UNIVERSITY OF LIMERICK
OLLSCOIL LUIMNIGH
School of Education

EPI·STEM
National Centre for STEM Education

A Green School Laboratory

A Mini Guidebook for Teacher's on Creating a Greener Laboratory

Introduction

This guide aims to provide chemistry teachers in Ireland with some fresh ideas and suggestions to support hands-on practical work for all students and at the same time take advantage of some new developments in micro-scale chemistry and related areas that might assist you in rethinking how you might best design your school laboratory spaces. How can you and your colleagues work toward achieving green and sustainable school labs that can help to integrate eco-friendly practices into science education. This booklet is not a comprehensive guide in how to do this, rather it is a starting point, giving you access to a number of websites that you may not be familiar with and helping to inspire you to new ways of organising your laboratory.

Please complete the evaluation on the back page and let us know if there is anything additional we in EP•ISTEM National Centre for STEM Education can do this summer to support you in this endeavour.

.

A Green School Laboratory

Microscale Chemistry

Katelyn O'Neill Research Assistant,
EPI•STEM National Centre for STEM Education,
School of Education, University of Limerick

Microscale Chemistry

Microscale chemistry involves performing experiments with very small quantities of chemicals.

Advantages of Microscale Chemistry

- ✓ **Lower costs –** Reduces spending on chemicals, glassware, and lab maintenance, making experiments more affordable.
- ✓ **Easier equipment setup –** Simple, compact apparatus that is quick to assemble and disassemble.
- ✓ **Less laboratory waste –** Reduces hazardous chemical disposal, minimising environmental impact.
- ✓ **Lower energy consumption –** Requires minimal heating, cooling, saving power and resources.
- ✓ **Improved safety –** Lower volumes of hazardous chemicals mean fewer risks of spills, toxic fumes, and exposure to hazardous materials.
- ✓ **Less cleaning required –** Disposable or easily cleaned materials reduce washing time and water usage.
- ✓ **Faster experiments –** Allowing multiple trials or variations within a single lesson.
- ✓ **Supports sustainability goals –** Aligns with green chemistry principles by reducing chemical waste and energy consumption.

Microscale Chemistry

Example Experiment on the Microscale

Effect of Concentration on Reaction Rate (Microscale Acid–Thiosulfate Reaction)

Summary

This experiment investigates how changing the concentration of sodium thiosulphate affects its reaction rate with hydrochloric acid.

Using microscale wells, students prepare different dilutions of sodium thiosulphate solution and mix each with hydrochloric acid. As sulphur precipitate forms, it gradually blocks the visibility of a printed "X" beneath the reaction well. Higher concentrations of sodium thiosulphate result in faster precipitation and a shorter reaction time. This method reduces chemical use, enables multiple trials in a single setup, and minimises sulphur dioxide exposure, while still providing clear, measurable results.

Apparatus Required

Comboplate, three glass drop bottles (with scale), laminated sheet with ‘X’ marked on it, wash bottle, stopwatch, graph paper, pencil, ruler.

Chemicals Required

Hydrochloric acid (2M), sodium thiosulphate solution (0.2M), water.

Set up:

Sodium thiosulphate solution (0.2M)

Comboplate

Printed X

Timer

Hydrochloric acid (2M)

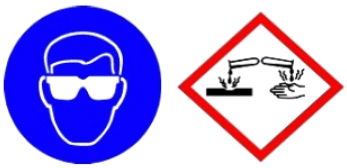
Washbotttle

Water

Example Experiment on the Microscale

Effect of Concentration on Reaction Rate (Microscale Acid–Thiosulfate Reaction)

Safety precautions



- Safety glasses should be worn at all times.
- Hydrochloric acid is corrosive.
- Do not inhale sulphur dioxide gas evolved in reaction

Step-by-Step Procedure

Well	Drops of sodium thiosulfate	Drops of water
A1	8	0
A2	7	1
A3	6	2
A4	5	3
A5	4	4
A6	3	5
A7	2	6
A8	1	7

1.Prepare dilution series: Using the dropper from the glass drop bottle, add 0.2 M sodium thiosulphate solution and distilled water into a row of wells (e.g. A1 through A6) to create different concentrations. For example, in well A1 put 8 drops of thiosulphate and 0 drops water; A2: 6 drops thiosulphate + 2 drops water; A3: 4 drops thiosulphate + 4 drops water, etc. (all wells should have the same total volume of drops). You can measure in drops or for more precision read the scale on the side of the glass dropper.

2. Position the X: Place a laminated white card marked with a black "X" underneath the plate, aligning the X under the first reaction well

3.Initiate reaction: To the first well (highest thiosulphate concentration), quickly add a fixed number of drops of 2 M hydrochloric acid (e.g. 1–2 drops, whatever volume has been predetermined to produce an opaque mixture) and simultaneously start a stopwatch

4.Gently stir: Gently stir the well (e.g. with a glass rod, metal stirrer) once to mix.

5. Observe and time: View the X from directly above the well. As the reaction proceeds, sulphur precipitate forms, turning the solution increasingly cloudy. Stop the timer the moment the black X is no longer visible when viewed from above. Record the time for that trial.

Example Experiment on the microscale

Effect of Concentration on Reaction Rate (Microscale Acid–Thiosulfate Reaction)

6. Repeat for other concentrations: Move the X card under the next well, add hydrochloric acid and time the disappearance again. Continue for all wells A1–A6 (rinsing or using a new dropper for the acid each time). Ensure consistent procedure for each trial (same person observing, same lighting).

7.Results: Note the trend. Plot a graph of sodium thiosulphate concentration (or drops) vs. reaction time to visualise the relationship.

8.Cleanup: Rinse the comboplate using a washbottle. Clean and dry the plate for future use.

Procedure adapted from CLEAPSS PP041 - The thiosulfate-acid reaction: rate and concentration

Benefits of Micoscale in this Experiment

Less Chemicals, Lower Cost, Less Waste – Microscale requires only tiny amounts of sodium thiosulphate and hydrochloric acid, reducing chemical consumption and hazardous waste disposal. This makes the experiment more cost-effective and environmentally sustainable

Minimal Fumes - Traditional thiosulphate rate experiments use large volumes that release noticeable sulphur dioxide. Microscale uses just drops of solution, dramatically reducing SO_2 vapours (improving safety and odour issues).

Easy Setup & Cleanup- Instead of multiple flasks or beakers, the reaction series is done in a single comboplate with tiny wells. No large glassware to wash – a quick rinse of the comboplate.

Parallel Tests- Multiple concentrations can be prepared side by side in the plate's wells. This allows students to run a series of reactions quickly, one after another (or even simultaneously in groups), making it easier to compare results within one lab class.

Microscale Chemistry

Resources: More Microscale Experiments

RSC (The Royal Society of Chemistry) is another invaluable resource for schools and teachers looking to implement microscale chemistry in their laboratories.

Their comprehensive collection of teaching materials, safety sheets, and step-by-step experimental procedures supports safer, more cost-effective, and sustainable science education.

The RSC's extensive library includes Leaving Certificate chemistry experiments such as the preparation of ethyne, redox reactions, reactions of metals, titrations, and other core practicals, all adapted to microscale

To access RSC resources, schools and teachers can visit the RSC website, where they can sign up for membership for free.

By using RSC microscale chemistry materials, schools ensure high-quality, low-waste laboratories.

RSC Microscale Chemistry Laboratories

Website: https://edu.rsc.org/resources/collections/microscale-chemistry

Microscale Chemistry

Resources: More Microscale Experiments

CLEAPSS (Consortium of Local Education Authorities for the Provision of Science Services) is an invaluable resource for schools and teachers implementing microscale chemistry.

Their extensive library of guides, safety sheets, teaching materials and experimental procedures includes Leaving Certificate chemistry experiments such as the titration of vinegar, making soap, and various green chemistry adaptations.

To access CLEAPSS resources, schools and teachers should register for membership for by contacting membership@cleapss.org.uk or registering directly through their website.

Membership provides ongoing support, ensuring schools have the latest safety guidelines and best practices for sustainable, cost-effective laboratories.

CLEAPSS Microscale Chemistry Laboratories

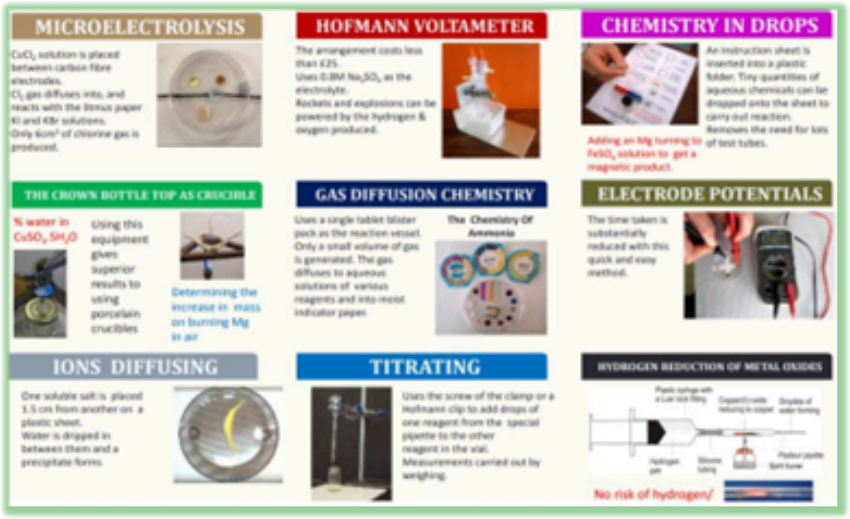
Website: https://science.cleapss.org.uk/resources/resource-search.aspx?search=microscale

Microscale Chemistry

Resources: More Microscale Experiments

Irish Science Teachers' Association
Eol Oidí na hÉireann

The Microscale Chemistry Presentation, created by David O'Connell for the Irish Science Teachers Association Summer Schools 2020, provides a comprehensive collection of microscale practical experiments specifically tailored to the Leaving Cert Chemistry curriculum. The experiments have been abstracted and adapted from the CLEAPSS website, offering teachers a valuable resource to incorporate microscale chemistry in the laboratory



ISTA Microscale Chemistry Presentation

Website: https://www.ista.ie/wp-content/uploads/2020/10/Microscale-Chemistry-David-OConnell.pdf

Microscale Chemistry

Investing in a Greener Laboratory: Saving money

Microscale chemistry laboratories, which require only drops of chemicals rather than large volumes, schools can significantly reduce chemical consumption and waste, making laboratory practices more cost-effective and environmentally sustainable.

The initial investment in microscale equipment is relatively low and quickly offsets costs through long-term savings on chemical purchases. Once a microscale laboratory is established, funding can be redirected toward enhancing other areas of science education rather than being spent on large quantities of chemicals.

Microscale Chemistry Equipment

Comboplate (Micro Well Plate) (~€100-150 per 20-pack)

- Ideal for titrations, reaction rates, redox, gas collection

Pipettes (~€5-15 per 100-pack)

- For precise liquid transfer & drop-based titrations

Syringes (1-5 mL) (~€10-30 per set)

- Alternative to burettes for safer microscale titrations

Gas Collection Vials (5-10 mL) (~€5-15 per set)

- Used for collecting gas (e.g., ethyne) in small reactions

Micro Measuring Cylinders (1-10 mL) (~€10-20 per set)

- Accurate for preparing microscale solutions

Dropper Bottles (30-50 mL, Amber) (~€10-30 per set of 10)

- Stores and dispenses reagents safely.
- Amber bottles protect light-sensitive solutions (bromine, chlorine, iodine)

Microscale Chemistry

Microscale Chemistry Equipment

.Micro Funnels (2-5 cm) (~€5-15 per set)

- For transferring tiny volumes into vials.

Microfilter Paper & Holders (~€5-15 per pack)

- For microscale filtration of precipitates.

Micro Spatulas & Scoops (~€5-15 per set)

- For transferring very small amounts of powders.

Plastic Gas Collection Tubing & Connectors (~€10-25 per set)

- For gas-generating reactions (ethyne, oxygen, CO_2).

Digital Scale (0.01 g Precision) (~€20-50 each)

- For measuring tiny reagent quantities in microscale experiments

Hot Plates (~€20-50 each)

- Sustainable alternative to bunsen burners.

Pocket-Sized Digital pH Meters (~€20-40 each)

- Reusable alternative to pH paper, for acid-base reactions.

Mini Spectrophotometer (~€150-500 each)

- For advanced chemistry labs for microscale colorimetric analysis.

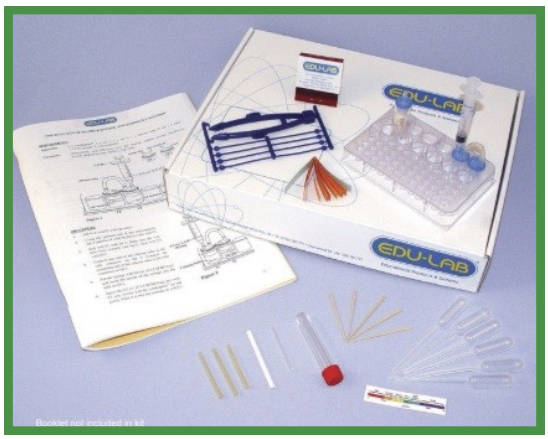
(Example) Websites to Purchase Microscale Chemistry Equipment:

- Lennox Educational (Ireland) https://www.lennoxeducational.ie
- Edulab https://www.edulab.com
- Fisher Scientific https://www.fishersci.com
- SLS Science https://www.science2education.co.uk

Microscale Chemistry

Microscale Chemistry Kits

MicroChem Basic Kit S-310-003 €55



Chemistry topics that may be covered with this kit include:

- Chemical Equilibrium
- Acid Base Chemistry
- Rates of Reaction
- Stoichiometry
- Reactions of Metals & Their Salt Solutions
- Enthalpy Changes
- Reactivity of Group 7 Elements
- Industrial Pollution
- Diffusion
- Solubility of Sulphates in Water
- Diffusion

MicroChem Basic Kit S-310-003

Website: https://www.lennoxeducational.ie/Chemistry/593-MicroChem-Basic-Kit.html

Microscale Chemistry

Microscale Chemistry Kits

MicroChem Advanced Kit S-310-004 €75

The Advanced MicroChem Kit provides all the equipment to perform the experiments incorporated in the Microchem Basic Kit S S-310-003, and in addition the following chemistry topics areas may be explored:

- Reduction of Copper Oxide
- The Zinc/Copper Cell
- Compounds, Elements, Pure Substances & Mixtures
- Conductivity and pH of Solutions of Acids and Bases
- Preparation of Oxygen, Carbon Dioxide and Hydrogen
- Preparation of Iron (III) Chloride
- Preparation of Iron (II) Chloride
- Organic Chemistry: Saturated and Unsaturated Hydrocarbons
- Extraction & Purification of Gold from its Ore (analogy using Cu)
- The Reaction of a Sulphate with Oxygen
- The Reaction of a Metal with Oxygen

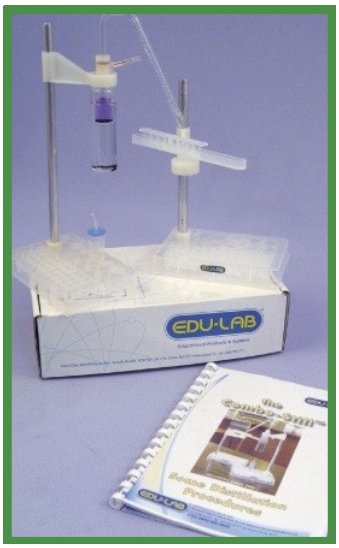
MicroChem Advanced Kit S-310-004

Website: https://www.lennoxeducational.ie/Chemistry/595-MicroChem-Advanced-Kit.html

Microscale Chemistry

Microscale Chemistry Kits

MicroChem Combostill Kit S-310-009 €146



The Combostill Kit is designed to replace expensive organic chemistry apparatus. Microscale chemistry apparatus provides many significant advantages over traditional organic chemistry methods. Most activities can be set up and conducted in roughly a third of the time of while the smaller volumes of chemicals required mean a huge cost savings and a much safer laboratory environment.

Moreover, the cost, safety and simplicity of microscale chemistry methods makes it much easier to implement teaching where smaller groups if students or even individuals can conduct their own experiments, resulting in much better learning outcomes.

MicroChem Combostill Kit S-310-009

Website: https://www.lennoxeducational.ie/Chemistry/594-MicroChem-Combostill.html

Microscale Chemistry

Resources: Learning More About Microscale Chemistry

Designing Small-Scale Chemistry for General Chemistry Practical Work

This study explores the development and implementation of small-scale chemistry (SSC) as an alternative to traditional laboratory practices. The research follows an ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) to create laboratory manuals and practical kits that minimise chemical usage, waste production, and cost while maintaining experiment accuracy. The results of the study demonstrates that SSC enhances laboratory safety, student engagement, and sustainability, making it an effective approach for modern chemistry education.

Read Study

Website:https://www.researchgate.net/publication/366741919_Designing_Small-scale_Chemistry_for_General_Chemistry_Practical_Work_Course_

A Green School Laboratory

Laboratory Design
General Lab Sustainability
Lesson Ideas
Fun Chemistry ICT

Anthony Sweeney Research Assistant & PhD student,
EPI•STEM National Centre for STEM Education,
School of Education, University of Limerick

Investing in Improved Laboratory Design

A thoughtfully designed school laboratory provides an interactive space where students can engage in science in a way that fosters critical thinking, problem-solving, and collaboration.

As a learning environment, a laboratory layout should facilitate teamwork, allowing students to work together in groups, share ideas, and tackle challenges from different perspectives. This collaborative approach mirrors real-life scientific practices, where teamwork and diverse viewpoints are essential to developing creative solutions.

At the same time, a school laboratory's design must prioritise safety and accessibility, ensuring that all students can interact with the material in a secure and inclusive manner. The space should accommodate various learning needs and be equipped with proper safety features.

Ideas for a interactive laboratory layout:

Laboratory Design

Investing in Improved Laboratory Design

The Association for Science Education provides valuable guidance and best-practice recommendations on designing laboratory spaces that support effective, safe, and sustainable science teaching. They emphasise creating environments that enhance hands-on learning

The Association for Science Education

Website: https://www.ase.org.uk/ase-resource-hub

Improving Practices

General Lab Sustainability Practices

my green lab.

My Green Lab is a leading nonprofit organization based in San Diego, California, committed to promoting sustainability in scientific research and education. Their "How to Green Your Lab" guide provides chemistry teachers with practical strategies for making their classrooms and labs more environmentally sustainable. Through this resource, educators can learn how to reduce waste, conserve energy, and minimise the environmental impact of lab activities. The guide offers actionable tips on sourcing greener materials, adopting eco-friendly practices, and engaging students in sustainability efforts. By incorporating these strategies, teachers can reduce their lab's carbon footprint while educating students about the crucial role sustainability plays in scientific research and daily life. This resource is invaluable for chemistry teachers looking to foster environmental responsibility in their teaching.

My Green Lab

Website: https://www.mygreenlab.org/?gad_source=1&gclid=CjoKCQjwy46_BhDOARIsAIvmcwNzKI93H8n4Oq9wZtLoty_hcJGxiFBjc3y8Sa6ugIDHdetloqpiNhoaAmpeEALw_wcB

Lesson Ideas

Lesson Ideas to Incorperate Sustainability

Example Activity

Make Your Own Eco-Friendly Cleaning Products

The *Making Your Own Cleaning Products* guide offers chemistry teachers a practical way to introduce sustainable practices and chemistry concepts in the classroom. This resource provides step-by-step instructions for creating eco-friendly cleaning products using simple, non-toxic ingredients. Chemistry teachers can use this activity to explore key topics such as chemical reactions, pH levels, and the science behind common cleaning agents, while engaging students in discussions about sustainability, waste reduction, and the environmental impact of chemicals. It's an excellent hands-on project that not only fosters environmental responsibility but also deepens students' understanding of the chemistry behind everyday products and empowers them to make eco-conscious choices at school and at home.

Eco Cleaning Product Activity

Lesson Ideas

Lesson Ideas to Incorperate Sustainability

The *Green Schools Ireland* Resources website offers a comprehensive collection of materials to help educators incorporate sustainability into their classrooms. Green Schools Ireland, an initiative by An Taisce, is dedicated to promoting environmental education and sustainability in schools across Ireland. The site provides a range of lesson plans, activity guides, and teaching resources focused on key environmental topics such as waste management, energy conservation, water conservation, and biodiversity. These resources are designed to engage students in hands-on learning and promote environmental awareness.

The site is an invaluable tool for integrating real-world environmental issues into the curriculum. The resources allow chemistry educators to explore sustainable practices, such as green chemistry, renewable energy, and waste reduction, all through practical, student-centered activities. By using these materials, chemistry teachers can demonstrate how scientific concepts relate to pressing global challenges, inspiring students to take an active role in finding solutions. The Green Schools programme also supports schools in adopting initiatives that promote environmental responsibility, helping teachers create a lasting impact in their classrooms and beyond

Green Schools Ireland Resources

Website:https://greenschoolsireland.org/resources/

Chemistry ICT

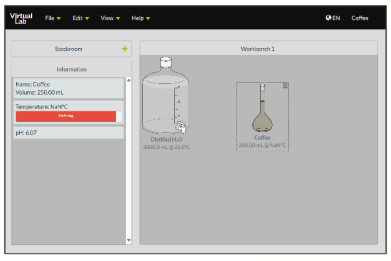
Fun Interactive Chemistry Tools

ChemCollective

As a project in the *National Science Digital Library (NSDL)* provided by the Carnegie Mellon University USA, the *ChemCollective's* goals are to support a community of instructors interested in improving chemistry education through interactive and engaging online activities. *ChemCollective* provides online virtual labs where students can conduct experiments using standard aqueous reagents in a safe, interactive environment. The platform simulates real-world lab processes, allowing students to mix chemicals, adjust concentrations, and explore reactions just like in a physical lab, but without the risks or costs associated with traditional experiments.

Key Benefits:

- **Zero-Waste & Eco-Friendly:** Virtual labs eliminate the need for chemicals, glassware, and other materials, reducing waste and environmental impact.
- **Accessibility:** Students with disabilities or mobility challenges can fully participate, making it an inclusive tool for all learners.
- **Engagement:** Interactive, hands-on experiences cater to both visual and kinesthetic learners, enhancing understanding of complex concepts.
- **Critical Thinking:** Encourages students to make decisions, adjust variables, and analyse results, fostering problem-solving and scientific inquiry skills.
- **Time & Resource Saving:** Teachers save time on setup, cleanup, and resource management. Immediate feedback is provided for assessment.



Website: https://chemcollective.org/vlabs

Chemcollective Virtual Labs

Chemistry ICT

Fun Interactive Chemistry Tools

Ptable

Ptable is free web application, created by Micheal Dayah, from Knoxville Tennessee, it provides a highly interactive periodic table that allows students to interact with elements to discover information like atomic number, mass, electron configuration and more. Perfect for exploring elements and their properties.

The **Compounds** tab allows students to visualise and understand how elements combine to form compounds. This tool shows common compounds for each element, their chemical formulas, and bonding information, making it easier to teach concepts like chemical bonding, molecular structure, and stoichiometry.

Student can view electron configurations and oxidation states of elements, helping to visualize how electrons are arranged in atoms and what oxidation states elements can adopt in chemical reactions

Ptable

Website:https://ptable.com/?lang=en#Properties

Message to Teachers

Thank you for taking the time to explore this booklet. We hope that the ideas and resources presented here have inspired you to consider new ways of incorporating micro-scale chemistry and sustainable practices into your laboratory teaching.

Website: https://epistem.ie/research/research-projects-2/

Instagram: @epi_stem

Podcast:
https://open.spotify.com/show/3jkEuPWlS32Wg1iz55F6fh?si=b7ab0620cf03412f

Stay connected with EPI·STEM to keep up to date with insights, resources, and updates in STEM education and sustainability research.

Evaluation Survey

Please scan the QR code below to let us know if you find this guide to a greener and more sustainable school laboratory useful.

What else might we do to better support you in this regard?

Thank you in advance for your cooperation in completing this evaluation.