VCE Chemistry: Sample teaching plan

Sample course outline – VCE Chemistry Unit 3: How can design and innovation help to optimise chemical processes?

**Note:** This is a sample guide only and indicates one way to present the content from the *VCE Chemistry Study Design*. VCE units are designed based on a minimum of 50 hours of class time; this sample teaching plan is based on 3 hours per week over 19 weeks and includes activities covering the eight scientific methodologies. Teachers are advised to consider their own contexts in developing learning activities: Which local issues lend themselves to debate and investigation? Which experiments can students complete within the resource limitations of their learning environments? Which local fieldwork sites and chemistry-based facilities would support learning in the topic area? Which chemical industries would be appropriate for site visits?

| **Week** | **Area of study** | **Key knowledge** | **Learning activities**  | **Science skills focus** | **Assessment tasks** |
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| **1** | ***Area of Study 1:******What are the current and future options for supplying energy?*** | **Carbon-based fuels** (fuel definition; fuel sources for society and body; photosynthesis; cellular respiration; bioethanol production; exothermic and endothermic reactions; energy profile diagrams; limiting reagents; complete and incomplete combustion) | * *Literature review:* View real or virtual displays of fuel samples (for example, coal, crude oil, kerosene, paraffin oil, candles, peanut oil, biodiesel, bioethanol, wood); predict melting points and boiling points based on the physical states of each sample; compare predictions with experimentally determined or accepted values from chemical databases
* *Literature review*: Investigate and compare the use, renewability and environmental impact of the sourcing and combustion of a selected fossil fuel and a selected biofuel energy source
* *Experiment:* Conduct a series of short hands-on activities to visualise photosynthesis (for example, fitting a balloon over flasks containing *Elodea canadensis*in water and subjecting them to different amounts of light, and comparing the amount of oxygen formed)
* *Case study:* Analyse and evaluate the development of a biofuel demonstration facility in the Hunter Valley in NSW
* *Case study:* Summarise the social and scientific issues involved in the [utilisation of seaweed (macroalgae) as a biofuel](https://www.scientificamerican.com/article/could-our-energy-come-from-giant-seaweed-farms-in-the-ocean/)
* *Unit conversions*: Design a flow chart to show unit conversions for and relationships between pressure, volume and temperature of gases
* *Experiment*: Determine the enthalpy of a sodium thiosulfate solution
* *Calculations*: Use enthalpy calculations to discuss the use of an appropriate number of significant figures in calculations, including the use of calculators and ‘rounding off’
* *Representations*: Use energy profile diagrams to distinguish between exothermic and endothermic reactions
* *Experiment:* Demonstrate the concept of a limiting reagent; for example, by testing how much copper carbonate will react with a given quantity of acid; use stoichiometry to confirm recorded observations
 | * determine appropriate investigation methodology
* systematically generate and record primary data, and collate secondary data, appropriate to the investigation
* record and summarise both qualitative and quantitative data
* organise and present data in useful and meaningful ways, including schematic diagrams, flow charts, tables, bar charts, line graphs
* process quantitative data using appropriate mathematical relationships and units
* use appropriate numbers of significant figures in calculations
* plot graphs involving two variables that show linear and non-linear relationships
* use appropriate chemical terminology, representations and conventions, including standard abbreviations, graphing conventions, algebraic equations, units of measurement
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| **4** | **Measuring changes in chemical reactions** (fuel combustion stoichiometry; specific heat capacity of water; solution calorimetry including temperature-time graphs; energy from fuels and food) | * *Experiment*: Investigate the heat of combustion of ethanol, including determination of the energy efficiency of its combustion using data from a data table, and identification of sources of energy loss through energy transformation and energy transfer
* *Calculations*: Apply the principle of mass–mass, mass–volume and volume–volume stoichiometry to determine the heat energy and amounts of major greenhouse gases (CO2, CH4 and H2O) released from the combustion of fuels
* *Calculations*: Undertake quantitative exercises related to solution calorimetry
* *Experiment*: Determine the calibration factor of a calorimeter; determine the enthalpy change of chemical reactions; analyse temperature-time graphs obtained from solution calorimetry
* *Experiment*: Compare the energy content of a biscuit determined by calorimetry with that stated on the packaging
* *Experiment*: Compare the heats of combustion of various fuels; compare experimentally determined values with published values for heat of combustion; suggest improvements to the experimental methodology
 | * identify, research and construct aims and questions for investigation
* design and conduct investigations
* systematically generate and record primary data, and collate secondary data, appropriate to the investigation, including use of databases and reputable online data sources
* organise and present data in useful and meaningful ways, including flow charts, tables, line graphs
* process quantitative data using appropriate mathematical relationships and units
* plot graphs involving two variables that show linear and non-linear relationships
* use appropriate chemical terminology, representations and conventions, including standard abbreviations, graphing conventions, algebraic equations, units of measurement and significant figures
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| **7** | **Primary galvanic cells and fuel cells as sources of energy** (redox reactions and equations; design features of primary galvanic cells and fuel cells; electrochemical series; Faraday’s Laws; innovation in fuel cell design including green chemistry principles) | * *Experiment*: Observe metal displacement reactions under stereomicroscopes; identify the products, oxidising and reducing agents, and conjugate pairs; write balanced chemical equations, including states, for observed reactions
* *Experiment*: Determine the relative strengths of reducing agents and oxidising agents using metal displacement reactions; construct and test simple galvanic cells based on the findings
* *Experiment*: Construct simple galvanic cells and explain in general principles their operation in terms of reactions occurring at the electrodes and the movement of electrons and ions
* *Explanation of chemical concepts*: Capture photos or images of the progress of a galvanic cell; use the images and add text to produce a photo essay of the progress of the reaction, identifying products formed and writing half and overall equations for the redox reactions involved
* *Experiment*: Use the electrochemical series to predict the outcome of competing electrode reactions in galvanic cells; design and perform experiments to test predictions; identify the limitations of the use of the electrochemical series in predicting electrode reactions
* *Experiment*: Construct a simple fuel cell and measure its voltage output; draw an annotated diagram of the cell, identifying its key features and annotate equations for the cell processes
* *Literature review*: Investigate developments and applications of fuel cell technology; compare the advantages and disadvantageous of fuel cells with other energy sources
 | * identify, research and construct aims and questions for investigation
* identify independent, dependent and controlled variables in experiments
* design and conduct investigations
* formulate hypotheses to focus investigations
* predict possible outcomes of investigations
* work independently and collaboratively as appropriate and within identified research constraints, adapting or extending processes as required and recording such modifications in a logbook
* systematically generate and record primary data
* record and summarise both qualitative and quantitative data
* process quantitative data using appropriate mathematical relationships and units
* analyse and explain how models and theories are used to organise and understand observed phenomena and concepts related to chemistry, identifying limitations of selected models/theories
* use appropriate chemical terminology, representations and conventions, including standard abbreviations, graphing conventions, algebraic equations, units of measurement and significant figures
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| **9** | **SAC task 1: Problem-solving, including calculations, using chemistry concepts and skills applied to real-world contexts** (50 minutes):Apply problem-solving and design-thinking to improve the voltage of a poorly constructed galvanic cell (provided by the teacher) which does not produce a useful voltage, including reference to the electrochemical series, Faraday’s laws, and stoichiometry. |
| **10** | ***Area of Study 2:******How can the rate and yield of chemical reactions be optimised?*** | **Rates of chemical reactions** (factors affecting particle collisions and rate of chemical reactions; role of catalysts in increasing reaction rate; energy profile diagrams) | * *Modelling*: Create an animation or develop an analogy to illustrate collision theory
* *Experiment*: Compare the rate of reaction between [zinc granules and sulfuric acid](https://edu.rsc.org/experiments/catalysis-of-the-reaction-between-zinc-and-sulfuric-acid/1713.article), with and without copper as a catalyst, by measuring the rate of production of hydrogen gas bubbles
* *Experiment:* Compare the use of a data logger and a thermometer to measure and record temperature changes over time for an exothermic and an endothermic chemical reaction; discuss how accuracy, precision, repeatability, reproducibility and validity are affected when a data logger, rather than a thermometer, is used
* *Experiment:* Conduct a laboratory investigation on the effect of temperature, solution concentration and surface area on the rate of reaction; predict outcomes of investigations based on kinetic molecular theory; calculate reaction rates
* *Experiment:* Investigate quantitatively the [effect of a catalyst](https://www.beyondbenign.org/bbdocs/curriculum/high-school/Catalysts_and_Oxygen.docx) on the rate of a chemical reaction
 | * identify, research and construct aims and questions for investigation
* identify independent, dependent and controlled variables in experiments
* design and conduct investigations
* determine appropriate investigation methodology
* systematically generate and record primary data
* organise and present data in useful and meaningful ways, including tables, line graphs
* process quantitative data using appropriate mathematical relationships and units
* plot graphs involving two variables that show linear and non-linear relationships
* identify and analyse experimental data qualitatively, handling, where appropriate, concepts of: accuracy, precision, repeatability, reproducibility, resolution, and validity of measurements; and errors (random and systematic)
* identify outliers, and contradictory, provisional or incomplete data
* repeat experiments to evaluate the precision of data
* evaluate investigation methods and suggest ways to improve precision, and to reduce the likelihood of errors
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| **12** | **Extent of chemical reactions** (reversible and irreversible reactions; equilibrium; factors affecting changes in equilibrium position; Le Chatelier’s principle; reaction quotient; conflict between optimal rate and temperature; green chemistry principles) | * *Experiment:* Conduct a laboratory investigation related to the reversible nature of reactions using the hydration and dehydration of copper(II) sulfate
* *Video*: View and discuss the high-speed video of the [effect of pressure change](https://www.sciencephoto.com/media/627886/view) on the NO2 / N2O4 equilibrium system
* *Experiment:* Conduct a laboratory investigation of the effect of changing temperature, changing concentration, and adding chemical species (AgNO3) to the homogenous equilibrium Co(H2O)62+ + 4Cl- → CoCl42- + 6H2O
* *Simulation*: Use a spreadsheet to manipulate data to illustrate the constancy of Kc at constant temperature; perform calculations based on the equilibrium law, reaction concentrations and Kc
* *Classification and identification*: In a variety of equilibrium reactions, use Le Chatelier’s principle to make predictions about changes (concentration, temperature, pressure) made to a system at equilibrium
* *Case study*: Use the ‘ammonia from hydrogen and nitrogen’ example to discuss the conflict between optimal rate and temperature considerations in producing equilibrium reaction product, considering the green chemistry aspects of catalysis and designing for energy efficiency
 | * identify, research and construct aims and questions for investigation
* identify independent, dependent and controlled variables in experiments
* formulate hypotheses to focus investigations
* predict possible outcomes of investigations
* systematically generate and record primary data, and collate secondary data, appropriate to the investigation, including use of reputable online data sources
* record and summarise both qualitative and quantitative data
* organise and present data in useful and meaningful ways, including tables, line graphs
* process quantitative data using appropriate mathematical relationships and units
* use appropriate numbers of significant figures in calculations
* plot graphs involving two variables that show linear and non-linear relationships
* identify and explain when judgements or decisions associated with chemistry-related issues may be based on sociocultural, economic, political, legal and/or ethical factors and not solely on scientific evidence
* use appropriate chemical terminology, representations and conventions, including standard abbreviations, graphing conventions, algebraic equations, units of measurement and significant figures
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| **13** |  |
| **14** | **SAC task 2: Comparison and evaluation of chemical concepts, methodologies and methods, and findings from at least two practical activities** (50 minutes):Use the results from practical investigations related to rate and Le Chatelier’s principle to analyse and explain the conflict between rate and extent of reaction for equilibrium reactions, and the implications for the production fo useful materials for society. |
| **15** | **Production of chemicals using electrolysis** (electrochemical series; design features of electrolytic and secondary cells; production of ‘green’ hydrogen; Faraday’s Laws) | * *Modelling*: Create an animation of the processes occurring in a typical electrolytic cell, including at the particle level
* *Experiment*: Predict and test the products of electrolysis of aqueous solutions
* *Experiment*: Observe what happens during the [electrolysis of brine](https://edu.rsc.org/experiments/electrolysis-of-brine/735.article) (sodium chloride solution), using universal indicator to help follow the reaction that takes place
* *Experiment*: Construct a simple electrolytic cell to identify factors that determine the products of electrolysis
* *Modelling*: Draw simplified diagrams to explain how a rechargeable battery works, including half and overall cell reactions
* *Data analysis*: Analyse data showing the relationship between the amount of metal deposited in an electrolytic cell and the charge flowing through the cell
* *Experiment*: Use the electrochemical series to predict the products of the electrolysis of potassium iodide solution; determine experimentally the products and account for any differences between predictions and results
* *Calculations*: Use Faraday’s laws in quantitative calculations related to electrolysis
* *Calculations*: Calculate the value of the Faraday constant from [the quantitative electrolysis of copper(II) sulfate solution](https://edu.rsc.org/experiments/quantitative-electrolysis-of-aqueous-copperii-sulfate/1883.article)
* *Conceptual understanding*: Explain why some batteries are rechargeable while others are not; annotate a cross-section of a non-rechargeable battery to identify design features that could be changed to make the battery rechargeable
* *Product development*: Construct a [simple lead-acid accumulator](http://www.rsc.org/learn-chemistry/resource/res00000391/rechargeable-cell-the-lead-acid-accumulator?cmpid=CMP00005907) and suggest how to test for factors that affect the operation of the battery
* *Case study*: Research and investigate the role of innovative design of cells to produce ‘green’ hydrogen (including equations in acidic conditions)
 | * formulate hypotheses to focus investigations
* predict possible outcomes of investigations
* design and conduct investigations
* determine appropriate investigation methodology
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* systematically generate and record primary data, and collate secondary data, appropriate to the investigation
* record and summarise both qualitative and quantitative data
* organise and present data in useful and meaningful ways, including schematic diagrams, flow charts, tables, bar charts, line graphs
* process quantitative data using appropriate mathematical relationships and units
* use appropriate chemical terminology, representations and conventions, including standard abbreviations, graphing conventions, algebraic equations, units of measurement and significant figures
* apply sustainability concepts (green chemistry principles, development goals and the transition from a linear towards a circular economy) to analyse and evaluate responses to chemistry-based scenarios, case studies, issues and challenges
* analyse and explain how models and theories are used to organise and understand observed phenomena and concepts related to chemistry, identifying limitations of selected models/theories
* critically evaluate and interpret a range of scientific and media texts (including journal articles, mass media communications and opinions in the public domain), processes, claims and conclusions related to chemistry by considering the quality of available evidence
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| **18** | **Unit revision** |
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