



# Chemistry

## In Action!

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**A sign of the future - zero emission vehicles**

# Contents

1. Contents
2. Editorial #117
3. In this issue
4. Education News and Views
7. RSC Ireland Update John O'Donoghue
8. Chemistry Outreach in a Virtual World at TCD John O'Donoghue
9. Report from the Chemistry Olympiad Ireland
12. Proceedings ChemEd-Ireland 2020
13. Laying down the foundation: teaching the chemical basics Peter E. Childs
32. Using microscale apparatus for teaching LC Chemistry practicals David O'Connell
34. The rationale for implementing 'blended learning' in science teaching Ryan Gallagher
38. Chemists you should know No. 8:  
Professor Eva Maria Philbin (4/1/1914 – 24/6/2005) Adrian J. Ryder
43. Teaching Chemistry as a Story John Leisten
47. Electric vehicles – are they all they're hyped up to be?
49. Chemical Myths Exploded! #2 Acids and bases
53. The Colourful World of Gemstones: Part 2 Adrian J. Ryder
59. Research Matters: learning from science education research:  
#1 Conceptual Change Model (CCM)
62. Oxalic acid (ethanedioic acid)  $\text{H}_2\text{C}_2\text{O}_4$
64. Chemlingo: More on metal poisoning Peter E. Childs
65. Elementary Chemistry
66. Information Page

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Contributions on any matter of interest to second-level chemistry teachers are welcome. Normally the results of research (chemical or educational) are **not** published, except in a general form or as a review. Articles should be submitted electronically (email) to [peter.childs@ul.ie](mailto:peter.childs@ul.ie) or to one of the assistant editors.

**For subscription details etc. see inside back cover.**

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# Editorial #117

## A year like no other

It's now just over a year since covid struck and the country, and much of education shut down and switched to online learning. It has transformed the educational landscape at all levels, upended the exam system at school and affected LC grading system and third level entry. This year the JCSA exams are cancelled again and the LC assessment is a mixture of teacher grading and exam-based – students can choose which suits them best. The present 6<sup>th</sup> year students have had their education severely disrupted as both their LC years have been affected. It is too soon to say what long-term effect this will have on their further education and careers, as third level education has also been curtailed.

Many jobs have been lost and businesses closed, especially in the retail, tourism and leisure sectors. The high-tech jobs in IT and pharmaceuticals appear to have been largely unaffected, and still present good job opportunities for graduates.

As if a worldwide pandemic wasn't enough stress, since January we have also faced the challenges of Brexit, and its impact on the export and import of goods. There has already been a major drop in traffic of goods from and through the UK. The UK has left the EU and one consequence has been its exit from the Erasmus+ programme, except for NI. Ireland will benefit in many ways, as the only English-speaking EU member, in terms of student and staff exchange, participation in EU projects etc. We have already punched above our weight in leading and participating in EU projects, including many in science education. Although the UK will still participate in such programmes in future, I would expect to see its influence wane, and Ireland will probably become an even more popular choice as a partner country.

## Third level changes underway

As well as the effects of covid and Brexit on Ireland's economy, we have also seen changes in the landscape of higher education. The merger of the Institutes of Technology to form Technological Universities is continuing and will inevitably change the third level landscape in

Ireland. This is similar to the UK rebadging polytechnics as universities in the 1990s.

As of 2021, there is currently two designated technological universities, and three consortia engaged with the process to become designated as technological universities:

- **Technological University Dublin**, designated January 2019.
- **Munster Technological University (MTU)**, to be designated January 2021.
- **Technological University for the South-East Ireland (TUSEI)**, consisting of Waterford Institute of Technology and Institute of Technology Carlow.
- **Connacht Ulster Alliance (CUA)**, consisting of Galway-Mayo Institute of Technology, Institute of Technology Sligo, and Letterkenny Institute of Technology.
- **Athlone IT and Limerick IT consortium**, consisting of Athlone Institute of Technology and Limerick Institute of Technology. (Approved in May.)

It will raise their status internationally, as 'University' is more widely understood than the term 'Institute of Technology', and it should help in student recruitment and raising external funds. It will not solve the existing problem of mission creep, as IoTs seek to imitate the universities rather than fulfil their initial mandate of technical education, nor will it solve the existing problem of duplication of courses.

*A Technological University will be distinguished by a mission and ethos that is aligned and consistent with the current mission and focus of institutes of technology with an emphasis on programmes at levels 6 to 8 and industry-focused research.*

[Technological Universities | Policy | Higher Education Authority \(hea.ie\)](#)

Only time will tell if this statement from the HEA will be fulfilled.

*Peter G. Childs*

**Hon. Editor**



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# In this issue: #117

## Proceedings ChemEd-Ireland

The main focus of the Spring issue of *Chemistry in Action!* has, for many years, been the Proceedings of ChemEd-Ireland, held the previous October.

This depends, of course, on the cooperation of the organisers and speakers in being willing to prepare written versions of their talks. A ppt presentation and a written lecture are two very different things, as I know from experience. The reason why we had no Proceedings of ChemEd-Ireland 2019, held in TU Dublin, was not due to covid-19, as far as I know, but the fact that I didn't manage to get back any articles from the speakers. We have now had another ChemEd-Ireland, held in October 2020 in Cork, a very successful on-line conference, with the biggest attendance ever. I have only been able to get three of the talks back in time from this conference for this issue, though this is infinitely better than 2019.

The reason for publishing a Proceedings of the ChemEd-Ireland conferences is mainly to have a permanent, archival record of the conference, but also to widen its availability beyond the teachers who were able to attend, and thus reach more teachers, increasing the impact of the conferences.

In the first few years, when the conferences were held in Thomond College of Education, before its merger into the University of Limerick in 1991, a separate Proceedings book was produced. However, this was expensive and didn't fulfil the second purpose of making it widely available. I thus decided to start publishing the Proceedings in the Spring issue, which has continued successfully to this day.

I was responsible for the first talk at the 2020 on the 'Basis of Chemistry, emphasising the importance of laying a good foundation of the basic ideas of chemistry, right at the start in junior science. (p. 13) The other two talks that are included in this issue are from two of Declan's ex-students: David O'Connell on 'Microscale chemistry' (p. 32) and Ryan Gallagher on 'The rationale for implementing 'Blended learning' into modern day science teaching', a talk based on his PhD work p. 34.)

Earlier in my career I taught chemistry in Makerere University, Kampala, Uganda (1970-76). While there I met Professor John Leisten, who set up an innovative chemistry degree at the new University of Malawi in the late 1960s. Since his retirement to Australia, he has continued his interest in chemical education by devising approaches to introduce chemistry in primary schools. I came across an interesting article he had written on the internet, on 'Teaching chemistry as a story', and managed to get back in touch with him, and his article fits in well with my own article. Professor Leisten has used this approach very successfully at primary level, but his ideas will, I think, be helpful to teachers teaching chemistry in junior science (see p. 45.)

Continuing Adrian Ryder's series on Chemists You Should Know, in this issue he features Professor Eva Philbin (p. 38) one of Ireland's own famous chemists. There is also part two of his fascinating article on Gemstones (p. 53). Adrian Ryder has written a book on gemstones which can be accessed at:

<http://evanryder.com/downloads/practical-gemmology.pdf>

Also in this issue we look at some mythconceptions(!) about acids and bases (p. 49), the challenge of switching to electric vehicles (p. 47), and a new series on chemical/science education research and its value to the teacher (p. 59). You can also find out about oxalic (ethanedioic) acid, the most common dicarboxylic acid (p. 62), as well as more on the language of metal poisoning (p. 64).

If you have ideas for articles or questions to be answered, please send them to the Editor. Even better if you can send in an article relating to the teaching of chemistry at junior or senior level. I am interested in the impact that the new junior science course has had on teaching LC chemistry, although this transition has been affected by covid.

***"The important thing in science is not so much to obtain new facts as to discover new ways of thinking about them."***

**William Lawrence Bragg**

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# Education News and Views

The Editor welcomes contributions and news of interest to chemistry teachers in this section.

## The glass ceiling shattered

Until 2020 no Irish university had a woman President. In 2020 Professor Kersten Mey took over as interim President at the University of Limerick. Since then three more universities have appointed women Presidents, no doubt a precedent for the future. In December 2020 Professor Maggie Cusack was appointed the first President of the new Munster Technological University. In March 2021 Professor Eeva Leinonen was appointed President of Maynooth University and finally in April 2021, Professor Linda Doyle was appointed Provost of Trinity College, Dublin (from a short list of three women).

\*\*\*\*\*

## New technological universities

The merger of Institutes of Technology into Technological Universities is gathering pace.



First off the block was TU Dublin, a merger of Dublin Institute of Technology, IT Tallaght and IT Blanchardstown, in January 2019.



This was followed by the Munster Technological University in January 2021, a merger of Cork IT and IT Tralee. Expected later in 2021 is a merger of Athlone IT and Limerick IT (announced in early May.) On the drawing board is a merger of Galway-Mayo IT, Letterkenny IT and Sligo IT in a Connacht-Ulster alliance, and in the South-East a merger of Waterford IT and Carlow IT. These new institutions will change the educational landscape, providing courses from apprenticeships to PhDs. This change is

analogous to the rebranding of Polytechnics in the UK as universities in 1992. It will definitely change the educational landscape in Ireland.

\*\*\*\*\*

## 40<sup>th</sup> ChemEd-Ireland

The 40<sup>th</sup> ChemEd-Ireland is scheduled for October 16<sup>th</sup>, hosted by DCU. The main organiser is James Lovatt and it may be online or blended, a mix of online and face-to-face.

### Calling all Chemistry Teachers!

Do you have a favourite chemistry idea, experiment or activity? Do you have an interesting approach to support students with difficult concepts in chemistry? We would love to hear all ideas no matter how big or small! If you are interested in sharing these at *ChemEd-Ireland 2021* please complete the [following form](#) - or simply email [James.lovatt@dcu.ie](mailto:James.lovatt@dcu.ie) to discuss before **June 21st!**

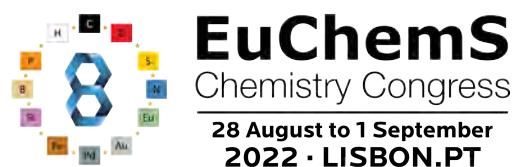
For more information on ChemEd-Ireland 2021 please visit our website:

<https://castel.ie/chemed-ireland2021/>

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## European conference for Dublin

The Institute of Chemistry of Ireland was due to host the prestigious European Chemistry Congress (ECC) in 2022. But due to Covid this has now been postponed to 2024. This conference is sponsored by EuChemS, the European Chemical Society. The 2022 ECC will be held in Lisbon, Portugal, postponed from 2020.



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## 60<sup>th</sup> ISTA conference

The 59<sup>th</sup> ISTA conference was held by Zoom on March and was a great success. The 60<sup>th</sup> conference is scheduled to be held in Cork on April 8-9 2022, and it is hoped that it will post-covid and face-to-face.

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## Michael Seery steps down

In 2020 Dr Michael Seery (ex DIT) was inaugurated as Professor of Chemical Education at the University of Edinburgh in Feb. 2020. You can watch his augural lecture here: [Michael Seery Inaugural Lecture - YouTube](#)

He has a popular chemistry education blog ([michaelseery.com](http://michaelseery.com)). In 2019 he took over from Keith Taber as the editor of *Chemistry Education Research and Practice*, the free, electronic chemical education journal plbished by the RSC. CERP is now one of the top chemical education journals in the world. He announced in Sept. 2020 that he is stepping down as Editor of CERP ([Passing on the Editor's pen at CERP – Michael Seery](#)) and handing over to Professor Gwen Laurie.

\*\*\*\*\*

## Pioneers of Science Education

This is an ongoing series of articles in the ISTAs *Science* magazine. The last three people featured were:

- #10 Alec Johnstone (56(1), 2020)
- #11 Justus von Liebig (56(2), 2021)
- #12 John Tyndall (56(3), 2021)

The series can also be found on [www.cheminaction.com](http://www.cheminaction.com).

\*\*\*\*\*

## PISA 2021 Postponed

PISA 2021 was due this year but has been postponed to 2022 and PISA 2024 to 2025. PISA 2022 will focus on matematics and PISA 2025 will focus on science, and include an assessment of foreign languages and on Learning in the Digital World.

\*\*\*\*\*

## Redressing gender imbalance in STEM



[review-of-literature-to-identify-a-set-of-effective-interventions-for-addressing-gender-balance-in-stem.pdf \(education.ie\)](#)

This report was launched by Minister Norma Foley in Nov. 2020. The recommendations for action are given below.

### 11. Towards Action

*Based on the findings of this systematic review, we propose that a worthwhile purpose for the STEM education enterprise is to develop STEM capital through formal and informal education. This in turn requires developing, strengthening, and organising the entire STEM ecosystem. The STEM ecosystem operates at the interconnected levels of learner, family, school, and society. Our analysis of the literature on effective interventions was largely silent on societal level interventions, even though contextual factors related to “society, legislation and policies” were mentioned in one-third (40/122) of the intervention studies we identified. However, it may be useful to consider the recommendations of the US National Academies (2020) report, which placed significant emphasis on policy change in formulating the following recommendations:*

- 1. Drive transparency and accountability: Articulate, monitor, and deliver on measurable goals and benchmarks.*
- 2. Adapt data-driven approaches to address underrepresentation of women: Disaggregate data on barriers by discipline and level of education and recognise that interventions may need to be contextualised to discipline and specific target groups.*
- 3. Reward, recognise, and resource equity, diversity, and inclusion efforts: Offer positive incentives that promote cultural change.*

4. Fill knowledge gaps: Although scholarly research has yielded abundant information on causes of gender disparities, critical knowledge gaps remain and require close attention (e.g., understanding strategies and practices that are demonstrably effective).

Following on from this systematic review, decisions about prioritising a response might identify intervention points for maximum effect while customising the response to the Irish context. For example, attention could be given to points where students make subject choices, such as in choosing (or not) to study science in Junior Cycle. The introduction of new subjects, such as Leaving Certificate Computer Science, offers a test bed for investigating and addressing gendered patterns of student engagement. Curricular structures, such as the Transition Year in post-primary education, can also open up opportunities to broaden all students' STEM experiences at school and in extra-curricular programmes, away from a high-stakes assessment environment. While the longer-term goal of building STEM capital needs to be kept in view, short term initiatives that contribute to this goal can be pursued at the same time.

With this "parallel processing" approach in mind, our systematic review points to the value of targeting two key phases in a young person's educational life:

- Early childhood: to build strong foundations and engage parents in learning at home and at school;
- Early adolescence: to avert disengagement, influence subject choices, and take advantage of a low-stakes assessment environment as an opportunity for broadening students' STEM experiences at school and in informal learning.

Further research is also needed to conceptualise STEM capital and evaluate its development, if this is to be used as a measure of the quality and coherence of Ireland's STEM ecosystem.

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## Women in STEM Ireland

A report from [www.stemwomen.co.uk](http://www.stemwomen.co.uk) on women in STEM in Ireland.

[Women in STEM Ireland: Statistics and Key Findings - STEM Women](#)

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## Microchemistry conference

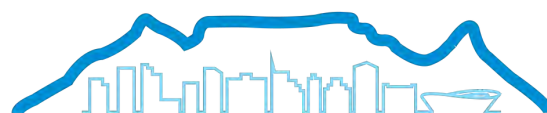


### The Puddle Logo Design by Isobel Everest The 11th International Symposium on Microscale Chemistry The Contribution of Microscale Chemistry to Education

Bob Worley is organising the 11<sup>th</sup> International Symposium on Microscale Chemistry online in July 13<sup>th</sup> and 14<sup>th</sup>. Details are on the website below. There is a small charge but it should be well worth signing up.

[Home \(weebly.com\)](http://Home.weebly.com)

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ICCE 2022 Cape Town, South Africa 18-22 July 2022  
[www.ICCE2022.org.za](http://www.ICCE2022.org.za)

## ICCE 2022

The International Conference on Chemical Education was originally scheduled for 2020, then 2021 and now 2022! It will now be held, covid permitting, in Cape Town, S. Africa, 18-22 July 2022. Hopefully by then enough people will be vaccinated and infections will be down so that face-to-face conferences can resume.

[ICCE 2022](#)

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## 9<sup>th</sup> Eurovariety conference

This biennial conference will be held online from 7 - 9 July 2021 in Ljubljana, Slovenia.

The conference, run under the auspices of the EuCheMS Division of Chemical Education, is a European counterpart of the UK conference "Variety in Chemistry Education" and is devoted to practical aspects of chemical education at tertiary level (general and vocational higher education institutions, HEIs), at both undergraduate and postgraduate levels. The conference brings together chemistry lecturers and educational professionals to improve understanding of chemistry teaching and learning.

[Eurovariety 2021](#)



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## 27<sup>th</sup> BCCE 2022

This conference has been postponed to 2022 at Purdue University, summer 2022, dates to be announced.

[www.bcce2022.org](http://www.bcce2022.org)

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## State of the Art in STEM

I came across an interesting article describing the current state of STEM education in Ireland, part of a European Erasmus+ project. The Steaming Project focusing on the promotion of STEAM education in Primary Schools in Clare. Some more information on the project can be found at <https://steamingproject.eu/>. The Irish partners on the project are Clare Education Centre and the STEM Department in Mary Immaculate College. Leavy, A.M., O'Dwyer, A., Hourigan, M., and Corry, E. (2020). *State of the Art Report: Ireland*.

<https://steamingproject.eu/resoures/11-state-of-the-art-reports.html>

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## Gordon Research Conference on Chemistry Education Research and Practice postponed

The conference on Coordinating the Production and Consumption of Knowledge on Chemistry Teaching and Learning has been postponed from July 2021 to 2023. The CERP Research Seminar on *Research Contexts, Questions and Methodologies Across Chemistry Teaching and Learning Contexts* to be held in conjunction with the conference, has also been postponed to 2023.

[2021 Chemistry Education Research and Practice Conference GRC](#)

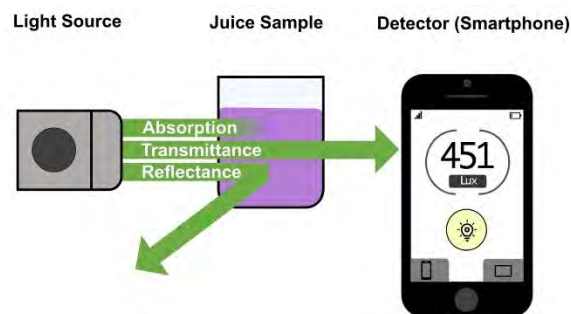
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## RSC Ireland Update:

John O'Donoghue

[John.ODonoghue@tcd.ie](mailto:John.ODonoghue@tcd.ie)

The RSC took a 'virtual first' approach to the 2020/21 academic year, developing a programme of online workshops and events for secondary teachers and other RSC members. The teacher professional development sessions were based on data insights gathered from numerous surveys carried out with teachers in the UK & Ireland. They also incorporated a rigorous Quality Assurance (QA) process, which incorporated national and international recommendations for teacher professional development standards. The sessions ran for the entire academic year every Tuesday and Thursday with each one lasting about 45 to 60 minutes. The Irish Chemistry Education Coordinator, John O'Donoghue, developed and delivered a year-long programme called "Smartphone Spectroscopy", which was designed to help teachers run hands-on investigations with their students in a lab, classroom or remotely at-home.



Smartphone Spectroscopy was hugely successful with live online sessions running 3 times during the year for teachers, accompanying a very popular Youtube Video that was published through the RSC's Youtube Channel in May 2020. This video has since amassed over 7,500 views, making it one of the most popular on the RSC's channel. Articles and resources to help teachers adapt the Smartphone Spectroscopy activity for older age groups, like TY and Leaving Cert, were also published through the RSC's *Education in Chemistry* magazine both online and in print. Thousands of teachers from all over the



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world attended the RSC's online workshops this year, with over 200 teachers specifically attending the live Smartphone Spectroscopy sessions.

Youtube Video link:

[https://www.youtube.com/watch?v=0954J\\_5NI88](https://www.youtube.com/watch?v=0954J_5NI88)

Education in Chemistry Link:

<https://edu.rsc.org/ideas/back-to-basics-with-spectrophotometry/4012965.article>

In addition to self-hosting workshops for teachers, the RSC Ireland team also provided live and recorded video content for various national events during the year. These included the teachmeet section of the Féilte conference run by the Teaching Council virtually on the 3<sup>rd</sup> of October, the ChemEd-Ireland conference hosted online by UCC on the 17<sup>th</sup> of October, the virtual BT Young Scientist in January 2021 and the Irish Science Teachers Association (ISTA) online Conference on the 27<sup>th</sup> of March.



The RSC also launched a new Primary Science website this year called Steps into Science. It brings together all the RSC's free primary resources into a single location, making it significantly easier for primary teachers to search through them and find what they need. It is divided into different age groups and themes, and also promotes some well-known Irish science centres like Lifetime Lab, the Rediscovery Centre and Birr Castle. The new website can be located here: <https://edu.rsc.org/primary-science>

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## Chemistry Outreach in a Virtual World at TCD

John O'Donoghue

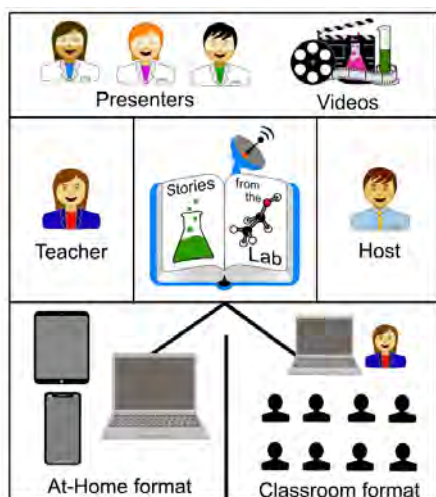
[John.ODonoghue@tcd.ie](mailto:John.ODonoghue@tcd.ie)

The School of Chemistry at Trinity College Dublin (TCD) has an established chemistry

education and public engagement (EPE) programme, which has been running for many years. Activities hosted on campus include public demonstrations, competitions and career talks among others. Teams of trained PhD students also visit dozens of secondary schools annually to deliver hands on workshops, in addition to public demonstrations at external events like science festivals. The majority of these activities, both on campus and external, are organized through the "Outreach Module", which forms part of a structured PhD programme. In addition to lectures and assignments, module participants are also required to complete face-to-face work experience to hone their communication skills, learn from their peers and reflect on their development.

TCD became the first higher level institution to report a case of COVID19 in Ireland on the 5<sup>th</sup> of March 2020, which led to all face-to-face activities moving online soon after. This also resulted in the cancellation of all outreach activities for the School of Chemistry at TCD. As well as teachers losing much valued real-world context, hands-on activities and role models for their students, this also left some participants of the Outreach Module with no opportunity to complete their required work experience component. However, a very quick pivot to providing online sessions based on surveys with teachers and PhD researchers, ensured outreach has continued throughout the pandemic.

'Stories from the Lab' sessions are run as a single one-hour live virtual session per school over Zoom. The time and date for each session is arranged individually with the teacher to best suit their timetable. Three researchers are recruited as presenters for each session from a pool of those who expressed an interest in taking part. Schools do not have a choice over which presenters they receive since this is based on the availability of presenters for the time and date chosen by the school. Where more than three presenters apply for a particular session, some voluntary redistribution between sessions ensures a variety of topics, backgrounds and diversity is maintained for each school.



Initially the sessions were run with students and teachers at home, however, for the 2020/21 academic year the format for 'Stories from the Lab' has adapted many times to match the circumstances. There have now been three formats: teachers and students at home, teacher and students in school and finally, teacher in school and students at home. In all instances, these sessions have received outstanding feedback from the students, presenters and teachers. 'Stories from the Lab' allows the TCD School of Chemistry to continue providing two of its three outreach aims: tangible role models and real-world context for the curriculum. Only hands-on experience is missing, but this has been supplemented instead by the Smartphone Spectroscopy investigation provided directly to teachers through the RSC online teacher workshops.

A multi-school version of 'Stories from the Lab' was also run for Science Week in November 2020, where 11 schools from all over Ireland tuned into the live zoom session with multiple speakers and panel discussions about Careers in Chemistry.

Stories from the Lab has been published in the *Journal of Chemical Education*:  
<https://pubs.acs.org/doi/10.1021/acs.jchemed.0c00636>

**TCD School of Chemistry**  
**Chemistry Careers 2020**  
 12th Nov, Online via Zoom

10.30am Joining Zoom	11.30am Q&A 1st Panel
10.40am John O'Donoghue RSC Chemistry Education Coordinator	11.45pm Maria O'Brien Marketing Analytics Manager, LinkedIn
10.45am Rebecca Wilson Science Week Lead & Smartfutures Manager, SFI	12.00pm Rachel Hersee Research Chemist, Henkel
11.00am Andrew Byrne Research Chemist, APC	12.15pm Michelle Browne Marie Skłodowska Curie Individual Research Fellow, TCD
11.15am Marta Lovisari PhD Chemistry Researcher, TCD	12.30pm Q&A 2nd Panel

Logos: Science Week, Trinity College Dublin, SFI, Henkel, RSC, LinkedIn, APC

## Report from the Chemistry Olympiad Ireland

### By the Irish Chemistry Olympiad Committee

The Irish Chemistry Olympiad (IrChO) is a competition for Irish students in the final year of second level education who are under 20 years on December 31 in the year of the competition. Students from Northern Ireland (NI) and the Republic of Ireland (ROI) are invited to take part in the competition and all second-level schools in both jurisdictions are invited to put forward students to participate in the National Chemistry Olympiad.

For the 2020 competition, participants were required to sit the Leaving Certificate/ A-level Examination or International Baccalaureate Diploma in 2020. The Irish Chemistry Olympiad Committee selects, prepares and mentors students who represent Ireland at the International Chemistry Olympiad (IChO) each year. This involves running several rounds of national (all island) competitions (IrChO) and then specialist preparation for the final team to participate internationally at IChO.

In 2020, the Irish Chemistry Olympiad Organising Committee comprised of a group of academic staff across four higher education institutes in Ireland – DCU, TCD, AIT and GMIT. For 2020, the Organising Committee had the following membership:

Dr. Carl Poree, TCD (Co-Chair), Dr. Brian Murphy, AIT (Co-Chair), Dr. Odilla Finlayson, DCU, Dr. Pat O'Malley, DCU, Dr. Cormac Quigley, GMIT and Dr. John O'Donoghue, TCD and RSC Education Coordinator. The voluntary Committee of academics are responsible for the promotion of the competition across all schools in NI and ROI as well as organising the entire team selection process. This includes setting and grading of the examinations in the various rounds and the training of the selected team members who represent Ireland at the International Chemistry Olympiad (IChO) hosted in July each year.

### **The 2020 Competition:**

In 2020, Round 1 of the competition took place for the first time in the Hamilton Building, in the School of Chemistry at Trinity College Dublin on February 15, 2020. 130 students from 70 schools across ROI and NI attended TCD and over the course of the day, took two examination papers as part of Round 1. This was followed by the Medal Award Presentation Ceremony.

Two Gold medals were awarded to Auriel Guarino, Coleraine Grammar School, NI and Ariane Hannon, St. Joseph's College Lucan, Dublin, ROI.

Recipients of the two Silver medals were Ben Gault, Coleraine Grammar School, NI and Laura Cosgrave, Midleton College, Co. Cork, ROI.

Four Bronze medals were awarded to Joseph Martyn, St. Muredach's College, Ballina, Co. Mayo, Michael Gadloff, Blackrock College, Dublin, Ceri Arnott, Wesley College Ballinteer, Dublin and Finlay Thomas, Mercy College Secondary School, Woodford, Co. Galway.

In addition, eight students were also ranked as Highly Commended.



**Irish Chemistry Olympiad Round 1 at TCD,  
February 2020**

Unfortunately, due to the Covid-19 global pandemic, it was decided by the organisers of IChO 2020 that it was not feasible or safe to conduct the competition in Istanbul in Turkey in 2020. This was the 52<sup>nd</sup> IChO. However, following a survey circulated by the International Steering Committee of IChO to participating countries, a high percentage of registered countries voted in favour of conducting a remote, theoretical-based examination, which would replace the competition originally scheduled to take place in Turkey in July 2020. On foot of this, the National Committee of IChO in Ireland decided that Ireland would be represented at the 2020 online, remote, theoretical competition and the Committee confirmed to the International Steering Committee that a team of four students would be representing Ireland, comprising of students from both ROI and NI.

Round 2 Training subsequently took place in June 2020 and 14 students participated in this remote training programme (11 students from ROI and 3 students from NI). A 3 hour online, remote theoretical examination for Round 2 took place on June 15, 2020, across multiple areas of Chemistry. Prior to the June 15 Round 2 examination, an extensive series of training sessions were organised by the National Committee, all conducted through Zoom. Based on the results of the Round 2 Examination, four of the highest performing students were selected to represent Ireland in the remote, theoretical examination of the international IChO competition on July 25. The following students were selected to represent Ireland:

Auriel Guarno, Coleraine Grammar School, Northern Ireland (NI), Ceri Arnott, Wesley College Ballinteer, Dublin, Michael Gadloff, Blackrock College, Dublin and Joseph Martyn, St. Muredach's College, Ballina, Co. Mayo.

During the month of July, prior to the competition, a further extensive series of online training sessions were organised by the Committee for the team. The academic team involved in the training of the Irish team included: Dr. Carl Poree (Organic Chemistry), TCD, Dr. John O'Donoghue (Spectroscopy), TCD and All-Ireland RSC Education Coordinator, Dr. Odilla Finlayson (Physical Chemistry), DCU, Dr. Pat O'Malley (Organic Chemistry), DCU, Professor Michael Lyons (Electrochemistry), TCD, Dr. Richard Hobbs (Physical Chemistry), TCD, Dr.



Cormac Quigley (Organic Chemistry), GMIT, and Dr. Brian Murphy, (Coordination Chemistry and Solid-State Chemistry), AIT.

Following the training programme, the Irish delegation for IChO 2020 were represented by the four student team members and two academic mentors, Dr. Carl Poree, TCD and Dr. Brian Murphy, AIT. Both Dr. Poree and Dr. Murphy comprised part of the International Jury at the competition. The competition took place from July 23 to July 30, 2020. 231 students participated in the competition, representing 60 countries. 170 Mentors were also involved. In 2020, 26 Gold Medals were awarded, 50 Silver Medals and 73 Bronze Medals. 15 Honourable Medals were also presented. The competition was hosted by the Ministry of Industry and Technology and The Scientific and Technological Research Council of Turkey.



**Some Members of Team Ireland at the School of Chemistry, TCD in July, 2021 after the 5-HR Theoretical Examination for the 52<sup>nd</sup> International Chemistry Olympiad.**

The examination which the teams took consisted of a five-hour examination. The theoretical examination consisted of nine integrated theoretical problems, across multiple areas of Chemistry. The problems in 2020 were entitled: Two Beauties of Turkey: the Van Cat and the Ankara Cat, A Tale of a Reactive Intermediate, ( $\pm$ )-Coerulescine, Symmetry Does Matter! Konya, Carrot, Beta-Carotene, Vitamin-A, Immune System, Vision, Thermodynamics through an Interstellar Journey, Phthalocyanines, Boron Compounds and Hydrogen Storage, and Quantification of Heavy Metal Ions. In 2020, the four Irish students performed well on several of these questions, in particular in areas such as Organic Stereochemistry and Coordination Chemistry, but unfortunately did not feature in the Medals category in 2020, due to a particularly strong international field.

2020 was a difficult year for a number of countries in the Chemistry Olympiad as the competition did not have any practical component, an area that the Irish students often excel in and in addition, some countries were able to hold face-to-face training sessions with their students, whereas others were not able to due to Covid-19 restrictions. The four Irish students took the examination on July 25 in both Coleraine Grammar School in NI and TCD, which was able to accommodate the holding of the examination following social distancing requirements.

Financial support was provided to the Irish team and academic staff from the four colleges, from the Department of Education and Skills (North-South Co-operation Section). The Head Mentor of the Irish team stated *"It is great to see Irish students participate at such a high level on an international stage. It is a testament to the importance of STEM subjects in the Irish curriculum and it would not be feasible to send an all-Ireland team to IChO each year without the continuous support of DES."*

The Committee thanks in particular the continued support of the Department of Education and Skills to allow the participation of the highest-achieving Irish students in Chemistry at this event on an annual basis and in addition acknowledges the support rendered by all four colleges who provide not only the facilities to host the national competition each spring but in addition provide the necessary academic and technical support in terms of the preparation of the students.

More information about IChO 2020 can be found at <https://icho2020.tubitak.gov.tr/>. The report from the International Steering Committee can also be read at: [https://icho2020.tubitak.gov.tr/storage/Guidelines%20&%20Decisions/IChO\\_2020\\_Final\\_Report\\_Turkey.pdf](https://icho2020.tubitak.gov.tr/storage/Guidelines%20&%20Decisions/IChO_2020_Final_Report_Turkey.pdf). The Results are given at: <https://icho2020.tubitak.gov.tr/storage/Results/Results.pdf>.

□

## 7 Simple rules for Science Teaching

A useful booklet from the RSC 21st 25 ideas to transform your teaching. Available at [www.eic.rsc.org/simple-rules](http://www.eic.rsc.org/simple-rules) Accessed 19/5/21.

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# Proceedings, ChemEd-Ireland 2020

Adapting to the Covid-19 restrictions, ChemEd-Ireland 2020 was run as a virtual conference on Zoom. It was very successful, with the largest turnout ever (over 220) and all the technical aspects worked well. There was an interesting programme and Declan Kennedy and his team and John O'Donoghue (tech support) are to be congratulated on pulling this off so successfully. It will provide a template for further online conferences in the covid era. The conference was free and teachers didn't have to leave home and travel to attend. These factors increased attendance although we lost the social dimension that have marked previous conferences. The programme for the event is given below, although we were only able to get three of the talks in on time for the Proceedings. The ppts of the presentations were made available on open access on the ISTA website. Thanks are due to the sponsors, especially BASF, who diverted the funding from the Summer School to ChemEd-Ireland 2021.



## 39<sup>th</sup> Annual ChemEd Conference and 9<sup>th</sup> Annual BASF Summer School for Chemistry Teachers

**Great ideas and teaching resources for teachers of  
Leaving Certificate Chemistry and Transition Year Chemistry**  
**Saturday 17<sup>th</sup> October 2020**

Webinar hosted by Eureka Centre, University College Cork, in collaboration with the Royal Society of Chemistry (Ireland), ISTA Cork branch and sponsored by BASF Ireland Ltd.



PROGRAMME	
9.00 – 9.30	<b>Registration – joining the webinar</b>
9.30 – 9.45	<b>Official Opening by BASF</b> <i>In this presentation we will receive a short overview of the work of BASF in Ireland and see how this work relates to the batch reactor process on the Leaving Certificate chemistry syllabus.</i> - Denis Beecher, Process Manager, BASF Ireland Ltd.
9.45 – 10.30	<b>Building a good foundation: teaching the basics of chemistry</b> <i>This presentation will show how simple models and real examples can be used to lay a good foundation of understanding for abstract theoretical ideas, and how we can head off misconceptions 'at the pass' by addressing them early on in our teaching</i> - Dr Peter Childs, Emeritus Senior Lecturer, University of Limerick.
10.30 – 11.00	<b>Using microscale apparatus for Leaving Certificate Chemistry Lab Practical work</b> <i>This presentation will demonstrate how students can safely carry out chemistry practical work when working individually on some of the Leaving Certificate Chemistry mandatory experiments.</i> - David O'Connell, Christian Brothers College, Cork.
11.00 – 11.15	Tea/ coffee
11.15 – 12.00	<b>A blended learning approach to Thermochemistry</b> <i>This presentation will focus on the use of multimedia as a tool to engage and increase the understanding of 2nd level students towards physical chemistry, with a focus on thermochemistry.</i> - Dr Evelyn Landers, Department of Life Science, Waterford Institute of Technology.
12.00 – 12.45	<b>Laboratory practical work – the journey from the lab to online.</b> <i>This presentation will describe how the speaker is addressing the challenges of taking a first year university chemistry laboratory practical work programme and teaching it online.</i> - Dr Ian O'Connor, Department of Chemistry, UCC
12.45 – 1.30	Lunch
1.30 – 2.15	<b>Some observations on students' performance in key topics on the Leaving Cert Higher Level Chemistry examination paper.</b> <i>This presentation will summarise some key observations made by a highly experienced examiner at Leaving Certificate chemistry level and will outline some advice to chemistry teachers when teaching a range of topics on the syllabus.</i> - Kieran Dennehy, formerly of Pobalscoil na Tríonóide, Youghal, Co. Cork.
2.15 – 3.00	<b>RSC Resources for teaching Transition Year Certificate Chemistry</b> <i>This presentation will provide some practical chemistry ideas to use with Transition Year students and a quick walkthrough of the free resources available on the new RSC education website that are useful for both face-to-face and remote teaching.</i> - John O'Donoghue, Royal Society of Chemistry Education Coordinator.
3.00 – 3.45	<b>Using blended learning in our teaching of Leaving Certificate Chemistry</b> <i>In this presentation Ryan will give an update on the online resources that he has created for Leaving Certificate chemistry teachers and their students and will also summarise the feedback and key recommendations received from those using his resources.</i> - Ryan Gallagher, St Aloysius College, Carrigrohilly, Co. Cork.
3.45 – 4.00	<b>Open Forum</b>




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# Laying down the foundation: teaching the chemical basics

Peter E. Childs

[peter.childs@ul.ie](mailto:peter.childs@ul.ie)

Emeritus Senior Lecturer, Department of Chemical Sciences, University of Limerick

Talk given at 39<sup>th</sup> ChemEd-Ireland 2020

## Getting the basics right – the key/core/big ideas of Chemistry: the particulate theory of matter

### Majoring on the basics

Our aim as Chemistry teachers, especially in junior science, is to help our students understand (as well as learn) the basics of Chemistry. But we also want to make Chemistry interesting and relevant to the real world. Also we need to take account of what our students bring into science lessons from primary science and their everyday experience. Our aim in teaching Chemistry in junior science is that our students will carry their understanding and interest into LC Chemistry and on into third level. For many of our students the junior science course will be their last exposure to Chemistry, as only ~17% will continue and take LC Chemistry. This means we must get the basics right in the junior cycle, as a foundation for scientific literacy of future citizens as well as a good foundation for further studies in Chemistry.

Many students have a negative view of science, and of Chemistry and Physics in particular, which for many is based on their experience in junior science. Listen to what an American reporter wrote.

### Why kids hate school – subject by subject

Roger C. Schank

*Washington Post*, September 7, 2012

**Chemistry:** *A complete waste of time. Why?*

*Do you really need to know the elements of the periodic table? The formula for salt? How to balance a chemical equation? Ridiculous.*

*Most of the people who take Chemistry in college, by the way, intend to be doctors and while there is Chemistry a doctor should know, they don't typically teach it in college. Why should you take Chemistry? Because someone is making you. Otherwise don't bother. You won't remember a thing (except NaCl.)*

[https://www.washingtonpost.com/blogs/answer-sheet/post/why-kids-hate-school--subject-by-](https://www.washingtonpost.com/blogs/answer-sheet/post/why-kids-hate-school--subject-by-subject/2012/09/06/0bf1acc4-f5d6-11e1-8398-0327ab83ab91_blog.html)

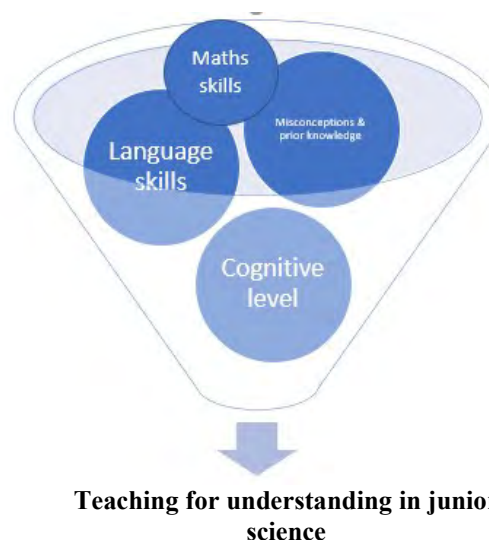
[subject/2012/09/06/0bf1acc4-f5d6-11e1-8398-0327ab83ab91\\_blog.html](https://www.washingtonpost.com/blogs/answer-sheet/post/why-kids-hate-school--subject-by-subject/2012/09/06/0bf1acc4-f5d6-11e1-8398-0327ab83ab91_blog.html)

We should always remember David Ausubel's prescription:

***"The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him/her accordingly."***

We need to take into account a number of factors when students come into second level school from primary school, but also throughout their science education (Figure 1):

- Maths skills
- Language skills
- Misconceptions & prior knowledge
- Cognitive level



**Figure 1: Factors to take account of in teaching junior science**

Each of these general factors can have a major effect on the ability of students to understand and learn scientific ideas, which are abstract and conceptually demanding, and involve new words and use maths. When it comes specifically to Chemistry there are additional factors which affect students' learning, and

thus also the teaching, of Chemistry (Figure 2). These will also apply at LC level and even in third level Chemistry courses. Failure to take account of these and teach accordingly, will affect student learning and performance.

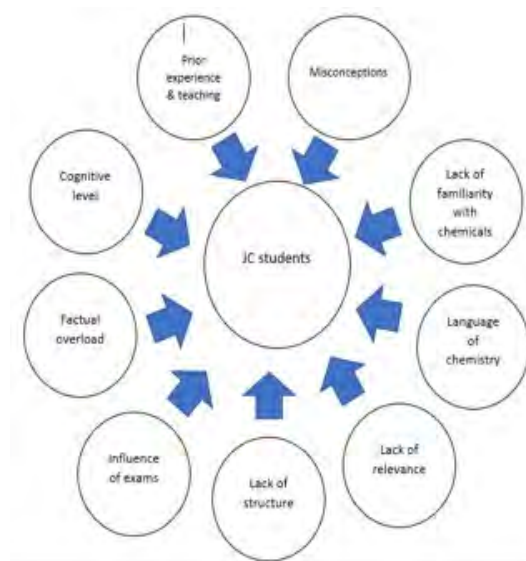


Figure 2: Factors affecting the teaching and learning of Chemistry at junior level

## The big/core/key ideas in Chemistry

When we introduce Chemistry for the first time, usually in the junior cycle, we must make sure that the students grasp the big ideas of Chemistry, on which Chemistry as a subject is based (see Childs, for a fuller discussion of this topic.) I have highlighted in bold those topics which are usually met in introductory Chemistry courses. The full set of key ideas would be met in LC or A-level Chemistry, at an appropriate level.

### Peter Atkins' 9 big ideas

**Matter is made of atoms**

**Elements display periodicity**

**Chemical bonds form when electrons pair**

**Molecular shape is a crucial feature in Chemistry**

**There are residual forces between molecules**

Energy is conserved

Entropy tends to increase

There are barriers to reaction

There are only four types of reaction

Another formulation of the Big Ideas in Chemistry is that of the Advanced Placement (AP) curriculum in the USA, designed for

high-level university entry. They are similar but not identical to those of Peter Atkins.

### Big ideas of AP Chemistry (USA)

**Big Idea 1: Structure of matter**

**Big Idea 2: Properties of matter-characteristics, states, and forces of attraction**

Big Idea 3: Chemical reactions

Big Idea 4: Rates of chemical reactions

Big Idea 5: Thermodynamics

Big Idea 6: Equilibrium

The big/core/key ideas in Chemistry which are relevant to an introductory course in Chemistry are:

1. **The particulate nature of matter**
2. **Structure and bonding and properties**
3. **Periodicity**

The first of these is a key idea in science and is common to Chemistry and Physics courses. The other two ideas are specific to Chemistry. These are in **most** initial Chemistry courses at second-level worldwide, except the Irish JCSA. You cannot teach the basics of Chemistry without a consideration of structure and bonding – it is literally what holds the world together and everything in it. This is not one of the learning outcomes in junior science. In this article I will focus on the first two big ideas, and mainly on the first and its chemical aspects.

They are also the topics students find most difficult and often do not understand. They are also topics riddled with misconceptions (alternative conceptions). **If students do not understand these basic ideas, then they cannot understand Chemistry.** Memorisation often substitutes for understanding. Chemistry and the other sciences are often taught as a mass of facts and definitions to be learned off. Figure 3, based on research by Maria Sheehan on topics that students perceive as difficult, shows the topics that students find difficult at various levels of their chemical education persist. This is an indication that the topics were not properly understood in the first place and this affects future learning.

**We must get the basics right at the start!**



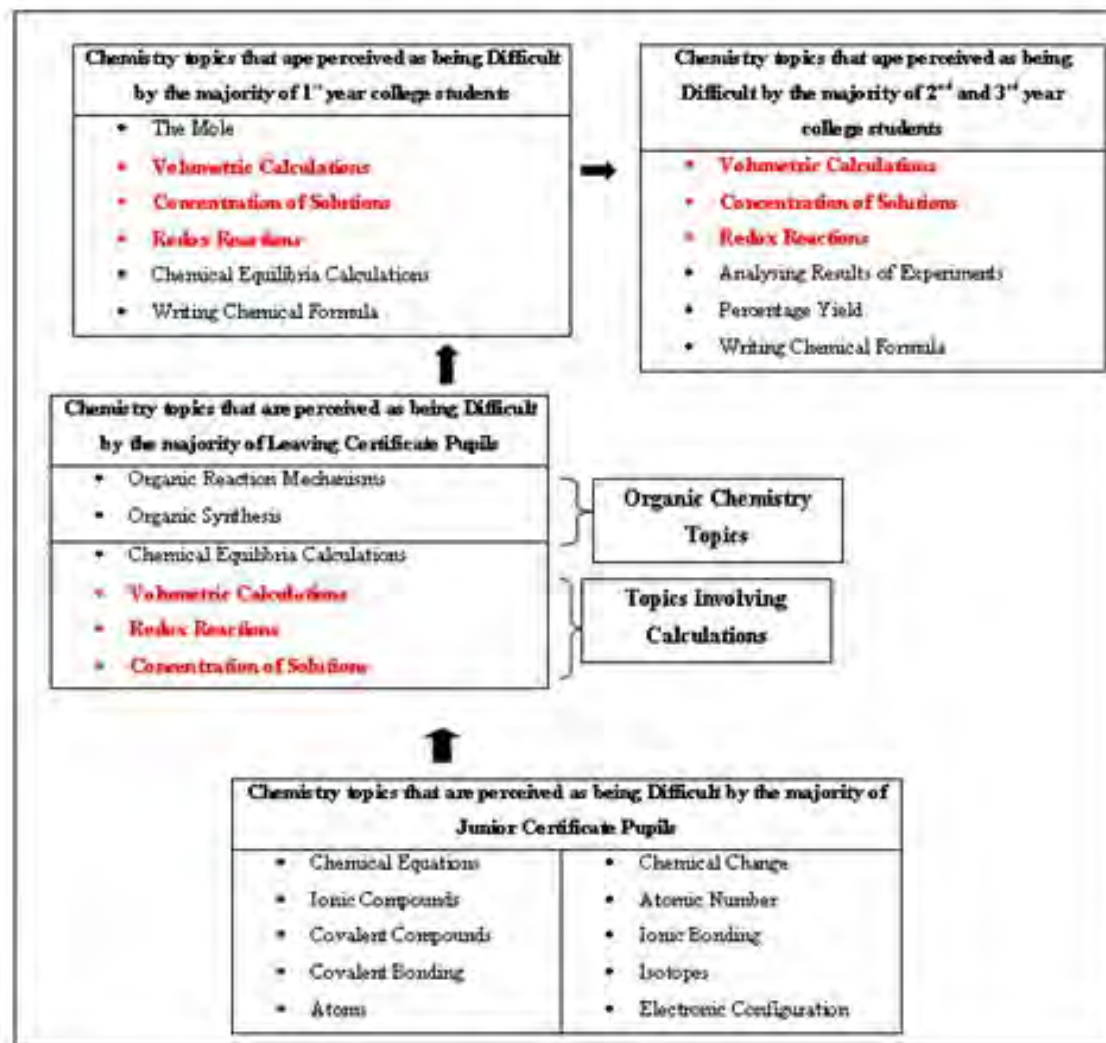


Figure 3: Chemistry topics that students find difficult during their education (Maria Sheehan, PhD, 2010)

**Key idea 1:**  
**Understanding atoms, elements, compounds, molecules, periodicity and bonding are the core ideas in Chemistry, which underpin everything else.**

Students find these key ideas difficult for several reasons: they are abstract and don't seem to relate to the real world; they have a high cognitive demand; they introduce new ideas, words and symbols. **Taken together they make high cognitive and linguistic demands on students, which are often beyond their level of competence.**

**Introducing Alex Johnstone's three levels and using models and visuals to introduce abstract ideas**

I hope all Chemistry teachers are familiar with Johnstone's Triangle (Figure 4), which

reminds us that Chemistry has three levels – the macroscopic (what we see, taste, smell, touch); the submicroscopic (the invisible world of atoms and molecules); the symbolic (symbols, formulae, equations).

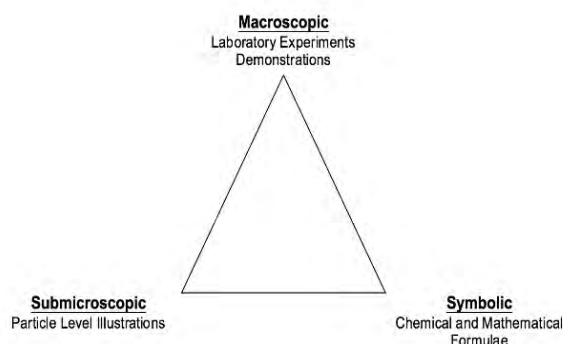


Figure 4: Alex Johnstone's triangle: 3 levels of Chemistry

The first is connected to our students' everyday experience; the other two are abstract



and conceptual. We can illustrate these three levels by using the illustration of sodium chloride (Figure 5). What we see and taste is a white, salty solid. This solid is made up of alternating sodium and chloride ions in a face-centred cubic structure, which is written symbolically as  $\text{NaCl(s)}$ , solid sodium chloride. It is helpful to do this for several substances to get the point across.

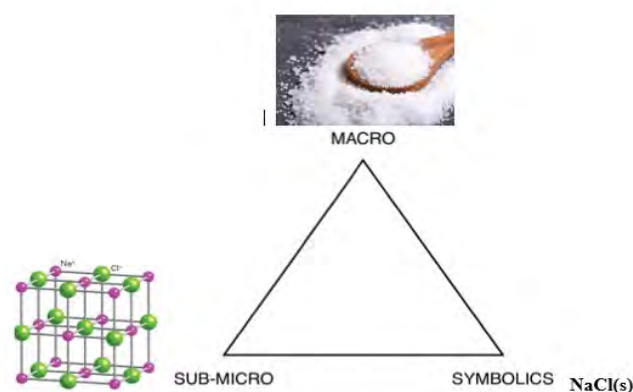


Figure 5: The three levels of Chemistry – illustrated by sodium chloride

**Important ideas to help in teaching the basics:**

- Know where students are coming from.
- Understand the topic thoroughly!
- Be aware of misconceptions in the topic.
- Always aim for understanding as a base for learning information, facts, definitions etc.
- **Start with the macroscopic**, the visible, the real, with models, illustrations, animations, experiments, demonstrations.
- **Move to visualising the submicroscopic** world using models, diagrams, animations.
- **Introduce the symbolic level of Chemistry last.**

Very often when teaching beginning students Chemistry, we start with the submicroscopic and symbolic levels: these are the most abstract and most conceptually difficult levels. We should always start with the real world and give our students some experience with the real, tangible, visible world of Chemistry first (Figure 6). It reminds me of the classic statement from a 1970s student's exam paper

in the USA: "Silver chloride is a pale green gas." You could not say this if you had added sodium chloride solution to silver nitrate solution and seen the white precipitate produced.

**Key idea: Always introduce Chemistry using real chemicals and reactions. Give students real experience of what Chemistry is about – reactions, colour changes, smells etc. We need to provide a context for the abstract ideas that come later.**

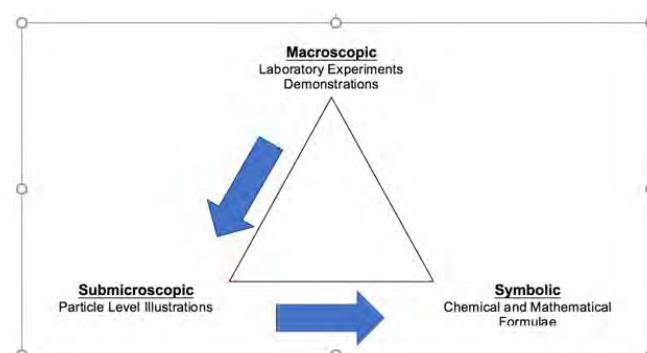


Figure 6: Order of teaching the three levels for beginners: macroscopic → submicroscopic → symbolic

**Elements, atoms, molecules and compounds – making the abstract visible and tangible to students**

When we move to teach about the invisible world of atoms and molecules and ions, we should introduce the abstract ideas using models. One way of doing this is to use plastic building blocks as models for atoms (Figure 7.)

(See Childs, P.E., (2009), *Chemistry in Action!*, #89, 19-24, available at [www.cheminaction.com](http://www.cheminaction.com))



**Figure 7: Modelling atoms using building blocks**

In talking about atoms as the building blocks of all matter, start with plastic building bricks – familiar to your students! We can introduce the following ideas:

- A limited number of building blocks (size, shape and colour)
- An infinite number of models from a finite number of bricks
- Analogy: the world of matter is made from a finite number (~90) of small particles called ATOMS
- Atoms are the building blocks of everything.

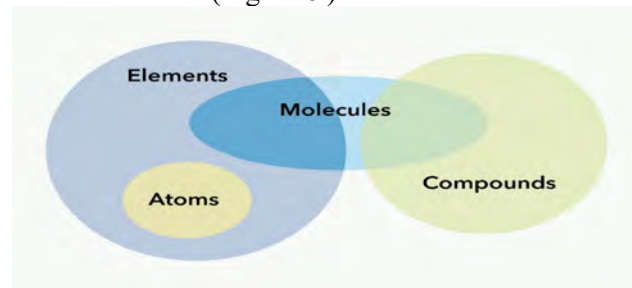
### Teaching about elements, compounds and mixtures

Plastic bricks are distinguished by colour and size. From plastic bricks to elements and compounds, atoms and molecules – elements contain one only sort of atom (brick), however they are connected together or not; a mixture contains two or more different bricks (particles).

Compounds are made from two or more different blocks (atoms) – size of the block determines how many others it can join with (valency).

A molecule contains two or more similar or different blocks (atoms) joined together.

**A molecule is not always a compound.** An element can exist as molecules, e.g.  $\text{Cl}_2$ ,  $\text{O}_3$ ,  $\text{P}_4$ . But an element can exist as atoms (noble gases), molecules or as giant network structures (metals, diamond), but only contain one sort of atom (Figure 8.)



**Figure 8: The relationship of elements, atoms, molecules and compounds**

What we are trying to do here is the reinforce the ideas, the definitions, with models so that students can visualise what we're talking about. Models can make the invisible world more tangible to students. However, we must always emphasise that these are models, not the real thing we are trying to describe.

### Visualising atoms, molecules, compounds – the submicroscopic world

Move from using physical models (plastic bricks or molecular models) to using diagrams to represent the same things. This is a way of picturing, imagining, what we can't see. Using diagrams reinforces the basic ideas and uncovers misconceptions. I hope you can see how the diagrams (Figure 9) relate to the models using plastic bricks. We could also use molecular models to illustrate this e.g. Molymod models. We want our students to understand the basic ideas and the labels and definitions, so that they can look at the models or diagrams and recognise an element, a compound, a molecule or a mixture.

**Repeating the definitions is NOT enough to demonstrate understanding.**

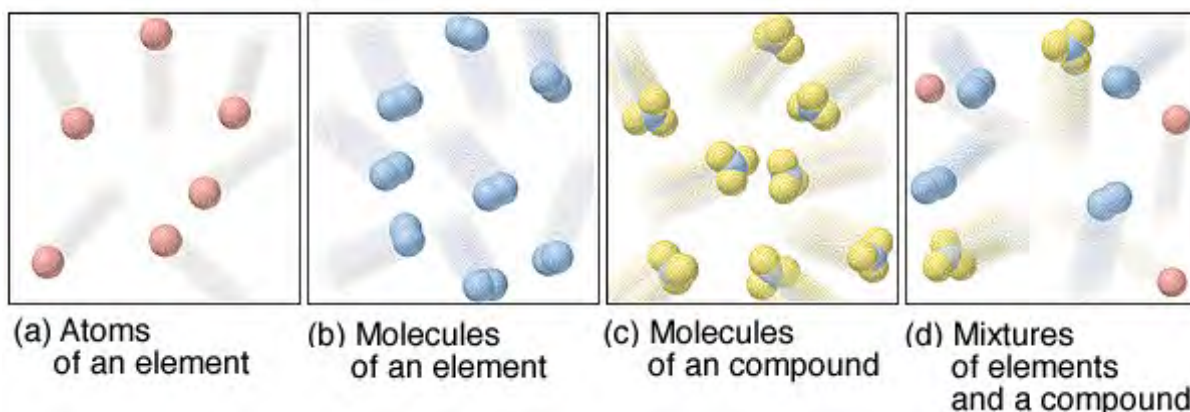


Figure 9: Illustrating the invisible submicroscopic world

We want our students to become familiar with different ways of visualising the invisible, submicroscopic world, so that it becomes real to them in their minds and imagination. However, we shouldn't visualise what they haven't already seen in the real world. For example, dissolving salt in water - the white solid particles seem to disappear as they dissolve in the water. Evaporating the water will recover the salt unchanged. We can now visualise what happens using diagrams (Figure 10) or an animation.

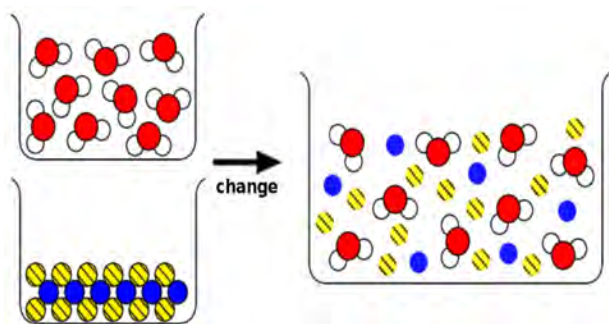


Figure 10: A diagrammatic representation of solubility of an ionic compound in water at a submicroscopic level.

Please note that there is nothing between the particles. We can use such diagrams to test our students' understanding the basic ideas using diagnostic tests such as Figure 11. Two-tier tests are even better, where we ask students to explain their choice of answer. Such questions are also more visual and interesting than traditional written questions. **Your students might actually enjoy the tests!**

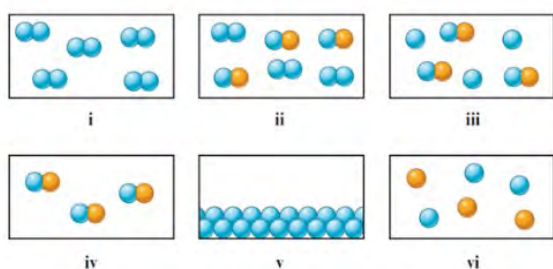


Figure 11: An example of a diagnostic test – which diagram(s) represents a solid element, a gaseous compound, a gaseous element, a mixture of gaseous element and compound, a mixture of two gaseous elements.

**Key idea: Use models and diagrams to underpin students' understanding of the submicroscopic world, so that they are able to visualise what is going on at an atomic or molecular level.**

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## Symbols and formulae

This would be a good place to introduce the symbols and names of the elements (first 20) and how to write a shorthand formula for simple molecules and compounds. This should be the last level we introduce in Johnstone's Triangle (Figure 6), and we should move from words and names to symbols and formulae.

Think of Chemistry as a new language that needs to be learned, in order to speak and read 'Chemistry'. Our students will meet as many or more new words in junior science as they do in learning a foreign language! Start with using words and make sure you name the compounds and relate to real samples. Using ~90 elements we can make millions of compounds.

**The element symbols are the alphabet of Chemistry.**

**Mn, Na, C, Cl ....**

**The formulae of compounds are the words of Chemistry.**

**NaCl, CO<sub>2</sub>, CaCO<sub>3</sub>, C<sub>6</sub>H<sub>12</sub>O<sub>6</sub> ....**

**The equations are the sentences of Chemistry.**

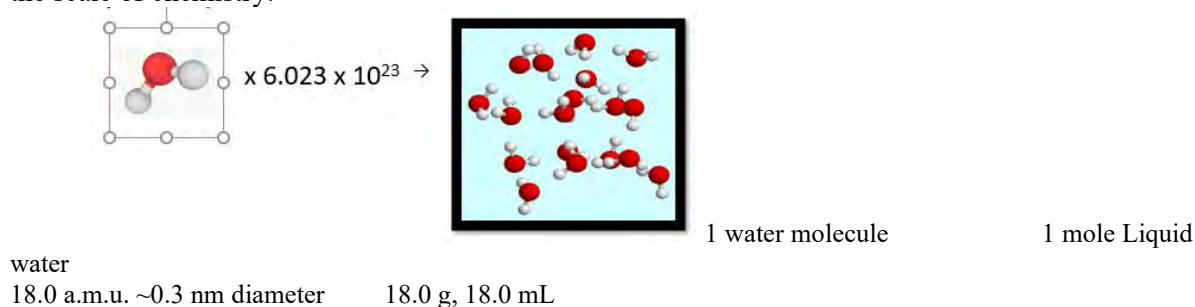
**2H<sub>2</sub>(g) + O<sub>2</sub>(g) → 2H<sub>2</sub>O(l)**

We need to make this learning of symbols and formulae fun by using word games and lots of practice. You can only learn a language by using it frequently. The idea of a chemical formula and valency can be related back to our plastic blocks, whose size determines how many and which other blocks they can combine with. A chemical formula is way and convention of writing down how many atoms are joined together e.g. H<sub>2</sub>O – two atoms of hydrogen combined with one atom of oxygen to form a molecule. All molecules of water are identical. In a solid like sodium chloride, NaCl, the formula shows the simplest ratio of atoms (1:1) – it does not represent a molecule.

## Understanding the scale of Chemistry: from the very large to the very small

Science involves both very small things and very large things (atoms and galaxies), and small numbers (an atom) and large numbers (number of atoms in a sample of matter). The video **Powers of ten video (77) Powers of Ten™ (1977) - YouTube**. [This gives a very good introduction to the size range of science and the importance of exponents, powers of ten.](#)

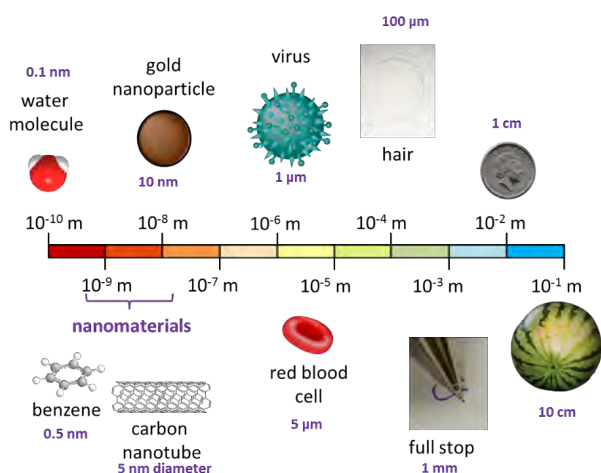
Chemistry includes the very small (atoms and molecules), with sizes in the range 0.1 nm upwards. But it also involves very large numbers – the number of water molecules (~0.3 nm in size) in 18 mL/18.0 g of water is  $6.023 \times 10^{23}$ . This is an unimaginable number. How many stars in the universe?  $10^{22}$ - $10^{24}$ . Molecules (and atoms) are very small but the number of them in any sample is very, very large. How many atoms in the universe? About  $10^{80}$ ! Our students need to grasp these ideas and understand the scale of chemistry.



**Figure 12: From 1 water molecule to a glass of water**

**Key idea: Students need to understand the scale of Chemistry – matter is made up of tiny particles (atoms, molecules and ions) but there are enormous numbers of particles in visible samples of matter.**

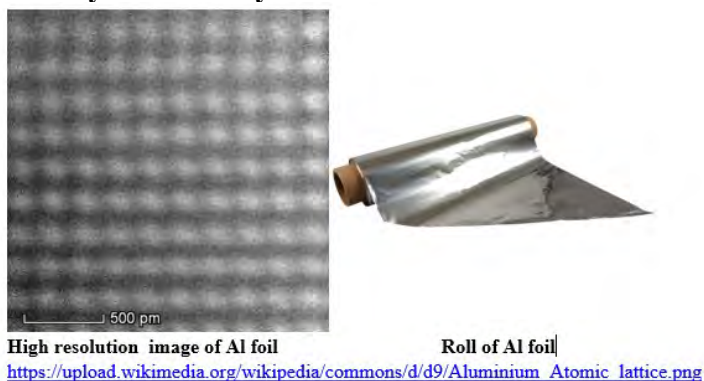




**Figure 12: The scale of Chemistry nanotechnology | ([chembam.com](http://chembam.com))**

We need to give our students some appreciation of the size of atoms and molecules in relation to other things we meet in science, as in Figure 12. We can do some simple activities to bring out the size of atoms and introduce some simple measurement techniques and some maths. It also gives good practice in using and converting between different units.

### Activity: How many atoms thick is Al foil?



**Figure 13: How many atoms thick is aluminium foil?**

Weigh the roll of aluminium foil (without the cardboard tube!) and measure and record its dimensions (length and width).

Use the density of Al ( $2.7 \text{ g/cm}^3$ ) to calculate the thickness of the foil. (get your students to work out to do this!)

Use the diameter of an Al atom (0.286 nm) to work out the number of atoms in one thickness of foil.

**Follow up exercise:** estimate how many molecules of sugar (sucrose) in a sugar cube or how many sodium and chloride ions in a grain of salt.

### Balancing equations: conservation of matter (mass)

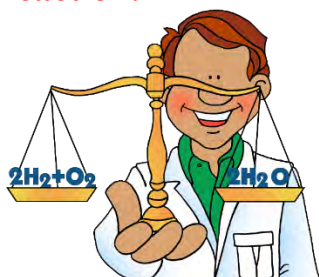
The idea of conservation of mass in chemical reactions is a key idea in Chemistry. This should be introduced and illustrated by doing chemical reactions and weighing before and after, under conditions where no loss of matter can occur. One way to ensure this is to do reactions inside sealed Ziplock bags or stoppered flasks or test-tubes– examples could include acid-base reactions (with an indicator), precipitation reactions and even calcium carbonate plus acid or Alka Seltzer plus water, where gases are produced. **Don't just state the principle – demonstrate it.** Your students may think

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that in combustion mass disappears – the wood burns away – because we can't collect all the products. Burning steel wool (or magnesium ribbon) results in an increase in mass – where does the extra mass come from? Make sure they understand that atoms are not lost, gained or changed into other sorts of atoms, but they do form new substances, they can lose or gain electrons. The products may look totally different to the reactants, because they are new substances, but they still contain the same number and type of atoms.

**This is one of the key ideas of Chemistry.**

**Key idea: Atoms are not created or lost in chemical reactions so the number of atoms (and mass) is the same at the start and the end of a reaction.**

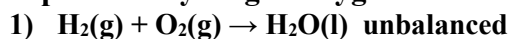


This idea is the foundation for balancing chemical equations, well-known as a difficult topic for beginners. Introduce this idea using a simple balance and plastic blocks to visualise what balancing an equation means. Using models, work through the balancing of an equation step by step and link it to the chemical formulae as you build up the equation. Suitable simple balances are used in primary schools and are available online.

#### **A model approach to balancing equations (1)**

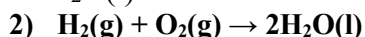
This approach uses the plastic blocks to help students understand what balancing chemical equations means.

**Example: The hydrogen-oxygen reaction:**



#### **A model approach to balancing equations (2)**

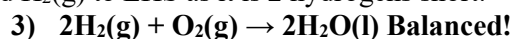
Add 1  $\text{H}_2\text{O}(\text{l})$  molecule to RHS to get right number of oxygen atoms on RHS





### A model approach to balancing equations (3)

Add  $\text{H}_2(\text{g})$  to LHS as it is 2 hydrogens short.



(g, l, s refer to the states of matter of the substances used – gas, liquid or solid)

Don't stick at just one example. Plastic blocks are better than molecular models as they don't need extra 'bonds', which affect masses. Reinforce the idea that the number of atoms is the same in the products as in the reactants, but they are combined (bonded) together differently. Chemical reactions produce new substances. Here two gases combine to give a liquid.



### A spiral approach to balancing equations

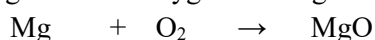
We should introduce the balancing of equations little by little ... but lots of practice. It is best done in a spiral manner i.e. we don't introduce everything all at once, but in deliberate stages. Thus we move from word equations (unbalanced) to using chemical formulae (balanced). Our overall aim is that they understand what balancing an equation means, that they write down the correct formulae of reactants and products, and can proceed step-by-step to balance an equation and check that it is balanced. What we don't want is students trying to memorise (photograph mentally) a number of balanced equations.

1. Start with reactions and visualising what's happening (DO THE EXPERIMENT!)
2. Identify starting material (reactants) and products: Mg,  $\text{O}_2$ , MgO
3. Write word equations:

Magnesium + Oxygen  $\rightarrow$  Magnesium oxide

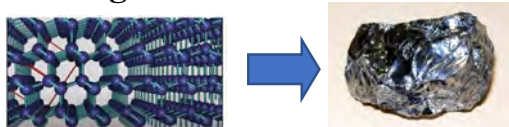
4. Write the formulae under the words (done previously).

Magnesium + Oxygen  $\rightarrow$  Magnesium oxide



5. Remind them of the conservation of matter (mass).
6. Use the simple balance to introduce balancing equations (see above).
7. Introduce states of matter (later)
8. Balancing redox equations – LC Chemistry

## Moving from models to real substances (and vice versa)



**Figure 14:** Use samples of elements and compounds to bridge from models and diagram to real substances.

Use same-size glass bottles (~200 mL) and weigh out 1 mole of various elements and compounds – label with name, formula and mass. These can be stored and used year after year. Bring them out again when doing the mole.



**Figure 15:** Using real samples to make Chemistry visible

Introduce the idea of elements, metals and non-metals.

The difference between elements and compounds e.g. iron, sulfur, iron sulphide, Chemical reaction produces a new substance with new properties.

Relate to the Periodic Table, and the periodicity of physical and chemical properties.

**Key idea: Use real samples to make Chemistry visible and familiar – elements and compounds.**



**Figure 16:** Samples of a variety of compounds – name, formula, molar mass (in sealed bottles!)

Include different classes of solid to relate later to the type of bonding e.g. zinc (metallic), silicon dioxide (covalent network), sugar (molecular), sodium chloride (ionic).

Return later to discuss the mole concept – they all contain 1 molar mass, thus the same number of ‘particles’.

Link to simple experiments comparing metals and non-metals, ionic and molecular compounds (investigating 5 white solids).

## Chemical reactions with visualisations

Don’t just do chemical reactions (but do lots of them!) but at the same time link what is going on, what we can see and smell, with models and diagrams of the chemicals involved and formulae and an equation to describe what is happening. Make students move between and use the three levels of Chemistry. Whenever possible do the reaction in class or use a good video clip (YouTube). They will remember what they see and hopefully link this to the other two levels. Two common examples are given below.

### 1. Burning magnesium in air (oxygen)



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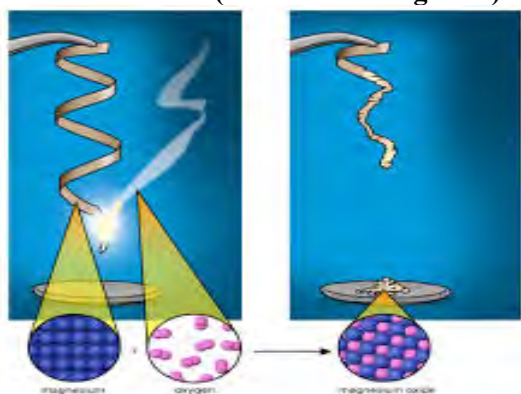
The experiment:



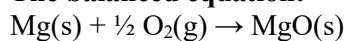
**The word equation:**

Magnesium + Oxygen → Magnesium Oxide

**The visualisation (models and diagrams):**



**The balanced equation:**



## 2. Sodium burning in chlorine gas

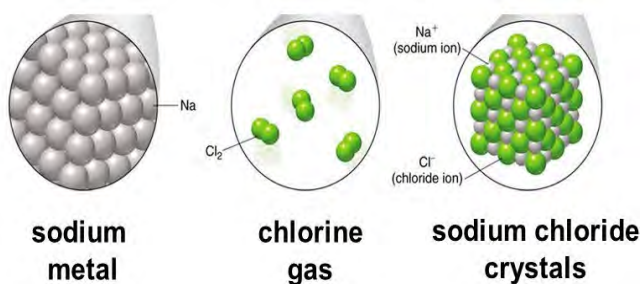
**The experiment**



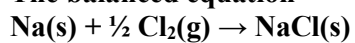
**The word equation**

Sodium + Chlorine → Sodium Chloride

**The visualisation (models and diagrams)**



**The balanced equation**



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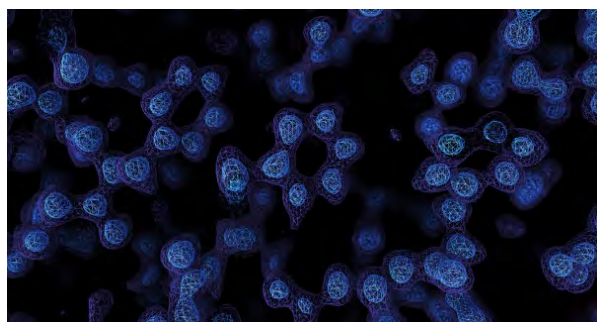
**Key idea: Continually link the macroscopic (real) world with the invisible submicroscopic world using models and diagrams and to the world of symbols (Johnstone's Triangle).**

### **Can we see atoms and molecules?**

*“A common occurrence in science classrooms is a child asking: If no one has seen atoms, how come we are drawing pictures of them? Such a child is raising one of the most interesting questions in the philosophy of science: the relationship of evidence to models, and of models to reality. Good science teachers should encourage such questions and be able to provide satisfactory answers, or suggestions for further questions. To reply “I do not know,” or “because it is in the book” is to forego the opportunity of introducing students to the rich methodological dimensions of science.”*

M.R. Matthews, (1994), Science teaching: the role of history and philosophy of science, London & New York: Routledge, p.4

This is of course a question about the Nature of Science. Students often ask, “Can we see atoms and molecules?” And “Why should we believe in what we can't see?” These are good questions. In fact, if your students don't ask them, then you are doing something wrong! The answer is, **“Yes we can!”** In the past few **decades** we have been able to image atoms and molecules using special microscopes e.g. the scanning tunnelling microscope (STM) and the atomic force microscope (AFM). When introducing atoms and molecules and trying to convince students of their reality, you should use some of the many pictures and animations available on the internet. We can't see atoms and molecules with the naked eye, just as we can't see bacteria, but the latest electron microscopes allow us to do so. There are many examples on the internet e.g. Figures 17 and 18.



**Figure 17: An image of the protein apoferritin created with cryo-electron microscopy. Credit: MRC Laboratory of Molecular Biology**

<https://www.freethink.com/articles/cryo-electron-microscopy>

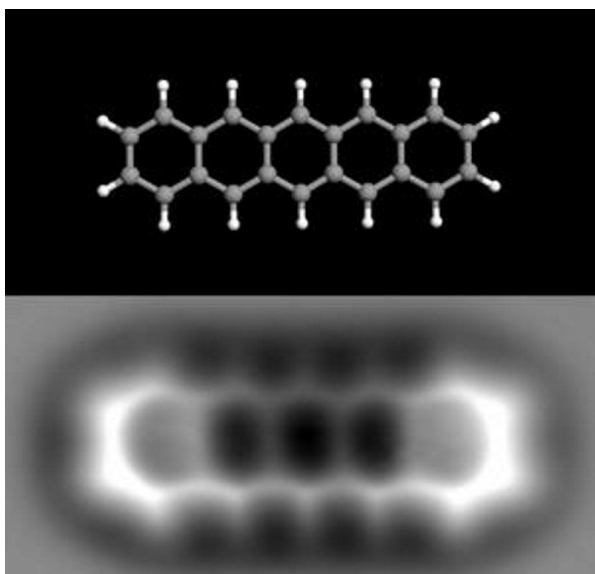


Figure 18: Making the real atomic world visible – the model and the image

## Dealing with misconceptions

*“The trouble with the world is not that people know too little; it’s that they know so many things that just aren’t so.”*

**Mark Twain**

This statement from Mark Twain is even truer in the age of fake facts, but we must remember that our students come to us with all sorts of ideas – some true, some false, some distorted and misunderstood. We must always be aware of and take account of our students’ misconceptions. Much research over the past 40+ years has investigated misconceptions in different areas of science. We haven’t time to discuss this in detail but it is important as Chemistry teachers that we are aware of the issue. We should also be aware that we may hold and propagate misconceptions because we haven’t understood something properly or from the way we were taught.

### Taking account of misconceptions:

- The topics of particulate nature of matter and chemical bonding are rife with student misconceptions.
- Much research over 40+ years on misconceptions in Chemistry (and other sciences).

Misconceptions are:

- Prevalent – widespread at all levels and in teachers and textbooks
- Persistent – hard to change and replace by correct views
- Pervasive – they undermine present and future learning of Chemistry
- Pernicious – they prevent students from proper understanding

### Where do misconceptions in Chemistry come from?

They come from various sources - prior experience and teaching, teachers, textbooks, media, , models, language ..... They are often the result of education not just of other sources of information. Teachers and textbooks are also sources of misconceptions, referred to as *didaktikogenic* – produced by teaching!

Didaktikogenic: Teacher induced, or induced by instruction. From Greek: didaktikos meaning "skillful in teaching", and -genic, meaning "induced by".

Didaktikogenic misconception: a misconception induced by the educational process.

*“That’s the way all the books were: They said things that were useless, mixed-up, ambiguous, confusing, and partially incorrect. How anybody can learn science from these books, I don’t know, because it’s not science.”*

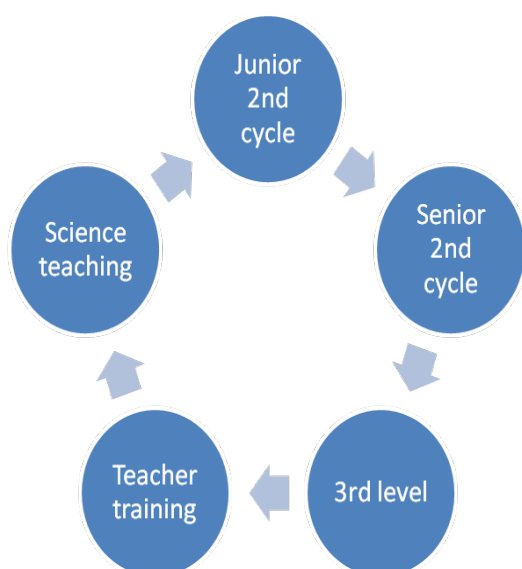
Richard Feynman, in *"Surely you're Joking, Mr. Feynman"*.



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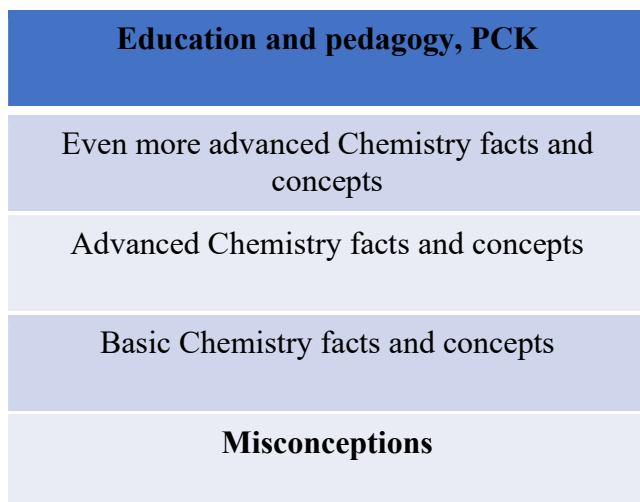
### The self-perpetuating system

Education is a cycle – someone studies Chemistry at school, then at third level, trains to become a Chemistry/science teacher and then goes back into school to teach Chemistry – usually without any experience outside the education system (Figure 19). The student adds layers of knowledge to their prior misconceptions, which often surface when it comes to teaching the basics. It is often true that: “Teachers teach as they were taught, not how they were taught to teach.”



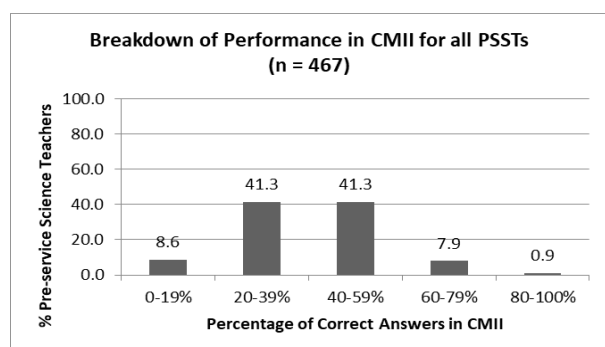
**Figure 19: The vicious cycle in perpetuating misconceptions**

The teacher may go back into school without having their own Chemistry misconceptions altered or challenged by their Chemistry education or teacher training, and without an in-depth understanding of their subject. We then have a vicious cycle perpetuating the errors of the past. This is why, I believe, all the research on misconceptions shows little change over the years, independent of the country, education system, language etc. I often use the illustration that it's like painting over rust, without removing or treating it first – eventually it will come back to the surface. So in our Chemistry education (Figure 20) we build up layers of knowledge, at more complex and advanced levels, but without dealing with misconceptions or making sure the basics are really understood.



**Figure 20: Layers of information built on misconceptions**

The research by Muireann Sheehan at UL illustrated this (Figure 21). A sample of 467 pre-service science teachers (PSSTs) across Ireland – on concurrent and consecutive courses, different years of study, post A-level and post-LC, showed a) poor understanding of the basics in every cohort, and b) that the amount of Chemistry studied before didn't have a major effect. **We have to do something differently in training Chemistry teachers if we want to break the vicious cycle!**



**Figure 21: Performance of the 467 Irish Pre-service Science Teachers in the diagnostic instrument.** Sheehan, M. and Childs, P.E., (2013), 'There is no failure except in no longer trying': Addressing the chemical misconceptions of pre-service science teachers. ESERA Conference Proceedings, ESERA 2013, Cyprus.

### **Misconceptions about the particulate nature of matter**

Much research over many years, in different countries, at different age levels, has identified many student misconceptions about the particulate nature of matter and states of matter. Some of these are listed below.

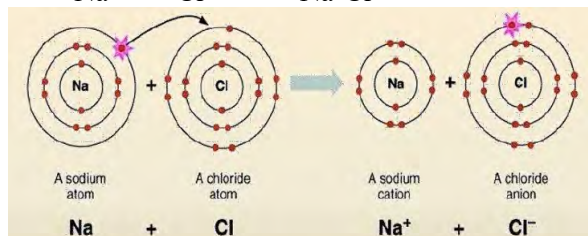
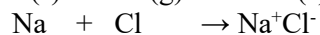
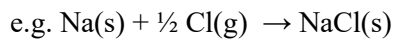
1. Matter is continuous (not particulate in nature).
2. When a substance melts and boils the particles (molecules) change size.
3. Individual atoms or molecules have the properties of the bulk substance e.g. carbon atoms are black, sulfur atoms are yellow.
4. Space between particles is filled with air.
5. Forces are responsible for particles moving (kinetic theory).
6. Particles change state rather than the bulk substance.
7. Atoms and cells are about the same size as both have nuclei.

Your students will hold some or all of these before you met them, and they may develop some or all of these in your classes unless you deliberately target them and teach in a way

which addresses them. (You may hold some of them, yourself!) This is not just by stating the correct view, but through experiment, using models and group discussion e.g. with concept cartoons.

### Example of misconceptions about ionic bonding – formation of sodium chloride

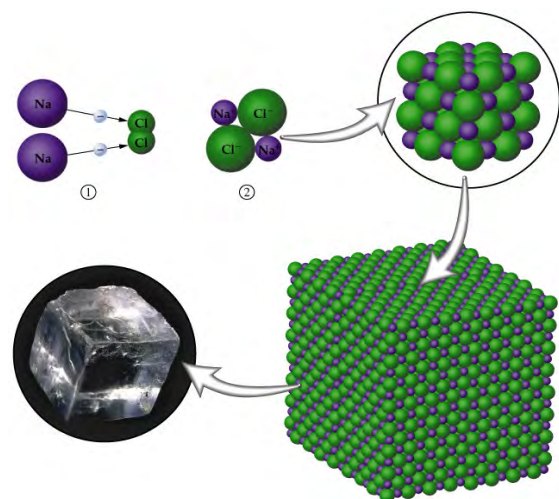
Presented as an electron transfer between one metal and one non-metal atoms:



### Misconceptions about ionic bonding

1. Elements react as isolated atoms.
2. Electron transfer produces an isolated ion-pair – an ionic molecule.

The diagram below (Figure 21) is a better representation of ionic bonding showing that we end up with a giant, 3D lattice of sodium and chloride ions not an ion-pair.



**Figure 21: Using visuals to overcome misconceptions about ionic bonding**

Be aware that models and diagrams have limitations and can create misconceptions, but they can help to visualise what is happening (see for example Figure 22).



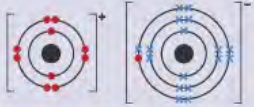

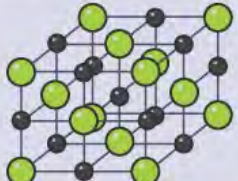
Model	Example	Does not show
Chemical formula	NaCl	<ul style="list-style-type: none"> <li>Charges</li> <li>Lattice structure</li> </ul>
Dot and cross diagram		<ul style="list-style-type: none"> <li>Lattice structure</li> <li>Ionic bonds</li> </ul>
2D diagram		<ul style="list-style-type: none"> <li>How ions were formed</li> <li>More than one layer</li> </ul>
3D diagram		<ul style="list-style-type: none"> <li>Charges</li> <li>That there are no spaces between ions</li> </ul>




Figure 22: Limitations of different models (<https://www.bbc.co.uk/bitesize/guides/zwxp8mn/revision/7>)

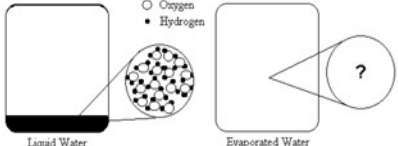
### Addressing chemical misconceptions

How do we address this problem of misconceptions in Chemistry (or other sciences)?

1. Be aware of common misconceptions in the topic being taught.
2. Check that your textbook doesn't contain misconceptions or misleading ideas.
3. Look at the resources from the RSC (see for example [States of matter and particle theory | CPD | RSC Education](#))
4. Correct your own misconceptions first!
5. Teach in a way that uncovers, addresses and corrects your students' misconceptions early on!
6. Use diagnostic texts and formative assessment to reveal misconceptions (Figure \*\*).
7. Use concept cartoons to uncover and address misconceptions. (See <https://www.millgatehouse.co.uk/>).
8. Don't assume that students being able to repeat things back to you means understanding.
9. Develop or use conceptual change texts designed to correct wrong ideas (see [159147568.pdf \(core.ac.uk\)](#))

Sample Question: The circle on the left shows a magnified view of a very small portion of liquid water in a closed container.

Key  
 Water  
 Oxygen  
 Hydrogen



Liquid Water      Evaporated Water

What would the magnified view show after the water evaporates?






(a)  (b)  (c)  (d)  (e) 

Figure 23: A sample question for assessing understanding of the submicroscopic world

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**Key idea: For each topic you teach, be aware of common student misconceptions and how they arise. Design your teaching to uncover, address and correct these misconceptions.**

### Final remarks:

This article has tried to emphasise the importance of laying a good foundation of the basic ideas of Chemistry from the beginning, and reinforcing these throughout a student's chemical education. Don't let your own misconceptions trip you up and mislead your students. Make sure you understand the basics yourself, and teach in such a way to introduce, develop and reinforce the basic ideas of Chemistry to give your students a good, sound basis for further study. If you make sure your students really understand the basics (s distinct from repeating what you or the textbook says), then this will stand them in good stead for future courses where they meet Chemistry.

This talk hasn't presented a syllabus or teaching order, or given an exhaustive treatment, but merely given some ideas of how you might teach some of the basic ideas in order to build understanding and avoid misconceptions. In the internet age there is no shortage of resources available on every topic – videos, animations, teaching ideas, diagrams, assessment questions, activities etc., not to mention the research literature. Many similar ideas have appeared in past issues of *Chemistry in Action!* often under the ChemTips heading.

### Biography

*Dr Peter Childs is Emeritus Senior Lecturer in Chemistry at the University of Limerick. He has taught Chemistry since 1970 at university level, first in Uganda, and since 1978 in Ireland, first at Thomond College of Education and then in the University of Limerick. He retired in 2009 but continues to be active in producing Chemistry in Action! and directing the Chemistry Education Research group. He started the ChemEd-Ireland conferences in 1982. He is a past President of both the ISTA and The Institute of Chemistry of Ireland.*

□

## Diary

### 2021

Many conferences scheduled for 2020 or 2021 have been postponed to 2022 or later, in the hope that international travel will be possible and most countries will have emerged from lockdown. It is likely that conference in 2021 will either be fully online (like the ISTA conference) or will be a mixture on online and face to face.

**9<sup>th</sup> Eurovariety conference**  
7 - 9 July 2021

Ljubljana, Slovenia

[Eurovariety 2021](#)

**Microchemistry conference**



**The 11th International Symposium on Microscale Chemistry**

**The Contribution of Microscale Chemistry to Education**

**13-14<sup>th</sup> July**

[Home \(weebly.com\)](#)

**40<sup>th</sup> ChemEd-Ireland**

Sat. 16<sup>th</sup> October

Dublin City University

[James.lovatt@dcu.ie](mailto:James.lovatt@dcu.ie)

<https://castel.ie/chemed-ireland2021/>

### 2022

**60<sup>th</sup> ISTA conference**

April 8-9

University College, Cork

[dkennedy@ucc.ie](mailto:dkennedy@ucc.ie)

[Irish Science Teachers'](#)

[Association – Irish Science](#)

[Teachers' Association \(ista.ie\)](#)



**ICCE 2022**

18-22 July

[ICCE 2022](#)



**27<sup>th</sup> BCCE 2022**

Dates tba

[www.bcce2022.org](#)



**EuChemS**

Chemistry Congress

28 August to 1 September  
2022 · LISBON.PT

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# Using microscale apparatus for teaching LC Chemistry practicals

David O'Connell

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*This presentation will demonstrate how students can safely carry out chemistry practical work when working individually on some of the Leaving Certificate Chemistry mandatory experiments.*

## What is microscale?

Microscale chemistry involves doing experiments on a small scale. With the current COVID-19 pandemic restricting practical work in schools, microscale may be a useful alternative.

Advantages of microscale include:

- ✓ Less cleaning of equipment, as most materials are disposable or easily cleaned
- ✓ Uses smaller quantities of chemicals and easy to assemble equipment
- ✓ Reduces sharing of equipment and need for students to move around the laboratory
- ✓ Less safety hazards compared to their macroscale equivalents
- ✓ Allows many experiments to be done quickly and sometimes outside of a laboratory
- ✓ Allows students to work independently using their own apparatus and equipment

CLEAPSS GL352 – Managing practical work in non-lab environments (COVID-19 pandemic) - lists some microscale activities that can be carried out in non-lab environments. However, it points out that some activities should not be carried out in non-laboratory environments, in particular those which involve heating.

Four Leaving Certificate Chemistry experiments were chosen and videos of these practicals were shared during the ChemEd-Ireland conference. Details of the experiments can be found in the references.

### 1. Steam distillation of clove oil

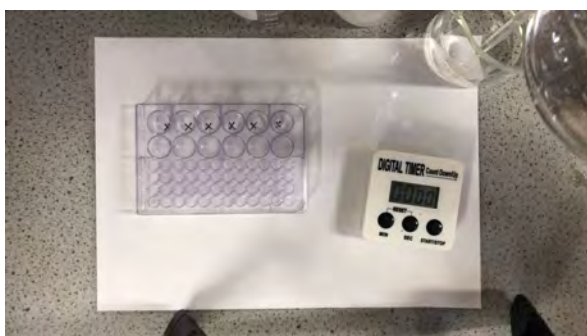


### 2. Preparation and properties of ethyne

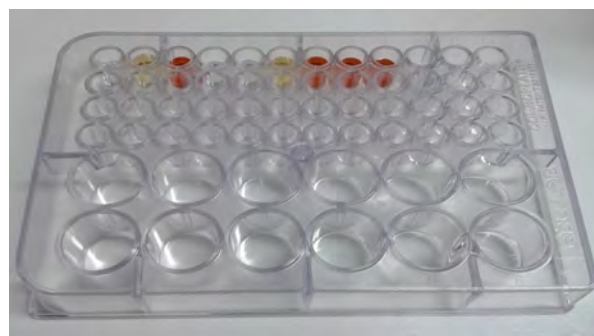


### 3. To investigate the effect of concentration on reaction rate





#### 4. To investigate some redox reactions using the halogens



### References

The following CLEAPSS resources are freely available for downloading by all schools:

CLEAPSS GL343 - Guide to doing practical work during the COVID-19 pandemic

<http://science.cleapss.org.uk/Resource/GL343-Guideto-doing-practical-work-during-the-COVID-19-PandemicScience.pdf>

CLEAPSS GL352 - Managing practical work in non-lab environments.

<http://science.cleapss.org.uk/Resource/GL352-Managing-practical-work-in-non-lab-environments-COVID-19-pandemic.pdf>

EDU-LAB resource folder of microchem worksheets

<https://edulab.com/product-category/chemistry/microchemistry/>

BASF 2<sup>nd</sup> Annual Summer school, microscale experiments handbook, 2013

RSC Online article, Bob Worley, 1 May 2012, Microscale chemistry revisited

<https://edu.rsc.org/feature/microscale-chemistry-revisited/2020193.article>

<https://edu.rsc.org/feature/microscale-chemistry/2020192.article>

Thanks to Dr. Declan Kennedy, UCC, Mr. Murty O'Dowd, Lennox, Dr. John O'Donoghue RSC, Ms. Margaret Cunningham and Mr. David Dowling, CBC Cork for their help and in making this presentation.

### Biography:

*Graduated from UCC in 2012 with Education in the Physical Sciences BSc(Ed) degree. Currently teaches Teach Junior Cycle Science and Leaving Certificate Chemistry full-time in the Christian Brothers College, Cork since 2013.*

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# The rationale for implementing 'blended learning' in science teaching

Ryan Gallagher

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## Introduction

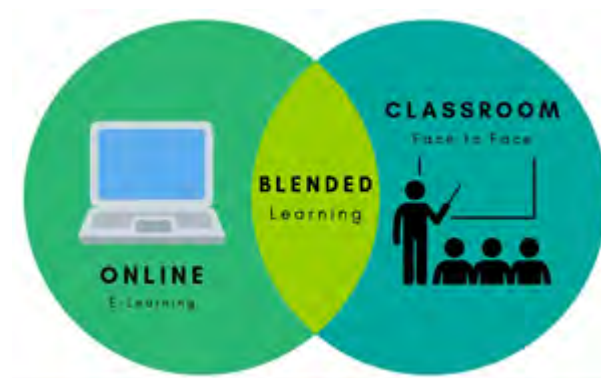
The pursuit of ideal teaching and learning methods has challenged educators for centuries. Many teaching methodologies and philosophies have been put forward regarding the most appropriate format for teaching. Didactic methods have been criticised for failing to emphasise practical problem-solving and critical thinking (Brown, Collins, & Duguid 1989; National Science Teachers Association, 1993 [cited in Hannafin & Land 1997]). *Are students actually learning effectively?* How students learn best has always been a hot debate among educators. *In what way has technology influenced teaching and learning?* We live in a digital age and our dependency on technology has become very apparent during lockdowns due to Covid-19. Many students have at least two smart devices today. Teachers are encouraged to ensure that notes and resources are placed online and every post-primary school has or is implementing a digital policy. *The Digital Strategy for Schools 2015 - 2020: Enhancing Teaching Learning and Assessment* is now coming to the end of its lifecycle and will no doubt be replaced by a more comprehensive document to reflect digital learning today. In recent times there has been considerable discussion on where the student is in respect to learning and teaching. *Is the learning student-centred? Is the teaching student-centred?* (Hannafin & Land 1997). The Leaving Certificate is a high stakes exam, therefore it is only natural to question: *does the use of online learning affect grades? And if so, is it in a positive or negative way?*

## Blended learning - The what and the why

It would be fair to say that teaching online can be quite difficult and presents many challenges in developing teaching strategies. These

challenges are further compounded by potential hardware and software issues. Teachers have had to be more creative, but creativity will only go so far in preparing students for a high stakes exam. To date there is hardly any relevant data collected about using only online teaching and learning for secondary school students, however, no research is necessary to recognise that teachers do not like teaching only online. It is equally evident that students are finding learning online difficult. The lack of infrastructure and training for teachers further cements these difficulties. If both the teaching and learning are difficult, then one can conclude that only online learning is not a cause worth pursuing.

However, perhaps the use of blended learning could be a happy medium. Blended learning (also referred to as hybrid learning) has been defined by many different authors. Two definitions I particularly like, which give a short and concise view of blended learning, are by Panopto - a world leading platform for online lessons at university level - and by Charles Graham, a highly respected researcher in the area of digital learning.



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*“Blended learning is a method of teaching that integrates technology and digital media with traditional instructor-led classroom activities, giving students more flexibility to customise their learning experiences” (Panopto 2017).*

*“Blended learning systems combine face-to-face instruction with computer mediated instruction” (Graham 2005).*

Blended learning encompasses many teaching possibilities. For example, blended learning can involve the teacher teaching the lesson and students then going online at home to complete assessment activities. Another scenario sees students watching short video clips or video lessons in their own time, to complement the learning that is taking place in the classroom. To an extent, many teachers are already using some form of blended learning by using very popular websites such as *The Physics Teacher*, *Studyclix* or *Khan Academy*. However, like most teaching initiatives, it is up to the teacher to decide the extent to which they will engage in blended learning.

Blended learning offers up some unique advantages for the teacher and student. The key advantages of blended learning may be summarised as follows:

1. It allows teachers to be more engaging and can provide better support within the classroom.
2. Teachers are empowered and do not feel under as much time pressure to cover content.
3. Students can learn at their own pace, while still keeping up with the class.
4. Students are more independent learners.

There has been much research carried out in recent years on analysing the degree of success of blended learning. There are a number of success criteria often referred to in literature such as: student engagement, classroom behaviour, student learning, and student results. Multiple international case studies carried out in secondary schools across New Zealand, Australia, Singapore, England and Finland agree that blended learning allows for much of the learning to be conducted outside of the classroom, thus allowing the teacher more time inside the classroom to focus on experiments, assessment and reinforcing conceptual ideas that require understanding.

Teachers reported they have greater flexibility in their teaching and were able to provide better support for students. Many of the case studies are highlighted and discussed in *Online and Blended Learning: A Survey of Policy and Practice of K-12 Schools Around the World* by Barbour et al (2011).

The case studies at post-primary level have shown that teachers are able to cover content in more depth and at a faster pace than traditional teaching. *Could the use of blended learning help ease the everyday pressures for Irish science teachers and allow science teachers more time to carry out more meaningful active teaching methodologies in the classroom?*

The final two advantages above emphasise the positive learning experience blended learning has on the student. Results from the international case studies conclude that students are more willing to engage in the content being taught, when they are able to claim ownership over the content being taught. The critical component to ensure blended learning is successful is that students are guided in their learning outside the classroom, like they would be inside the classroom. Bishop and Verleger (2013) both stress from their survey of the research in blended learning that adolescents need some structure or platform to use outside the classroom, as opposed to just being told to research or Google a topic. This in fact can be counter-productive and can lead to negative learning experiences in blended learning for the student. This leads us to some of the disadvantages of blended learning.

It would be unfair to promote blended learning as being perfect when research has consistently shown that this is not the case. The following four points highlight the main disadvantages with blended learning:

1. Student-teacher engagement is low or non-existent.
2. Success criteria are not always clear.
3. Quality of the lesson/resource may be poor,
4. Internet service/access may be a barrier.

Similar to completing homework, students need some guidance before using online resources. Bergmann and Sams (2012), two researchers who arguably are responsible for bringing blended learning to the foreground of

educational research, categorically state in their research that blended learning requires specific instruction for the students to ensure the desired outcome is achieved. Success criteria must be established so that the student knows when he or she has completed the work correctly and to the standard expected by the teacher.

Problems associated with the success criteria not being clear and lesson/resource quality are preventable with a little research on the teachers' part. The biggest problem in Ireland is the use of the internet service. Many rural parts of Ireland still do not have adequate access to broadband, making the use of online learning challenging for students at home. The saying 'if the wind blows, the signal goes' can be very apt for the 42% of Irish people living in rural areas (McMahon, 2016). This is a technical problem outside of the teacher's or student's control but thankfully internet services are improving.

The case for blended learning is positive overall. There are, of course, challenges that must be overcome and initially it will require more work from teachers before it begins to make life easier for them. Online learning is something that will continue to develop both here and internationally. The use of technology, like any resource or initiative, should be to enhance student learning without having a negative impact on teaching. Blended learning is a simple concept that could help reduce the pressures felt by teachers at the present time and enhance teaching and learning in the classroom. The word *enhance* is important here as it is important to realise that the use of online resources is there to complement the learning going on in the classroom, not replace it.

### ***The Conical Flask***



The use of online video lessons and tutorials is one of the focus points in blended learning. Many maths teachers use the Khan Academy as a resource for students to use at home to learn about a particular topic. This online video resource has a serious shortfall in that it is not specific to the Irish maths curriculum.

There are currently very few resources available that are specific to the current Irish syllabi. *The Conical Flask* is an online resource tailored for J.C. science students and L.C. chemistry and biology students. It is primarily designed for L.C. chemistry students and teachers. There are a number of reasons for the creation of the website, one of them is the question: *can the website be used for teaching chemistry? And if so, what level of success can be achieved?* For the past three years I have been using and upgrading the website. If students are to be encouraged to learn by themselves then there needs to be a student-friendly resource available to them.

Initially the website only featured videos, but feedback from teachers and students has meant that the website now includes notes, exam-specific videos, online assessment and interactive presentations. More recently bitesize chemistry videos have been added specially orientated to state exams and marking schemes. With the pre-recorded videos students, have the opportunity to simply 'pause a lesson' to reflect on what is being taught and then continue their learning. Using the blended learning approach, students have more flexibility with their learning without seeing any of the serious disadvantages associated with only online learning. Teachers have the opportunity to use 'The Conical Flask' to whatever extent they want as a free resource. An important factor is to realise that the role of the teacher is not diminishing or being replaced but hopefully being enhanced.

### **Covid-19 and Blended Learning Clarification**

Some educational articles state that the Covid-19 pandemic has increased the use of blended learning. However, this is not strictly correct. Blended learning requires both learning at home **and** traditional teaching in school. The lack of the classroom setting with a teacher means that students are simply learning online, as opposed to learning by means of blended learning.

### **Closing remarks**

While online courses are popular among college students we must remember that these students are adults. We cannot expect the same mindset from teenagers. Secondary school



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students need guidance, however, they are more capable of learning for themselves than we give them credit for. Student-centred learning can be achieved, providing that there are dedicated resources from which students can learn.. The teacher is crucial in assessing and deepening the students' understanding of the topic being taught. In other words, the teacher is irreplaceable and is an integral part of the student learning experience.

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## Biography

Ryan Gallagher is a teacher of biology and chemistry in St. Aloysius' College, Carrigtwohill, Co. Cork. He is in the final stages of his PhD which specifically focuses on blended learning. He created the website [www.theconicalflask.ie](http://www.theconicalflask.ie) to help teachers use blended learning.

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# Chemists you should know No. 8: Professor Eva Maria Philbin (4/1/1914 – 24/6/2005)

Adrian J. Ryder

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## Introduction

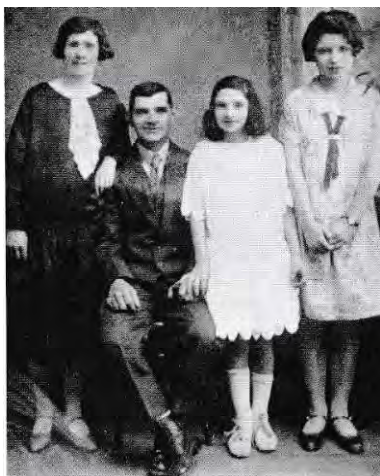
As I have pointed out in a previous essay on Marie Curie, (*Chemistry in Action!*, Issue no. 80, Winter 2006) the role of women in Chemistry up to the 19<sup>th</sup> century was next to none, but society was changing, and in the 19<sup>th</sup> Century some 18 are listed as having an impact by the Wikipedia Organisation. They show some 79 women of note in the 20<sup>th</sup> century with three, Marie Curie (1911), Irene Joliot-Curie (1935) and Dorothy Crowfoot Hodgkin (1964), receiving the coveted Nobel Prize. In the twenty-first century, to date, sees 11 women of note with two, Ada E. Yonath (2009) and Frances Arnold (2018), receiving Nobel Prizes.

The bias against women and change, is clearly shown in the Irish context. Although the Queen's Colleges were set up by 1850, the census of 1871 shows no female student in any Irish University. Indeed, the first Irish College to admit females was Belfast in 1882 and then only to Arts. Cork followed in 1885 and Galway in 1888. 1889 saw the first female graduates, 9 in all, five gaining an Honour, the

other four receiving pass BA degrees. The 1901 Census shows a total of 91 female students, seven in the Galway College out of a total of 272, with Trinity holding out against females until 1904 and then only allowing restricted facilities. Female representation improved slowly, Galway having 83 women shown in the 1911 Census out of a total of 307. Overall figures for the 1938 to 1960 show a 26 to 30% female student body. The figures for the 2015-2016 year show a 51% female entry to all Higher Education institutes.

Going through the lists from Wikipedia I find that only two Irish women are there, both from the twentieth century. They are Eva Maria Philbin, who worked in U.C.D., and a student of hers, Margaret M. Faul who, after finishing her M.Sc. in U.C.D, left to continue her study in the United States and worked there afterwards.

In this essay I am looking at the life of Eva Maria Philbin (1914-2005).



Eva on right with her sister Rita and father and mother George and Kate Ryder



Eva and husband Jack (John Madden Philbin).

## Eva's family and education

Eva Philbin, born Eva Ryder, (b. 4/1/1914), was the elder of two children, both girls, born to George Ryder (b. 29/12/1878, d. 29/6/1950) and his wife Kate (née Donegan of 22 Corbally, Castleconor West, Sligo) (d.19/9/1948 aged 60 years), living in Clare Street, Ballina, County Mayo. George Ryder was the eighth child of eleven born to Thomas Ryder (1839-15/Aug/1907) and his wife Catherine Cassidy (d.9/4/1927). Thomas, like his father John (1798-10/Jan/1870) was a nail-maker (later described in 1932 as blacksmith at the wedding of his youngest son Patrick Henry), who moved from Ennis in Co. Clare to Ballina where he married his wife in 1866. Eva's sister, Rita, (b. 20/05/1915, d.13/5/1991) married Gerry Timlin (d.14/8/1994) and the couple had four children, two girls and two boys. Gerry was to be a manager of a public

house and general store belonging to Rita's parents. George served as a post-man for thirty-two years in Ballina before retiring but later describes himself as a farmer on Eva's marriage certificate in 1943. The farm involved came with his wife Kate. The couple prospered, buying a general store and public house overlooking the Moy River in Ballina in 1928, which was now run on a yearly tenancy by his sister-in-law Margaret. However, the licence, remaining with him until his death, was returned to George in 1930 and the business was run by George and Kate themselves. Now financially comparatively well off, the couple were able to allow daughter Eva attend University at a time when the education of the vast majority, both male and female, was limited to the three Rs



**Eva Philbin's parent's grave in Leigue Cemetery Ballina.**  
*Inscription reads In Loving Memory of  
 Kate Ryder  
 Clare Street Ballina  
 Who Died 19th Sep 1948  
 Aged 64 years  
 Her Husband George Ryder  
 Who died 29th June 1950  
 Aged 71 Years  
 Their Grandsons  
 Gerard Timlin  
 Died 10th March 1961*

*John Timlin  
 Died 13th June 1987  
 Their Parents Rita Timlin  
 Died 13th May 1991  
 Gerry Timlin Died 14th Aug 1994  
 Timlin  
 Ryder*



**Ryder grave. Eva' Grand-father Tom,, Eldest Uncle John and aunt Eva Marsh, Toms fifth child and David his ninth.**

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It is probable that Eva attended the Convent of Mercy National School (now Scoil Chroí Íosa) in Ballina before moving on, in 1927, to the nearby St. Mary's Intermediate School, Convent of Mercy, Ballina. Here, proving herself a most able student, she felt able to take a year away from school in her fourth year, working as a pharmacist's assistant and returning afterwards to St Mary's where she headed her class at Leaving Certificate 1933 with the following results: Honours in English, Geography and Commerce with Pass in Mathematics, Irish and History (Pass with Honours). The school did not offer any LC science subject. She entered University College Galway the following Autumn to study science, coming second in the class with second class Honours at the end of her first year. Her second-year results saw her get the £25 scholarship going with her honours results.

Eva was conferred with her B.Sc. (1<sup>st</sup> Hons) in October 1936, being awarded a £100 grant for experimental research, and gaining her M.Sc. in October 1937 from University College Galway, where under Professor Tom Dillon, she worked on the identification of carbohydrates in sea-weeds. Their collaboration was to lead to the setting up of various companies, including Atlantic Alginates, Ballyconneely, utilising local seaweeds to prepare seaweed meal and sodium alginate, a basic ingredient in toothpaste and ice-cream. Such factories were a valuable source of income to local farmers. The chemistry laboratory at the time was situated at the north-east corner of the quadrangle, directly opposite to the entrance to the James Mitchell Geology Museum, later becoming the College Bar and now administrative offices, and was primitive compared to today's establishments.

### Early Career

After graduation she continued as the first female staff member in the Chemistry Department of UCG and also worked through the war years (1939-1945) with Hygeia Ltd. in Galway as chief chemist from 1940-45, and

### Her career in UCD

with its associated company Cold Chon (1939-43). With Cold-Chon she was responsible for the development and production of road dressings, while providing for the preparation and control of agricultural and pharmaceutical chemicals. With both Hygeia and Cold-Chon developed alternative sources of unavailable chemicals arising from World War Two, among which were the extraction of sulphur from the spent oxide of a local sulphuric acid plant. She was also involved with the preparation of organo-mercurial fungicides using natural mercury, a project which came to fruition a short time after her moving to Dublin.



**The imposing façade of Hygeia over-looking the River Corrib (Jan.2020). The Cold-Chon site at the end of the Long Walk has been totally built over. Both companies still exist and are now sited in Oranmore, Co. Galway.**

In June 1940 she lectured on the Chemistry of road-making before the meeting of the Irish Chemists' Association, which was held for the first time outside Dublin in Galway. On November 28<sup>th</sup> 1942, she gave a lecture to the Women Graduates' Association in UCG on Chemistry as a career and prospects for employment in an area of potential great development in Industry, based on the natural resources of Ireland.



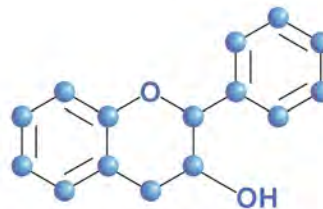


**Professor Eva Philbin (Photo: UCD Chemistry Department)**

She moved to University College Dublin in 1945 as a demonstrator, then as a junior lecturer and finally as a senior college lecturer collaborating with Professor Thomas S. Wheeler to establish a productive research school in the chemistry of natural products. She initiated a series of yearly visits with students to major continental University Chemistry departments, to widen their appreciation of the work done in these centres. She also welcomed visiting continental students, expanding their education in the UCD Chemistry research areas. Eva was a foundation member and fellow of the Institute of Chemistry of Ireland, which was founded in 1950. In June of the following year she was elected a Council Member of the Institute and in April 1966 became its first female president. In 1952 she was appointed an Examiner in Chemistry to the Pharmaceutical Society of Ireland, a position held for many years. 1954 saw Eva elected a Fellow of the Royal Institute of Chemistry, the first Irish woman elected for many years. 1954 also saw Eva's research studies come to fruition with the award of a PhD, and in 1958 a D.Sc. for work on flavonoids. She was to specialise in this field for the rest of her experimental career, with some 90 publications in this field of study. During some two months in 1955, Eva held a Research Fellowship working with Professor Vlado Prelog at the Eidgenössische Technische Hochschule in Zürich. Here she was introduced to the mysteries of stereochemistry and produced a joint report with him before leaving. She brought her new-found expertise back to UCD and saw the introduction of stereochemistry and its development over the coming years. In 1957 Eva was elected a member of the Royal Irish Academy, where

she was an active council member for many years and the first female senior vice-president. Eva was the author of the chemistry section (pp. 275-300) of T. Ó. Raifeartaigh's (ed.), *The Royal Irish Academy: a bicentennial history, 1785-1985* (Dublin, 1985).

### What are flavonoids?



Flavonoids are chemicals which give the colour and aroma to seaweeds, land plants, flowers, fruits, seeds, tea and wine. They are now considered as an indispensable component in a variety of nutraceutical, pharmaceutical, medicinal and cosmetic applications, apart from providing a range of protections to the plants in which they occur. Their basic structure is two phenolic groups linked in various ways with a further three carbon atoms. Various hydrogen replacements give a wide range of different compounds, some 6000 in number, many of them stereoisomers having different chemical and other properties.)

In March 1961 she was awarded a Fellowship, to be taken up that year with funding provided by the Organisation for European Co-Operation, studying teaching and research in chemistry in various American Chemistry departments.

On July 15<sup>th</sup> 1962 the *Irish Times* reported her appointment as Professor of Organic Chemistry, the first and only female Chemistry Professor in UCD to date, which later, following Professor Wheeler's death in the same year, saw her become Head of the Chemistry Department of UCD, a position held to her retirement in 1979. In her new role she was to continue the organisation of the removal of the Chemistry Department from the inadequate quarters in Merrion Square to the new campus in Belfield, being responsible for the development of staff, research and equipment in the new buildings. The department was to expand under her care with the introduction of a Professorship of Inorganic Chemistry in 1963 and later, in 1970, one of Physical Chemistry. The Science

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block itself was officially opened on the 24<sup>th</sup> of September 1964. Over the years she supervised more than eighty PhD students. Eva's department collaborated with the Chemistry Department of Trinity College, in 1970 between them having over 1000 students, holding joint weekly seminars, alternating the venues each week. Both Departments were well equipped with all the standard analytical equipment such as mass spectrometers, gas and liquid chromatographs and the newly (1969) available nuclear magnetic resonance instruments. Prior to this Irish Universities, depended on the goodwill of Harvard University in the United States for experimental data. Following her retirement Eva was honoured by being elected an Emeritus Professor by UCD in 1981.

She became a Fellow of the Royal Society of Chemistry. She was the outgoing President of the UCD Science Society in 1967. She became a member of the Natural Science Council in 1968, later becoming its first woman Chairperson. October 1978 saw her reappointed as a member of the Nuclear Energy Board having been appointed in 1977. The Board ceased to operate the following year.

As a result of caring for her child Liam, (19/10/1951-30/12/2013) her youngest child, who was developmentally challenged from the age of three, she developed a deep concern for those with learning difficulties becoming Chairperson of the Consultation Council on Mental Handicap in June 1970, a three-year term, with a brief to advise the Minister concerning the services for the mentally handicapped. She was also Hon. Treasurer of the National Association for the Mentally Handicapped of Ireland. Both Eva and Jack were to be involved with this Association well into their retirement years.

The *Irish Times* reported on April 29<sup>th</sup> 1943 as follows: "*The wedding took place at St. Andrew's Church, Westland Row, Dublin, of Mr John Madden Philbin, B.Comm., ACA, (b.2/08/1914) son of the late Mr William Philbin and of Mrs M. Philbin, and Miss Eva Ryder M.Sc., daughter of Mr. & Mrs. G. Ryder, Ballina. The Rev. Dr. W.J. Philbin, Maynooth College, officiated. The bridesmaid*

*was Miss R. Ryder and the best man was Prof. Cilian O'Brolchain. A reception was held in the Gresham Hotel.*" The couple lived at 33 Nutley Road, Ballsbridge for the rest of their lives. John was a chartered accountant and company secretary working with the Irish Glass Bottle Company, Ringsend, and the couple had three children, Eimer (b. 14/5/1944), Deirdre (b.23/09/1948) and Liam. John (Jack) was to predecease Eva, dying on July 1, 1997. Eva died, following five years of Dementia and three days of pneumonia, in the Ailesbury Nursing Home, Sandymount on the 24<sup>th</sup> of June 2005. Eva was laid to rest in Deans Grange Cemetery.

Since 2007, the Institute of Chemistry of Ireland Annual Award for Chemistry lectures series has been named in her honour as the Eva Philbin Public Lecture Series. There is also an Eva Philbin medal, which is awarded to the candidate who comes first at the third-year Chemistry examinations at UCD.

### Some References

[UCD School Of Chemistry | History of UCD Chemistry](#)

[https://en.wikipedia.org/wiki/Women\\_in\\_chemistry](https://en.wikipedia.org/wiki/Women_in_chemistry)

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*Lab Coats and Lace*, Ed. Mary Mulvihill, WITS, Dublin, 2009.

**Note:** *My Grandfather John James Ryder (1867-1922) was the eldest child of Thomas Ryder, which meant that Eva and I are first cousins once removed and it has been a privilege to be able to present this essay to you. Special thanks are due to Eva's daughters, Dr Eimer Philbin-Bowman and Dr Deirdre Philbin-Dargan, for use of family photographs and various family details, To my daughter Kendra Cassidy for her exhaustive trawl through the various newspapers for information on the families and to my son, Evan, for his collaboration with various photographs appearing in this article.*

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# Teaching Chemistry as a Story

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**A different way of introducing children to chemistry, illustrated by lessons that can be downloaded from the Web (see link above.)**

Chemistry starts with the handicap that its items are unfamiliar to most beginners. Alkalis, elements, pH, and oxidation have less immediate interest for children than the peoples, maps and mountains of geography, the frogs and flowers of biology, or even the lens, seesaws and magnets of physics.

A much used way of countering this disadvantage has been to exploit children's liking for chemical experiments (flashes and bangs!): but the present-day emphasis on safety restricts this activity even in schools; and playing with chemicals in the home, which hooked many chemists of my generation, has become educational history.

What remains to enthuse young beginners? Reading a succession of entries in a technical encyclopaedia would be unrewarding for most adults, and there is something of this about most introductions to chemistry. Children meet too many unconnected bits of chemistry, and meet them too briefly. Courses of the usual generality do not give our subject the clear and attractive identity that is needed to encourage further studies.

There is a better way to interest 21st century children in chemistry which starts by recognising that all chemical work is guided by particles.<sup>1</sup> Particle interpretations transform a set of seemingly unconnected items into a coherent and engaging subject, and if we use the right tactics this provides an approach with story-like attraction, with each event in its logical place and the action moving purposefully forward.

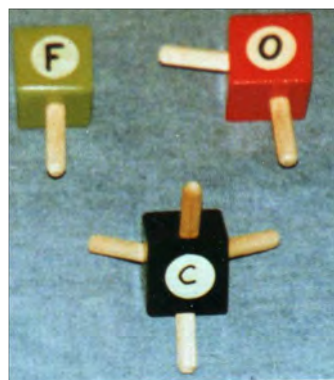
## Beginning the story

First impressions can colour attitudes for life, and for an opening chapter the traditional fare of elementary chemistry is too broad and diffuse. The beginning should be sharply focussed. Its subject matter should be chosen to suit the youngest students, and introduced

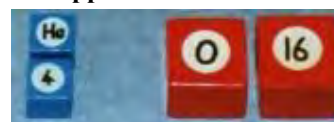
quite slowly, because a story with too many characters and events crowded together makes readers lose the thread. Electrons, protons, neutrons, and atoms presented all at once would soon have children looking out of the window!

The chemistry story needs particles from the very beginning, but it is best to start with just atoms and molecules. This leads to an introduction with the required charisma; and if we stay with atoms and molecules for two whole years, the pace is acceptable even to ten-year olds. Both of these conclusions are based on eighteen consecutive years of voluntary teaching in which the writer has worked with many different classes and their teachers in English and Australian primary schools.<sup>2</sup>

In the writer's first-year lessons, children meet molecular substances and their formulas, valency, molecular interpretations of the three states of matter, hotness as the degree of atomic/molecular motion, and the understanding of balloons. Molecular models provide essential motivation (Figure 1).

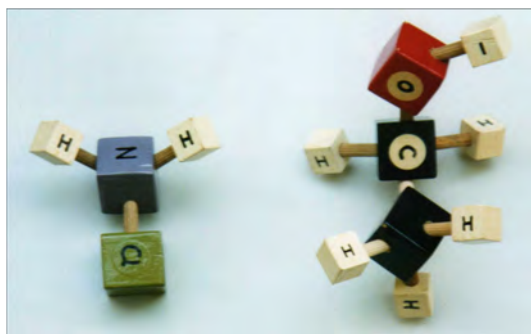


**Figure 1: Above: the number of holes in each cube tells children the atom's valency. Below: each cube has the symbol on one face and atomic weight on the opposite face.**



Molecular model making is a powerful tool for creating interest. It is a hands-on activity that pleases children, even those too young to be taught chemistry in other ways; and the variety of molecules that can be chosen makes it particularly successful at suiting individual talents. In a typical Year 6 lesson the children might be working on perhaps ten different models, adjusted (not too obviously) to their different capabilities (Figure 2).

The multiplicity of molecules that can be chosen gives a further advantage, for by steadily increasing the complexity of the models, lesson after lesson, the children's interest can be sustained, thus prolonging their exposure to atoms and molecules. That is important, because good story telling depends on making the characters seem familiar, and since atoms and molecules occur on every page of the chemistry story they must become unforgettable – like the alphabet or riding a bike. (To find whether this kind of familiarity is gained through conventional teaching, ask a few adults the difference between an atom and a molecule, and count the confident answers received from those who have been right through school chemistry courses!)



**Figure 2:** While one student models a small molecule (*left*) another might need more of a challenge (*right*).

### Piaget's legacy?

Many of the children's regular teachers have taken part in this teaching, and several have asked why such an attractive and penetrating way to start chemistry has been ignored for so long. The reason surely is that Piaget's work on cognitive development created long-lingering doubts about the ability of young minds to accommodate the invisible particles of matter. These doubts, and perhaps a desire

to avoid controversy, are enough to explain why the study of atoms and molecules has been reserved for older students.

Opinion is changing: the STArt! approach in California provides molecular modelling even for eight-year olds,<sup>3</sup> and the professional teachers of the writer's students have been adamant that the molecular modelling course is meaningful work for ten-year olds. They comment on the children's keenness and performance. Several have taught the course themselves, using the writer's models and lesson notes, and have remained supportive.

In tests set at the end of these lessons the marks are always high. (The questions are confined to the ideas that have been taught. Having learnt about gas pressure for example the children are not expected to predict the phenomenon of diffusion! Even university students need time to handle new ideas in a lateral way.) As to what is gained in the longer term, the progress is obvious when the children return to the same topic in the following year.

The first-year course is now displayed on the Web so that it can be examined and tried by others (free download <http://atoms.freehostia.com/>). It is in the form of sixteen very short lessons. To emphasise that specialist teaching is unnecessary, the lessons are aimed at enabling a parent to teach a child.

### The second year

In teaching chemistry as a story, the early start afforded by molecular modelling is important. It creates the time and space needed to continue the story without having to rush through it in later years. The work already described goes well with Year 6 classes, which means that a second year of molecular modelling can be fitted in before most schools would have even started teaching chemistry seriously.

Molecular modelling in the second year is continued, then extended to chemical reactions. This is a huge event in the chemistry story, and it starts when children watch a videoed hydrogen/chlorine gas explosion. They learn what happens in this chemical reaction by building models of  $H_2$  and  $Cl_2$ , and



then exchanging an H and a Cl as shown in Fig. 3. Writing the formula of each molecule as they model it gives  $\text{H}_2 + \text{Cl}_2 \rightarrow \text{HCl} + \text{HCl}$ . It thus introduces chemical equations, and helps to make the balancing of equations seem natural and necessary.



**Figure 3:** A chemical reaction. *Left:* before the reaction. *Right:* after the rearrangement of atoms.

This tactile way of dealing with chemical reactions can hold the interest of Year 7 pupils while the ideas are consolidated with more reactions. For example, our modellers can watch the burning of natural gas, model the reaction, and write  $\text{CH}_4 + 2 \text{O}_2 \rightarrow \text{CO}_2 + 2 \text{H}_2\text{O}$ . (Students of similar age elsewhere might be watching a candle and memorising a word equation such as “candle wax + oxygen  $\rightarrow$  carbon dioxide + water”.)

The second year of modelling ends with another interesting development. The children are already familiar with atomic weights (weights, not masses at this stage), because these are printed on the model atoms, and have been used in the first year for predicting the up or down movement of balloons filled with different gases. Cardboard squares for the 17 lightest atoms are now issued, each having the atomic weight on one side and the valency on the other, and children are asked to place them in order of increasing weight, in the holes of a prepared board. Turning the squares over to see the valencies they stumble upon the Periodic Table (Figs. 4 and 5). This is not another item to be ticked off a syllabus list, it is an important step in the story, and it must lead meaningfully onwards; so it is immediately used in another hands-on exercise to explain how it helped chemists in the search for atoms that had not yet been discovered.

H 1																	He 4
Li 7	Be 9	B 11	C 12	N 14	O 16	F 19	Ne 20										
Na 23	Mg 24	Al 27	Si 28	P 31	S 32	Cl 35											

**Figure 4:** Creating appetites for atomic structure! *Above:* squares representing atoms have been set out in order of atomic weight. *Below:* turning the squares over reveals an intriguing valency pattern.

H 1																	He 0
Li 1	Be 2	B 3	C 4	N 3	O 2	F 1	Ne 0										
Na 1	Mg 2	Al 3	Si 4	P 3	S 2	Cl 1											

## Continuing the story

The first two years work should be enough to show that in this way of teaching chemistry, the topics included and the order of presentation are decided by a storyline. Topics outside the story are omitted, and this must be accepted even when they are a traditional part of elementary chemistry: for example, there is no teaching in these two years of metals or salts or oxidation or acidity. As promised earlier, the story beginning is focussed rather than broad and diffuse; but the omissions can soon enough be repaired.



**Figure 5:** Discovering the Periodic Table.

After two years of molecular modelling the students are in secondary schools, hopefully with specialist teachers. They are already familiar with the Periodic Table, which is the best lead-in to atomic structure. The valencies of atoms, familiar to the students but hitherto taken for granted, can now be rationalised with electrons; and the missing themes of

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elementary chemistry can be introduced in a way that will not disappoint students who are used to the story approach. A chart showing electron shells that get smaller from group 1 to group 8 makes the existence of salts and metals understandable, and goes on to explain interesting differences in properties, such as the electrical conduction of solid metals, and molten salts, in contrast to the non-conductance of molecular substances.

Successful story telling requires ready understanding by listeners, and in the writer's student days there were two palpable story-stoppers: molecular geometry taught through orbitals (a reminder perhaps that sophistication has a second, pejorative meaning?) and equilibrium treated by classical thermodynamics. For today's students, simplified statistical treatments of equilibrium and theories such as VSEPR have changed story-stoppers into exciting sub-plots (and bridged an awkward gap between elementary and advanced chemistry teaching).

The chemistry story today is richer than any fiction. Told unhurriedly it can command attention for year after year, endlessly, with familiar characters viewed from different angles, unexpected twists, feasts of logic, and occasional lucky breaks, all the time increasing the students' interest, and bringing them to a fuller appreciation of the subject's great achievements.

### A summing up

Chemistry is worth more than its present place in education, and this is not subject chauvinism: there are many young people whose student years would be enriched by staying with it longer. To make that realistically possible for average students there must be a smooth development of chemical ideas from year to year; but the unfortunate trend, following the disappointments of the Nuffield era, has been to provide interesting episodes rather than consistent exposition. Have hopes for chemistry as an instrument of general education been abandoned?

The logical question-and-answer technique of *Programmed Learning* in the 1950s failed because it tried to push ideas into minds too quickly. The Nuffield courses were

also a case of too much in too little time. It is lack of time, not excess of logic, that blighted these initiatives. "Teaching chemistry as a story" is nothing other than a call to present chemical ideas in a logical order, but at a slower pace that students can take. The attention seeking phraseology is hopefully excused by the importance of the suggestion.

The writer's own experience quells doubts about chemistry's general appeal. In 1965 staff assembled in Malawi to start a new university, and knowing heads predicted that it would produce too few physical scientists: yet for many years, more students graduated in chemistry than in any other subject! These graduates made their ways into teaching and into every walk of life, surely not an unwelcome result in this age of science?

My colleagues and I tried hard, but the cause of this success was chemistry itself. It is a winning subject. There is probably none other that offers the average student such variety and interest. An effort to give chemistry students a sense of purpose and direction, and prevent them from getting lost in detail – keeping them in touch with the story! – is all that is needed to stop them looking for less exciting subjects that they can better understand.

### References

1. For contrary opinions see: Letters, *Chem. Br.*, 1993, **29**, 866.
2. J.A. Leisten, *Chem. Br.*, 1992, **28**, 331; *Sch. Sci. Rev.*, 1995, **77**, 279.
3. S.M Halpine, *Educ. Chem.*, 2004, **81**, 1431.

### Biography

*Professor John Leisten set up a new chemistry department in the University of Malawi 1965-1987, where he pioneered an innovative way of teaching chemistry. He is now retired and lives in Australia. Your editor met him in 1971 at a conference on Teaching Chemistry at University Level, in Nairobi in 1971.*

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## Electric vehicles – are they all they're hyped up to be?



The An Post van above and on the cover is a sign of the future. An Post currently has the largest fleet of electric vehicles in the country, over 1,000 vehicles. Electric vehicles are ideal for this sort of use – short distances, stop and start, mainly in urban centres, allowing for recharging overnight. The Irish government has an ambitious plan to put 1 million electric cars on the road by 2030. **Is this feasible?** At the moment sales of electric vehicles are ~ 4,000 per year (2020). There are about 30,000 EVs in Ireland at the moment with a target of 936,000 by 2030. This would require selling ~90,000 EVs per year. EVs are classified as BEVs (battery electric vehicles) or PHEVs (plug-in hybrid electric vehicles), but doesn't include regular hybrids.

There are many issues to do with switching to electric vehicles, which in the main will be battery driven. Hybrid vehicles are a half-way house, a mix of battery and fossil fuel engine, and fuel cell vehicles running on green hydrogen are also an alternative. Electric vehicles are only greener if the electricity they use is made from renewable sources; if it comes from a fossil fuel power plant, then their big advantage in reducing CO<sub>2</sub> emissions over petrol and diesel engines disappears.

All the manufacturers are rushing out electric cars and are phasing out making diesel and petrol cars. Some of the current issues with electric cars are:

- Cost – they are much more expensive than diesel or petrol cars, even with government grants;
- Range – the driving range is limited and 300 km is a good range;
- Recharging points – very few recharging points are available (Just over a 1,200 in the whole island, 900

in the ROI )and even home charging may be difficult in towns;

- Speed of recharge – a petrol or diesel car can be refuelled in minutes but recharging a battery takes much longer (hours depending on the model and type of charger), although a fuel cell car can be quickly recharged with hydrogen;
- Recycling – there are issues with disposal or recycling of the batteries, which are mostly based on lithium.
- Battery production has major environmental impacts (mining, waste, energy use).

Advantages include:

- Lower emissions at source but overall needs green electricity;
- Lower tax and maintenance costs (Service, Tax, VRT);
- Fewer moving parts to go wrong and cheaper service;
- Lower running costs – for 20,000 km per year, a monthly 'fuel' cost of €24.40 per month;
- Lower tailpipe emissions of harmful gases e.g. NO<sub>2</sub>, PM<sub>2.5</sub> particles.
- Much lower consumption of materials over its lifetime (if renewable electricity is used).

At the moment grants of €5,000 are available for new EV above €20,000. Many models are on the market and costs range from €27,000 to €95,000. From 2020 in Ireland no new fossil-fuelled cars will be sold. But the majority of vehicles will still be fuelled by oil in 2030.

Running costs: Nissan Leaf 40 kWh (cost €29,384) – 16,000 km would need 3,000 kWh and cost ~€29. A Ford Focus petrol car (cost €25,000) – 16,000 km would cost €1,580 in fuel. More mileage would mean more savings. The extra cost of an EV would be recovered in 4 years or less.

### Lifetime CO<sub>2</sub> emissions

This depends mainly on how the electricity was generated to charge the car battery. If fossil fuels are used to generate electricity

there is a small lifetime CO<sub>2</sub> saving; if renewable energy is used, the saving is considerable. There is a greater CO<sub>2</sub> costs in making the electric car, especially for the battery, but this is offset within a few years.



[Why electric cars are always green \(and how they could get greener\) - The Correspondent](#)

### Switch commercial vehicles first

Many commercial vehicles and delivery vans and trucks do short distances around towns, and stop and start often. The traditional milk float was electric, like the An Post vans. Local buses do relatively short distances during a day and could be replaced by battery or fuel cell vehicles. Hydrogen-powered buses are on trial in many countries around the world including Ireland. Switching such vehicles would reduce greenhouse emissions (assuming green electricity and green hydrogen is used), and also reduce local air pollution in cities, especially from diesel engines. The National Transport Authority (NTA) has already started the process of switching to cleaner vehicles: first hybrid buses and then all electric buses. This will be the sight in the future on our city streets.



Ireland: the National Transport Authority (NTA) has commenced the procurement process for up to **800 double-deck battery electric buses**. The [tender has been published on 18th December](#). Expressions of interest required by 12th February 2021. The NTA says it intends to purchase up to 800 buses under this Framework Agreement over a period of five years, with the **first buses expected to arrive in the second half of 2022**. A few days ago NTA unveiled the first of a batch of [100 Alexander Dennis Enviro400ER plug-in hybrid buses](#), and announced an order for a further 180 of these zero-emission capable buses for delivery in 2021. The orders form part of a **five-year framework agreement for a total of up to 600 Alexander Dennis Enviro400ER buses** [that was first announced in January 2020](#).

This topic of electric vehicles and their batteries would make an interesting TY Science project.

### Sources of information

[Pros & Cons of Electric Cars in Ireland | Liberty Insurance Ireland](#)  
<https://www.moneyguideireland.com/electric-cars-facts-figures.html>  
[NTA commences Procurement Process for up to 800 Electric Buses | Transport for Ireland](#)  
[Factcheck: How electric vehicles help to tackle climate change \(carbonbrief.org\)](#)  
[Why electric cars are always green \(and how they could get greener\) - The Correspondent](#)

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# Chemical Myths Exploded! #2



## Acids and bases

There is a massive research literature on students' misconceptions in chemistry (and other branches of science). They can be very hard to change and can undermine what we are trying to teach them. Wrong ideas persist and pervade subsequent learning. Teachers and textbooks can propagate wrong ideas themselves, so it is important that chemistry teachers make sure they understand correctly what they have to teach. Understanding what we teach is a primary condition for good teaching. In this series we will look at some common chemical misconceptions (myths) in more detail. We could call them mythconceptions as once embedded in Students' minds they are hard to dislodge. A brief introduction to 10 common chemical myths was given previously. (*Chemistry in Action!* #113, Spring 2019, 58-60) In this issue we will look at some misunderstandings about acids and bases.

### Myth: Concentrated acids are strong acids

There is a common confusion between strong and weak, and concentrated and dilute, when it comes acids and bases in solution. In everyday usage a 'strong solution of lye' (lye is sodium hydroxide) means a concentrated solution. This orange squash is too weak means it is too dilute. However, in chemistry when it comes to acids and bases, strong  $\neq$  concentrated and weak  $\neq$  dilute. The chemist would say this is a concentrated solution of sodium hydroxide and a dilute squash, or this is concentrated ethanoic acid, not strong acetic acid (or vinegar). One important cause of misconceptions is the difference between technical and everyday language, and between trivial (old) and systematic (modern) names: vinegar versus acetic acid versus ethanoic acid; strong versus concentrated; weak versus dilute.

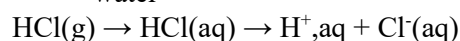
In chemistry concentrated and dilute are imprecise terms but always refer to concentration – measured in mol/L or g/mL; they have no absolute meaning as they are relative terms. In the laboratory dilute

hydrochloric acid could be 4M, 2M or 1M or less. Different countries have a different conventional meaning of dilute! This means we should always label bottles with the name and concentration (not just dilute or concentrated).

Likewise, concentrated acids usually refer to the pure acid or one with the maximum convenient concentration; conc. HCl is  $\sim 16.5$  M (36%), conc.  $\text{H}_2\text{SO}_4$  is  $\sim 18.4$  M (98%), conc.  $\text{HNO}_3$  is  $\sim 15.8$  M (70%), ethanoic acid is  $\sim 17.4$  M (99.5%) M. So concentrated has no absolute meaning – these conc. acids have different molarities (concentration) and purity. One thing they have in common is that they are very corrosive and must be handled with care!

In chemistry usage, strong and weak refer to the degree of ionisation/ dissociation of the acid or base in solution. A strong acid like HCl is  $\sim 100\%$  dissociated into ions in water, so that the  $[\text{H}^+, \text{aq}]$ , responsible for acidity and measured by pH ( $-\log_{10}[\text{H}^+, \text{aq}]$ ), is proportional to the  $[\text{HCl}, \text{aq}]$ . In this case the pure substance is molecular and a gas, but in water it ionises and dissociates into hydrated ions, releasing  $[\text{H}^+, \text{aq}]$ . For a strong acid,  $[\text{acid}, \text{aq}] = [\text{H}^+, \text{aq}]$ .

water



Nitric acid and sulfuric acid are both molecular substances, soluble in water, which ionise and dissociate in water into ions. A weak acid like ethanoic acid ( $\text{CH}_3\text{COOH}$ ) is also molecular and soluble in water, but in water it is only partly ionised and dissociated into ions. Most of it remains in solution as hydrated molecules. Thus in 1 M  $\text{CH}_3\text{COOH}(\text{aq})$  the  $[\text{H}^+, \text{aq}]$  is  $\ll 1$  M and the pH is higher than in 1 M  $\text{HCl}(\text{aq})$ .

**N.B.** because  $\text{pH} = -\log_{10}[\text{H}^+, \text{aq}]$ , low values correspond to high  $[\text{H}^+, \text{aq}]$  and high values to low  $[\text{H}^+, \text{aq}]$ . Also pH is a logarithmic scale so a difference of 1 unit means a factor of 10.

Many bases like sodium hydroxide are ionic solids, and so are fully ionised in the solid. When NaOH(s) dissolves in water the ions are hydrated and dissociate from each other and move about freely. NaOH(s) is a strong base so 1 M NaOH(aq) gives 1 M [OH<sup>-</sup>,aq]; for strong bases [base,aq] = [OH<sup>-</sup>,aq].

A weak base is usually a molecular (not an ionic) substance, like NH<sub>3</sub>(aq), so it is not ionised in the pure state. In water it dissolves, partly ionises and the hydrated ions dissociate from each other. This process usually involves reaction with water. In this case [base,aq] > [OH<sup>-</sup>,aq], and in 1 M NH<sub>3</sub>(aq), [OH<sup>-</sup>,aq] will be < 1 M and the pH will be lower than that of 1M NaOH(aq).

Not all hydroxides are soluble in water but the solids are still ionic and what does dissolve, is fully dissociated into hydrated ions. The [OH<sup>-</sup>,aq] will then be determined by the solubility of the metal hydroxide e.g. Mg(OH)<sub>2</sub>(s) and NaOH(s) are both strong bases, but the concentration of Mg(OH)<sub>2</sub>(aq) will be determined by its solubility, and the [Mg(OH)<sub>2</sub>,aq] will determine the pH. If reacted with excess acid, 1 mole of Mg(OH)<sub>2</sub>(s) will dissolve completely and will use up 2 mole [H<sup>+</sup>,aq].

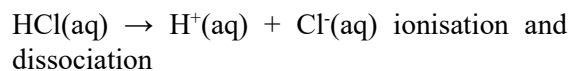
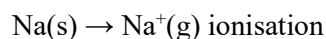
**Thus if we make up 1M solutions of acids and bases, the pH will tell us whether they are strong or weak. If the pH is greater than 1, it is a weak acid; if the pH is less than 14 it is a weak base.**

N.B. Solutions of acids and bases still contain the same concentration of acid or base, whether they are strong or weak; so that when we do a titration they will react with the same amount of base or acid, but the pH of the end-point will be different. As we perform the titration, the weak acid (or base) is used up and more dissociates and reacts, until it is all reacted.

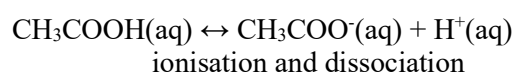
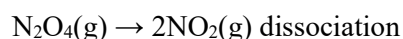
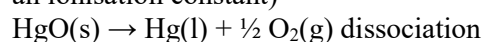
### Myth: Ionisation and dissociation are the same

These two terms are often used interchangeably but they are not the same. **Ionisation** refers to an uncharged species being converted into ions, e.g. by adding or losing an electron to form ions, or by a polar molecule splitting into ions by the exchange of

electrons. Ionisation can happen in the gas phase or in solution.



**Dissociation** is used to describe the splitting up of a compound into smaller particles: e.g. a compound into its elements; a molecule into smaller molecules; a covalent acid or base into ions. A strong acid is 100% ionised and dissociated into separate ions in solution. A weak acid is only partly ionised and the ions separated (dissociated) in solution. The partial splitting of weak acids or bases is usually called dissociation and the equilibrium constant is called a dissociation constant (not an ionisation constant)



### What makes an acid strong or weak?

Hydrochloric acid, nitric acid, and sulfuric acid are often known as mineral acids (because they are made from mineral substances), and they are all strong acids. Likewise, metal hydroxides are ionic and are strong bases when dissolved in water. Table 1 shows some strong and weak acids. You will notice that the weak acids are mostly organic acids.

**Table 1: Strong and weak acids**

Strong acids	pH 1 M solution	Weak acids	pH 1 M solution
HCl (aq)	0	CH <sub>3</sub> COOH (aq)	2.37
HBr (aq)	0	HF (aq)*	1.59
HNO <sub>3</sub> (aq)	0	C <sub>6</sub> H <sub>5</sub> OH	5.0
H <sub>2</sub> SO <sub>4</sub> (aq)	-0.3	C <sub>2</sub> H <sub>5</sub> COOH	2.44

HF(aq) is an exception as all the other hydrogen halides give strong acids in water. Interestingly though, pure HF is a superacid (see below). Most organic acids involve an -OH group and ionisation and dissociation requires breaking a strong O-H covalent bond. This is difficult and so in water the weak

(organic) acids are only partly dissociated. Most of the mineral acids also contain -OH groups and require breaking an O-H bond (except for HX). However, the OH group is bonded to a strongly electronegative atom (Cl, Br, N, S) which weakens the O-H bond, and also the anions are strongly hydrated; both factors result in ~100% ionisation and dissociation. In many organic acids the O-H is not weakened by an electron-withdrawing atom and the organic anions are more weakly hydrated, both factors result in only partial ionisation and dissociation. But this gives us a clue as to how we can make stronger acids.

Strong bases are already 100% ionised and if soluble, split up ~100% to give hydrated ions. Weak bases are again usually organic molecules, like amines (derivatives of ammonia). The strength depends on the ability of the base to split a hydrogen ion from a water molecule to form  $\text{OH}^-(\text{aq})$ , which requires breaking a strong O-H bond.

e.g.  $\text{CH}_3\text{NH}_2(\text{aq}) + \text{H}_2\text{O} \leftrightarrow \text{CH}_3\text{NH}_3^+(\text{aq}) + \text{OH}^-(\text{aq})$

## How to make a weak acid stronger

### How can one make a stronger organic acid?

$\text{CH}_3\text{COOH}(\text{aq})$  is a weak acid and in water the molecules are only partly ionised and dissociated into ions ( $\text{pK}_a = 4.76$  and  $\text{pH} = 2.37$  for a 1 M solution). The main reason (see above) is that we have to break a strong O-H covalent bond and then hydrate a large organic anion. Here water acts as a base to pull off  $\text{H}^+$  to form  $[\text{H}^+(\text{aq})]$ . How could we make the acid stronger? By using a stronger base than water or by weakening the O-H bond, so that it is easier (energetically speaking) for a water molecule to pull off  $\text{H}^+$ .

If we substitute the methyl hydrogens in  $\text{CH}_3\text{COOH}$  with an electron-withdrawing atom or group (more electronegative), this will weaken the O-H bond by pulling electrons away from the oxygen. Thus  $\text{CF}_3\text{COOH}$  will be a stronger acid than  $\text{CH}_3\text{COOH}$  (see Table 2). Why is it stronger than  $\text{CCl}_3\text{COOH}(\text{aq})$ ? Fluorine is more electronegative than chlorine and thus is more electron-withdrawing. A smaller value of  $\text{pK}_a$  means a stronger acid.

**Table 2: Some stronger organic acids**

Acid	pH 0.1 M	$\text{pK}_a$
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	solution	$(-\log_{10}K_a)$
$\text{CH}_3\text{COOH}$	2.88	4.76
$\text{CCl}_3\text{COOH}$	1.2	0.66
$\text{CF}_3\text{COOH}$	1.06	0.23

For a pH calculator see:

<http://pharmaceutics.me/weakacid.php>



## Superacids

**What is a superacid?** It is defined as an acid whose ability to donate  $\text{H}^+$  is greater than that of 100% sulfuric acid, i.e. an acid which is stronger than sulfuric acid. (<https://en.wikipedia.org/wiki/Superacid>) The pH scale breaks down below 0 and a different measure, the Hammett acidity function is used,  $\text{H}_0$ , which has negative values. For 100%  $\text{H}_2\text{SO}_4$ ,  $\text{H}_0$  is -12. The Table 3 below shows the  $\text{H}_0$  value for some superacids.

**Table 3: Some superacids**

Acid	$\text{H}_0$ value
100% $\text{H}_2\text{SO}_4$	-12
$\text{HClO}_4$	-13
$\text{FSO}_3\text{H}$	-15.1
$\text{HF} \cdot \text{BF}_3$	-16.6
$\text{H}_2\text{FSbF}_6$	-28

These acids are super corrosive and are used in chemistry to produce unstable carbocations.

To see how corrosive watch the video: [https://www.youtube.com/watch?v=zf8demMH\\_RMY](https://www.youtube.com/watch?v=zf8demMH_RMY). You don't want to mess with superacids.

## Why is hydrofluoric acid a weak acid in solution?

One of the anomalies of fluorine chemistry in group 17 is the fact that  $\text{HF}(\text{aq})$  is a weak acid, whereas  $\text{HCl}(\text{aq})$ ,  $\text{HBr}(\text{aq})$  and  $\text{HI}(\text{aq})$  are all strong acids. Strong acids are ~100% dissociated into ions in water. **Why is HF the odd one out?** It is also odd by being a liquid at room temperature, boiling at  $20^\circ\text{C}$ , the others being gases, due to strong hydrogen bonding.

Table 4 below shows some properties of the hydrogen halides. Notice the strength of the H-F bond. The high bpt. is due to the fact that  $\text{HF}(\text{l})$ , like  $\text{H}_2\text{O}(\text{l})$ , is a hydrogen-bonded liquid. The additional intermolecular bonding

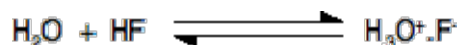
raises the bpt and makes it a liquid (just) at room temperature.

**Table 4: Properties of hydrogen halides HX (group 17)**

Properties	HF	HCl	HBr	HI
Melting point/K	190	159	185	222
Boiling point/K	293	189	206	238
Bond length(H—X)/pm	91.7	127.4	141.4	160.9
$\Delta_{\text{diss}} \text{H}^\circ/\text{kJ mol}^{-1}$	574	432	363	295
$pK_a$	3.2	-7.0	-9.5	-10.0

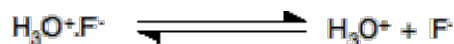
For something to be an acid in water it must first dissolve, ionise and be dissociated into separate ions. In the case of HX this involves breaking the H-X bond, followed by the hydration of the ions. Although the  $\text{F}^-$  ions would be strongly hydrated in water, this energy gain is not enough to offset the strong H-F bond. Thus HF is only partly dissociated into ions in water and is a weak acid. This simple answer turns out to be wrong, see below.

*There is good spectroscopic evidence that hydrogen fluoride ionises fairly completely in solution in water, but instead of producing free hydroxonium ions,  $\text{H}_3\text{O}^+$ , and fluoride ions, there is such strong attraction between these that they form a strongly bound ion pair,  $\text{H}_3\text{O}^+\cdot\text{F}^-$*



*The position of this equilibrium lies well to the right.*

*But to function as an acid, the hydroxonium ion needs to be free - not attached firmly to a fluoride ion,*



*and this equilibrium lies much further to the left.*

*So hydrofluoric acid is weak, not because ionisation is weak, but because the ions formed bind themselves together too strongly.*

*(<https://www.chemguide.co.uk/inorganic/group7/acidityhx.html>)*

So the problem is that  $\text{HF}(\text{aq})$  is ionised but the ions do not dissociate from each other, as the ions bond more strongly to each other than they do to water molecules. Thus  $[\text{H}_3\text{O}^+]$  is low in solution and  $\text{HF}(\text{aq})$  is a weak acid.

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**In this series I hope to look at some common misunderstandings in chemistry. If you have queries, send them to [peter.childs@ul.ie](mailto:peter.childs@ul.ie).**

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# The Colourful World of Gemstones:

## Part 2

Adrian J. Ryder

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The previous essay dealt particularly with three groups of popular gemstones: the Peridots, Beryls and Diamonds, and included two experimental methods requiring minimal equipment. In this second essay we begin with the first of the remaining groups being considered, viz. the Corundum series, the Rubies and Sapphires.

### Ruby and Sapphire



**Photo 2.1 (Author): Massive Ruby and Sapphire. Top L to R. Brown Sapphire with Ruby inclusions (590 ct), Ruby (1455 ct), Brown pendant Sapphire (104 ct). Bottom L to R. Lighter colour Ruby (1146 ct), Sapphire (2290 ct), Dark red Ruby (2892 ct).**

The members of the corundum series have the chemical composition of  $\text{Al}_2\text{O}_3$ , aluminium oxide. The members coloured by Chromium are deemed Ruby, all others are deemed Sapphire but basically they are the same. Traditionally the Ruby and Sapphire were two of the four so-called precious stones, the other members being the Emerald and Diamond met with previously.

The members of the corundum series are allo-chromatic and, as in all the allo-chromatic series, a colourless member is found which is the true shade of the pure gemstone.

#### NOTE:

**Allo-chromatic** - means accidentally rather than inherently pigmented: variable in color —used of certain minerals that are without pigmentation when pure.

**Idio-chromatic** means coloured inherently and characteristically: having a distinctive and constant coloration.



**Photo 2.2 & 2.3 (Author): Left Lab white Sapphire 51 ct; Right 2 Natural white sapphires (2.85 ct)**

The Ruby gets its colour from Chromium atoms replacing some of the Aluminium, and the greater the amount of Chromium the deeper the colour. A bluish tint that is sometimes found is credited to the presence of Iron atoms as well. Inclusions (trapped foreign matter) occur in all but a very few extremely clear stones. Rutile needles can give the rare cats-eye effect in a Ruby cabochon and also are the cause of the sought after six-rayed star Ruby.



**Photo 2.4 & 2.5 (Author); Left 4 Natural gem quality Rubies (2.8 ct); Right 32.4 ct natural cloudy opaque Ruby with darker inclusions**

Poor quality Rubies are often heat treated which improves the clarity by burning off inclusions. Cracked stones are often glass filled. The darker natural Rubies show the magnetic effect to a small extent. Man-made Rubies and lightly coloured Rubies show no magnetic effect. One may take it that any clear large Ruby is a lab creation.

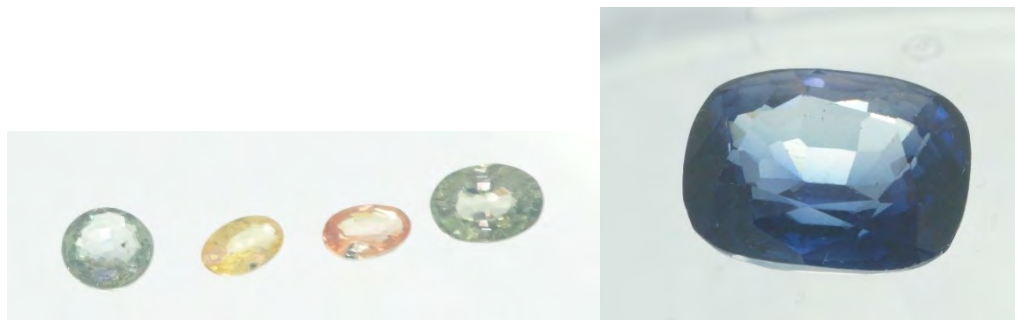


**Photo 2.6 (Author): 3 Man-made rubies (70 ct)**

The Ruby's cousins, the Sapphires, come in all shades of colour. The Blues are coloured by the replacement of Aluminium atoms with those of Iron and Titanium and appear to be the only ones

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showing the magnetic effect, which increases with depth of colour. Violet-coloured sapphires are coloured by Vanadium. Yellow and green Sapphires owe their colouring to a small amount of Iron. Pink to light red Sapphires are coloured by Chromium and one chooses then to describe them as Sapphire or light-coloured Ruby. If traces of Titanium are also present the stone will have a more purplish pink hue. Orange colour in Sapphire arises from a mix of Iron and Vanadium atoms.



**Photo 2.7 & 2.8 (Author); 4 small natural Sapphires (0.15 to 0.3 ct) ; Blue 12.5 ct Sapphire-Spinel doublet.**

As was the case with Rubies, rutile inclusions can lead to six-sided star stones when cut as cabochons. Heating cloudy non-distinctive coloured Sapphires can change them to a bright permanent blue. It can be assumed nowadays that all clear blue Sapphires have been heat treated.

The specific gravity of Ruby and Sapphire at 3.97-5.05 and 3.95-4.03 respectively, give no help in distinguishing a Ruby from a red Sapphire.

We now move on to another oxide compound also containing Aluminium, the Spinel.

## Spinel



**Photo 2.9 (Author) A nine carat blue spinel.**

The chemical formula for Spinel is  $\text{MgAl}_2\text{O}_4$  and it is allo-chromatic, neither Magnesium nor Aluminium giving colour to a stone. The colouring agents are Iron, Chromium, Vanadium and Cobalt. Generally, the Spinel are small, and large stones are uncommon and star stones are very rare. Indeed any large Spinel, greater than 2 carats, should be treated with the upmost distrust if offered for sale as it is most probably man-made. Trade names for the various varieties of Spinel are still in use but the use of a colour prefix is becoming to be more used.

Some of the trade names follow:

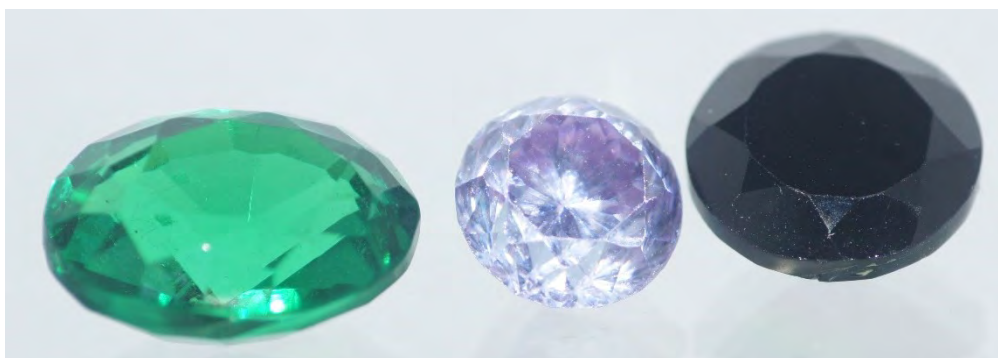
**Flame spinel** (rubicelle) - Bright-orange to orange-red spinel, which has also been called "rubicelle". Coloured by Chromium replacement of the Aluminium.

**Balas spinel** - Pale-red spinel. Originally taken to be Ruby, the Black Prince's Ruby set in the English Imperial Crown is in fact a Spinel. The colouration is due to Chromium and some Iron replacement of the Magnesium and Aluminium.



**Photo 2.10 (Author); left Colourless 0.35ct Spinel. Right Slight Pinkish 0.55 ct Spinel**

**Pleonaste** (Ceylonite) –  $(\text{Mg,Fe})\text{Al}_2\text{O}_4$ , Dark-green to blackish, iron-containing opaque spinel. The change of  $\text{Fe}^{2+}$  to  $\text{Fe}^{3+}$  deemed to be the cause of the green coloration.



**Photo 2.11 (Author): L-R: Green 11.5ct Spinel. 5.3ct Spinel-Amethyst Triplet. 20ct Black Spinel**

**Hercynite** –  $\text{Fe}^{2+}\text{Al}_2\text{O}_4$ , Dark-green to black spinel that contains iron replacing the Magnesium of the formula and giving the coloration. Changes of the  $\text{Fe}^{2+}$  to  $\text{Fe}^{3+}$  is thought to give the resulting green coloration.

**Gahnite** –  $\text{ZnAl}_2\text{O}_4$ , Blue, violet or dark-green to blackish spinel. Sometimes called "zinc spinel" due to the replacement of the Magnesium by Zinc in the formula.. Some Cobalt replacement in the formula leads to the blue coloration.

**Gahnospinel** –  $(\text{MgZn})\text{Al}_2\text{O}_4$ , blue to dark-blue or green material that is between spinel and gahnite and has its colour due to small amounts of Iron replacing the Mg and Zn.

**Picotite** – Chrome Spinel,  $\text{Fe}(\text{Al,Cr})_2\text{O}_4$ , Brownish, dark-green or blackish spinel. Also called "chrome spinel" the Iron and Chromium content ratio deciding the coloration.

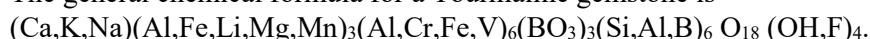
Whereas the colourless variety of Spinel will not show a magnetic effect, those Spinel containing Iron or Chromium will do so, the effect being determined by the concentration of these two elements in the stone, the blues showing only a very slight effect, while the black showed a very strong effect, so much so that the black would be an ideal stone to float showing the magnetic effect. (See part 1 of these essays.)

The Specific Gravity of the Spinel ranges from 3.54 to 3.63 while that of synthetic Spinel range from 3.58 to 3.80, which can be used to separate the natural from the man-made stones.

Our next gemstone is the Tourmaline which is a Borate-Silicate mineral and has the most complicated general formula of all the gemstones.

## Tourmaline

The general chemical formula for a Tourmaline gemstone is



Which makes it just as well that one does not have to remember the formula when dealing with this series of gemstones! In spite of 15 elements being shown on the general formula, no single Tourmaline has all the elements in it.



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The elements inside each set of brackets exist in varying amounts. A peculiarity of the Tourmalines is the absence of man-made varieties due to the complexity of its chemical formula. Other gemstones, such as the Spinel, may be offered as simulants. Specific Gravity of the Tourmalines ranges from 2.82 to 3.90, with the higher value associated with the darker-coloured stones.



**Photo 2.12 (Evan Ryder): Mix of cabochon and faceted Tourmalines.**

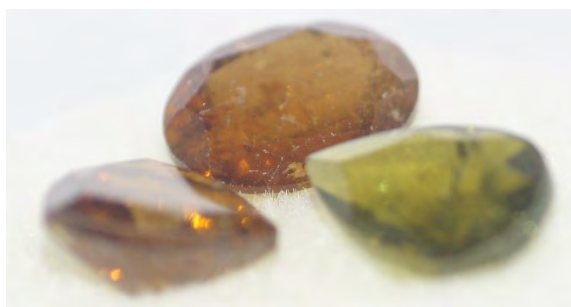
The colouring agents, as seen in previous stones are, Iron, Manganese, Chromium, Vanadium and Boron with the final colouration depending not only on the concentration of each, but also on the interaction of each on the colouration caused by the others. Many Tourmalines are ideo-chromatic but allo-chromatic Tourmalines also exist. Water is generally found trapped in the crystal and this can be removed by heating the crystal to a red heat. Fluorine is rarely absent but Lithium and Manganese enter the composition of only a few Tourmaline varieties. Iron as  $\text{Fe}^{++}\text{O}$  is an important but variable constituent, which may range from zero to as much as 20% of the stone. Those Tourmalines with a large Iron content are always dark in colour, often black and opaque.

As with the Spinel, trade names are still in use although the practice of just prefixing the colour to Tourmaline is becoming more prevalent.

The principal trade names are:

**Achroite** for the colourless variety (rather rare in nature)

**Dravite**,  $\text{NaMg}_3\text{Al}_6(\text{BO}_3)_3\text{Si}_6\text{O}_{18}(\text{OH})$ , a Magnesium Tourmaline, yellow-brown to dark brown. We saw that traces of Boron in Diamond gave a blue colouration but here its effect is neutralised by traces of other elements substituting in the formula.



**Photo 2.13 (Author): 4.75ct Brown and Green Tourmalines**

**Indicolite**, all shades of blue due to relatively large ratios of ferrous oxide,  $\text{FeO}$ . A blue stone from Paraiba in Brazil owes its colour to Copper tempered by traces of Manganese. This is the only transparent gemstone containing Copper.

**Rubellite or Siberite**, pink to red with a violet tint at times. This is the variety confused with the Ruby. The ratio of the Manganese to Iron present is claimed to be the colouring principle of these stones.

**Schorl**, iron Tourmaline,  $\text{NaFe}_3^{2+}(\text{Al}, \text{Fe}^{3+})_6[(\text{OH})_4(\text{BO}_3)_3\text{SiO}_{18}]$ , black Tourmaline which is very common in nature and was traditionally used in mourning jewellery.

**Verdelite**, green in all shades due to ferrous iron,  $\text{FeO}$ , or chromic oxide,  $\text{Cr}_2\text{O}_3$ , Titanium is sometimes also present.

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Some of the above have individual varieties which have been given specific names in the past, but here we will ignore them and have concentrated on the general types named above.

In general, in a Tourmaline containing small amounts of Manganese and Lithium and little or no Iron, the stone is usually colourless with rose red to darker red or light green depending on the Manganese to Iron ratio. The darker red shade is attributed to considerable Manganese present and the dark green to the presence of considerable ferrous iron. Some green Tourmalines contain chromic oxide, which gives the Emerald its magnificent green colour.

Synthetic Tourmalines are only used in industry and the simulants are only coloured man-made Spinel imitating the Tourmaline.

Tourmalines when heated and subsequently cooled, or when pressure is applied, e.g. by rubbing, attracts dust particles and even small scraps of paper. This phenomenon was used by the Dutch who first imported the stones into Europe, who used the heated stone to extract ash from their meerschaum pipes and indeed called the stone *aschentrekker* (ash puller.)

Most Tourmalines demonstrate the magnetic effect with increase from little to large in stones giving the colours of the visible spectrum from red to blue and black.



**Photo 2.14 (Author); 3.55ct Multi-colour Tourmaline**

A peculiarity of the Tourmaline is that crystals of it can be found with bands of different colour within it. The green and red variety is commonly called water-melon Tourmaline. The green is due to Iron substitution and the pink occurring when the Iron levels are used up and Manganese is substituted in the original material of the stone.

## References

[\*Precious Stones\* by Max Bauer in two Volumes, Dover Publications Inc., New York and Charles Griffin & Co. Ltd., London, 1968](#)

[\*Gemmology\* by Peter G. Read, 2006, Elsevier, Butterworth Heinemann, Amsterdam etc.](#)

[\*Exotic Gems\* Volume 3 by Renée Newman, International Jewellery Publications, Los Angeles, 2014.](#)

<https://www.gemselect.com/gem-info/spinel/spinel-info.php>

<https://en.wikipedia.org/wiki/Tourmaline>

[https://www.gemstonemagnetism.com/tourmaline\\_black\\_blue\\_and\\_green.html](https://www.gemstonemagnetism.com/tourmaline_black_blue_and_green.html)

□

**N.B. both colour and magnetism are due to transition metal ions with unpaired electrons.**

**Adrian Ryder has written a book on gemstones which can be accessed at**  
<http://evanryder.com/downloads/practical-gemmology.pdf>.

# Research Matters: learning from science education research

## #1 Conceptual Change Model (CCM)

There has been much research on misconceptions (alternative conceptions) in science over the past few decades, but it seems to have had very little impact in classrooms and lecture theatres. Research shows that misconceptions in every science are prevalent and persistent and if not addressed, undo our efforts to teach our students the scientific explanations of phenomena. Teachers need to recognise common misconceptions themselves and then they need to teach in such a way that addresses the misconceptions and enables students to recognise them and adopt the correct views, which are then embedded in their long-term memory. A superficial approach where we ask students to learn off material, and reproduce it in exams, does not deal with their deep-seated misconceptions – they just get buried and pop out again, like weeds, in the future. One teaching approach to tackling this problem is the use of Conceptual Change Texts (CCTs) in carefully designed Conceptual Change Courses (CCC) or programmes using the CCM.

The use of conceptual change programmes has been shown by John Hattie (2008), from his meta-analysis of research studies, to have a high effect size of 0.99, where 0.4 is an average impact. This is quite encouraging.

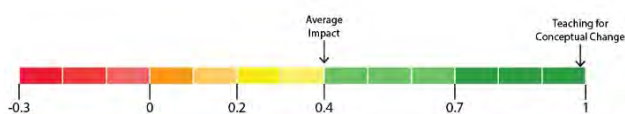


Figure 1: The effect size of conceptual change programmes. (Hattie, 2008)

Many studies have shown CCTs to be effective in tackling misconceptions (see for example the review in McKenna, 2014).

*“These studies demonstrated that Conceptual Change Texts are effective at: helping students identify and remediate their own misconceptions, providing teachers with formative assessments about misconceptions that exist within their classroom, and finally helping students to retain correct understanding of scientific concepts long-term.”* (McKenna, 2014, p. iv)

The CCM was first proposed by Posner *et al.* (1982) and involves four steps:

*“These conditions [for conceptual change] are:*

- (1) students must become dissatisfied with their existent conceptions;*
- (2) the new conception must be intelligible for the student;*
- (3) the new conception must be logical and acceptable for the student; and*
- (4) the new conception must have a potential for explanations in new fields).”* (Atasoy *et al.*, 2009)

A CCT is a piece of text structured around a four-stage teaching methodology, which is used in teaching any new topic:

1. Identify misconceptions,
2. Create cognitive dissonance,
3. Explain the correct conception,
4. Have students engage with what you have taught them.

Very often in teaching a topic we start at step 3, without taking time to identify and deal with our students’ misconceptions. Attention must also be paid to prior knowledge and the use of new vocabulary and terminology.

### 1. Identify misconceptions

Before starting to teach any new topic, the teacher should find out what are the common misconceptions held by students. Students should be asked searching questions and asked to explain what they understand about the topic, to uncover their misconceptions.

### 2. Creative cognitive dissonance

Students are exposed to the common misconceptions in the topic and asked to compare them with their own views, especially through group discussion.

### 3. Explain the correct conceptions

The teacher introduces the correct ideas with examples and simple activities to reinforce the correct ideas, so students can see the evidence supporting the concepts.

### 4. Encourage student engagement with the topic

Students should be given extension work where they apply the ideas in other scenarios to show their understanding of the concepts. Ask them questions to bring out their understanding; get them to critically compare their old and new views; ask them to apply their new ideas to explain a new situation.

The lesson plans by McKenna (2014) give examples of how this can be used in general science topics in earth science. The paper by Beerenwinkel *et al.* (2011) is a good example of

using a CCT to address students' misconceptions of the particle theory in chemistry, a key idea in chemistry which is difficult to teach and where students have many misconceptions.

Figure 2 shows the structure of the CCT developed in the study by Beerenwinkel *et al.* (2011), covering the same content in the same class time as the traditional text. The CCT is often longer than the traditional text because it spends more time identifying and answering misconceptions.

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*Macrostructure of the conceptual change text*

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*Substances are built up of smallest particles* (main headline)

*You learn in this text ...* Presentation of learning goals

*What you should know.* Presentation of a rough definition of the notion of substance (prior knowledge)

*A problem.* Description of the experiment of mixing water and alcohol

*The limits of our perception.* Discussion about the limits of our perception. Introduction into the discreteness of the structure of matter. Introduction of the notions of building block, particle and model

*How do we imagine the particles?* Presentation of a particle model

*When do particle models help?* Information that the presented particle model can be used to explain specific phenomena

*The mysterious volume reduction.* Explanation of the experiment of mixing water and alcohol using the particle model

*The mysterious disappearance of salt.* Presentation of the phenomenon of salt dissolving in water. Addressing of the misconception that particles are small fragments of the substance. Explanation of the phenomenon using the particle model

*No heading.* Prompt to remind that the particle model is only an idea that helps to explain phenomena

*Do the particles have a colour?* Addressing of the misconception that the particles have the same features as the bulk substance

*What is between the particles?* Addressing of the misconception that air fills the space between the particles of a substance

*Is there a "correct" model?* Addressing of the misconception that a model is correct or false

*At the end.* Prompt to review each paragraph and to compare the main ideas presented in the text with one's own ideas

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**Figure 2: The CCT used in teaching about the particle theory of matter (Beerenwinkel *et al.*, 2011, p. 1245)**

The study used a control and experimental group and pre- and post-test evaluation, as described below.

*"The study was conducted with the nine classes described above at the end of the school year. The experiment took place in a regular classroom situation during two consecutive weeks. In the first week, students completed the pre-test (20 min). The following week, the students were randomly assigned to read the conceptual change text (111 students) or the traditional textbook text (103 students). After 15 min, the texts were collected, and the students were given the post-*

*test (25 min). There was no other training than reading the conceptual change text and the traditional textbook text, respectively."* (Beerenwinkel *et al.*, 2011, pp. 1242-143)

After the lessons, the students received the same post-test with 18 closed-end and 2 open-end questions. The results are summarised below and showed a significant ( $p < 0.001$ ) improvement of the experimental group (CT) over the control group (TT).

*"CT and TT readers scored mean values of 502 and 498 on the pre-test, respectively. On the post-*



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test, CT readers excelled TT readers with a mean value of 683 compared to a mean value of 551.” (ibid, p. 1252)

The authors summarise their work:

“..it is very positive that a learning effect could be found after a treatment as small as reading a text. The results suggest that the conceptual change text helped students in becoming aware of alternative ideas and in distinguishing them from the scientifically accepted view, i.e. that the text supported students in developing metaconceptual awareness. However, for fostering long-lasting conceptual change processes, comprehensive teaching approaches are needed including conceptual change texts as only one of several tools.” (ibid, pp. 1254-1255)

The CCT approach to dealing student misconceptions has a lot of promise but the approach should be taken over the whole course, and topics revisited later to reinforce the correct ideas. It is also important that the assessment (formative and summative) uses questions which test understanding of concepts and not just recall of definitions. There is a big literature on CCM and CCT relating to teaching science, but the report by McKenna (2014) and the paper by Beerenwinkel *et al* (2011) will give you an introduction to the topic..

#### References

Atasoy, B., Akkus, H., and Kadayifci, H. (2009). ‘The effect of a conceptual change approach on understanding of students’ chemical equilibrium concepts.’ *Research in Science Education*, 27(3), 267-282.

Beerenwinkel, A., Parchmann, I., & Gräsel, C. (2011). ‘Conceptual Change Texts in Chemistry Teaching: A Study on the Particle Model of Matter.’ *International Journal of Science & Mathematics Education*, 9(5), 1235-1259.

doi:10.1007/s10763-010-9257-9 Online at [10763\\_2010\\_Article\\_9257.pdf \(rero.ch\)](https://www.rero.ch/10763_2010_Article_9257.pdf) Accessed 5/5/21

This paper deals with a topic common to all introductory chemistry courses and one which is rife with misconceptions.

Hattie, J., (2008), *Visible Learning*, London: Taylor and Francis

McKenna, D.M. (2014), *Using Conceptual Change Texts to Address Misconceptions in the Middle School Science Classroom*

[Using Conceptual Change Texts to Address Misconceptions in the Middle School Science Classroom \(brockport.edu\)](https://www.brockport.edu/Using_Conceptual_Change_Texts_to_Address_Misconceptions_in_the_Middle_School_Science_Classroom)

A useful account of a programme to design conceptual change texts to teach areas of basic earth sciences, with examples of lesson plans. These lessons would be useful in teaching the Earth and Space strand in Junior Science, and includes a lesson on air pressure.

Posner, G.J., Strike, K.A., Hewson, P.W. & Gertzog, W.A. (1982). ‘Accommodation of a scientific conception, toward a theory of conceptual change.’ *Science Education*, 66(2), 211-227.

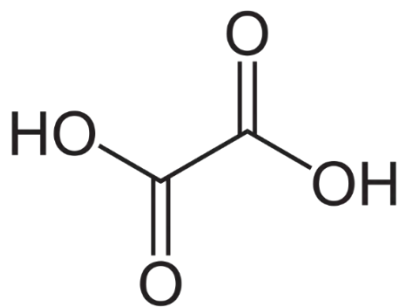
#### Short guide to using CCM:

[The Conceptual Change Process: What Is It? When & How Do I Use It? \(evidencebasedteaching.org.au\)](https://evidencebasedteaching.org.au/The_Conceptual_Change_Process:_What_Is_It?_When_&_How_Do_I_Use_It?)

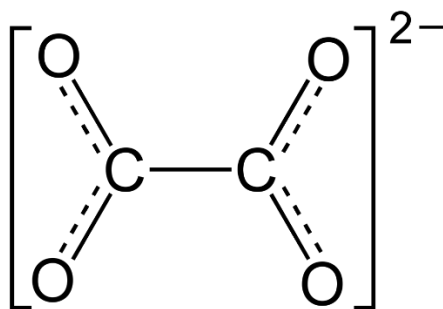
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**Let us know if this article is useful and whether you have tried the lesson plans in McKenna’s work. If you’ve found a chemistry/science education article useful in your own teaching, we would welcome an article from you explaining how it was useful.**

## Oxalic acid (ethanedioic acid) $\text{H}_2\text{C}_2\text{O}_4$



Ethanedioic acid  
(Oxalic acid)



Ethandioate ion  
(Oxalate ion)

Ethanedioic (oxalic) acid is a dicarboxylic acid, the first member of a series of such acids (Table 1). It was named oxalic acid after the plant wood sorrel, which belongs to the *Oxalis* family.

It is familiar in the chemistry laboratory as a reducing agent used in potassium permanganate titrations. These titrations are unusual in three ways: the acid needs to be heated first to give an adequate reaction rate, as oxidation involves breaking a strong C-C bond; once started it is autocatalytic; and it doesn't need an indicator, as  $\text{KMnO}_4$  is its own indicator.

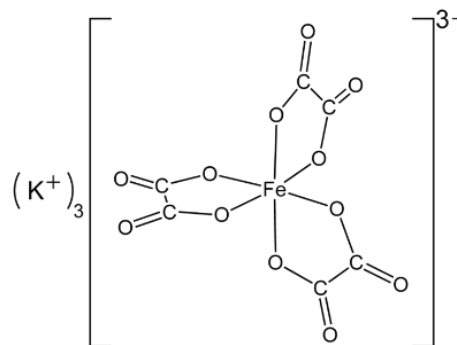
Most titrations involve reactions between ions or electron transfer and are fast; reactions which require breaking covalent bonds (in organic molecules) are usually slow unless heated or when a catalyst is present.



One of the striking things about ethanedioic acid is that it is a fairly strong acid, compared to other carboxylic acids –  $\text{pK}_{\text{a}1}$  is 1.27 compared to  $\text{pK}_{\text{a}}$  for ethanoic acid of 4.76 (see Table 1). Carboxylic acids are usually weak acids as the -O-H bond is hard to break, unless an electron withdrawing group is attached to the carbon next to -COOH. **So why is ethanedioic acid so much stronger for the first dissociation?** A carboxylate ion is

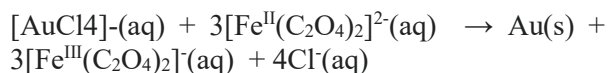
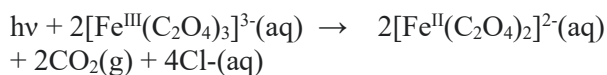
stabilised by delocalisation over the two oxygens and carbon, and in ethanedioic acid, the second -COOH group is an electron-withdrawing group, increasing acidity. This effect is reduced if there is a -CH<sub>2</sub>- in between as in malonic acid (Table 1).

Ethandioate ion is a chelating agent as it can bond through both -COO<sup>-</sup> groups (through -O<sup>-</sup>) to a metal ion. This lies behind its ability to remove iron stains. The ethandioate ion complexes the iron(III) in the stain to form a soluble complex, which can be washed away.

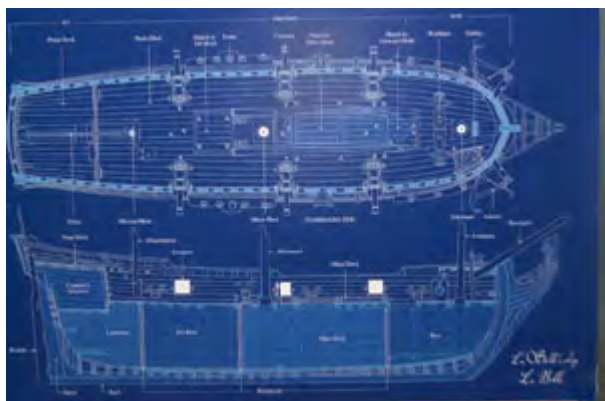


$\text{K}_3[\text{Fe}(\text{C}_2\text{O}_4)_3]$

This same complex was the basis of a photographic process called the siderotype process, invented by Sir John Herschel. UV light converts iron(III) in the oxalate complex to iron(II). This is a reducing agent and can reduce noble metal salts to the metal, producing an image. When gold salts were used they were known as chrysotypes, with silver argentotypes and with mercury, celenotypes. Later platinotypes and palladiotypes were developed, each with their particular appearance. (See Mike Ware, 2007, 'The enduring image', *Chemistry in Britain*, August, pp 62-65.)



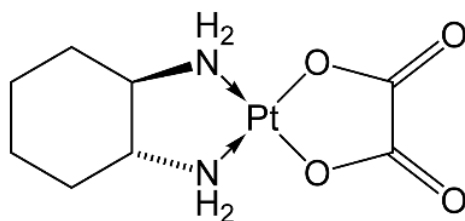
The iron(II) complex can also be coupled with hexacyanoferrate(III) to produce a blue colour. This was called the cyanotype process but later became better known as the blueprint, a reprographic process for large drawings which lasted into the late 20<sup>th</sup> century. (See [Cyanomicon \(unblinkingeye.com\)](http://unblinkingeye.com)) Later oxalate was replaced by citrate. It gives a white image on a blue background.



A blueprint [LaBelle Blueprint - Blueprint - Wikipedia](#)

Oxalic acid solutions are widely used as domestic stain removers, e.g. removing dark stains from wood.

Oxaliplatin is an anti-cancer drug which has greater water solubility than other platinum-based drugs.



[Oxaliplatin - Wikipedia](#)

The ethanedioate (oxalate) ion forms insoluble salts with divalent ions, like calcium, and this is a problem because when foods containing oxalate are eaten, they can form calcium oxalate, which in turn can form painful kidney stones. Eating milk or custard with rhubarb feels furry/gritty in the mouth, as the calcium in the milk forms calcium oxalate.

**Table 1: Common dicarboxylic acids ([Dicarboxylic acid - Wikipedia](#))**

n	Common name	Systematic IUPAC name	Structure	pK <sub>a1</sub>	pK <sub>a2</sub>
0	<a href="#">Oxalic acid</a>	<a href="#">ethanedioic acid</a>		1.27	4.27
1	<a href="#">Malonic acid</a>	<a href="#">propanedioic acid</a>		2.85	5.05
2	<a href="#">Succinic acid</a>	<a href="#">butanedioic acid</a>		4.21	5.41
3	<a href="#">Glutaric acid</a>	<a href="#">pentanedioic acid</a>		4.34	5.41
4	<a href="#">Adipic acid</a>	<a href="#">hexanedioic acid</a>		4.41	5.41
5	<a href="#">Pimelic acid</a>	<a href="#">heptanedioic acid</a>		4.50	5.43

□

## Quotable Quotes

***“As almost all chemistry is nanotechnology and I am a chemist, I’ve been working on nanotechnology without knowing for these past forty years.”***

Harry Kroto *THES* 18/7/03

***“Chemical nomenclature is rather like visiting the dentist: nobody enjoys it; it’s painful, and everyone agrees that it is important and necessary.”***

Ian Farrell *Chemistry World* April 2004 p. 61

***“I think, however, that there isn't any solution to this problem of education other than to realize that the best teaching can be done only when there is a direct individual relationship between a student and a good teacher - a situation in which the student discusses the ideas, thinks about the things, and talks about the things. It's impossible to learn very much by simply sitting in a lecture, or even by simply doing problems that are assigned. But in our modern times we have so many students to teach that we have to try to find some substitute for the ideal.***

**Richard P. Feynman**

***There’s plenty of room at the bottom***

Richard Feynman 1960

[Nanotechnology: There’s Plenty of Room at the Bottom – Richard Feynman](#)

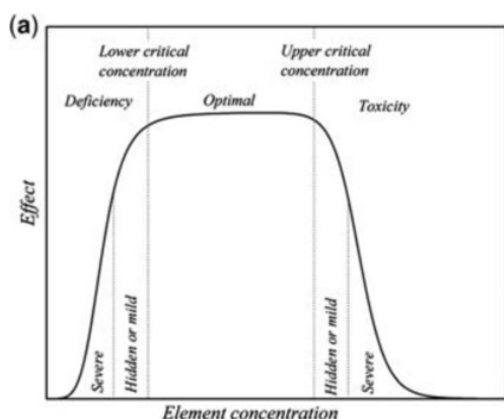
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# Chemlingo: More on metal poisoning

Peter E. Childs

In the previous Chemlingo (*CinA!* #116, 2020, p.62) we looked at some examples of heavy metal poisoning. Here we look at some more examples.

Copper poisoning (*copperiedus*) may be due to ingesting copper salts (1 g of copper(II) sulfate is a poisonous dose!) or due to a metabolic disease, causing accumulation of copper, when it is known as Wilson's disease. Copper is an essential element: if we don't get enough in our diet we suffer deficiency and if we have too much, it poisons us. This is true of many essential trace elements. This is shown in the idealised dose-response curve below. It gives a new meaning to the phrase 'the happy mean' – we all must live within our trace element means, different for each trace element.



**A response-dose curve for a trace element**

Cobalt behaves similarly – we need trace amounts in our diet to produce vitamin B12, but too much and cobalt is a poison. Pernicious anaemia is due to a lack of B12 and may result from a vegetarian diet. Cobalt poisoning is known as *cobaltism*. The LD50 is 150-500 mg/kg or 15-50 g for a 100 kg person. This is a lot of cobalt and only a trace would be found in cobalt chloride paper.

*Manganism* or manganese poisoning is due to chronic exposure to manganese, and was also known as manganese madness, when first identified in 1837 by James Couper. Its symptoms are similar to those of Parkinson's Disease. It is found among manganese miners and workers producing dry cells, which use manganese(IV) oxide.

Exposure to platinum salts can result in *platinosis*. Cadmium poisoning due to inhaling cadmium dust can cause *cadmiosi*s. Chromium poisoning due to Cr(VI) in water was highlighted in the film *Erin Brockovich*, whereas chromium (III) is relatively safe. This is what lies behind the banning of dichromate in Irish schools. Not just the dose but also the oxidation state matters.

Even iron can be a poison in excess and *siderosis* is the name given to iron poisoning. The name comes from the Greek for iron, *sideros*. It usually occurs when children eat iron tablets. A metabolic disorder, called haemochromatosis, causing the accumulation of iron, can also lead to ill-health and death, and is usually treated by blood-letting.

We need to be wary of exposure or ingestion of all heavy metals, but it is also true that many are also essential elements, but in trace amounts. Too little and too much of the same element can both be harmful. [Paracelsus](#) (1494-1541) first expressed the classic toxicology maxim "*All things are poison, and nothing is without poison; the dosage alone makes it so a thing is not a poison.*"



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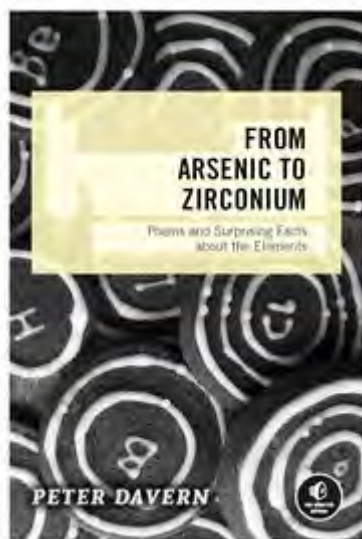
# Elementary Chemistry

## Neon lighting

Georges Claude (24 September 1870 – 23 May 1960) was a French engineer and inventor ([Georges Claude - Wikipedia](#)). He produced a discharge in a tube filled with neon gas in 1902. He made the first public display of neon lighting in Paris in 1910. Claude Neon, his company, introduced neon signs into the USA.



## From Arsenic to Zirconium



This is a revised version of the book self-published on Amazon, with improved presentation and graphics. The book is a collection of limericks and information on each of

the elements by Dr Peter Davern of the University of Limerick. It is available from the Book Depository at €14.15 inc. p&p. It is full of interesting information on the elements to enliven your lessons. It would also make a good present or prize for an aspiring young chemist. Some of the earlier limericks were published in CinA! Peter is to be congratulated on his creativity and energy.

\*\*\*\*\*

**1 tonne of scrap from old PCs contains more gold than 16 tonnes of gold ore. 35 mobile phones contain about 1 g gold. 1 tonne gold ore contains between 1-6 g gold and each year about 2,700 tonnes of gold are mined.**

\*\*\*\*\*

## Chemical limericks

*There once was a lady called Harris  
Whom nothing could ever embarrass.  
'Til the bath salts one day  
In the tub where she lay  
Turned out to be Plaster of Paris.*

Why not get your students to write some chemical limericks, as an exercise in creativity? Send in the best to *Chemistry in Action!* and it may get published. They have to be original, so no copying!

\*\*\*\*\*

## Remember the score

*When Oxygen Tech played Hydrogen U.  
The Game had just begun, when Hydrogen  
scored two fast points  
And Oxygen still had none  
Then Oxygen scored a single goal  
And thus it did remain, At Hydrogen 2 and  
Oxygen 1  
Called off because of rain.*

\*\*\*\*\*

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## Information page

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Send by email as a Word document when submitting material. Do not embed diagrams, photos or tables but just insert between paragraphs.

You can contact the editor by email at: [peter.childs@ul.ie](mailto:peter.childs@ul.ie) or one of the assistant editors.

\*\*\*\*\*

### Internet version

The most recent back issues plus some TY Science modules and other resources are available at: [www.cheminaction.com](http://www.cheminaction.com)

For information contact the web editor, Maria Sheehan at [mariasheehan400@gmail.com](mailto:mariasheehan400@gmail.com)

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### TY Science Modules

We have discontinued selling these modules in print, as postage got too expensive. At present 6 of them are available online, free of charge, at our website:

[www.cheminaction.com](http://www.cheminaction.com)

We hope to make more of them available in future.

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### In the next issue:

**Chemical Myths Exploded Part 3**

**Gemstones Part 3**

**Metal mirrors**

**Sample Chemical Olympiad Questions**

## *Acknowledgements*

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