
Contents

1. Contents
2. Editorial
3. Education News and Views
6. Chemistry and the Holocaust Jane Essex
9. Context-based Chemical Education: how to improve it? Onno de Jong
14. The value of using demos in teaching Brigid Corrigan
16. Thinking about Big Questions: a website to support teaching about how science works
Keith S Taber, Berry Billingsley, Fran Riga & Helen Newdick
19. Games to consolidate learning in Chemistry Maeve Liston
21. The Instrument Makers #1 Petrus Jacobus Kipp 1808 – 1864
Adrian Ryder
25. Proceedings 30th ChemEd-Ireland 2011
26. Nanochemistry in the new LC Chemistry Syllabus Justin D. Holmes
34. Chemistry for Non-Specialists John Daly
41. Problems with Ozone Marten J. ten Hoor
44. Conference Reports:
50th ISTA Annual Meeting, Dublin
SMEC 2012
46. More Laboratory Accidents Sarah Hayes
48. Diary
49. Tested Demonstrations #7 Reactions of sodium with water
50. Tested Demonstrations #8 Turpentine (α - pinene) and iodine
52. Information Page

Disclaimer

The views expressed in *Chemistry in Action!* are those of the authors and the Editor is not responsible for any views expressed. *Chemistry in Action!* does not represent the official views of any institution, organisation or body. Any unsigned articles or items are the responsibility of the Editor and if reprinted the Editor should be credited. If any errors of fact are published, or anyone's views are misrepresented, then the Editor will be glad to publish either a correction or a reply.

The Editor is not responsible for any actions taken as a result of material published in *Chemistry in Action!*. Any experiments or demonstrations are done at your own risk and you should take all necessary safety precautions, including wearing eye protection. Teachers may copy materials from *Chemistry in Action!* freely, without prior permission, for use in their schools. Articles and other material in *Chemistry in Action!*, except those originating in other publications, may be used freely in other educational publications without prior permission. Please acknowledge the source and author and send a copy of the publication to the Editor. Prior permission is needed if material is being used in commercial publications.

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 or disc) to peter.childs@ul.ie together with a printed copy.

For subscription details etc. see inside back cover.

Cover photo: Bob Becker lights up the 50th ISTA conference in TCD. (Photo: P.E. Childs)

Editorial

Change is in the air

Despite the economic cut-backs it seems that real curriculum change is in the air. The three LC science subjects – Biology, Chemistry and Physics – were sent out for consultation last year and the results of the consultation have been put on line and the syllabi have been revised in the light of the comments. The Education Officers for the three sciences – Brendan Duane (Chemistry), Kevin Maume (Biology) and Michael Halton (Physics) – have been working on the details of the practical assessment (the major innovation in the new courses) and on the written assessment. There are real signs of joined-up thinking in trying to relate learning outcomes and the assessment, and trying out different approaches, before the syllabi are finally introduced (possibly by 2014). Workshops have been held on writing written assessment questions and giving teachers experience of the new practical assessment tasks. A project between the NCCA and NCE-MSTL has been looking at bringing inquiry-based learning into the Physics classroom.

In the past there has not been enough correlation between the curriculum (what is taught), pedagogy (how the subject is taught), and assessment (how the subject is assessed). The right things might be said in the introduction to the syllabus, explaining its philosophy and how it should be taught, but this has rarely transferred into the classroom and laboratory. The way teachers have taught the curriculum has been largely dictated by the final examination (100% theory) and the interpretation of the curriculum by the textbooks. The stated aims and objectives have not always been apparent in the examinations, which have largely used lower-order questions. It is no wonder that outside bodies – industry, universities, professional institutions – have complained that the LC examinations reward rote-learning and regurgitation of information, do not develop critical thinking, understanding or creativity, and do not fit students either for higher education or the world of work. The ‘points race’ for third level entry is usually blamed for these failures, but the real culprit is the formulaic, predictable nature

of the examinations, which usually only require lower order answers.

You cannot change the way the curriculum is taught, however good it may be, unless the form of assessment is changed. It is often said that assessment is the tail that wags the educational dog, and not just in Ireland. It is possible to teach for understanding within the constraints of the current chemistry syllabus, as the *ITS Chemistry* and *Organic Chemistry in Action!* action research projects have shown. However, this approach would be much easier if the syllabus and assessment were designed to promote inquiry-based learning and understanding.

Curriculum development and educational change is expensive when done properly. It requires appropriate and adequate CPD before a new curriculum is implemented, and teachers need to be aware of what the final assessment will be like when they start teaching the course, not near the end. The biggest costs in changing the LC science syllabi, along the lines proposed by the NCCA, will be for the practical assessment and for CPD. If it is introduced for all three syllabi at once, then there will have to be practical assessments for ~40,000 students across the three sciences. This will be incredibly costly in terms of the materials, organisation, examiners etc. and will be an annual recurrent cost. It would make more sense to trial the changes in the smaller subjects first – Physics and Chemistry. If teachers are required to adopt a new teaching approach e.g. using inquiry-based teaching and learning, then they cannot change learning styles overnight or on the back of a few hours of CPD. In fact I heard someone say that to change teacher behaviour needs 80 hours of CPD!

In the past good ideas for curriculum reform in Ireland have been undermined by poor implementation – new courses have been rushed in without proper trialling, without evaluation and with inadequate teacher preparation. Let us hope the lessons have been learnt and that the new science syllabi will be implemented properly and not rushed in to meet a political agenda. Education is a long-term game and unfortunately politicians have only a short-term view.

Peter E. Childs

Hon. Editor

Education News and Views

Consultation report on LC science courses

You can access information on the proposed changes to the LC science syllabi on the NCCA website at:

http://www.ncca.ie/en/Consultations/Senior_Cycle_Science/Senior_Cycle_Science_Consultation.html

The NCCA published the results of the consultation on the proposed new LC science syllabi in April 2012.

The report concluded:

“The consultation responses signal a broad welcome for the focus of the review of the science syllabuses. There is a general acceptance that throughout the courses involved learners should engage in inquiry with the attendant change in focus of the practical activities as currently undertaken. As learners develop knowledge and understanding of fundamental science concepts and ideas, they will develop key skills and appreciate how science impacts on society. To enable this to happen, and to be achievable within the 180-hour time frame, the learning outcomes will have to be limited in number, but rich in content. This is an area where the consultation process failed to reach consensus.

Although there were repeated calls for reduction in content in all three syllabuses, teachers find it difficult to imagine a syllabus that does not retain all of the traditional areas of learning. There is also new content to be added. Technology has had a phenomenal impact on our understanding of science; developments at the Nano scale, genome mapping, space exploration, the Large Hadron Collider and the impact of humanity on Earth’s ecological balance all deserve their place in a 21st century science syllabus.

One of the main areas of feedback emerging from the consultation was a strong desire for a change in assessment. There was consensus that the assessment of the revised syllabuses should not reward rote learning; assessment that meets the objectives of the revised syllabuses will include higher order thinking and problem solving. It will

not be predictable, rather it will require learners to deal with unseen and unfamiliar concepts by applying prior learning.”

This consultation document is available at:

http://www.ncca.ie/en/Curriculum_and_Assessment/Post-Primary_Education/Senior_Cycle/Consultation/Science_Consultation_Report.pdf

□

Schools to drop subjects due to cutbacks

Sixty-four per cent of 151 second-level schools surveyed by the ASTI are considering dropping one or more subjects from their Leaving Cert programme as a result of Budget 2012 education cuts, a study commissioned by the ASTI has found. (Published 4/4/12)

The Leaving Cert subjects most likely to be dropped by schools in September 2012 are accounting, chemistry, physics, and economics. Amalgamation of higher, ordinary and foundation level classes is another likely response to Budget cuts. Fifty-seven per cent of schools indicated that they are likely to amalgamate some classes at Leaving Cert level. Thirty-two per cent said they are considering amalgamating some 5th and 6th year classes.

[http://www.asti.ie/index.php?id=38&no_cache=1&tx_ttnews\[tt_news\]=603](http://www.asti.ie/index.php?id=38&no_cache=1&tx_ttnews[tt_news]=603)

Comment: *so much for promoting the knowledge-economy and encouraging the take-up of the sciences.*

□

New report on Maths

The National Competitiveness Council published a new report on 4/7/12 by Sean McDonagh and Tony Quinlan on the place of Maths in the Irish curriculum and particularly on the lack of high achievers and popularity of Maths.

<http://www.rte.ie/news/2012/0704/Mathsreport.pdf>

They contrasted the popularity of subjects for the Scottish Higher, UK A level and Irish LC Higher examinations for males and females (see below).

a) Males

	Scottish Highers	UK A-level	Irish Higher Leaving Cert.
1	English	Maths	English
2	Maths	Biology	Geography
3	Physics	English	Biology
4	Chemistry	Physics	Construction
5	PE	Chemistry	Bus. Studies
6	History	History	French
7	Geography	Gen. Studies	Irish
8	Biology	Bus. Studies	Maths
9	Modern Studies	Geography	History
10	Bus. Management	Economics	Engineering

b) females

	Scottish Highers	UK A-level	Irish Higher Leaving Cert.
1	English	English	English
2	Maths	Psychology	Biology
3	Biology	Biology	Geography
4	Art/Design	Art/Design	Irish
5	History	Maths	French
6	Chemistry	History	Home. Econ.
7	Modern Studies	Sociology	Bus. Studies
8	Bus. Management	Chemistry	Art
9	Geography	Gen. Studies	Maths
10	French	Media/TV	Music

The report mainly highlighted the position of Maths, which is much higher for males and females in Scotland and the UK. However, we should also note the position of the sciences: biology is the most popular science for females and for males in the UK and Ireland. In Ireland biology is the only science in the top 10 for both males and females and chemistry and physics are not present. In Scotland for males physics and chemistry are 3rd and 4th, and 4th and 5th in the UK. For females chemistry is 6th in Scotland and 8th in the UK. Although Maths is the enabling subject for science and engineering, we should also be worried about the popularity of the sciences, particularly the physical sciences. Scotland, in particular, is doing a good job in making the physical sciences popular, as is the UK for males. In Scotland this has been ascribed to the

introduction of new context-based syllabi, which are more attractive to students.

The report makes the claim that “Mathematical literacy drives economic growth”. Not only do small numbers take Higher Level Maths (even though almost everyone takes Maths at some level), but the % of high achievers in Maths in Ireland is well below the OECD average, as measured in the 2009 PISA test. Ireland ranked 32nd out of 65 countries and 0.9% of Irish students were at the highest level (compared to an OECD average of 3.1%) and only 5.8% at the second level of achievement compared to an OECD average of 9.6%. Thus Irish students are under-achieving in Maths. The report makes the point that Maths should be treated differently and is not just ‘another subject’:

3.1 There is a widespread, false and dangerous view that Mathematics is just another subject. Indeed until recently, the Points System unintentionally supported that view, in that it awarded Mathematics the same points as any other subject. This view in the past informed decisions to reduce time for Mathematics at primary and lower second level to make time for other subjects.

3.2 Mathematics is a double examination subject (i.e. students sit two examination papers) - a fact that gets no recognition in the Points system (so too is English, also unrecognized). As mentioned above about 16 percent do Higher Level Mathematics in contrast to the 70 percent, on average, of other subject students who do the Higher course (excluding Math and Irish). Mathematics develops vital intellectual capabilities and enhances generic skills such as logical analytical reasoning and problem solving skills. It requires student application and develops self learning skills. It is a prerequisite and enabler of other disciplines. (p.8)

The report also looked at the effect of Maths performance on persistence (retention) in higher education. Those with 60 or more points from Maths had much better persistence rates than those with lower scores. The authors state: “Mathematical achievement is one of the best predictors of persistence and success in Higher Education (HE). Improving Mathematical achievement improves preparedness for higher studies and the quality of higher qualifications and skills.” (p.9)

This is an important and timely report and it makes some important recommendations to improve achievement in Maths by Irish students. Whether Project Maths can deliver all that is expected of it, remains to be seen.

□

New postgraduate Maths course for out-of-field teachers

The National Centre for Excellence in Mathematics and Science Teaching and Learning (NCE-MSTL) based at the University of Limerick is to lead a national programme for up-skilling out-of-field teachers of mathematics, which will run over the next three years. The Minister of State for Research and Innovation, Seán Sherlock, TD today officially launched funding for the Professional Diploma in Mathematics for Teaching (Part-time) on 25/5/12.

Professor John O'Donoghue, Director, National Centre for Excellence in Mathematics and Science Teaching and Learning (NCE-MSTL) said; *"This decision represents an historic step in moves to reform post-primary mathematics. Ireland's urgent need to raise science and mathematics knowledge and skills in order to serve critical national educational, economic and entrepreneurial needs is well documented. This programme will support teachers to focus on subject knowledge and practice that will impact student performance and stimulate interest in mathematics and science"*

The programme will be accredited jointly by the UL and NUI Galway through their strategic alliance, and the NCE-MSTL will be responsible for all aspects of course design, delivery and administration. Approximately 400 teachers will begin the course this autumn.

□

New report on Inquiry-Based Science Education (IBSE)

ALLEA is the Federation of 53 National Academies of Sciences and Humanities in 40 European countries, and the Royal Irish Academy is Ireland's adhering body. ALLEA has just published (2012) a major report on *A Renewal of Science Education in Europe*, based on surveys done in 2010 and 2011. The report makes a strong case for IBSE to be

adopted as the solution to renovating science education in Europe.

26 countries including Ireland (p. 57) describe science education activities in their countries.

The report can be accessed at <http://www.allea.org/Content/ALLEA/WG%20Science%20Education/Helsinki/Report%20ALLEA%202012%20last.pdf>

This report is largely derived from the Rocard Report of 2007 *"Science Education NOW: A renewed Pedagogy for the Future of Europe"* (http://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf) which recommended:

"A reversal of school science-teaching pedagogy from mainly deductive to inquiry-based methods provides the means to increase interest in science. Inquiry-based science education (IBSE) has proved its efficacy at both primary and secondary levels in increasing children's and students' interest and attainments levels while at the same time stimulating teacher motivation. IBSE is effective with all kinds of students from the weakest to the most able and is fully compatible with the ambition of excellence. Moreover IBSE is beneficial to promoting girls' interest and participation in science activities. Finally, IBSE and traditional deductive approaches are not mutually exclusive and they should be combined in any science classroom to accommodate different mindsets and age-group preferences."

This is turn led to the EU funding a large number of IBSE projects in Europe in the last few years, including the FP7 projects ESTABLISH and SAILS, both coordinated by DCU. It remains to be seen whether putting all our science education eggs in the IBSE basket will indeed lead to the renovation of science education in European schools.

□

Chemistry numbers up in 2012

Provisional figures show that 8,399 students took LC Chemistry this year, 15.45% of the LC cohort (92.1% at HL), a welcome increase on last year's figures (7,677 and 13.85%). This is a 9.4% increase in numbers taking LC Chemistry.

□

Chemistry and the Holocaust

Jane Essex

Keele University, Staffordshire, U.K. j.e.essex@keele.ac.uk

Introduction

World Holocaust Memorial Day is an annual event intended to commemorate victims of genocide. Science subjects, including Chemistry, have an important perspective to bring to the story of the persecution and murder of 6 million Jews and an estimated 5 million other victims of Nazi Germany.

Chemistry provided essential materials for the Third Reich's expansion and implementation of the Holocaust and was crucial for the execution of the policy, but individual chemists were often not afforded respect for their contribution to the chemical sciences. This article looks at the contribution of chemistry to the Holocaust, identifying some of the chemists who implemented Nazi policies. It then considers the fate of some of the individual chemists who were affected by the events of, and preceding, the Holocaust.

Chemistry provides the materials of war

In the wake of a costly defeat in World War 1, the German government sought to regenerate business by encouraging companies to collaborate. IG Farben (Interessengemeinschaft Farbenindustrie Aktiengesellschaft, or the 'Syndicate of Dyestuff Industry Corporations') was one such industrial coalition, and one which had a major focus on chemical manufacturing. The largest company in Europe at the time, IG Farben was formed in the 1920s by the collaboration of several companies including the Agfa film company and B.A.S.F. (Badische Anilin- und Soda-Fabrik). B.A.S.F. had enjoyed huge commercial success through developing the means of manufacturing of ammonia from atmospheric nitrogen. This major development had been based on an idea of Fritz Haber's which was bought by B.A.S.F. and made technically possible by a B.A.S.F. engineer, Carl Bosch. The Haber Bosch process was first run on an industrial scale in 1913, and it made ample quantities of ammonia available for the production of fertilisers, explosives, dyes and medicines. Despite his major contribution to Germany's fortunes, Haber, whose story is

described in the accompanying biography, was later forced to flee Germany as the Nazi regime became increasingly hostile to 'non-Aryans'.

A further consequence of Haber and Bosch's development was the availability of high pressure technology for the synthesis of other materials. The products included methanol ('wood alcohol') and crude oil substitutes from coal, which could be manufactured on a commercial scale. These syntheses involved the reaction of gases under pressure; carbon monoxide and hydrogen for methanol, or steam with the graphene molecules in coal to produce kogasin. High pressure technologies were a key development in the Third Reich's war effort because Germany lacked reserves of crude oil, but had coal deposits. Kogasin was a diesel-like substance, essential to keep military vehicles moving; unfortunately this fuel cost ten times more than the same material from crude oil and was very labour-intensive to manufacture.

Another essential oil-substitute was the synthetic rubber, Buna; the name is a shortened form of butyl-diene, now called buta-1,3-diene, and the symbol for sodium. The manufacture started with the heating of coal and lime; the resulting calcium carbide was hydrolysed, producing ethyne. Ethyne, in turn, underwent an addition reaction which yielded buta-1,3-diene. This alkene served as the monomer for a further addition polymerisation reaction in the presence of a sodium catalyst to give the rubber. Buna was needed for the war effort, mostly for the tyres of military vehicles, but when war broke out there was only sufficient stock for two months. The National Socialist government's plans to build a 'colony' east of Germany where prisoners could be set to work, offered the opportunity for Farben to increase Buna production with minimal labour cost. In total, IG Farben built six labour camps, including Monowitz (Auschwitz III) where almost half of the Buna output was manufactured.

Monowitz was described as 'systematic and ordered squalor' by Primo Levi, who worked there and later wrote a number of books and

poems about his experiences. Conditions for the slave labourers in work camps were almost universally appalling, reflecting the Nazi s' view that the Untermenschen (sub-human) population was a 'disposable' commodity. Primo Levi, had worked successfully as an industrial chemist before the war, as outlined in his biography. His knowledge enabled him to be placed in a specialist work group (Kommando) and, finally, to work in the laboratories at Monowitz. Levi attributed his survival to his redeployment into the laboratory. He describes the work he was doing before entering the laboratory; it sounds very unpleasant but was far from the worst job in the work camp.

'There were six of us, scraping and cleaning the inside of an underground petrol¹ tank; the daylight only reached us through a small manhole. It was a luxury job because no one supervised us; but it was cold and damp. The powder of the rust burnt under our eyelids and coated our throats and mouths with a taste almost like blood.' (Levi, 1987: 115)

In a very few cases, the officer in charge of a work camp did attempt to help their hapless slaves. A noteworthy example of this is an army officer and chemist, Major Karl Plagge, who protected the work force at the vehicle repair workshop which he ran in Lithuania, despite the personal risks involved. His story, described in the accompanying biography is unusual, not only as that of a chemist who was a rescuer, but also as someone whose scientific background helped him to evaluate critically the Nazi propaganda on racial 'science'.

Chemistry in the ghetto

In contrast to Primo Levi's monotonous work, the biochemists Ludwik and Hanka Hirszfeld continued to do authentic research, even after their incarceration in the Warsaw ghetto in 1941. They set up a laboratory, where they studied typhus, a disease which was killing many ghetto dwellers, and the effects of starvation on people. Ludwik wrote about the causes of typhus in the ghetto, denying that it was specific to Jews and Slavs, as the German authorities claimed. Instead, he identified the conditions in which ghetto-dwellers lived as the cause of the epidemics. Based on prior knowledge, and drawing upon his

own, detailed observations, he wrote about how, when it was impossible for people to change and wash their clothes, the eggs of the fleas which carry the bacteria were able to hatch and the young fleas transmitted the disease. He was the most prominent of the ghetto's scientists who taught at an unofficial medical school, set up to train ghetto inhabitants to become much-needed doctors. Despite the horrors of their surroundings, Ludwik and Hanna continued to believe in the value of science and its power to improve lives.

Chemistry kills

Just before the war broke out a euthanasia programme was established, which initially targeted children with disabilities. Carbon monoxide in exhaust fumes was the poison first used, but it was quite slow to act and difficult to make in the large quantities needed as mass exterminations of adults began. Hydrocyanic acid (HCN) is a volatile liquid which prevents cells from carrying out respiration. It had previously been used as a pesticide, to remove insects from crops and infested buildings. However, it was not very stable and could be explosive in high concentrations. In the 1920s two new formulations of hydrocyanic acid were patented, the second one being Zyklon B (Cyclone B in English, the B stood for Blausäure, the non-systematic German name for hydrogen cyanide). The improved system used absorbent crystals, a stabiliser to slow release and a smell (methyl 2-bromoethanoate) to warn operators of its presence; it was invented by an assistant of Fritz Haber at the Kaiser Wilhelm Institute in Berlin. Later, between 1940 and 1941, officers at Auschwitz conducted a trial of Zyklon B with prisoners; their findings of which paved the way for its widespread use in death camps. Amongst the victims of Zyklon B was the eminent Dutch chemist, Professor Ernst Cohen, who had studied variations in metal crystals, focusing on tin, and also electrochemistry. He was killed at Auschwitz in 1944.

Chemistry in the aftermath of the Holocaust

Whilst science provided the means of murder, individual scientists found the moral courage to oppose the mass killings. Kurt Gerstein, an SS officer who had worked as a mines engineer, gave vital testimony to post-war investigators. His accounts of the properties of Zylon B, combined with his estimates of the quantities of residual

¹ Probably kogasin

clothing after one cycle of gassing at Treblinka and Belzec, proved essential to the post-war efforts to uncover the full scale of the atrocities of the death camps. He died in captivity immediately after the war, possibly at the hands of fellow officers.

The impact of the events during the Holocaust continued to impact on both chemists and the practice of chemistry. One indirect victim was the future Nobel prize winner for Physics, Walter Kohn. He escaped to Canada as a teenager but, as a German refugee, was not permitted to fulfil his ambition of studying Chemistry.

In the light of the abuses that had been carried out in the guise of 'science', new ethical codes of conduct were drawn up for scientists; it would never again be acceptable to do something simply because it might further scientific knowledge.

Conclusion

Whilst the practice of chemistry underpinned the Third Reich's war efforts, the regime inflicted

great hardship on individual chemists. A number of these victims are closely connected to the Chemistry we currently teach; World Holocaust Memorial Day offers an opportunity both to remember their scientific contributions and also to reflect on the consequences of Chemistry applied without a conscience.

Biography

Cornwell, J. (2003) *Hitler's Scientists: Science, War and the Devil's Pact*, Penguin Books

Good, M. (2006) *'The search for Major Plagge'* Fordham University Press, New York

<http://London.iwm.org.uk/server/show/ConWebDoc.1454> regarding The Holocaust Exhibition, Imperial War Museum, London

Hirszfeld, L. (2010) *'The story of one life'* University of Rochester Press

Levi, P (1987) *If this is a man; The Truce* Abacus

Setkiewicz, P.(2008) *The Histories of Auschwitz IG Farben Werk Camps 1941-1945*, Auschwitz-Birkenau State Museum

□

Context-based Chemical Education: how to improve it?

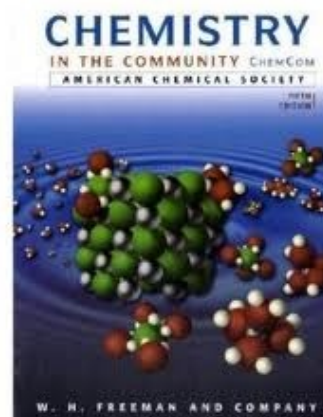
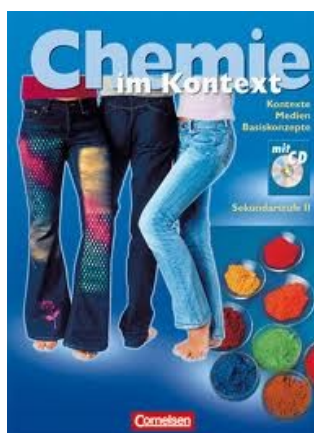
Onno De Jong

Karlstad University, Sweden and Utrecht University, The Netherlands

O.deJong@uu.nl

Introduction

Chemical education reform is under way in many countries. An important reason for this reform is the growing dissatisfaction with the position of many chemistry curricula: quite isolated from students' personal interest, from current society and technology issues, and from modern chemistry. One of the efforts to abolish current curriculum isolation is the use of meaningful contexts for teaching and learning chemistry. From the 1980s, context-based curriculum projects were implemented in mainstream chemistry courses, for instance, the USA project of 'Chemistry in the Community' (ChemCom) and the UK project of 'Salters Chemistry'. Quite recently, new projects were implemented, such as the USA project of 'Chemistry in Contexts: Applying Chemistry to Society' (CiC), and the German project of 'Chemie im Kontext' (ChiK). Contexts were adopted to encourage a more positive attitude and a better understanding of chemistry. However, it appears that the implementation of contexts-based courses is not as simple as it looks like, and effects on students' understanding of chemistry concepts are somewhat disappointing. The present paper discusses some important conditions for improving context-based chemical education.



Contexts: where are they come from?

Contexts can be defined in several ways. Very often, contexts are described as situations that help students to give meaning to concepts, rules, laws, and so on. This definition can be expanded by the notion that contexts can also be described as practices that help students to give meaning to activities in the school laboratory.

Nevertheless, these definitions are quite general. In my opinion, we need more precise descriptions to improve the clarity of discussions about contexts and their use in chemical education. A more precise way of defining consists of looking at the domains of origin of contexts. I would make a distinction between the following four domains of origin (see Table 1).

The personal domain. Contexts taken from this domain are important because schools should contribute to the personal development of students by connecting chemistry with their personal lives. Many everyday life issues are useful. For instance, the context of personal health care can be related to poisonous effects of substances on the body in terms of biochemistry processes, and the context of personal body lotions can be linked with the chemical characteristics of the components of these liquids

The social and society domain. Contexts taken from this domain are important because schools should contribute to prepare students for their roles as responsible citizens by clarifying chemistry and its role in social issues. Many of these issues can be used. For instance, the context of acid rain effects on the environment can be connected with the chemical topics of acid-metal reactions and neutralization reactions, and the context of climate changes can be related to the chemistry of combustion processes or reactions between radicals in the ozone layer of the atmosphere.

The professional practice domain. Contexts taken from this domain are relevant because schools should prepare students for their coming role as professional workers in public or private areas. Several practices are useful. For instance, the practice of chemical engineers can be linked with small scale designing and testing of industrial processes, such as the small scale production of glues or polymers, and the practice of chemical analysts can be related to the chemical topic of investigating the quality of water, food, or medicines.

The scientific and technological domain. Contexts taken from this domain are relevant because schools should contribute to the development of scientific and technological literacy of students. Several issues can be used, especially issues that clarify scientific ways of handling and reasoning. For instance, the context of scientific research methods can be connected with open-inquiry in the school lab, and the context of paradigm shifts in meaning of models and theories in chemistry can be related to the development of acid-base models (e.g. models of Arrhenius, Brønsted, and Lewis) or the shift from the old phlogiston theory towards modern oxidation theories.

Finally, it will be clear that a particular context can be taken from more than one domain. For instance, the context of consumption of food can come from the personal domain as well as from the social and society domain.

Table 1. Four origins of contexts

Origin of a context	Example of a context
*Personal domain	*Personal health care
*Social and society domain	*Acid rain effects on the environment
*Professional practice domain	*Practices of chemical engineers
*Scientific and technological domain	*Historical models and theories

Teaching approaches and functions of contexts

In teaching, the order of presentation of contexts and related concepts can vary, and, for that reason, the function of contexts can also vary (see Table 2). In many traditional context-based approaches, contexts follow concepts. For instance, after teaching the first ten hydrocarbons (from methane to decane), the role of these hydrocarbons in society is addressed. In this teaching, contexts often have two functions. Firstly, contexts are presented as illustrations of concepts that already have been taught, especially in the case of abstract concepts. Secondly, contexts are presented to offer the possibility to students of applying their knowledge of a concept. This can lead to the transformation of the existing meaning of a concept or to the addition of a new meaning to the concept.

In many more modern context-based approaches, contexts precede concepts. For instance, a discussion about environmental pollution and the combustion of petrol in cars and airplanes is followed by addressing the main components of petrol and their chemical characteristics. In this teaching, two other functions of contexts are often emphasized. Firstly, contexts are presented as the starting point or rationale for teaching concepts. Secondly, these contexts not only have an orienting function, but can also enhance motivation for learning new concepts. In some most recent context-based approaches, contexts not only precede concepts but these concepts are also followed by (other) contexts (see Table 4). In this teaching, the four functions of contexts are combined.

Table 2. Context-based approaches and functions of contexts

Teaching approach	Order of presentation	Function of context
* Traditional	* Contexts follow concepts	* Illustration * Application
* More modern	* Contexts precede concepts	* Orientation * Motivation
* Recent	* Contexts precede concepts and (other) contexts follow them	* All functions mentioned above

Effects of context-based approaches

Most of the studies of effects of context-based approaches in chemical education focus on students' learning outcomes, and students' motivation and attitude. The research results show that it is not easy to come to a unanimous judgment about these effects. I will clarify this by presenting results of some exemplar studies below. Some studies indicated that there is hardly any advantage of context-based courses in terms of the development of students' understanding. For instance, Ramsden (1997) compared the effects of a context-based course and a more traditional course to British high school students' understanding of key chemistry concepts. Her study indicated that there is little difference in levels of understanding of concepts such as element and compounds, chemical reaction, and the Periodic Table. In contrast, other studies reported some advantages to students in context-based courses in terms of their understanding. For instance, Barker and Millar (2000) undertook a comparative study of British high school students following a context-based course or a conventional course. They found a slight advantage in developing understanding (about chemical thermodynamics and chemical bond) of students in the context-based course. Nevertheless, they also reported the tenacity of a number of misunderstandings among students of both groups. Some studies also looked at effects on students' motivation and attitude. The comparative study of Ramsden (1997), dealing with British high school chemistry students, showed some benefits associated with a context-based approach in terms of stimulating students' interest in chemistry. Sutman and Bruce (1992) noted that North-American high school students

were much more willing to engage with context-based chemistry materials than with more traditional materials.

A summarizing meta-analysis of 66 studies of the effects of context-based (and science-technology-society) approaches is given by Bennett, Hogarth and Lubben (2003). They reviewed studies of approaches in the teaching of secondary school science that used contexts as the starting point for the development of scientific ideas. The majority of the courses under consideration came from the USA (e.g. the ChemCom project), the UK (e.g. the Salters Chemistry project), the Netherlands (e.g. the PLON project) and Canada (several STS projects). The meta-analysis showed the following interesting results:

- (i) There is some evidence to support the claim that context-based approaches motivate students in their science lessons and enhance more positive attitudes to science more generally.
- (ii) There is good evidence to support the claim that context-based approaches do not adversely affect students' understanding of scientific ideas.

In conclusion, the reported outcomes of context-based approaches are positive from an affective development perspective, but they are somewhat disappointing from a cognitive development point of view. The absence of effects on learning outcomes can be caused by a weak relationship between contexts and relevant concepts in the perception of students and teachers. This situation underlines the need for improving context-based teaching.

How to improve context-based chemistry teaching?

In the last section, I will address some important conditions for improving context-based teaching from three different perspectives: (i) the student, (ii) the professional development of teachers, and (iii) the curriculum.

From *the student perspective*, I would point out the importance of selecting adequate contexts for incorporating in student courses, especially when contexts are used as starting points for teaching concepts. These contexts should take into account students' specific difficulties in relating contexts to concepts. These difficulties have different possible causes. First, the contexts may be not really be relevant for students and will not motivate them to study the chemistry content. For instance, the use of a technological context as the

construction of chemical weapons will not stimulate many school girls to study the accompanying chemistry, while the use of a personal life context as the properties and composition of several kinds of lipsticks and other cosmetics will not be an interesting issue for many school boys. Second, and in contrast with the former cause, the contexts can be so interesting that they distract students' attention from the related concepts. Third, the contexts can be too complicated for students to help them to make proper links with concepts. Finally, the contexts can be confusing for students, because everyday life meanings of topics do not always correspond with science meanings. For instance, the acidity of acid rain is expressed in a number (pH); in everyday life, people will reason that a high acidity will correspond with a high number, but in science this acidity should have a low number.

In conclusion, an important condition for improving context-based chemistry teaching is a careful selection of contexts. Some criteria for selecting adequate contexts are given in Table 3. Finally, I will argue that the introduction and use of contexts should be accompanied with a lot of care for bridging the gap between meanings of concepts in a daily life context and meanings of these concepts in a chemistry context.

Table 3. Criteria for selecting adequate contexts

Characteristics of adequate contexts
* Contexts should be well-known and relevant for students (girls and boys)
* Contexts should not distract students' attention from related concepts
* Contexts should not be too complicated for students
* Contexts should not confuse students

From *the teachers' professional development perspective*, I would point out the importance of helping teachers to undertake context-based teaching in a successful way. In a study of a teacher development course for teaching chemistry concepts in contexts, Stolk, Bulte, De Jong and Pilot (2005) found that it is quite difficult for experienced teachers to link an introductory context with chemistry content. The introductory context dealt with properties of diapers for babies and included a student experiment to find out the maximum amount of water that can be absorbed by a diaper. The students were surprised to observe the unexpected

big amount of water uptake (about one litre) by the diaper (for a baby of three years old). The aim of this experiment was to evoke students' 'need-to-know' about the chemistry beyond (property-structure relations of polymer networks). However, after the experiment, the teachers did not use students' questions about the phenomena as a starting point for linking with chemistry concepts, but referred directly to a general chapter about organic chemistry in the students' textbook. In other words, after the introductory experiment, they taught according to their familiar routines. This teaching did not contribute to enhance the relationship between the introductory context and related concepts.

In conclusion, teachers' professional development courses should relate course activities with context-based teaching practices at school. In my opinion, it is very important that teachers get the opportunity to discuss and reflect on teaching experiences with linking contexts with concepts. An illustrative example of an in-service course for chemistry teachers who want to learn to enhance this relationship is given by Stolk, Bulte, De Jong and Pilot (2006). In this course, teachers prepared, enacted, and evaluated lessons that include the use of a context-based unit. In this unit an introductory context as well as a follow-up inquiry context was given. The strategy that the teachers used for context-based teaching is summarized in table 4. The project is still evolving, and, for that reason, it is too early to evaluate the value of this strategy properly.

Table 4. Strategy for context-based teaching

Phase of context-based teaching	Aim of the phase
* Offering an introductory context	* Evoking students 'need-to-know', that is, students' questions
* Collecting and adapting students' questions	* Preparing students for finding answers by learning about relevant concepts
* Restructuring textbook content or selecting website information	* Enhancing links between the questions and information in textbooks or website
* Offering a follow-up inquiry context	* Evoking students 'need-to-apply' their knowledge

From *the curriculum perspective*, I would point out the importance of a proper position of contexts in chemistry curricula. The structure of many modern curricula is still based on the conventional relationship between school chemistry topics; contexts do not have a central position. Because of this situation, students and teachers are not inclined to take contexts very seriously. For instance, when contexts are used as post-theory illustrations of topics, many students do not see these illustrations as meaningful, because of their experience that very often the illustrations are not incorporated into testing and assessment. Moreover, teachers often consider the contexts in textbooks as useful for learning but they see the teaching of them as too time-consuming and skip many of them.

In conclusion, an important condition for improving context-based chemistry teaching is a more dominant position of contexts in curricula, but without loss of attention to chemistry concepts. It is my opinion that this can be realised by developing curricula in which contexts are the lead in determining the curriculum structure of chemistry topics.

Finally, I would emphasize the importance of combining courses for chemistry teachers with chemical education research. Up till now, many context-based innovation projects mainly focus on the development and implementation of new materials. In the near future, more attention should be given to accompanying research projects for investigating the value of context-based chemical education. In this field, special attention should be given to factors that contribute to improve students' understanding of chemistry topics.

References

1. V. Barker and R. Millar (2000). Students' reasoning about basic chemical thermodynamics and chemical bonding: what changes occur during a context-based post-16 chemistry course? *International Journal of Science Education*, **22**, 1171-1200.
 2. J. Bennett, S. Hogarth, and F. Lubben, (2003). A systematic review of the effects of context-based and Science – Technology - Society STS approaches in the teaching of secondary science. In: *Research Evidence in Education Library*. London: EPPI-Centre.
 3. J. M. Ramsden (1997). How does a context-based approach influence understanding of key chemical ideas at 16+? *International Journal of Science Education*, **19**, 697-710.
 4. M. Stolk, A. Bulte, O. De Jong, and A. Pilot (2005). Teaching concepts in contexts: designing a chemistry teacher course in a curriculum innovation. In K. Boersma, M. Goedhart, O. De Jong, and H. Eijkelhof (Eds.). *Research and the Quality of Science Education* (pp. 169-180). Dordrecht, The Netherlands: Springer Publishers.
 5. M. Stolk, A. Bulte, O. De Jong, and A. Pilot (2006). Empowering teachers for designing context-based chemistry education. In I. Eilks and B. Ralle (Eds.). *Towards Research-based Science Teacher Education*, (pp. 159-170). Aachen: Shaker Verlag.
 6. F. Sutman and M. Bruce, (1992). Chemistry in the community-ChemCom: a five year evaluation. *Journal of Chemical Education*, **69**, 564-567.
- Onno De Jong (O.deJong@uu.nl) is emeritus professor of chemical education at Karlstad University, Sweden, and a senior supervisor for research in chemical education at Utrecht University, The Netherlands.
- He has published on education in open-inquiry, use of models and analogies, problem solving, and students' understanding of electrochemistry. His current research interests include context-based chemistry teaching and the development of chemistry teachers' knowledge base.
- This article based on the plenary lecture presented at the 19th ICCE, Seoul, Korea, 12-17 August 2006. It was published in *Chemistry Education International*, 2007/8, Vol. 8 available at <http://old.iupac.org/publications/cei/vol8/index.html> [accessed 20/2/12) and reprinted by permission of the author.

□

The value of using demos in teaching

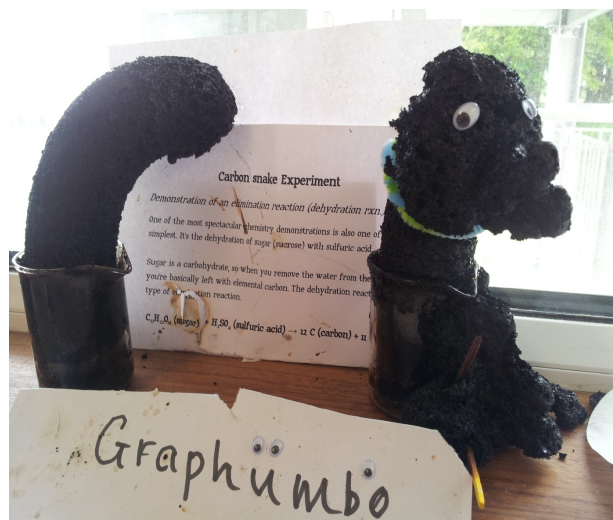
Brigid Corrigan

Chemistry Teacher in Mount Sackville Secondary School, Chapelizod, Dublin

“They sat on the familiar wooden stools, behind the dark lab benches, awaiting the start of their first chemistry class, as 6th years. The anxious, serious look on their faces said it all.

Serious hard work, rote learning of definitions that had big, unpronounceable words in them, stoichiometry, moles, metals, non-metals, volumetric analysis, ahh ... just some of the topics on the list for revision, from chapters covered last year! And this was how I was feeling, as the teacher!

I could only imagine (while remembering) what was going through their heads. They were the ones who had to sit *that* exam at the end of it all. What was I going to do to relieve those stressed faces while engaging their minds? The mood in the lab was very tense that day. Something ‘miraculous’ was needed.”



Carbon snake Demo: An excellent demonstration of both an exothermic and a dehydration reaction. (It also provided the opportunity to be *creative and artistic*, hence the birth of the ‘Graphumbo’.)

If you can relate to any of the above you will be interested in my experience, involving the use of *chemistry demonstrations*, in class, as a teaching and learning aid. After attending the ^{+5th} **Chemical Demonstration Workshop in UL** last summer, I returned to school at the end of August, unusually enthusiastic and excited. I could hardly wait to get to that *first* 6th year chemistry class

because I was armed with an array of *tried and tested* ‘Fun experiments’, with relevant applications, following my week long attendance on my first ‘Chemistry Camp’.

These chemical demonstrations had sufficient relevance to the course material to justify the chemicals they would use, but more importantly, the attention these demonstrations commanded, the fun and excitement they generated was, as the *ad* says, ‘priceless’.

I was *blown away* by their appetite for these ‘fun’ demonstrations, as often students, especially academic 6th year students, focussed on the ‘points’ race, can shy away from such events. From that first class, where I used the 9 volt battery to set the steel wool on fire, to demonstrate the ‘particle size’ effect (part of the Rates of Reaction topic), my 6th year chemistry class became enthralled. They also became my ‘Fire Princesses’.



My Fire Princesses: From L-R: Shannon Kelly, Robyn Collins, Helen Shiel, Naoise Penco, Elaine Egan, Ciana Diskin, Alex Orobator.

We used a ‘hair colour’ bottle (because of the suitable nozzle) to blast cornflour across a Bunsen burner, to demonstrate a *dust explosion*. The popular ‘iodine snake’ (demonstrating homogeneous catalysis) became *Elephant’s Toothpaste* with the addition of some red and blue food colouring. In no time we had the *Rates of Reaction* chapter covered and not an anxious face in sight.

Suddenly, my 'Fire Princesses' were arriving eager and early for chemistry class, wanting to know what demonstration experiments we could do that day.

With Science Week approaching an idea came to me, which gave my chemistry class an opportunity to show off their *new found love of chemistry* through **demonstrations**. We would put on a *fire-themed show* at lunch time using the *chemistry fun demonstrations* carried out in class and invited the rest of the school.



Alex, Robyn, Helen and Naoise are set on Fire, while Ciana watches

My 'Fire princesses' wholly embraced the idea and with some costume headgear I made especially for the event, the show was a big hit. We even managed to set off the smoke alarm. Through the use of *Methane Bubbles* and **Lightning under water*, the *Carbon Snake* and the *Ethyne Gas bang demonstration*, chemistry theory that was once stale, stagnated, and misunderstood paragraphs in a chemistry book, had now *come alive* and was *respected*.

I saw such a change in these students, who morphed before my very eyes into interested and engaged individuals, who now laughed and joked about life in chemistry class, while *learning* chemistry, while having *fun*.

The stress of the Leaving Cert and the 'points' race had been banished, from my chemistry class at least.

My Fire Princesses had become *pyromaniacs*, who I now believe will 'set the world on fire', for all the *right* reasons. If nothing else, for some, the line in the song may now have real meaning, 'We found *love* in a hopeless place', hopefully a life-long *love for chemistry*!

Chemistry classes in Mount Sackville Secondary School will never be the same again!

Some quotes from my 'Fire Princesses';

"I love setting things on fire" – Robyn Collins

"I love the way we did crazy fire experiments, they were also very educational" – Alex Orobator

"We love a good colour change" – Elaine Egan

"Chemistry is my favourite subject. Always so much fun in class. Our teacher manages to keep it interesting all the time." – Helen Shiel

"Chemistry has turned us all into pyromaniacs" – Ciana Diskin

"The experiments make chemistry fun. Our teacher is fabulous". – Naoise Penco

**Lightning under water* demonstrates Oxidation-Reduction, Combustion, and Chemiluminescence.

⁺The 'Chemical demonstration workshops' are run by Peter E. Childs and his team at the University of Limerick. This year's Workshop was run from June 18-22 and a report can be found will appear in the next issue.

□

Thinking about Big Questions: a website to support teaching about how science works

Keith S Taber, Berry Billingsley, Fran Riga & Helen Newdick

Science teachers are increasingly asked to teach about the nature of science, so that students can learn to appreciate the processes of science as well as its findings. It is hoped that learning about the nature of science, or 'how science works', will prepare young people for their adult lives in a world where scientific knowledge is often presented in partial or distorted ways. This is increasingly important when science faces many challenges from those who want to persuade the public that as science 'just' offers theories, it should not be seen as offering reliable knowledge. That reflects a key challenge facing all science teachers: how do we help our learners appreciate both the inherently provisional nature of scientific knowledge (always open to new evidence), yet see that in many areas of life science offers the most reliable and robust basis for making decisions: for example, about purchasing decisions; about environmental issues; about choice of health-care. Science does not have all the answers, but in many important domains science offers better-supported answers than any of the other voices competing for the minds (and money and votes) of young people.



Figure 1 Physicist Prof. Jim Al-khalili talks about the nature of evidence for the 'big bang'

A resource for teaching about how science works

Science teachers often feel that they are less knowledgeable and skilled in teaching about the nature of science than about the current theories and models that science offers in different topic areas, and so they often welcome resources designed to support them in teaching this aspect of the curriculum. One new resource is the 'FaradaySchools' website (<http://www.faradayschools.com/>), which includes a major section on 'How science works' offering classroom resources on a range of topics, supported by notes for teachers (at <http://www.faradayschools.com/how-science-works/>).

The site was recently launched, and already includes materials on a range of topics for both lower secondary and upper secondary age students. The intention is to develop the number of themes explored. The site has been put together to appeal to school age learners, and includes many short film clips, including scientists talking about their work (Figure 1), and footage of school pupils working on activities or offering their ideas (Figure 2).

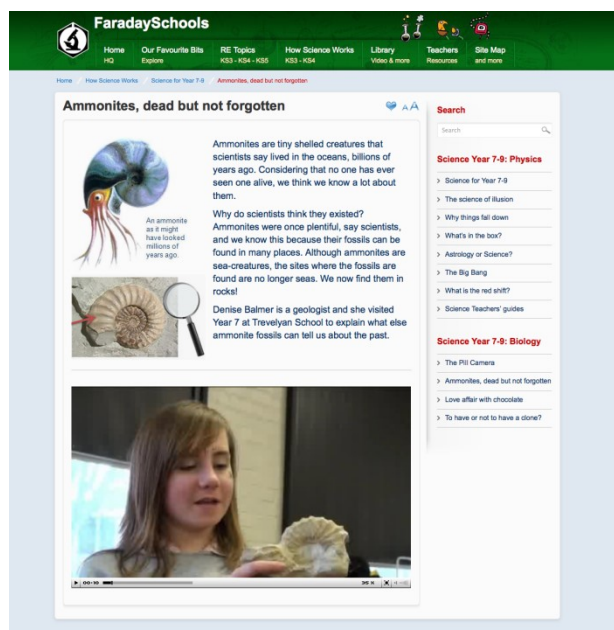


Figure 2: A year 7 pupil examines a fossil during a school visit from a geologist

Considering the big questions

Whilst the site features material on a range of topics, there is a particular focus on ‘big questions’, such as the how the universe came about and how living things have evolved. These topics are often of particular interest to young people, but they are also given prominence here because of our interest in a specific aspect of the nature of science: its relationship to religious belief. The website has been put together as part of the work of the *Learning About Science and Religion* (LASAR) project (Taber, Billingsley, & Riga, 2010) which includes research into what secondary age students think about science and religion. The name, FaradaySchools, alludes to the LASAR project falling under the auspices of The Faraday Institute for Science and Religion, which is based at St Edmund’s College, Cambridge.

The research is being undertaken in England, and suggests that many secondary students think that they have to choose between science and religion, and that accepting the big bang and natural selection is incompatible with faith in God. Of course, some religious traditions would suggest this, but our research suggests that surprising numbers of pupils from Christian traditions (such as the Church of England and the Roman Catholic Church) mistakenly think their own religion rejects these important scientific theories. We also found that quite a high proportion of students seem to assume that being a scientist necessitates

being an atheist (Taber, Billingsley, Riga, & Newdick, 2011a, 2011b). Such misunderstandings do not help science teachers when teaching these scientific ideas. On the FaradaySchools site, teachers and pupils can find examples of scientists talking about this issue, showing that some, but by no means all, scientists reject religion.

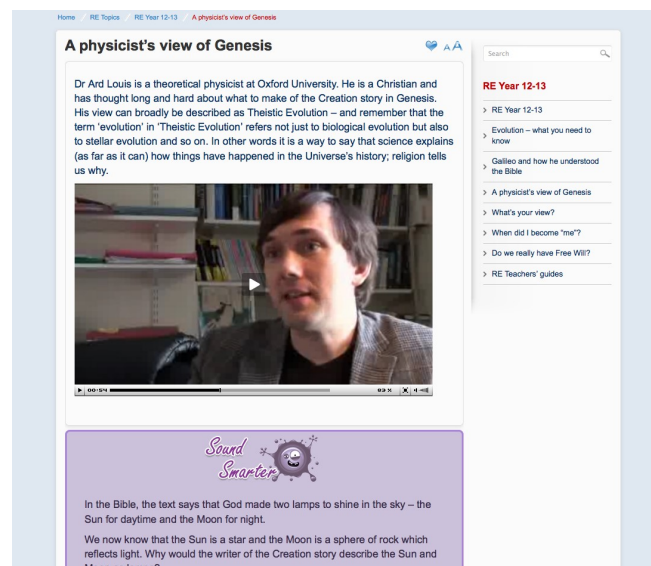


Figure 3. Oxford University research physicist Ard Louis talking about how a scientist can take scripture seriously without considering it a challenge to scientific thinking

What are your students told about science in other subjects?

Some science teachers may not be aware that students are likely to be taught about the nature of science outside of the science classroom. In England, the recommended framework for teaching religious education/studies (RE) to all lower secondary age pupils includes consideration of the relationship between science and religion, that is meant to build upon what pupils are learning about how science works in their science lessons. We wonder how often RE teachers and science teachers get together to discuss how this issue should be addressed in RE classes. In our experience, this seldom happens. So, many RE teachers are teaching pupils about the nature of scientific knowledge, and talking about how the big bang and evolution might be understood from different faith perspectives. We have talked to RE teachers who show considerable awareness of the sensitivity of these issues, and are often keen to tackle them carefully. However, understandably, most RE teachers have limited knowledge of the scientific theories they are critiquing in their

lessons. So there is a whole section on the FaradaySchools website that is aimed at RE teachers, to provide them with resources when teaching about the nature of science in their lessons (<http://www.faradayschools.com/re-topics/>). Of course, there is nothing to stop science teachers or RE teachers exploring or using any of the references on the site.

Finding balance

One thing that RE teachers tend to be well prepared for, and highly skilled in, is dealing with potentially controversial issues in a balanced and sensitive way. Science teachers often have less preparation for this, as much of what is taught in science has long since ceased to be controversial. Pupils may think that fungi are plants, that moving objects naturally slow down, or that chemical reactions occur so that atoms can fill their shells, and once they have committed to these ideas, they can be difficult to overcome. However, such topics are hardly likely to be central to their sense of worth as human being, or to their core identity as part of a family or community. Yet ideas about science and religion do sometimes meet such an intense response. As far as possible in setting up the FaradaySchools website, the writing team have tried to offer pupils access to a wide range of views, and present arguments as evenly as possible, so that the pupils can make up their own minds about issues. However, as scientists and science teachers we want students to appreciate that although science offers knowledge that is always open to critique and review, well-established scientific ideas, such as evolution by natural selection, are very robust, and it seems very unlikely they will ever be fundamentally discredited by any new evidence that may come to light.

A work in progress

We are open to advice on anything that teachers feel we have not quite got right, and each page includes a link to contact us with your views and

comments. The FaradaySchools site is a work in progress that we hope will prove to be a useful resource for many teachers: so we welcome any comments or suggestions. We hope that many colleagues will want to take a look at the site and consider how it could support their teaching.

References

Taber, K. S., Billingsley, B., & Riga, F. (2010). How should science teachers respond to the 'science and religion' debate? *Education in Science*(236), 20-21.

Taber, K. S., Billingsley, B., Riga, F., & Newdick, H. (2011a). Secondary students' responses to perceptions of the relationship between science and religion: stances identified from an interview study *Science Education*, 1-26. doi: 10.1002/sce.20459

Taber, K. S., Billingsley, B., Riga, F., & Newdick, H. (2011b). To what extent do pupils perceive science to be inconsistent with religious faith? An exploratory survey of 13-14 year-old English pupils. *Science Education International*, 22(2), 99-118.

Keith S Taber (kst24@cam.ac.uk) is Senior Lecturer in Science Education in the University of Cambridge Faculty of Education.

Berry Billingsley (b.billingsley@reading.ac.uk) directs the LASAR project, and is Lecturer in Primary Science at the University of Reading Institute of Education.

Fran Riga and Helen Newdick are researchers on the LASAR project.

The FaradaySchools site can be found at <http://www.faradayschools.com/>

The LASAR project's research site is at <http://sites.google.com/site/lasarproject/>

Originally published as: Taber, K. S., Billingsley, B., Riga, F., & Newdick, H. (2012). Thinking about 'big questions': a website to support teaching about how science works. *Education in Science* (246), 16-17, and reprinted with permission.

□

Games to consolidate learning in Chemistry

Maeve Liston

Lecturer in Science Education, Mary Immaculate College, Limerick maeve.liston@mic.ul.ie

Introduction

The decline in the number of students choosing to study Chemistry at Leaving Certificate level is a well documented problem in Ireland (Childs, 1995; Matthews, 1995; Sweetman, 1999; Lyons, 2006). Fensham (2004) believes that the most important problem in chemical education today is the lack of students' interest. However more significantly research has shown that many students claim that science is hard to learn and view chemistry as one of the most difficult subjects to study (Johnstone 1991). Al-Marashda (2002) found in his study of secondary school students that they had difficulties in learning chemical concepts such as: writing chemical formulae, the periodic table, chemical bonds, writing chemical equations, the mole and chemical calculations, liquids and solutions, organic chemistry, solubility product, titration, Faraday calculations, and metals. These listed areas encompass a very large proportion of most chemistry curricula. Therefore it is not surprising that it has been reported in many countries, the understanding of scientific ideas by the majority of students is thought to be very poor (Gott and Johnson 1999). The results of Al-Marashda study shows clearly that learning chemistry places demands on both the students and teachers that can seem insurmountable (Stiff and Wilensky 2002).

The solution: Chemistry Games?

It has been reported that traditional modes of science teaching have contributed to the decline in the proportion of students taking science subjects (ICSTI 1999). A significant amount of literature states that science teachers need to de-emphasise the memorisation of facts and place a further emphasis on scientific inquiry and scientific concepts in everyday life through the process of inquiry based learning (Singer *et al.* 2000; OECD 2006; Timmerman *et al.* 2008). However large amounts of theory need to be learned in chemistry. Therefore teachers need interesting activities that allow the students to interact with large amounts of theory and

material in a more informal fun manner. Many chemistry instructors are now using games and puzzles to make learning chemistry more fun and interesting. Listed below are some of the published chemistry games based on the periodic table.

Periodic Table Games

Understanding atomic structure and the periodic table are critical for learners since these topics serve as the foundation for understanding chemistry. These topics occur early in science syllabi in junior second level classes internationally, where students learn the atomic structure for the first twenty elements of the periodic table. As the periodic table hangs in thousands of classrooms across the globe, it has in itself become a visual metaphor and serves now as a template for presentation of knowledge in various domains. The following list of games provided for the chemistry classroom are all based on the periodic table of elements.

Chemical Elements Bingo

This board game requires the periodic table and cards with the Bohr atom type of pictures of the elements on the front and the element's properties on the back. The object is to see how many cards the students can place on the board in a certain time. This game should help students see the relationship between number of valence electrons and the periodic table.

Publication: Teyada, S.; Palacios, J. *J. Chem. Educ.* **1995**, 72, 1115.

Accessed at:
<http://pubs.acs.org/toc/jceda8/72/12>

The Electron Game

This courtyard game is outlined like the 1s, 2s, and 2p orbitals. Students must place 10 players (electrons) into the court following the aufbau rules.

Publication: Wiseman, F. L. Jr. *J. Chem. Educ.* **1978**, 55, 325.

Accessed at:
<http://pubs.acs.org/doi/pdf/10.1021/ed055p325>

Odd Man Out

This classroom game provides students with a list of elements and a list of properties. They must match elements and properties, two elements to each property with one left over.

Publication: Armitage, G. M. *J. Chem. Educ.* **1979**, *56*, 609.

Accessed **at:**
<http://pubs.acs.org/doi/pdf/10.1021/ed056p609.1>

Castle Mendeleev

Castle Mendeleev is an imaginary journey through a mansion built by Dmitri Mendeleev. It provides a history of Dmitri Mendeleev. The three story castle has eighteen rooms. In each room the walls, floor and ceiling are made solely of one of the elements that occurs in the first three rows of the periodic table. Period 3 is the 1st floor, Period 2 is the 2nd floor and Period 1 is the 3rd. In order to exit the room the students must identify the element based on its physical properties at room temperature. They move from room to room once they have successfully answered all of the questions.

Accessed at: <http://hs-staffserver.stjames.k12.mn.us/~fraken/Physical%20Science/Castle%20Mendeleev/castlemendeleev.html>

References

Al-Marashda, H. 2002. *Difficulties in learning chemistry in secondary stage in UAE*. The First Chemistry Conference in UAE, Ministry of Education and Youth, United Arab Emirates.

Childs, P.E. (2002) 'Securing the Future of Chemistry: A Case Study of Developments in Chemical Education in Ireland', *Chemistry Education: Research and Practice in Europe*, 3(3), 361-369.

Fensham, P. F. (2004). Teaching chemistry through history; *J. of Research in Science Teaching*, 33, pp.

513 – 540.

Gott, R., and P. Johnson. 1999. Science in school: Time to pause for thought. *School Science Review* 81, no. 295: 21–8.

Johnstone, A. H. (1991). Why is Science Difficult to Learn? Things are seldom what they seem. *J. Computer Assisted Learning*; New York, Vol. 7(2), pp. 75 – 83.

Lyons, T. (2006) 'The Puzzle of falling enrolments in Physics and Chemistry Courses: Putting some Pieces Together', *Research in Science Education*, 36,285-311.

Matthews,P. (2006). 'The Relevance of Science Education (ROSE) in Ireland'. Royal Irish Academy, Dublin.

OECD (2006) *Evolution of Student Interest in Science and Technology Studies – Policy Report*; Global Science Forum, Paris.

Singer, J., Marx, R. W., and Krajcik, J. 2000. Constructing Extended Inquiry Projects: Curriculum Materials for Science Education Reform. *Educational Psychologis* 35, no.3:165-178.

Stiff, M., and U. Wilensky. 2002. ChemLogeo: An emergent modeling environment for teaching and learning chemistry. Proceedings of the Fifth Biannual International Conference of the Learning Sciences, Northwestern University.

Sweetman, M. (1999). 'The Irish science and education paradox, Technology Ireland Dublin: Enterprise Ireland.

Timmerman, B. E., Strickland, D. C. and Carstensen, S. M. 2008. *Curricular reform and inquiry teaching in biology: where are our efforts most fruitfully invested?*.England: Oxford University Press.

Dr. Maeve Liston, is a Lecturer in Science Education at Mary Immaculate College, Limerick and works with the National Centre for Excellence in Mathematics & Science Teaching & Learning; www.nce-mstl.ie

□

The Instrument Makers

Adrian J. Ryder tutorajr@gmail.com

Introduction

The chemistry apparatus in use in school laboratories is generally taken for granted. But who was the first to make use of each item? In this, and subsequent issues, the lives of those credited with being the inventor/adaptor of pieces of chemical equipment are examined.

The humble test tube was invented by the Englishman Michael Faraday, 1791-1867, (article by author in *Chemistry in Action!*, Summer 2005, #76) some time after 1827. His chemistry text book, *Chemical Manipulation* (1827), still shows small wine glasses as his method of holding and mixing small quantities of liquids. He later took one of these glasses, heated it over a small furnace, pulled it out by the stem, and then snapped it off to give the prototype test tube.

Filter paper was invented by the Swedish Jöns Jacob Berzelius, 1779-1848, (see *Chemistry in Action!*, Winter 2007, #83) shortly before 1815.

In this year J.H. Munkell's paper mill at Grycksto, on Berzelius's advice, began production of this, now, commonplace item. Prior to this the principal method of separation of solids from liquids was by decanting. Berzelius is also credited with the first use of rubber tubing in the laboratory.

The everyday Bunsen burner was invented by Robert Wilhelm Eberhard Bunsen, 1811-1899, in 1855 (see *Chemistry in Action!*, Summer 2008, #85). Previously, in 1841, he had invented the zinc/carbon cell. Bunsen went on to invent in 1858, with Gustav Robert Kirchhoff, 1824-1887, the modern day spectroscope and was the first to produce magnesium ribbon in quantity.

The inventor of the gas producing apparatus used by generations of chemists and known as Kipp's apparatus is the subject of the first of this series, The Instrument Makers.

#1 Petrus Jacobus Kipp 1808 – 1864

Petrus Jacobus Kipp, the youngest child of Anthonius Johannes Kipp (1754-1810) and Adriana Maria van Haastert (1771-1841), was born in the town of Utrecht in Holland on the 5th of March 1808 and was baptized the following day in the local church. Just how many siblings Kipp had is unclear, with only two being found in the records: Catharina Bernadina (1804-1822) and Johannes Petrus (1805-1874)

Kipp took up the study of Pharmacy in the University of Utrecht and gained his diploma on the 22nd of October 1829 with a dissertation on six substances. These were:

Potassium antimony tartrate - used in making insecticides, pesticides and parasiticides. It was also in use as an emetic and expectorant;

Succinic acid - a sweetener;

Oleum succinic - (oil of amber) a by-product of the destructive distillation of amber in the production of succinic acid: it is a stimulant, diuretic and antispasmodic;

and three narcotics

Morphine - a potent opiate analgesic;

Morphine acetate - (another name for heroin);
and **Meconic acid** - a mild narcotic derived from opium.

With the intention of opening his own pharmacy, Kipp moved to the town of Delft, where he found his new diploma was not recognized (it was not until 1877 that a national diploma was to be recognized) and he had to be examined again there by a Provincial Medical Commission before being permitted to practice as a pharmacist. Kipp got over the difficulty speedily and on the 1st of August 1830 he opened his own premises beside the old canal, at Oude Delft No. 29 (now 160). As well as the pharmacy Kipp set up a company Kipp en Zonen to sell chemicals and chemical apparatus. The chemical apparatus he sold was at the beginning imported from French and German manufacturers but as time went on he began to produce his own pieces of apparatus. It was not long before he was to make more money from the sale of chemicals and apparatus than from the pharmacy itself.

On the 16th of September 1830 Kipp married Hanna Petronella Regina Heijligers (1811-1874) and the couple had nine children, six boys and three girls, however only six of the children survived to adulthood.

[Adriana Johanna Petronella Kipp](#)

b. 07 Mar 1832, d. 27 Aug 1833

[Johannes Wilhelmus Kipp](#)

b. 17 Apr 1833, d. 06 Jul 1910

[Anthonius Johannes Kipp](#)

b. 24 Oct 1834, d. 05 Dec 1915

[Wilhelmus Arnoldus Kipp](#)

b. 24 Mar 1837, d. 17 Sep 1906,

[Adrianus Petrus Kipp](#)

b. 05 Sep 1838,. (presumably died shortly afterwards.
Death not recorded.)

[Gijsbertus Wilhelmus Kipp](#)

b. 19 Oct 1839, d. 30 Apr 1841

[Petrus Wilhelmus Carel Kipp](#)

b. 05 Jul 1841, d. 21 May 1894

[Susanna Augustine Adriana Kipp](#)

b. 03 May 1843, d. 15 Dec 1912

[Odilia Johanna Bernardina Kipp](#)

b. 03 Feb 1846, d. 15 Mar 1922



The Kipp family in 1843. A painting by William Hendric Schmidt 1908-1849

L to R. JAnthonius, Petrus Jnr., Petrus Snr., Wilhelmus, Hanna, Johannes, Baby Susanna in crib.

In 1840 Kipp was elected to the Medical Council of the city of Delft and undertook investigations on the quality of the water supplies and the oil for the street lamps for the civic authorities.

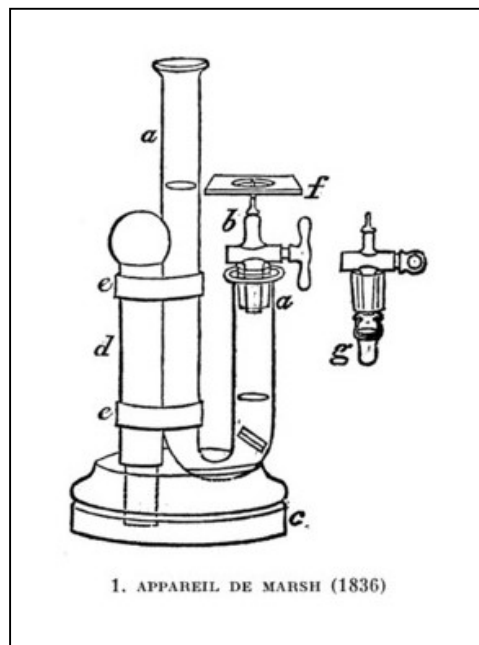
Apart from this work Kipp undertook various investigations of his own. He had a paper printed in August 1842 detailing his findings which showed

that ingested arsenic in rabbits could be detected in the liver and kidneys as well as in the stomach and intestines. A further paper printed in December 1845 was on the use of potassium thiocyanate in determining the purity of nitric acid .

In 1842 Kipp became a founder member of the Dutch Company for the Advancement of Pharmacy. This body was pressing for the national recognition of Pharmacy training and the issuing of a national certificate to be valid throughout the various provinces of Holland. This was to be a long and tedious process culminating in recognition only in 1877.

The Kipp business received a boost in sales when King William II founded the Royal Academy for Civil Engineers and Merchants (now the Delft Technical University) In 1842. Kipp was proposed as Professor of Chemistry in the new institution but declined, probably fearing he would not have time to keep his company operating. The post was subsequently given to his friend Carel Frederik Donnadieu. Apart from the supply of chemicals and apparatus to the Academy, Kipp made further monetary gains by translating German text-books on chemistry into Dutch between 1844 and 1850 for use in the Academy.

In 1842 a debate on where arsenic, on ingestion into the body, accidentally or maliciously, was to be found was taking place in scientific circles. James Marsh, 1790-1846, from England had invented his test for arsenic in 1836.

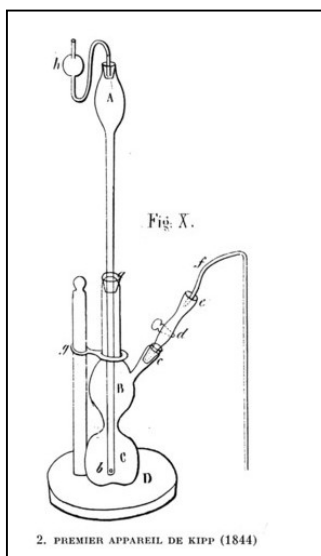


Marsh's hydrogen generator for his arsenic test is shown above. The reaction of zinc and dilute sulphuric acid produces hydrogen gas and sodium sulphate left in solution.

The hydrogen gas pushes down the surface of the acid, finally exposing the zinc after which the reaction stops. The acid rises in section 'a' of the apparatus and on opening the stop-cock, hydrostatic pressure forces the hydrogen gas out the nozzle 'b'. The zinc, shown below the surface of the acid on the right, tends to break up with the result that the amount of gas produced may cause the acid to spill out through the opening at 'a'.

In the Marsh test some of the organ under test is dropped into the acid and then the zinc is added. The hydrogen gas coming off is ignited at the nozzle 'b' and the flame is allowed to touch a clean porcelain plate ('f'). The amount of blackening of the plate is proportional to the amount of arsenic in the sample.

In his investigation on arsenic, detailed above, Kipp found that Marsh's generator was erratic in its production of the gas and also that it needed to be cleaned after each sample tested. He felt that having a separate generator of the gas to be fed into another container in which the sample was held and the gas then ignited would be easier to use. He designed his first model for the generation of the gas and got the German glassblower Heinrich Geissler to make it.



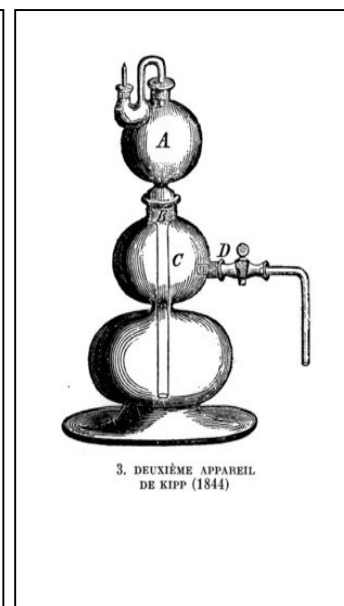
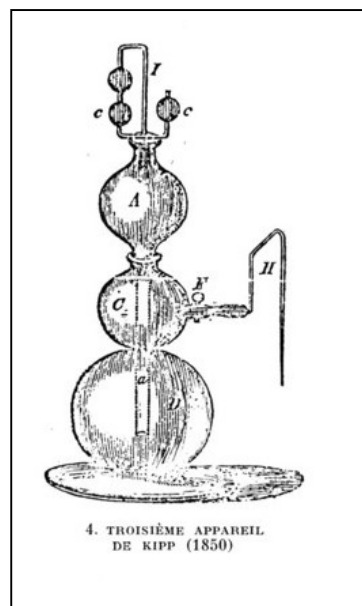
As can be seen in the diagram above, the apparatus is delicate and easily broken. Zinc is inserted through the nozzle opening on the right and the acid poured in through the top opening. The acid fills the lower compartment rising to meet the zinc. The ensuing reaction pushes the acid out of the chamber with the zinc and after clearing the chamber of its initial air the hydrogen is then ready for use. As the zinc chamber fills with gas, the reaction stops to be renewed as the hydrogen is allowed out through the stop-cock on the right.

Kipp's first generator.

Kipp now produced a more stable form of the generator as seen below in his second and third models, below on the left. A modern apparatus is shown on the right. Models two and three were again blown by Geissler and were to become the design for all future models.



**Apotheek W.A. Kipp Dhr. drs. B.J.
H.M. Borret, apotheker
Van Beresteynstraat 169a 2614 HE Delft**



In 1850 Kipp produced a catalogue of German and French imported instruments, which led to a large increase in the sales of scientific apparatus. Whereas up to this the pharmacy and chemicals were his main source of income, now the apparatus sales became the more important. The increase in the business meant that his premises had too little room and so in 1855 he Kipp's family moved along the road to larger premises at Old Delft No. 6 (now 204), where a pharmacy under the name W.A.Kipp flourished after his death. The old buildings is now gone but the name continues on as shown in the photo above.



See also:

<http://www.rsc.org/chemistryworld/Issues/2007/November/ClassicKitKippsApparatus.asp>

□

Kipp died suddenly of a fever on February 3rd 1864 and his wife and two of his sons, A.J. (Anton) and W.A. (Willem) took over the running of Kipp & Zonen. Willem managed the pharmacy shop and Anton took care of the chemicals and instruments. In the following year sales received a boost with the start of the export of scientific instruments to Japan and China. While they did make some instruments, they relied mainly on imports to meet demand until 1880, when Anton invested in a large workshop to produce their own instruments. Jan Willem Giltay was engaged to manage the instrument making side of the business and on the retirement of Antonius took over the company, while Wilhelmus Arnoldus continued the separate pharmacy which still exists.

In 1996 the Canadian firm SCI-TEC Instruments acquired Kipp en Zonen but changed its own name to the better known Kipp en Zonen Inc. the following year. This company is listed on the Toronto Stock Exchange.

P.J. Kipp himself would have been proud to see his business surviving the various traumas of the 20th century to continue to trade after 180 years.

References

[http:// www.mtaonline.net/~rvh/dat86.htm](http://www.mtaonline.net/~rvh/dat86.htm)
Le pharmacien P. J. Kipp (1808-1864) et son appareil [Harry-A.-M. Snelders](#), Revue d'histoire de la pharmacie, Année 1972, Volume 60, [Numéro 212](#), pp. 3-12
Chemical Manipulation, Michael Faraday, 1827, w. Phillips, George yard, Lombard St., London.
http://mattson.creighton.edu/History_Gas_Chemistry/ErnstHomburgArticle.html
<http://www.kippzonen.com/?page/37172/History.aspx>
[X](#)

Proceedings 30th ChemEd-Ireland Conference

22 Oct. 2011, University College, Cork

The 30th. ChemEd-Ireland conference (started in 1982 by Dr. Peter Childs at Thomond College, Limerick) was held in UCC on October 21st. 2011. The conference was a resounding success with ~140 delegates (the largest number ever in the history of the conferences) and it was organised by Dr Declan Kennedy and his team from UCC. The conferences and associated workshops were located in the new Eureka Centre in UCC, and this was an opportunity to show off the excellent facilities for science education. The theme of the conference was ***"Preparing for the Future of Chemical Education"***, in the light of the new LC chemistry syllabus.



The following talks were given at the conference:

***Nanochemistry in the new LC Chemistry Syllabus**, Justin Holmes (UCC)

Chemistry for non-specialists, John Daly (Blackrock College)

*Safety in the school laboratory, Miriam Horgan (DoES)

*Innovating nanoscience: education, communication and outreach Mary Colclough (CRANN)

*Consultation on senior cycle science, Anna Walshe and Brendan Duane (NCCA)

LC Chemistry examination 2011, Tim Desmond (SEC)

You can access Powerpoints of some of the talks (*) given at the conference at: <http://www.ista.ie/news/chemed-conference-2011> The ones in bold are included in this Proceedings.

Publication of the Proceedings depends on the authors being willing to turn their PowerPoint presentations into an article, and we only got submissions from two of the authors at this year's conference. It may be possible to include others at a later date.

Nanochemistry in the New Leaving Certificate Chemistry Syllabus

Justin D. Holmes

Professor of Nanochemistry, Department of Chemistry, University College, Cork

j.holmes@ucc.ie

New Leaving Certificate Chemistry Syllabus

The draft revised leaving certificate syllabus in chemistry was approved for consultation by stakeholders in February 2011 [1]. Overall the development of the syllabus was welcomed by educators, particularly in the area of 'Nano' [2]. Section 2.6 of the draft syllabus, on the technological applications of chemistry, specifically relates to the topics of nanoscience, nanochemistry and nanotechnology, as shown in Figure 1.

Students learn about	Student should be able to
2.6 Technological applications of chemistry	<ul style="list-style-type: none">• Discuss the terms : nanoscience, nanochemistry and nanotechnology• Describe and discuss how incorporation of carbon nanotubes into polymer composites can alter the mechanical properties of these composites• Describe/discuss the electronic properties and potential applications of carbon nanotubes

Figure 1. Specific 'Nano' topics highlighted in the draft revised Leaving Certificate syllabus in chemistry [1].

The aim of this article is to provide a brief overview of nanoscience, nanochemistry and nanotechnology and to highlight the importance of incorporating these relatively new, interdisciplinary topics into the science Leaving Certificate syllabus.

What is Nano?

Nano, Greek for 'dwarf' means one billionth. Nanoscience is therefore the study of atoms and molecules on a nanometre length scale ("nm") and nanochemistry is the utilisation of synthetic approaches to make nanoscale materials with different size, shape, composition, surface structure, charge and functionality. However, the concept of nanoscience is not new; Chemists will tell you that they have been working in nanoscience for hundreds of years. For example,

the orange, purple, red and greenish colours seen in the stained glassed windows in many churches, such as those in the Honan Chapel at University College Cork (UCC), is due to the incorporation of different sized gold nanoparticles within the glass [3, 4].

What is new about current nanoscience and nanochemistry is the focus on developing new and improved products from this knowledge, i.e. nanotechnology, and the emergence of new instruments which allow materials to be imaged and manipulated. For example, early scientists first spotted living bacteria with a light microscope, whilst current researchers in nanoscience often use electrons, not light, to image and investigate the properties of nanomaterials. For example a transmission electron microscopes (TEMs) can see objects that are thousands of times smaller than a light microscope and hundreds of thousands of times smaller than can be observed by the human eye. The resolution of many TEM instruments is typically around 0.1 nm, which is the typical resolution between 2 atoms in a solid. The ability to synthesise, visualise and manipulate matter at the nanoscale potentially allows future researchers to build and change the structure of everyday things, from cancer cells to computers, and improving our standard of living.

At the nanoscale, interactions between atoms often result in different properties that are not observed at larger length scales. For example, as mentioned above gold nanoparticles display different colours, melting points and chemical properties depending on their size which is not found for a gold "bar" held as gold reserves by central banks. The reason for this difference is that the interaction of gold atoms in the gold bar average out, influencing the overall properties and appearance of the object. However, a red, 10 nm sized gold nanoparticle, can be thought of as a tiny object, free from the averaging effects of countless numbers of atoms. Hence the growing interest in 'nano' is due to advances in science and engineering which have allowed new approaches

for synthesising, positioning, connecting and imaging nanomaterials with controlled shape, composition and structure for use in the macroscopic real world.

Why Nano?

One great thing about nanoscience is that it is interdisciplinary. In research laboratories throughout the world, chemists, physicists and medics work with engineers, computer scientists, biologists to determine the applications and development of nanotechnologies. Many companies, e.g. pharmaceutical industries, computer manufacturers, healthcare companies, have nanotechnology research programmes, which will not only financially benefit these companies but will improve our standard of living, due to advances in nanotechnology which are expected over the next decade. The ability to engineer the surfaces of nanomaterials will lead to products with better mechanical, wetting, chemical resistant and optical properties, e.g. anti-graffiti or anti-fouling coatings, biocompatible implants, faster and more energy efficient transistors in microelectronic circuits, anti-bacterial wound dressings, super lightweight materials, novel drugs, improved water purification, cell phones with longer battery life etc [5].

However, nanotechnology is not all about the future. Manufacturers are currently utilising nanoscience and nanochemistry to enhancing old products, which go beyond products available from bulk materials. For example transparent sunscreens, such as those manufactured by Nanophase Technologies [6], contain nanosized particles of zinc oxide (ZnO) or titanium dioxide (TiO₂). The high surface areas of the nanosized particles provide improved deflection of the sun's harmful UV radiation, compared to the larger particles which were present in earlier bright white sunscreen products. Other examples include stain-resistant trousers and ties produced by companies like Nanotex [7]. Transistors in computers are already below 100 nm, which has allowed electrical devices, such as mobile phones, to become smaller and more powerful [8]. The cosmetic industry has been among the first adaptors of nanotechnology through the use of engineered nanoparticles to enhance the performance of their products, e.g. to improve the feel and texture of a face creams as well as providing UV protection to the skin [9]. Nanomaterials in cosmetics have also been

reported to help increase the penetration of active materials into the skin.

Whilst it is easy to imagine all kinds of new materials, devices and products that can be manufactured using nanochemistry, some projects are unlikely to, or will never, materialise. For example, life-threatening nanoscale robots ('nanobots'), described by Eric K. Drexler in his book 'Engines of Creation: The Coming Era of Nanotechnology' [10], that could replicate using nanoscience to build objects one atom at a time. Another example comes from Michael Crichton's book 'Prey' in which he describes a deadly cloud of nanomachines which escape from a laboratory, with the intention on wiping out mankind [11]. Add such writings to media hype and you end up with a lot of misinformation on what nanoscience may lead to in the future, rather than what could never happen based on the laws of chemistry, physics and biology. For example, using molecular chemistry to build nanobots would be extremely difficult and involve controlling the positioning atoms in three dimensions, which would involve controlling the motion of each and every atom within the structure. Nanobots made from organic molecules are also likely to find themselves being devoured by bacteria whilst large amounts of time, synthetic processing and resources would be required to produce nanobots from inorganic materials (such as sand).

Smart Materials From Carbon

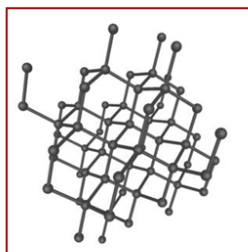
Nearly every industry, e.g. energy, electronics, biomedical, will benefit from nanotechnology through the processing and chemical synthesis of new materials. Many applications are just waiting for the right nanomaterial to be created, for examples materials for energy efficient solar cells. To understand how nanomaterials might be used, we need to understand not only how are they synthesised but what are their structures. Carbon is a common element of choice for use in nanotechnologies as it offers a wide range of properties, which include [12]:

- the formation of strong covalent bonds with other carbon atoms, resulting in the formation allotropes of carbon with different physical and chemical properties, e.g. graphite and diamond. Figure 1 and table 1 show different allotropes of carbon, including some of their physical properties.
- bonding with a range of other atoms, e.g. oxygen, nitrogen, sulphur, silicon to make a range of organic and inorganic materials with a range of different properties.

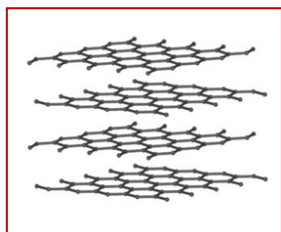
- the ability to form covalent bonds with four other atoms at a time, which is more bonds than most atoms can form, allowing the formation

of chains of atoms and hence the formation of materials with different properties.

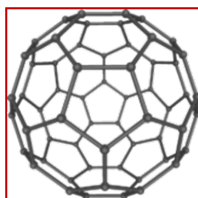
Allotropes of carbon have different covalent bonding arrangements



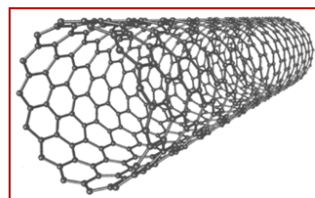
diamond



graphite



buckyball



nanotube

- Carbon atoms form covalent bonds by sharing outer shell electrons with each other
- Diamond, graphite, buckyballs and carbon nanotubes all have different covalent arrangements of carbon atoms
- The differing covalent arrangements of carbon atoms lead to the different properties of carbon allotropes

Figure 1. Different allotropes of carbon [13].

Allotrope	Hardness	Tensile Strength	Conducts Heat	Conducts Electricity
Coal	+	+	+	No
Graphite	++	++	+++++	+++++
Diamond	+++++	Not Known	+++	No
Buckyballs	+++++	+++++	+	+
Carbon Nanotubes	++++++	+++++	+++++	++++++

Table 1. A comparison of the properties of different carbon allotropes [13].

Carbon nanotubes (CNTs) are allotropes of carbon with a cylindrical nanostructure and can exist as either single-walled carbon nanotubes (SWNTs) or multi-walled carbon nanotubes (MWNTs). A

SWNT has a single cylinder, whereas a MWNT consists of multiple concentric nanotube cylinders, as shown in Figure 2.

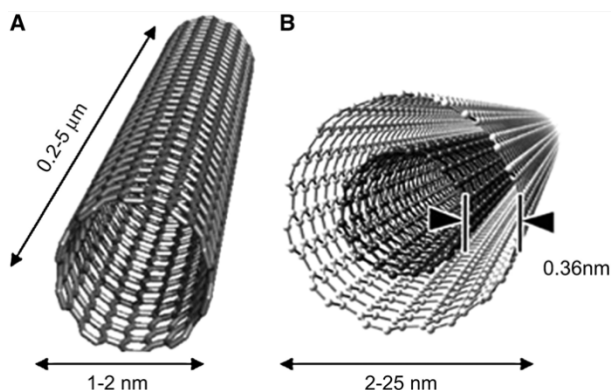
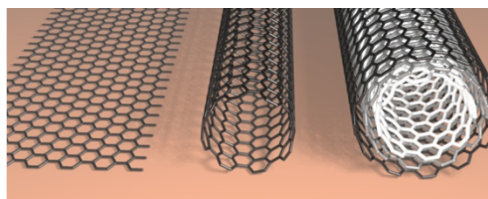


Figure 2. Conceptual diagrams of (A) a SWNT and (B) a MWNT, formed from a graphene sheet.

The discovery of single and multi-walled CNTs has had one of the greatest impacts in nanoscience and nanotechnology, as they have unparalleled

strength and high thermal and electrical conductivities, making them ideal building blocks for a wide range of applications [15]. This article will highlight some of the properties of SWNTs, as they have been the most widely researched. SWNTs have been found to conduct heat as well as diamond and are two hundred times stronger than steel, at one sixth of the weight. Depending on their structure, SWNTs can also have outstanding electrical properties. As nanotubes are composed of carbon, chemists are able to bond other atoms or molecules to their surfaces creating new nanomaterials for use with biological systems or as composite materials.

Depending on the angle which a graphene sheet is rolled up, called a roll-up vector, the electrical properties of SWNTs can be changed dramatically. Nanotubes having a helical twist in their structure have semiconducting properties, while achiral tubes are metallic. The structure of metallic 'zig-zag' and 'armchair' tubes, as well as chiral semiconducting SWNTs are shown in Figure 3.

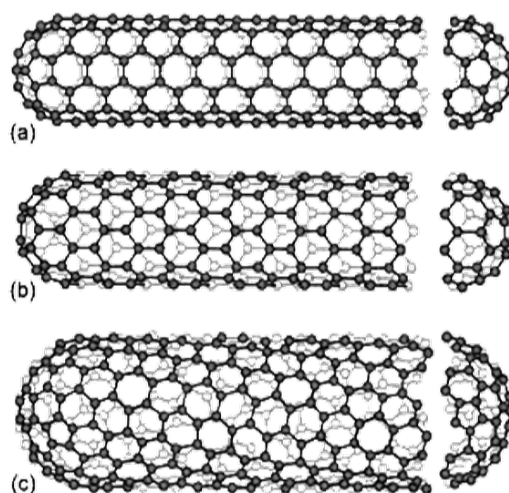
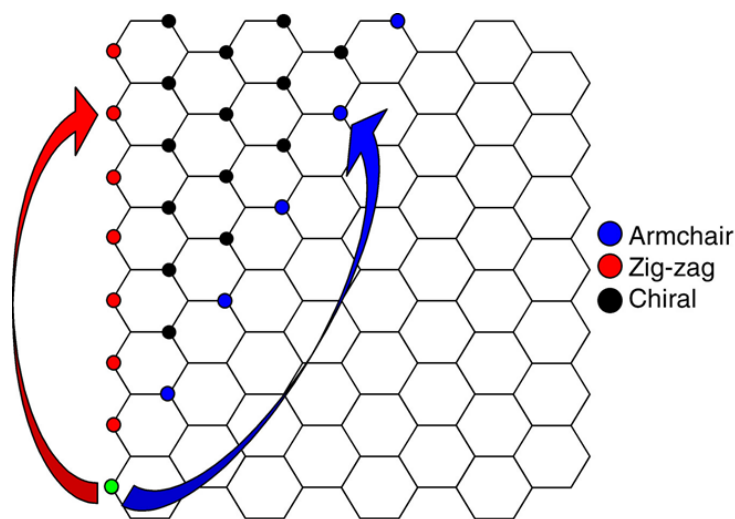


Figure 3. Graphic showing how a graphene sheet can be rolled to form different SWNT structures: (a) a metallic 'zig-zag' nanotube, (b) a metallic 'armchair' nanotube and (c) a chiral 'semiconducting' nanotube [3].

Ballistic electron transport (electrical conductivity without phonon and surface scattering) has been observed in metallic SWNTs, resulting in nanotubes with a higher electrical conductivity than copper. As a result of their electrical properties, helical carbon nanotubes have enabled the fabrication of the first nanotube transistors, a step towards molecular electronics.

Carbon Nanotube Chemistry

An issue with using SWNTs in commercial applications is their tendency to aggregate. To overcome this problem, a number of chemical approaches have been developed to modify nanotubes, allowing them to be solubilised in a range of matrices. Oxidation of CNTs using strong acid, e.g. nitric acid, opens up the ends of nanotubes and introduces carboxylate

functionalities, imparting modest solubility of CNTs in polar solvents. Several chemical reactions have also been employed to graft molecular or polymeric species onto the surfaces of CNTs, for the application of these materials as chemical or biological sensors [15]. Sensors using SWNTs have are able to detect chemical vapours, e.g. nitrogen dioxide (NO_2) in explosives, at part per billion (ppb) concentration levels. However, one problem is that many molecules can interact with CNTs, so in order to ensure that CNT sensors detect the right chemical, chemists have successfully coated SWNTs with polymers that only allow certain molecules to reach the

nanotube and blocks other species. For example, SWNTs coated with the polymer polyethyleneimine allows CNT sensors to detect NO_2 , but minimises their sensitivity to ammonia (NH_3). Conversely, coating CNTs with a polymer called Nafion, prevents NO_2 penetration but allows a CNT sensor to detect NH_3 . Figure 4 shows a range of application of both purified and functionalised SWNTs.

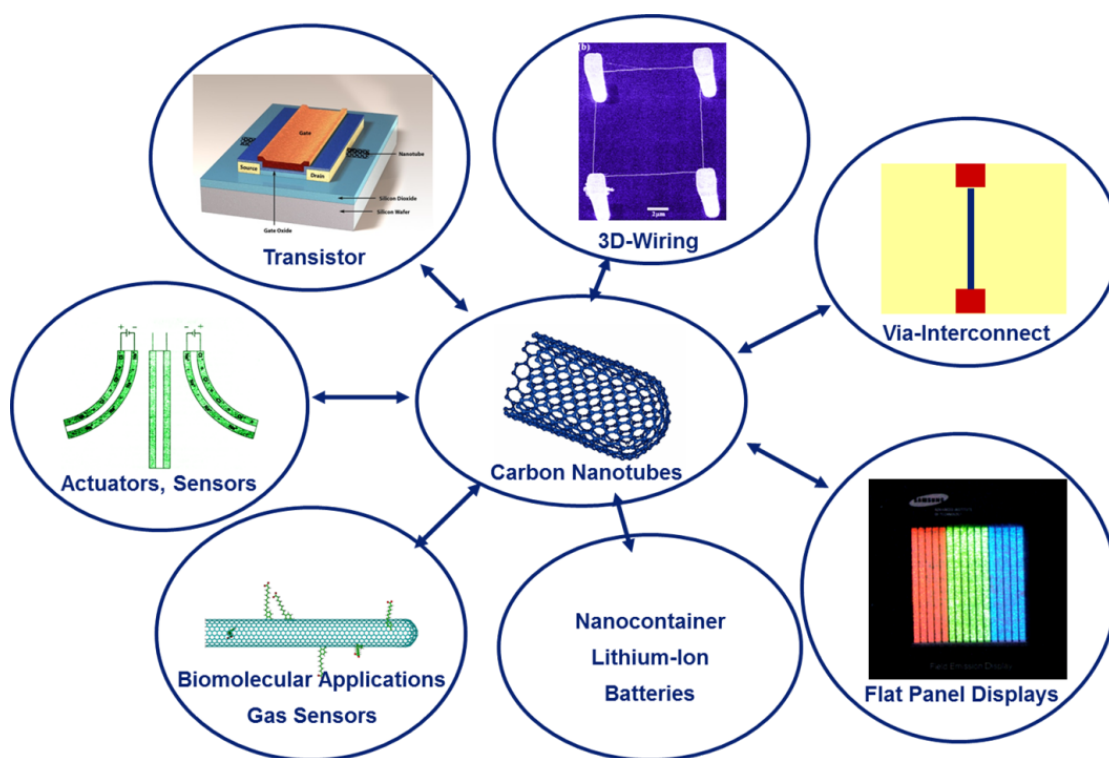


Figure 4. Some applications of purified and functionalised SWNTs [16].

Carbon Nanotube Composites

A composite is an engineered material composed of two or more components. Many of the outstanding properties of carbon nanotubes can be best exploited by incorporating them into some form of matrix, and the preparation of nanotube containing composite materials is now a rapidly growing research area. A commonly used method for preparing CNT/polymer composites has involved mixing nanotube dispersions with solutions of the polymer and then evaporating the solvents in a controlled manner. Much of the research undertaken to-date on the preparation of CNT/polymer composites has been driven by a desire to exploit the stiffness and strength of

CNTs. Even where the interest has been focused on other properties, the ability of nanotubes to improve the mechanical characteristics of a polymer has often been a valuable added benefit. Composite materials containing conventional carbon fibres in a metal matrix, such as aluminium or magnesium, are used in a number of specialist applications. Such composites combine low density with high strength and modulus, making them particularly attractive to the aerospace industry. There is growing interest in the addition of CNTs to metal matrices. Significantly, a number of sports equipment manufacturers are supplying composite materials containing CNTs for lightweight, robust racquets, with larger 'sweet

spots' for hitting a ball. For example, the badminton racquet manufacturer Yonex incorporates CNTs into their cup stack carbon nanotubes racquets. American baseball bat manufacturer Easton Sports has formed an alliance with the nanotechnology company Zyvex to develop baseball bats incorporating CNTs and Babolat have incorporated CNTs into their tennis racquets. The Swiss manufacturer bicycle BMC, were the first company to manufacturer a super light-weight bicycle frame (the 'Pro-Machine') incorporating CNTs, which was first tested out by the Phonak Cycling Team in the 2005 Tour de France (Figure 5).

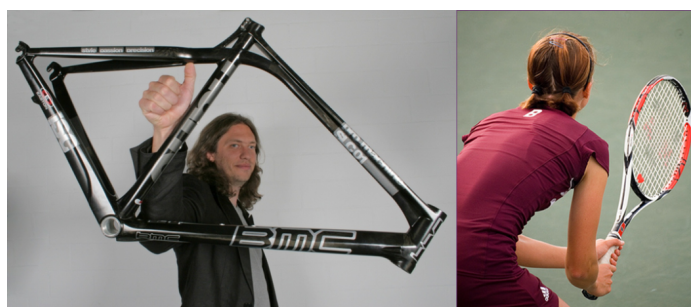


Figure 5. Images of strong but lightweight CNT composites used to in the production of bicycle frames (BMC) [17] and tennis racquets (Babolat) [18].

Nanoscience – The International Context

Many nanotechnology breakthroughs have already started to have an impact in the market place [19]. 2009 values for nanotechnology-enabled products were approximately worth €74 billion in the US and €206 billion worldwide. Trends suggest that the number of nanotechnology products and workers will double every three years, achieving a €2.5 trillion market with six million workers by 2020. Nanotechnology research and development has therefore become a socio-economic target in many countries. Industry giants such as Intel, IBM, Hewlett-Packard, DuPey, Pfizer, GSK and Eli Lilly are just a few companies with sites based in Ireland with interests in nanotechnology. The resources, processes and facilities many of these large companies already have in place should allow them to take advantage of nanotechnology discoveries to initially improve existing products, as well as developing new and innovative products.

As mentioned previously, nanotechnology is a multi-disciplinary research field. Chemists are

working with physicists and biologists, who might work with engineers and computer scientists to model very specific chemical/physical interactions of a nanomaterial. This interconnectedness of nanotechnology is a big part of nanotechnology development. Both large and small companies developing commercial nanotechnologies are likely to have to develop partnerships and collaborations, not only between different industries but also between different companies and universities. Additionally, many of the tools required for developing future nanotechnologies, e.g. electron microscopes, are too expensive to purchase and maintain for many companies, particularly SMEs. However, in Ireland Government funded nanoscience research centres, such as the Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN, www.crann.tcd.ie), based at Trinity College Dublin and the Tyndall National Institute (www.tyndall.ie) based at University College Cork, allow businesses to access and train their staff on state-of-the-art equipment required for nanoscience research at a reasonable cost. These nanoscience research centres also facilitate collaborations between industry and universities in Ireland to create and commercialise research outputs, as well as the development of new instruments and tools required for further nanotechnology growth.

Ireland's Science Is Punching Above Its Weight!

Table 2 below shows Ireland's national science ranking in (nano)materials science between 2000-2010 based on Thomson Reuters Essential Science Indicators, and as reported in the Times Higher Education Supplement [20]. As expected, the number of materials science journal articles published by Irish Scientist (which incorporates research publications in the field of chemistry, physics and biology) in this period was lower than countries with large 'scientific populations', such as the US, Japan and England. However the impact of the research published by Irish scientists is significant. The number of citations per paper for Ireland, which is a measure of the number of times a research article is referred to by other researchers throughout the world and therefore a measure of 'research quality', was greater than for Germany, England, France and Japan. Out of the 81 nations listed in this study, Ireland was ranked 8th in the world, meaning that for a small country Ireland certainly does punch above its weight in science. Further investment in science education

in schools is therefore essential to facilitate the training of future Irish nanoscientists. Only through investment in science will Ireland be able to improve its status as a world leader in nanotechnology and retain and attract further company investment into the country.

Rank	Country	Papers	Citations	Citations Per Paper
1	Netherlands	4,881	58,477	11.98
2	US	67,902	774,556	11.41
3	Switzerland	4,713	51,436	10.91
4	Israel	2,321	25,146	10.83
5	Denmark	1,526	15,740	10.31
6	Singapore	5,183	52,000	10.03
7	Scotland	1,658	16,494	9.95
8	Ireland	1,351	12,468	9.23
9	England	19,752	182,130	9.22
10	Belgium	3,958	34,595	8.74
11	Austria	3,439	29,160	8.48
12	Germany	31,964	261,247	8.17
13	France	21,861	172,352	7.88
14	Sweden	5,995	46,747	7.80
15	Canada	11,023	81,115	7.36
16	Italy	10,344	75,541	7.30
17	Spain	11,073	80,196	7.24
18	Australia	7,475	53,616	7.17
19	Norway	1,333	9,318	6.99
20	Japan	50,155	335,049	6.68

Table 2. Ranking in materials science is by citations per paper among nations that published 1,000 or more papers during the period to reveal weighted impact [20].

Summary

Nanotechnology is the next big scientific and industrial wave and will impact all industries, from healthcare to the next generation of computers and communications. Presently, 10% of all Irish exports are enabled by nanoscience, with the global nanotechnology market predicted to be worth €1.5 trillion by 2015. Nanotechnology already touches our society in many areas, economically, socially and ethically. With nanotechnology innovations creating new

chemistries, materials and devices there will be an impact on both educational and workforce requirements. Education in this area is also necessary to remove potential economic barriers for the application of nanotechnologies into Irish industry.

While nanoscience, nanochemistry and nanotechnology are not necessarily thought of as topics for the high school classroom, introducing such cutting-edge topics into the leaving certificate syllabus is likely to provide a means to motivate student interest in science and engineering. The challenge of preparing a 'nanoeducated' workforce is dependent on the country's education system, which is currently limited to undergraduate and graduate programs at Universities, in unison with national research institutes. However, the importance of introducing the concepts of nanoscience at an earlier stage cannot be overstated. The introduction of nanochemistry into the leaving certificate syllabus will foster explorations in science at the nanoscale and provide connections between and among the sciences that will help students to develop an understanding of the relationships between disciplines. Implementation of nanoscience education into schools is a common process worldwide and Ireland cannot afford to delay any longer. The current 'crop' of high school students is Ireland's 21st century workforce in nanotechnology and hence education at this level is essential for Ireland's economic future.

References

1) 'Leaving Certificate Chemistry: Draft Syllabus for Consultation', National Council for Curriculum and Assessment (NCCA), February 2011.

(http://action.ncca.ie/media/942/draft_lc_chemistry.pdf)

2) 'Senior Cycle Science: Report on the Consultation', National Council for Curriculum and Assessment (NCCA), April 2012.

(http://www.ncca.ie/en/Curriculum_and_Assessment/Post-Primary_Education/Senior_Cycle/Consultation/Science_Consultation_Report.pdf)

3) Ozin, G. O.; Arsenault, A. C. 'Nanotechnology: a Chemical Approach to Nanomaterials' RSC Publishing, 2005.

4) <http://honan.ucc.ie/vrtour.php?media=stAilbe>

5) Williams, L.; Adams, W. 'Nanotechnology Demystified: a Self-Teaching Guide', McGraw-Hill publishers, 2007.

6) <http://www.nanophase.com/>

7) <http://www.nanotex.com/index.html>

8) <http://www.intel.com/content/www/us/en/silicon-innovations/silicon-innovations-technology.html>

9) http://chantecaille.com/product_anti-aging_detail.cfm?cat=36&pid=34

10) Drexler, E. 'Engines of Creation: the Coming Era of Nanotechnology', Anchor Books, 2nd Ed. 1990.

11) Crichton, M. 'Prey', HaperCollins Publishers, 1st Ed. 2002.

12) Booker, R.; Boysen, E. 'Nanotechnology for Dummies' Wiley Publishing, 2005.

13) <http://www.accessnano.org/teaching-modules/>

14) <http://www.pa.msu.edu/cmp/csc/nanotube.html>

15) Zhou, Z. 'Carbon Nanotube Transistors, Sensors and Beyond', VDM Verlag, 2008.

16) <http://dsc.discovery.com/technology/tech-10/carbon-nanotubes-uses.html>

17) www.bmc-racing.com

18) www.babolat.com

19) http://www.wtec.org/nano2/Nanotechnology_Research_Directions_to_2020/chapter00-0.pdf

20) <http://www.timeshighereducation.co.uk/story.asp?sectioncode=26&storycode=413239&c=1>

Justin D. Holmes is Professor of Nanochemistry at University College Cork (UCC), Ireland. Since joining the Chemistry Department at UCC in October 1999, he has established an active research group in the synthesis, assembly and characterisation of nanoscale materials for electronic, energy, environmental and catalytic applications. He is Group Leader of the Materials Chemistry and Analysis Group at the Tyndall National Institute in Cork, which incorporates the Electron Microscopy and Analysis Facility (EMAF). Prof Holmes is also a Principal Investigator within the Centre for Adaptive Nanostructures and Nanodevices (CRANN), based at Trinity College Dublin (TCD), where he leads a research strand in the development of new materials for nanoscale electronic devices. He also holds an adjunct position within the School of Chemistry at TCD. Prof Holmes is co-founder and currently Chair of the Scientific Advisory Board for the UCC spin-out company Glantreo Ltd.

□



Chemistry

for Non-Specialists

John Daly

Blackrock College, Dublin and the RSC Education Division Ireland Region

Background

The Royal Society of Chemistry (RSC) is an international organisation with almost 48,000 members worldwide working for the advancement of chemistry as a science. Its Education Division promotes chemistry related educational developments at all levels. For the last six years, in the UK, it has supported the development and delivery of a CPD course for second level teachers with the above title.



The pharmaceutical company GlaxoSmithKline has given significant financial support to this course. This has meant that the cost per teacher there has been reduced from £700 to £200. Since 2006 over 5000 teachers throughout the UK have availed of the opportunity this course provides to up-skill themselves in the chemistry aspects of their GCSE Science teaching.

On the island of Ireland, the Education Division (Ireland Region) committee functions with a modest budget to promote and organise lectures, conferences and chemistry activities.



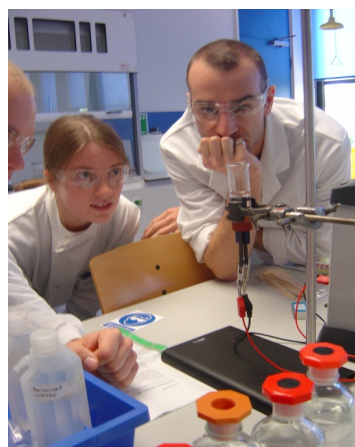
I

have been a member of this committee for a number of years and in the Spring of 2010 I became aware of the CfNS course and felt that it might be feasible to adapt and localise the above UK course for the benefit of teachers of Junior Certificate science in the Republic of Ireland for whom chemistry is not their specialist area. I have in the past organised, with

others, a joint Chemistry and Physics intervention for the Irish Science Teachers' Association and I saw then the need for a course like this and the support it got from science teachers interested in achieving the highest professional level in their work.

The reasoning behind courses like these will come as no surprise. Professional chemists are needed for the future. Where are they going to come from? There should be more doing senior school chemistry and more doing chemical sciences and chemical engineering degrees and more wanting to be professional chemists. How can we change this? By inspiring them early on and throughout their school career.

Only a small percentage of secondary school science teachers are chemistry specialists. The consequence is that most of the chemistry at junior post-primary level is taught by non-chemistry specialists. Their background makes it difficult to put the topic chemistry over with confidence and flair. Just as I, a chemist, would find a similar difficulty without support in the Biology and Physics areas.



Chemistry for Non-Specialists Course UK

UK Delivery uses RSC trainers at the satellite venues of the regional Science Learning Centres in England, and at selected venues in Wales and Northern Ireland.

It consists of 2 days residential, then 2 separate days one term apart; either Key Stage3 and/or Key Stage4 focused. 3 of the 4 days have a heavily practical chemistry content in a familiar school environment.

Key components of the 2-day course:

Hands-on circus of experiments; Demonstration experiments session; Key concepts at KS3/KS4; Chemistry club/fun activities; Introduction to RSC resources; Allowing time for questions.

Day 1

09.30 Registration and welcome

10.10 Hands-on circus of experiments

11.25 *Coffee*

11.40 Hands-on circus of experiments

13.00 *Lunch*

13.45 That's banned isn't it?

Introduction to CLEAPSS materials.

14.45 *Coffee*

15.00 Demonstration experiments

16.15 Q&A session

16.30 Close/Check into accommodation

Day 2

09.00 Registration and welcome

09.15 Hands-on circus of experiments

11.05 Review of homework

11.45 *Coffee*

12.00 Introduction to RSC resources

12.40 Use of Science Learning Centre portal for post-course discussions

13.10 *Lunch*

14.00 Hands-on circus of experiments

15.30 Course evaluation/Q&A

16.00 Close

Follow-up days:

On days 3 and 4 course activities are tailored to suit the needs of the course participants, but will include some or all of the following: Further experiments and demonstrations; Use of models to teach chemistry; Teaching chemistry to gifted and talented students; Aspects of chemistry theory; Misconceptions.

Typical resources for delegates:

- Course Book
- Inspirational Chemistry (for KS4)
- Careers pack
- Safety specs
- CLEAPSS website access
- Kitchen Chemistry
- Chemistry for the Gifted and Talented
- Particles in Motion CD-ROM

Feedback:

Best INSET I have ever been on, brilliant!

Loads of great practical ideas that I can't wait to put into practice

Wonderful to have time to learn, try and practice experiments

Thanks - I really learnt a lot & feel more confident

The whole course was exceptional. Very interesting & fun!!

Chemistry for Non-Specialists Course ROI

For Teachers of Junior Certificate Science in the Republic of Ireland

1. Origin & Design

Committee member Dr. Jim McCarthy and I attended CfNS courses at two different venues in the UK during the summer and autumn of 2010. We then set about adapting the UK course over the winter and spring of 10/11. The next step was a search for funding for a training of trainers course which we held at DIT Kevin St. Dublin in July 2011. Many of the volunteer trainers for that course are already involved with PDST in other capacities.

I would like to thank the chemistry teachers who took part in the training of trainers course last summer:-

Mary Mullaghy, Brendan Dwan, Maria Sheehan, Jim McNamara, Peter Jackson, Camille King

Seamus McManus, Terry White, Mick O'Callaghan, Declan Kennedy

The CfNS ROI course is designed to provide teachers with the confidence, flair and enthusiasm to teach chemistry. It is specifically aimed at those who are not chemistry specialists.

It is supported by an extensive course book and a PDF file on a CD enclosed with the course book.

The course is designed to; increase a teacher's understanding of chemistry topics; make a teacher more competent and confident in the teaching of chemistry; rehearse relevant and interesting practical experiments and demonstration; develop an understanding of common student misconceptions and how these can be addressed; develop the effective use of scientific models relevant to the teaching of chemistry.

I would also like to thank the following stakeholders in science education in Ireland who have supported the CfNS ROI to date and have, in particular, supported the training of trainers

RSC Education Division (Ireland Region)

Dublin Institute of Technology, Kevin St.,

Professional Development Service for Teachers (PDST)

Irish Science Teachers' Association

Discover Science & Engineering

PharmaChemical Ireland



2. Outline of some of the course contents

2a. Introduction

We found that working in pairs encourages 'ice-breaking' and an immediate hands on approach encourages participants to develop confidence and improve their own skills.

We felt that time should be allotted for practising demonstrations. This is essential before showing to a class. We designed a circus of experiments so that participants get to:

- ... choose experiments they have not tried before
- ... work at their own pace
- ... take a student's eye view of practical work
- ... network with other participants
- ... develop skills and confidence

2b. Sample practical activities

A sample of some of the activities on the CfNS ROI course are illustrated below to give you a flavour of the two day course. Here for example is an excerpt from

the list of eighty practical activities detailed on the coursework CD

12 Generating, collecting, and testing gases 45

13 An alternative to using compressed gas cylinders

14 Making a reaction tube 51

15 Ammonia fountain 53

16 Titrating sodium hydroxide with hydrochloric acid 57

17 Using indigestion tablets to neutralise an acid 61

18 A thermometric titration 64

19 Universal indicator 'rainbow' 66

20 An effervescent universal indicator 'rainbow' 68

21 Neutralisation circles 69

22 Indicators and dry ice: demonstration 71

23 Thermal decomposition of calcium carbonate 74

24 Reacting elements with oxygen 77

25 Reacting elements with chlorine 81

26 Identifying the products of combustion 83

27 The 'Whoosh' bottle demonstration 86

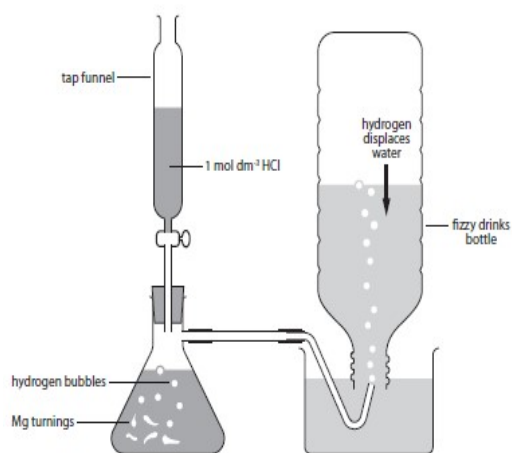
28 Fat-pan fire! 88



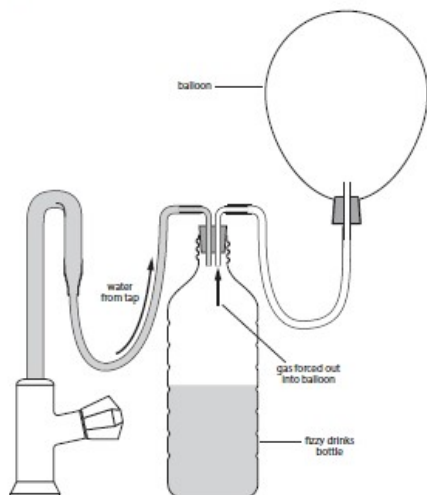
Photograph taken during the trainers' training course in July 2011.

Example 1...Filling a Hydrogen Balloon

Part 1



Part 2



Very few science teachers have access to a hydrogen gas cylinder. This is a very clever low cost way to fill a balloon with hydrogen.



Filling a PET bottle with hydrogen



Igniting the hydrogen

Example 2 ...An Effervescent Universal Indicator 'Rainbow' Manual Page 68



Sodium carbonate solution is added to a burette containing a little hydrochloric acid and Universal Indicator. The two solutions react, with effervescence, and the liquid in the burette shows a 'rainbow' of all the colours of Universal Indicator from red through orange, yellow, green and blue to purple.

This experiment will take around five minutes.

Example 3 ...Neutralisation Circles Manual Page 69

- Drops of acid / alkali in circles
- 10 minutes soak to meet
- Drop of universal indicator at meeting point
- Hair Dryer

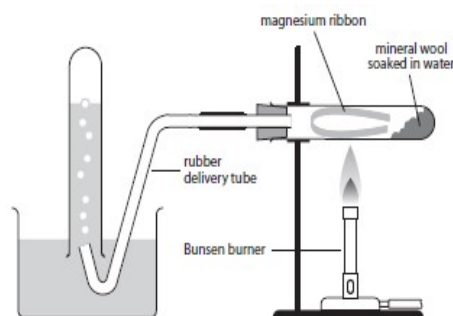
- Pupils Keep the dried paper



Example 6 ...Magnesium Reacting with Steam

Manual page 138 – 139

The diagram and photo below show two different methods for demonstrating this reaction. In the



ember 2009

photograph a plait of magnesium which has already been ignited in air is suspended in steam over boiling water.



The photograph below shows one useful variation in action, where the hydrogen gas generated is ignited at the tip of a glass tube emerging from the boiling tube of the diagram.



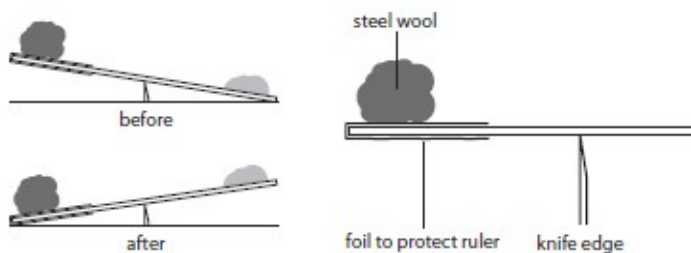
Example 4 ...Combustion of Iron Wool

Manual

Page 109

Procedure

- Cover one end of the meter ruler with foil to protect it from the Bunsen burner flame. Take about 4 g of steel wool and tease it out so that the air can get around it easily. Tie a piece of the strands to attach it to the end of the ruler.
- Balance the ruler on a knife edge or triangular block at the 50 cm mark. Weight the empty end with plasticine until this end is just down (see the diagram). This part is

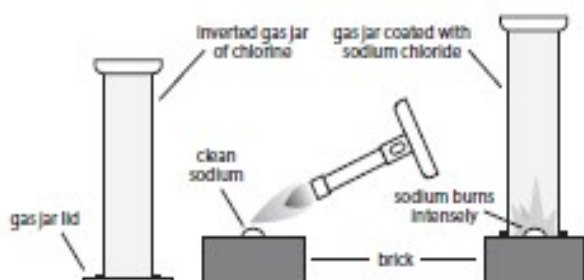


- Place a heat resistant mat underneath the steel wool.
- Wear eye protection. Light the Bunsen burner and heat the steel wool from the bottom. It will glow and some pieces of burning wool will drop onto the heat resistant mat. Heat for about a minute by which time the meter ruler will have become so heavy that the iron wool side is down.

Example 5 ...Sodium Reacting with Chlorine

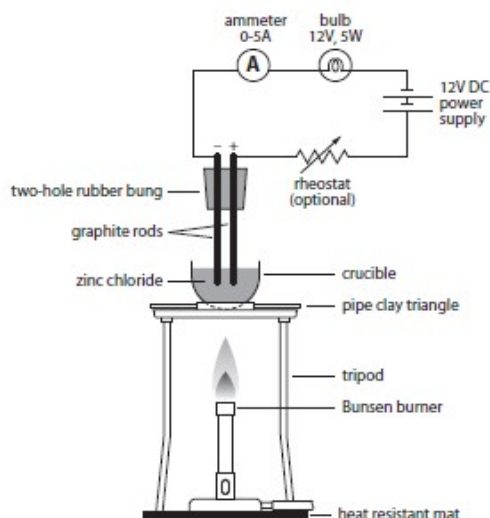
Manual page 150

(Possibly something new even for the more experienced teacher) Easily done in a fume hood.



Example 7 ...Electrolysis of Zinc Chloride

Manual Page 164

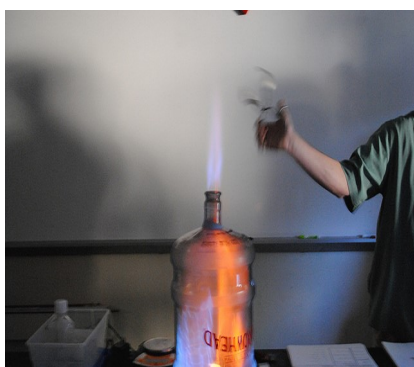


During discussions on ionic bonding in salts, it can be very effective to demonstrate electrolysis of a salt. Lead salts were traditionally used but are now considered to be too hazardous. Zinc Chloride is a good substitute and will melt at a reasonable temperature. This demonstration should be carried out in a well-ventilated room. The quantities of chlorine generated are acceptable.

When the salt melts, the lighting-up of the bulb and the demonstration of current flow on the ammeter offer strong concrete support for the concept formation required of the pupil.

Example 8 ...The Whooooosh Bottle

manual page 86



A mixture of alcohol and air in a large polycarbonate bottle is ignited. The resulting rapid combustion reaction is often accompanied by a dramatic 'whoosh' sound and flames.

This demonstration requires careful preparation, with strict adherence to the conditions required by the risk assessment provided.

It is recommended that any repeat demonstrations use spare dry reaction vessels.

Course practical sessions such as these will naturally lead to discussions on:

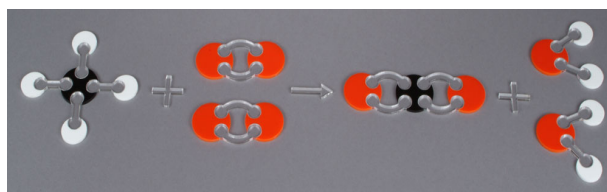
- Class Practicals vs Demonstrations
- When and why do we want to carry out a demonstration?
- When and why do we want students to carry out a practical activity for themselves?
- Which experiments are best demonstrated?

2c. Modelling & Concept clarification

Underlying the best of teaching in chemistry is a clear understanding of the basic concepts. These can be quite counter-intuitive and a session of the course is devoted to teasing out any ambiguities.



Molymod™ molecular models



Chemistry jigsaws

2d. The CLEAPSS organisation

CLEAPSS is an advisory service providing support in science and technology for a consortium of UK local authorities and their schools. It also provides a huge range of resources to **Associate Members** around the world. A number of schools in the ROI are already associate members (cost per annum ~ £70 Stg). CLEAPSS offers help from nursery education through to Second-level studies. Their services cover health & safety, risk assessment, sources and use of chemicals, living organisms and equipment. See <http://www.cleapss.org.uk>

2e. Online Resources, video clips & DVDs

A guided tour of available resources, both web based and DVD based makes up another of the

sessions. Some of the resources discussed are listed below:

Royal Society of Chemistry www.rsc.org

Periodic Table of Data

www.rsc.org/Education/Teachers/Resources/PeriodicTableOfData.asp

Databook

www.rsc.org/Education/Teachers/Resources/Databook/

Online help with carrying out practicals
<http://practicalchemistry.org>

Directory of resources Chemistryteachers.org
Chemistry Demonstrations DVDs

3. Possible Strategies for Implementation

The committee is currently working with Pharmachemical Ireland to identify a funding source from the Irish Pharmachemical Sector so that we can run courses starting in the summer of 2012. The PDST has also expressed interest in being involved, in so far as its budgets allow. In the light of the proposed revision of the Junior Certificate programme, there may be additional support for our work forthcoming from the Department of Education & Skills.

Adapting the Current UK CPD model (Two consecutive days in a school laboratory setting followed by two consolidation days spread over a period of a year) is the challenge. As this is still a work in progress I would be delighted to hear feedback and suggestions from the readers of *Chemistry in Action*. Please email me at: jdaly@blackrockcollege.com

Conclusion

Let us hope that funding for this course can be found so that the quality of teaching and learning of chemistry in Ireland can be further enhanced.

I am aware that most readers of *Chemistry in Action!* are chemistry specialists. Could I encourage you therefore to promote this course amongst your

science teacher colleagues with other science specialisms, particularly those new to the teaching profession.

I would like to acknowledge the assistance of the following people without whom the project could not have proceeded to this point:-

Dr. Claire McDonnell, DIT Kevin St. for her invaluable work as Chair of the committee as well as for organising the excellent resources of DIT Kevin St., for the training of trainers course.

Dr. Jim McCarthy, RSC Committee for his research and design work on the course as well as for his enthusiasm and invaluable contacts with the PDST.

Ms. Amanda Middleton, RSC London for her willing support from RSC head office.

Mr. David Everett RSC Trainer for the excellent job he did in training trainers.

□

Update:

Since this talk was given the first of these courses in the Republic was run in Blackrock College at the end of June 2012.

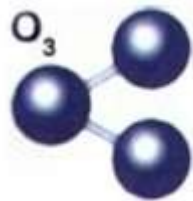
Editor's note:

Many of the experiments and demonstrations done in this course are similar to those covered in the Chemistry Demonstration Workshops at UL, which uses a similar hands-on philosophy. Although primarily aimed at chemistry teachers these workshops also welcome non-chemists who wish to brush up their chemistry for teaching Junior Science. Those non-chemists who have attended have found them very beneficial.

Problems with Ozone

Marten J. ten Hoor

J. W. Frisolaan 40, 9602 GJ Hoogezaand, The Netherlands



Ozone is a Janus-faced gas. High up in the sky it protects us from harmful solar radiation, but down to earth it may cause lung damage (some details have been given by Leh¹), and even death.

Despite its association with clean, fresh air, ozone is deemed² “one of the most toxic inorganic chemicals known”. Its MAC value³ is only 0.06 ppm for 8 hours a day, 5 days a week. Fortunately, we can detect the presence of ozone, by its characteristic pungent smell, at concentrations as low as 0.01 ppm⁴. Indeed, in 1839 Schönbein observed this smell in his poorly ventilated laboratory⁵, when he electrolyzed dilute sulfuric acid. He concluded that a new substance had been formed, and he named it ozone, derived from the Greek word “ozein” (= to smell). Although he tried to establish the formula of ozone, he did not succeed. Nearly 30 years later⁵, it could be proved that ozone’s formula is O₃. Schönbein’s experiment was revived by several authors⁶⁻⁸ for use in schools. Blume *et al*⁸ electrolyzed a 5 M solution of sulfuric acid in a Hofmann apparatus, using a decomposition voltage of 10 V. They found that the gas mixture produced at the anode contained ozone, which could be detected by its smell.

Ozone may also be prepared by subjecting oxygen (or air) to electric discharges in a so-called ozoniser. The ozone content of the obtained gas mixture can be determined as follows: a sample of the gas is injected into a solution of potassium iodide, for the reaction

$$\text{O}_3 + \text{H}_2\text{O} + 2 \text{I}^- \rightarrow \text{O}_2 + 2 \text{OH}^- + \text{I}_2 \quad (1)$$

proceeds fast and quantitatively⁹. The amount of liberated iodine is subsequently determined by titration with a solution of sodium thiosulfate. Using the needed volume of the

titrant, the amount of O₃ can be calculated on the basis of eq (1). Several direct-reading ozone monitors, such as a piezoelectric crystal detector¹⁰, are also available.

A strong oxidizing agent

Ozone is, especially in an acidic environment, a strong oxidizing agent. A measure of the strength of an oxidizing agent is the value of the standard reduction potential associated with the corresponding redox couple. The larger this value, the greater the oxidizing strength of the oxidized species of that couple. Most textbooks on general chemistry contain a list of standard reduction potentials, ordered from large to small values. Those given in Table 1 have been taken from the *CRC Handbook*¹¹. Depending on whether the environment is acidic, neutral, or basic, the reduction half-equations of Table 1 show how the oxidized species of a redox couple could change into its reduced form. An oxidation half-equation shows how the reduced species of a redox couple could change into its oxidized form. This half-equation can be found by writing the reduction half-equation of that couple in reverse order.

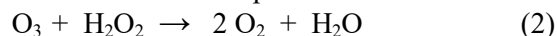
Table 1 Some reduction half-equations and their standard reduction potentials

Reduction half-equation	E°/V
A. $\text{O} + 2 \text{H}^+ + 2 \text{e}^- \rightarrow \text{H}_2\text{O}$	2.42
B. $\text{O}_3 + 2 \text{H}^+ + 2 \text{e}^- \rightarrow \text{O}_2 + \text{H}_2\text{O}$	2.08
C. $\text{H}_2\text{O}_2 + 2 \text{H}^+ + 2 \text{e}^- \rightarrow 2 \text{H}_2\text{O}$	1.78
D. $\text{O}_3 + \text{H}_2\text{O} + 2 \text{e}^- \rightarrow \text{O}_2 + 2 \text{OH}^-$	1.24
E. $\text{O}_2 + 4 \text{H}^+ + 4 \text{e}^- \rightarrow 2 \text{H}_2\text{O}$	1.23
F. $\text{O}_2 + 2 \text{H}^+ + 2 \text{e}^- \rightarrow \text{H}_2\text{O}_2$	0.70
G. $\text{I}_2 + 2 \text{e}^- \rightarrow 2 \text{I}^-$	0.54
H. $\text{O}_2 + 2 \text{H}_2\text{O} + 4 \text{e}^- \rightarrow 4 \text{OH}^-$	0.40
I. $\text{O}_2 + 2 \text{H}_2\text{O} + 2 \text{e}^- \rightarrow \text{H}_2\text{O}_2 + 2 \text{OH}^-$	-0.15

The position of a reduction half-equation in Table 1 is important, because the oxidized species of a redox couple has the capacity to oxidize the reduced species of the couples of all half-equations below it. This property enables us to construct the equations of redox reactions by combining appropriate half-

equations with each other. For example, eq (1) can be found by combining the reduction half-equation D with the oxidation version of half-equation G.

Table 1 shows that O_3 can oxidize H_2O_2 , and even H_2O . In the case of H_2O_2 , the equation of the reaction in an acidic, neutral, or basic environment is found by combining the reduction and oxidation versions of the half-equations B and F, D and F, or D and I. In all three cases we end up with



In the case of H_2O the equation of the reaction in an acidic environment follows from the combination of the reduction half-equation B with the oxidation version of half-equation C, or E. The first combination leads to



and the second one gives



For the reaction in a neutral or basic environment, reduction half-equation D should be combined with the oxidation version of half-equation E, and now eq (4) is found again.

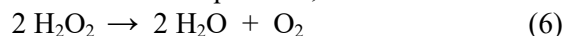
Taking a closer look

Eq (4) is a surprising result, because it only shows the decomposition of ozone. Although water is supposed to be a reactant, from which part of the produced oxygen is derived, it is not present in the final equation. To find out what has been overlooked, I assume that pure $^{18}O_3$ reacts with pure $H_2^{16}O$. Combination of reduction half-equation B with the oxidation version of half-equation E now leads to

$$2 \text{ } ^{18}O_3 + 2 H_2^{16}O \rightarrow \text{ } ^{16}O_2 + 2 \text{ } ^{18}O_2 + 2 H_2^{18}O \quad (5)$$

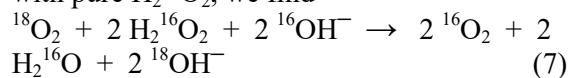
We see that water molecules indeed react, and are replaced by other ones.

A similar problem arises, if we oxidize H_2O_2 in a basic environment with O_2 . Combining reduction half-equation H with the oxidation version of half-equation I, we find



and it appears as if H_2O_2 just decomposes.

However, if we assume that pure $^{18}O_2$ reacts with pure $H_2^{16}O_2$, we find



Apparently, $^{18}O_2$ subtracts hydrogen from $H_2^{16}O_2$, and eventually $^{18}OH^-$ is formed.

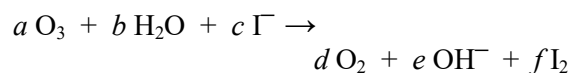
The reduction half-equations B and D suggest that the oxidizing action of O_3 boils down to transfer of an O atom with co-production of O_2 . That is, the initial step of the oxidation process seems to be



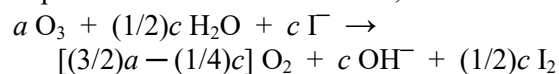
Indeed, reduction half-equation B is just the one-to-one combination of eq (8) and reduction half-equation A.

Part of the oxygen atoms produced in reaction (8) might subsequently combine to form O_2 molecules. If we now assume that the oxidizing action of ozone is *usually* initiated by eq (8), then most of the equations of redox reactions in which O_3 partakes can *not* be balanced in a unique way. To see this more clearly, I now consider the mathematical method for balancing equations that represent chemical reactions.

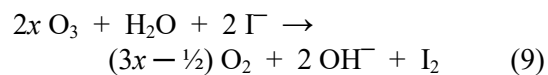
First, I consider eq (1), and I assume that all reactants and all products have been accounted for. Using coefficients *a-f*, this equation can be written as



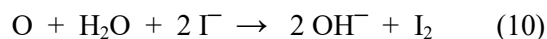
Four mathematical equations (three involving the conservation of nuclei, and one due to the conservation of electrical charge) are not enough to determine all coefficients. If we express them in terms of *a* and *c*, we find



I now multiply by 2, divide by *c*, and take $x = a/c$. This leads to

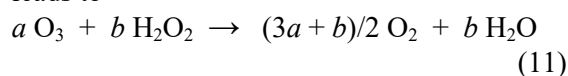


This equation shows that the original amount of O_3 is related to the amount of produced O_2 , but (surprisingly) *not* to the amount of liberated I_2 . If initially all O_3 decomposed according to eq (8), then $2x$ mol O_2 and $2x$ mol O had been formed. Eq (9) shows that subsequently $(2x - 1)$ mol O formed ($x - 1/2$) mol O_2 , and the remaining 1 mol of O reacted according to

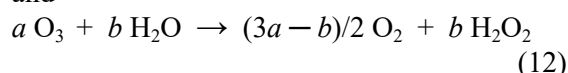


Clearly, the amount of liberated I_2 equals the amount of O that did *not* form O_2 . Only if we assume that *all* of the produced O reacts according to eq (10) [that is: if $x = \frac{1}{2}$], then eq (9) reduces to eq (1). Usually, the amount of O_3 to be determined is relatively small. Then the reactive O atom will meet a iodide ion, rather than another O atom, and the analytical determination of O_3 on the basis of eq (1) will yield a reasonable result.

The mathematical treatment of eqs (2) and (3) leads to



and



respectively. These equations reduce to eqs (2) and (3) only, if $a = b = 1$. Whether these two choices are the only meaningful ones should be decided on the basis of the results of experiments.

Conclusion

If the equation of a redox reaction is to be determined, mechanical combination of half-equations may lead to a misleading, or even incorrect, result. If we would have used the mathematical method of linear equations, then *always* a correct result is obtained. However, it now may happen that some of the coefficients of the chemical equation cannot be determined uniquely. If so, these should be derived from the results of suitable experiments.

References

1. Leh, F. J. *Chem. Educ.* **1973**, *50*, 404.
2. Bailey, R.A., Clarke, H.H., Ferris, J.P., Krause, S. and Strong, R.L. *Chemistry of the Environment*. Academic Press: New York, 1978; p 249.
3. FAQ's Ozone - Lenntech.mht
4. Greenwood, N.N. and Earnshaw, A. *Chemistry of the Elements*. Pergamon Press: Oxford, 1984; p 707.
5. Ihde, A.J. *The Development of Modern Chemistry*. Harper & Row: New York, 1964; p 364-365.
6. Ibanez, J.G.; Mayen-Mondragon, R.; Moran-Moran, M.T.; Alatorre-Ordaz, A.; Mattson, B. and Eskestrand, S. *J. Chem. Educ.* **2005**, *82*, 1546.
7. Kaminski, B. *CHEMKON* **1996**, *3*, 85.
8. Blume, R., Wiechoczek, D., Hildebrand, A. and Hilgers, U. *Praxis (Chemie)* **1996**, *45*(2), 35.
9. Cotton, F.A. and Wilkinson, G. *Advanced Inorganic Chemistry. A Comprehensive Text*, 3rd ed. Interscience Publishers: New York, 1972; p 410.
10. Fog, H.M. and Rietz, B. *Anal. Chem.* **1985**, *57*, 2634.
11. Lide, D.R., Ed., *CRC Handbook of Chemistry and Physics*, 80th ed. CRC Press: Boca Raton, 1999; pp 8-21 ff.

□

Conference Reports 2012

50th ISTA Annual Conference, 20-22 April 2012 Trinity College. Dublin

The 50th ISTA Annual Conference saw
The gathering of the great and the good in the
Science Gallery at TCD.



The opening reception in the Science Gallery, TCD



Sr. Rita, Paddy Hogan and Sr. Mercedes



Angela McKeown, the new RSC Education Officer
for Ireland, on the RSC stand

One of the highlights of the conference was Bob
Becker's demonstration lecture: the photos below
were taken at his lecture.



A helium 'hot air' balloon



A nitrogen-filled soap bubble

There were some simple but spectacular
demonstrations – especially the methane mamba
(below).



The methane mamba (1) - before



The methane mamba (2) – after, the fireball

There was a good attendance, especially on Saturday (350 in total) and the organisers are to be congratulated on a well-run conference and an interesting programme. I thought the bag packed lunch was a great idea and saved time queuing for lunch.

The introductory lecture on Friday night by John Boland on nanoscience was excellent. At the banquet Mary Mullaghy swept the board with

awards – she became the new Chairperson of the Association and also won the Science Educator of the Year Award, presented as usual by Oliver Ryan, in his inimitable style.

Charlie Dolan from Eli Lilly took over from Matt Moran (Pharmaceutical Ireland) as President of the Association.

ζ MEC 2012

Science and Mathematics
Education Conference

SMEC 2012 7-9 June Dublin City University

The theme of this year's biennial SMEC conference was 'Teaching at the heart of learning'. It was the largest SMEC yet as it was combined with an ESTABLISH meeting, and so there were many teachers from across Europe who are involved in the FP7 ESTABLISH project, which is coordinated by DCU.

There was a mix of ESTABLISH workshops, showing off some of the inquiry-based materials that are being developed, and the normal paper sessions with oral research papers, plus plenary lectures. There was

almost too much on and I would have liked to have seen the oral sessions in parallel with each other and the workshops in parallel, but not competing with each other.

There was also an extensive poster session and the large numbers made for a good buzz in the coffee breaks. The papers from the SMEC conferences are usually published online, so watch the website for this: <http://www4.dcu.ie/smec/2012/index.shtml>

More Laboratory Accidents

Sarah Hayes

CERG and NCE-MSTL, University of Limerick, Limerick sarah.hayes@ul.ie

Introduction

This article is the second in a series which will take a critical look at many accidents that have taken place in the Science laboratory, discussing the chemistry involved and the precautions which could have been taken to prevent the accident.

The last article on laboratory accidents looked at three accidents in the Science classroom: 'Ice on Fire', the 'Whoosh Bottle' and an incident where concentrated H_2SO_4 was accidentally thrown into organic waste. (*CinA!* #95, 2011, p.43) Similarly this article will look at some other commonly occurring laboratory accidents, the science behind the experiments and the accidents, and how these incidents could have been prevented.

Before conducting an experiment or demonstration it is vital that the science underpinning the experiment or demonstration is understood completely by the teacher, that a full safety audit has been done for it, and that it has been tried out. A full safety audit seems like a lot of work, but it is very helpful to make one stop and really think about what you are doing, and how it could be improved and made safer. Once completed, it should be revised regularly (typically every six months to a year), but it is essentially complete and on record. It is well worthwhile making the effort to do a safety audit for the activities carried out in the laboratory, and thus begin to stockpile these into a safety folder. This is also important for briefing other teachers in the school who may want to do the experiments themselves.

Flame Tests

This accident which will be described here can occur all too commonly. Flame tests to illustrate the characteristic colours (emission spectra), which are shown when the salts of metals are heated, are frequently used in the Science classroom. The use of flame tests allows pupils to see these characteristic colours in a spectacular and highly visible fashion. The test can be conducted in a variety of ways; typically it involves introducing a sample of the element or compound to a Bunsen flame, and observing the

coloured flame that results. Samples are usually held on a platinum wire cleaned repeatedly with hydrochloric acid to remove traces of previous salts. It is also common to use wooden splints. In order to introduce the topic many teachers set up the various salts in small porcelain dishes and soak the salts in methanol, so that when lit the dishes each hold a different colour flame. The accident which occurred involved a teacher presenting this demonstration to the class. The teacher gathered the pupils around a bench, and showed them the porcelain bowls containing the metal salts soaked in methanol. The teacher then lit the methanol-soaked salts in the bowl. It is worth noting that the pupils were not wearing any Personal Protective Equipment (PPE), such as safety glasses or white coats. A pupil noted that one flame was beginning to extinguish and the teacher took a large jug of methanol from a nearby sink and began to pour some into the dish that was extinguishing. A large ball of flame exploded out of the jug setting two pupils alight. The pupils suffered significant burns and spent much of the following year recovering from their burns.

What can be learned from this accident?

There are several issues in play here. The key thing to remember with most laboratory accidents is that they are usually preventable. In this case the teacher should not have had all of the pupils pressing around a bench to see this demonstration. It should have been done in a visible location with the pupils **at least** 1m from the demonstration. The teacher should have never attempted to pour methanol onto the flame. Methanol is highly flammable, which would only serve to make the initial small flames much bigger. However, methanol also vaporises easily. The large container of methanol that the teacher used would have had methanol vapour around the mouth of the container, which aided the flame being carried back into the container. Pupils were also not wearing PPE, which offers some degree of protection in situations like this.

This demonstration should not be done near any sources of ignition and only very small amounts of methanol should be used. All possible

flammable substances need to be kept away from the area in which the experiment is to take place. After pouring out the methanol, stopper the container, and put it on one side. Ideally the container of methanol should be stored in a tightly sealed metal container in a “dry” box away from all oxidising agents or in a flammables cupboard. Also, the teacher/demonstrator should be wearing appropriate Personal Protective Equipment, such as a laboratory coat, safety glasses and flame proof gloves. Water can be used to quench methanol fires, but fire blankets should also be used and should be readily available in the laboratory. When doing this experiment it is very useful to have a white tile to hand as it can be placed it over the porcelain dish, thus cutting off the source of oxygen. Any spillages of methanol should be mopped up immediately and the area should be well ventilated.

Mind your chemicals

The accidents described here have happened in numerous schools with a variety of chemicals, which can catch fire spontaneously. Of the two most common stories, one involves phosphorus and the other involves alkali metals.

The first accident involved a teacher who cut up a stick of white/yellow phosphorus into small pieces for a group experiment. He turned to write on the blackboard, and while doing so a pupil stole a piece and put it in the pocket of his trousers. After a while, his trousers caught fire and the pupil’s leg was badly burnt. His hand was burnt too when he tried to remove the piece of burning phosphorus from his pocket.

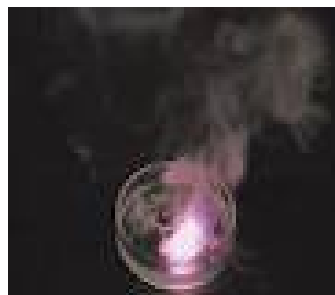
The second accident was similar to the first one, and involved demonstrations with the alkali metals. After showing pupils how sodium (Na), lithium (Li) and potassium (K) react with water, the teacher continued to teach the class. However, the laboratory in this instance did not contain adequate storage facilities, and the one pupil noted where the metals were stored, and after class, when in the laboratory alone, took a piece of potassium and placed it in his pocket. Later that day after the oil on the chunk of potassium had rubbed off, the pupil accidentally spilled some liquid on himself and the pupil’s trousers caught fire.



Source of image:
<http://en.wikipedia.org> 2

What can be learned from this accident?

The first accident involving the phosphorus occurred due to the nature of phosphorus. White phosphorus is sometimes called yellow phosphorus due to its yellow colouring, which results from impurities. It is highly reactive and thus dangerous. It should be stored under water to prevent exposure to air as it can spontaneously ignite in moist air. It is not advisable to do demonstrations involving white or red phosphorus, as they are both quite dangerous. When doing a demonstration pupils should always be warned beforehand of the potential hazards and dangers of the chemicals involved. Hazardous chemicals should never be left unattended.



Source of image:
<http://en.wikipedia.org> 1

The second accident, similarly to the first one, is mainly concerned with the adequate storage of chemicals and creating awareness of the dangers that certain chemicals pose. The alkali metals (Group 1 elements) are all excellent reducing agents, good conductors of heat, malleable and ductile. They all exhibit a vigorous reaction with water, emitting hydrogen gas. Potassium gives the most vigorous reaction of the three metals used in schools (sodium, lithium and potassium). The equation for the reaction is:

$$2K(s) + 2H_2O \rightarrow 2KOH(aq) + H_2(g).$$

Both of these accidents were easily preventable and avoidable had adequate precautions been put in place. The hazardous nature of these chemicals means that they should also be kept under lock and key, either in a locked cupboard or room. Also no pupils should have access to a laboratory or store room without a teacher being present. Laboratories and stores should always be kept locked when not being used.

Prevention is better than cure

All of the accidents described in this article were preventable, had appropriate precautions and thought been applied before the experiment or demonstration. Remember that the teacher is often the person most at risk in a demonstration as you are closer to the action! You should always wear eye protection, a lab coat, and gloves where required. Where necessary you should have a full-face protector and safety screen. If you are demonstrating to a class the pupils must also be protected - they should wear safety glasses and if necessary a safety screen should be used. You should also make sure that you have a suitable fire extinguisher and fire blanket available. Don't forget to consult Material Safety Data Sheets

regularly when completing a risk assessment or keep them on file in an easily accessible folder in the laboratory. The Professional Development Service for Teachers has an excellent supply on their website:

http://chemistry.slss.ie/ph_materialsafetydata.html

When MSDSs are consulted, if the worst happens, then appropriate first aid can then be given. By completing a risk assessment, you are forced to stop and think about what you are doing, to imagine any possible dangerous scenarios, and to put in place appropriate measures to avoid them.

Dr Sarah Hayes completed her PhD in chemical education in 2011 and is now doing a postdoc with Dr Peter Childs in the Chemistry Education Research Group at UL. She has done many science magic shows in schools and is joint organiser with Peter Childs of the Chemistry Demonstration Workshops in UL.

This is part of a series of articles on Laboratory Accidents. If you were involved in an accident at school please share it with your colleagues – no names will be used! Your experience might help prevent an accident.

Diary 2012



Euroscience Open Forum

11-15 July

Convention Centre, Dublin

www.dublinscience2012.ie/

22nd ICCE/11th. ECRICE *Stimulating Reflection and Catalysing Change in Chemistry Education*

July 15-20

Rome, Italy

www.22icce.org/home.html

22nd BCCE 2012

July 29 – August 2

Pennsylvania State University

www.2012bcce.com/

Variety in Chemistry Education

August 30-31

Edinburgh

31st ChemEd-Ireland

Sat. October 20

Dublin City University,
Dublin

Odilla.finlayson@dcu.ie

2013

ASE Annual Conference

University of Reading

Eurovariety 2013

3-5 July

University of Limerick

www.euorvariety2013.ul.ie

peter.childs@ul.ie

32nd ChemEd-Ireland

Sat. October 20

Limerick Institute of
Technology,
Limerick

Marie.walsh@lit.ie

Tested Demonstrations #7

Reactions of sodium with water

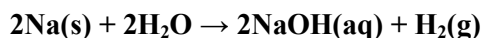
This demonstration involves reacting sodium with water and varying the conditions.

The basic reaction

The reaction of sodium metal with cold water is a common chemical demonstration, although it is safe enough to be done by pupils themselves. Safety glasses and lab coats should be worn, whether doing or watching this experiment. . A drop of two of phenolphthalein is added to the water. A small piece* of sodium is selected with a pair of tweezers and mopped dry of oil on a piece of filter paper. It is then added to the water and pupils asked to observe and record what happens. (** A small piece is about the size of small pea or a cube with ~ 2-3mm sides. This should be cut off a larger piece using a scalpel and stored under oil.*)

Initially nothing much happens and then the sodium starts to react: bubbles appear at the surface, the piece of sodium turns into a sphere and starts to run around the surface and the water turns pink indicating an alkali has been formed.

The reaction is:



The bubbles are hydrogen and as the sodium reacts with water it gives out enough heat to melt the sodium (mpt 97°C), so that the piece turns into a sphere and the hydrogen given off jet-propels it around the surface. This reaction is safe enough to do in a glass petri dish or glass dish on an OHP, so everyone in the lass can see it. The reaction indicates the reactivity of the alkali metals and if the reaction is done with the series lithium, sodium and potassium, then the change in reactivity down the series can be clearly seen. The reaction gets faster, heat is given out more quickly as you go down the series and with potassium it usually catches fire. The heat is given out fast enough to raise the temperature so that the hydrogen ignites and the potassium also burns, giving a lilac flame. Sodium and lithium do not react fast enough with cold water to reach ignition temperature.

Reaction with dilute acid

What would you expect to happen if sodium was reacted with dilute acid e.g. 2M HCl(aq)? The reaction involves the breaking of an O-H bond in water and this requires energy. Metals typically

react with acids to liberate hydrogen and the reaction is faster the higher the concentration. The reaction to produce hydrogen requires less energy if protons are present in high concentrations and O-H bonds do not need to be broken. Reactive metals like sodium can react with very weak acids like water, with low concentrations of protons. So we would predict that sodium should react faster with dilute acids.

The demonstration should be done as above except that 2M HCl(aq) is used instead of water and phenolphthalein is not used. A small piece of sodium is selected with a pair of tweezers and mopped dry of oil on a piece of filter paper. It is then added to the acid and pupils asked to observe and record what happens.

The reaction is slow to start with (as the film of oil and oxide on the surface gets in the way) but when it starts to react it is much faster and will often catch fire, burning with a yellow flame.

Reaction with hot water

Repeat the demonstration above except use hot water instead of cold, and add phenolphthalein indicator.

A small piece of sodium is selected with a pair of tweezers and mopped dry of oil on a piece of filter paper. It is then added to the hot water and pupils asked to observe and record what happens.

When heated reactions usually speed up as the particles move faster and collide with more energy. We would thus expect to get the same reaction of sodium with hot water but it will be faster. When the sodium is added, it should start reacting sooner and when it does the reaction is much faster so that the sodium catches fire and burns with a yellow flame.

Thus the reason potassium, but not sodium, catches fire in cold water is just due to the speed of the reaction not because it is a different sort of reaction. Sodium behaves the same if the reaction is speeded up by using hot water.

N.B. The last two parts could also be done on an OHP but in this case a high-sided, flat-bottomed beaker should be used (not a petri dish) to avoid splashing. The projector should be focused on the

surface of the liquid before adding the sodium. You could also use video camera or visualise to project an image of the demonstration so all the class can see safely.

Tested Demonstrations: # 8

Turpentine (α - pinene) and iodine

In the James Herriott books and TV series about a Yorkshire vet in the late 30s and 40s, one of the old remedies used is the reaction between turpentine and iodine. This is a spectacular and vigorous reaction, which gives off iodine fumes and was used to force iodine (an antiseptic) into a deep wound. It also looked like magic and added to the mystique and aura of the vets.

“As we moved around, Farnon's manner became more and more animated. His eyes glittered and he talked rapidly. Often, he reached up and caressed a Winchester on its shelf; or he would lift out a horse ball or an electuary from its box, give it a friendly pat and replace it with tenderness. ‘Look at this stuff, Herriot,’ he shouted without warning. ‘Adrean! This is the remedy, par excellence, for red worms in horses. A bit expensive, mind you – ten bob a pocket. And these gentian violet pessaries. If you shove one of these into a cow's uterus after a dirty cleansing, it turns the discharges a very pretty colour. Really looks as though it's doing something. And have you seen this trick?’

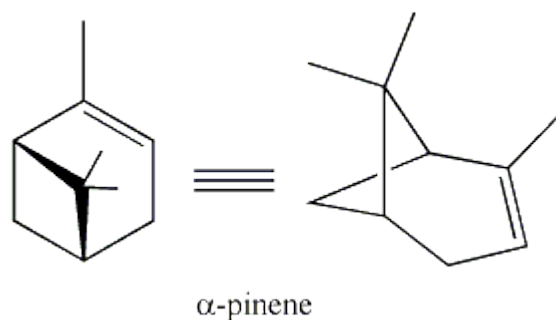
He placed a few crystals of resublimated iodine on a glass dish and added a drop of turpentine. Nothing happened for a second then a dense cloud of purple smoke rolled heavily to the ceiling. He gave a great bellow of laughter at my startled face. *‘Like witchcraft, isn't it? I use it for wounds in horses' feet. The chemical reaction drives the iodine deep into the tissues.’*

‘It does?’
‘Well, I don't know, but that's the theory, and anyway, you must admit it looks wonderful. Impresses the toughest client.’ ”

From *All Creatures Great and Small* by James Herriot

Iodine is not very reactive, compared to chlorine and bromine, and hardly reacts with hexane or cyclohexene. It dissolves rather than reacting. Turpentine, however, contains the highly strained molecule, α - pinene, see the structure below, which does react vigorously and exothermically with iodine. You can see a demonstration of this on the site below. The reaction happens as soon as the chemicals are mixed.

The reaction should not be done in the open laboratory as it produces copious iodine fumes. It can be done in a fume cupboard or inside large gas jar. Put some iodine crystals in the bottom and then add a few drops of turpentine or α - pinene, and replace the lid of the gas jar. This will contain the iodine fumes and the reaction can still be seen. It can be compared with a second gas jar using hexene or cyclohexene instead. The difference in reaction is due to the relief of strain in the highly-strained α - pinene molecule.



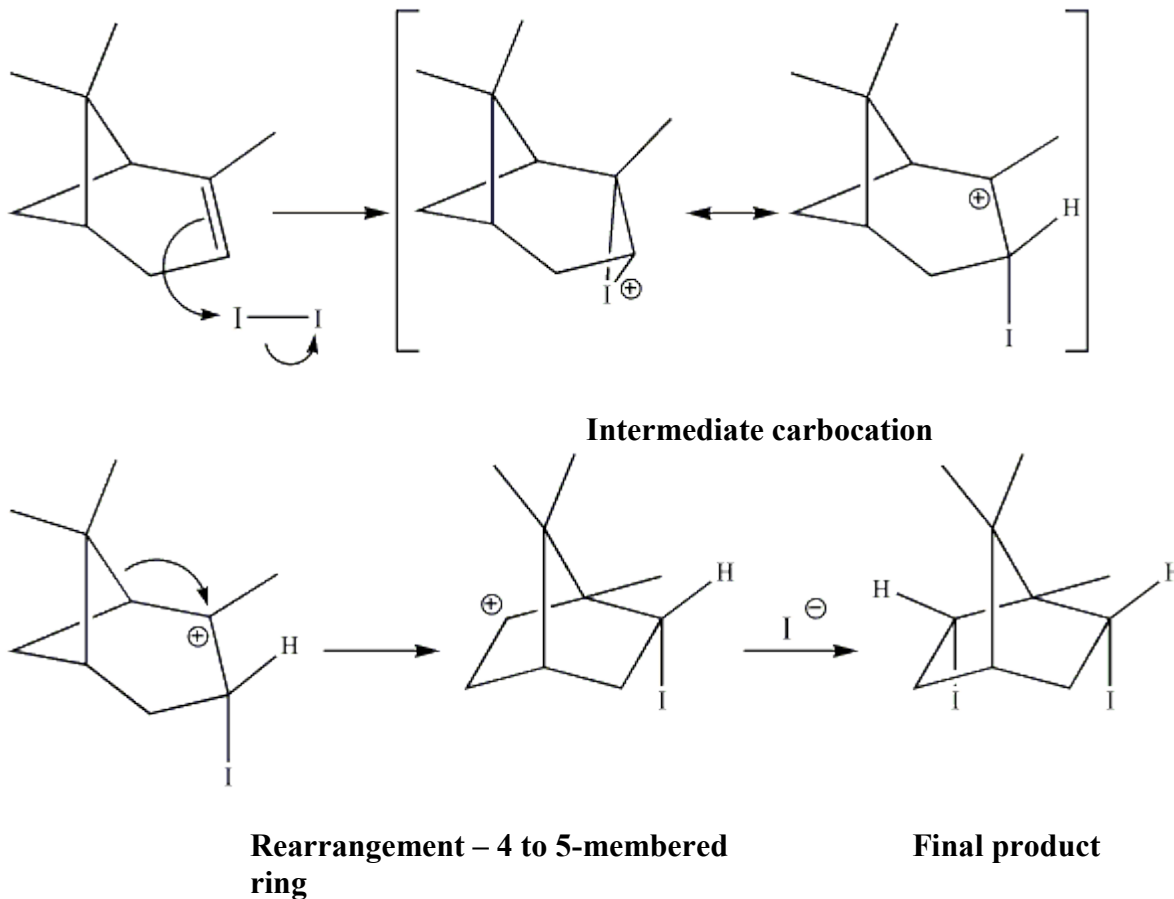
<http://www.chem-toddler.com/organic-chemistry/alpha-pinene-with-iodine.html>

The reaction will only work with natural turpentine produced from pine trees, not turpentine substitute often sold in hardware

shops. I found natural turpentine, which works well, in HomeBase.

When the iodine adds across the double bond, the molecule rearranges from a 4 membered

to a 5-membered ring to relieve strain, which liberates heat and vaporises excess iodine. The reaction is shown below and the product is a substituted norbornane.



References

For a video of the reaction and explanation of the chemistry see:

<http://www.chem-toddler.com/organic-chemistry/alpha-pinene-with-iodine.html>

<http://www.doane.edu/Academics/Majors/Crete/a-c/chemistry/research-video/purple-genie/>