VCE Chemistry

Examples of learning activities specific to green chemistry principles

Seven green chemistry principles are nominated in the VCE Chemistry Study design to be taught across Units 1 to 4.

The table below provides examples of learning activities that illustrate these principles, focusing on those that are practical and hands-on, and that have been designed and tested by green chemistry curriculum researchers worldwide. While each activity is listed next to one green chemistry principle, all activities can be used to address multiple green chemistry principles.

*Table of example learning activities (with description and external links to teaching resources) relevant to a specific green chemistry principle.*

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| Green chemistry principle | Examples of learning activities |
| Atom economy | Students investigate the [atom economy of saponification](https://www.acs.org/content/dam/acsorg/greenchemistry/education/resources/cleaning-up-with-atom-economy.pdf), and how the green chemistry principle of atom economy influences decisions to make this process ‘greener’. |
| Catalysis | Students research and evaluate alternative catalysts for common chemistry reactions undertaken in the high school chemistry classroom. For example, in a controlled experiment, determine the ideal temperature and concentration conditions to demonstrate that [Vitamin C can be used as catalyst](https://www.beyondbenign.org/bbdocs/curriculum/high-school/Catalysts_and_Oxygen.docx) to speed up the decomposition of hydrogen peroxide. |
| Design for degradation | Students can make degradable biopolymers with different observable physical properties with [combinations of readily available citric acid, glycerol, and tapioca root starch.](http://csp.umn.edu/wp-content/uploads/2019/11/DyeingtoDegrade_HS.pdf) Students then investigate how ‘degradable’ the biopolymers are, using simple qualitative comparisons of degradation rates in aqueous solutions. Alternatively, [a dye can be added for quantitative assessment,](http://csp.umn.edu/wp-content/uploads/2019/11/DyeingtoDegrade_HS.pdf) where the polymer samples are observed to degrade in an aqueous sodium hydroxide solution, releasing the dye, and either ultraviolet–visible spectroscopy. Or smartphone colorimetry can be used to measure the resulting dye concentration.  Students take common biodegradable and non-biodegradable single-use plastics sold in supermarkets and deliberately degrade them (excess light stimulation, abrasion, soaked in solutions), and relate their increasing degradation to the structure and behaviour of the monomer of the polymer. |
| Design for energy efficiency | Students undertake the [extraction of essential oils (for example from lemons)](https://www.beyondbenign.org/bbdocs/curriculum/high-school/Essential_Oil_Extraction_Using_Liquid_CO2.docx) and compare the energy requirements using traditional techniques, steam distillation and using novel approaches such as pressurised liquid CO2. |
| Designing safer chemicals | Students can inquire about the ‘greenness’ of common reaction pathways, through a [reagent guide](https://reagents.acsgcipr.org/reagent-guides) maintained by the American Chemical Society Green Chemistry Institute. For a particular reaction (for example, oxidation of primary alcohols to form carboxylic acids) students can compare the greenness of historically used reagents (SeO2), traditional reagents (Cr6+, Mn7+), and novel reagents (H2O2 with metal catalyst, enzymes).  Students [make and test the effectiveness of less harmful and less toxic sparklers](https://doi.org/10.1515/cti-2020-0012), replacing the toxic barium nitrate with strontium nitrate as the oxidising agent.  Students use natural dyes (carrot tops, onion skins, different teas) to demonstrate how the [pH changes the colour formed when dyeing wool](https://www.beyondbenign.org/bbdocs/curriculum/high-school/Natural_Dye_Lab-Cogent_Industry_Example.zip) (which has both cationic and anionic sites). Metal ions can also be used as additives (mordants) to further change the intensity of the colours formed. As well as investigating acid-base chemistry, students can compare this experiment to industry innovations focused on reducing the use of heavy metals such as antimony in fabric production. |
| Prevention of waste | Students make edible, [biodegradable food-safe calcium alginate beads (edible water capsules)](https://www.degruyter.com/document/doi/10.1515/cti-2021-0027/html) and can investigate how varying the pH and concentration of the acidic beverage juices used impacts the stability and durability of the water capsules formed.  In investigating the relationship between reaction rate and the reagent concentration, students can investigate a [‘green’ version of a clock reaction](https://www.beyondbenign.org/bbdocs/curriculum/high-school/Greening_the_Clock_Reaction.docx) using starch solution, Vitamin C in solution, 3% hydrogen peroxide, tincture of iodine, and water. The effectiveness, and also the safety and waste considerations, of this version can be compared with the ‘Old Nassau’ clock reaction, which includes mercury(II) chloride, metabisulfite and iodate ions which are all moderately to highly toxic. |
| Use of renewable feedstocks | Students [make absorbable medical sutures from renewable feedstocks](https://csp.umn.edu/wp-content/uploads/2017/05/MedicalSutureExperiment-2.pdf), and compare their tensile strength and degradation with commercial other absorbable and non-absorbable sutures. |