VCE Chemistry Unit 3-4

STAV- VCE CON- 2025

CHEMISTRY EDUCATION ASSOCIATION

My Acknowledgement of this beautiful country

- I would like to acknowledge this beautiful country that I stand upon, a country that has lent me atoms enough to replace all my original atoms several times over by now and held me in its arms safely. I cherish the land, water and all its creatures, that have been looked after for thousands of year by the people who have loved and respected it. I feel their pain as they might have gone through years of not being acknowledged or respected.
- I wish to pause and praise the traditional owners of this land from the bottom of my heart and pay my utmost respects to the Bunurong people and all Aboriginal and Torres strait islander peoples, their elders past, present and emerging.
- **Gayatri Vazirani**

Teaching Unit 3 and 4 VCE Chemistry

Gayatri Vazirani

Cornish College

CEA- Treasurer

Pinya Senevirathne

Berwick College

CEA- Committee member

Please download the Miro app

You will need it later for some collaborative work

Today's Plan

Systems thinking → Some practicals → SACs- Some ideas → Unit timeline → AoS 3 practical investigation → Digital resources

Systems thinking has emerged as a pivotal approach in chemistry education, aiming to equip students with the ability to understand and address complex, interconnected chemical systems.

My literature review highlights key ideas that integrate systems thinking in chemistry education, bringing to the forefront the theoretical frameworks, practical applications, and some future directions of this pedagogy.

Systems Thinking in Chemistry Education (STICE) was created to catalyze and support efforts by the global chemistry education community to infuse systems thinking into chemistry education, with a particular focus on large enrollment introductory chemistry courses at the postsecondary and upper secondary levels. One substantial motivation was to facilitate embedding sustainability considerations into chemistry education.

Systems thinking pedagogy

- Aligned with the 2030 Agenda for Sustainable Development, the United Nations Sustainable Development Goals (SDGs) were created in 2015

- The goals are interconnected, require interdisciplinary collaboration at an international level and require consideration of entire dynamic systems (both individual and interlinked systems) to address them employ visual or graphical tools to help conceptualize the problem or system at hand.

https://thesystemsthinker.com/

Bibliography

1. Mahaffy, P., Seery, M. K., Talanquer, V., & Bentley, A. K. (2019). Systems thinking for education about the molecular basis of sustainability. *Journal of Chemical Education, 96*(12), 2730–2740. https://doi.org/10.1021/acs.jchemed.9b00637
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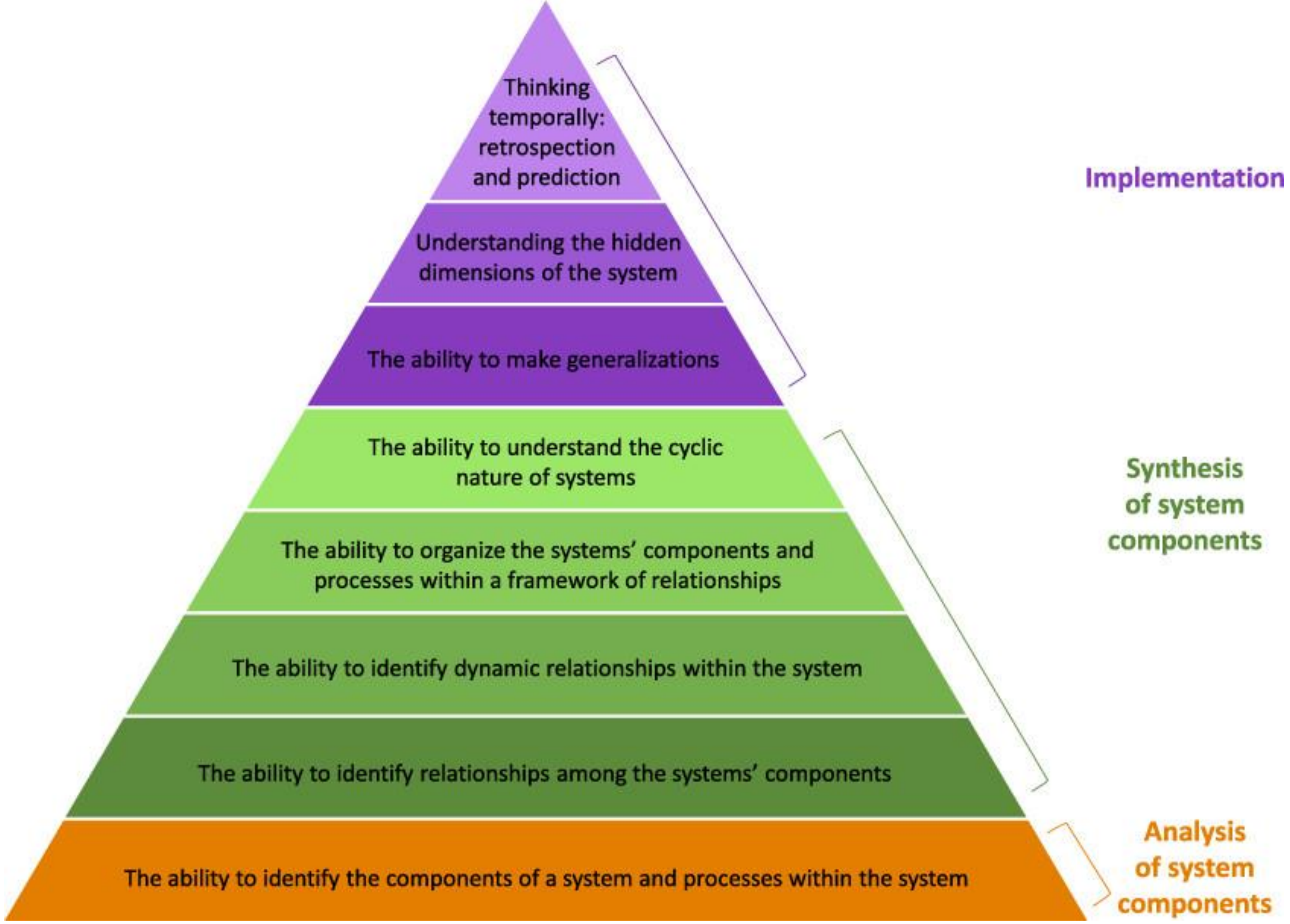
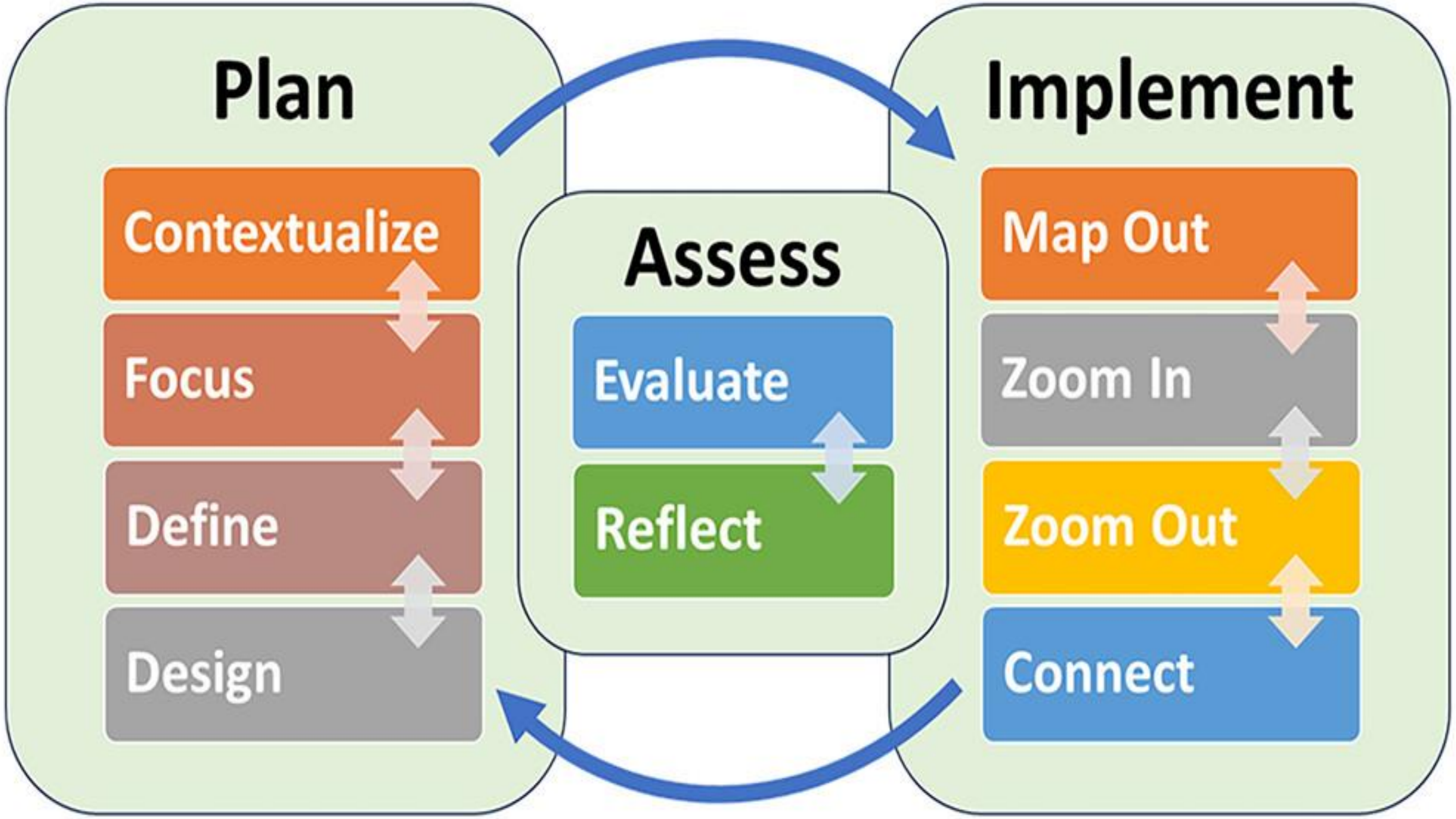


System thinking

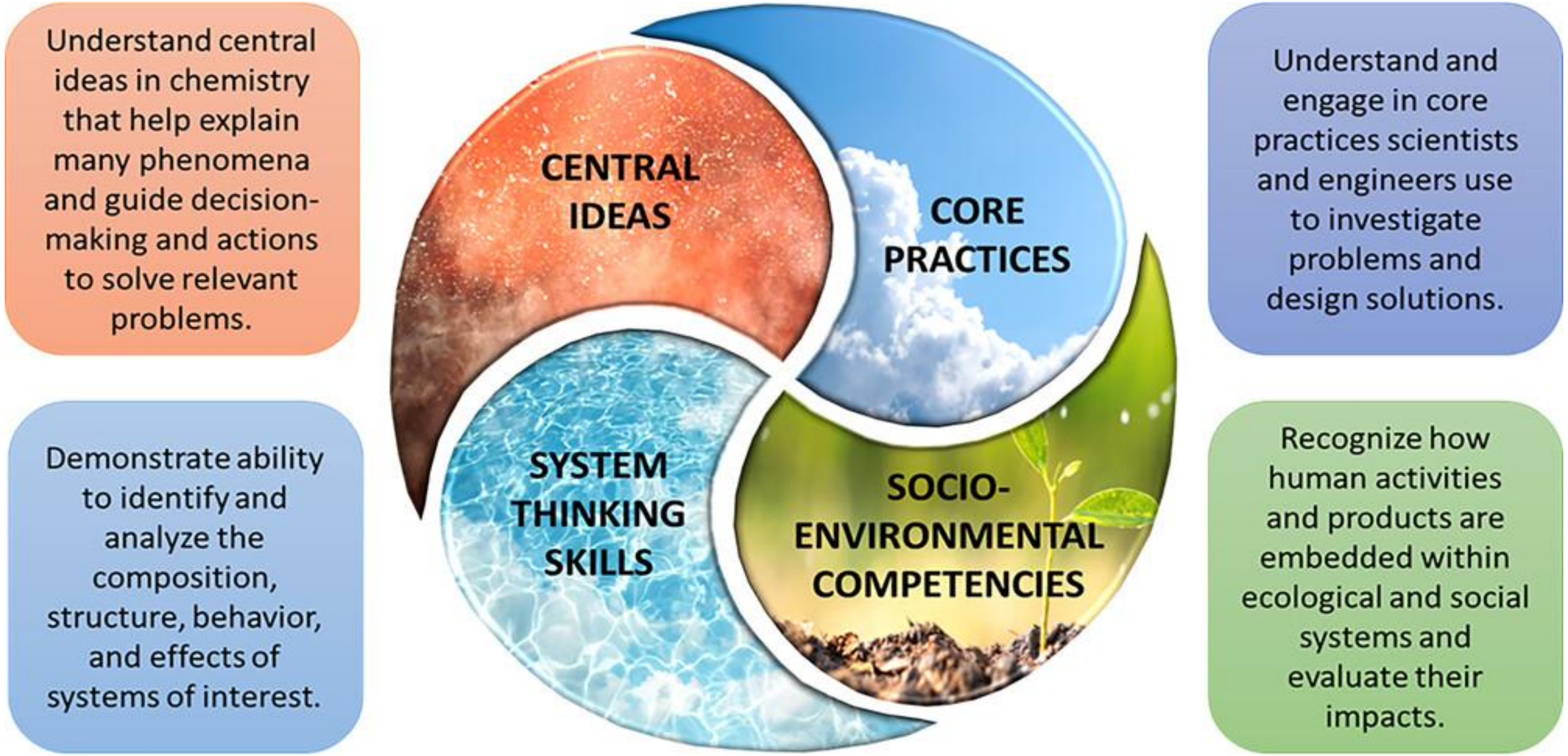
https://pubs.acs.org/doi/epdf/10.1021/acs.jchemed.9b00169?ref=article_openPDF



DOI: (10.1021/acs.jchemed.4c00216)

Table 1. Example of the Application of the ST Educational Framework in the Planning, Implementation, and Assessment of a Chemistry Unit Using Greenhouse Gases as a Context

Stage	Task	Example
Plan	Contextualize	The analysis of the composition and structure of greenhouse gases (GHGs), their interactions with electromagnetic radiation in the atmosphere, and the effects of those interactions on average temperatures on our planet presents an ideal context to introduce and apply central chemical concepts such as electronegativity, partial charge, bond polarity, molecular polarity, and light-matter interactions using an ST perspective. This context can be used to explore the central idea that the composition and structure of chemical substances at the submicroscopic level determine their physical and chemical properties.
	Focus	This lesson will focus on the analysis of the chemical composition and structure of GHGs and the consequences of their interactions with the infrared solar radiation reflected by Earth on our planet's temperature.
	Define	As an integrated learning outcome for this unit, students should be able to analyze a set of commonly used substances (e.g., refrigerants) and determine whether they may act as GHGs if they escape into the atmosphere, predict and justify their light−matter interactions based on molecular models, analyze their potential global warming effects based on data, and propose and evaluate the effectiveness of strategies to reduce these emissions considering environmental, social, and economic factors.
	Design	The unit of instruction is designed using a sequence of activities that students are expected to complete in small collaborative groups and then share their ideas in whole class discussions. In these activities, students are asked to analyze data (e.g., types of radiation emitted by the Sun and our planet), make models (e.g., build models of molecular polarity), and generate explanations (e.g., explain why not all atmospheric components absorb IR radiation). Activities also allow students to develop systems thinking skills (e.g., analyze the composition, structure, behavior, and effects of relevant interacting systems) and build socio-environmental competencies (e.g., analyze specific actions to reduce GHG emissions).
Implement	Map Out	During this stage of the unit, students are asked to use their prior knowledge and experiences to build an initial system map identifying major atmospheric components and their interactions with diverse subsystems (e.g., radiation from the Sun and Earth, living organisms, and human communities). Students use online tools, like SOCKit,[31] to build their maps.
	Zoom In	In this part of the unit, students identify important atmospheric components (O_2, N_2, CO_2, H_2O) and explore properties that affect their interaction with electromagnetic radiation. Students are introduced to the concepts of bond polarity and molecular polarity and use an interactive tool to infer the polarity of different chemical entities in the atmosphere. Later in the lesson, the students explore how bond and molecular polarity determine whether molecules absorb infrared radiation and, thus, may contribute to global warming.
	Zoom Out	Once students understand the targeted phenomenon at the submicroscopic level, they are asked to analyze the emission spectra for the Sun and Earth in combination with the absorption spectra of H_2O and CO_2 to infer consequences for our planet.
	Connect	In this last stage of the unit, students engage in activities that allow them to apply their knowledge in making decisions and suggesting individual or collective actions directed at addressing the environmental problem under consideration.
Assess	Evaluate	The different activities interspersed through the unit create opportunities to formatively assess student learning and provide specific feedback to advance their understanding to meet the lesson's learning objectives. As a summative assessment, students are asked to analyze the composition and structure of less commonly known GHGs in our atmosphere, predict their properties, and analyze their potential global warming effects.
	Reflect	The formative assessment data gathered during the lesson is used to critically reflect on aspects of the unit that need to be modified to support student learning of the central chemical ideas, core practices, systems thinking skills, and socio-environmental competencies that are targeted.



Fundamental learning outcomes in a systems thinking approach to chemistry education (all images belong to the public domain).

DOI: (10.1021/acs.jchemed.4c00216)

5 essential characteristics of System thinking in a lesson plan/ unit plan

RECOGNIZE A SYSTEM AS WHOLE, NOT JUST A COLLECTION OF PARTS

EXAMINE THE RELATIONSHIPS BETWEEN THE PARTS OF THE SYSTEM AND HOW THOSE INTERCONNECTIONS LEAD TO A CYCLIC SYSTEM BEHAVIOURS.

IDENTIFY VARIABLES THAT CAUSE SYSTEM BEHAVIOURS (BUTTERFLY EFFECT) -STOCHASTIC BEHAVIOURS (PROBABILITY BUT NOT PRECISE PREDICTION).

EXAMINE HOW SYSTEM BEHAVIOURS CHANGE OVER TIME

IDENTIFY INTERACTIONS BETWEEN SYSTEM AND ITS ENVIRONMENT, INCLUDING HUMAN COMPONENTS OF THE ENVIRONMENT

Teaching through observation in real time

- 1. Making bioethanol- display fermentation, distillation, calorimetry (fuels and intermolecular forces, energy, instrumentation)
- 2. Microscale- equilibrium shift with cobalt chloride (rate and extent)
- 3. Demo- Oscillating equilibrium (hook for equilibrium as demo)
- 4. Making Paracetamol RSC (medicinal chemistry and Instrumentation)

Overarching principles of green chemistry and sustainability

Bio-ethanol : Collaboration

Miro board- Bioethanol

PLAN

Context: Fuels

Focus: Renewable fuels

Define: **Renewable** fuel refers to a resource or energy source that is naturally replenished over time and can be used repeatedly without running out.

Design: How to make bioethanol

IMPLEMENT

- **Map out:** Research the method to make bioethanol
- **Zoom in:** Discuss the ability to make the reaction in the laboratory for testing.
- **Zoom out:** Discuss the details of the environmental and human impact
- **Connect:** connect each step to the whole process

Miro board- Bioethanol

Context: Bioethanol, a renewable energy source derived from biomass, plays a significant role in reducing greenhouse gas emissions and promoting sustainable energy solutions. Understanding the chemical processes involved in bioethanol production and their environmental and economic implications is essential for students to appreciate the role of chemistry in addressing global challenges.

Focus: The lesson centers on the fermentation process used to produce bioethanol, emphasizing the chemical reactions, the role of enzymes, and the conversion of biomass into fuel. Students will investigate how different substrates affect ethanol yield and consider the efficiency and sustainability of bioethanol production

Zoom In: Students will conduct a hands-on experiment to produce ethanol through fermentation. Working in groups, they will test various substrates—such as corn syrup, corn starch, table sugar, apples, and honey—to determine which yields the highest ethanol production.

Zoom Out: Following the experiment, students will engage in discussions and activities that connect their findings to larger systems, including:

- **Environmental Impact:** Evaluating how large-scale bioethanol production affects ecosystems, land use, and carbon emissions.
- **Economic Considerations:** Discussing the cost-effectiveness of bioethanol as an alternative fuel and its influence on agricultural markets.
- **Societal Implications:** Exploring the role of biofuels in energy security and policy-making, and their potential to reduce dependence on fossil fuels.

Resources for checking the purity of ethanol made in the lab.

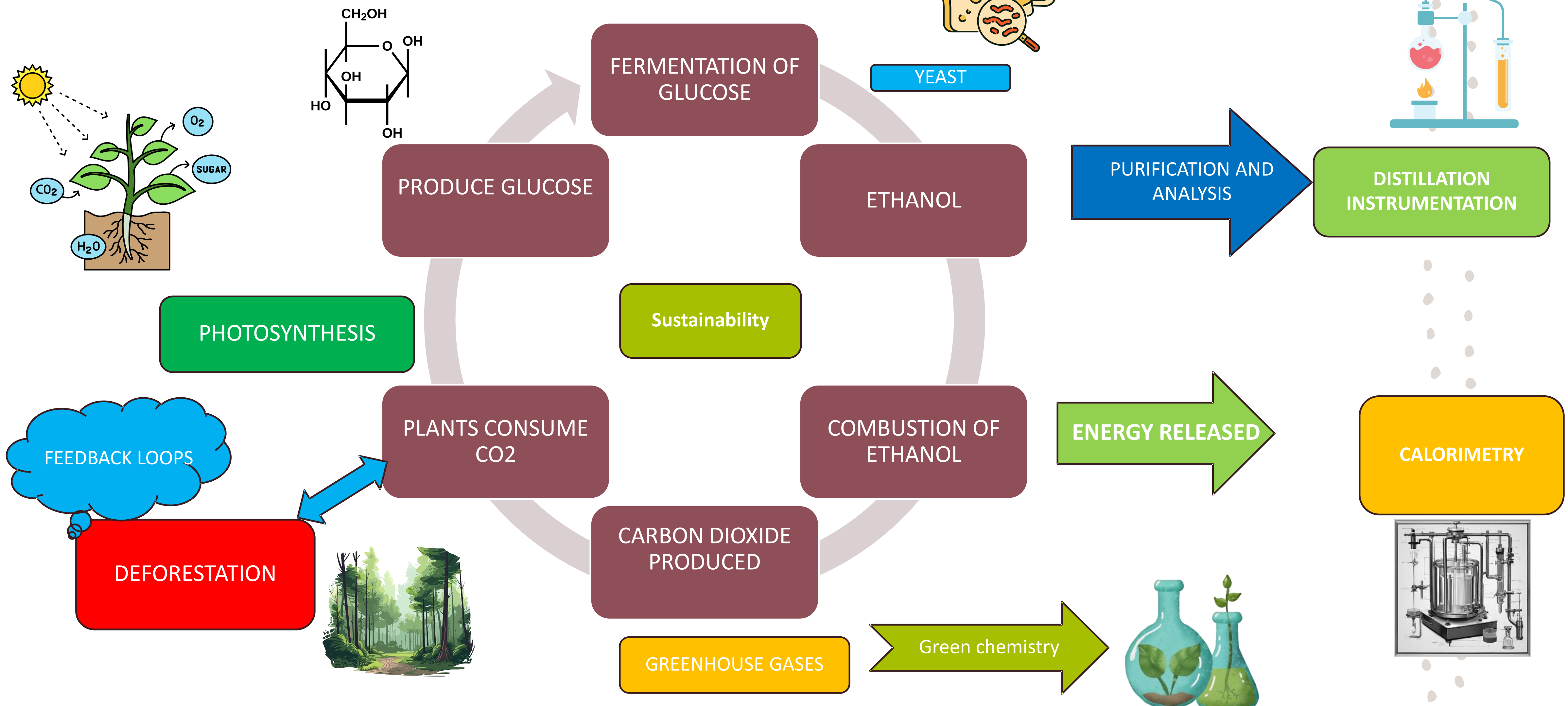
PRIMARY DATA

- Testing the purity of the ethanol produced on fermentation
- Thiele tube Boiling point- pure substances will have a sharp BP
- How to measure the boiling point of ethanol

SECONDARY DATA

- IR spectrum of ethanol.
- H and C- NMR Spectrum of Ethanol
- Mass spec

RENEWABILITY AND SUSTAINABILITY of bioethanol



I would like to acknowledge the Traditional Owners of the land on which we meet today. I would also like to pay my respects to Elders past and present.

Pinya Senevirathne

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Study design Changes

CEA WEBSITE-RESOURCES

VCE CHEMISTRY RESOURCES | ASSOCIATION | AUSTRALIA

Key Knowledge points extracted from VCE Chemistry Study Designs © VCAA 2022 and 2016

Colour code – blue = new (or changed emphasis or newly explicit reference) in 2024, red = removed from 2017-2023 SD

Key science skills (2024 Study design only shown here)
Develop aims and questions, formulate hypotheses and make predictions: • identify, research and construct aims and questions for investigation • identify independent, dependent and controlled variables in controlled experiments • formulate hypotheses to focus investigations • predict possible outcomes of investigations
Plan and conduct investigations: • determine appropriate investigation methodology: case study; classification and identification; controlled experiment; correlational study; fieldwork; literature review; modelling; product, process or system development; simulation • design and conduct investigations; select and use methods appropriate to the selected investigation methodology, including consideration of sampling technique and size, equipment and procedures, taking into account potential sources of error and causes of uncertainty; determine the type and amount of qualitative and/or quantitative data to be generated or collated • work independently and collaboratively as appropriate and within identified research constraints, adapting or extending processes as required and recording such modifications
Comply with safety and ethical guidelines: • demonstrate safe laboratory practices when planning and conducting investigations by using risk assessments that are informed by safety data sheets (SDS), and accounting for risks • apply relevant occupational health and safety guidelines while undertaking practical investigations • demonstrate ethical conduct when undertaking and reporting investigations
Generate, collate and record data: • systematically generate and record primary data, and collate secondary data, appropriate to the investigation, including use of databases and reputable online data sources • record and summarise both qualitative and quantitative data, including use of a logbook as an authentication of generated or collated data • organise and present data in useful and meaningful ways, including schematic diagrams, flow charts, tables, bar charts and line graphs • plot graphs involving two variables that show linear and non-linear relationships

Where to start?

VCAA Resources

- VCAA Chemistry main page
- VCAA Chemistry past papers and examiner reports
- Chemistry Study Design
- VCAA assessment advice
- VCE assessment principles
- Command Terms and their definitions
- VCAA Sample teaching plans for units 1-4
- Sample activities Units 1 – 4
- Key science skills across Units 3 - 4
- VCAA planning your course
- Planning for your SACs
- New SD implementation videos
- Pages - NHT examination specifications, past examinations and examination reports

CEA Resources

VCE Chemistry Resources | Chemistry Education Association | Australia

Other Resources

- Pat Oshea's site
- Sue Hardy's site
- Early Careers Chemistry Network (ECCN) | Facebook
- VCE Chemistry Teachers' Group | Facebook
- PhET Simulations
- Dynamic Science Chemistry-Index
- Chemistry - VCE - past exam questions - organised on topics

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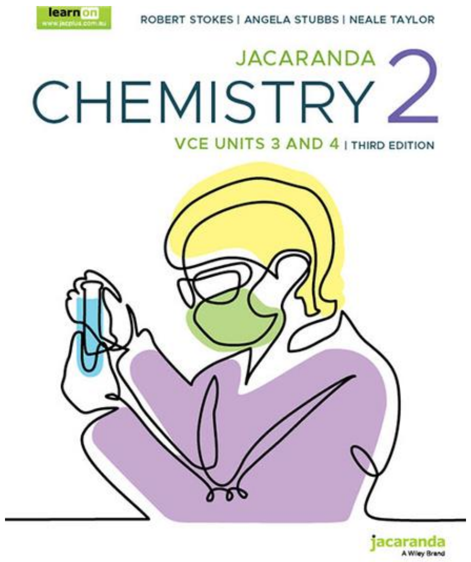
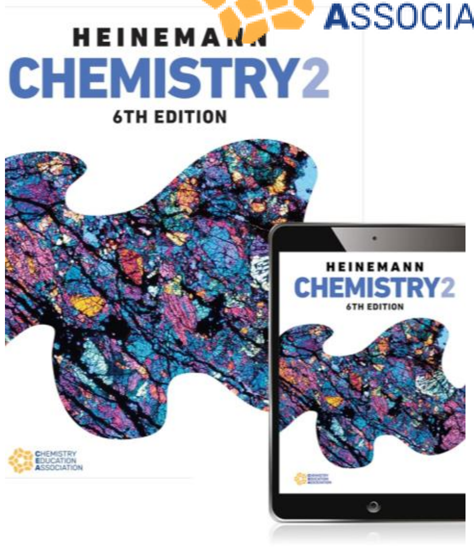
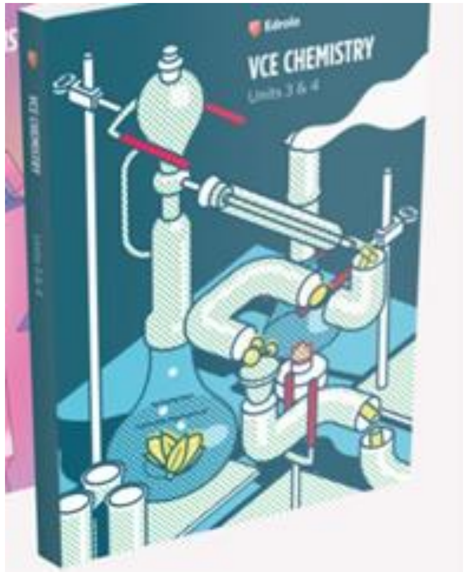
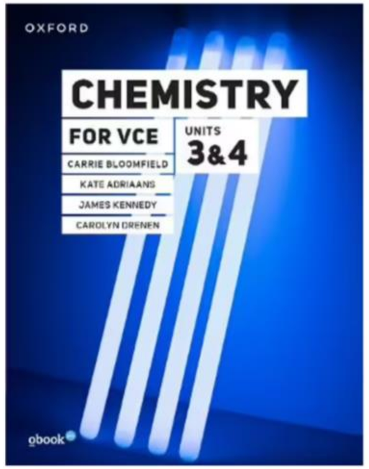
Textbooks?

Different textbooks have different strengths (and weaknesses). In addition to the book your students are using, try to acquire a few other books for yourself. Your school may be able to purchase some for you.









Your unit plan

Possible UNIT 3 TIMETABLE

Prepared by Penny Commons for CEA VCE Implementation workshops, October 2023

This timetable is based on the VCAA Study Design and the Pearson Heinemann Chemistry 2, 6th Edition.

The VCAA has provided *Sample teaching plans* for each area of study. These are well worth examining, especially their *Learning Activities column*. This could also be helpful when designing SACs for the year.

Section review questions at the end of each section in the Heinemann text book are most helpful as checkpoint questions or homework or weekend study.

Please complete your own minimum list of **Chapter review** questions (in column 4 below) will enable students to determine what they need to carefully revise in that particular area of study.

All **Unit Review** questions should be done as revision of the entire Area of Study.

Week	**Concepts**	**Heinemann Chemistry 2 Text Chapter**	**You need to list a minimum set of *End of Chapter Review* questions. (Use section questions as class and homework)**	**VCAA minimum of 10 hours of prac across Areas of Study 1 and 2** **VCAA minimum of 10 hours across Unit 4 Area of Study 3 (can be done anytime on Unit 3 or 4 material)** **Practical activities (PA) and Worksheets (WS) found in Heinemann *Skills and Assessment book* (SAB)** **Demonstrations are from the 'old' *Demonstrations in Chemistry* Chris Commons et al. You may find some of them on You tube.**	**SAC Dates and details You will need to discuss with your colleagues and school program and decide what content and which style of SACs will be held when.**
Semester 1: Unit 3: How can design and innovation help to optimise chemical processes? **Area of Study 1: What are the current and future options for supplying energy?**					
1	Carbon based fuels • Exothermic and endothermic reactions o Energy profile diagrams ▪ Activation energy ▪ ΔH o Thermochemical equations • Fuels o Non-renewable fuels o Renewable fuels o Fuels for the body o Energy from combustion ▪ Complete ▪ incomplete	2		SAB WS 1 Knowledge review—mole, stoichiometry and redox Demonstrations: ▪ Endothermic reaction between two solids ▪ Chemical oven SAB WS 2 Combustion of fuels—energy profile diagrams and calculations SAB WS 3 Motor fuels—today and tomorrow	**Outcome 1 statement:** Compare fuels quantitatively with reference to combustion products and energy outputs, apply knowledge of the electrochemical series to design, construct and test primary cells and fuel cells, and evaluate the sustainability of electrochemical cells in
2	• Measuring changes in chemical reactions	3		SAB WS 4 Energy changes and stoichiometry—limiting reactants	

Penny Commons July 2023

CEA's unit plan follows the Heinemann text, but all publishers have their suggested unit plans that aligns with their text. Make it visible to the students.

[Link to CEA unit timeline]

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Unit 4 AOS 1 SAC – part 2

SAC advise sheet

Format: test /Answers to a set of structured questions

Date: 03/08/22

Time: 3.30pm-4.30pm

Venue: in A3 and A4

Permitted items: Data book (provided)

Communicate the date and format of the SACs in advance

sample sac advice sheet

• determination of the structures of simple organic compounds using a combination of mass spectrometry (MS), infrared spectroscopy (IR) and proton and carbon-13 nuclear magnetic resonance spectroscopy (NMR) (limited to data analysis)

• the principles of chromatography including use of high performance liquid chromatography (HPLC) and construction and use of a calibration curve to determine the concentration of an organic compound in a solution

• determination of the concentration of an organic compound by volumetric analysis, including the principles of direct acid-base and redox titrations (excluding back titrations).

Use the Study Design

VCAA Study Design is your guide on what to teach. Get your students to look at the study design too. Always refer to weblink for most updated guide.

[Link to the SD]

You can provide the students the following breakdown of topics derived by Lanna Derry based on the VCAA study design.

[Key Topics to study/teach]

Writing Your SACs

- SD page 37 Pages - Chemistry
- No task type may be repeated across Units 3 and 4.
- Sustainability must be addressed in at least one task.
- Time constraints per task: 50–70 minutes for written components and 10 minutes for multimodal/oral presentations.

Suitable tasks for assessment in this unit may be selected from the following:

Outcome 1 and Outcome 2

For each outcome, at least one task selected from:

- a report of a laboratory or fieldwork activity, including the generation of primary data
- comparison and evaluation of chemical concepts, methodologies and methods, and findings from at least two student practical activities
- reflective annotations of one or more practical activities from a logbook
- a summary report of selected practical investigations
- critique of an experimental design, chemical process or apparatus
- analysis and evaluation of generated primary and/or collated secondary data
- a modelling or simulation activity
- a media analysis/response
- problem-solving involving chemical concepts, skills and/or issues
- a report of an application of chemical concepts to a real-world context
- 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)
- an infographic
- a scientific poster.

If multiple tasks are selected for Outcome 1 and/or Outcome 2, they must be different. The same task cannot be selected more than once across Outcomes 1 and 2.

Where teachers allow students to choose between tasks, teachers must ensure that the tasks they set are of comparable scope and demand.

Outcome 3

- a report of a student-adapted or student-designed scientific investigation using a selected format, such as a scientific poster, an article for a scientific publication, a practical report, an oral presentation, a multimedia presentation or a visual representation

Dos and Don't about SACS

- Have a look at Pat O'Shea's site for some ideas of SACs. (You cannot use them as real SACs as they are publicly available) Pat O'Shea's site
- Do not use commercial SACs without modifying them significantly. This is a VCAA requirement.
- Do not repeat the same SACs each year, modify them/change them.
- You can give a copy of the SACs back to your students to keep, but you need to keep the original with you.
- VCAA administrator handbook 2025 pages 72–82 are the most relevant to you.

Which SACs fit best with which Area of Study?

- comparison and evaluation of chemical concepts, methodologies and methods, and findings from at least two practical activities
- analysis and evaluation of primary and/or secondary data, including identified assumptions or data limitations, and conclusions
- problem-solving, including calculations, using chemistry concepts and skills applied to real-world contexts
- analysis and evaluation of a chemical innovation, research study, case study, socio-scientific issue, or media communication.

Mapping the outcome against the SAC Type

- **Unit 3 Area of Study 1 -** What are the current and future options for supplying energy?

Outcome 1

Compare fuels quantitatively with reference to combustion products and energy outputs, apply knowledge of the electrochemical series to design, construct and test primary cells and fuel cells, and evaluate the sustainability of electrochemical cells in producing energy for society.

- **Unit 3 Area of Study 2 -** How can the rate and yield of chemical reactions be optimised?

Outcome 2

Experimentally analyse chemical systems to predict how the rate and extent of chemical reactions can be optimised, explain how electrolysis is involved in the production of chemicals, and evaluate the sustainability of electrolytic processes in producing useful materials for society.

Mapping the outcome against the SAC Type

• **Unit 4 Area of Study 1 -** How are organic compounds categorised and synthesised?

Outcome 1

On completion of this unit the student should be able to analyse the general structures and reactions of the major organic families of compounds, design reaction pathways for organic synthesis, and evaluate the sustainability of the manufacture of organic compounds used in society.

• **Unit 4 Area of Study 2 -** How are organic compounds analysed and used?

Outcome 2

On completion of this unit the student should be able to apply qualitative and quantitative tests to analyse organic compounds and their structural characteristics, deduce structures of organic compounds using instrumental analysis data, explain how some medicines function, and experimentally analyse how some natural medicines can be extracted and purified.

• **Unit 4 Area of Study 3 -** How is scientific inquiry used to investigate the sustainable production of energy and/or materials?

Outcome 3

On completion of this unit the student should be able to design and conduct a scientific investigation related to the production of energy and/or chemicals and/or the analysis or synthesis of organic compounds, and present an aim, methodology and method, results, discussion and conclusion in a scientific poster.

Individual/group	Task	Time
Group	Introduction of poster investigation	1 hour
	Students research about a suitable investigation	2 hours
	Submit research proposal ideas for discussion with the class	1 hour
	Identify the risk management strategies, obtain teacher's permission for the experiment	1 hour
	Submit final research question, aim, hypothesis, variables and a rough method.	1 hour
	Submit material list, refined method and risk assessment	1 hour
	Conduct experiment Gather raw data	1.5 – 2 hours
Individual	Complete the logbook	1 hour
	Complete the poster (under SAC conditions)	1 hour

U4 AOS 3 practical Investigation

Topics of practical investigation

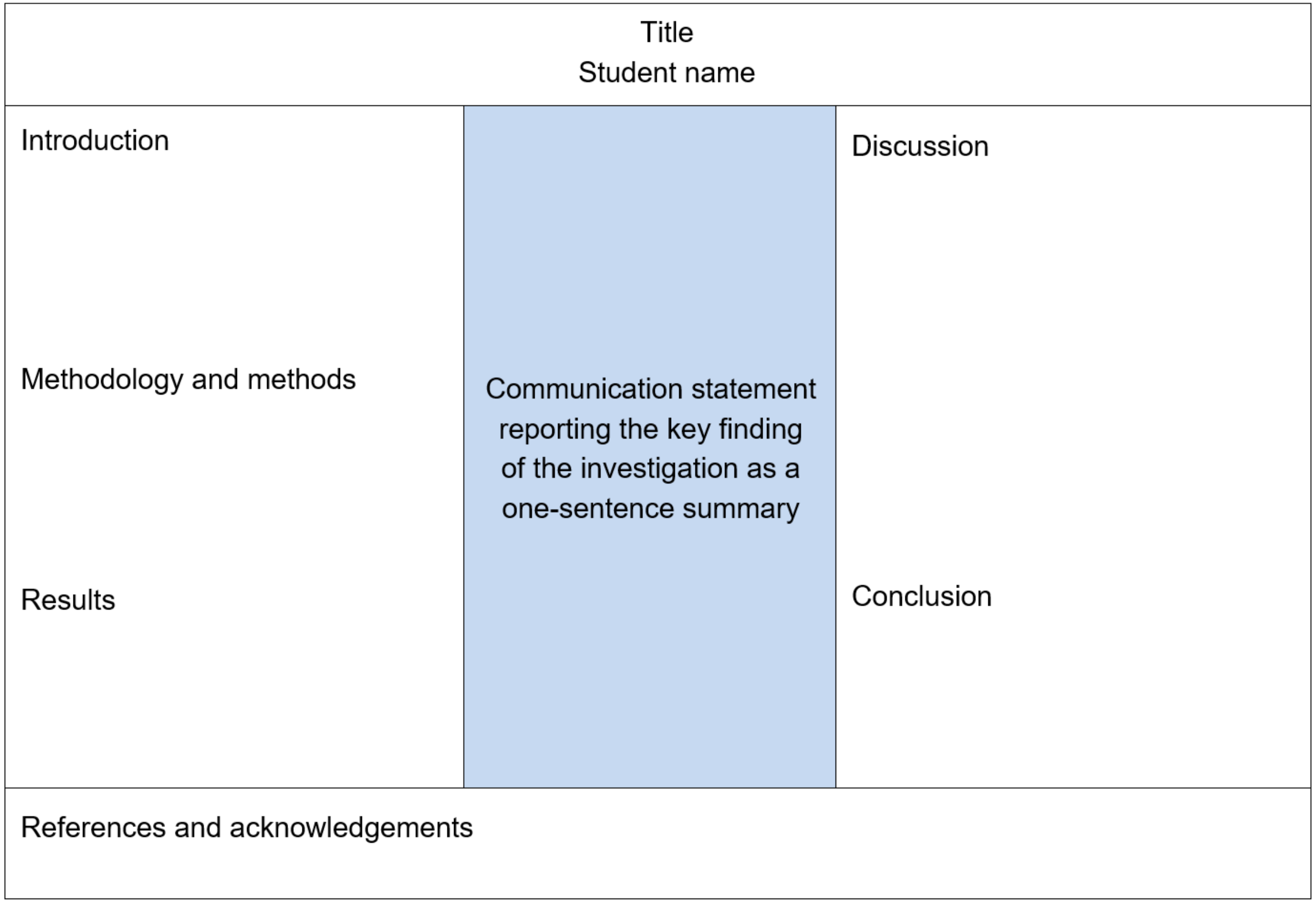
- "Outcome 3 - Design and conduct a scientific investigation related to the production of energy and/or chemicals and/or the analysis or synthesis of organic compounds, and present an aim, methodology and method, results, discussion and conclusion in a scientific poster" - VCAA SD

Some possible investigations

- Effect of temperature (or other variables) of half-cell solutions on cell voltage
- Measure and compare the thermal energy released during the combustion of various alcohols
- Calculation of energy content of a different coal types/bio masses by combustion
- Production of bioethanol, biodiesel under different variables
- Production of aspirin or paracetamol
- Extraction and purification of chemicals from native plants
- Analysis of vitamin C content of finger lime or Kakadu plum

Poster

- VCAA SD Page 14



VCAA has used these on slides 29 and 30 as examples, but not exemplars.

Are Aldi decaffeinated coffee pods completely caffeine free?!

StuDent

Introduction

According to the National Coffee Association (NCA), "Decaffeination removes about 97% or more of the caffeine in coffee beans. A typical cup of decaf coffee has about 2 mg of caffeine, compared to a typical cup of regular coffee, which has about 95 mg of caffeine".

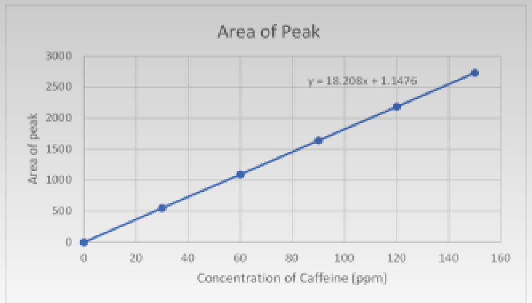
My aim is to find whether Aldi decaffeinated coffee is completely caffeine free. My hypothesis is that there's a little bit of caffeine content found within the decaffeinated coffee pod, thus it is not completely caffeine free.

Methodology

HPLC analysis:

1. Make standard solutions (150 ppm)
2. Measure standards in HPLC & create calibration curve
3. Prepare samples
4. Dilute samples to fit in the calibration curve
5. Measure samples in HPLC
6. Use calibration curve to interpolate caffeine concentration
7. Take into account dilution to find caffeine content of original sample

Results



Discussion

I compared the caffeine content in Aldi coffee pods with four other caffeinated samples . I found that the decaffeinated sample had significantly less caffeine content than the other samples, which is to be expected given that it is 'decaffeinated'. These results support my hypothesis that there is in fact some caffeine content in decaffeinated coffee pods (10.65 mg in a 43 mL serve). There weren't any unexpected results in this experiment, given that the caffeine levels were significantly lower in decaffeinated coffee. However the experiment supported my hypothesis that decaffeinated coffee is not completely caffeine free. There were no errors with the method, as the HPLC analysis flowed smoothly and the results were collected efficiently and accurately.

Conclusion

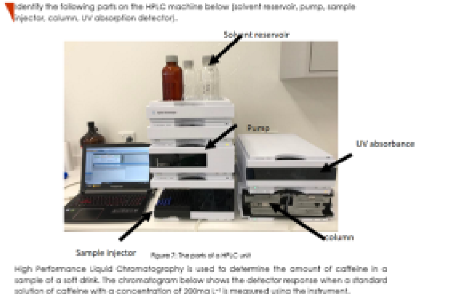
The results indicate that my hypothesis is supported, given that there is in fact *some* caffeine content in decaffeinated coffee pods (10.65mg in a 43 mL serve, according to sample A from source 2). Therefore, decaffeinated coffee pods from Aldi are not completely caffeine free, and there is some caffeine content in decaffeinated coffee pods from Aldi, despite there being significantly less caffeine content than regular coffee pods.

NEWS FLASH:

Your decaffeinated coffee might not be *completely* caffeine free!!

(woahhhh!)

Read on for more...



HPLC machine used in caffeine experiment

References

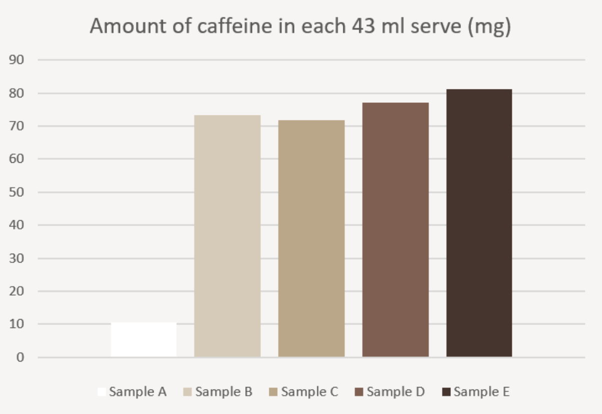
• Mr Tex Sapor, from Brandnew School, for assisting with the analysis
• Ms T. Cha, for encouraging me to always check my calculations

Is decaffeinated coffee truly caffeine-free?

Aim: to investigate whether "decaffeinated coffee" truly contains no caffeine, and if not, to what extent/proportion it is present compared to the other strength levels.

Hypothesis: If strength number determines caffeine content, then the decaf coffee will contain a small amount of caffeine, because extracting 100% of the caffeine from coffee beans is difficult and unrealistic.

Results:
The results derived show that decaf coffee does contain a very small amount of caffeine, however in comparison to the other samples, it is negligible.



Your cup of decaf might be "caf"ed after all!

But does that really matter? While decaf contains a small amount of caffeine, it's not enough to affect you.

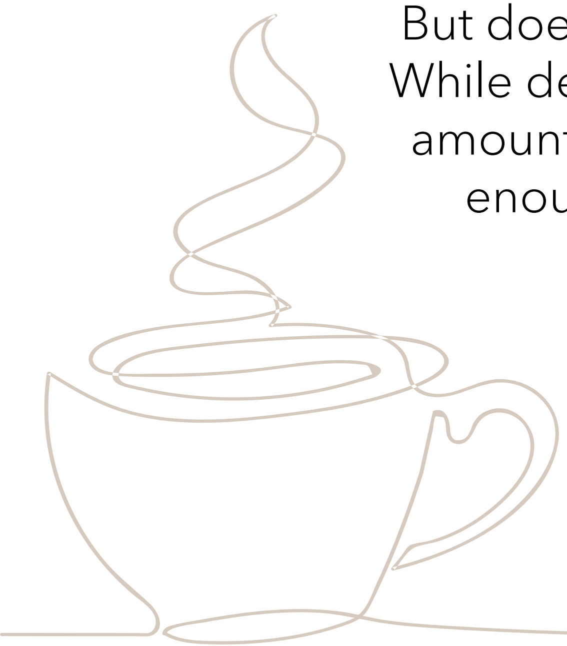


Table 1 Composition of standard solutions

Caffeine stock (μL)	0	200	400	600	800	1000
DI water (μL)	1000	800	600	400	200	0
Caffeine (ppm)	0	30	60	90	120	150

Table 2 HPLC results

Caffeine (ppm)	Retention time of peak (min)	Area of peak
0	0	0
30	2.686	550.092
60	2.693	1091.640
90	2.695	1639.954
120	2.698	2187.144
150	2.700	2731.944

Table 3 Caffeine content data

Sample	Retention Time of Peak	Area of Peak	Concentration (ppm) diluted	Concentration (ppm) original	Amount of caffeine per serve (mg)
A	2.714	226.592	12.381	247.62	10.65
B	2.712	1554.962	85.333	1706.66	73.39
C	2.712	1522.344	83.541	1670.82	71.85
D	2.705	1634.897	89.723	1794.46	77.16
E	2.704	1722.048	94.509	1890.18	81.28

How is the mass of copper deposited at the cathode in an electrolytic cell affected by the concentration of the electrolyte?

Introduction

Electrolytic cells involve the conversion of electrical energy from a power supply to chemical energy through a non-spontaneous redox reaction. At the anode, the strongest reducing agent is oxidised preferentially; at the cathode, the strongest oxidising agent is preferentially reduced (Derry et al., 2023). Using the half equations in the electrochemical series (VCAA Chemistry Data Book 2023), it is predicted that copper will be formed at the cathode and Cu^{2+} ions will be formed at the anode during the electrolysis of $CuSO_4$(aq) using copper electrodes.

Aim: To determine how increasing the concentration of the electrolyte effects the mass of copper deposited at the cathode during the electrolysis of $CuSO_4$(aq) using copper electrodes.

Hypothesis: An electrolytic cell with an electrolyte of a higher concentration will result in a greater mass of copper deposited at the cathode in a given time because the higher concentration will result in a greater rate of reaction.

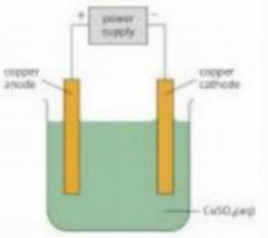
Methodology and methods

Methodology: A controlled experiment was used.

Method:

1. Using 1.0 M copper sulfate solution, prepare 0.50 M, 0.25 M and 0.10 M solutions by dilution of this solution.
2. Set up electrolytic cell using 80 mL solution (1.0 M, 0.50 M, 0.25 M and 0.10 M) according to Figure 1.
3. Record mass of cathode for each experiment before starting.
4. Set powerpack to 12 volts and use variable resistor to set and maintain current at 1.0 A for 10 minutes.
5. Rinse each cathode in acetone, dry and weigh, then record mass.
6. Repeat three times for each concentration.

Figure 1 Electrolysis cell



Risks:

- $CuSO_4$(aq) is corrosive and causes serious eye damage, so safety glasses, a lab coat and gloves were worn throughout the investigation.
- Any remaining Cu(s) and $CuSO_4$(aq) was returned to the laboratory prep room for safe disposal or future use.

Communication statement

As the concentration of a $CuSO_4$ solution decreases during electrolysis, the conductivity of the solution decreases and the mass of copper deposited at the cathode decreases.

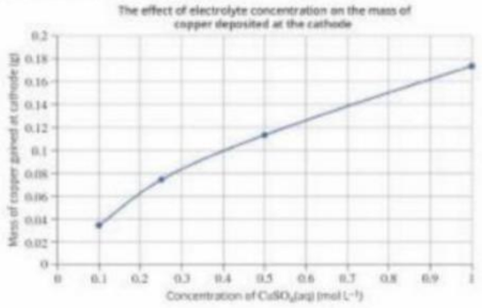
Results

Table 1 Summary table of results

Concentration of electrolyte (M)	Average mass gain (g)	Percentage difference (%)
1.0	0.174	11.7
0.50	0.114	42.1
0.25	0.075	61.9
0.10	0.035	82.2

Discussion

Figure 2 Graph of results



While the graph does not show a linear relationship, the mass of copper gained at the cathode definitely decreases as the concentration of the electrolyte decreases.

Conclusion

The effect of changing the concentration of the electrolyte in the electrolysis of $CuSO_4$(aq) using copper electrodes was investigated. It was found that as the concentration of the electrolyte increased, the mass of copper deposited at the cathode also increased. The results support the hypothesis. These results have a significant degree of inaccuracy because it was not possible to keep the current to the ideal value of 1.0 A throughout all trials and considerable amounts of copper fell off the cathode before it could be weighed.

Further research that eliminates sources of error, such as the change in current and the copper that did not adhere to the cathode, should be conducted in order to achieve results that are more accurate and to ensure the reliability of the method.

References:

Chan, D., Commons, C., Commons, P., Derry, L., Freer, E., Huddart, E., Lennard, L., MacEoin, M., Moylan., M., O'Shea, P., Ross, B., Vanderkruk, K., & Waldron, P. (2023). *Heinemann Chemistry 2* (6th ed.) Pearson Australia.

Safety Data Sheet (copper(II) sulfate pentahydrate) from https://shop.chemsupply.com.au/documents/CL0681CH2B.pdf

Acknowledgements:

I would like to thank the laboratory technicians, Karen and Tanneale, for their help in preparing the solutions for this investigation.

FIGURE 1.6.2 An example of a student's scientific poster

Derry, L. *et al*. (2023) *Heinemann Chemistry 2*. Melbourne, Vic: Pearson Australia.

Preparing students for the exam

Teach students how to study early on.

"Studying" is an Active Process: Emphasise that studying is not just about passively reading. It is about actively engaging with the material. Explain that it involves:

- **Summarising:** Rewriting information in their own words.
- **Questioning:** Asking themselves questions about the material and trying to answer them.
- **Concept Mapping/Mind Mapping:** Creating visual representations to connect ideas.
- **Practice Problems:** Working through exercises and applying concepts.
- **Teaching the Material:** Explaining concepts to someone else.

Effective study habits of highly successful students (by James Kennedy)

habits | James Kennedy

CHEMISTRY EDUCATION ASSOCIATION

Preparing students for the exam

1. **Regular Classwork Checks:** Implement a system for regularly checking students' completion of set work. This could involve quick quizzes, peer reviews, or brief discussions.
2. **Early Exam Question Exposure:** Incorporate practice exam questions into lessons from the beginning of the unit. This helps students understand the exam format and identify areas for improvement early on.
3. **Utilise Online Resources:** Encourage students to use online platforms like Studyclix or Dynamic Science Link to practise questions and target specific topics.
4. **Peer Marking & Feedback:** Implement peer marking activities where students assess each other's work, providing constructive feedback and identifying areas for improvement.
5. **Post-Test Reflections:** Require students to complete a reflection after each class test. This should include an analysis of their performance, identification of strengths and weaknesses, and a plan for improvement.
6. **Collaborative Answer Development:** Facilitate discussions where students collaboratively develop high-scoring answers to exam-style questions. This helps them understand the expectations and learn from each other.

Deriving indicative Grades for VASS

"The VCAA has no preferred position on how a school arrives at a set of indicative grades, except to advise that the process should be defensible. " - [Pages - External assessment]

Your school may have a system for indicative grades, or you can derive your own by looking at the grade distribution in previous years grade distribution data.

[https://www.vcaa.vic.edu.au/Documents/statistics/2023/section3/vce_chemistry_ga23.pdf]

It is wise not to entirely rely on the SAC grades when deriving the indicative score. Combine it with practice exam and topic test scores as well.

[important dates in VASS calender]

CHEMISTRY EDUCATION ASSOCIATION

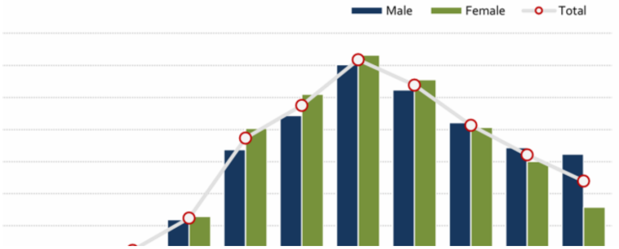
Chemistry

Graded Assessment 3
WRITTEN EXAMINATION
2023

	D	D+	C	C+	B	B+	A	A+	NR	Total
	316 6.4	533 10.7	638 12.9	795 16.0	717 14.5	616 12.4	539 10.9	519 10.5	0 0.0	4,959 100.0
	323 6.6	592 12.1	696 14.2	816 16.6	741 15.1	595 12.1	491 10.0	351 7.2	0 0.0	4,906 100.0
	3 7.9	11 28.9	3 7.9	8 21.1	5 13.2	3 7.9	2 5.3	1 2.6	0 0.0	38 100.0
	642 6.5	1,136 11.5	1,337 13.5	1,619 16.3	1,463 14.8	1,214 12.3	1,032 10.4	871 8.8	0 0.0	9,903 100.0
4	45-60	61-83	84-107	108-132	133-154	155-172	173-190	191-240	N/A	Max 240

5 students assessed has been assigned to the category of NR (Not Reported).

rade Distribution



Resources

Google Drive link with today's resources

Enjoy the journey: Thank you!

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