

Safety in the Laboratory

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Safety in the laboratory: two scenarios

Glassware everywhere - spread over benches and tables, some half-full of liquid; dirty glassware waiting to be cleaned; broken burettes lying on the bench... Bottles of chemicals, solid and liquids, some open, some without labels - scattered over the side benches and over the student's benches. Equipment scattered about on window sills. Graffiti on drawers and benches. Safety equipment is conspicuous by its absence. Is this what your laboratory looks like? Do you think it offers a safe working environment for students and teachers? Does it set a good example?

In contrast, another school laboratory is bright and cheerful, with clean, tidy benches. Glassware and chemicals are safely stored on labelled shelves, in drawers and presses. Safety equipment is prominently displayed and there is a rack of safety goggles. Equipment is stored carefully and kept clean. Apparatus and chemicals are taken out, used, cleaned and returned to storage. Does this describe your laboratory?

Which one is yours? The first one is dangerous, a bad example and offers a poor learning experience. The second one is safe, an example of good practice and promises an effective learning experience. The first is a mockery of good science teaching, the second is what it ought to be like. The chance of an accident is high in the first laboratory, as both teachers and students have a poor understanding of safety and their working environment contains many hazards. In the second the laboratory is organised and run in such a way that indicates safety is important and understood, and the risks of accidents are much reduced.

There are two ways of reducing risks in the school laboratory: one is to do nothing at all and the other is to teach safely and provide safe working experiences for students, so that knowledge helps to prevent accidents without avoiding experiments. The untrained pupil with no experience is more dangerous in a laboratory, to themselves and others, than the one who learned progressively the safe working skills needed in the laboratory. One has been equipped for life in a world of hazards; the other is being sent out as an uneducated innocent into a world of risk.

Which laboratory is yours?

The learning package on Laboratory Safety for Junior Science described above in this issue by Bernadette Ni Chathain (p.15) is one approach to integrating safety into the science curriculum. Safety is not just about teaching science, it is about preparing students for life. The laboratories described above are a composite of laboratories we have seen over the years in visiting schools on teaching practice.
P.E. Childs

ISTA National Inservice Course

John Daly

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A Report on the Irish Science Teachers' Association National Inservice Course, Autumn 1998/Spring 1999: Chemistry & Physics Practicals for Junior Certificate Science

This one-day workshop was designed for teachers whose training lies principally in the area of the biological sciences. Its aim was to offer training in the organisation and management of a set of class experiments and thought provoking teacher demonstrations in the Chemistry and Physics areas of the Junior Certificate Science syllabus and to maximise the use of existing school resources, while making allowance for limited laboratory time, limited preparation time and an ever increasing emphasis on safety.

The course was run at venues around the country during October and November. Tom Bolger, John Daly, Fiona Desmond and Philippa Moran collaborated on the design of the course and the production of the resource material. An extensive course material booklet was written. The booklet was then edited, type-set and printed for the ISTA by Blackrock Printers. The high quality of the 120 page booklet was acknowledged by many who attended the course. "Very thorough and well prepared" was the comment from a member of the Science Inspectorate.

Eight all-day Saturday courses were run, with lunch being provided for those attending. Three more presenters were drafted in as a result of unforeseen accidents and illnesses. They were Noel Brett who teaches in Colaiste Chriost Ri, Cork; Randal Henly, recently retired from Mount Temple School, Dublin and Graham Hewston who teaches in St. Clare's Comprehensive School, Manorhamilton.

The evaluation reports filled in by the participants and summarised in the Inservice Course Reports of the presenters, were overwhelming in their approval of the day's activities and many who attended were grateful for the additional resource material provided. Many teachers further commented that more time could be given in the future to workshops of this nature. The feed-back from teachers was so positive that I must thank all the presenters for a thoroughly marvellous job well done.

The financial support of the In-Career Unit of the Department of Education & Science is welcomed by the ISTA. In-career Development is co-funded by the Department of Education & Science and the European Social Fund. The support of the three major schools science equipment suppliers, Alkem Chemicals Limited, Lennox Chemicals Limited and Shaw Scientific Supplies Limited, in providing equipment and consumables was also of crucial importance to its financial viability.

200 Science Teachers around the country have volunteered a Saturday for an Inservice Course which the ISTA can say, from the feedback, is of a high calibre. At

least another 200 applicants for the course were disappointed when the places available were filled up in a matter of days. The Association however intends to run a similar course in eight new venues in the Spring of 1999. Watch out for the brochures in early 1999.

The support of the staff of the Blackrock Education Centre has been invaluable and makes a huge difference to the efficiency with which the course is organised. The interest taken by its Director, Seamus Cannon, has been of great help to the Association. I am especially grateful for the dedication, patience and efficiency of Evelyn Logan, who acts as the contact person for all those wishing to attend the Course.

We, the presenters of the course, were gratified by the enthusiasm and dedication of the teachers who attended. The need for the professional support offered by this course became evident very early on. Many of the teachers attending were young, in their first few years of teaching. A large number of them had been launched into schools which have too few and/or badly equipped laboratories. Often there was a limited support structure in place in the school for developing that teacher's ability to teach science and run pupil practical work. The inadequacy of their initial teacher training was mentioned on several occasions.

We concentrated on the development of practical skills for teachers of science, with particular reference to Chemistry and Physics areas of the Junior Certificate Science Course. We set out to develop skills in the ordering, preparation and use of science equipment. We tried to inculcate, in the short time available, class-room management skills which are particularly applicable to the running of practical science classes. We made a special effort to raise the awareness levels of those present about safety in the school science laboratory.

There is an urgent need for a permanent support structure for the on-going development of science teaching and laboratory management skills. This should be developed in parallel with the current efforts to improve funding for science laboratories for pupils in all the post-primary schools in Ireland. A feature of many schools, mentioned in conversations with the teachers attending, was the absence of a management structure within the science departments. This makes the work of the "new " or younger teacher even more difficult. The absence of laboratory assistants, formal budgets, stock control, common syllabi, common school examinations were all quoted as hindering the development of "best practice" by the new entrant to the profession.

Another area of concern was raised at one of the courses. An example was quoted where, in the interests of "inclusivity" the new posts of management in that school could no longer list "Science Coordinator ". This example may not be widespread but if it has happened at all it will not help to improve the teaching of science.

In conclusion, I am happy that we, in the Association, have taken some first steps in this area. Our information, that there are many teachers struggling, without adequate support, to teach curricula to the best of their ability in difficult situations, has been proven correct. I am saddened by the absence of a

comprehensive support system for these teachers. I can see that many pupils are losing out on experiencing practical science for themselves. It is clear that what we have done so far, is just a small beginning in dealing with a very large problem.

Biographies of the team members:

Tom Bolger teaches in St. Peter's College, Wexford. He is a past-chairman of the ISTA and has been a member of the ISTA physics sub-committee on many occasions. He is well known as a presenter of inservice lectures and workshops all around the country.

John Daly teaches in Blackrock College, Dublin. He is immediate past chairman of the ISTA and a member of the ISTA chemistry sub-committee. He has presented demonstration lectures for Transition Year students in UCD and in the RDS for a number of years. He was the course organiser.

Fiona Desmond teaches in The Cork College of Commerce. She is currently convener of the ISTA physics sub-committee and the Association representative on the NCCA Physics committee. She is a past chairman of the Cork Branch of the ISTA.

Philippa Moran teaches in Templeogue College, Dublin. She is outgoing National Treasurer of the ISTA, and convener of the ISTA finance sub-committee. She has presented a chemistry practical workshop for H. Dip.in Ed. students in Dublin with John Daly for a number of years. She has also presented a workshop on Transition Year material for the Biology Committee of the Royal Irish Academy.

Comment:

The ISTA produced an excellent book to accompany these workshops, which was given to all participants. I'm not sure if it is available for sale, but it ought to be. It describes 13 chemistry pupil experiments (with pupil pages and teacher's notes) and 6 teacher demonstrations, with information on organisation, making up solutions and guidelines on demonstrations. There is a similar number of physics experiments and demonstrations. If you didn't get to the workshops, try and get hold of a copy.

PEC

Quantity Calculus for Chemsits

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Introduction

I love American textbooks on general chemistry because of their appealing lay-out, clear drawings and other illustrations, subject treatment which is often easy to follow, boxed-in extra's (sometimes written by guest-authors), worked examples, and glossaries. Therefore, I consider myself fortunate to possess three such texts¹⁻³ which, judged by the number of university teachers mentioned in their acknowledgments, must enjoy an ever increasing popularity. These texts resemble each other in the way in which they treat the chemical calculations, and it is this way that I hate.

The technique of performing calculations, that seems to be firmly rooted in the history of American chemical education, has been given different names, such as the factor-label method⁴ and dimensional analysis⁵, but nowadays its name refers to (unit) conversion factors. I shall argue presently that, for the few cases where the method is applicable, it is not needed, whereas for all other cases it is based on nonsense.

The authors¹⁻³ have embraced "Le SystŠme International d'Unit,s", or SI, though not always wholeheartedly and certainly not completely. For chemists the most important SI base quantity is "amount of substance", which is measured in moles. Despite a clear warning in one of the books: the mole "should be used exactly as the international community has specified"⁶, it is taken for "the chemist's dozen"⁷, or a particular mass⁸, or Avogadro's number of objects⁹. None of these descriptions is in agreement with the specifications of the international community, i.e. the 14th CGPM of 1971. These incorrect interpretations of the SI definition of the mole are the roots of inconsistent statements made later on in these texts.

Before going into details, the concept of *dimension* should be brought into play.

Dimension analysis

SI consists of seven base quantities and its other quantities are derived ones. The dimension of a derived quantity shows how it is constructed, using base quantities as bricks. By definition, this dimension is equal to the product of powers of the base quantities involved. For the sake of the argument, I assume that there might be a need for a derived quantity Q with a dimension that involves all base quantities. Then its dimension is given by:

$$\text{dim}(Q) = \text{length}^a \cdot \text{mass}^b \cdot \text{time}^c \cdot (\text{electric current})^d \cdot (\text{thermodynamic temperature})^e \cdot (\text{amount of substance})^f \cdot (\text{luminous intensity})^g$$

in which a, b, etc, denote positive or negative powers. Using the standard notation, this result can be written more compactly in the form

$$\dim(Q) = L^a.M^b.T^c.I^d.t^e.N^f.J^g$$

which is independent of the language in question. The SI unit of quantity Q can be found by replacing each of the base quantities by its base unit, thus:

$$[Q] = m^a.kg^b.s^c.A^d.K^e.mol^f.cd^g$$

In practice the dimensions of quantities can be used to check an equation, in which different quantities partake. In such a dimension analysis numerical factors are neglected. Thus, an equation (like $E_k = mv^2$) may be dimensionally correct but factually wrong. However, if the dimensions of the quantities on both sides of an equation are not equal to each other, then that equation certainly is wrong.

One reason for including this section stems from my impression that the concept of dimension is not well-known, and even less well-understood. To underpin this impression I give two quotations. In an apparently successful book on problem solving dimensions are confused with units (and worse): "Every number that represents a measurement is given with its dimension - for example, 12 men, 16 feet, 5 miles"¹⁰. In a similar book it is maintained that "dimensional analysis [is] a method of analyzing the units of physical measurements and calculations"⁵. However, from the foregoing it should be clear that dimension analysis has to do with dimensions, and these depend on base quantities, not units.

Conversion of units

Units can only be converted into other units, if they are of same type, i.e. if they can be used to measure the same quantity. As the conversion of such SI units into each other is rather trivial, I shall only consider the conversion of English units into SI units. The following examples have been taken from textbooks.

Example 1.

*The diameter of a piece of glass tubing is given as 1.50 inches (1.50 in). Convert that measurement to centimeters*¹¹.

To solve this problem, we need to know the relationship between inches and centimeters. By definition, 1 inch is equal to exactly 2.54 centimeters. This information can be written in the form of an equation:

$$(1) \quad 1 \text{ in} = 2.54 \text{ cm}$$

Next, both sides of this equation are divided by "1 in". The right-hand side of the resulting equation

$$1 = \frac{2.54 \text{ cm}}{1 \text{ in}}$$

is called "conversion factor". Using this factor the textbook solution is given as:

$$(2) \quad \text{"Diameter (cm)} = 1.50 \text{ in} \times \frac{2.54 \text{ cm}}{1 \text{ in}} = 3.81 \text{ cm}"$$

The gist of the method is the fact that the conversion factor is equal to 1, and multiplying anything by 1 should not change anything.

From a mathematical point of view multiplication of anything by 1 and division of anything by 1 are equivalent operations, because they yield exactly the same result. So, why not divide by the conversion factor? The result of this calculation,

$$(3) \text{ Diameter} = 1.50 \text{ in} : \frac{(2.54 \text{ cm})}{1 \text{ in}} = 0.591 \frac{\text{in}^2}{\text{cm}}$$

is, of course, *perfectly* correct, but it may not be of great practical value. For that reason I can accept that multiplication by 1, as in eq.(2), yields a useful result, whereas division by 1, as in eq. (3), does not. But it bothers me that the results of two equivalent calculations are so different. It does not seem right. Even if I disregard eq. (3), my uneasiness with respect to the conversion factor lingers on. Let me try to explain, why.

If I multiply a number, 17 say, by 1, then the result is 17, so nothing is changed. Next, I multiply "1.50 in" by 1: $(1.50 \text{ in}) \times 1 = (1 \times 1.50) \text{ in} = 1.50 \text{ in}$, so nothing is changed. Now I repeat the calculation, but I disguise 1 as a conversion factor. This calculation is shown in eq. (2). It yields a new numerical value and a new unit, so *everything* is changed. Multiplication by 1 has changed everything. See, what I mean?

Cannot I just forget about the enigmatic conversion factor, and solve the problem in another way? Yes I can, and very easily so, by using the *method of substitution*. It goes like this:

$$d(\text{tube}) = 1.50 \text{ in} = 1.50 \times 1 \text{ in}$$

I have multiplied by 1, but nothing is changed. Now I use eq. (1), and substitute "1 in" by "2.54 cm". I then get:

$$d(\text{tube}) = 1.50 \times 2.54 \text{ cm} = 3.81 \text{ cm}$$

The method of substitution can even be used, if the basic information had been given in another form, for example: $3 \text{ in} = 7.62 \text{ cm}$. In that case I write:

$$d(\text{tube}) = 1.50 \text{ in} = 0.50 \times 3 \text{ in} = 0.50 \times 7.62 \text{ cm} = 3.81 \text{ cm}$$

Example 2:

Light travels at a speed of 6.70×10^8 miles per hour. Express this speed in centimeters per second⁴.

The textbook solution, given as:

$$\frac{\text{cm}}{\text{sec}} = \frac{6.70 \times 10^8 \text{ mi}}{\text{hr}} \times \frac{5.28 \times 10^3 \text{ ft}}{\text{mi}} \times \frac{1.20 \times 10^1 \text{ in.}}{\text{ft}} \times \frac{2.54 \text{ cm}}{\text{in}} \times \frac{1 \text{ hr}}{6.00 \times 10^1 \text{ min}} \times \frac{1 \text{ min}}{6.00 \times 10^1 \text{ sec}} = 3.00 \times 10^{10} \text{ cm/s}$$

is based on a multiplicative chain of five conversion factors. Of course, this chain could be shortened, for example, by combining the last two conversion factors.

However, chains of three or four conversion factors are not uncommon in the solutions of other more or less complicated worked examples. In these examples various units (and other details !) are first written down, only to be crossed out later. It seems to me that the method of problem solving, that is based on conversion factors, high-lights a waste of ink, time and effort.

To solve the problem of Example 2 by the method of substitution, we need the well-known relationship between hours and seconds ($1\text{ hr} = 3600\text{ s}$) and the relationship between miles and centimeters. Starting from eq. (1), I found that the relation $1\text{ mi} = 160,934.4\text{ cm}$ is exact [and, while travelling along the inch-foot-yard-chain-furlong-mile path, I wondered how a great nation could have put up with such units for so long!]. Finally, the solution can be written as:

$$c = 6.70 \times 108 \frac{\text{mi}}{\text{hr}} = 6.70 \times 108 \times \frac{1.6093 \times 10^5 \text{ cm}}{3600} = 3 \times 10^8 \text{ cm s}^{-1}$$

Now I should turn to problems that are solved using (what I shall call) *would-be* conversion factors. However, because the mole plays a crucial role in most of these calculations, I first have to address its intricacies.

The amount of substance and its mole

I must start with the SI definition of the mole:

*"The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon-12. When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles"*¹².

In constructing this definition of the mole, the 14th CGPM has given birth to a brand-new physical base quantity that has been given the name "amount of substance".

According to three (British) dictionaries, "amount" can mean "quantity" and "substance" can mean "matter". Hence, "amount of substance" can mean "quantity of matter". I found it quite amusing that in one book¹³ "quantity of matter" is associated with mass, which is a *different* SI base quantity, whereas in another book¹⁴ a certain equation is said to represent a "mass balance" where "amount of substance balance" would be more appropriate. In any case, the mole has been designed to measure a quantity that can be attributed to a system which contains *elementary entities*.

The nature of the elementary entities is specified in the second part of the definition. Clearly, an elementary entity must be a *particle*. However, ionic substances are built up from *different* particles. To be able to use the concept of amount of substance also for such substances, the "specified group of particles" has been introduced. Thus, the elementary entity of common salt is the $(\text{Na}^+)(\text{Cl}^-)$ ion pair, and the elementary entity of $\text{Al}_2(\text{SO}_4)_3$ is the ion quintet, consisting of two Al^{3+} ions and three SO_4^{2-} ions. Bearing this in mind I shall, from now on, use the term "particle" instead of "elementary entity".

A chemical bond is neither a particle, nor a specified group of particles. It is an abstraction that is used to

explain why material particles stay together. Amount of substance, like mass, is an attribute of *matter*, not of something that is immaterial. As the mole is the unit-amount of substance, it cannot have anything to do with chemical bonds. Hence, one cannot speak of "1 mole of bonds". Those who do so^{15, 16} confuse the mole with Avogadro's number, and open the door to notions like "1 kilogram of bonds".

In thermodynamics the universe is divided into two parts, a system and its surroundings. A system is a particular part of the universe, chosen by us for the purpose of satisfying our scientific curiosity. A simple example of such a system is a beaker, including its contents.

As I intend to keep the discussion as simple as possible, I shall restrict myself to pure substances. Consequently, I shall, from now on, use the term "sample" instead of "system". More specifically, "sample" stands for a "finite, thus measurable, amount of a pure substance". Examples of such samples are: a sip of water, a cake of soap, a lump of sugar and a pinch of salt.

It took me a while to arrive at the notion that "amount of substance" is a quantity that can be attributed to a *sample* which contains *particles*.

A sample of carbon-12 that has a mass of exactly 0.012 kg contains a particular number of atoms. This number is called "Avogadro's number", and it shall be denoted by the symbol N_0 ¹⁷. Now consider a sample of argon, say, that contains N_0 atoms. By definition, the amount of substance of this sample is equal to 1 mol [here I use, for the first time, the symbol "mol" by which the unit with the name "mole" is designated]. Consider a second sample of argon, exactly twice as large as the first one. This new sample obviously contains $2 N_0$ atoms, hence its amount of substance is 2 mol. It follows that amount of substance is an extensive quantity, because it increases linearly with the size of the sample. Put in another way: the amount of substance of a sample is proportional to the number of particles of that sample, but it is not necessarily equal to that number.

Mass is also an extensive quantity. Hence, the mass of a sample is proportional to the number of particles of that sample. We know, however, that mass is not equal to that number. So, why should amount of substance be different in this respect, that is: why should (for our original sample of argon) 1 mol be equal to N_0 particles? Later on I shall show that this equality does not hold. For the present I only make the following suggestion: if the international scientific community, represented by the CGPM, or IUPAC (possibly backed by IUPAP), had wanted the mole to be equal to N_0 particles, it easily could have decreed so. The official SI definition could then have been something like "The mole is the number of elementary entities that is equal to the number of atoms in 0.012 kilogram of carbon-12". Since such a choice has not been made, the current definition (given at the beginning of this section) has to do.

The sample and its size

For a large part chemical calculations relate to samples of substances. Apart from special cases (such as a piece of aluminum foil, the size of which can be determined from its given length) the size of a sample is fixed by stating its mass, its volume, its amount of substance, or its number of particles. The first three quantities seem to vary continuously with the size of the sample, whereas its number of particles emphasizes the discontinuous nature of matter.

If a sample has a large mass, we find it heavy or weighty, so mass is related to its heaviness or weightiness. Indeed, the experimental determination of the mass of a sample by weighing is based on equalization of weights.

If a sample has a large volume, it occupies much space, it is spacious. Hence, volume is related to the sample's spaciousness.

If a sample has a large amount of substance, we could say that we are dealing with a substantial sample. So, amount of substance is related to the sample's "substantialness". Equal volumes of different ideal gases, measured at the same T and the same p , have equal "substantialness", but different heaviness.

Mass, volume, amount of substance and number of particles are different properties which emphasize different characteristics of one and the same sample. These extensive quantities are not properties of a substance, but of a sample of a substance. For example, if we sloppily say that "the mass of copper is 12.3 g", we mean to say that "the mass of a particular sample (or piece) of copper is 12.3 g".

Calculating chemists are primarily interested in two things:

1. How to find a certain quantity of a sample, if another quantity of that same sample is given.
2. How to find a quantity of a sample of one substance from a given quantity of a sample of another substance, if both substances are related to each other by a chemical reaction.

Apparently such problems can be solved in different ways. In my opinion, the only way that is paved with logic is found in the Realm of Quantity Calculus. So let's enter that beautiful land.

Quantity Calculus

The essence of quantity calculus has been described by Mills et al.¹⁸: "Quantity calculus is a system of algebra in which symbols are consistently used to represent physical quantities, rather than their measures, i.e. numerical values in certain units. Thus we always take the values of physical quantities to be the product of a numerical value and a unit, and we manipulate the symbols for physical quantities, numerical values, and units by the ordinary rules of algebra. This system is recommended for general use in science."

Before going into details, I have to make some remarks about these symbols and their notations. Extensive lists of ISO normsymbols for physical quantities can be found in the literature^{19,20}. As for their typography²¹, it may be reminded that:

1. The symbol for a physical quantity, even if used as a subscript or superscript, should be printed in italic (sloping) type.
2. The symbol for a subscript or superscript that is not a physical quantity or a numerical variable, as well as the symbol for a unit, should be printed in roman (upright) type.

To appreciate the sense of these rules the typography of two well-known symbols, K_p and K_a , may be compared.

The quantities mass, volume, amount of substance and number of particles have been given the symbols m , V , n and N , respectively. When using such symbols, we should always mention the type of particle(s) involved. In general this type shall be denoted by the symbol X . Thus, " $m(X)$ " represents the mass of a sample, consisting of particles of type X . The statement " $m(\text{Hg}) = 5.0 \text{ g}$ " now means that the mass of a particular sample of pure mercury is equal to 5.0 grams. This shows that using symbols for quantities and units is a much more efficient way to convey information, than using words. If we would want to convey that our statement refers to mercury in the gas phase, we simply write " $m(\text{Hg(g)}) = 5.0 \text{ g}$ ". Other useful information can be incorporated in a similar way, so that the right-hand side of the statement consists of a numerical value and a unit *only*. Then, and only then, the right-hand side has the format of a physical quantity, as it (of course) should have. Here there is no place for "descriptive units" [so ardently advocated by some^{22, 23}] which are not units at all, but (often) mere objects, such as atoms and molecules, or formulas of substances.

Now that the necessary preliminaries have been dealt with, I turn to the all-important question of how we can find a desired quantity, when another quantity is given. The answer is that we use, what I shall call, *bridge-quantities* which have been specially designed to do the job.

Any extensive quantity, such as $E_2(X)$, can be divided by any other extensive quantity, such as $E_1(X)$, to yield an intensive quantity $I_{2,1}(X)$, thus

$$(4) \quad I_{2,1}(X) = \frac{E_2(X)}{E_1(X)}$$

In this way a set of intensive bridge-quantities $\{I_{n,1}(X); n = 2, 3, 4, \dots\}$ can be generated. The elements of this set have in common that all of them have been obtained by the rule: divide by $E_1(X)$. Intensive quantities do not depend on the size of the sample. They are (usually with certain restrictions) *constants* that can be tabulated.

Suppose we know $E_1(X)$ and we want to find $E_2(X)$. We just look up $I_{2,1}(X)$ in the appropriate table and then calculate $E_2(X)$ using the equation

$$E_2(X) = I_{2,1}(X) \times E_1(X)$$

which can easily be derived from eq.(4). With the help of $I_{2,1}(X)$ we have bridged the conceptual gap between $E_2(X)$ and $E_1(X)$ which are *different* quantities that, for that reason, cannot be converted into each other by means of a conversion factor.

Remarkably, the number of different sets of bridge-

quantities, that are used in practice, is not large. Here it suffices to consider only two such sets. If we take $E_1(X) = V(X)$, then eq.(4) yields a set of *volumic*²⁴ bridge-quantities. An element of that set is the volumic mass, defined by:

$$(5) \quad r(X) = \frac{m(X)}{V(X)}$$

but this quantity is better known by the name "(mass) density".

Especially for the convenience of chemists the set of molar^[1] bridge-quantities has been devised. This set can be obtained by making, in eq. (4), the substitution $E_1(X) = n(X)$. Very useful elements of this set are the molar mass,

$$(6) \quad M(X) = \frac{m(X)}{n(X)}$$

the molar volume,

$$(7) \quad V_m(X) = \frac{V(X)}{n(X)}$$

and the molar number of particles,

$$(8) \quad N_A = \frac{N(X)}{n(X)}$$

The molar quantity N_A is also called "Avogadro's constant". Before considering its relationship with Avogadro's number, N_0 , I will write eq. (8) in the form

$$(9) \quad n(X) = \frac{N(X)}{N_A}$$

This equation shows how the amount of substance of a sample and the number of particles of the same sample are related to each other. In fact, eq. (9) can be regarded as the *definition* of the concept "amount of substance". Earlier we found that $n(X)$ is proportional to $N(X)$. Now eq. (9) shows that the proportionality factor has been chosen to be equal to the reciprocal of Avogadro's constant, and *not* equal to 1. To appreciate this last statement, I consider a sample of which the amount of substance $n(X)$ is equal to exactly 1 mol. By definition, $N(X)$ of this very special sample is equal to N_0 . Substitution of these results into eq. (9) yields²⁵

$$(10) \quad 1 \text{ mol} = \frac{N}{N_A}$$

This result is independent of X and differs markedly from the notion that " $1 \text{ mol} = N_0$ ". Finally, if I write eq. (10) in the form:

$$N_A = N_0 \text{ mol}^{-1}$$

it can be seen that (as implied by its name) Avogadro's number ($N_0 = 6.022 \times 10^{23}$) is the numerical part of Avogadro's constant ($N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$).

Returning to the other molar quantities, I must stress that the molar mass is *not* a particular mass, the molar volume is not a particular volume, and the molar number of particles is not a particular number of particles. The molar quantities are *new* quantities, completely different from the ones from which they have been derived. Using dimension analysis it can easily be shown that (for example) molar mass and mass have different dimensions. Therefore, these two quantities can *never* be equal to each other. Statements like "The molar mass is the mass in grams of one mole of a substance"²⁶, "the volume 22.4 L is called the *molar volume* of an ideal gas at 0°C and 1.00 atm."²⁷ and " $1 \text{ mol} = 6.022 \times 10^{23}$ objects"⁹ are all wrong, and I doubt whether digestion of such nonsense will enhance the students' *understanding* of chemical calculations. Such mistakes would probably not have been made if quantity calculus had been used. Tackling problems on the basis of relations like eqs. (5)-(8) is quantity calculus par excellence.

The right answer for the wrong reason

In this section I shall consider two worked examples, and I shall compare the textbook solutions, obtained by using "conversion factors", with those found by quantity calculus.

Example 3.

Calculate the number of moles of methane in 50.0 g of methane²⁸.

The textbook solution goes like this: "The formula mass of CH_4 is 16.0, and so there are 16.0g per mole of methane. To determine how many moles there are in 50.0g, we must convert grams of methane to moles of methane. We carry out this conversion using the unit conversion factor:

$$(11) \quad 1 \text{ mol CH}_4 = \frac{1 \text{ mol CH}_4}{16.0 \text{ g CH}_4}$$

Thus:

$$\text{mol CH}_4 = (50.0 \text{ g CH}_4) \cdot \frac{(1 \text{ mol CH}_4)}{16.0 \text{ g CH}_4} = 3.13 \text{ mol CH}_4$$

Clearly, this solution is based on the relation:

$$(12) \quad 1 \text{ mol CH}_4 = 16.0 \text{ g CH}_4$$

which states that a certain amount of substance is equal to a certain mass. As amount of substance and mass are *different* quantities (or properties) of a sample, they can never be equal to each other, and the unit conversion factor of eq. (11) should perform the impossible task of converting grams into moles. Hence, it is a *would-be* conversion factor that has its origin in nonsense.

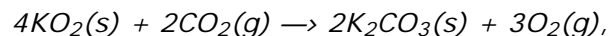
Using quantity calculus the solution is found, from a rewritten form of eq. (6), as:

$$m(\text{CH}_4) = \frac{m(\text{CH}_4)}{M(\text{CH}_4)} = \frac{50.0 \text{ g}}{16.0 \text{ g mol}^{-1}} = 3.13 \text{ mol}$$

When you compare both solutions, disregarding the difference in notation, you might ask: so, what's the difference? The answer is that the difference in notation implies an enormous difference in the way of thinking. The second solution does not make use of the equality of two quantities (as suggested by eq. (12)) but it does the opposite: it stresses the difference between the two. We just cannot convert mass into amount of substance, but we must "build a special bridge" to reach our goal. For this problem the appropriate bridge-quantity is the molar mass. To be able to do the job, molar mass has been given as dimension the suitable combination of the dimensions of mass and amount of substance. Therefore it can be used to determine the amount of substance of a sample, when the mass of the same sample is known.

Example 4.

Given the reaction:



calculate the mass of KO_2 needed to react with 50L of carbon dioxide at STP²⁹.

I cannot but reproduce a large part of the textbook solution:

"Strategy: We convert from volume to moles of CO_2 , then from moles of CO_2 to moles of KO_2 , and finally from moles of KO_2 to mass of KO_2 by using its molar mass (71.1 g/mol).

Solution: The three conversions are based on three relations:

$$\begin{aligned} (13) \quad & 22.4 \text{ L CO}_2 = 1 \text{ mol CO}_2 \\ (14) \quad & 2 \text{ mol CO}_2 = 4 \text{ mol KO}_2 \\ (15) \quad & 1 \text{ mol KO}_2 = 71.1 \text{ g KO}_2 \end{aligned}$$

The result we require is therefore:

$$\begin{aligned} \text{Mass of KO}_2 \text{ g} &= 50 \text{ L CO}_2 \times \frac{1 \text{ mol CO}_2}{22.4 \text{ L CO}_2} \times \frac{4 \text{ mol KO}_2}{2 \text{ mol CO}_2} \\ &\quad \times \frac{71.1 \text{ g KO}_2}{1 \text{ mol KO}_2} = 3.2 \times 10^2 \text{ g KO}_2 \end{aligned}$$

After my remarks with respect to eq. (12), I need not discuss the nonsense presented in eqs. (13) and (15) in detail. Here it is maintained again that different quantities of the same sample of the same substance can be equal to

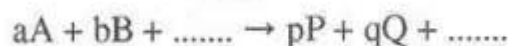
each other. However, eq. (14) plays in quite a different league. Now we are invited to believe that amounts of different substances can be equal to each other. Just picture this: on one side of your lab bench a tank containing colorless CO₂ gas, and on the other side a dish displaying a heap of yellow KO₂. Nothing more needs to be said.

Quantity calculus follows the strategy outlined above in spirit, but the calculation is done in steps.

1. Rewrite eq.(7) to obtain:

$$n(\text{CO}_2) = \frac{V(\text{CO}_2)}{V_m(\text{CO}_2)} = \frac{50 \text{ L}}{22.4 \text{ L mol}^{-1}} = 2.23 \text{ mol}$$

2. To make the transition from CO₂ to KO₂, I use a relation dug up by Tykodi³⁰, who deserves a medal for saving de Donder's work from oblivion. The de Donder relation for the reaction



(where a,b, etc, are coefficients, and A,B, etc, are formulas of substances) is:

$$\frac{n(A)}{a} = \frac{n(B)}{b} = \dots = \frac{n(P)}{p} = \frac{n(Q)}{q} = \dots$$

This relation shows that the de Donder ratios (like n (A)/a) for the reactants and the products of a chemical reaction are all equal to each other. Choosing the suitable de Donder ratios for the reaction under consideration, we have

$$(16) \quad \frac{n(\text{KO}_2)}{4} = \frac{n(\text{CO}_2)}{2}$$

from which: $n(\text{KO}_2) = 2n(\text{CO}_2) = 4.46 \text{ mol}$.

3. Finally, rewrite eq 6 to obtain:

$$m(\text{KO}_2) = n(\text{KO}_2) \times M(\text{KO}_2) = 4.46 \text{ mol} \times 71.1 \text{ g mol}^{-1} = 3.2 \times 10^2 \text{ g}.$$

Eq. (16) differs markedly from eq. (14). The equation of the reaction shows that 4 mol KO₂ can react with 2 mol CO₂. So, if we take 12 mol KO₂, we expect that then 6 mol CO₂ can react. This proportionality can be written as:

$$n(\text{KO}_2) : n(\text{CO}_2) = 4 : 2,$$

from which eq. (16) can be derived. Hence, this (or any other) de Donder relation only expresses an obvious proportionality, nothing more and nothing less. It does not suggest (as does eq. (14)) that 2 mol CO₂ is equal to 4 mol KO₂.

The analysis of the solutions of these two representative textbook problems shows that quantity calculus is superior to the method using "conversion factors", because the

former is based on logic, whereas the latter is based on nonsense.

Conclusion

The authors of the textbooks considered here (and, presumably, many others) wander in the desert of would-be conversion factors. It would be a blessing for chemical education if they, some day, could reach the promised land of quantity calculus.

Footnote:

[1] I must mention straight away that the adjective "molar" is not a logical one. Instead, we should use an adjective that is derived from the name "amount of substance".

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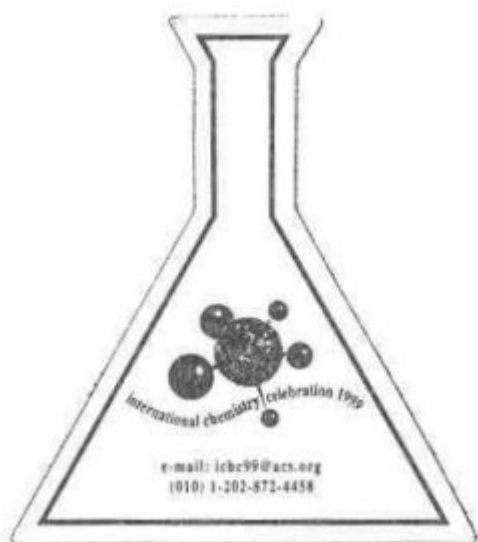
Any correspondence on this article should be addressed to the author at the address given at the head of the article.

Who is this ?



Answer in Issue #58

International Chemistry Celebrations 98-99 Design a Chemistry Magazine Competition



The Schools Information Centre on the Irish Chemical Industry (SICICI) together with Roche Ireland Ltd. is sponsoring a competition for Transition Year students to mark International Chemistry Celebration. The brief is to produce an A4 size chemistry magazine aimed to interest 3rd./4th, year students. It should have between 8-12 A4 pages (2-3 A3 sheets printed both sides). The magazine should feature the ICC logo on its front cover. The magazine must be word-processed and a DTP package should be used e.g. MS Publisher. The magazine should include colour and could include any or all of the following:

- interesting news items
- element or chemical profiles
- cartoons
- jokes or anecdotes
- short stories
- profiles of people or local industries
- quizzes, crosswords, wordsearches etc.
etc.

The judges will be looking for:

- attractive presentation
- variety of content
- interesting material
- accurate chemistry

Closing date for completed magazines: **May 30th. 1999**

Prizes: £250 first prize; £150 second prize; £50 third prize. The prizes will be given to the school to spend on chemistry books.

The magazine may also be produced in Irish and a separate prize of £200 will be awarded to the best all-Irish entry (if there are sufficient entries).

It is also hoped to print and distribute the winning magazine to schools as part of Ireland's International Chemistry Celebration activities.

Please get your students working away - it should provide an opportunity for them to develop IT skills and learn something about chemistry and get them more interested in chemistry as a subject and as a career.

Chemillennium Issue: Spring 2000, #60

The first issue of Chemistry in Action! in the new millennium, Spring 2000, will mark 20 years of publication and will be the 60th. issue. This will another milestone in the history of this publication and I hope we get there! I would like to mark it with a special issue to remember the last 20 years and to look forward into the future. I will be asking various people to write something for the special bumper issue, but I would also like to invite others to send in items for #60: poems, short stories, teaching or scientific anecdotes, historical items, interesting everyday chemistry, jokes etc. Anything publishable in fact! Please try to get items to me by the end of **September 1999** and make it a chememorable issue.

Peter E. Childs

Hon. Editor

CHEMICAL CLASSICS:

"A Chemical History of a Candle"

Michael Faraday (1861)

In this issue we present the fourth of Michael Faraday's famous lectures on "A Chemical History of A Candle". The first lecture appeared in issue #54 and the other lectures will be presented in subsequent issues. The notes are numbered sequentially from the first letter and are printed at the end of each letter.

LECTURE IV

HYDROGEN IN THE CANDLE - BURNS INTO WATER - THE OTHER PART OF WATER - OXYGEN

I see you are not tired of the candle yet, or I am sure you would not be interested in the subject in the way you are. When our candle was burning we found it produced water exactly like the water we have around us; and by further examination of this water we found in it that curious body, hydrogen - that light substance of which there is some in this jar. We afterwards saw the burning of that hydrogen, and that it produced water. And I think I introduced to your notice an apparatus which I very briefly said was an arrangement of chemical force, or power, or energy, so adjusted as to convey its power to us in these wires; and I said I should use that force to pull the water to pieces, to see what else there was in the water besides hydrogen; because, you remember, when we passed the water through the iron tube, we by no means got the weight of water back which we put in in the form of steam, though we had a very large quantity of gas evolved. We have now to see what is the other substance present. That you may understand the character and use of this instrument, let us make an experiment or two. Let us put

together, first of all, some substances, knowing what they are, and then see what that instrument does to them. There is some copper (observe the various changes which it can undergo), and here is some nitric acid, and you will find that this being a strong chemical agent will act very powerfully when I add it to the copper. It is now sending forth a beautiful red vapour; but as we do not want that vapour, Mr. Anderson will hold it near the chimney for a short time, that we may have the use and beauty of the experiment without the annoyance. The copper which I have put into the flask will dissolve: it will change the acid and the water into a blue fluid containing copper and other things, and I purpose then showing you how this voltaic battery deals with it; and in the meantime we will arrange another kind of experiment for you to see what power it has. This is a substance which is to us like water - that is to say, it contains bodies which we do not know of as yet, as water contains a body which we do not know as yet. Now this solution of a salt¹⁵ I will put upon paper and spread about, and apply the power of the battery to it, and observe what will happen. Three or four important things will happen which we shall take advantage of. I place this wetted paper upon a sheet of tinfoil, which is convenient for keeping all clean, and also for the advantageous application of the power; and this solution, you see, is not at all affected by being put upon the paper or tinfoil, nor by anything else I have brought in contact with it yet, and which, therefore, is free to us to use as regards that instrument. But first let us see whether it is in the state in which it was last time. We can soon tell. As yet, when I bring them together, we have no power, because the conveyers - what we call the electrodes - the passages or ways for the electricity - are stopped; but now Mr. Anderson by that [referring to a sudden flash at the ends of the wires] has given me a telegram to say that it is ready. Before I begin our experiment I will get Mr. Anderson to break contact again at the battery behind me, and we will put a platinum wire across to connect the poles, and then if I find I can ignite a pretty good length of this wire we shall be safe in our experiment. Now you will see the power. [The connexion was established, and the intermediate wire became red-hot.] There is the power running beautifully through the wire, which I have made thin on purpose to show you that we have those powerful forces; and now, having that power, we will proceed with it to the examination of water.

I have here two pieces of platinum, and if I lay them down upon this piece of paper [the moistened paper on the tinfoil] you will see no action; and if I take them up there is no change that you can see, but the arrangement remains just as it was before. But now see what happens: if I take these two poles and put either one or the other of them down separately on the platinum plates, they do nothing for me, both are perfectly without action; but if I let them both be in contact at the same moment, see what happens [a brown spot appeared under each pole of the battery]. Look here at the effect that takes place, and see how I have pulled something apart from the white - something brown; and I have no doubt, if I were to arrange it thus, and were to put one of the poles to the tinfoil on the other side of the paper - why, I get such a beautiful action upon the paper,

that I am going to see whether I cannot write with it - a telegram, if you please. [The Lecturer here traced the word 'juvenile' on the paper with one of the terminal wires.] See there how beautifully we can get our results!

You see we have here drawn something, which we have not known about before, out of this solution. Let us now take that flask from Mr. Anderson's hands, and see what we can draw out of that. This, you know, is a liquid which we have just made up from copper and nitric acid, whilst our other experiments were in hand; and though I am making this experiment very hastily, and may bungle a little, yet I prefer to let you see what I do rather than prepare it beforehand.

Now see what happens. These two platinum-plates are the two ends (or I will make them so immediately) of this apparatus; and I am about to put them into contact with that solution, just as we did a moment ago on the paper. It does not matter to us whether the solution be on the paper or whether it be in the jar, so long as we bring the ends of the apparatus to it. If I put the two platins in by themselves, they come out as clean and as white as they go in [inserting them into the fluid without connecting them with the battery]; but when we take the power and lay that on [the platins were connected with the battery and again dipped into the solution], this, you see [exhibiting one of the platins], is at once turned into copper, as it were; it has become like a plate of copper; and that [exhibiting the other piece of platinum] has come out quite clean. If I take this coppered piece and change sides, the copper will leave the right-hand side and come over to the left side; what was before the coppered plate comes out clean, and the plate which was clean comes out coated with copper; and thus you see that the same copper we put into this solution we can also take out of it by means of this instrument.

Putting that solution aside, let us now see what effect this instrument will have upon water. Here are two little platinum-plates which I intend to make the ends of the battery, and this (C) is a little vessel so shaped as to enable me to take it to pieces, and show you its construction. In these two cups (A and B) I pour mercury, which touches the ends of the wires connected with the platinum-plates. In the vessel (C) I pour some water containing a little acid (but which is put only for the purpose of facilitating the action, it undergoes no change in the process), and connected with the top of the vessel is a bent glass tube (D), which may remind you of the pipe which was connected with the gun barrel in our furnace experiment, and which now passes under the jar (F). I have now adjusted this apparatus, and we will proceed to affect the water in some way or other. In the other case, I sent the water through a tube which was made red-hot; I am now going to pass the electricity through the contents of this vessel. Perhaps I may boil the water; if I do boil the water. I shall get steam; and you know that steam condenses when it gets cold, and you will therefore see by that whether I do boil the water or not. Perhaps, however, I shall not boil the water, but produce some other effect. You shall have the experiment and see. There is one wire which I will put to this side (A), and here is the other wire which I will put to the other side (B), and you will soon see whether any disturbance takes place. Here

it is seeming to boil up famously; but does it boil? Let us see whether that which goes out is steam or not. I think you will soon see the jar (F) will be filled with vapour, if that which rises from the water is steam. But can it be steam?

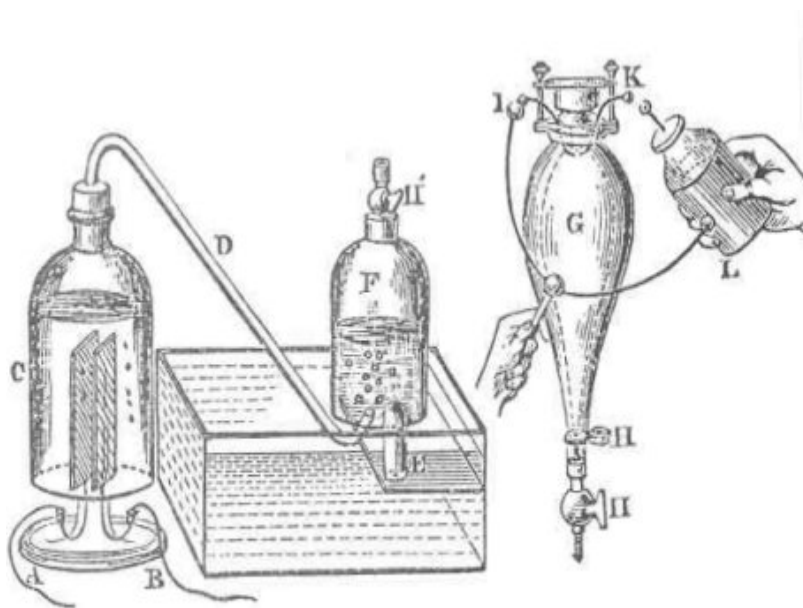


Fig. 19

Why, certainly not; because there it remains, you see, unchanged. There it is standing over the water, and it cannot therefore be steam, but it must be a permanent gas of some sort. What is it? Is it hydrogen? Is it anything else? Well, we will examine it. If it is hydrogen, it will burn. [The Lecturer then ignited a portion of the gas collected, which burnt with an explosion.] It is certainly something combustible, but not combustible in the way that hydrogen is. Hydrogen would not have given you that noise, but the colour of that light, when the thing did burn, was like that of hydrogen; it will, however, burn without contact with the air. That is why I have chosen this other form of apparatus, for the purpose of pointing out to you what are the particular circumstances of this experiment. In place of an open vessel, I have taken one that is closed; (our battery is so beautifully active that we are even boiling the mercury, and getting all things right - not wrong, but vigorously right;) and I am going to show you that that gas, whatever it may be, can burn without air, and in that respect differs from a candle, which cannot burn without the air. And our manner of doing this is as follows: - I have here a glass vessel (G) which is fitted with two platinum wires (I K), through which I can apply electricity; and we can put the vessel on the air-pump and exhaust the air, and when we have taken the air out we can bring it here and fasten it on to this jar (F), and let into the vessel that gas which was formed by the action of the voltaic battery upon the water, and which we have produced by changing the water into it, for I may go as far as this, and say we have really, by that experiment, changed the water into that gas. We have not only altered its condition, but we have changed it really and truly into that gaseous substance, and all the water is there which was decomposed by the experiment. As I screw this vessel (G H) on here (H), and make the tubes well

connected, and when I open the stop-cocks (H H H), if you watch the level of the water (in F), you will see that the gas will rise. I will now close the stop-cocks, as I have drawn up as much as the vessel can hold, and being safely conveyed into that chamber, I will pass into it an electric spark from this Leyden jar (L), when the vessel, which is now quite clear and bright, will become dim. There will be no sound, for the vessel is strong enough to confine the explosion. [A spark was then passed through the jar, when the explosive mixture was ignited.] Did you see that brilliant light? If I again screw the vessel on to the jar, and open these stop-cocks, you will see that the gas will rise a second time. [The stop-cocks were then opened.] Those gases [referring to the gases first collected in the jar, and which had just been ignited by the electric spark] have disappeared, as you see: their place is vacant, and fresh gas has gone in. Water has been formed from them; and if we repeat our operation [repeating the last experiment], I shall have another vacancy, as you will see by the water rising. I always have an empty vessel after the explosion, because the vapour or gas into which that water has been resolved by the battery, explodes under the influence of the spark,

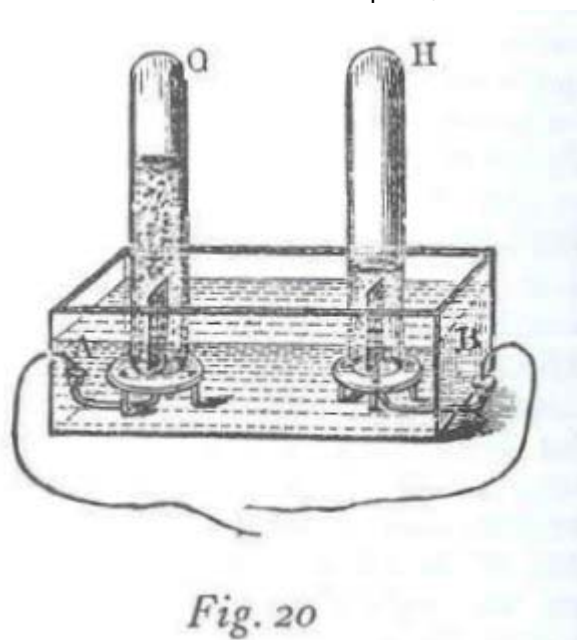


Fig. 20

and changes into water; and by and by you will see in this upper vessel some drops of water trickling down the sides and collecting at the bottom.

We are here dealing with water entirely, without reference to the atmosphere. The water of the candle had the atmosphere helping to produce it, but in this way it can be produced independently of the air. Water, therefore, ought to contain that other substance which the candle takes from the air, and which, combining with the hydrogen, produces water.

Just now you saw that one end of this battery took hold of the copper, extracting it from the vessel which contained the blue solution. It was effected by this wire; and surely we may say, if the battery has such power with a metallic solution which we made and unmade, may we not find that it is possible to split asunder the component parts of the water, and put them into this place and that place? Suppose I take the poles - the metallic ends of this battery - and see what will happen with the water in this apparatus

(Fig. 20), where we have separated the two ends far apart. I place one here (at A), and the other there (at B), and I have little shelves with holes which I can put upon each pole, and so arrange them that whatever escapes from the two ends of the battery will appear as separate gases; for you saw that the water did not become vaporous, but gaseous. The wires are now in perfect and proper connexion with the vessel containing the water, and you see the bubbles rising; let us collect these bubbles and see what they are. Here is a glass cylinder (O); I fill it with water and put it over one end (A) of the pile, and I will take another (H) and put it over the other end (B) of the pile. And so now we have a double apparatus, with both places delivering gas. Both these jars will fill with gas. There they go, that to the right (H) filling very rapidly; the one to the left (O) filling not so rapidly; and though I have allowed some bubbles to escape, yet still the action is going on pretty regularly, and were it not that one is rather smaller than the other, you would see that I should have twice as much in this (H) as I have in that (O). Both these gases are colourless; they stand over the water without condensing; they are alike in all things - I mean in all apparent things; and we have here an opportunity of examining these bodies and ascertaining what they are. Their bulk is large, and we can easily apply experiments to them. I will take this jar (H) first, and will ask you to be prepared to recognise hydrogen.

Think of all its qualities - the light gas which stood well in inverted vessels, burning with a pale flame at the mouth of the jar, and see whether this gas does not satisfy all these conditions. If it be hydrogen, it will remain here while I hold this jar inverted. [A light was then applied, when the hydrogen burnt.] What is there now in the other jar? You know that the two together made an explosive mixture. But what can this be which we find as the other constituent in water, and which must therefore be that substance which made the hydrogen burn? We know that the water we put into the vessel consisted of two things together. We find one of these is hydrogen: what must that other be which was in the water before the experiment, and which we now have by itself? I am about to put this lighted splinter of wood into the gas. The gas itself will not burn, but it will make the splinter of wood burn. [The Lecturer ignited the end of the wood and introduced it into the jar of gas.] See how it invigorates the combustion of the wood, and how it makes it burn far better than the air would make it burn; and now you see by itself that other substance which is contained in the water, and which, when the water was formed by the burning of the candle, must have been taken from the atmosphere. What shall we call it, A, B, or C? Let us call it O - call it 'Oxygen'; it is a very good distinct-sounding name. This, then, is the oxygen which was present in the water, forming so large a part of it.

We shall now begin to understand more clearly our experiments and researches; because when we have examined these things once or twice, we shall soon see why a candle burns in the air. When we have in this way analysed the water - this is to say, separated, or electrolysed its parts out of it - we get two volumes of hydrogen, and one of the body that burns it. And these two are represented to us on the following diagram, with their weights also stated, and we shall find that the oxygen is a

very heavy body by comparison with the hydrogen. It is the other element in water.

	8	Oxygen	88.9
1	Oxygen	Hydrogen	11.1
Hydrogen	9	Water	<hr/> 100.0

I had better, perhaps, tell you now how we get this oxygen abundantly, having shown you how we can separate it from the water. Oxygen, as you will immediately imagine, exists in the atmosphere; for how should the candle burn to produce water without it? Such a thing would be absolutely impossible, and chemically impossible without oxygen. Can we get it from the air? Well, there are some very complicated and difficult processes by which we can get it from the air; but we have better processes. There is a substance

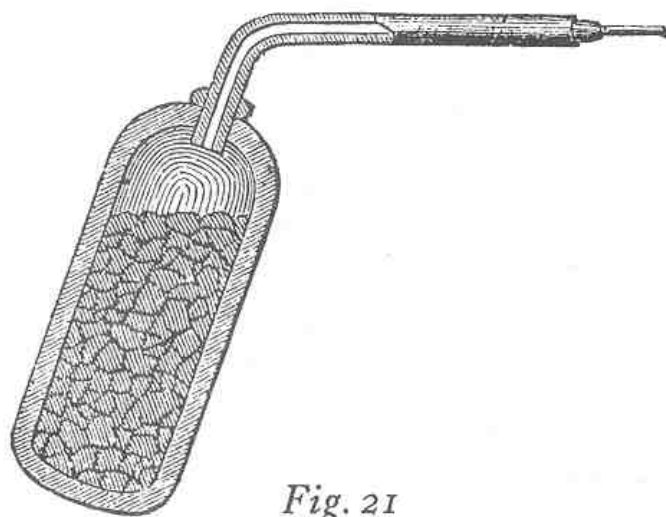


Fig. 21

called the black oxide of manganese; it is a very black-looking mineral, but very useful, and when made red-hot it gives out oxygen. Here is an iron bottle which has had some of this substance put into it, and there is a tube fixed to it, and a fire ready made, and Mr. Anderson will put that retort into the fire, for it is made of iron, and can stand the heat. Here is a salt called chlorate of potassa, which is now made in large quantities for bleaching, and chemical and medical uses, and for pyrotechnic and other purposes. I will take some and mix it with some of the oxide of manganese (oxide of copper, or oxide of iron would do as well); and if I put these together in a retort, far less than a red heat is sufficient to evolve this oxygen from the mixture. I am not preparing to make much, because we only want sufficient for our experiments; only, as you will see immediately, if I use too small a charge the first portion of the gas will be mixed with the air already in the retort, and I should be obliged to sacrifice the first portion of the gas because it would be so much diluted with air; the first portion must, therefore, be thrown away. You will find in this case that a common spirit lamp is quite sufficient for me to get the oxygen, and so we shall have two processes going on for its preparation. See how freely the gas is coming over from

that small portion of the mixture. We will examine it, and see what are its properties. Now, in this way we are producing, as you will observe, a gas just like the one we had in the experiment with the battery, transparent, undissolved in water, and presenting the ordinary visible properties of the atmosphere. (As this first jar contains the air, together with the first portion of the oxygen set free during the preparation, we will carry it out of the way, and be prepared to make our experiments in a regular, dignified manner.) And inasmuch as that power of making wood, wax, or other things burn, was so marked in the oxygen we obtained by means of the voltaic battery from water, we may expect to find the same property here. We will try it. You see there is the combustion of a lighted taper in air, and here is its combustion in this gas [lowering the taper into the jar]. See how brightly and beautifully it burns! You can also see more than this - you will perceive it is a heavy gas, whilst the hydrogen would go up like a balloon, or even faster than a balloon, when not encumbered with the weight of the envelope. You may easily see that although we obtained from water twice as much in volume of the hydrogen as of oxygen, it does not follow that we have twice as much in weight; because one is heavy and the other a very light gas. We have means of weighing gases or air; but without stopping to explain that, let me just tell you what their respective weights are. The weight of a pint of hydrogen is three-quarters of a grain; the weight of the same quantity of oxygen is nearly twelve grains. This is a very great difference. The weight of a cubic foot of hydrogen is one-twelfth of an ounce; and the weight of a cubic foot of oxygen is one ounce and a third. And so on we might come to masses of matter which may be weighed in the balance, and which we can take no account of as to hundred-weights and as to tons, as you will see almost immediately.

Now as regards this very property of oxygen supporting combustion, which we may compare to air, I will take a piece of candle to show it you in a rough way - and the result will be rough.



Fig. 22

There is our candle burning in the air: how will it burn in oxygen? I have here a jar of this gas, and I am about to put it over the candle for you to compare the action of this gas with that of the air. Why, look at it; it looks something like the light that you saw at the poles of the voltaic battery. Think how vigorous that action must be! And yet during all

that action nothing more is produced than what is produced by the burning of the candle in air. We have the same production of water, and the same phenomena exactly, when we use this gas instead of air, as we have when the candle is burnt in air.

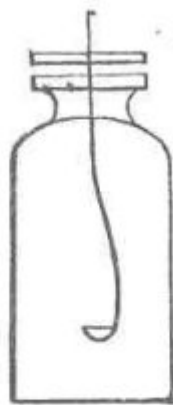
But now we have got a knowledge of this new substance, we can look at it a little more distinctly, in order to satisfy ourselves that we have got a good general understanding of this part of the product of the candle. It is wonderful how great the supporting powers of this substance are as regards combustion. For instance, here is a lamp which, simple though it be, is the original, I may say, of a great variety of lamps, which are constructed for divers purposes - for lighthouses, microscopic illuminations, and other uses; and if it were



Fig. 23

proposed to make it burn very brightly, you would say, 'If a candle burnt better in oxygen, will not a lamp do the same?' Why, it will do so. Mr. Anderson will give me a tube coming from our oxygen-reservoir, and I am about to apply it to this flame, which I will previously make burn badly on purpose. There comes the oxygen: what a combustion that makes! But if I shut it of, what becomes of the lamp? [The flow of oxygen was stopped, and the lamp relapsed to its former dimness.] It is wonderful how, by means of oxygen, we get combustion accelerated. But it does not affect merely the combustion of hydrogen, or carbon, or the candle; but it exalts all combustions of the common kind. We will take one which relates to iron, for instance, as you have already seen iron burn a little in the atmosphere. Here is a jar of oxygen, and this is a piece of iron wire; but if it were a bar as thick as my wrist, it would burn the same. I first attach a little piece of wood to the iron, I then set the wood on fire, and let them both down together into the jar. The wood is now alight, and there it burns as wood should burn in oxygen; but it will soon communicate its combustion to the iron. The iron is now burning brilliantly, and will continue so for a long time. As long as we supply oxygen, so long can we carry on the combustion of the iron, until the latter is consumed.

We will now put that on one side, and take some

*Fig. 24*

other substance; but we must limit our experiments, for we have not time to spare for all the illustrations you would have a right to if we had more time. We will take a piece of sulphur: you know how sulphur burn in the air; well, we put it into the oxygen, and you will see that whatever can burn in air can burn with a far greater intensity in oxygen, leading you to think that perhaps the atmosphere itself owes all its power of combustion to this gas. The sulphur is now burning very quietly in the oxygen; but you cannot for a moment mistake the very high and increased action which takes place when it is so burnt, instead of being burnt merely in common air.

I am now about to show you the combustion of another substance - phosphorus. I can do it better for you here than you can do it at home. This is a very combustible substance; and if it be so combustible in air, what might you expect it would be in oxygen? I am about to show it to you not in its fullest intensity, for if I did so we should almost blow the apparatus up; I may even now crack the jar, though I do not want to break things carelessly. You see how it burns in the air. But what a glorious light it gives out when I introduce it into oxygen! [Introducing the lighted phosphorus into the jar of oxygen.] There you see the solid particles going off which cause that combustion to be so brilliantly luminous.

Thus far we have tested this power of oxygen, and the high combustion it produces by means of other substances. We must now, for a little while longer, look at it as respects the hydrogen. You know, when we allowed the oxygen and the hydrogen derived from the water to mix and burn together, we had a little explosion. You remember also that when I burnt the oxygen and the hydrogen in a jet together, we got very little light, but great heat; I am now about to set fire to oxygen and hydrogen, mixed in the proportion in which they occur in water. Here is a vessel containing one volume of oxygen and two volumes of hydrogen. This mixture is exactly of the same nature as the gas we just now obtained from the voltaic battery; it would be far too much to burn at once; I have therefore arranged to blow soap-bubbles with it and burn those bubbles, that we may see by a general experiment or two how this oxygen supports the combustion of the hydrogen. First of all, we will see whether we can blow a bubble. Well, there goes the gas [causing it to issue through a tobacco-pipe into some soap-suds]. Here I have a bubble. I am receiving them

on my hand, and you will perhaps think I am acting oddly in this experiment, but it is to show you that we must not always trust to noise and sounds, but rather to real facts. [Exploding a bubble on the palm of his hand.] I am afraid to fire a bubble from the end of the pipe, because the explosion would pass up into the jar and blow it to pieces. This oxygen then will unite with the hydrogen, as you see by the phenomena, and hear by the sound, with the utmost readiness of action, and all its powers are then taken up in its neutralisation of the qualities of the hydrogen.

So now I think you will perceive the whole history of water with reference to oxygen and the air, from what we have before said. Why does a piece of potassium decompose water? Because it finds oxygen in the water. What is set free when I put it in the water, as I am about to do again? It sets free hydrogen, and the hydrogen burns; but the potassium itself combines with oxygen; and this piece of potassium, in taking the water apart - the water, you may say, derived from the combustion of the candle - takes away the oxygen which the candle took from the air, and so sets the hydrogen free; and even if I take a piece of ice, and put a piece of potassium upon it, the beautiful affinities by which the oxygen and hydrogen are related are such, that the ice will absolutely set fire to the potassium. I show this to you today, in order to enlarge your ideas of these things, and that you may see how greatly results are modified by circumstances. There is the potassium on the ice, producing a sort of volcanic action.

It will be my place when next we meet, having pointed out these anomalous actions, to show you that none of these extra and strange effects are met with by us - that none of these strange and injurious actions take place when we are burning, not merely a candle, but gas in our streets, or fuel in our fireplaces, so long as we confine ourselves within the laws that Nature has made for our guidance.

Notes:

15. solution of acetate of lead submitted to the action of the voltaic current, yields lead at the negative pole, and brown peroxide of lead at the positive pole. A solution of nitrate of silver, under the same circumstances, yields silver at the negative pole, and peroxide of silver at the positive pole.

Faraday's definition of a 'philosopher' (i.e. a scientist in today's language):

"The Philosopher should be a man willing to listen to every suggestion, but determined to judge for himself. He should not be biased by appearances, have no favourite hypotheses; be of no school; and in doctrine have no master. He should not be a respecter of persons, but of things. Truth should be his primary object. If to these qualities he added industry, he may indeed hope to walk within the veil of the temple of nature."

H. Bence Jones The Life and Letters of Faraday, 1870, vol. I, p.198

SICICI's 1998 Chemistry Jobs Survey

Marie Walsh

SICICI, University of Limerick

In 1998 we continued the practice of the previous 3 or 4 years, of compiling a record of jobs in chemical and allied sectors advertised in the main in the Friday edition of the Irish Times. We are well aware of the fact that these jobs are only the tip of the iceberg, in so far as many industries and employers recruit directly from colleges/universities, or in some cases advertise only in the local press. With that in mind, it can be said that the year 1998 was the best year on our records!

In previous years we recorded around 300 jobs advertised and 1997 saw a total of 334. The total for 1998 was **517!** 1998 also saw the biggest number of positions in one advert, when Warner Lambert advertised 150 new jobs (Irish Times 16/10/98) in a variety of posts for the new tablet plant at Ringaskiddy, Co. Cork.

The totals for various sectors were:

Biochemistry	17
Engineering	17++
Pharmacy	29
Miscellaneous	4
Technicians	23+
Sales/business	19
Education	31
Research	18
Industry	359++

So the total for industry alone was greater than the gross total in other years surveyed. Another point is regarding the annotation + on some of the figures: if I were applying for any of the jobs in those sectors I would be most frustrated to see jobs advertised in plural, but no indication of whether that means 2 or 22! For the purposes of the survey, the plural was ignored, so in fact the grand total should be even greater than the figure recorded.

The education sector appears to be particularly buoyant, with jobs at third level the length and breadth of the country.

Chemical engineering recruitment did not seem to be as vigorous in previous years. For those students who find they have a head for business but have lost their attraction to pure chemistry, there is a steady jobs market in chemical and pharmaceutical sales, or how about applying good writing skills to a scientific background by becoming an *Abstract Writer*?

With a large number of jobs advertised, in all areas of the country (but especially East Coast and Munster); with opportunities for all levels from certificate through diploma to degree and beyond; with the promise of good conditions of employment in an industry which shows steady growth; the message is loud and clear: keep your job options open - study chemistry.

SICICI 1998

In 1998 SICICI continued the work which it has been doing since 1989 (we're just about 10 years old this Spring!) - i.e. to collect, collate and impart information relevant to all aspects of chemistry which might be useful to chemistry teachers. Since the launch of SICICI in March 1989, we have met many of you and corresponded with many others, so most people reading this will be aware of what we have to offer.

We have created and continue to expand a video library with a range of titles to enhance teaching of science, with the major focus on chemistry. Teachers hire these for a variety of reasons, but the main thing is that they attempt to complement the efforts to get students to "see" the chemistry.

We try to promote chemistry as a career choice and can supply a 'careers pack' of cuttings, posters etc. to promote chemistry as a career.

During 1998 we started to update the Directory of the Irish Chemical Industry and put it up on our website (accessed via www.ul.ie/~childsp)

Another highlight of 1998 was the joint RSC/SICICI Industry Study Tour to Cork in June. This involved 10 teachers each from the UK and Ireland and was very successful. Another one is planned for June 28-30th. (see p.44).

We have also reprinted the illustrated Periodic Table and copies are available for purchase. The smaller Periodic Table will also be reprinted in 1999 in a slightly larger A5 size.

Dr. Childs also revised the booklet on Aughinish Alumina and the 3rd. edition was published in 1998 and circulated with the last issue of **Chemistry in Action!**.

We are hoping to update the 1994 Resources for Chemistry Teaching, which is now out-of-date.

Chemical and Mining News

Marie Walsh

SICICI, University of Limerick

Firm to mine for gold in Omagh

Irish Times 7/12/98

The first mining of gold in Ireland in two centuries will be carried out by Omagh Minerals in 1999, at the Kearney deposit at Cavanacaw, four miles west of Omagh. The deposit has been evaluated as having an 11 tonne gold reserve in 1.55 million tonnes of gold ore. The parent company, European Gold claims to have established gold reserve of 450,000 ounces, worth at current prices of \$292 an ounce, over £130 million, and it has made agreement with three jewellery manufacturers.

Gold was last mined commercially in Ireland, during what has been described as the "Avoca mini-gold rush" in Co. Wicklow at the turn of the 19th century. The new open-cast mine will have an initial workforce of 15 to 20, increasing in the short term to about 40 people, with a start up annual production of 17,000 ounces annually. Omagh Minerals has a licence to mine a 189 square kilometre area in Tyrone, described by the company's manager as "one of only a plethora of known gold-bearing veins in the area".

Norbrook's profits soar to £10.1m

Irish Times 18/1/99

The Newry-based pharmaceutical group, Norbrook Laboratories, has reported a dramatic increase in profits in 1998 from £3.6 million (sterling) to £10.1 million. The group, which has plants in Newry and Monaghan, as well as international facilities in a number of countries, produces medical and veterinary pharmaceuticals and also manufactures raw materials. It currently sells its own brand products in 110 countries and supplies raw materials to 9 of the 10 leading pharmaceutical manufacturers.

The profits were boosted by an insurance claim for £7.5 million in compensation for interruption of one of the firm's production processes, so in fact the operating profits were slightly weaker than the previous year. However, they still gave cause for satisfaction in the light of widespread trading difficulties for a number of UK/Northern companies in the current economic climate.

Alcan sells Aughinish Alumina

Irish Times 22/1/99

The Swiss company Glencore has bought the Aughinish Alumina plant in Co. Limerick for an undisclosed price, but with an after tax loss for Alcan (the previous owners) of \$120 million. The plant was built in 1983, with an initial alumina production target of 800,000 tonnes annually. It now employs 450 people (whose jobs appear secured following the takeover) and produces 1.4 million tonnes per annum.

Alcan has said that the sale meets its "global strategy of concentrating on its core activities and exploiting its advantages to become the lowest cost producer of aluminium metal". It will also remain a

customer of the Aughinish refinery.

Glencore said that Aughinish will complement its investment in Italy where it has a 44% interest in the Eurallumina alumina refinery in Sardinia. Glencore employs 2,000 people worldwide and had annual sales of \$40billion in 1997. The first action of the new owners was to appoint Mr. Michael Collins, Financial Controller, as Managing Director.

Jobs in Arklow

Irish Times 27/1/99

Iropharm in Arklow, a subsidiary of the US company Allied Signal, has announced a €19m expansion to create 33 new jobs over the next 3 years. Iropharm manufactures bulk pharmaceuticals, mainly anti-depressants, antihistamines and heart drugs. The firm currently employs 64 people.

IFI up for sale

Irish Times 7/1/99

Turnover for IFI in the year ending Sept. 30th. 1998 was slightly up on 1997 at £157.844m but there was a pre-tax loss of £10.721m (compared to a profit of £7.115m in 1997 on a similar turnover). A dramatic fall in fertilizer prices of 20% in the last years across Europe produced this loss, due to over-capacity in the industry. Over the last 10 years, however, IFI has made average annual profits of £8m, despite price fluctuations up and down of 20%. In 1996, for example, profits were £18.7m slumping to a loss of £10.7m in 1998 due to changes in the market. However, the accumulated profits and investment means that IFI is in a strong position to weather the market, especially as it has a strong local market in Irish agriculture, North and South.

	1997	1998
Turnover	£156.427M	£157.844
Pre-tax - profit (loss)	£7.115m	(£10.721)
Retained profit (loss)	£5.538	(£10.721)

IFI is actively looking for a buyer as its two shareholders - ICI (49%) and NET (51%) have both agreed to sell. ICI has divested itself of its fertilizer interests in the past few years and IFI is its remaining stake in the market. The managing director of IFI, Tom Jago, expects that a sale will go ahead early in 1999. Possible buyers include BASF (Germany), Kemira (Finland), TERRA (USA) and IAWS (Ireland). The fertilizer market should improve in 1999 and prices should rise. Europe produces 35Mt of fertilizer each year, an excess of 2-3Mt. IFI has recently spent £35m on a new nitric acid plant in Belfast, increasing production from 400,000t to 500,000t per year. This state-of-the-art plant will also reduce costs, but delays in commissioning it in 1998 costs €2-3m in profits.

Concerns over explosives plant

Irish Times 21/12/98

Plans to site an explosives plant on the Shannon Estuary near at Cahercon near Kildysart, Co. Clare have aroused local concern. The plant is being promoted by the

Canadian company ETI, a major explosives manufacturer, and the Whelan group Ltd., based in Ennis. Ireland used to be a major explosives producer in the last century and up until 1918 (see **Chemistry in Action!** #55, pp. 10-20.)

Lisheen mine nears production

The Lisheen mine in Co. Tipperary is nearly finished and it is hoped that the first zinc concentrate will be mined and shipped by the end of 1999. The mine will employ 200 people full-time when it is operational. The ore concentrate will be sent by road to Cork for shipment to the smelters.

Chemical and Mining News

Marie Walsh

SICICI, University of Limerick

Communicating Science

The UK Minister for Science launched a new internet-based press centre for European science in September 1998. The centre aims to bridge the gap between science researchers and journalists, providing access to news material, background briefings, contact addresses and listings of future events. The service is free for both contributors and journalists, with simple, quick on-line registration. The site, **AlphaGalileo** is at <http://www.alphagalileo.org>

Your Future

This new video from the CIEC at University of York comprises 11 scenes, offering no commentary but conversation from 11 characters across the whole range of employment options in a chemical industry. This means that it is a careers video across a broad range of options from science, through business subjects to languages. The video is accompanied by a small booklet with teen profiles of the characters and guidelines to obtaining more information on careers in the industry. Details of price and ordering procedures from CIEC at University of York: Tel.: 01904 432523 or Fax: 01904 434078 or email: ciec@york.ac.uk

New BBC Website

BBC Education/Science is launching a new Hands-on Science website, to be produced by Carmen Pryce (former Tomorrow's World presenter). The site is aimed at amateur science enthusiasts, hobbyists, parents and children and hopes to deliver an extensive interactive and educational experience in an entertaining way which will also appeal to general web users.

Scientists are being asked to contribute to the Specialists Subjects section of the site. The plan is to seed these sections with general ideas and then help them to grow and develop, inviting contributions from the users week on week.

Further details are available from:

carmen.pryce@bbc.co.uk

Royal Irish Academy Chemistry Essay

The National Committee for Chemistry at the RIA has announced a chemistry essay competition, which will have prizes at two levels,

1. second level students
2. third level and postgraduate students.

The entrants are asked to write an essay, aimed at the non-scientific reader, about chemistry and its applications. The winners will each receive a specially commissioned bronze sculpture and €250. Further information available from:

**National Committee for Chemistry,
RIA, 19 Dawson St.,
Dublin 2**

Primary Science at last!

Primary Curriculum Review, NCCA, Nov. 1998

The revised primary School Curriculum was due to be submitted to the Minister for Education at the end of 1998. There are six curriculum areas, one of which - Social, environmental and scientific education contains science as a definite component. This is the first time it has appeared explicitly in the primary curriculum and in a way that can't be avoided. Each topic is presented as a curriculum statement and as teacher guidelines. The curriculum is focused on learning:

- It is focused on the learner;
- The strands of the curriculum enable children to learn in different ways
- It will support flexible teaching approaches responsive to different learning needs;
- It promotes learning for understanding through a range of active learning approaches;
- It outlines problem-solving strategies that enable children to become independent learners;
- Its focus on the learner promotes teaching approaches that can enable every child to experience success in school.

Science is part of the Social, environmental and scientific topic which also includes history and geography. "SESE Science builds on the sound foundations of the social and environmental studies programmes which schools are currently teaching and sets out a science curriculum that is broad and flexible.

Content of the Curriculum

Living Things:

Human life, Plant/animal life

Energy and Forces:

Light, sound, heat, magnetism and electricity; forces

Materials:

Properties/characteristics, Materials and change

Environmental awareness and care:

Science and the environment, Caring for the environment

Working Scientifically

Practical investigation is central to learning in the Science curriculum and at each level children will be encouraged to investigate and explore their physical and natural surroundings. This first-hand experience helps pupils realise that they can provide their own answers to problems and that they can learn from their interaction with things around them. The fundamental skills of enquiry will include: observing, asking questions, suggesting explanations, predicting outcomes, and planning investigations to test ideas.

Designing and making

This innovative aspect of the science curriculum will provide opportunities to explore the practical application of scientific ideas in everyday situations. The children will be challenged to explore, plan and make artefacts and models that provide solutions to practical problems. Designing and making simple magnetic games, wind/water mills, floating vessels, telescopes, useful

containers, electrical circuits and so on will give pupils an awareness of the value of technology in the world in which they live."

(See also Comhairle, NCCA, Nov. 1998)

Irish Environmental News

EPA warns leaks at disused mine

Irish Times 14/1/99

An EPA investigation has found that pollutants which pose a risk to public health are leaking without control from a large tailings facility attached to a disused mine at Silvermines, Co. Tipperary.

The lead-zinc mine, which was operated by Mogul, closed in 1982. Mogul sold its interest to Ennex International in 1984. Following a "dust blow incident" in 1985, Mogul took remedial action funded entirely by Ennex. During this incident the tailings pond had dried out allowing the release of toxic dust clouds into the local environment. The pond was thereafter filled-in and rehabilitated and subsequently sold-on to a local farmer, who actually began grazing sheep on the land in late 1998. The current controversy centres around the maintenance of the site, with the EPA stating that "significant resources" are needed to ensure the site is maintained properly, and to prevent hazardous tailings becoming airborne under certain climatic conditions.

Pharmachem companies do well in 1997

HORIZONS No.20 Jan 99

The pharmachem sector features prominently in the EPA's third annual report summarising its Integrated Pollution Control (IPC) licensing and control functions. The report gives comprehensive information on the performance of those industries now licensed under the EPA. Overall compliance with IPC licences remains extremely high, with the majority of companies rating at 98-100%. The report also recognises a swing from end-of-pipe technologies to source reduction of pollutants. The following is a list of examples of this from within the pharmachem sector:

- Klinge reduce ammonia by recycling;
- NOx emissions down by 24% at Schering Plough;
- Olin reduced sulphate emissions by 50 tonnes/annum;
- Janssen Pharmaceutical reduce usage of caustic and hydrochloric acid by upgrading waste water treatment plant;
- Klinge Pharma eliminate usage of dichloromethane (28 tonnes annually) from one process;
- Roche eliminate use of toluene;
- Leo Labs reduce solvent usage by 9% despite a 132% increase in production between 1991 and 96;
- Cara Partners reduce Class III emissions by 22%;
- Pfizer Pharmaceuticals reduce carbon usage from 17,000kg in 1991 to 4,200kg in 1996

Editorial

Falling Numbers

The falling numbers doing chemistry (and) Physics at school is definitely 'issue of the year'. This was discussed briefly in the last issue (#56, pp. 35-37). FAS has convened a working group to produce an information pack on careers in the physical sciences for schools. The group is consulting widely to ensure all views are represented and that efforts are not duplicated or wheels reinvented.

The Irish Pharmaceutical and Chemical Manufacturers Federation (IPCMF) is also concerned as is the Institute of Chemistry of Ireland (ICI). The Institute is organising a conference on April 29th. in Dublin to consider the topic: "Chemical Education in a Changing Marketplace". This will deal in part with the issues of falling numbers at school and college and the implications for industry. As the 1998 SICICI Jobs Survey on p.40 shows, the chemical industry in Ireland has never been more buoyant and jobs are being created at a record rate. Who is going to fill them in the future?

This issue carries the talks given at ChemEd-Ireland 1998 on "Practical Work in Chemistry". Two of the topics are of particular interest in relation to popularising chemistry in schools: The Chemistry Club, sponsored by the UK Salters' Institute and the Promotion of Chemistry in Schools Project sponsored by IPCMF, SICICI and the University of Limerick. I know there are other efforts underway, nationally and locally. What we need is more effort by more companies, both nationally and locally, which is sustained and tailored to the need of schools and students. I'd be interested to hear reports of other activities and how successful they are.

Get involved, get moving

At the start of a new year why not make a resolution? Why not decide to attend at least one conference, workshop, study tour, in-service course in 1999? There is a good range on offer as the Diary shows, nationally and internationally. Start by getting to Galway in April for the annual ISTA meeting - a must for Irish science teachers. There is the enormous ASE event every January in the UK (already over for this year), and various conferences in the USA. The 15th. ChemEd in Fairfield, Conn. in August should be very good and worth fitting into a holiday in the USA. You might pick up some good ideas for new experiments like Randal Henly (p.8). There is the continuing series of ISTA Junior Science workshops moving around the country, ChemEd-Ireland in October (you mean you've never been to one?), Industry Study Tours etc. If you really make the effort there is bound to be one you can make this year. The benefits are in boosting your enthusiasm and energy, giving you new ideas and materials to use, the opportunity to talk to fellow teachers - a conference is like a tonic. So if you're feeling jaded and need some new ideas, get yourself off to one of the many events on offer. You won't regret it.

Peter E. Childs
Hon Editor

DISCLAIMER

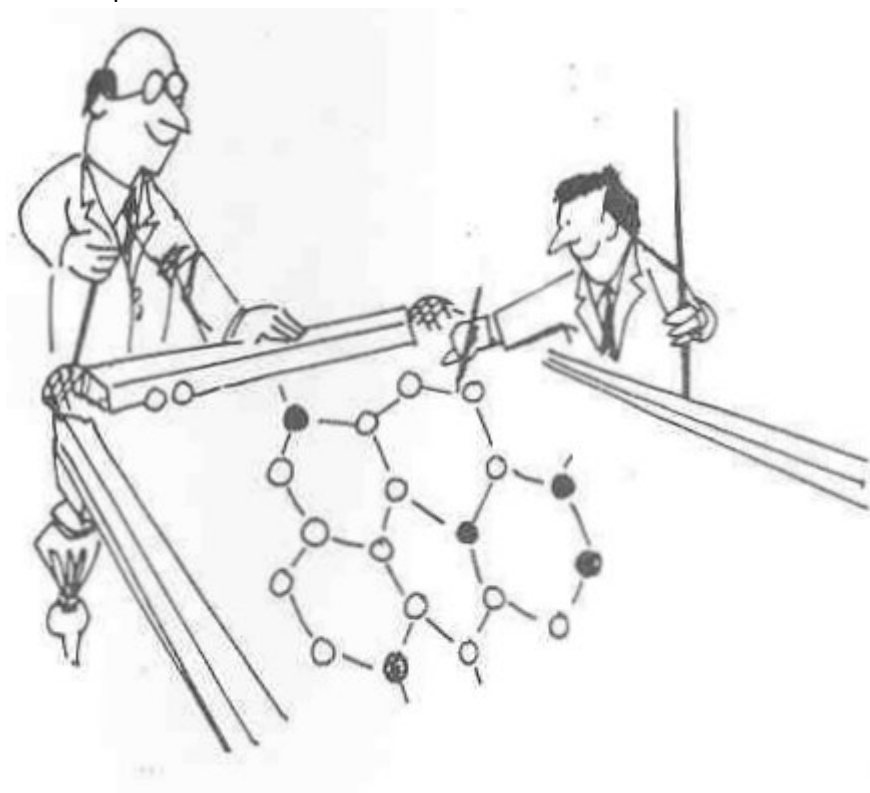
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Contributions on any matter of interest to second-level chemistry teachers is welcome. Normally the results of research are not published.



Chemicals: snippets of chemical news

18 millionth substances registered

June 15th. 1998 saw a chemical milestone at the Chemical Abstracts Service (CAS) of the American Chemical Society. This service logs every new chemical, gives it a unique registry number, and publishes abstracts of new papers and patents. On that date the 18 millionth substance was registered: 1S-cis)-2-phenyl-3-cyclohexene-1-carboxylic acid (# 207110-49-4). Now if anyone asks you how many chemical substances are known, you can tell them: "More than 18 million". The new compound was in a patent application filed by Merck & Co., Inc. The 16 and 17 millionth substances were added to the registry in 1997. At that rate 1999 should see the 19 and possibly the 20 millionth substances registered. These are only the substances identified after isolation or synthesis and there are many more waiting to be discovered in natural products.

(Chemistry Oct. 1998 p. 22)







World Records in Chemistry

H-J. Quadbeck-Seeger, R. Faust, G. Knaus and U. Siemeling

Wiley-VCH 1998 €16.95

ISBN: 3-527-29574-7

If you're interested in more information like the note above, then this is the book for you. It is a "Guinness Book of Records" for chemistry. It includes such information as:

-  the most revolting smelling substance
-  the biggest fibre producer
-  the heaviest element
-  the longest carbon chain
-  the biggest chemical plant
-  the best-selling pharmaceutical etc.

The book is a collection of world records in chemistry and as such it is almost certainly out-of-date as soon as it is published.

However, it sounds like a fun book to use for finding odd and obscure information.

The birth of Chemistry

The practice of chemistry is the deliberate transformation of matter from one set of substances to another by chemical processes such as heating or mixing solutions together. The production of many familiar products such as soap, beer, glass, dyes involves chemistry and their origin is mostly unknown. All we can date is the first appearance of a product which involves chemical modification of other starting materials. A recent report in Nature (11/2/99) claims that the Egyptians founded the science of chemistry 4,000 years ago. They also developed the first perfumes, face powder and eye shadow (not to mention embalming). The name chemistry is thought to derive from Al Khimia (via alchemy), an ancient name for Egypt. The evidence for the birth of chemistry is contained in the many jars of cosmetics found in Egyptian tombs and stored in museums. Chemists from the laboratories in the Louvre in Paris, working with those from L'Oreal (a cosmetics firm) found two lead compounds - laurionite and phosgenite - in the jars. These have been used for centuries in cosmetics but have to be made as they

are not found naturally. Someone had to have synthesised them and mixed them with oils to produce the cosmetics. That is, they had to have done some chemistry to produce the products. The chemists then recreated the ancient chemistry, mixing lead(II) oxide (a by-product of silver mining) with sodium chloride and water, and produced laurionite. If soda water was used instead phosgenite resulted. As well as making blue pigments using heat around 2,500 B.C. the Egyptians also developed solution chemistry by 2,000 B.C.

(Guardian 11/2/99, report by Tim Radford)

The importance of teaching

Walter Kaminsky is a senior academic in the Department of Chemistry at the University of Hamburg, involved in administration and research. He also lectures eight times a week to undergraduates, because he thinks teaching is important.

"A lot of the problems that we have at the moment regarding the image and motivation of chemistry come because we have not got the right teachers in schools. Students grow up being afraid of chemistry because they have never been taught it properly, so they go on to take up other careers - or become 'Greens'. It is very important that they get interested in the subject from a teacher who knows a lot about chemistry. I teach because I think I can provide a good overview, and because of my connections with industry I can see what is necessary for the future."

(Chemistry in Britain, Feb. 1998 p.44 from 'Life in the fast lane', Cath O'Driscoll 43-44)

Computers versus organic chemistry

Michael Dell, founder of Dell Computers, started out to do a Biology degree at Texas State University as preparation for a medical degree. He dropped out in 1984 to run his own fledgling direct-sale computer company full-time. He said this about his choice:

"Computers were a whole lot easier to understand than organic chemistry."

Sunday Times 26/4/98

Wot! No Chemistry?

"I am reminded of a day in 1950 at Columbia University when another graduate student came from the physical chemistry lab and announced the astonishing news that a solution of $\text{Cu}(\text{NO}_3)_2$ was acid! This was news to the several other first-year graduate students who happened to have assembled between classes. I expressed surprise that this was not common knowledge. When asked why I said that, the simple answer was that this was a salt of a weak base and a strong acid, another revelation, and in response to further questioning I gave other examples of compounds, which when dissolved, would give an acid or basic solution.....

Personally, I have never been able to understand how a person can be deemed to be a chemist when he or she cannot look at the formula of an inorganic salt or simple organic compound and deduce how the compounds are apt to behave in solution, when heated, or in combination with other compounds, bases, or acids. I believe chemical education has suffered from the lack of a grounding in descriptive chemistry that has arisen through research and publication pressures on faculty to the detriment of the simpler practical aspects of the discipline that I have always believed are fundamental to a rational understanding of theory."

Arvid Zuber

From a letter in C&EN 28/6/93 p.4

Training science teachers at UL

The University of Limerick has been producing graduates in science education with B.Sc.Ed. degree since 1984. These graduates were able to teach science for the intermediate and group certificate, and LC Biology and Agricultural Science. The programme was revised in 1994 and students on the course could take the option of studying chemistry or physics as a second subject, along with biology and agricultural science. The first graduates of this new degree in Biological Science were produced in 1998. They are able to teach Junior Science and LC Biology and Agricultural Science plus either Chemistry or Physics. This course is now well subscribed with about 30 students per year and a breakdown of about 2:1 between Chemistry and Physics. The entry standard is high and the points required are around 420, comparable to the mainstream science courses at UL. The course integrates the science subjects with education and teaching practice over the four years, so that when they graduate they are fully qualified to teach. The alternative route to science teaching in the Republic is to take an honours science degree (four years) and then do an H.Dip.Ed. in Trinity College or one of the NUI colleges.

Most science teachers in Ireland have come through the H.Dip.Ed. route and aren't familiar with the alternative concurrent model operated at UL. In addition to the B.Sc.Ed. students UL also produces between 1 and 5 Physical Education graduates a year who can teach Junior Science and LC Chemistry as well.

Anniversaries in 1999

1999 sees some notable chemical anniversaries. It marks the 100th. anniversary of the marketing of aspirin by Bayer in 1899 and the synthesis of novocaine by A. Einhorn, and the 10th. anniversary of Prozac (made in Cork). In 1899 Andr. L. Debierne (died 1949) discovered actinium (element #89) and 50 years later berkelium (#97) and californium (#96) were made in the USA. The star event of the year must be the invention of the electric battery by Alessandro Volta) following on from the observations of Luigi Galvani) in 1799 and first communicated in English in 1800. Joseph Black, famous Scottish chemist and discoverer of CO₂, died in 1799. In 1899 Robert Wilhelm Bunsen and Sir Edward Frankland died, and Paul Müller, discoverer of DDT, was born. In 1849 William Thomson (Lord Kelvin) coined the word thermodynamics, Edward Frankland made the first organometallic compounds (zinc alkyls) and Johann Wolfgang Döbereiner (of the triads) died.

Just 50 years Dorothy Hodgkin was the first person to use computers to solve organic structures when she applied them to penicillin. 25 years ago F. Sherwood Rowland and M. Molina first warned that CFCs could seriously damage the ozone layer. Please let us know if you come across any other notable anniversaries. We hope to feature some of these events in Chemistry in Action! this year.



Caption - Chemistry is fun at ChemEd-Ireland!

Pesticides in Fruits and vegetables

Susan E. Kegley and Laura J. Wise

University Science Books, Sacramento, Cal. 1998

ISBN 0-935702-46-6; £14.95 paper

(Distributed by Macmillan Distribution Ltd., Houndmills, Basingstoke, Hants. RG21 6XS.

www.macmillan-mdl.co.uk;

email: mdl@macmillan.co.uk)

This book is a laboratory manual describing experiments to test for organochlorine pesticides in fruits and vegetables. Its level is probably too high for TYO or LC students, but it provides lots of informative background for the teacher in this controversial area. It would be useful for introductory third-level courses or for project work. It introduces gas chromatography, but it also has simple experiments on solubility.

Also in this series:

The Chemistry of Water

Susan E. Kegley and Joy Andrews

University Science Books ISBN 0-935702-44-X

Surfing the Net: Chemistry websites:

There are so many interesting chemistry/science sites that it's hard to keep up with them. If you come across any good ones, please send in details and a brief review so that other teacher's can try them. We hope to surf the net at ChemEd-Ireland 1999 on October 23rd.

Virtual Chemistry Club, VC2

A new site from the Education Division of the American Chemical Society: the Virtual Chemistry Club, VC2.

The site includes product reports, chemistry mysteries, careers materials, science fair information, puzzles, activities etc.

<http://www.chemcentre.org/VC2>

WonderNet

This site features hands-on science activities and complements the publication Wonderscience. New topics and activities will bimonthly.

<http://www.chemcentre.org/wondrnet/welcome.htm>

freeweb.pdq.net/headstrong

A collection of weird experiments!

www.uky.edu/~holler/periodic/periodic.html

Chemical comic relief! This site contains pages from comics featuring chemical themes.

See also:

paul.merton.ox.ac.uk/science

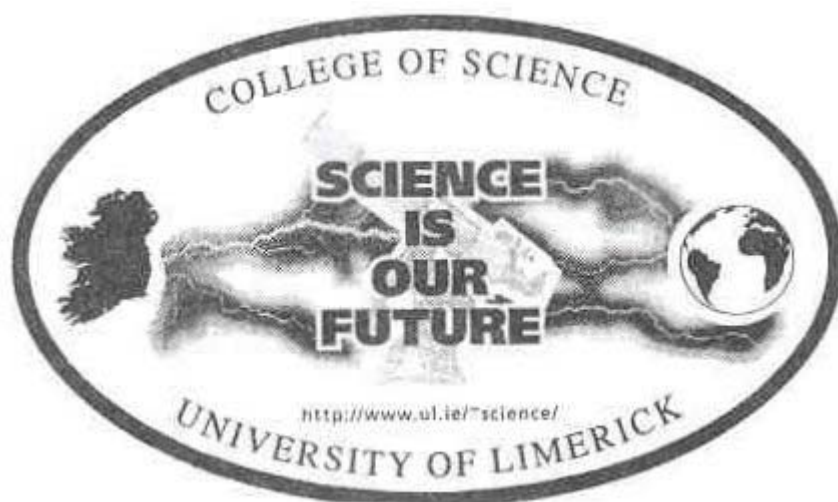
For science jokes.

ELEMENTS magazine

You may remember ELEMENTS magazine, produced to popularise science, maths, informatics and engineering by the University of Limerick. Three issues were produced and are still available at the website: <http://www.ul.ie/~childsp/elements>. After a delay the 4th. edition is in preparation and it is hoped to send it out into schools after Easter. It will be produced as a newspaper-style version for individual students and 50 copies will be sent to each school. The full version will be accessible free-of-charge at the ELEMENTS website. We want students to read it and further copies can be ordered if desired. We hope that students will get interested in a particular topic or subject and will follow it up in the web edition. Look out for it.

The sticker (produced for National Science Week) below is available in bulk on request from:

Ms. Bernie Quiligan,
College of Science,
University of Limerick,
Limerick.



How many elements are there?

This is a hard question to answer as the goal posts keep moving. A recent report announced the synthesis of element 114 (mass no. 289) at the research centre in Dubna, in Russia. It had an amazingly long half-life measured in seconds not milliseconds and may mark the beginning of the long-predicted "island of stability". It means that most books and Periodic Tables are out-of-date yet again and it adds to the list of elements from 110 onwards which are awaiting names. I'm not sure if element 113 has been made or not.

The diagram below shows all the elements that have been named arranged alphabetically in an element tree.

Alphabetical List of the Elements by Symbol

Ac Ag Al Am Ar As At Au
B Ba Be Bh Bi Bk Br
C Ca Cd Ce Cf Cl Cm Co Cr Cs Cu
Db Dy
Er Es Eu
F Fe Fm Fr
Ga Ge Gd
H He Hf Hg Ho Hs
I In Ir
K Kr
La Li Lr Lu
Md Mg Mn Mo Mt
N Na Nb Nd Ne Ni No Np
O Os
P Pa Pb Pd Pm Po Pr Pt Pu
Ra Rb Re Rf Rh Rn Ru
S Sb Sc Se Sg Si Sm Sn Sr
Ta Tb Tc Te Th Ti Tl Tm
U
V
W
Xe
Y Yb
Zn Zr

The importance of nomenclature

"Lavoisier considered that by creating a new language for chemistry [in 1789], it would be possible not only to correct the mistakes of the past but to map out the future progress of the science. In the sense that a nomenclature provided a classification of chemical compounds, Lavoisier's hope was justified and the new chemical nomenclature can be compared in scope at the end of the eighteenth century with the Periodic Table of Mendeleev in the nineteenth century."

Maurice P. Crossland p. xiv in
Historical Studies in the Language of Chemistry,
London: Heinemann 1962

ChemEd-Ireland 1998

Practical Work in Chemistry

October 17th 1998

University of Limerick

PROCEEDINGS

Last year's ChemEd-Ireland conference was #17 in the series and looked at the perennial topic of "Practical Work in Chemistry". This was also considered at the second ChemEd-Ireland conference in 1983. This issue contains printed versions of the talks given at the conference and I would like to thank the speakers again for taking part and for preparing their talks for publication. Attendance at the ChemEd-Ireland conferences has been very good since 1990 but at most 90-100 teachers convene in Limerick and take part in the actual conference. A brief report on last year's conference appeared in Chemistry in Action! #56, p.27-28. The printed Proceedings reach a much wider audience - over 600 teachers in the Republic, 1000 schools in the UK and others around the world. Publishing the Proceedings is an important way of communicating more widely the various contributions that were presented orally at ChemEd-Ireland. In this way important materials have been preserved and made available to teachers, for example, the excellent series of papers on various analytical techniques (in issues #51 and 52) and on industrial chemistry (in issue #54). The complete listing of ChemEd-Ireland conferences and their Proceedings is given below for reference.

I was also pleased to welcome two overseas speakers to this year's conference: our plenary speaker, Dr. Roger Maskill from the University of East Anglia, and Paul Priest, from Academy Equipment Ltd., who ran the workshops. The early ChemEd-Ireland conferences all featured a distinguished guest speaker, but this has lapsed in recent years. This year's conference reminded me how valuable this was, even though it increases the costs.

The 1998 conference included a hands-on workshop on Microscale Chemistry, which was very worthwhile, although more awkward to organise. It is hoped that the 18th. ChemEd-Ireland on "Information Technology in Chemistry" on October 23rd. 1999 will also feature a hands-on workshop using computers. The conference was also notable for the weight of 'freebies' which participants took away with them, worth more than the registration fee in fact.

I would also like to thank the Institute of Chemistry of Ireland, the Ireland Region Committee of the Royal Society of Chemistry's Education Division and Academy Equipment Ltd. for sponsoring the conference. I am also grateful to the Education Department of the RSC for donating copies of their book on Microscale Chemistry to each participant. Who knows (I don't yet) what freebies next year's conference will bring.

ChemEd-Ireland 1998
"Practical Work in School Chemistry"
Programme

9.00 a.m. Registration and coffee

Morning session

9.30 a.m. Welcome: Peter E. Childs

9.45 a.m. **#1 Practical Work in Science**
Roger Maskill

10.45 a.m. **#2 The Chemistry Club**
Bridget Ryan and Philip Mathews

11.15 a.m. Coffee break & Bookstall

11.45 a.m. **#3 Microscale Chemistry - an introduction**
Paul Priest (Academy Equipment Ltd.)

12.15 noon Lunch/workshops/bookstall
Group A: Workshop on Microscale chemistry
Group B goes to lunch in the Stables

1.00 p.m. End of workshop A
Group A goes to lunch in the Stables

1.15 p.m. Group B: Workshop on Microscale chemistry

2.00 p.m. End of workshop B

Afternoon session

2.15 p.m. **Courses in Chemistry at UL**
Tim Smyth

2.30 p.m. **#4 Some new demonstrations**
Randal Henly

3.00 p.m. **#5 Some simple experiments**
Frank Roden

3.30 p.m. Coffee break and bookstalls

4.00 p.m. **#6 Integrating safety into the Junior Science course**
Bernadette ni Chathain

4.30 p.m. **#7 Chemistry Magic Show**
Elaine Regan

5.00 p.m. End of conference

Unfortunately Roger Maskill's article didn't arrive in time for this issue. I hope it will be published in issue #58.


PEC


The Chemistry Club


Bridget Ryan


Scoil Pól, Kilfinane, Co.Limerick


The Salters' Chemistry Club is an initiative of the Salters' Institute of Industrial Chemistry. The Chemistry Club's main objectives are to make chemistry more visible, more interesting and more attractive to pupils, especially those aged 11 to 14, by creating a network of chemistry clubs in schools, which are linked to local companies and third level institutions. The Chemistry Club provides an opportunity for students to experiment with wet, bench-top chemistry, where they may have little opportunity for this in class. The Club's ultimate goal is to help increase the scientific literacy of our young people and maintain the supply of high-calibre graduates in chemistry and related subjects, both to create wealth through industry and teach the next generation.


 Starting a Salters' Chemistry Club in school mainly involves:


 Registering with Salters


 Arranging a time-table to suit you and the club members

 Getting access to a laboratory

 Checking insurance cover if club activities are outside normal school hours

 Arranging a programme of activities

 Checking the safety of all activities beforehand

 Checking that sufficient equipment and chemical are available

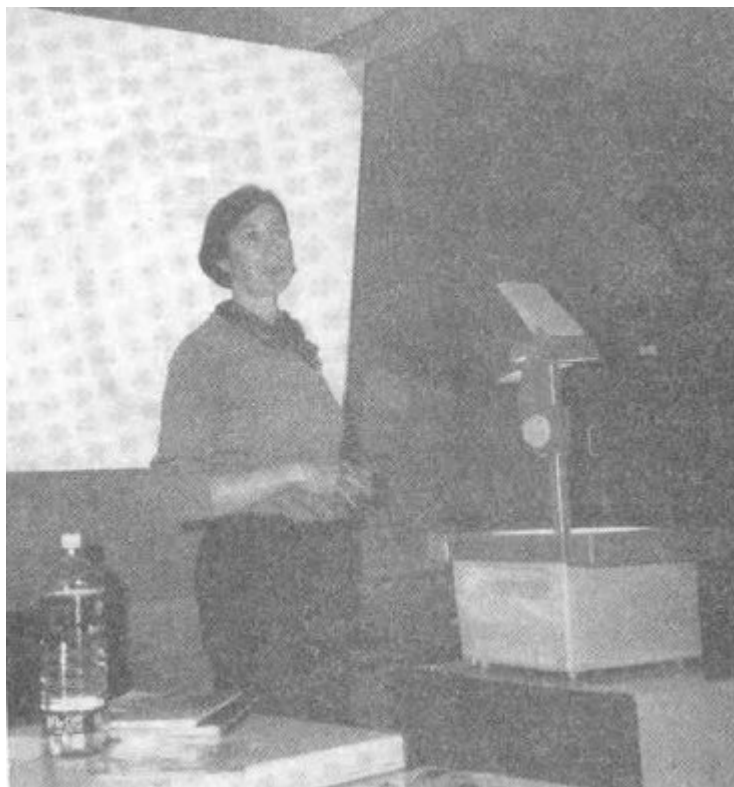
I started up a Chemistry Club in my school in October 1997. Firstly, I registered with Salters, from whom I subsequently received a start-up grant of €100 and the Salters' Chemistry Club Handbook. The grant was used to buy chemicals for the experiments outlined in this handbook and others I planned to do with the Club. It was actually January before I had carried out the experiments myself and checked that we had sufficient resources. Unfortunately our school does not have a lab technician, which meant a lot of work for me preparing solutions, finding equipment/glassware and in tidying up afterwards. Our club started with about 10 students, which in one way may seem small, but on the other hand it means that each student can actually carry out experiment/exercise themselves. I took the group of students once a week for an hour after school. Finding a suitable time is one of the biggest problems in setting up a club. Lunchtime, unless a long one, will not suffice.

Making contact with local industries is also an area the students can look into. In March they started working on their project. Most of their experiments had been done towards mid-April. They then wrote up their report book and put their presentations together. The presentation involves selecting 4 to 5 experiments on one theme, and displaying material carried out on other work on the project. At the end of May 1998, festivals were held in Ireland - in Dublin, Cork and Belfast - and in other

centres in the U.K. At the festival each club is represented by a team of 3/4 students, who present their project. Egg-races are also carried out with lots of prizes and certificates for each member of the club. The winning team from each festival goes forward to the Grand Final, held at University College, London. If a club does not take part in a festival they are obliged to return their start-up grant.

I found the setting up of the Chemistry Club very worthwhile. It was an opportunity to work with students outside the classroom and apart from a specified syllabus. For the students they get to develop many skills - experimental, researching, presentation and at the festivals they get to meet other students with a similar interest in chemistry, and they also get an insight into third-level institutions.

Bridget Ryan teaches science and chemistry at Scoil Pól, Kilfinane and she is secretary of the Limerick Branch of the ISTA.

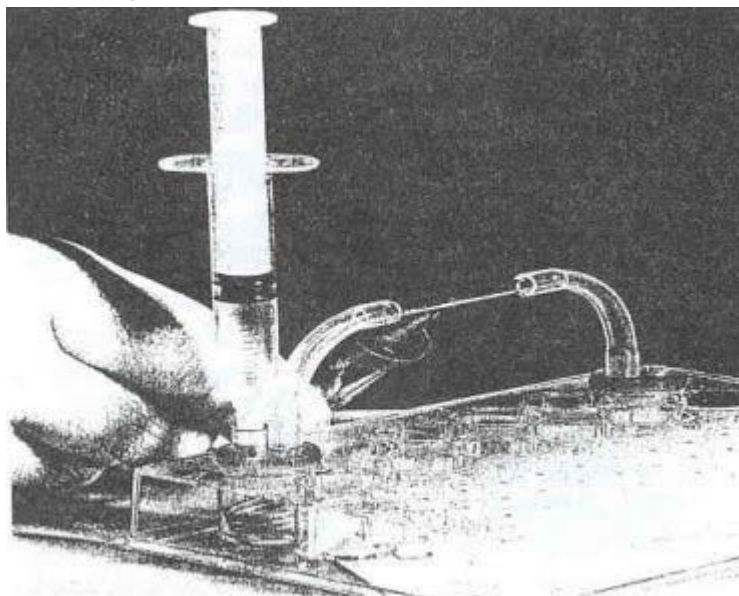


Microscale Chemistry

Paul Priest

Academy Equipment

Microchem™ is a micro-scale chemistry system with purpose designed small scale equipment. At the heart of Microchem™ is the Comboplate™, a plate approximately 125 x 80 x 20mm and containing a combination of 12 large wells and 48 smaller wells, effectively a pocket size laboratory bench.



Reduction of copper oxide

Caption - Reduction of copper oxide

Microchem™ was developed at the RADMASTE Centre based at the University of Witwatersrand, Johannesburg, South Africa in association with Somerset Educational who produce these kits at their factory in Somerset East, SA. Designed with the needs of the third world in mind, it soon became obvious that there were many benefits to be gained by even the best-equipped schools, colleges and universities across the United States, Australasia and Europe. Microchem™ has been introduced to teachers, technicians, advisers and inspectors across Europe by Academy Equipment over the last two years, mainly by a series of practical 'hands-on' workshops similar to those held at ChemEd Ireland. (Workshops are also planned for the ISTA conference in Galway in April 1999.)

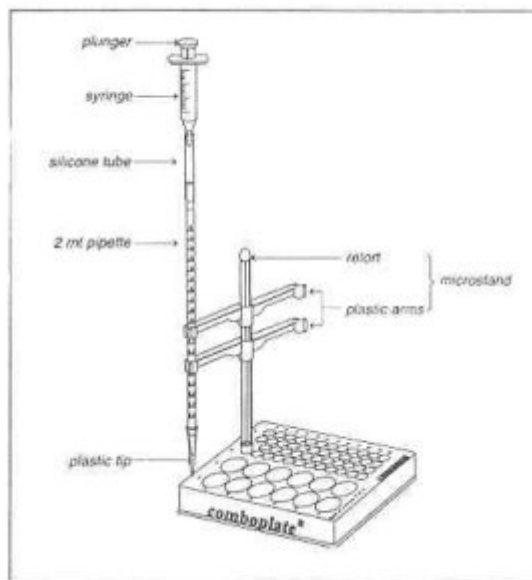
Whilst initially concentrating on micro-scale chemistry, the system has been developed across the other sciences and there is now a complete MicroScience range, including Biology (MicroBio), a starter kit for electricity (MicroPhysics) and now a water quality testing kit (MicroLife).

The key benefits that have made MicroScience so popular are:

- Low-cost equipment
- Savings on consumables (estimated at >90%)
- Safer than macro-scale due to the very small quantities required
- Faster than macro-scale, gives the opportunity

- to carry out more tests, discussion and analyses
- Hands on for all - enables individual students to have their own personal laboratory
- Environmentally friendly - minimal waste disposal problems

A microtitration set-up



Caption - A microtitration set-up

There are at present three separate chemistry kits available - the standard Microchem Equipment Kit, MEK001, which sells at a little more than the cost of a 2 litre Pyrex beaker; a MicroTitration Kit MEK003 and an Add-on Titration Kit, MEK002 that contains the supplementary items required for titration that are not included in the MEK001. With both the MEK001 and MEK002 it is possible to carry out over 30 separate experimental procedures that are included in the sets of Student Worksheets. In the UK, these worksheets have been cross-referenced to the National Curriculum and cover Key Stages 3 and 4 and A-Level. Other worksheets are available in various languages and linked to the different curricula. Almost all of the equipment is used over and over again with very few items requiring replacement. However, all components are available in larger pack quantities.

Included in the Key Stage 3 worksheets is 'The Reduction of Copper Oxide', which is one of the practicals in the workshops along with 'Rates of Reaction' and 'Acids & Bases'

A recent development in MicrochemTM has seen the introduction of the OrganoplateTM, the same style as the original comboplate but moulded in polypropylene which gives it an opaque appearance. The benefit here is that this plate will withstand organic solvents and therefore opens up the potential for Organic Chemistry. Already over twenty separate procedures have been successfully tested and are currently being written-up. This means that with the aid of the Organoplate and a few supplementary items along with a new set of worksheets, it will soon be possible to carry out procedures such as 'Cracking of petroleum', 'Esterification', 'Distillation' and many many more.

New products and concepts etc. are often looked on

with a great deal of suspicion and Microchem™ was no exception. However, its rapidly growing popularity has without doubt being accelerated by the support received from some of the major influential bodies in chemistry education. In the UK, Academy Equipment have been very well supported by the Royal Society of Chemistry, who earlier this year purchased 7,000 sample Microchem™ kits and sent one to all UK secondary schools and RSC members along with a publication of their own entitled Microscale Chemistry - experiments in miniature. The RSC cemented their support for microscale chemistry by assisting Academy Equipment with workshops at the ASE Annual Regional Conference held in Liverpool in January 1998. Academy Equipment have also held practical workshops at all the regional ASE Conferences over the last two years and have been able to give several hundred teachers the opportunity to try Microchem for themselves. Thousands of kits are now in use in the UK now and the number is growing weekly.

World-wide, the World Bank Organisation have been instrumental in supporting many conferences and workshops, recently sending delegates to Bulgaria, Moldova and South Africa. UNESCO have been very active in promoting micro-scale chemistry via workshops all over the world and recently part-funded a project to supply schools in eighteen Francophone countries with Microchem™ equipment. Indeed, in recognition of the work carried out by the dedicated team in Witswatersrand, the RADMASTE Centre was inaugurated as a UNESCO Associated Science Centre, which can only enhance the development of the MicroScience system.

As mentioned earlier, MicroScience now includes MicroBio, MicroPhysics and MicroLife. MicroBio experiments include 'Food Testing' and 'Enzyme Analysis' - procedures such as tests for carbohydrates, lipids and proteins and seven separate enzyme tests. MicroPhysics has just begun with an introduction to basic electricity and MicroLife offers a range of tests and equipment for water testing, including turbidity, electrical conductivity, microbiological water quality and dissolved oxygen concentration.

In conclusion, MicroScience is here and cannot be ignored. It is not intended to be 'all things to all men', but offers a serious science teaching alternative in many situations. The MicroScience range of equipment and worksheets are available ex-stock from Academy Equipment. Schools in Ireland should order directly from the newly appointed sole distributors, Shaw Scientific Ltd of Dublin (details below).

For enquiries anywhere within Europe contact should be initially via Academy Equipment but there are already appointed agents in many European countries.

United Kingdom & Main European Distributor:

Academy Equipment Ltd.,

P O Box 53, Cheadle,

Cheshire SK8 4GZ, United Kingdom

Contact: Paul Priest

Tel: + 44 161 282 5194

Fax: + 44 161 282 5767

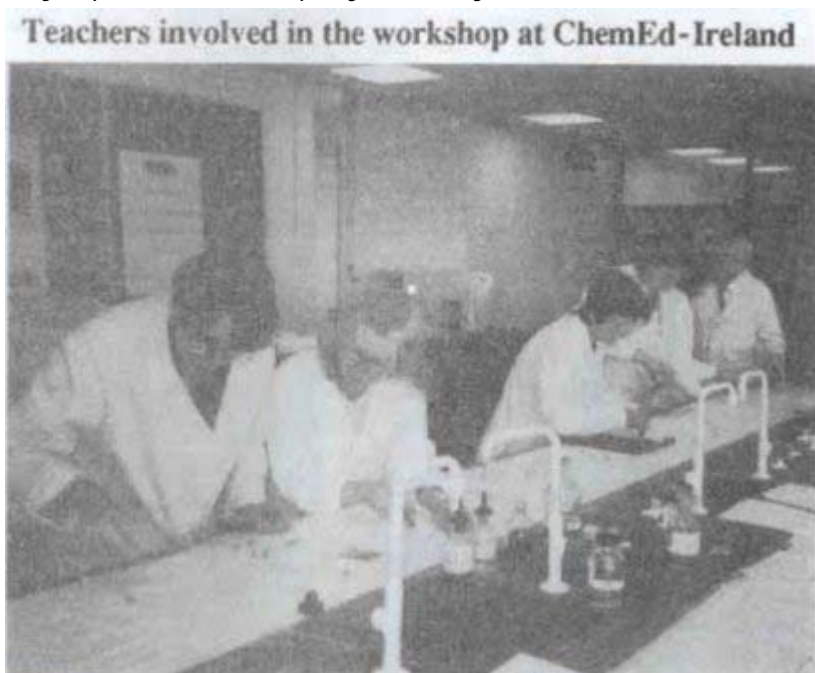
E-mail: ACADEMYLTD@aol.com

WebSite: <http://www.academyequipment.co.uk>

Ireland:

Shaw Scientific Ltd.,
Greenhills Ind. Estate, Walkinstown, Dublin 12
Contact: Mr Derry Shaw
Tel: + 353 1 450 4077
Fax: + 353 1 450 4328
E-mail: shawsci@indigo.ie
WebSite: <http://www.shawscientific.com>

Paul Priest worked for Griffin & George for 20 years until 1986 and since then has worked in a number of companies, including consultancy work for the World Bank. In 1994 he formed Academy Equipment Ltd. to supply a range of furniture and equipment for science and technology teaching. Microchem was introduced in 1997 and is now a major part of the company's activity.



Caption - Teachers involved in the workshop at ChemEd-Ireland

Novel Experiments from America

Randal Henly

The "ChemEd" conferences are held in North America every two years, moving about, as do the ISTA and ASE Annual Meetings, to different venues each time. ChemEds started in the 1970s at the University of Waterloo, Canada, but recent ones have been hosted in the USA. At this stage I have attended three of them: Indianapolis in 1993, Norfolk Virginia in '95, and Minneapolis in '97. Although essentially for chemistry teachers, there is a considerable physics content too. I have found all of them to be a tremendous source of inspiration, ideas and material. Like the ASE meetings, you wish you could be in half a dozen different places at any one time. There are lectures, demonstrations, workshops, social events, visits, and a great trade exhibition.

The ideas for most of the demonstrations that I am about to present have come from ChemEds. The next ChemEd (August 1999) is to be held at Sacred Heart University, Fairfield, Connecticut, which is about an hour's drive from New York and which is as near as it ever can be to Ireland. Information about it can be obtained from the website: www.sacredheart.edu, or by writing to ChemEd 99, Sacred Heart University, Fairfield, CT 06432, USA, or by e-mail to ChemEd99@sacredheart.edu. For anyone thinking of going, it should be possible to combine ChemEd with a visit to New York.

DISAPPEARING POLYSTYRENE PELLETS

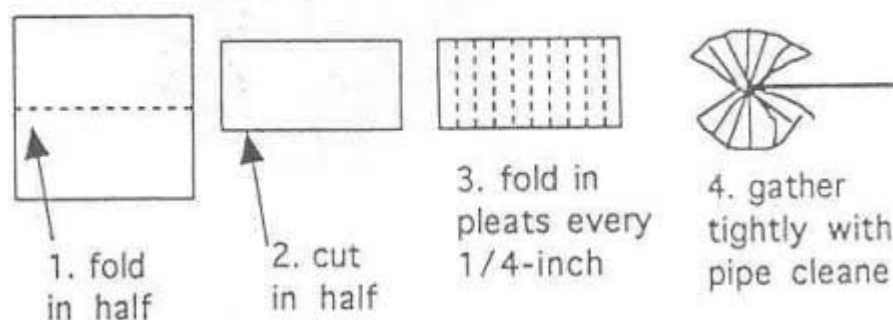
I use this experiment to introduce first years to the concept of solubility, although I don't tell them what they are about to study; at the start, it is just an exercise in estimation. Take a large clear (500-600 cm³) beaker filled with expanded polystyrene packing pellets. Place about 30 cm³ of propanone (acetone) in an opaque vessel of much smaller volume - half or less. "How many of these polystyrene pellets do you think will fit into this beaker? Consider the size of a pellet, and the size of the beaker and make a reasonable estimate." Start putting them in - until the entire number has been added; by then the whole class is goggle-eyed! (The explanation is that the propanone dissolves the pellets.) A suitable pattern is useful during the demonstration because the pellets must be put in slowly, about two per second maximum. Inevitably at about the half-way stage, when the vessel should be full, there are comments like "There's an awful lot going in" or "There must be a hole in the vessel" (without thinking that there would have to be a hole in the bench as well for that explanation to be valid!). The explanation can then be given and the idea of solubility introduced.

INSTANT CARNATIONS

This experiment can also be used as an "attention-getter". I usually do this as a sequel to the class in which I have taught about indicators. I ask for explanation from the class rather than just telling them.

Prepare white paper "carnations" from tissues and pipe-cleaners, as follows. The diagram should explain what to do.

Figure 1 Folding the tissue



Caption - Figure 1 Folding the tissue

Separate each of the eight pieces by pulling the tissue separately to the centre, forming a ruffled flower. Prepare several flowers. Spray each of them with one of the following solutions: 5% phenolphthalein (for pink flowers), 5% thymolphthalein (for blue flowers), 5% p-nitrophenol (for yellow flowers). Let the flowers dry - this takes several hours, although you could use a hair dryer if necessary.

To bring up the colour, spray the flowers with dilute alkali (sodium hydroxide or ammonia) from a plant sprayer. If ammonia is used, the flowers can be made to fade again by blowing on them. This causes both the ammonia to evaporate and also acidifies them with carbon dioxide.

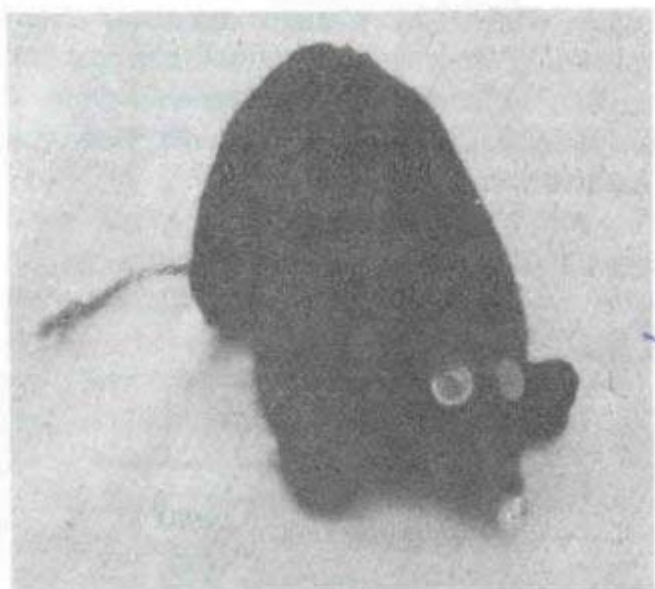
OSCILLATING POPCORN

This experiment can be used as an illustration in a class on density, or on properties of acids, or just as an attention-getter at perhaps, a school open days or a parents' evening.

Put two Alka Seltzer tablets into a beaker of water. Add unpopped popcorn - which then starts to oscillate. When bubbles of CO₂ form on the popcorn, it becomes less dense and rises. On reaching the surface, it releases the bubble of gas and sinks, and the process is repeated. A colourless carbonated drink such as "Sprite" can also be used, and raisins are an alternative to popcorn.

STUFFED MOLES

A strategy that is constructive to educating is in giving hints/prompts to make pupils think along the right lines or to recall knowledge that may be latent. Pupils love gimmicks, and this aid is used to make 5th/6th years think along the right lines when moles are needed in calculations, such as "how many molecules are contained in a litre of oxygen?"

Figure 2 A stuffed mole**Figure 2 A stuffed mole**

To make a reasonable-sized mole, enlarge the pattern shown in Figure 3 to about 200% (so that the mole is 9" long). Cut out cloth pieces for the sides and the bottom of the mole using the pattern. Sew the two upper body halves together, from nose to tail along the spine of the mole (the pattern allows a 1 cm margin). Sew the bottom on to the two sides but leave a 5 cm section near the rear not sewed. Turn the mole inside-out through this gap so that the seams are on the inside. Stuff the mole, and hand-stitch the gap to close it. If desired, sew on eyes and feet if desired.

I got my own mole from Lee Merek who gave a workshop at the last ChemEd. For a homework exercise, he had got the pupils in one of his classes to make moles - which he then gave out to those who attended his workshop!!

Figure 3 The Mole Template

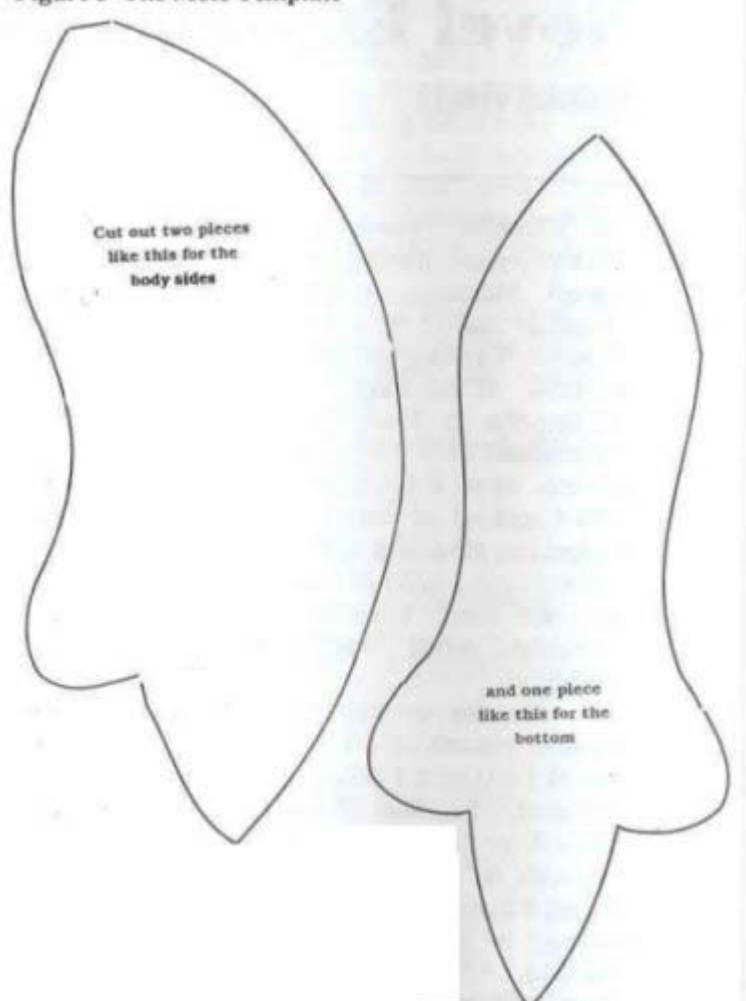


Figure 3 The mole template

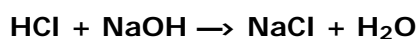
ADDITIONAL EXPERIMENTS1) $1 + 1 = 2$

Most pupils can cope with this; there is no need for an experiment!

2) $1 + 1 > 2$

Prepare 500 cm³ of 2M sodium hydroxide solution and 500 cm³ of 2M hydrochloric acid. Each of these solutions contains 1 mole of the solute. The solution should be in 500 cm³ volumetric flasks to emphasise their exact volumes.

With the aid of a funnel, simultaneously pour these two solutions into a 1 litre volumetric flask. The volume comes to about 1018 cm³. The extra 18 cm³ is the volume of the mole of water that is produced.



(The explanation is not actually as simple as that; there are other factors involved. However, using hydrochloric acid and sodium hydroxide solution, the extra volume is "right" for the reaction involved. It is too good an experiment not to use it to reinforce the chemistry involved.)

3) $1 + 1 < 2$

Half-fill a long glass tube (the bigger the better - within limits) with water. A 50 cm³ burette can be used but the demonstration

is not then so effective. Carefully, so as not to encourage mixing, fill the remaining half, right up to the brim, with ethanol (methanol will work also). Stopper the tube so that no air (none at all) is trapped. Holding the stopper(s) in place, repeatedly invert the tube so that the water and alcohol mix. A small bubble appears, and grows in size, until eventually there is quite a noticeable volume of liquid "missing".

It adds to the effect, and also highlights the mixing, if the water is coloured yellow (with food dye) and the alcohol coloured blue

The molecules of the two substances pack more tightly into each other than the molecules of the substances on their own.

Query: what does the bubble consist of? If this question is asked to the class, a common answer is "air" or perhaps a vacuum.

Neither is these is correct; air couldn't have entered the stoppered tube, and in the presence of both water and alcohol, a vacuum is not possible. The space most likely consists of alcohol vapour, with perhaps water vapour too, although it will probably be at less than atmospheric pressure.

HYDROGEN BONDING

Fill three large test tubes (or 100 cm³ graduated cylinders that can be stoppered) with, respectively, propanol, "ethylene glycol" (commercial anti-freeze) and glycerol. Add a marble to each and stopper the tubes. Mount the three tubes on a suitable rigid backing. When inverted, the marbles fall through the liquids, the speed depending on the amount of hydrogen bonding in each liquid - and this in turn, depends on the number of -OH groups in the molecule of each substance. The structures shown in Figure 4 should explain why the marble falls most slowly in the glycerol and least slowly in the propanol. Shown below is the acetate that I use to explain the chemistry after having done the demonstration.

Figure 4

HYDROGEN BONDING AND VISCOSITY

The amount of hydrogen bonding in the molecule of a substance has an effect on the viscosity of the substance.

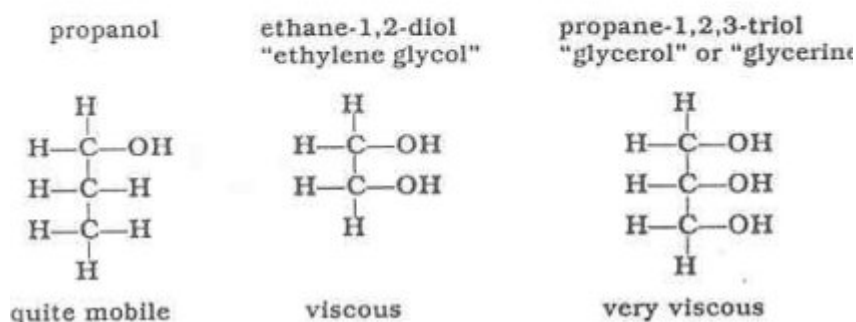


Figure 4

THE COLLAPSING BOTTLE

This is quite a spectacular demonstration - albeit a fairly simple one - that illustrates neutralisation, effect of atmospheric pressure and heat of reaction. Advance preparation involves filling a 1.5 or 2 litre plastic bottle with carbon dioxide.

For the demonstration, unscrew the cap, quickly pour in about 30 cm³ of 6M (or thereabouts) sodium hydroxide solution,

and immediately screw on the cap - tightly. Shake the bottle vigorously. The carbon dioxide reacts with, and is absorbed by, the alkali. The atmospheric pressure squashes the bottle. The temperature rises considerably because the reaction is very exothermic. **(Take care with the sodium hydroxide solution; a 6M solution is quite concentrated and would cause skin irritation. Splashes in the eye are very dangerous - wear eye protection.)**

If the bottle is left until the next day, a large crystal of sodium carbonate will have formed.

ACIDIC NATURE OF CARBON DIOXIDE

Experiment 1: To about 250 cm³ of water in a graduated cylinder, add some universal indicator and drops of dilute sodium hydroxide solution until the pH is about 10 (purple colour). Pour the solution into a graduated cylinder. Drop in an Alka Seltzer tablet. The solution will quickly proceed through a series of colour changes as the pH decreases owing to the carbon dioxide bubbling through it.

Experiment 2: Set up the apparatus as before. Instead of adding Alka Seltzer, blow through a tube into the bottom of the cylinder. As the pH slowly drops, various colour changes occur. Blowing can be stopped at any stage, in order to hold a particular pH and its corresponding colour.

RATE OF REACTION

Simultaneously add Alka Seltzer tablets to each of three beakers of water, one ice cold, one warm and one hot. Chemistry teachers reading this should be able to predict and explain the result - if not, they will have to try it!

LIGHT STICKS

Light sticks have become fairly common in the last few years. If any have not come across them, their main use is as a source of emergency light for campers, sailors, etc. They make use of the reaction in which luminol is oxidised - a chemiluminescent reaction (i.e., a chemical reaction emitting light). Inside the stick are two solutions, one of which is inside a glass ampoule. When the stick is bent in two, the glass container is broken, the two solutions mix, and the luminescent reaction takes place. Commercially-produced sticks can give light for up to 6 hours, and they are available in four colours - red, green, blue and yellow.

Normal use in chemistry class is to show a chemiluminescent reaction. However, their use can be extended to show rates of reaction. You need the lights out for this demonstration. Of the three sticks that I have, one has been immersed in ice-water, one is at room temperature and one is in hot water. When the three are broken simultaneously, the rate of reaction is greatest in the one at the highest temperature and the light is brightest. Conversely, the light from that one that has been in ice-water is the poorest (however, it will continue to emit for longer).

For a further sequel, I can cut open one of the sticks and pour the contents over tissue in a beaker. or over my plastic gloves, and in this dark room you now have ghostly hands waving about!

BOYLE'S LAW USING A POTATO "GUN"

This experiment shows the effect of Boyle's Law quite dramatically - it is not though, a way of showing that pressure x volume is constant). Take a length (50-70 cm) of electrical

conduit metal tubing. File the inside of each end so that the openings are slightly flared (use a small to medium-sized half-round file).

Push one end of the "gun" through a small to medium-sized potato (do not use a large potato) so that a potato plug is cut out and left in the gun. Repeat at the other end. Using a ram-rod such as a wooden dowel rod (the "half-inch" size is recommended) push the plug at one end towards the other end. The volume between the two plugs becomes smaller; the pressure of the gas within is therefore increased, and at some stage, the "bullet" is ejected with great force and speed.

IT IS ESSENTIAL THAT THE GUN IS POINTING TOWARDS EITHER THE CEILING OR A BLANK WALL WHEN DOING THIS.

To save time and the effort of flaring both ends of the metal tube, flare only one end. When the plug of potato is inserted into this end, push it up to the other end with the ram-rod (leaving it just inside the opening).

THE DISAPPEARING PENNY

This is a nice colourful demonstration with lots of good chemistry involved. At senior level, the chemistry can be explained - and should be, but for juniors, it is probably best used as just an interesting chemical spectacle.

Figure 5 Diagram of apparatus

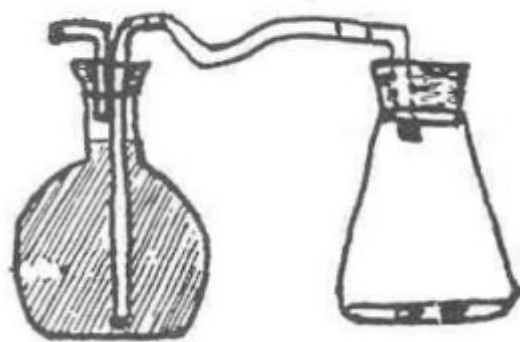


Figure 5 Diagram of aparatus

Arrange the apparatus as shown in Figure 5. The conical flask contains about 30 cm³ of concentrated nitric acid. The round flask contains water to which a few drops of dilute alkali (about 3M) have been added, and then sufficient universal indicator to give a good purple colour.

Remove the stopper from the conical flask, drop in a **pre-1988*** penny and replace the stopper. The penny reacts with the acid, generating both heat and brown nitrogen dioxide gas, which is driven over into the round flask. There it reacts with the alkali, slowly neutralising it so that the colour of the indicator changes to yellow. When the evolution of gas has finished, the conical flask cools and the nitrogen dioxide contracts, leaving a partial vacuum. The liquid from the round flask is driven back into the conical, where it turns blue owing to the copper nitrate present in that flask.

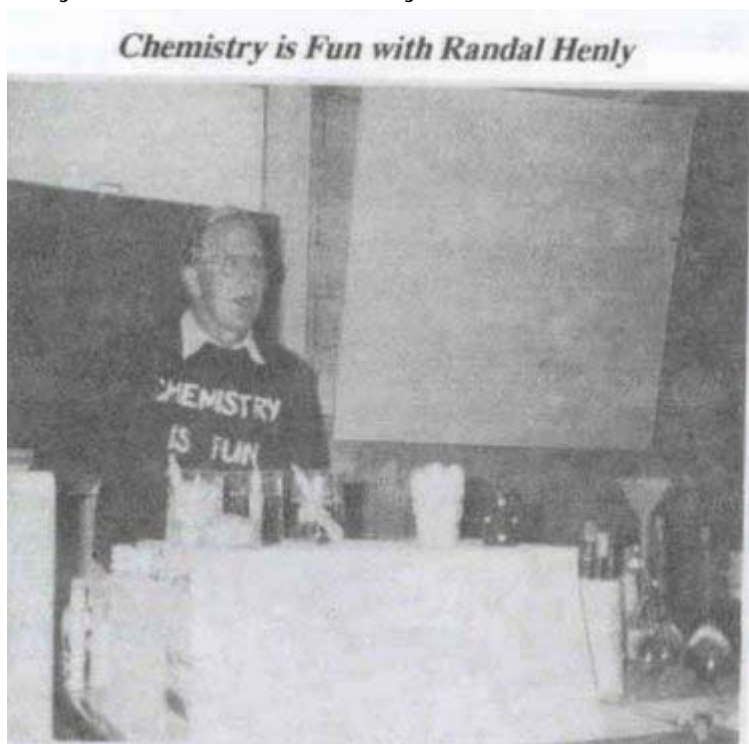
(*) Post-1988 pennies are not made of copper.

RATE-DETERMINING STEP

On a stand, set up three funnels of different delivery sizes, one above the other. Pour (coloured) water through the funnels. The delivery speed is dependent on the funnel of **smallest** aperture. The order of the funnels can be altered, with the same result.

*Randal Henly is well-known to every science teacher in Ireland for his chemical magic shows and his editorship of **Science**, the ISTA journal. he has just retired from teaching after 36 years (since 1972 at Mount Temple School) and is now "busier than ever". He has promised to write an article for **Chemistry in Action!** on "36 years in science teaching" - something to look forward to. He has received The BP Science Educator of the Year (1984) and the Lodge Award (1987) from the ISTA in recognition of his contributions to Irish science teaching.*

Chemistry is Fun with Randal Henly



New Experiments for L.C. Chemistry

Frank Roden

Loreto College, Swords, Co. Dublin

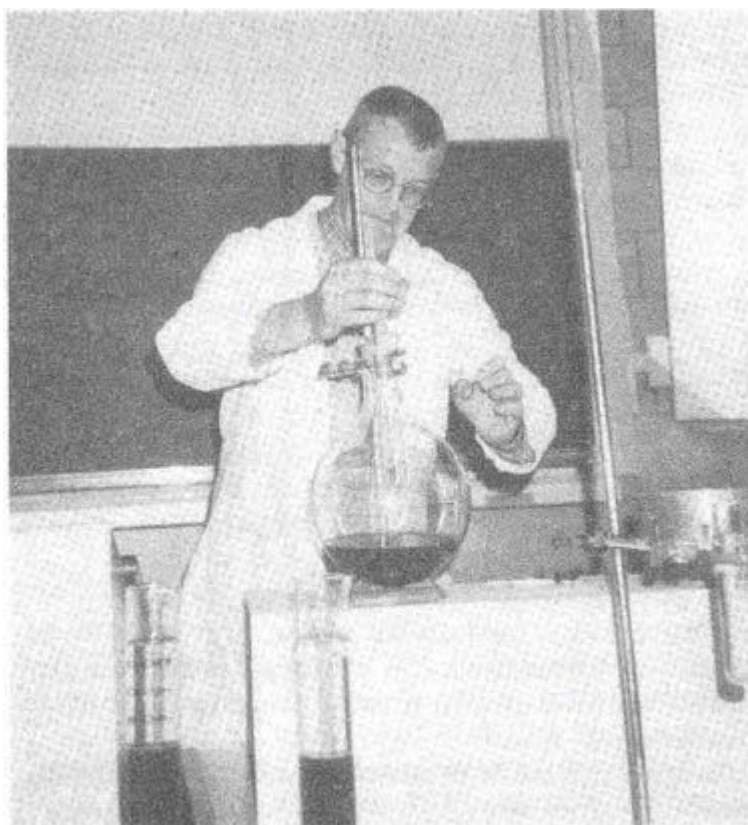
I have found the following demonstrations useful when presenting topics in the Leaving Certificate Chemistry course and I hope you do too.

The 'Blue Bottle'

This is a well-known demonstration in which a sealed flask containing an alkaline solution of the dye, methylene blue, and glucose is shown to the class. In its reduced form this dye is colourless. However, immediately it is shaken, the dye is converted to the blue form by the oxygen in the atmosphere above the solution. When left undisturbed the solution gradually becomes colourless once again.

I have found that the following mixture works well in a 1.0L Volumetric flask:

500mL of 0.7M aqueous KOH
5g of glucose
A few drops of methylene blue.



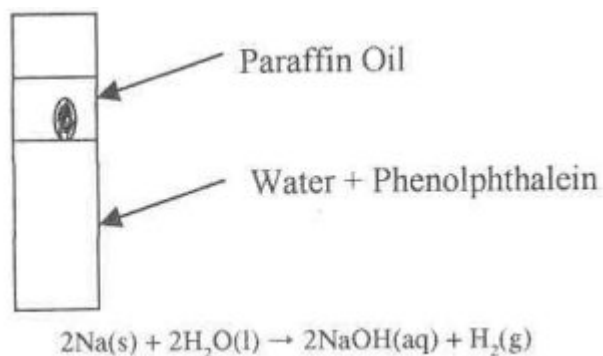
Will it work?

Reaction of Sodium with Water under Paraffin

Half-fill a large graduated cylinder (e.g. 1L) with water and add a few drops of the indicator phenolphthalein. Add liquid paraffin on top of the water so that its depth is about half that of the underlying aqueous layer.

If a small (pea-sized) piece of sodium is dropped into paraffin it will sink until it reaches the aqueous layer. It will then react producing hydrogen and will be carried up

through the paraffin by a bubble of the hydrogen. Simultaneously, the phenolphthalein turns red as the solution becomes alkaline.



The reference below suggests a combination of different indicators that can be used to produce a 'rainbow' effect. (Journal of Chemical Education, 74(8),1997, 942)

An Endothermic Reaction

The reaction of barium hydroxide and ammonium chloride is sufficiently endothermic to freeze water and thus stick the flask containing the reactants to a block of wood.

Materials:

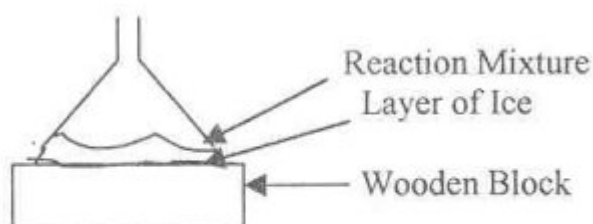
32g hydrated barium hydroxide, $\text{Ba(OH)}_2 \cdot 8\text{H}_2\text{O}$

11g ammonium chloride, NH_4Cl .

Procedure:

Put the above quantities of these two chemicals (both solids) into a 250mL conical flask. Using a glass rod mix the chemicals as thoroughly as possible, while being careful to avoid breathing the ammonia, which is produced by the reaction. If the flask is now placed on top of some water on a wooden block and left undisturbed for a few minutes the water will freeze and the flask will stick to the wooden block. The flask can be lifted up bringing the block with it.

I would suggest that the flask should not be passed around for pupils to touch because the temperature reached by the flask and its contents may be sufficiently low to cause injury.



(Source: B.Z. Shakhshiri, *Chemical Demonstrations*, Vol. 1, p.10, University of Wisconsin Press, 1983)

Seeding of a Supersaturated Solution

If a single small crystal of sodium acetate is added to a supersaturated aqueous solution of this salt, long glass-like crystals are seen to form within the solution. The crystal formation can be demonstrated very well by illuminating the solution from below.

Materials:

250g hydrated sodium acetate (ethanoate),

$\text{NaC}_2\text{H}_3\text{O}_2 \cdot 3\text{H}_2\text{O}$

100mL water.

Procedure:

Mix the above chemicals together in a conical flask. Cautiously heat the mixture until a clear solution is obtained. Allow the solution to cool to room temperature.

The solution may now be poured into boiling tubes. If a spatula tip-ful of the original sodium acetate is now added to this solution, long glass-like crystals will be seen to develop throughout the solution.

(Source: B.Z. Shakahashiri, Chemical Demonstrations, Vol.1, University of Wisconsin Press, 1983, p.27)

Effect of Temperature on Equilibrium

Cobalt(II) can form a variety of different complexes, some of which are red and others blue.

A solution of hydrated cobalt(II) chloride in alcohol contains two of these complexes and the position of equilibrium is dependent on the temperature.

Materials:

1.0g hydrated cobalt(II) chloride, $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$

100mL industrial methylated spirits

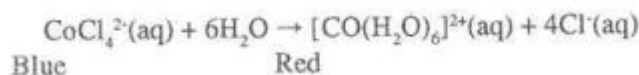
Procedure:

Dissolve the cobalt(II) chloride in the alcohol. The quantities specified are not critical.

Now add water drop-wise to the resulting blue solution until the pink colour is restored.

If a flask of this solution is now immersed in hot water it will turn blue. If it is then cooled it turns pink.

The following equation has been suggested for the change that is involved:



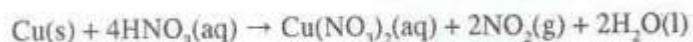
(Source: Journal of Chemical Education, 28, 1951, 640)

Acidic Nature of Non-Metal Oxides

The unpleasant, irritating and even toxic natures of nitrogen dioxide and of sulphur dioxide make it difficult to demonstrate the properties of these gases to a class. The following arrangements make this possible.

Nitrogen dioxide, NO_2 :

Nitrogen dioxide is a red-brown gas that is soluble in water forming an acidic solution. It is produced when copper reacts with concentrated nitric acid.

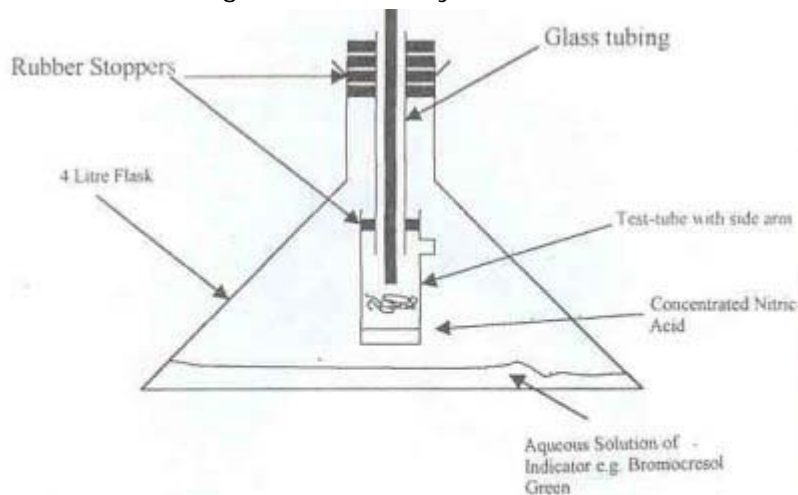


Procedure:

Assemble the apparatus as shown below. Put nitric acid into the test-tube to a depth of about 1cm. Insert copper foil into the test-tube in such a way that friction against the sides of the tube holds it just above the acid. When you wish to present the demonstration push the copper into the acid by means of the glass rod. Quickly withdraw the rod from the glass tube and seal the tube with a rubber pipette bulb.

Red fumes of nitrogen dioxide are produced which escape into the flask. By gently rotating the flask these will be absorbed by the water in the flask causing the dissolved

indicator to change from blue to yellow.

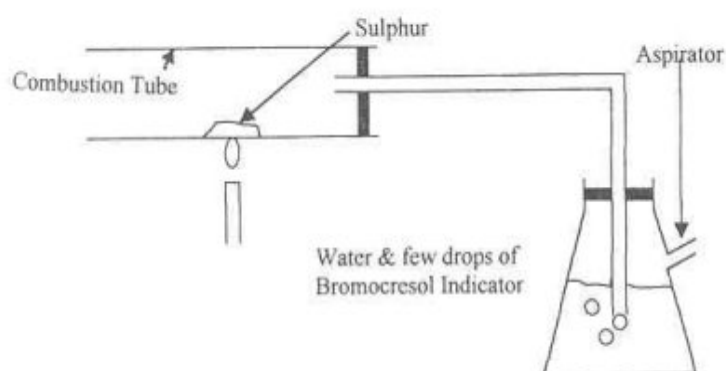


(Source: *Chemical Demonstrations*, Vol. 3 B.Z. Shakhashiri, University of Wisconsin Press, 19***, p.116)

Sulphur dioxide SO_2 :

Sulphur dioxide is formed when sulphur, or fuels containing sulphur, are burned in air. It is a toxic gas and even in very small quantities it is most irritating to the eyes, throat and nasal passages.

Its acidic nature can be demonstrated safely in the following way:



Procedure:

Set up the aspirator to draw air through the apparatus at a moderate rate. Heat the combustion tube strongly just below the sulphur until the sulphur burns with the characteristic blue flame, then remove the Bunsen flame. The sulphur will continue to burn as the stream of air is drawn across it and the resulting sulphur dioxide will be swept into the flask containing the solution of indicator.

Frank Roden teaches at Loreto College, Swords, Co. Dublin. After completing a chemistry degree at UCD in 1966 Frank went to teach in Sierra Leone for two years. On returning to Ireland he did the H.Dip.Ed course and started teaching at Loreto College, Dublin where he has remained ever since. In 1982-83 he did an M.Sc. in Chemical Education at East Anglia, with Roger Maskill as his supervisor. More recently he spent a few months at the University of Western Australia working with Dr. Jack Harrowsfield, using UV-Visible

spectrometry to measure the transition metal content of complexes.

Integrating safety into Junior Science

Bernadette Ní Chathain

Department of Life Science, University of
Limerick

Introduction

This article is based on my final year dissertation, which led to a B.Sc. degree in Biological Science Education (Chemistry Option) at the University of Limerick in 1998. The purpose of this dissertation was to investigate a means of integrating the topic of safety into the Junior Certificate Science Curriculum, in an informative and fun way.

The main problems found in this area were:

- No recognised method to provide students with safety education.
- No method of monitoring students' acquired skills in the safe manipulation of apparatus, chemicals etc.
- No written text, guidelines or activities incorporated into current Junior Certificate textbooks to aid teachers in the promotion of safety education to Junior Certificate level.

Until November 1st, 1989, safety and health legislation applied in the Irish context mainly to industrial, construction and quarrying operations. Since that date and the implementation of the Safety, Health and Welfare at Work Act 1989, education is now one of the new entrant sectors covered by protective safety legislation. As all entrants to the workforce pass through the education system much of the success of this important new statute depends on the impact made in schools in the sphere of safety management, safety and health literacy for pupils. Schools should therefore play an important role in planning for safer environments. Much depends on the raising of safety awareness among teachers and pupils alike and on their mutual co-operation to ensure the objectives of The Act are met.

Practical work at school

When the Junior Certificate Science Syllabus was introduced in 1989, it placed a new emphasis on practical work in the laboratory by students. Practical work in the science laboratory has a number of very educational worthwhile advantages.

- Motivates pupils to do science and helps to keep them interested.
- Teaches skills to pupils (e.g. the ability to make accurate observations, manipulation skills etc.).
- Helps to promote logical thinking.

- Helps pupils to understand (or accept) the theory (i.e. the idea of seeing is believing).
- Provides an opportunity for pupils to develop communication skills and to learn through group discussion.
- Provides an opportunity for pupils to work together as part of a team.

For pupils, science is seen as a practical subject and practical work is fun. A variety of types of practical work may be adopted, but they should all fulfil three major aims:

1. They should motivate pupils to do science;
2. Pupils should learn something from the experience; and
3. **They should be safe.**

Safety implications often discourage teachers from carrying out experiments, as does the fact that young people are a high risk in any laboratory. However, with adequate forethought and due care, experiments can be successfully carried out with pupils of all ages. I believe, that if safety were to become incorporated into the science curriculum, that it would improve the future workforce in terms of safety awareness and responsibility for safety while also reducing science teacher's worries about allowing pupils to carry out experiments.

Cover from the teaching package



Cover from the teaching package

Why integrate safety at second level?

The main goals of occupational health and safety education are the promotion of:

- general awareness of safety,
- safe skill development,
- of hazard identification, and

- of safe attitude development¹

The most essential goal of integrating safety into the curriculum is the fostering of attitudes in students which will motivate them as employed persons now or later in life to protect their safety and health on the job.

*"Safety isn't a special topic to be mentioned at the start of a course or a new school year. Safety should permeate every science lesson. We want to teach pupils how to handle apparatus and chemicals safely, not just in school but outside school. We want to develop safety habits which will last a lifetime."*²

Health and safety report³

The report quoted from above made a number of key recommendations. One essential recommendation included promotion of health and safety awareness among pupils in preparation for the workplace. The committee recommended that the Health and Safety Authority should establish consultative links with the Department of Education both in relation to curriculum changes and in the approval of new textbooks. It recognised that in relation to the curriculum, good practices in health and safety were generally covered implicitly in the subjects taught at Junior and Leaving Certificate level. However, it still begs the question: "Why not develop a text which will incorporate safety on a need to know basis for pupils?". This was my goal when I began to develop the "Safety First in School Science" package.

How can safety be integrated into school science?

There are numerous ways to ensure that pupils know that safety is important and that safe procedures are required at all times in the science laboratory. Knowledge, communication, good example, development of skills and good habits are all essential elements for the integration of safety.⁴

- **Knowledge:**
Teachers need to find out about safety by reading books, reading science/education journals etc. so that they are familiar with hazards and what to do about them.
- **Communication:**
This acquired knowledge must now be passed onto pupils in appropriate ways throughout their science course. Could this be achieved in the form of an integrated safety curriculum?
- **Good example:**
As teachers, we serve as role models for our pupils. Therefore we must not only encourage and promote safety, we must also act safely at all times e.g. in the way we use apparatus and chemicals.
- **Development of skills:**
Throughout their science course, pupils gain valuable skills of investigation and observation to name but a few. Pupils should also learn and practice the skills of behaving

safely and with responsibility when carrying out practical work, e.g. the skill in using a Bunsen Burner safely or the skill in handling chemicals safely.

- **Good habits:**

Continual practice and emphasis on safety can only develop good habits. This should begin in first year and permeate every year at second level. Repetition lays the foundation for good habits in the laboratory.⁵

"Safety First in School Science" Package

I decided to structure this package in the most 'user friendly' way possible for pupils, therefore it is divided up into twelve distinct safety sections. They are:

1. Laboratory safety rules
2. First Aid
3. Good housekeeping
4. Personal Protective Equipment (PPE)
5. Practical work
6. Glassware Safety
7. The Bunsen Burner
8. Electrical Safety
9. Fire Safety
10. Chemical Safety
11. Biology Safety
12. Fieldtrips

Each section consists of relevant safety information accompanied by various written and practical activities. The above layout of the package allows the teacher and their pupils to cover safety sections as they meet them during their course. The layout of the package does not imply any particular order for implementation of the package.

The package may be used in three different ways, the third which is considered the most ideal:

1. The package may be used as a separate pack for pupils - i.e. as a workbook.
2. It may be used as a resource package for teachers. In this way teachers could convert information sections into overheads and activity sheets into handouts for pupils.
3. Ideally - I would hope that this package, or a similar one, would become incorporated into Junior Certificate Science textbooks and would also form part of the final examination for Junior Certificate Science.

Sample exercise from the package

GOOD HOUSEKEEPING



Tick the correct statements below.

All sinks should be kept free from waste material? ☐ T ☐ F

Lab benches and equipment should be cleaned and dried at the end of each class? ☐ T ☐ F

Broken glass can be put in the same waste container as paper? ☐ T ☐ F

Aisle-ways and exits are to be kept clear of obstructions at all times? ☐ T ☐ F

Equipment and glassware can be left on benches after an experiment? ☐ T ☐ F

Glassware should be washed thoroughly at the end of each lab session? ☐ T ☐ F

Chemicals and rubbish can be disposed of using the same method? ☐ T ☐ F

Hazard warning signs and notices (e.g. fire drills etc.) should not be displayed in the lab? ☐ T ☐ F

Bins should be emptied at the end of each day? ☐ T ☐ F

There is no need to unplug electrical appliances? ☐ T ☐ F

All gas, electricity and water taps should be turned off at the end of the day? ☐ T ☐ F

Chemicals can be left in the lab at the end of the day? ☐ T ☐ F

Just Remember -



Sample exercise from the package

Pupil Assessment

'Merits' will be allocated on the basis of the standard of the completed tasks. A record should be kept by the teacher on each pupils progress. In this way pupils' safety knowledge and skills are continually assessed. At the end of each year, a final exam would count for 30% of the marks awarded. For this final exam, pupils could be asked to demonstrate an experiment following safety guidelines; they could be asked to complete a written task, and they could also sit an oral examination. A "Certificate in Safety Awareness" should then be presented to pupils in the form of a ceremony to acknowledge their level of achievement in their safety course.

Evaluation of the Package

Junior Certificate Science teachers were contacted, and asked to evaluate this safety package in terms of its content and effectiveness in the promotion of safety. Positive feedback was received and many valuable suggestions made which I proceeded to incorporate into the package, however further improvements could be made. It is hoped to distribute this package to teachers who requested it at ChemEd-Ireland 1998 shortly. The package has not been tested in schools on a long-term basis, therefore its effectiveness has yet to be discovered.

In conclusion, I believe that the "Safety First in School Science" package is an essential text for all Junior Certificate Science teachers who wish to convey the ideas and skills associated with safe science to their pupils.

I would like to take this opportunity to thank all of the Junior Certificate Science teachers who assessed the "Safety First in School Science" package in April 1998. Your valuable help and comments were greatly appreciated.

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3. Health and Safety and Safety Authority (1995). Report of the Advisory Committee on Occupational Safety and Health at First and Second levels in the Education sector to the Health and Safety Authority. Dublin: National Authority for Occupational Safety and Health. p.2.
4. Childs, Peter E. (1993). *ibid*, p.28
5. Childs, Peter E. (1993). *ibid*, p.28.

Bernadette Ni Chathain is currently a postgraduate student in the Department of Life Sciences at the University of Limerick. She completed a BSc degree in Science Education at UL in 1998 and this paper is based on her final year project, supervised by Dr. Peter E. Childs.