 Depth study: Industrial application of chemistry case study

Module 8: Applying Chemical Ideas[[1]](#footnote-1)

Outcomes

Working scientifically

* + CHE11/12-1 develops and evaluates questions and hypotheses for scientific investigation
  + CHE11/12-3 conducts investigations to collect valid and reliable primary and secondary data and information
  + CHE11/12-4 selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media
  + CHE11/12-5 Analyses and evaluates primary and secondary data and information
  + CHE11/12-7 communicates scientific understanding using suitable language and terminology for a specific audience or purpose

Knowledge and understanding

* + CHE12-15 describes and evaluates chemical systems used to design and analyse chemical processes

Teacher notes

Students will create a website that evaluates an aspect of a named industrial chemical synthesis process. As they engage in this depth study, students should develop their knowledge and understanding of the factors that need to be considered when designing a chemical synthesis process, including but not limited to:

* availability of reagents
* reaction conditions
* yield and purity
* industrial uses (for example pharmaceutical, cosmetics, cleaning products and fuels)
* environmental, social and economic issues

Suggested Timeline

This depth study can be timetabled for a minimum of 8 hours with scope to timetable up to 12 hours.

* 1-2 hours: Review and discuss examples of websites containing industrial chemistry information. What type of information is included? What purpose do they serve? Some examples are provided below.
  + [The chemical industry](http://www.essentialchemicalindustry.org/the-chemical-industry/the-chemical-industry.html)
  + [RAFT: making better polymers](https://www.csiro.au/en/Research/MF/Areas/Chemicals-and-fibres/Chemistry-and-biotechnology/RAFT)
  + [Getting Rid of the Last Bits of Sulphur in Fuel](https://www.caltech.edu/about/news/getting-rid-last-bits-sulfur-fuel-54225)
  + [Bioenergy Australia – How is ethanol made?](http://biofuelsassociation.com.au/biofuels/ethanol/how-is-ethanol-made/)
  + [How is chlorine produced?](http://www.eurochlor.org/the-chlorine-universe/how-is-chlorine-produced.aspx)
* 1 hour: Background research, identifying examples of important and industrially synthesised chemicals.
  + Students should initially search for chemicals of high value or importance, either globally or specifically to a region.
  + Chemicals utilised in medicines, mining, energy generation and the manufacture of other commercial products will generally be good candidates for investigation in this depth study.
  + A short-list of 3-4 chemicals should be produced
  + At this point, students should begin a logbook to document their progress.
* 2-3 hours: Generating a research question.
  + Students are to complete further background research into the industrial synthesis of their chosen chemical(s). Students should identify:
  + -The most common process used along with any notable alternatives.
  + -The most relevant issue(s) associated with its synthesis. For example, monitoring purity, increasing yield, reducing/storing waste products, altering the required reaction conditions or related environmental, social or economic issues.
  + Students generate a research question in response to issues identified in their background research.
* 4-6 hours: Research and website design
  + Students complete the task as outlined and create a website that evaluates an aspect of a named industrial chemical synthesis process.

Resources

All students have access to [Google Sites](https://sites.google.com/) through the department’s portal, which will enable to create and share a website easily. While are many alternatives available, it is recommended that students be limited to using a common platform for building their site. This will help to ensure that the primary focus of the task is the generation of meaningful content and evaluation of a chemical synthesis process. Teachers may set other means of scientific communications, such as a media article.

Task

Synopsis

You have been asked to create a website outlining an industrial application of chemistry. The website must describe a chemical synthesis process and explain how factors affecting the yield, purity or waste are managed. The website should be supported by relevant diagrams, equations and quantitative data.

Instructions

* Identify an important chemical that is (or could be) synthesised industrially
* Generate a research question focussed on factors affecting the yield, purity, waste, or reaction conditions of a process used to synthesise it. This question must be able to be investigated scientifically considering the time and resources available.   
  For example:
  + “Are acid-base titrations sufficiently accurate and reliable for ensuring that synthesised aspirin is of the required purity for medicinal use?”
  + Why do the properties of polymers of vinyl monomers produced using RAFT polymerisation differ from those produced by traditional processes?
  + “How are the conditions for the industrial synthesis of ethanol via fermentation optimised?”
  + “Have sulphur reduction methods used in the production of diesel fuel been effective at reducing SO2 emissions in Australia?”
  + “Can existing coal-fired power stations in Australia be effectively converted into ‘clean coal’ power stations?”
  + “How effective are current monitoring and treatment processes at managing saline waste generated by coal seam gas projects in NSW?”
* Write a hypothesis that is linked to your research question and is informed by your knowledge of chemical processes or by preliminary research.
* Research and detail the current chemical process(es) utilised in the identified industrial synthesis process. This should include balanced chemical equations, diagrams and the specific equipment used in the industry.
* Collect and process relevant secondary data to support an evaluation of your hypothesis.
* Ensure that your website clearly states your research question and includes a conclusion.
* Provide a reference list using APA referencing
* MAX 1500 words

Marking criteria:

| The section in the assignment | Connection to Syllabus | Outstanding (5) | High (4) | Sound (3) | Basic (2) | Limited (1) |
| --- | --- | --- | --- | --- | --- | --- |
| Research question and hypothesis | develops and evaluates questions and hypotheses for scientific investigation CHE11/12-1 | The question is discussed and justified. The hypothesis is justified; it is testable and is written so that the test is valid. | The question and hypothesis are justified with evidence | The research question is clearly stated, and the hypothesis relates to the question | The research question is stated, or a hypothesis is made | The research question or hypothesis is included but is unsuited for scientific evaluation |
| Knowledge and understanding of relevant chemical processes | Describes and evaluates chemical systems used to design and analyse chemical processes CH12-15 | Applies extensive knowledge and understanding to describe and evaluate chemical systems used to design and analyse chemical processes | Applies thorough knowledge and understanding to describe chemical systems used to design and analyse chemical processes | Demonstrates sound knowledge and understanding to describe chemical systems used to design chemical processes | Demonstrates basic knowledge and understanding to outline chemical systems used to design chemical processes | Demonstrates elementary knowledge and understanding of some scientific principles used in the industry |
| Quality and acknowledgement of resources | Selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media CH12-4 | Select and extract information from a wide range of reliable secondary sources and acknowledge them using an accepted referencing style. Effectively gathers, selects, organises and processes secondary sourced data and information to evaluate issues and inform creative solutions.  Data relates directly to the hypothesis | Select and extract information from a wide range of secondary sources and acknowledge them using an accepted referencing style. Systematically gathers, selects, organises and processes secondary sourced data and information to explain issues and inform problem-solving. | Select and extract information from a wide range of secondary sources and acknowledge them. Gathers and selects secondary sourced data and information to identify issues and participate in problem-solving. | Selects and extracts information from a limited range of secondary sources and vaguely acknowledges them. Uses secondary sourced data and information, and appropriate digital technologies, to assist in the problem-solving process. | Extracts information from secondary sources but no acknowledgement present. |
| Drawing links from resources | Analyses and evaluates primary and secondary data and information CH12-5 | Uses critical thinking skills to evaluate trends, patterns and relationships to draw an evidence-based scientific conclusion. The work is exceptionally well conceived, coherent, logical, original and lucid as well as professionally prepared. | Uses critical thinking skills to explain trends, patterns and relationships to draw scientific conclusions. The work is well conceived, coherent, logical and lucid as well as professionally prepared. | Explains trends, patterns or relationships to draw scientific conclusions. Evidence that the task is logical and coherent and professionally prepared. | Describes trends and concludes. The task is mostly logical, coherent and flowing. | Describes trends or patterns and/or draws some conclusions. |
| Presentation and quality of writing | Communicates scientific understanding using suitable language and terminology for a specific audience or purpose CH12-7 | Outstanding and original depth of understanding of the content and discipline is displayed. Clearly identified focus topic, linked to evidence-based concepts and additional readings presented using appropriate digital technologies. Superior organisation of concepts and key ideas. | Thorough and comprehensive understanding of the content. Clearly identified focus for discussion linked to evidence-based concepts and additional readings represented using appropriate digital technologies. Consistently strong organisation of concepts and key ideas. | Considers the topic and issues in the broader disciplinary context. Evidence of having understood key concepts; clearly identified the focus for discussion, using appropriate digital technologies. Strong organisation of concepts and key ideas. | Demonstrates understanding of content, with a focus for further discussion evident. Evidence that consideration has been given to organising concepts and key ideas. | Content is displayed but lacks organisation or links to the research |

Total: 30

1. This document references the [Chemistry Stage 6 Syllabus](http://educationstandards.nsw.edu.au/wps/portal/nesa/11-12/stage-6-learning-areas/stage-6-science/chemistry-2017) © 2019 [NSW Education Standards Authority (NESA)](http://syllabus.nesa.nsw.edu.au/copyright/) for and on behalf of the Crown in right of the State of New South Wales. [↑](#footnote-ref-1)