assessed
    b. Part 2: the development of the topic.
3. **Logistic issues**
    a. Offering all choices to the students would increase student engagement and prevent teachers having to mark many, very similar, projects. This would, however, create too much work as the teacher would need to know some information on each topic to offer guidance.
    b. If a fewer number of choices were offered, perhaps select those which offer connections to Year 12. Although this is not essential as the skills are what are important for Year 12 not the content.
4. **A generic timeline and scaffolding**
    a. This could be helpful to all students
    b. It could increase the efficiency of the process overall
    c. Suggestions in Chapter 11 *Heinemann Chemistry 1.*
5. **Authentication issues**
    - Students to complete a log book to be submitted as part of assessment. The log book could be electronic e.g. One Note.
    - Students to complete at end of each lesson a summary sheet that contains any websites visited and any major findings
6. *AFL chemistry* has a great activity about molecules in space, which has instructions and great pictures and could be used as a launch for the stars topic.

This is Year 11 and there is flexibility in the way you present and complete this material.

Year 11 Practical investigation Unit 2

This is a Year 11 practical assessment task that presents independent findings. It is suggested that it is presented as a scientific digital poster in order to practice these skills for Year 12.

See Chapter 21 in new 5th Edition Pearson Heinemann Chemistry 1 for information of how to develop of the necessary skills and ideas to complete this investigation in 4-6 hours. Skills practice is provided here as well as suggested timelines.

VCAA

Substances that are dissolved in water supplies may be beneficial or harmful, and sometimes toxic, to humans and other living organisms. They may also form coatings on, or corrode, water pipes.

In this area of study students design and conduct a practical investigation into an aspect of water quality. The investigation relates to knowledge and skills developed in Area of Study 1 and/or Area of Study 2 and is conducted by the student through laboratory work and/or fieldwork. (4-6 hours work all inclusive).

The investigation requires the student to

- develop a question
- develop a hypothesis
- plan a course of action that attempts to answer the question
- undertake an investigation to collect the appropriate primary qualitative and/or quantitative data (which may including collecting water samples)
- organise data clearly
- interpret and evaluate the data
- reach a conclusion in response to the question.

VCAA Key knowledge

- the chemical concepts specific to the investigation and their significance, including definitions of key terms, and chemical representations
- the characteristics of laboratory techniques of primary qualitative and quantitative data collection relevant to the investigation: sampling protocols; gravimetric analysis, acid-base titrations and/or pH measurement; precision, accuracy, reliability and validity of data; and minimisation of experimental bias
- ethics of and concerns with research including identification and application of relevant health and safety guidelines
- methods of organising, analysing and evaluating primary data to identify patterns and relationships including identification of sources of error and uncertainty, and of limitations of data and methodologies
- observations and experiments that are consistent with, or challenge, current chemical models or theories
- the nature of evidence that supports or refutes a hypothesis, model or theory
- options, strategies or solutions to issues related to water quality
- the key findings of the selected investigation and their relationship to solubility, concentration, acid/base and/or redox concepts
- the conventions of scientific report writing including chemical terminology and representations, symbols, chemical equations, formulas, units of measurement, significant figures and standard abbreviations.

Presentation

The report of this student-designed quantitative laboratory investigation can be a:

- digital presentation,
- oral communication,
- scientific poster (good idea to practice this as a digital poster for Year 12)
- written report.
- VCAA template:

The following template is to be used by students in the development of the scientific poster for the investigation undertaken.

Section	Content and activities
Title	Question under investigation is the title
Introduction	Explanation or reason for undertaking the investigation, including a clear aim, a hypothesis and/or prediction, and relevant background chemical concepts
Methodology	Summary that outlines the methodology used in the investigation and is authenticated by logbook entries
	Identification and management of relevant risks, including the relevant health, safety and ethical guidelines followed in the investigation
Results	Presentation of collected data/evidence in appropriate format to illustrate trends, patterns and/or relationships
Discussion	Analysis and evaluation of primary data
	Identification of outliers and their subsequent treatment
	Identification of limitations in data and methods, and suggested improvements
	Linking of results to relevant chemical concepts
Conclusion	Conclusion that provides a response to the question
References and acknowledgments	Referencing and acknowledgment of all quotations and sourced content as they appear in the poster.

Suggested topics

1. The analysis of a local water supply

Students could measure such factors as

- Solubility – precipitation reactions of ionic substances and/or solubility gases (O_2 and CO_2) in water.
- Temperature at specified depth
- turbidity of the sample
- pH
- conductivity
- dissolved oxygen (Year 11 TRAB page 104) and biological oxygen demand
- titration to determine concentration

2. Growing crystals

Students could experiment with different factors to determine which enables the formation of biggest/most pure crystals (Year 11 TRAB page 33, 68-72, new prac in *Heinemann Chemistry 1* practical activities)

3. Corrosion and its prevention

Students could set up simple experiments to

- determine the conditions which cause corrosion and
- determine the factors that can be controlled to reduce or prevent corrosion. (Year 11 TRAB page 95, 96)

4. Effects of acidity on water

Students could set up samples of different pH including a sample of the local water supply. They could measure some of the factors above and compare to another student groups results.

5. Gravimetric analysis

Students can determine the percentage of soluble salts in a sand or soil sample. (Year 12 TRAB page 11). This could be combined with measuring some of above factors of the water supply associated with the soil.

6. Studying the fizz in soft drinks

Students could study the effect of dissolved CO_2 gas on the pH of mineral water or soft drinks**.** They could measure some of the factors listed above and determine the effects varying concentrations of CO_2 might have on these factors. (Year 12 TRAB page 22) This could involve a titration.

7. Properties of water

Students can select which properties of water they wish to investigate. Some help can be found in Year 11 TRAB pages 61-66. Such aspects as:

- density of ice and water
- freezing point of water
- polar bonds within water molecules
- Solubility of compounds in water
- deriving a solubility curve
- ability of water to wet surfaces
- surface tension of water

If schools have PASCO Data logging equipment, the PASCO Water Quality Field Guide (2010) PS-2829A ISBN 987-1-886998-18-6, shows ideas using sensors for pH, temperature, conductivity, salinity, turbidity, dissolved oxygen, colorimetry, ion-selective electrodes etc.

Suggestions and ideas from the Developmental Workshops

1. **Suggestion timing**
    a. Middle of Term 3
    b. Early Term 4 – this could be difficult for those students who are doing Year 12 subjects.
2. **Possibly present as 2 parts**
    a. In Part 1: students develop their question, prac method, general outline and teacher provided feedback for all students.
    b. Part 2: practical activity is completed and poster produced.
3. **Logistic issues**
    a. Focus on a limited number of questions and/or methodology.
    b. It may not be practical for students to carry out certain investigation depending on resources available to schools.
    c. Students could select their own investigation within a theme provided by the teacher such as: Suggested theme might be *Water Pollutants*, and possible student investigations within this theme being Cl- presence and concentration, temperature variations and associated ion concentrations, precipitates, total dissolved solids, phosphorus levels.
4. **A generic timeline and scaffolding**
    a. This could be helpful to all students
    b. It could increase the efficiency of the process overall
    c. Stress the importance of the scientific conventions of report writing
    d. Suggestions in Chapter 21 *Heinemann Chemistry 1.*
5. **Authentication issues**
    a. Students to complete a log book to be submitted as part of assessment.
    b. Varying topics will help in preventing plagiarism between students.

Year 12 Practical investigation Unit 3/4

This is a Year 12 experimental assessment task that allows students to present valid results as a scientific poster.

See the new 5th Edition Pearson *Heinemann Chemistry 1* for assistance in the development of the necessary skills and ideas of how to go about this investigation. The Student Workbook also has suggestions.

VCAA

The task is a student-designed or adapted practical investigation related to energy and/or food and relates to knowledge and skills developed across Unit 3 and/or Unit 4.

The investigation requires the student to identify an aim, develop a question, formulate a hypothesis and plan a course of action to answer the question and that complies with safety and ethical requirements.

The student then undertakes an experiment that involves the collection of primary qualitative and/or quantitative data, analyses and evaluates the data, identifies limitations of data and methods, links experimental results to science ideas, reaches a conclusion in response to the question and suggests further investigations which may be undertaken.

Findings are communicated in a scientific poster format according to the template below.
This template is to be used by students in the development of the scientific poster for the investigation undertaken.

Section	**Content and activities**
Title	Question under investigation is the title
Introduction	Explanation or reason for undertaking the investigation, including a clear aim, a hypothesis and/or prediction, and relevant background chemical concepts
Methodology	Summary that outlines the methodology used in the investigation and is authenticated by logbook entries Identification and management of relevant risks, including the relevant health, safety and ethical guidelines followed in the investigation
Results	Presentation of collected data/evidence in appropriate format to illustrate trends, patterns and/or relationships
Discussion	Analysis and evaluation of primary data Identification of outliers and their subsequent treatment Identification of limitations in data and methods, and suggested improvements Linking of results to relevant chemical concepts
Conclusion	Provides a response to the question
References and acknowledgments	Referencing and acknowledgment of all quotations and sourced content as they appear in the poster.

VCAA *Advice to Teachers for Units 1 and 2*

Among other things the following topics have been addressed in the VCAA document and will be extremely helpful:

- Determining the significance of the hypothesis
- The measurability and definitioof the variables
- The role of the log book in authentication and marking
- Actual role of the poster in grading

The investigation requires the student to

- Identify an aim
- Develop a question
- Form a hypothesis
- Identify the variables (independent, dependent and controlled)
- Ensure the IV and DV are measurable quantitatively
- Perform a viable experiment
- Collect valid data
- Connect results to concepts taught
- Write a conclusion to the original question
- Suggest further investigations
- Ensure all complies with safety and ethical requirements.
- Present as a scientific digital poster

The investigation requires that the teacher will

- Teach how to develop a hypothesis and aim
- Teach the idea of variables
- Help provide a concrete pathway so students can answer the question
- Be careful not to allow questions with too many variables which can't all be controlled and tested
- Consider OH and S, for example students could use an on-line risk assessment program such as the student version of Risk Assess
- Help students to consider what will and won't work practically and economically in a classroom
- Suggest methods to follow
- Provide URLs to excellent links explaining background to this topic that they can give their students – non-complicated, accurate and clearly written.
- Provide a general process that will enable students to complete this task, including the poster, within a given time frame of 7 -10 hours of classroom time.

VCAA Key knowledge

- independent, dependent and controlled variables
- chemical concepts specific to the investigation and their significance, including definitions of key terms, and chemical representations
- the characteristics of scientific research methodologies and techniques of primary qualitative and quantitative data collection relevant to the selected investigation: volumetric analysis, instrumental analysis, calorimetry and/or construction of electrochemical cells; precision, accuracy, reliability and validity of data; and minimization of experimental bias
- ethics of and concerns with research including identification and application of relevant health and safety guidelines
- methods of organising, analysing and evaluating primary data to identify patterns and relationships including sources of error and uncertainty, and limitations of data and methodologies
- models and theories and their use in organising and understanding observed phenomena and chemical concepts including their limitations
- the nature of evidence that supports or refutes a hypothesis, model or theory
- the key findings of the selected investigation and their relationship to thermochemical, equilibrium and/or organic structure and bonding concepts
- the conventions of scientific report writing and scientific poster presentation including chemical terminology and representations, symbols, chemical equations, formulas, units of measurement, significant figures, standard abbreviations and acknowledgment of references.

Suggested topics

Energy

If energy was chosen for this activity/investigation, then the teacher could possibly choose a theme from one of three areas. Then the students could select a small area within this theme. Possibilities are:

- Biofuels
    - Explore the effect of conditions on the fermentation process
- Energy from fuels
    - Measure and compare the energy released by wood, coal and different alcohols
- Galvanic cells
    - Determine an electrochemical series for a given set of unknown half cells
    - Investigate the effect of non-standard conditions on the electrochemical series.
- Electrolysis
    - Explore the optimum conditions for electroplating
    - Determine Faraday's Law and calculate Avogadro's constant
- Fuel cells
    - Compare characteristics of fuel cells with galvanic cells such as a car battery.

Food

If food was chosen for this activity/investigation, then the teacher could possibly choose a theme from one of three areas or choose one of the three nutrients or water-soluble vitamin (vitamin C) or fat-soluble vitamin (vitamin D). Then the students could select a small area within this theme. Possibilities are:

- Analysis of organic compounds
    - Use acid base or redox titrations to analyse the active ingredients in different commercial products, e.g. ethanoic acid in vinegar, ethanol or sulfur dioxide in wines.
- Enzymes
    - Explore the effect of temperature, pH, tannic acid in strong tea, ethanol, or heavy metals ions on the denaturation of egg white.
    - Compare the catalytic action of different materials on hydrogen peroxide.
- Nutrients in food
    - Determine the nutrients that are present in selected foods.
    - Compare the rate of hydrolysis of pure amylose and amylopectin and also goods containing varying proportions of these forms of starch.
- Investigate antioxidants
    - Test the effect of the presence of vitamin C on the rate of oxidation of different foods.
    - Explore the effect of temperature or exposure to air on concentrations of vitamin C.
    - Analyse the concentrations of vitamin C in commercial fruit juices.
- Energy and composition of foods
    - Determine the energy content and composition of foods such as biscuits or different nuts.

Suggestions and ideas from the Developmental Workshops

1. **Suggestion timing**
    c. If you choose Energy then you could start at beginning of Term 3 or end of Term 2, when Unit 4 begins.
    d. If you choose Food then you could do it in the last 2 weeks of Term 3.
2. **Possibly present as 2 parts**
    a. In Part 1: students develop their question, prac method, general outline and teacher provided feedback for all students.
    b. Part 2: practical activity is completed and poster produced.
3. **Logistic issues**
    a. Focus on a limited number of questions and/or methodology.
    b. It may not be practical for students to carry out certain investigation depending on resources available to schools.
    c. Students could select their own investigation within a theme provided by the teacher.
4. **A generic timeline and scaffolding**
    a. This could be helpful to all students
    b. It could increase the efficiency of the process overall
    c. Stress the importance of the scientific conventions of report writing
    d. Suggestions in Chapter 21 *Heinemann Chemistry 1, in the Student Workbook for Units 3 and 4 and online Pearson support materials to Heinemann Chemistry 2 and from VCAA.*
5. **Authentication issues**
    a. Students to complete a log book to be submitted as part of assessment.
    b. Detailed notes of all steps, processes, recording of results and problems throughout the time.
    c. Varying topics will help in preventing plagiarism between students.
    d. Change topic questions each year