VCE Chemistry

Implementation webinar:

Units 1 and 2 (2023–2027) knowledge, skills and assessment

VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

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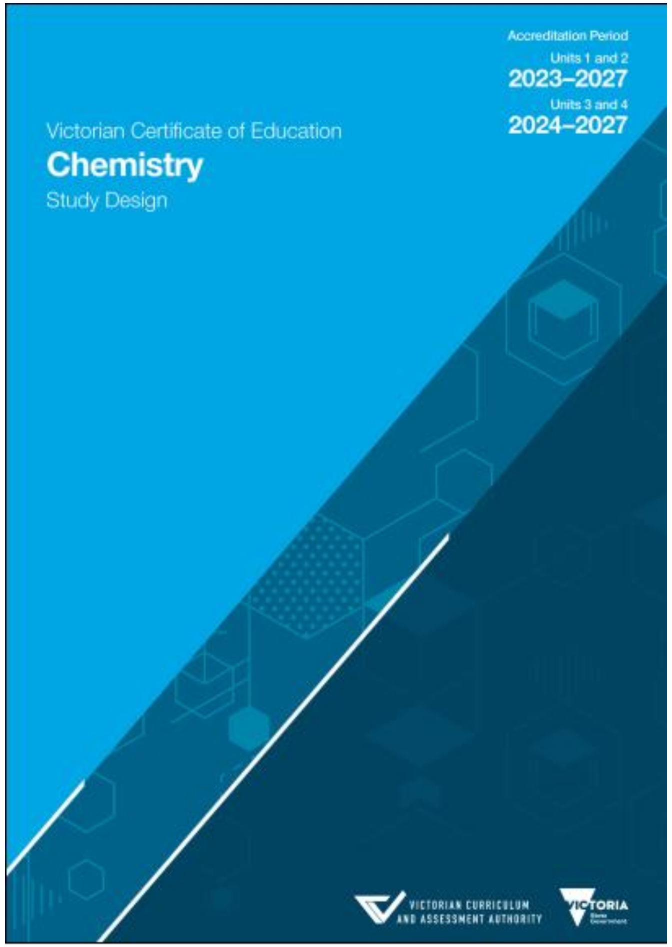
Acknowledgement of Country

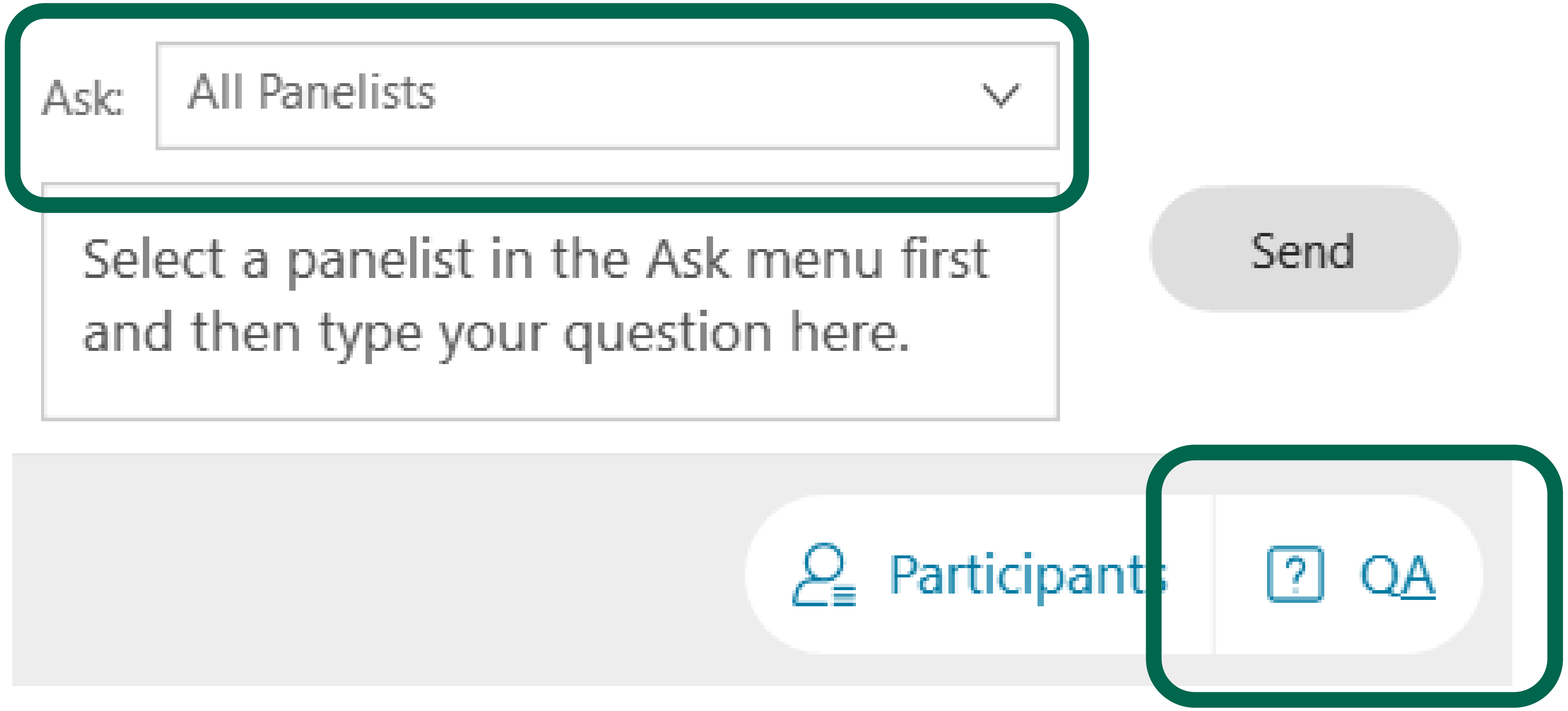
The VCAA respectfully acknowledges the Traditional Owners of Country throughout Victoria and pays respect to the ongoing living cultures of First Peoples.

Purpose



- **Respond to submitted webinar questions:**
  - review the major study design changes
  - provide examples of Aboriginal and Torres Strait Islander applications
  - provide assessment examples
- **Respond to other questions arising during the webinar**

Asking Questions



Staged implementation

- Units 1 & 2: 2023 – 2027
- Units 3 & 4: 2024 – 2027

Questions:

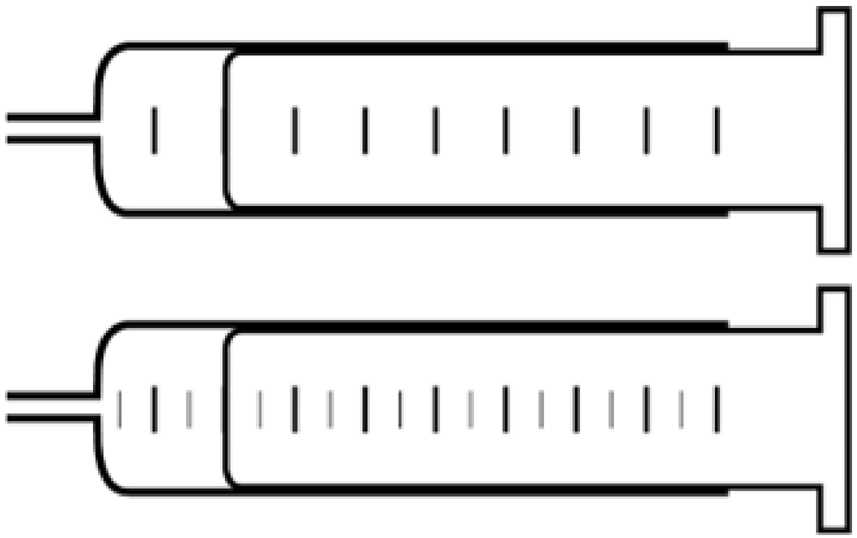
- Would you highlight the main changes between study designs? What is new? What has changed? What is deleted?

Key science skills

Key science skill	Major changes for contextualised Chemistry skills
Develop aims and questions, formulate hypotheses and make predictions	• Formulate hypotheses to focus investigations • Predict possible outcomes of investigations
Plan and conduct investigations	• Determine appropriate investigation methodology…
Comply with safety and ethical guidelines	• Use risk assessments that are informed by safety data sheets • Demonstrate ethical conduct
Generate, collate and record data	• …including use of databases and reputable online data sources • Organise and present data in useful and meaningful ways
Analyse and evaluate data and investigation methods	• Use appropriate numbers of significant figures in calculations • …repeatability, reproducibility, resolution… • Evaluate investigation methods and suggest ways to improve precision, and to reduce the likelihood of errors
Construct evidence-based arguments and draw conclusions	• Distinguish between opinion and evidence, and between scientific and non-scientific ideas
Analyse, evaluate and communicate scientific ideas	• Apply sustainability concepts…to analyse and evaluate… • …explain…decisions…may be based …not solely on scientific evidence

Resolution

This is a new term in the study design that relates to the measurement instruments used in experiments.



The bottom gas syringe has more graduations than the top syringe, so it can measure smaller changes. We can say it has a higher **resolution**.

Precision is used in reference to repeated measurement values, and shouldn't be used instead of **resolution**.

Key skills across the VCE sciences

- **Question:** How consistent is the science inquiry terminology (e.g., validity, reproducibility, etc.) with the other sciences? Will students be confused if they study multiple sciences and have different expectations?
- **Answer:** There are slight variations across the sciences, in line with scientific conventions and practices. There should be no confusion since we have defined terms consistently. Note:
  - the use of the term ‘resolution’ would apply to the quantitative sciences (including Chemistry) where different instruments are used.
  - ‘Reliability’ is a term used in the social sciences, for example, Psychology, but does not appear in the standard metrology references for Chemistry and Physics (e.g., GUM and VIM). ‘Repeatability’ and ‘reproducibility’ are defined in GUM and VIM, and VCE definitions are aligned to these.
  - The terms ‘true value’, ‘accuracy’, ‘precision’, and ‘measurement result’ are also defined in GUM/VIM
  - The term ‘validity’ may be applied to both the validity of the methodology/method and the validity of the data
  - Significant figures relate only to VCE Chemistry and Physics, and their treatment has been specified in the same way in both study designs.

Hours of practical work

Question: How strict are we in adhering to the minimum 17 hours of class time for practical/investigation work in each of Units 1 and 2?

Answer: The study design uses the word 'should' in describing the minimum hours allocated to practical work and investigations. Chemistry is a practical-based study where most concepts can be taught through practical work.

Given the broad definition of 'practical work' i.e., activities including laboratory experiments, fieldwork, simulations, and modelling, the time guidelines reflect current teaching practice.

It should be easy to determine at least two practical activities for each of the named sub-sections in each area of study in the study design, which will meet the practical work guidelines.

"Each VCE unit involves 50 hours of scheduled classroom instruction. In addition, it is expected that students will undertake up to 50 hours of self-directed learning for each unit."

From https://www.vcaa.vic.edu.au/administration/vce-vcal-handbook/sections/Pages/01QualificationsVCE.aspx

Sample practical activities

Unit 1 AoS1	Unit 1 AoS2	Unit 2 AoS1	Unit 2 AoS2
Elements and the periodic table: build-an-atom simulation; periodic table trends in properties	**Quantifying atoms and compounds**: modelling the mole; empirical formula determination; %Mg in MgO	**Water as a unique chemical**: modelling solid ice and liquid water; specific heat capacity of water	**Measuring solubility and concentration**: effect of temperature on solubility; removal of impurity using precipitation
Covalent substances: physical models of H_2, O_2, Cl_2, N_2, HCl, CO_2, H_2O, NH_3, CH_4, C_2H_6, C_2H_4; physical properties of covalent substances; modelling of diamond and graphite	**Families of organic compounds**: use plasticine with toothpicks to model the isomers of a range of alkanes and alkenes; use a closed capillary to determine boiling points of methanol, ethanol and propanol;	**Acid-base (proton transfer) reactions**: neutralisation reactions; accuracy and precision re pH of natural indicators, commercial indicators and pH meters	**Analysis for acids and bases**: preparation of standard solutions; titration (including preparation for RACI (Vic) Titration Competition)
Reactions of metals: metal crystals under a stereomicroscope; reactivity of metals with H_2O, HCl and O_2	**Polymers and society**: make a polymer glue from milk; make edible water capsules; make absorbable medical sutures from renewable feedstocks	**Redox reactions**: metal displacement reactions; Daniell cell construction	**Measuring gases**: molar volume of H_2 in the reaction between HCl and Mg – comparison of the method with https://www.youtube.com/watch?v=6dmtLj2dLi0
Reactions of ionic compounds: physical properties of ionic compounds; mystery powders - solubility tests; modelling $CsCl_2$ https://edu.rsc.org/feature/modelling-crystal-structure-using-marshmallows/3007559.article			**Analysis for salts**: water of hydration of $CuSO_4$; colorimetric analysis of $CuSO_4$ in an ore
Separation and identification of the components of mixtures: flower petal chromatography – paper vs thin-layer			

Unit 1 Area of Study 1 changes

What’s new?	• Critical elements and importance of recycling for element recovery • Metal recycling as an example of a circular economy • Formulas and names of ionic compounds including polyatomic ions • New section: separation and identification of the components of mixtures
What’s modified?	• Shift of ‘Quantifying atoms and compounds’ section to Unit 1 AoS2 • Shift of ‘solubility tables and precipitation reactions’ from Unit 2 AoS1 • Specification of covalent substances to be modelled • Specification of shapes of molecules to be studied
What’s deleted?	• Relative and absolute sizes of particles • Spectral evidence for the Bohr model • Schrödinger model of the atom • Limitations of models • Metal extraction from its ore • Metal coatings, heat treatment, and alloy production • Nanomaterials • Factors affecting crystal formation of ionic compounds

Unit 1 Area of Study 2 changes

What's new?	• Structures of haloalkanes (links to study of polymers) • Plant-based biomass as an alternative renewable source of organic chemicals • Everyday organic compounds: benefits and health and/or environmental hazards • Condensation reactions • Categorisation of different plastics as fossil fuel based and as bioplastics; plastic recycling; compostability, circularity and renewability of raw ingredients • Innovations in polymer manufacture using condensation reactions, and the breakdown of polymers using hydrolysis reactions, contributing to the transition from a linear → circular economy
What's modified?	• Inclusion of 'Quantifying atoms and compounds' section from Unit 1AoS2 • Structures and names of organic compounds – non-cyclic compounds up to C8 (not C10) and structural isomers up to C5 (Not C7) • Advantages and disadvantages of the use of polymer materials
What's deleted?	• Origin of crude oil and its use as a source of hydrocarbon raw materials • Esters (included in Unit 4) • Linear polymers in terms of % crystalline areas and addition of plasticisers

Unit 2 Area of Study 1 changes

What’s new?	• Density of solid ice compared with liquid water at low temperatures • Types of antacids and their use in neutralising stomach acid • Calculation of pH using the ionic product of water • Accuracy and precision in measurements through a comparison of pH measured using natural and commercial indicators, and pH meters
What’s modified?	• Shifted from U2AoS2: distribution and proportion of available drinking water • Causes and effects of a selected issue related to acid-base chemistry • Causes and effects of a selected issue related to redox chemistry • Shifted to Unit 1 AoS1: comparison of solution processes in water for molecular substances and ionic compounds (modified) • Shifted to Unit 2 AoS2: dilutions of solutions (linked to titrations)
What’s deleted?	• Melting point trends in Group 16 hydrides • Latent heat

Unit 2 Area of Study 2 changes

What's new?	• Use of precipitation reactions to remove impurities from water • New section: 'Measuring gases', including a shift of *pV=nRT* from Unit 3 AoS1 - includes: major gases that contribute to the natural and enhanced greenhouse effect; SLC conditions; ideal gas equation, including unit conversions; gas stoichiometry; calculations of molar volume or molar mass of a gas
What's modified?	• Shift of 'distribution and proportion of available drinking water' to Unit 2 AoS1 • Shift from Unit 2 AoS1: molar ratio of water of hydration for an ionic compound
What's deleted?	• Sampling protocols including equipment and sterile techniques • Definition and example of a chemical contaminant • Solution concentrations measured in mg L^{-1}, %m/m and ppb • Atomic absorption spectroscopy (AAS) • High performance liquid chromatography (HPLC) – included in Unit 4 AoS2 • Sources of acids and bases found in water

Unit 2 Area of Study 3 changes

What’s new?	• Sub-heading sections:
	  - Investigation design
	  - Scientific evidence
	  - Science communication
	• Primary data characteristics
	• Distinction between an aim, a hypothesis, a model, a theory and a law
	• ‘repeatability’ , ‘reproducibility’ and ‘resolution’
	• Logbook as authentication of primary data
	• Implications of the selected scientific investigation

What’s modified?	• Distinction between ‘methodology’ and ‘method’ • Limitations of investigation methods and methodologies, and of data generation and/or analysis
What’s deleted?	• Reliability • Sources of uncertainty • Nature of evidence that supports or refutes a hypothesis, model or theory • Options, strategies or solutions to issues related to water quality

‘Solubility’ in the study design

Question: What is the difference between the key knowledge required regarding solubility tables and precipitation reactions, under Unit 1, AOS 1 *Reactions of ionic compounds*, compared with Unit 2, AOS 2 under *Measuring solubility and concentrations*?

Answer: Unit 1 AoS1 takes a qualitative approach to precipitation reactions including writing ionic equations and half equations. Students will build an understanding that some ionic compounds dissolve in water and will therefore be in an aqueous (aq) state, whereas other ionic compounds do not dissolve and/or form a precipitate, and so will be in a solid state. Students will be scaffolded to learn how to write net ionic equations, such as that for the reaction between K_3PO_4 solution and $Ca(NO_3)_2$ solution, resulting in: $3Ca^{2+}(aq) + 2PO_4^{3-}(aq) + Ca_3(PO_4)_2(s)$

Unit 2 AoS2 takes a quantitative approach to investigating ionic solids in water. The use of solubility tables reinforces the work completed in Unit 1 AoS1 and students now will investigate quantities, beginning with learning how concentration is measured (including units) and learning how to draw solubility graphs. They will investigate how solubility changes with temperature and – as a new inclusion in the study design – will learn how precipitation reactions can be used to purify water.

New inclusions in the study design

Questions:

- To what extent should the new components in the study design be covered?
- Could you talk more about the dot points surrounding environmental concerns?

Answer:

The specific knowledge required is included in the key knowledge points, e.g.,

> "metal recycling as an example of a circular economy where metal is mined, refined, made into a product, used, disposed of via recycling and then reprocessed as the same original product or repurposed as a new product" (Unit 1 AoS1)

Inclusion of sustainability concepts or applications (green chemistry principles, sustainable development goals, and linear/circular economies) have been specifically referred to once or twice across Units 1&2, and then once or twice across Units 3&4, so that it is manageable.

Refer to the outcome statement as a guide to the essence of each area of study.

Excursion opportunities

The study design provides opportunities for excursions. Schools are encouraged to consider local chemical industries and/or scientific laboratory facilities. Other opportunities for excursion alternatives, including online virtual tours, may also be accessed.

Unit 1 AoS1	Unit 1 AoS2	Unit 1AoS3	Unit 2 AoS1	Unit 2 AoS2
• Community facilities involved in metal recycling • Olive leaf distillery • Oil refinery • Laboratory: chromatography	• Recycling plants: plastic • Polymer manufacturing or recycling plant • Laboratory: mass spectrometry	• Local manufacturing industries: inquire about their sustainability initiatives and innovations	• Water treatment plants (e.g., Western Treatment Plant virtual tour) • Field trip – water sampling	• Water analysis laboratory (e.g., virtual tour of Central Highlands Water Laboratory) • Corrosion prevention
Note: A number of organisations offer VCE-aligned programs: these are currently under development, e.g., STEM Specialist Schools (particularly VSSEC, Quantum); technical schools (e.g., KIOSC – analytical analysis of environmental water samples); universities (instrumentation, for example, analysis of the iron content of an iron supplement using U-V Visible Spectroscopy)				

Question:

- **What is the VCAA expectation for Unit 1 Area of Study 3?**

Flexibility in meeting the outcome

Unit 1 Outcome 3: "…the student should be able to **investigate and explain how chemical knowledge** is used to create a **more sustainable future** in relation to the **production or use of a selected material**."

- the outcome applies to all four investigation topics
- schools are encouraged to offer all four investigation topics to support student agency
- may use 'flipped classroom' and 'Socratic seminar' delivery modes
- investigation topics may be introduced to students through:
  - a provided list early in the year for students to consider
  - 'tasters' by embedding some key knowledge points from options into the 'core', for example, the question in Investigation topic 1 'Why is helium classified as a critical and endangered element, and how can it be saved given that its atmospheric recovery is almost impossible?' can be linked to Unit 1 AoS1 in terms of 'critical elements' and 'bonding'.

Unit 1 options: equity of assessment

Question: If I offer different investigation topics and research questions to my students, how can I make sure that my assessment is equitable?

Answer: The outcome statement and the set of key knowledge points on pages 29 and 30 of the study design apply to **all** investigation topics.

- These key knowledge points can be used as the basis of assessment, for example, by taking key ideas from the key knowledge as the basis of criteria for a rubric
- The set of key science skills should also be referred to in developing assessment schemes, noting that some aspects of the key skills relate directly to the key knowledge, particularly those under the ‘Scientific communication’ section of the key knowledge
- Teachers are advised to provide students with assessment rubrics prior to students undertaking the task
- Teachers should check students’ research questions to ensure that they are comparable to other questions in terms of the level of complexity, time involved in research, and relevance to the study design.

Questions:

- **How do the Units 1 and 2 assessment tasks link to the Units 3 and 4 assessment tasks?**
- **What are some examples of the new assessment tasks?**

Sample task: comparison and evaluation of two practical activities

Pre-assessment discussion:
Different metals rust at different rates. The rate of rusting, or oxidation, is dependent on environmental conditions. Discuss different factors that may affect the rate of rusting.

Assessment task:
Students will generate data about metal reactivity from two different experiments. They will then compare the data obtained and draw relevant conclusions.

Method 1: Reactivity of metals in water and acid
Method 2: Displacement of metal reactions

Comparison report

Students should report on their findings. Teachers may ask an open question such as, ‘How do the two methods compare in terms of determining a reactivity series of metals?’ or ‘Which of the two methods do you think is better in determining a reactivity series of metals? Justify your choice.’

Open questions may be assessed using rubrics.

Scaffolding assessment tasks

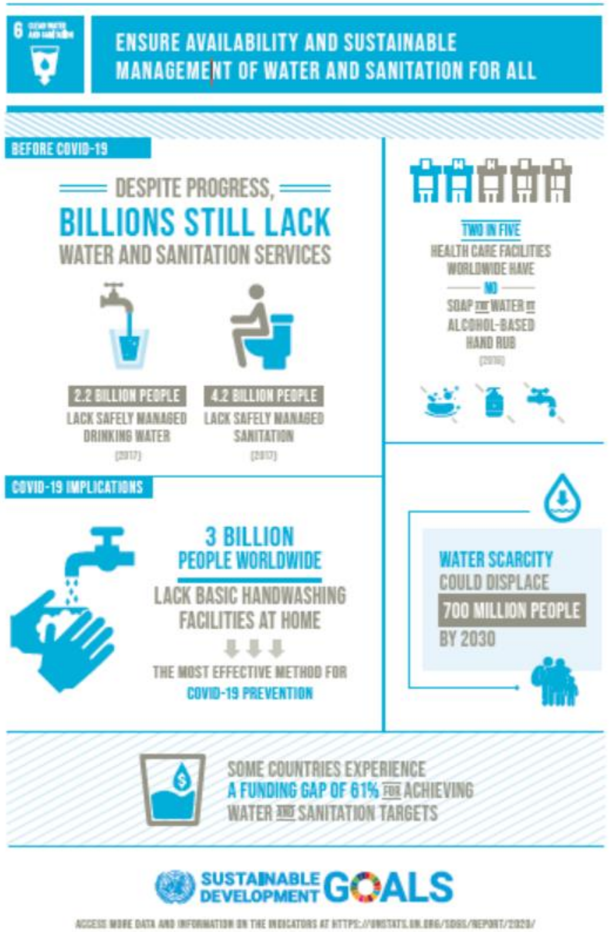
The 'metal reactivity' assessment task on the previous slide may also be assessed through a set of scaffolded questions which are allocated marks, for example:

- Determine a ranking of metal reactivity from both experiments. (4 marks)
- Compare the rankings obtained. (2 marks)
- Refer to the periodic table to explain the rankings. (4 marks)
- Write balanced equations for the reactions occurring. (4 marks)
- Draw evidence-based conclusions from your experimental findings. (4 marks)
- Justify a choice of a preferred method for determining a reactivity series of metals. (2 marks)
- Suggest how each experiment could be improved as a method for determining a reactivity series of metals. (4 marks)

Links in assessment tasks across Units 1 – 4

2023-2027 Units 1 & 2 tasks	2024-2027 Units 3 & 4 task
• analysis and evaluation of generated primary and/or collated secondary data • a report of a laboratory or fieldwork activity, including the generation of primary data • a modelling or simulation activity (must include data) • an infographic (presentation mode) • a scientific poster (presentation mode)	analysis and evaluation of **primary and/or secondary data**, including identified assumptions or data limitations, and conclusions

Presentation mode: infographic



- Infographics are particularly suited to presenting numerical information
- Data related to polymer use (Unit 1 AoS2), water quality (U2 AoS1), and surveys can be presented as infographics
- Good examples of infographics include the United Nations 17 Sustainable Development Goals (Goals 2, 6, 7, 9, 11, 12, 13, 14, and 15 are relevant to VCE Chemistry)
- Free templates at https://www.canva.com/infographics/templates/

Links in assessment tasks across Units 1 – 4

2023-2027 Units 1 & 2 tasks	2024-2027 Units 3 & 4 task
• problem-solving involving chemical concepts, skills and/or issues • a report of an application of chemical concepts to a real-world context (quantitative) • a critique of an experimental design, process or apparatus • analysis and evaluation of a chemical innovation, research study, case study, socio-scientific issue, secondary data or a media communication, with reference to sustainability (green chemistry principles, sustainable development and/or the transition to a circular economy)	**problem-solving**, including calculations, **using chemistry concepts and skills applied to real-world contexts**

Sample assessment task: critique of an experimental design

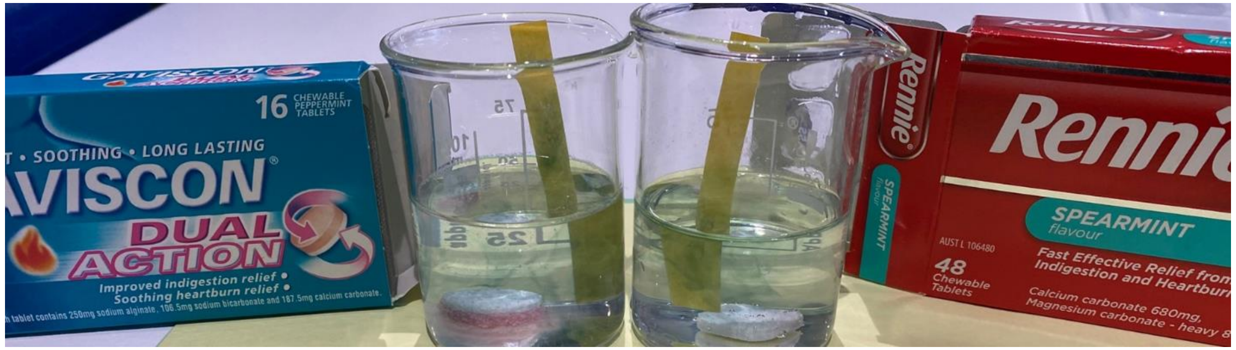
Task: Student instructions

In this experiment, you will set up a galvanic cell and record the voltage it produces. Your teacher will deliberately provide you with materials that will lead to a cell that performs poorly and does not produce a useful voltage.

You are asked to:

- **set this cell up and to record its voltage**
- **critique the cell, making recommendations as to how to improve the performance of the cell**
- **justify the changes you are recommending**
- **set up a re-designed cell that incorporates some of your suggested changes.**

Problem solving – antacid formulations



Experimental set-up for the testing of two commercial antacid tablets using universal indicator paper.

Pre-assessment task learning:
Students conduct a laboratory experiment to investigate the effectiveness of different commercial antacid tablets.

Sample assessment task:

Students will use the results of their testing of commercial antacids with provided information about antacid formulations (a table of comparisons of the benefits and side effects of the active ingredients that are used in antacids). Students will:

- **select two different bases that could be used in an antacid formulation.**
- **test the effectiveness of five different antacid formulations in neutralising an acid. The formulations will be made up of different proportions of the two selected bases.**

Links in assessment tasks across Units 1 – 4

2023-2027 Units 1 & 2 tasks	2024-2027 Units 3 & 4 task
• analysis and evaluation of a chemical innovation, research study, case study, socio-scientific issue, secondary data or a media communication, with reference to sustainability (green chemistry principles, sustainable development and/or the transition to a circular economy) • critique of an experimental design, chemical process or apparatus • a report of an application of chemical concepts to a real-world application • a media analysis/response	**analysis and evaluation** of a chemical innovation, research study, case study, socio-scientific issue or media communication

Sample task: sustainability of a product (partial)

Lego has moved towards a circular economy by making building bricks from recycled plastic bottles. Review the definitions of, and the distinctions between, a 'linear economy' and a 'circular economy'.

Green chemistry considerations	Products	Explain how the case study illustrates how green chemistry can be applied to developing products in the marketplace that are:
	• design of an environmentally safe marine antifoulant by the Rohm and Haas Company (now a subsidiary of The Dow Chemical Company) • production of fuel from used coffee grounds	• more environmentally benign than an existing alternative • more economically viable than an existing alternative • functionally equivalent to, or outperform, existing alternatives.

Sample assessment task – chemistry in real-world contexts

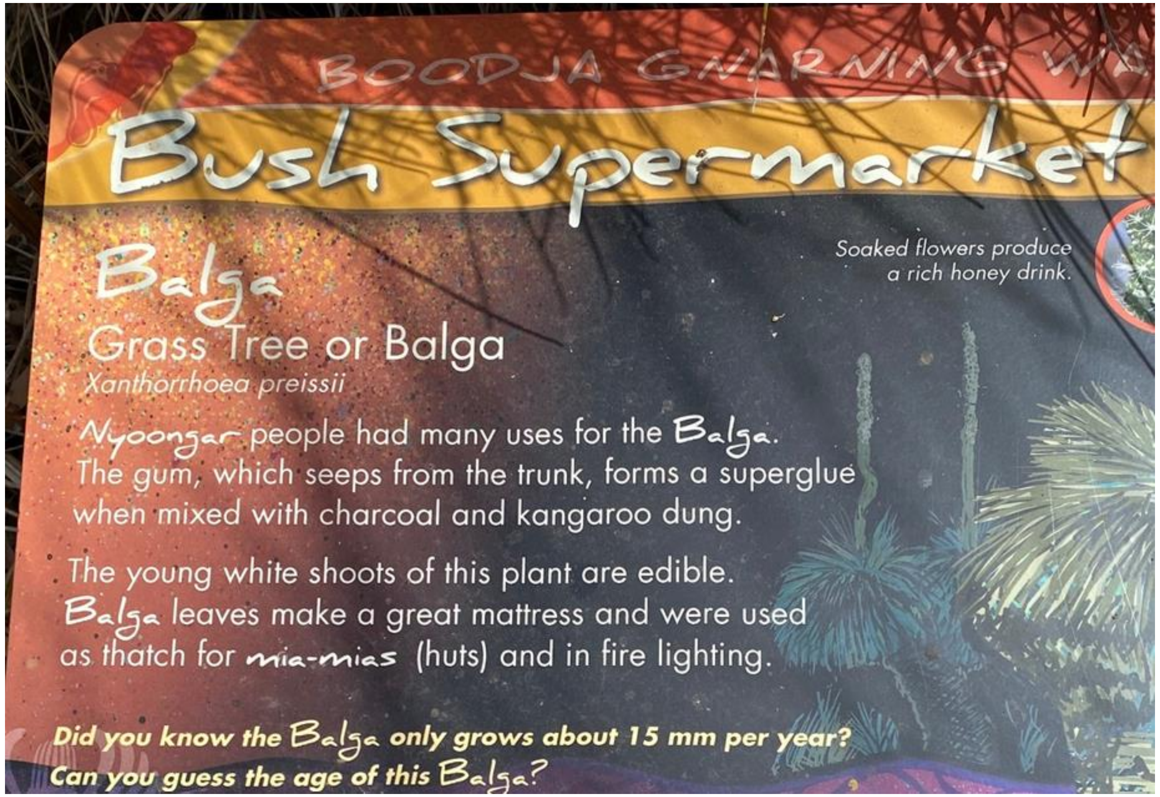


Photo from a display board in Kings Park Perth, outlining the components of a glue favoured by the Nyoongar people.

One of the assessment task types for Units 1 and 2 is a 'report of an application of chemistry to a real-world context'. This task can be used to support student agency through individual selection of topics of interest. A set of generic questions and a common rubric can be used to ensure that the task meets the VCE assessment principle of 'equity'.

Example:

A student had visited Kings Park in Western Australia and became curious about how glue could be produced from the local grass trees, after reading about the many uses of grass trees by the Nyoongar people from south-western Australia.

Comparison of the components of Indigenous and epoxy resin composite glues

Components:

- Epoxy resin monomer
- Hardener
- Fibre reinforcement

Components:

- Tree resin monomers
- Hardener (ash)
- Fibre reinforcement (kangaroo dung)

The chemistry of glue from grass trees

Before heating, the resin is thermoplastic. After heating, it is a thermoset, as the solvents are driven off and the charcoal and heat cause crosslinks between these molecules to form.

Sample assessment task: media analysis

Aspect of the media item	Guiding questions for analysis for each item
Article	• What is the main point of the article? What are the subsidiary points in the article? • Are the scientific ideas correctly used? • What evidence does the author cite? • Does the evidence come from reputable sources? • Are the arguments presented legitimate and relevant?
Author	• Who is the author and are they qualified to write about this topic? • Does the disclosure statement about their funding sources raise a question mark about the article?
Comments	• What general positions about the article are expressed in the comments? • Do the comments use scientific ideas correctly? • Do the comments cite other reputable evidence? • Are the arguments in the comments legitimate and relevant? • What proportion of the comments make a cogent contribution to the discussion? • Does the author of the article participate in the discussion?
Conclusion	• What is your view?

Sample assessment task: media analysis

Topic: Innovations in plastic recycling

Student instructions: Your teacher will provide you with two related articles on the innovations in plastics recycling undertaken by Licella and other companies.

- Article 1: Licella's proposal to develop the plastic recycling capacity of Timor Leste. The technology proposed is new in that it does not remould the plastic, instead it breaks it down to a synthetic oil. (Aussie first: Soft plastic food wrapper made from recycled material)
- Article 2: The use of this same technology to recycle waste plastic into new, food-grade polymers. (Timor Leste aims to become the world's first plastics-neutral country)

You will have one week to review these articles before completing an assessment task in response to these two articles. Your response might take the form of a written report, a poster, a graphic organiser, a table to be completed, a slideshow or another presentation form as negotiated with your teacher.

Links in assessment tasks across Units 1 – 4

2023-2027 Units 1 & 2 tasks	2024-2027 Units 3 & 4 task
• a report of a laboratory or fieldwork activity, including the generation of primary data • a scientific poster (presentation mode) • an infographic (presentation mode) • (for Unit 2 Outcome 3) a report of a practical investigation (student-designed or adapted) using a selected format, for example, a scientific poster, an article for a scientific publication, a practical report, or an oral/ multimedia/ visual presentation	communication of the design, analysis and findings of a **student-designed** and **student-conducted investigation** through a structured scientific poster and logbook entries

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