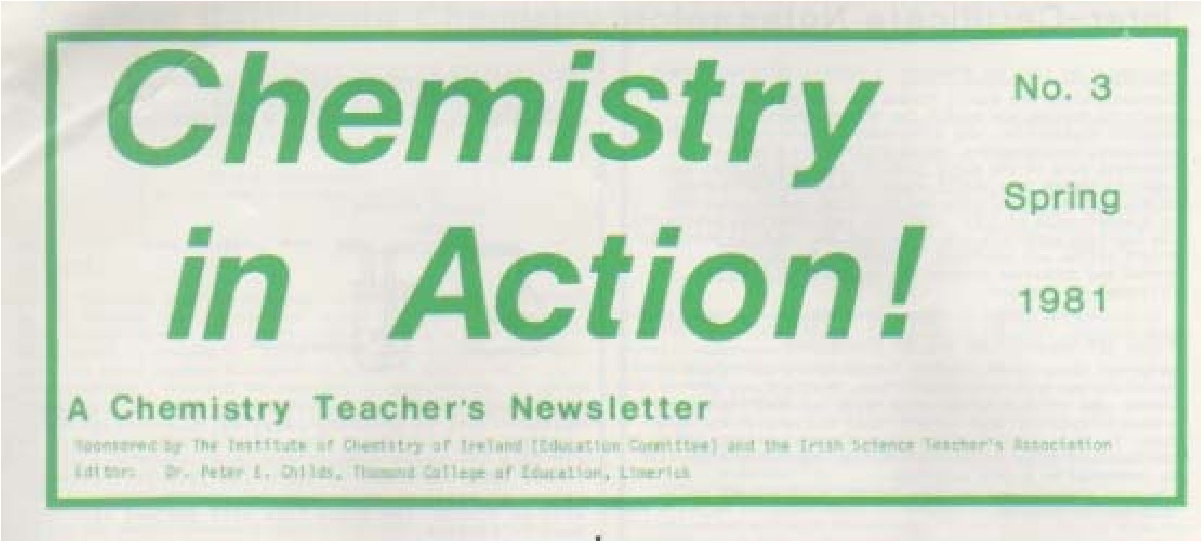


Chemistry in Action!

No. 3

Spring

1981

A Chemistry Teacher's Newsletter

Sponsored by The Institute of Chemistry of Ireland (Education Committee) and the Irish Science Teacher's Association
Editor: Dr. Peter E. Childs, Thomond College of Education, Limerick

Editorial

I'm sure many of you have been wondering where the next issue of "Chemistry in Action" had got to. It is intended that there will be three issues a year, roughly one for each school term – starting with this issue they will be datelined Spring, Summer and Autumn. This issue has been delayed partly due to inaction and partly due to the editor's other commitments. The Summer issue should be out on time and will consist mainly of the papers given at the 25th. Teachers Refresher Course held in January (see p.9).

The visual aid of the future

At this time of year I, and the other staff at Thomond, are out visiting our students who are in schools on teaching practice – a fact that will not have escaped some of our readers. I find this to be a very rewarding experience in being able to visit a variety of schools and to meet many science teachers. I've been impressed again this year by the disparity in provision between different schools for laboratories and equipment. I've been particularly impressed to find video-recorders in all the vocational schools I visited, and the use being made of them, especially in science. Colour video-recordings are very effective audio-visual aids which can be used and reused, stopped, played back etc. always under complete control of the teacher. The cost of tape at about £5 per hour for cassette recorders is also very reasonable, and more and more material is becoming available from commercial publishers. The video-recorder makes it possible, at last, to use educational T.V. properly instead of being constrained to the broadcast timetabling. Video will be the educational aid of the 80's and will undoubtedly become more widely available.

How many practicals?

A reader expressed doubt that Michael O'Dwyer (p.8, issue 2) could do as much practical work in the time described – and do anything else! In this issue (p.3) Adrian Somerfield describes how he includes at least 50 student experiments (not counting teacher demonstrations) over the two years of the senior cycle, a feat that many of you will find incredible. The truly awful thing is that in some schools students do no experiments at all! This means that the school-leavers with L.C. Chemistry must present a very wide spectrum of practical ability and experience, a matter of real concern to employers requiring some chemical background and to chemistry teachers in third-level institutions.

Don't miss these...

Two articles in this issue deal with the current standing of Chemistry at school: Eric Martin discusses the decline of Chemistry (p.6) and is followed by Sr.Kathleen Kennedy's essay on "How can we make Chemistry courses more attractive?". The latter article was the only entry to the 1980 essay competition – but you have another chance (see p.27). A number of teachers have requested information about the safety of chemicals at school. The centre pages contain an important report on "Restricted Chemicals" produced by the A.S.E., and indicating which chemicals should be used at school for different purposes. Read it carefully and note the recommendations. Concern about chemical safety is not an excuse for avoiding practical work at school – rather it ensures that suitable practical work can be done with the minimum of risk to teacher and pupils. Safety information to help you teach Chemistry safely will be an important feature of "Chemistry in Action". Take note as well of the feature on "The safe preparation of hydrogen" on p.18. The Careers page has a feature on the chemistry taught at the Royal College of Surgeons of Ireland. A new "How to do it" feature deals with inserting thermometers and glass tubing through rubber stoppers, a frequent cause of accidents and cuts at school. I've found that many teachers don't know how to do this safely – everyone ought to know, so read and practice this skill.

Thank you to all those teachers who sent in questionnaires with information for the Teacher's Register, and for those who said nice things about "Chemistry in Action". I hope that you find this third issue contains things of interest and use to you in teaching. Try and make an effort to send in something yourself (see the Wanted ads below) – it'll do you good and add variety to our coverage.

Dr.P.E.Childs
Hon.Editor

Relevant Chemistry in perspective

“Remember that the chemical industry operates in order to make profits, and not to illustrate the finer points of chemistry on a tonnage scale.”
D.E.Wilson in
“Essential Ideas in Inorganic Chemistry”

WANTED: poems, limericks, jokes, pupil howlers, anecdotes, cartoons etc. of a chemical/scientific nature to liven up our readers.
WANTED: your favourite demonstration, student practical, project idea, laboratory tip, idea for models or apparatus or visual aids – anything that would help another teacher. Please share your experience with others.
WANTED: contributors of material related to the Inter-Certificate Chemistry syllabus.

Inter Certificate Notes

Decomposition into the elements: a demonstration/experiment

Compounds which are easily formed and can be broken up easily by heating are useful for showing the nature of chemical combination, the difference between elements and compounds, stoichiometry. Mercury(II) oxide played an important role in the early days of chemistry in this way. Lead(II) iodide is a useful example which is easily made by mixing lead(II) nitrate and potassium iodide solutions, in a molar ratio of 1:2. (CAUTION: lead compounds are toxic) The starting materials are colourless and lead(II) iodide is bright yellow and insoluble. A compound has obviously formed and potassium nitrate can be recovered from the filtrate, if required.

$Pb(NO_3)_2(aq) + 2KI(aq) \longrightarrow PbI_2(s) + 2KNO_3(aq)$

Filter off the solid and dry the precipitate.

Weigh out about 1g of lead(II) iodide into a hard-glass test-tube and heat in a bunsen flame. Purple fumes of iodine come off before the solid melts and when these stop a bead of metallic lead is left. Cool and reweigh the test-tube. The mass of lead left enables the stoichiometry of the compound to be checked/determined. The iodine vapour can be condensed on a cold test-tube.

The pure elements and the compound can be displayed to show the differences.

N.B. I found this reaction out by accident while trying to melt lead(II) iodide to measure its conductance. If I'd thought about it I should have predicted its instability: both metal and non-metal are 'soft', easily polarisable and the compound will be appreciably covalent and unstable. The fluoride and chloride will be more ionic and more stable than the iodide. To measure the m.pt. of lead(II) iodide one would have to measure it under pressure to prevent decomposition i.e. an application of Le Chatelier's principle.

$PbI_2(s) \longrightarrow$ heat $Pb(s) + I_2(s)$

Pressure increases will favour the backward reaction and thus prevent decomposition below the m.pt.

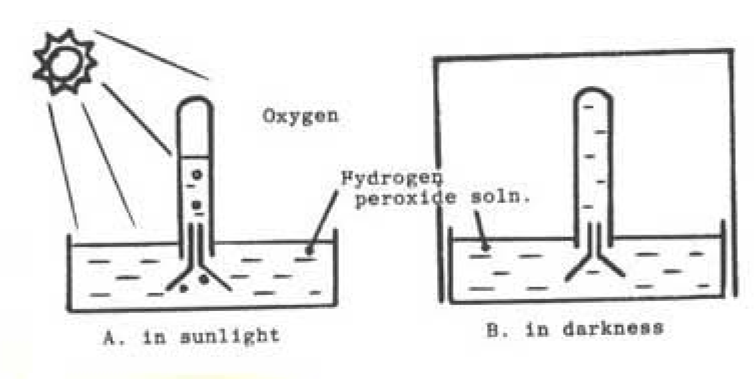
* * * * * * * * * * * * * * * * *

Demonstrations for inter-cert science
From Leo O'Donoghue, Tubber, Co.Clare

Instability of hydrogen peroxide in sunlight

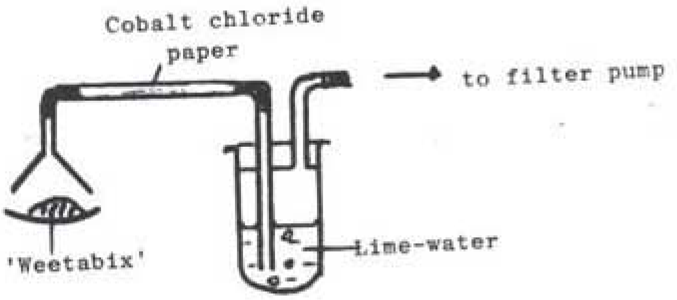
Set up two experiments as shown below using 20 vol. hydrogen peroxide. The control is covered with an opaque cover e.g. a bucket and both are placed in sunlight. The sunlight decomposes the peroxide giving oxygen, and this can lead into the preparation of oxygen and the use of manganese(IV) oxide as a catalyst to speed up the decomposition.

$H_2O_2(aq) \longrightarrow H_2O + ½O_2(g)$



The chemistry of respiration

The apparatus below can be used to sample a reaction producing gas and test for the product by sucking the gas through a test solution. In this case we test for CO_2 by sucking the gases through lime-water.



The 'weetabix' is soaked in ethanol to make it burn better – this is slightly cheating, but ethanol is also consumed by humans. Set fire to the weetabix and suck the gases through the apparatus. The cobalt chloride paper in the glass tube will change colour as water is given off and the lime-water will go cloudy. The glass tube will get hot showing heat is evolved.
Since we know that oxygen is needed for combustion we can write a simple equation:

Food + oxygen $\longrightarrow$ CO_2 + H_2O + heat

which is a simple respiration formula, showing how food is 'burnt' in the body.

(See p.3, issue 2 for another way of testing for evolved gases using a plastic syringe.)

Lightness of hydrogen gas

Demonstrating that hydrogen is lighter than air is often difficult if the gas flow/pressure is not high enough to inflate a balloon or plastic bag. An old idea is to bubble the hydrogen through soap solution: bubbles are formed which are lighter than air and also burn!

"Where do you find cents per pound on this thing?"

reprinted from CHEMTECH FEBRUARY 1980

Leaving Certificate Chemistry Notes

50+ Experiments for L.C.Chemistry

by A.E.Somerfield, St.Columba's College, Dublin 16.

Prologue

In my "Personal View" on syllabus reform ("Chemistry in Action", no.2, October 1980), I remarked that I was able to integrate some 50 experiments into the two years leading to the Leaving Certificate in Chemistry. Since I have been challenged to show how this could be done I thought it might be helpful if I described how I approach the teaching of this subject. I do not claim that this is the only way, or even the best way, but it is the way as it has evolved in my school over the last twenty years or so. I have five periods a week, two of which come together to form a "double". This is when practicals are done. I have classes in the 15-24 number range. Every three or four weeks we have "in class" tests.

To set the scene: I usually receive into the class boys and girls who have done some chemistry, and some which have done very little. I reckon that, at some time, I will have to cover the whole course, including preliminary material.

Teaching sequence, including experiments

In my Block 1 we do elementary chemistry and chemical arithmetic; that is, elements and compounds, formulas, percentage composition, empirical formulas from composition, Avogadro's law, moles, and so on. This usually takes about five weeks. Experiments include

(1) Find x in $MgSO_4.xH_2O$ by heating to constant mass.
(2) Percentage of chloride in $BaCl_2$ by gravimetry, using sintered glass funnels.
(3) Percentage of nickel in a nickel alloy by gravimetry, with dimethylglyoxime.
(4) Relative molecular mass of chloroform by a Dumas-type method.

Block 2 is a short introduction, from gas laws, into kinetic theory. During this we usually use one double period to do a simulated random-walk experiment on diffusion using dice, and I usually finish this off by obtaining an estimate of molecular size by diffusion of ammonia.

Block 3 is Thermochemistry, part 1. Here we do the usual enthalpies of combustion, formation, neutralisation, etc., and the experiments are

(6) Hess's law, to find DH for hydration of $CuSO_4$.
(7) Enthalpies of neutralisation of acids.

Block 4 is back to chemical arithmetic with some volumetric analysis; some have done titrations before, but others have not. Experiments are usually

(8) Estimate concentration of HCl by use of borax.
(9) Some other acid/alkali titration (varies yearly).
(10) Estimate percentage of magnesium carbonate by back titration.

During this block I usually contrive to run over the principal bond types, ionic and covalent, and make a start on chemical electronics. I try, during this, to introduce the idea of shapes of molecules by electron-repulsion theory and also the idea of resonance. It will be seen that I have not at this stage touched orbitals, nor do I intend to; a knowledge of chemistry must precede its theory.

Block 5 takes us into Organic Chemistry. Reactions we usually do are

(11) Preparation and properties of ethyne.
(12) Simple preparation of an ester.

(13,14) Hydrolysis of ethyl benzoate: this occupies two double periods because I include in this the determination of melting points, iodoform test, and so on.
(15) Oxidation of propanol to propanal; reactions of aldehydes and ketones.
(16) An aromatic nitration.

Here I usually demonstrate the catalytic effect of a pinch of iron filings on a solution of bromine in benzene, and talk about aromatic compounds in general. I will also by this time have demonstrated polarised light and optical activity and have dealt with geometrical isomerism. I use the idea of resonance here in dealing with benzene. I don't at this stage reduce nitrobenzene to aniline, but I talk about the general importance of aniline, and we do:

(17) Diazotisation and three simple reactions, including a coupling.
(18) Preparation of acetanilide.
This gives me an opportunity to introduce, as useful compounds, acid chlorides and acid anhydrides. I can also link up with the peptide bond, and so into polymers. At some stage now will come
(19) Depolymerisation and repolymerisation of perspex.
Also in this general area will be
(20) An experiment on aspirin.
This involves the hydrolysis of aspirin leading to some work on phenols, ferric chloride colours, and such like, and we usually do
(21) Benzamide from benzoyl chloride and ammonia.

By now we need a change; I try to do a bit here about the theory of organic reactions. I know that some would say that I should do this right from the start, but with my very mixed ability classes I find it preferable to bulk it together now; free radical substitution and ionic addition, acidity of phenol and a simple introduction to Markownikoff and direction of aromatic substitution. Experiments round here might include

(22) Preparation of bromoethane (and the reactions of alkyl halides).

At this stage we are into the summer term, and we go back to kinetic theory for Block 6 and so to Raoult's law. If I feel strong enough I usually do a Raoult experiment (R.M.M. [Relative Molecular Mass] of naphthol in ether) as a demonstration, but I usually get on quickly to other colligative properties.

(23) Relative molecular mass of urea and sodium chloride (apparent!) by boiling point elevation.
(24) R.M.M. of acetanilide by f.p. depression.
(25) Eutectic curve between naphthalene and I-naphthol. (I know that eutectics are not "on the course", but it gives a bit of practice and quite a lot can be learnt from it; it has bearings on geology and alloys too.)

Depending on how time is going we normally do about now:

(26) R.M.M. of chloroform by Victor Meyer; this is usually enjoyed because of the ingenuity it allows in setting up.
(27) Silver nitrate titrations.

The time has now come for a bit more theory; we are just about at the end of the first year, and it fits in nicely with my Physics course to get on to spectra. As far as Chemistry is concerned, I like to show spectra of helium (to see the lines) and hydrogen (it is astonishing how many people have never seen this, and actually believe it to be a pure line spectrum!), and a few other things. There are not many experiments strictly relevant, so I usually interlock Block 7 (Spectra) with Block 8 Redox, where there are lots more experiments than theory. So while I move into energy levels, Schrödinger, and orbitals, they get on with some titrations:

(28) Iron(II) with permanganate
(29) Iron(III) with $KMnO_4$ after reduction with zinc amalgam
(30) Oxalate with $KMnO_4$

(31) Hydrogen peroxide with $KMnO_4$
I know that iodine titrations are not on the course, but they are so beautiful we usually do some, say:
(32) Iodine with thiosulphate
(33) Chlorine in Parazone.
(34) Concentration of bench potassium dichromate, via iodine and thiosulphate.

The time has come for more energetics, so back we go to thermochemistry, and on to bond energies. A few more experiments slot in here in Block 9.

(35) Enthalpy of reaction of sulphuric acid with water.
(36) Enthalpy of bromination of cyclohexene, and bond energy of C-Br bond.
(37) Enthalpy of solution of potassium iodide, and lattice energy.
I normally use a double period at about this time to
(37a) Estimate ionisation energies of argon, helium and xenon, and perhaps another one to
(37b) Investigate the polarity of molecules, by plastic rods and also by relative permittivity of solutions. This includes positional isomerism in benzene, and in dichloroethenes. True, in these I do most of the work but there is a fair amount of pupil involvement in taking measurements.
For Block 10 we go to reaction rates and effects on them. Experiments include
(38) Effect of concentration on rate (usually based on an “iodine clock” reaction).
(39) Effect of temperature on rate (usually oxalate and permanganate). For the brighter members we go on to calculate from this the value of the activation energy using simplified arithmetic to help with the exponentials.
This naturally is leading to Block 11, Equilibrium.
(40) Estimate the equilibrium constant between ethanol, ethyl ethanoate, ethanoic acid, and water.
This leads inevitably to Block 12, Acidity and pH.
(41) Find how pH varies during the titration of hydrochloric and ethanoic acid with NaOH.
(42) Set up a range of buffers and observe the colours of some indicators as a function of pH.
(43) Estimate pKa for benzoic or formic acids by half-neutralisation with bromophenol blue as indicator, and find pKIn.
(44) Compare the enthalpy of neutralisation of the strong sulphamic acid with that of the weak benzoic acid. This, as we do it, is actually such a crude experiment that we can learn a lot from discussion of its sheer approximations! Around now I usually get out the pH meter and demonstrate its use, say in doing a titration curve for phosphoric acid; one can also identify which is cis and which trans in maleic and fumaric acids if it is a bright class.

If I haven’t done it before, we have Block 13 on Radioactivity; I show the properties of the radiations with a Geiger counter and we talk about tracers, but we tend to do more of this in Physics. Also somewhere we slot in Block 14 on electrolysis. I would show Hofmann’s voltameter and use it to find the value of the Faraday, and they would do the following:

(45) Find the number of coulombs needed to deposit one gram of copper.
But we do not always do these; it depends on what was done in Form IV and also what is done in Physics. Usually I include
(46) An ion-exchange titration; estimate the concentration of a copper sulphate solution.
By now time is running out; the “mock” is looming up, but it is time for a crack at revision organic chemistry. While they are brushing up on this, we collect all the retort stands in sight and get set up to
(47-49) Reduce nitrobenzene to aniline.
Actually this takes three double periods; in the first we get the reduction done, in the second we do the steam distillation and ether extraction, and in the third we distil off the ether etc. We also

frequently have
(50) Hofmann's degradation (production of methylamine).
So that about completes the course. Naturally one cannot do the same every year; half-holidays, exams, etc. intervene, and some-times you like to try a new experiment or bury an old one. It is also useful to have a few "spare experiments" in hand, such as
(51) Reduction of a ketone with lithium tetrahydroborate (which is useful to introduce metallic hydrides).
(52) Estimate lead by gravimetry via lead chromate.
(53) How much magnesium hydroxide is there in a 'Milk of Magnesia' tablet?
(54) Find the equilibrium constant for the reaction between iron (III) and thiocyanate by colorimetry (or use colorimetry to estimate iron).
(55) Analysis of anions (qualitative)

There is really no shortage of experimental work available!

Postscript

However, I admit that the provision of practical work does involve teachers in preparing the apparatus outside class time; it also involves getting washing up done (but a pupil will often do this by arrangement). It means that supplies must be got in, and grants arranged, but in my experience the Government grants are adequate, taken from year to year. Personally I would find it very unsatisfactory not to have students doing practical work, and not to be able to do lots of demonstrations myself. I hope that this article may help younger teachers to do more in this direction, knowing that it is possible.

How much of the above will survive the onslaughts of the syllabus revisers remains to be seen; but I would hope to be able to retain most of it, and it would certainly by my intention to have once again at least fifty experiments to illuminate the course.

From the Editor

The list of experiments above is very impressive and I'm sure we'd all agree that Dr.Somerfield's pupils are lucky to have such a gifted teacher. Teachers who have attended past Teachers Refresher Courses (1980 for example) will have seen Dr.Somerfield in action and will have appreciated his simple and elegant demonstrations. The results obtained by Dr.Somerfield's pupils don't appear to suffer by doing so much practical work: indeed, I'm sure their chemical knowledge, understanding and skills are impressive. But many pupils in Irish schools today do no practical work at all in 5th and 6th year, and this should be of major concern to all involved in chemistry teaching. A variation from one school to another of zero to over 50 practicals is certainly not ideal. The new chemistry syllabus us expected to give more emphasis to practical work and provide more guidelines to teachers on suitable experiments. Unfortunately, this will not ensure that all chemistry students do an adequate amount of practical, or even any practical work at all. I know that many teachers do value practical work and include as much as they can in their teaching. I hope that "Chemistry in Action" will encourage others to take up the gauntlet, and give them ideas and help in doing practical work in chemistry. I would also urge other experienced teachers, like Dr.Somerfield, to share their hard-won knowledge with other teachers. Randal Henly's book "Practical Chemistry for Today" (with the associated "Teacher's Guide") gives details of over 80 experiments and advice to the teacher. If you want some ideas for experiments that can be done, get hold of a copy today.

"Sure, we do lots of 'experiments' from the book - but we never actually DO any experiments."

"No bubble is so iridescent or floats longer than that blown by the successful teacher."
Sir William Osler

<u>MOLAR VOLUMES:</u> the molar volume of a substance is the volume occupied by 1 mole of the substance i.e. an Avogadro number of molecules. This volume changes from element to element and from substance to substance, although each contains the same number of particles (atoms, ions, molecules) as the mass and size of the particles changes. It is quite a good idea when teaching about the mole to illustrate it, not only by doing problems, but by showing pupils or better letting them weigh out moles of different substances, and having them labelled in bottles as a display e.g. 1 mole of calcium carbonate (100g); 1 mole of sodium hydroxide (40g); 1 mole of iodine (127g); 1 mole of methanol (32g); 1 mole of water (18g); 1 mole of gas (see above for a model of 1 mole of gas) etc. The display can be as large as you like using substances that the pupils have already come across and is easily made up using a top-pan balance. The rich variety of states of matter, texture, colour and amount have only one thing in common – the number of particles, the number of moles.

<u>NO PRETENCE!</u>
"…there can be no pretence about teaching and learning. In the acquisition of scientific information, for example, the teacher may set up an 'experiment' in which the pupil has to 'find out' what a result will be.
Now part of such experiments may be the acquisition of skills and so far they are legitimate. But very often there is a profound bogusness about them, if the pretence is that the outcome is unknown. Indeed, if the outcome is not what is expected, the 'experiment' is usually by-passed and recourse has to be made to the textbook instead."
Mary Warnock
TES 19/12/80

CHEMISTRY IN ACTION: some aluminium chemistry

A diver heater's tale

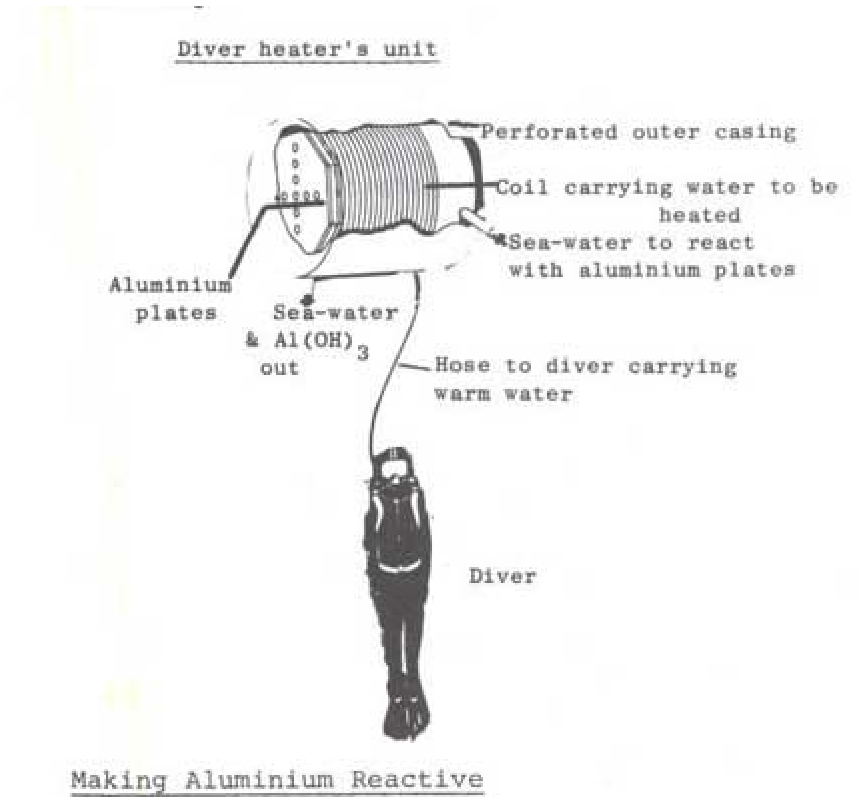
Aluminium has an electrode potential of –1·6V but is stable in air and water due to a surface oxide film which prevents corrosion. It should react vigorously with water to produce hydrogen according to its electrode potential. The surface oxide layer can be broken down by amalgamating with mercury, which prevents the formation of an oxide layer. The reaction with water is then vigorous and generates hydrogen and heat (it is an exothermic reaction).

$Al(s) + 3H_2O(l) \longrightarrow Al(OH)_3(s) + 3/2\ H_2(g)$

$\Delta H^{\theta} = -418 kJ\ mol^{-1}$

The rate of reaction is limited by the diffusion of aluminium through the mercury layer, and doubles for a 30º rise in temperature. The aluminium going into solution at the pH of tap-water or sea-water produces aluminium hydroxide, while the mercury remains inert. The reaction can run out of control unless the heat is removed. This reaction has been used to generate steam for a turbine to drive a torpedo. It has also been proposed by scientists at the B.P. Research Centre in England as a source of heat for deepsea divers. Sea-water is pumped over amalgamated aluminium plates and a heat exchanger circulates hot water at a constant temperature down an umbilical pipe to heat the diver's suit. Controlling the water flow over the plates controls the heat output, and aluminium hydroxide sludge is rejected. Good heat exchange between the coil and the reacting aluminium plates is helped by the stirring effect of the hydrogen bubbles. No doubt the hydrogen could also be collected and used as a fuel. This is an interesting and elegant application of chemistry to solve a practical problem, and the principle involved can easily be demonstrated in the laboratory.

Diag, p.5 Diver heater's unit



Making Aluminium Reactive

Place some aluminium foil in a test-tube or petri dish and cover with a dilute aqueous solution of mercury (II) chloride for a few minutes. (CAUTION: mercury compounds are very poisonous) The less reactive mercury is displaced from solution by the aluminium, and is deposited on the surface of the metal forming an amalgam layer. Wash with distilled water. Leave half the foil in air and observe it carefully. Does it get warm?

Notice the growth of aluminium hydroxide on the surface. Place the other half of the foil in distilled water or tap-water and observe what happens. Compare its behaviour with that of a piece of untreated foil. Try the action of dilute acid on the treated and untreated foils.

NOTE: It is interesting that in this case an amalgam increases the reactivity of a metal by destroying the protective surface layer. Amalgamation is also used with the alkali metals to reduce their reactivity e.g. in sodium amalgam, by diluting the reactive metal with an inert solvent (mercury). A sodium amalgam electrode can be made in this way and used in aqueous solutions.

An amalgam is an alloy containing mercury as one compound. Mercury amalgam with tin and silver is still used for filling teeth, and with tin for coating mirrors.

DEMONSTRATING VAPOUR PRESSURE

A simple, highly visible way of demonstrating and doing experiments on vapour pressure is described below. It is based on an idea by H.J.Thompson, published in “Tested Demonstrations in Chemistry”, A.C.S. 1965, p.145.

Materials:	Glass tube about 100cm long, fitted with a rubber septum cap at one end. (Alternatively: 50mL burette, fitted with a drying tube, see diagram.) Small plastic syringe fitted with a narrow needle Water Large beaker or small bowl Diethyl ether Meter ruler
Method:	Fill the glass tube with water, having sealed one end with the rubber septum cap. This seals the end but allows liquid or gas to be injected into the tube, and seals itself afterwards. Invert the tube under the water level in a beaker or small bowl, and clamp vertically. Fill the syringe with air (about 10mL), and inject the air into the top of the glass tube. You should now have an air space above the water level, saturated with water vapour. Measure the height of the water level above the water level in the beaker (h1).
N.B. using warm water makes this demo more dramatic	Measure the temperature of the water in the tube. Draw up about 1mL of diethyl ether into the syringe, being careful to trap no air. Insert the needle of the syringe through the rubber cap, ask the class to watch carefully, and then inject the ether. The liquid level in the tube should shoot down, depending on the temperature of the water, as the more volatile ether evaporates and exerts its vapour pressure in the air space. When the liquid level has become steady, record the height above the outside water level (h2). If there isn’t a small layer of ether sitting on top of the water, you will need to inject a little more ether. The vapour pressure exerted does not depend on the amount of liquid ether present – this can be demonstrated by adding more ether. This demonstration is very dramatic as injecting 1mL of a liquid makes the water level go down many cm. The difference in heights before and after adding the ether (h1 – h2) gives the pressure exerted by the ether i.e. its vapour pressure.

Effect of temperature on vapour pressure

Vapour pressure of a liquid depends exponentially on the absolute temperature. The increase of vapour pressure with temperature can be shown dramatically using the apparatus above. Warm the tube near the ether layer using your hand or a cloth soaked in hot water. The water level is pushed down showing an increase in vapour pressure. There will also be a contribution from the water but this will be small compared with the effect of the ether.

"There is no doubt that even rather simple ideas sometimes are very elusive."
Linus Pauling

Personal View
The decline of Chemistry
Dr.Eric Martin, Waterford R.T.C.

Summary

It seems that few students entering science courses in Waterford Regional Technical College (WRTC) want to study chemistry. We have tried to find reasons for this comparative lack of interest and have attempted to improve the situation in our region.

The Problem

In common with most RTC's, Waterford offers two technician courses which have a common first year. One of the courses leads to a biology qualification, the other to a qualification in applied chemistry. When we interview students for places on the course we always ask which option they will choose in order to give some guide for future planning. Their preferences don't influence selection procedures, nor are they binding on the students should they later change their minds. There has always been a greater number who are interested in biology; usually we accept this as a fact of life, but in September 1979 less than 10% of prospective students showed an interest in chemistry. Even when we allowed for some students changing their minds when they'd had more exposure to chemistry we were very worried as it seemed to show that the imbalance was getting worse.

Cause of the Problem

We decided to try and find the causes of this lack of interest in chemistry, and to attempt to generate interest if at all possible.

We tried three approaches to find the cause by:
1. Studying Department of Education statistics on L.C. results.
2. Speaking to teachers in the region.
3. Interviewing the September 1980 intake of students.

Statistical Figures

The statistics issued by the Department of Education for LC results between 1976 and 1979 showed that the numbers taking biology increased from 39% to 51%, this growth was largely caused by an increase in the percentage of girls taking LC took chemistry and this figure was more or less constant over the years.

The statistics also showed that the proportion of students taking the honours paper in chemistry increased slightly, whilst the corresponding proportion for biology showed a significant decrease.

We could see from these figures that while chemistry was not actually getting less popular it had not caught the interest of schools and students as biology had.

We could also see that as the intake to LC biology got larger, the overall standard of the entrants had fallen while chemistry was being taken by (or maybe offered to?) mainly the stronger students, as nearly 70% took the honours paper. Many of these students would enter universities rather than RTC's. Even so, it was clear that the numbers taking chemistry should not have declined as much as they had. Based on LC entry we should have expected a 3:1 preference for biology rather than 10:1 found. It seemed certain that students who took both chemistry and biology were more interested in biology. We were therefore keen to find out why students preferred biology. (Now that these students have reached second year it is interesting to note that the biologist : chemist ratio is close to 3:1 with a few students still undecided. Perhaps exposure to practical chemistry has converted some of them).

Views of Teachers and Students

Students said that they found biology easier and more attractive than chemistry. Chemistry, even in this day and age, was regarded as a subject for boys. When it was grouped with other subjects such as business studies it too often ended up as a second choice.

Teachers confirmed these views and added that many people found biology more relevant to their chosen careers (nursing, for example), more relevant to everyday life. This point about relevance was underlined by one teacher in Waterford City who saw the physics class grow to about four times its normal size because of a growing interest in microcomputers and the belief that it is necessary to have physics to take up a career in this area.

Many teachers and students thought that it is easier to do well and amass points by doing biology. Mathematics in chemistry was a frequently mentioned deterrent. For many teachers the LC syllabus in chemistry was a bête noire with its emphasis too firmly on recall of information rather than application, and comprehension.

So we were forced to conclude that students just don’t see the importance of chemistry in Ireland today, and that the excitement of the subject was not getting across. Teacher wanted to do more practicals but didn’t feel it was possible with the pressure of trying to cover a syllabus. Some of them put forward the idea that there should be practical examinations to ensure that some practical work should be done, but generally it was felt that practical examinations are not a good idea educationally. Certainly we at WRTC would be happy to see them disappear from our assessment schemes, but that’s another story!

So, to summarise, we’ve got to put the ooh! and the ah! back into chemistry at all levels and try to make it more relevant.

What can we do?

We’ve tried to stimulate interest in our region in two ways, so far. We organised a seminar and lecture for local teachers in March 1980 and it was at this meeting that we heard their views, outlined above. Later, after a three course meal prepared by the College chef, we were all in a very receptive mood when Dr Roy Brown of TCD showed us some demonstrations suitable for LC chemistry.

In April 1980, Dr Pat Duggan of WRTC organised a seminar for LC students and their teachers on general theme of chemistry in Ireland. About 250 pupils and teachers attended. The speakers were, in order of appearance: Dr Barry Harrington of the IIRS (information division) who spoke on ‘Career Opportunities in Chemistry in the 80’s’; Dr Pat Shannon from the Petroleum Affairs Division of the Department of Energy who gave a talk entitled ‘Offshore Oil Exploration and Development’; Mr Ed Storey of the Shannon Water Laboratory, IIRS, who talked about ‘Chemistry and the Environment’; and Dr Ray O’Donnell, Head of Quality Control and Planning, Merck Sharp and Dohme (Irl.) Ltd. on ‘Chemical Technology and the Chemical Industry’.

An open forum concluded the Seminar and it is a measure of the success of the event that many pertinent (and some impertinent) questions were asked.

We think the experiment worked and we will be organising such seminars every year under the umbrella title ‘Chemistry Tomorrow’ (corresponding of course to ‘Biology Today’). Future seminars will examine more selective aspects of the subject.

We’re also hoping to organise an annual lecture series for intermediate certificate students (getting them before they choose LC subjects!) to attempt to interest them in chemistry. We are always looking for ways to assist teachers and would welcome suggestions from anyone interested.

How can we make Chemistry courses more attractive?

Sr Kathleen Kennedy, St.Leo's, Convent of Mercy, Carlow

In order for a subject to earn a place in the school curriculum it must be relevant. To illustrate this point we have only to examine the situation in our country over the past ten years. Latin which was once required for entry into many faculties is no longer necessary and consequently the number of pupils studying this subject to Leaving Cert. level has fallen from 8292 in 1970 to 2200 in 1978. On the other hand French and German have risen during this period – French from 7567 in 1970 to 20,890 in 1978. This is probably due to our entry into the E.E.C. and a greater interest in travel. There is a growing need for pupils to study Science subjects to meet the requirements of today's and tomorrow's society. To attract and encourage young people to follow this course of studies we must stand back and take a critical look at ourselves to see what positive steps we as teachers must take.

The teaching of any subject – and here I deal specifically with Chemistry – depends on a combination of many factors. Among these I would like to single out: Syllabus content and its relevance to our environment; practical work; and the presentation and enthusiasm of the teacher. Much of what is in our present course should, and must remain. What I would like to see introduced are those topics which relate to everyday life. We are basically an agricultural country but still we do not include the study of fertilisers, food processing, pesticides, pollutants and their control. These topics could be inserted without some others being removed, alternatively two of these topics might be selected from the group at the teacher's choice as options. We still spend much valuable time finding relative molecular mass from boiling point and freezing point relationships. Of what practical use is this and will our students ever need them again? Is it really necessary to spend so much energy memorising the proportions of the ingredients in many organic compounds e.g. Phenol, Aniline? The good housewife always has a cookery book at hand, why not the chemist?

So much for content, but what about the practical work? It is here that the conscientious teacher can show his or her true self. It is true you can teach with using only chalk-and-talk, but I feel that the number of pupils wishing to follow a chemistry course under such conditions will dwindle. When the good Lord created us, he gave us five senses and if we are told that he who sings prays twice, then he who does practical work learns at least four times over – he sees, hears, smells and touches (but be careful of tasting!) Apart from the enhanced learning, he enjoys his work much more and what we do in a pleasant situation is much easier recalled. Even very weak students can remember what they have seen and prepared themselves. Practical work does demand organisation and careful preparation. We must plan our work and see that the chemicals and apparatus are available and in working order. This is not as difficult as it seems and when the laboratory is properly arranged. The presses should be numbered and the apparatus in each press, listed and posted in a prominent place. Then pupils and teachers have little difficulty. The first few experiments are the hardest for the young teacher but you soon gain confidence and the sense of satisfaction that you get from seeing the students enjoying their work and their ability to recall what they did, makes all your efforts very worthwhile. I generally give part of the previous class preparing for the practical and it is surprising how efficient the pupils become in assembling the apparatus. There is an abundance of practicals suitable for Inter-Cert. chemistry, though not all topics on the Leaving Cert. course can be dealt with in such a practical manner. Here I mention atomic structure, bonding, hybridisation, molecular shapes and crystal structure. The use of models is invaluable here and lots of inexpensive materials can be used so that each person makes his own models. Useful materials are balloons, pipe cleaners and drinking straws, plasticine and matches etc. Film-strips are also available to cover some topics and all schools have slide projectors. There are also some television programmes and if your school has a video-recorder these programmes can be taped for use at a more appropriate time.

The attitude of the teacher I also find very important. Given that the syllabus is reasonable and the school facilities (laboratory and audio-visual equipment) are fairly satisfactory, then the final output must rest with the teacher. Personally I find it important to be a member of the I.S.T.A. and to attend the meetings at the local branch. Here the sharing of ideas, the exchanging of tips and the listening ear are most supportive and encouraging. The need too to attend refresher courses is of the utmost importance. The A.G.M. each year gives teachers an opportunity to see what is available from the point of view of apparatus and books. This is the only time that we get a chance to see equipment as none of the suppliers have display-rooms as far as I know. Of course there is always the social side to the A.G.M. which is most enjoyable. The inspectors too move freely among the teachers during this week-end and are entirely helpful and approachable.

As I have already indicated my purpose in writing this is to see how we can make the teaching of chemistry more attractive. I could take a very negative approach and criticise the syllabus and the school facilities but I feel that would not serve any purpose. No one has ideal conditions to work in but we can all make the best of what we have and try to improve them. We should avail of local meetings, courses and department grants. A lot depends on the attitude of the teacher if she/he is going to take the easy way out and not bother until the last minute then teaching will be drab and uninteresting. If on the other hand work is planned and organised then chemistry classes will be exciting and interesting. Someone has said “You get out of life what you put into it” – how true in this instance also.

How To Do It: 1
Boring holes in rubber stoppers

One of the major causes of serious accidents in the chemistry/science laboratory is the incorrect insertion or removal of glass tubing (taps, tap-funnels, thermometers) in stoppers. This is particularly true of rubber stoppers. Forcing the glass into the stopper often results in breaking the glass which plunges into the hands. The recommended method does NOT work well in practice in inexperienced hands: lubricating the glass with glycerol, soap etc., and screwing into the stopper, holding the glass near the stopper in a cloth. It does work often but not always. There is, however, a safe and fairly foolproof method that works well almost invariably and this is described below. Practise this method and use it whenever you have to insert or remove glass in any form into or from stoppers. It will reduce nasty accidents and breakages (especially of thermometers which are expensive and release mercury into the laboratory). It will also give you more confidence in making up apparatus. The lack of confidence and gear at doing this simple job may well prevent many teachers from doing practical work which involves assembling glass apparatus with stoppers.

What you need: set of cork borers (at least up to size 6)
cork or rubber stoppers
cloth
glycerol etc. as a lubricant for the borers
glass tubing, thermometers etc.

Make sure you keep your cork borers sharp – you can buy a simple sharpener for this. A blunt borer will not cut cleanly or easily.
Rubber stoppers are preferable to corks for gas-tight seals.

N.B. The use of Quick-fit type all-glass apparatus with ground glass joints is recommended as a replacment for the old glass and stopper apparatus, and avoids the need to bore stoppers and insert glass.

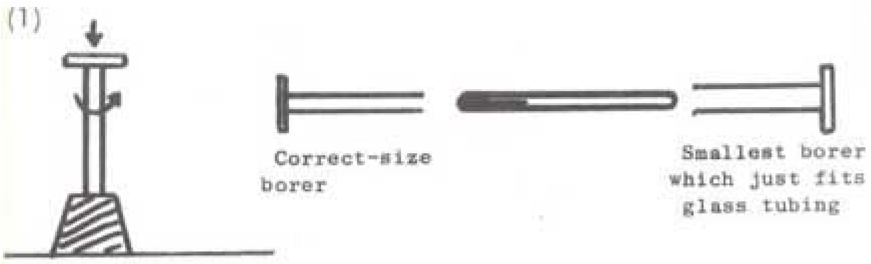
A safe method of inserting glass tubing, thermometers, taps etc. through rubber stoppers, corks etc.

When boring holes in corks use a borer one size smaller than the tubing, and for rubber one size larger. Rubber stoppers are very hard to bore, even with a boring machine, and it is better to buy ready-made one-hole or two-hole stoppers.

When boring holes place the stopper on a hard surface (1), NOT in the palm of your hand, and twist the borer into the stopper. Hold the stopper steady with one hand and keep the borer vertical. When the borer is nearly through (note the bulge on the bottom side) – stop, remove the borer and finish cutting the hole from the other side. Otherwise the borer may break through and with cork pieces may break off.

Lubricate borers with a little glycerol (glycerine), detergent, soap etc. before inserting into holes or starting to bore.

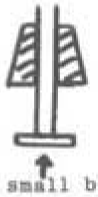
(1)



Boring the hole

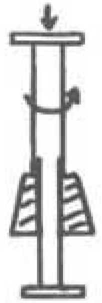
Now remove the borer and clean it out. Re-insert from the top-side (2).

(2)



Insert small borer from top-side

(3)



Insert large borer from bottom side over small borer

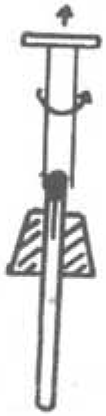
Choose a larger size of borer which the glass tubing, thermometer just slides inside. Lubricate the borer and insert over the first borer, with a twisting motion, until the large borer has passed through the stopper, freeing the small borer (3).

Withdraw the small borer and insert the glass tube/tap/thermometer from the top-side to the correct depth (4).

(4)

Insert glass tubing into large borer from top-side

(5)



Remove large borer from bottom-side (to remove glass reverse this process)

Now withdraw the borer from the bottom-side thus leaving the glass tubing firmly held in the stopper (5). Hold the glass firmly while removing the borer, holding the stopper and glass in one hand (left) while withdrawing the borer with the other hand (right) with a twisting motion.

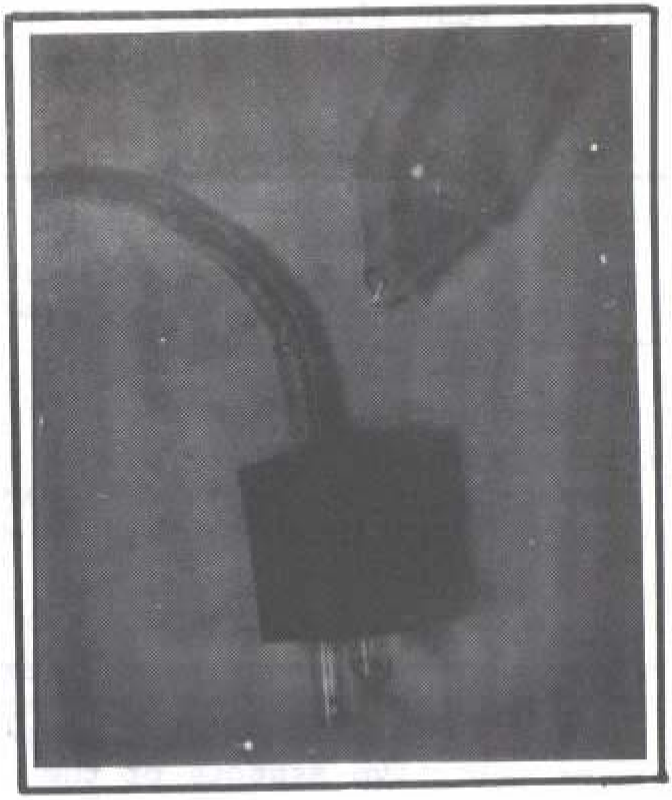
Removing glass tubing etc. from a stopper

Choose a borer just large enough to slide over the glass tubing and lubricate it. Repeat step (5) above in reverse: screw the borer over the glass tubing from the bottom side until it is free, and then remove the glass tubing. Finally remove the borer. This method works even with old rubber stoppers since the borer cuts the rubber away from the glass, even though it is usually stuck on. Other methods e.g. cutting the stopper, are much less reliable and are more dangerous.

The method described above works perfectly – almost like magic and I found it to be new to many teachers, although it is a well established method. Once you have practised it you will find it is also quick and quite easy.

HOW NOT TO DO IT!

The photo here shows a broken tap-funnel which was NOT properly inserted into a rubber stopper and which produced a nasty cut requiring 6 stitches. The method used was the 'classical' method of lubricating the glass and inserting with a screwing motion, and a cloth was used. Take the warning!



"Arts and sciences are not cast in a mould but are formed and perfected by degrees, by often handling and polishing."
Michel de Montaigne

SAFETY

RESTRICTED CHEMICALS

This article is reprinted from the April 1980 issue of Education in Science, pages 19 to 26, by kind permission of The Association for Science Education. The introduction has been shortened slightly, and a small number of corrections supplied by the general Secretary of the Association have been incorporated. Readers should note that systematic names are used more consistently than in North America: acetic acid is found under ethanoic acid, for example, and hypochlorites are listed under chlorates (I). The statutory restrictions refer to the United Kingdom only.

INTRODUCTION

Many Education Authorities have their own lists of prohibited and restricted chemicals. Differences in these have already led to some difficulties, e.g., in practical examinations, and could in the event of an accident be used to weaken the defence or question the competence of the Authority involved to prepare or implement an adequate safety policy. In drawing up the following list of recommendations the Working Party convened by the Association for Science Education to examine safety in schools has sought the views of many science advisers, teachers and chemical suppliers. The “distillation” of their experience has been used to prepare what is intended as a guide to good practice rather than as a set of hard and fast rules. It must be emphasised that these matters are only recommendations. Each Education Authority should prepare its own advice and guidance, and it is hoped that these recommendations will assist with this task.

The categories of restriction suggested below are based on the likely experience of pupils at a particular stage in their school career. However, it must be remembered that teachers know best the capabilities of their pupils, and also that the science teacher, (graduate, specialist?) must be allowed to exercise a certain amount of professional judgement in choice and use of materials. Thus, a teacher with sufficient expertise who is working in a school with adequate facilities for safely handling certain hazardous chemicals, possibly even some of those listed below as being “not recommended” for school use, should perhaps be permitted to use them for special cases e.g. sixth form project work. Clearly in such a case, his employer will have to be satisfied that such substances can be safely handled. It must be further pointed out that teachers have a duty under the Health and Safety at Work Act to comply with any safety instructions given them by their employer and there may be science teachers in some areas who find that their Authority has banned a certain chemical which may have been shown as suitable for restricted use on the list following. In such cases, the teachers have a legal duty to follow their employer’s instructions; having complied with such instructions, they may then find out why the chemical is banned, and if they consider the reason inadequate, they may ask to have the ban lifted.

The Working Party has endeavoured to balance the educational value obtained by using a particular chemical against the risk presented. One course of action is to recommend the exclusion from school of only a relatively small number of the more hazardous substances hitherto found in schools and to provide teachers with information relating to the hazards of the remaining materials, thus enabling them to handle those materials in a professional manner. Unless the use of each chemical is visualised it is impossible for anyone to place on it a user restriction or a use restriction which is valid rather than one which is administratively convenient.

In some cases it has been possible to suggest alternatives for particular uses of certain chemicals, e.g. methylbenzene can be used as a suitable alternative to benzene as a solvent. Similarly benzene (liquid at room temperature) and naphthalene (solid) can be replaced respectively in change of state experiments by cyclohexane and the higher alcohols and acids. However to show the properties of a particular substance there is often no alternative to using the substance itself and if unfortunately that substance is judged to be too hazardous then the educational objectives will clearly have to be sought by other means.

The absence of a chemical from this list cannot be used to imply anything about it. The list simply covers those chemicals which have been found in schools, and which present sufficient risk to have been noted by Education Authorities and by members of the Working Party. As new information relating to hazards becomes available it will be necessary to add or subtract from the restrictions. For example, a few years ago it was common to see pupils preparing N-nitrosamines in open test-tubes. Syllabuses do change and this often results in new materials being used and often in some hitherto well used chemicals being left unused on shelves.

The labels on the containers of most chemicals recently purchased will probably carry limited information as to the hazards and the precautions for handling. Suppliers and manufacturers are willing to provide information but teachers may wish to have at hand a reference book. A number of these have been included in the Safety Bibliography published in the September 1979 issue of Education in Science.

Many chemicals present an intrinsic hazard in being toxic, highly flammable, explosive or corrosive. Others are unstable in storage e.g., potassium which forms unstable peroxides on prolonged storage, or react unfavourably with ubiquitous materials such as air, moisture, wood etc. e.g., chloric(VII) acid. For some substances it is the experimental method employed and/or their incompatibility with other chemicals which give rise to the hazard e.g., propane-1,2,3,-triol (glycerol) is not regarded as an intrinsically hazardous substance but it will react vigorously if mixed with potassium manganate(VII).

The categories of restriction are listed below as 1-7.

1. Chemicals to be excluded from Schools X

These should not be stored nor should they be isolated in a preparation. These are:

> (i) a small number which have been prohibited by statutory instrument including naphthalene-2-amine (2- or beta-naphthylamine), biphenyl-4,4’-diamine (benzidine), 4-amino-biphenyl, 4-nitrobiphenyl and their salts.
> (ii) others which in the opinion of the Working Party give rise to such a degree of hazard that their use in schools cannot be justified.

2. Chemicals not recommended to be normally held or stored N

These pose a high degree of risk and most syllabuses will not require them, but they may be needed for sixth year projects and options. E.g., some analytical procedures likely to be used in environmental studies need the use of small amounts of potassium cyanide as a masking agent. It is felt that exceptions can be made in such special cases provided that –

> (i) schools have adequate facilities to handle such materials, i.e., secure storage, fume cupboards, ventilation, etc. and are equipped for A level or Sixth Year Studies Work.
> (ii) Teachers and pupils have the appropriate information and experience.
> (iii) Employers may insist that teachers seek advice from them before making such decisions. In cases of doubt teachers should seek advice from their employers.

*These two classes are underlined . This version was reprinted from Chem13News, Nov.1980.

3. Chemicals restricted to small quantity for observation or exhibition only E

Many wish to store small samples of materials for observation purposes only. These should be kept securely and it should be borne in mind that the forbidden status of such chemicals makes them more attractive to some pupils.

4. Chemicals restricted to small quantities – in storage R

It is difficult to give a recommended maximum value for the amount to be stored owing to the differences in syllabuses and the courses followed and in the local geography of the school. Some schools are on more than one site and others have laboratories which are widely separated within the one building. The dangers involved in transporting commonly used chemicals would be greater than those involved in storing twice the amount divided between the two sites.

However, if it is found that most of the stock is consumed in the course of a year or of a term, then that amount should not be exceeded.

5. Chemicals restricted to certain users

(a) Teachers only T
(b) Senior pupils, i.e., post ‘O’ grade and post ‘O’Level S
(c) ‘O’ Grade, ‘O’Level or CSE and above (meaning the
last two/three years of these and similar courses). O
(d) Years 1 and 2 of secondary school (11/12 years upwards)
with close teacher supervision. t

All practical work to be carried out by pupils should in the first instance be supervised, in the sense that experimental details in texts and investigation sheets be checked and if necessary modified to suit the experience of the pupils and the facilities available. (During the use of some chemicals by certain users closer supervision is required, to these the suffix “t” has been added. For example see bromine element.)

A number of chemicals which are not required by the syllabuses of some Examination Boards until after ‘O’ Grade or ‘O’ Level are required by others at an earlier stage. The designation of user category made on this list (i.e., O or Ot or S) has been decided on the basis of the hazards involved and on the likely experience and ability of pupils at a particular stage rather than on the demands of individual syllabuses.

6. Chemicals restricted to use in special circumstances only F

E.g., for use in fume cupboards

Again it will be necessary to exercise discretion; e.g., it would be no less safe to use lead (II) bromide or its solution outside of a fume cupboard than inside one, but if the salt were molten in order to electrolyse it then a fume cupboard is required. Though not ideal many substances can be safely handled in a well ventilated open laboratory, provided that the scale of operation is small, e.g., up to 5 cm3 of propanone. If a larger scale is used with open vessels then the use of a fume cupboard is recommended. (F)

7 Chemicals with a short safe shelf-life L

These should only be purchased in small quantities and replaced by new stock at regular intervals, preferably not more than a year in most cases. Date stamping of new stock is recommended. Many chemicals are available in several portions of small quantities, e.g., phosphorus(v) oxide can be purchased in 4 x 25g sealed containers and each upon opening can be used up within a short period of time. Purchased in this way the cost per gam is usually high, but on the other hand any initial saving, resulting from the purchase of one single large amount, is lost if disposal proves necessary. A visual check should be kept on such materials, and those in unopened sealed containers may be kept for longer periods. Such substances have been marked with an L.

Finally, the Working Party would welcome suggestions from science teachers as to other chemicals which might be included in this list, and for safer alternatives to any of the restricted chemicals.

SUMMARY OF KEY

X excluded from school laboratories (1)
N not recommended (2)
E exhibition sample only (3)
R restrict inventory (4)
T teacher use only (5)
S also used by senior pupils (5)
O also used by pupils on ‘O’ Grade,
‘O’ Level or CSE and similar courses. (5)
t can with close teacher supervision be
used by years one and two of secondary
school (The suffix t following on a user
restriction implies that more direct
supervision may be advisable.) (5)
F to be used in fume cupboard (6)
(F) to be used in fume cupboard if in open
vessels on a scale other than small (6)
L short safe shelf-life (7)

Numbers in brackets refer to paragraphs in the Introduction.

NAME	RESTRICTION
Acetonitrile (methyl cyanide)	R, S, F
Aerosol sprays	R, Ot, F
Alcohols other than ethanol	R, O, (F)
Aldehydes other than methanal	R, O, (F)
Alkyl halides	R, Ot, (F)
All unlabelled bottles which contain substances of unknown composition	X
Aluminium powder	Rt
Aluminium bromide, anhydrous	R, S, L
Aluminium carbide	R, T, L
Aluminium chloride, anhydrous	R, S, L
4-aminobiphenyl	X
Ammonia ‘880’	Ot, (F)
Ammonical silver nitrate (Tollens reagent)	X Prepare as required and immediately dispose of excess
Ammonium chlorate(VII) (perchlorate)	X
Ammonium dichromate (VI)	S
Ammonium nitrate	R, St
Ammonium peroxodi-sulphate(VI) (persulphate)	St avoid raising dust
Ammonium sulphide	Ot, (F)
Anhydrone	N, L alternatives are calcium sulphate, calcium chloride (both anhydrous) and molecular sieves
Anthracene	E
Antimony	E
Antimony compounds	S
Aromatic amines (except aminobiphenyls or naphthalenamines)	R, St, F
Arsenic	E
Arsenic compounds	N if Marsh’s Test needs to be shown use impure zinc
Asbestos, soft forms paper fibre mats platinised centred gauzes	X ceramic wool forms of paper,wool and platinised wool available. Calcium silicate matrix heat resistant platinised & ceramic centred or stainless centred gauzes available. Use heat resistant leather
Azo dyes	R,Ot

Barium, metal	T
Barium compounds, solid	S
Barium compounds, dilute solution	t
Barium chromate (VI)	N should not be isolated from any preparation
Barium peroxide	R, T, L
Barium sulphate	O
Benedict's solution	O
Benzamide	S
Benzene, use as a solvent	X use methylbenzene as alternative solvent. Use cyclohexane for change of state experiment.
Benzene, use as reagent	R, St, F (small scale preparative work).
Benzenecarbaldehyde (benzaldehyde)	R, S, (F)
Benzenecarbonyl chloride (benzoyl chloride)	R, S, F
Benzene-1,3-diamine (m-phenylenediamine)	R, S, F
Benzene-1,4-diamine (p-phenylenediamine)	R, S, F
Benzene-1,2-diol (catechol)	S
Benzene-1,3-diol (resorcinol)	Ot, F
Benzene-1,4-diol (quinol or hydroquinone)	S
Benzenesulphonic acid	St
Benzene-1,2,3-triol (pyrogallol)	S
Benzonitrile	R, S, F
Beryllium	E
Beryllium compounds	X
Biphenyl-4,4'-diamine (benzidine)	X
Bis (4-isocyanatophenyl) methane (Caradate 30)	R, St, F
Bismuth	S
Bismuth compounds	O
Bleaching powder	R, O, L
Bromates	R, S
Bromine, element	R, St, F
dilute solutions	O
Bromobenzene (phenyl bromide)	S
1-bromobutane (n-butyl bromide)	R, S, (F)
2-bromobutane (sec-butyl bromide)	S, (F)
Bromoethane (ethyl bromide)	R, S, (F)
Bromomethane (methyl bromide)	R, T, ?
2-bromo-2-methylpropane (t-butyl bromide)	R, ?, (F)
Bromopropane (propyl bromides)	R, S, (F)

3-bromoprop-1-ene (allyl bromide)	R, S, F
Butanal	R, O, (F)
Butane cylinder	N not recommended in lab.
Butan-1-ol (n-butanol)	O, (F)
Butan-2-ol (sec-butanol)	O, (F)
Butanone (methyl ethyl ketone)	O, (F)
Cadmium	R, St
Cadmium compounds	R, St
Calcium, metal turnings	R, Ot
Calcium dicarbide	R, St, L
Calcium hydride	R, St, L
Calcium oxide	R, Ot, L
Calcium phosphide	N
Calcium sulphide	R, S, F
Carbon dioxide, solid	Ot
Carbon monoxide	X small scale preparation St, F
Carbon disulphide	N use dimethylbenzene as solvent for preparing rhombic sulphur and ethyl cinnamate for prism experiment.
Camphor	S
Chlorates(I) (hypochlorites)	R, Ot, L purchase sodium salt as solution; ensure cap is vented
Chlorates(III) (chlorites)	N
Chlorates(V) (chlorates)	R, St
Chlorates(VII) (perchlorates)	N small quantities may be isolated as in fractional crystallisation of dis-proportionation products of potassium chlorate(V) – not to be stored
Chloric(VII) acid (perchloric acid)	X
Chlorine cylinder	N
Chlorobenzene	S
Chlorobutanes (butyl chlorides)	R, S, (F)
Chloroethane (ethyl chloride)	R, S, (F)
Chloroethene (vinyl chloride monomer)	X
(Chloromethyl) benzene (Benzyl chloride)	R, S, F
Chloropropanes (propyl chlorides)	R, S , (F)
Chlorosulphonic acid	R, St, F
Chromates(VI) and dichromates(VI)	
solutions	O
solids	S
Chromium(VI) oxide (chromium trioxide)	R, S
Chromium(III) compounds (chromic compounds)	O
Cleaning mixture (dichromate(VI)/conc. sulphuric acid)	T Do not store. Decon 90 good alternative

Crude oil	Ot, F
Cyanates	R, T
Cyanides	N
Cyclohexane	O, (F)
Cyclohexanol	S, (F)
Cyclohexanone	S, (F)
Cyclohexene	O, (F)
DDT	N

Decanedioyl dichloride Ot, F
(sebacoyl chloride)
Devarda’s alloy O
N,N’-dialkylphenylamines R, S, F
(N,N’-dialkylanilines)
Di(benzenecarbonyl) peroxide N di(dodecanoyl) peroxide is alternative
(benzoyl peroxide) polymerisation catalyst
1,2-dibromoethane N may be formed as in test for
(ethylene dobromide) unsaturation, but should not be isolated
1,2-dibromopropane (propylene R, S, F
dibromide)
Dichlorobenzenes R, S, F 1,2-isomer most toxic of the three isomers
Dichlorobiphenyl-4,4’-diamines X
(chlorobenzidines)
Dichlorodimethylsilane R, T, F
1,2-dichloroethane (ethylene R, T, F
dichloride)
Dichloroethanoic acid R, S
(dichloroacetic acid)
2,4-dichlorophenols R, S
Di (dodecanoyl) peroxide R, Ot
(lauroyl peroxide)
Diethylamine R, Ot, F
Diethylamine, dilute solution O
Diethyl sulphate X
Diiodine hexachloride (iodine R, St, F
trichloride)
3,3’-dimethoxybiphenyl X
-4,4’-diamines
Dimethylamine R, Ot, F
Dimethylamine, dilute solutions O
3,3’-dimethylbiphenyl X
-4,4’-diamine (o-tolidine)
Dimethyl formamide R, S, F
Dimethyl sulphate X
Dinitrobenzenes R, St
3,5-dinitrobenzoic acid R, S
4,4’-dinitrobiphenyl X
2,4’-dinitrobromobenzene R, T
2,4-dinitrochlorobenzene N
2,4-dinitrofluorobenzene N
Dinitrophenols R, St
2,4-dinitrophenyl-hydrazine R, S
Dioxan R, St, L
Dipentene R, O
Diphenylamine, solution R, St otherwise N
for redox indicator
Esters (general) R, O, (F)
Ethanal (acetaldehyde) R, O, (F)
Ethanal tetramer (metaldehyde) Ot
Ethanal trimer (paraldehyde) R, S, F

Ethane cylinder N
Ethane-1,2-diamine (ethylene R, S, F
diamine)
Ethanedioic acid and salts
(oxalic acid and salts)
solid R, S
dilute solution R, Ot
Ethanoic acid, glacial Ot, (F)
(acetic acid, glacial)
Ethanoic anhydride R, S, (F)
(acetic anhydride)
Ethanol O, (F)
Ethanoyl chloride S, F
(acetyl chloride)
Ethene cylinder (ethylene) N
Ethers (general) R, S, F
Ethoxyethane (diethyl ether) R, S, F, L
Ethoxyethanol (cellosolve) S, F
Ethylamine R, Ot, F
Ethylamine, dilute solution O
Ethylbenzene O, (F)
Ethyl benzoate O, (F)
Ethyl carbamate N
Ethyl ethanoate (ethyl acetate) O, (F)
Ethyl methanoate (ethyl formate) O, (F)
Ethyne cylinder (acetylene) X
Fehlings solution No.2 Ot Use water bath.
Alternative is Benedict’s or Barfoed’s solution
Fluorine N
Fluorene N
Fluorenone N
Fluorides, solid R, T
Fluorides, solutions Ot
Germanium tetrachloride R, S, F
Heptane R, O, (F)
Hexacyanoferrates(II) S
(ferrocyanides)
Hexacyanoferrates(III) S
(ferricyanides)
Solutions of hexacyanoferrates Ot no heating, no addition of strong acids
Hexamethylcosane (squalene) O
Hexamine R, S, F
Hexane R, O, (F)
Hexane-1,6-diamine Ot
(hexamethylenediamine)
Hexanedioic acid (adipic acid) O
Hexanedioyl dichloride Ot, F
(adipoyl chloride)
Hexenes O, (F)
Hydrazine X
Hydrazine chloride R, St
Hydrazine hydrate R, T
Hydrazine sulphate R, St
Hydrides, metal R, St
Hydriodic acid R, S
Hydrobromic acid R, S
Hydrocarbons, aliphatic O small scale, (F)
Hydrocarbons, aryl S, (F)
Hydrochloric acid, conc Ot
Hydrofluoric acid X
Hydrogenation catalysts R, St
Hydrogen cyanide X
Hydrogen cylinder T
Hydrogen peroxide
20 volume t, L
100 volume R, T, L
Hydrogen sulphide gas S, F aqueous solutions may be
used outside fume cupboard
2-hydroxybenzoic acid O

(salicylic acid)
Indicator powders T
Indium compounds S
Iodates(V) S
Iodic(V) acid R, T
Iodine, solid O, lower levels t, if heated t, (F)
Iodine(V) oxide (iodine pentoxide) N
Iodoethane (ethyl iodide) R, T, F
Iron(III) chloride, solid O
Iron(II) sulphide O
Isocyanates R, T, F
Lead alkyls N
Lead(II) bromide Ot, if fused for electrolysis F
Lead(II) chloride Ot
Lead(II) chromate(VI) N
Lead(II) ethanoate (lead acetate) Ot
Lead(II) methanoate (lead formate) Ot
Lead oxides all levels t
Lithium R, Ot if heated T
Lithium compounds R, S ü lithium borohydride or
Lithium aluminium hydride R, St, F, L ý sodium borohydride are more
Lithium hydride R, T, F, L þ stable and are suitable for
Lithium hydroxide R, S some applications
Magnesium powder Ot
Magnesium ribbon t
Mercury R, St in well ventilated room on spillage tray
Mercury alkyls X
Mercury salts, solids St
Mercury salts, solution Ot
Methanal (formaldehyde, formalin) R, Ot in F unless very dilute. Do not use in presence of hydrogen chloride
Methanoic acid (formic acid) Ot, (F)
Methanol Ot, (F)
2-methoxyphenylamine R, S, F
(o-anisidine)
4-methoxyphenylamine R, S, F
(p-anisidine)
Methylamine S, F
Methylamine, dilute solution O
Methylbenzene (toluene) Ot, (F)
3-methylbutanol O
(iso-amyl ethanoate)
3-methylbutyl ethanoate S, (F)
(isoamyl acetate)
Methyl ethanoate (methyl acetate) O, (F)
Methyl ethyl ketone peroxide Ot
Methyl methanoate O, (F)
(methyl formate)
Methyl 2-methylpropenoate R, S, F, L
(methyl methacrylate)
Methylphenols (cresols) R, S
N-methylphenylamine R, St, F
(N-methylaniline)
Millon's reagent R, S alternatives are Albustix, Cole's Modification of Millon's reagent or Sakaguchi Test
Molybdenum R, S
Naphtha R, T, F liquid paraffin is preferred for storing alkali metals
Naphthalen-1-amine X
(1-naphthylamine)
Naphthalen-2-amine X
(2-naphthylamine)
Napththalene O For cooling curves use hexadecan-1-ol, octadecan-1-ol, hexadecanoic or octodecanoic acid
N-naphthylethane-1,2-diamine R, St
as solution (N.E.D. or
N-naphthylethylenediamine)
Naphthylthiourea (ANTU) R, T
Nessler's reagent R, S
Nickel, dust R, St

Nickel salts, solid S avoid raising dust
Nickel salts, solution O
Ninhydrin, solid R, T
Ninhydrin, aerosol spray R, Ot, F
Nitric acid, conc Ot
Nitric acid, fuming R, St, F
Nitrobenzene R, St, F
4-nitrobiphenyl X
Nitrocellulose X
Nitrogen dioxide O, F
Nitrogen triiodine X
Nitromethylbenzenes (nitrotoluenes) N
Nitronaphthalenes X
Nitrophenols R, St
4[(4-nitrophenyl) azo] O
benzene-1,3-diol solution
(Magneson I)
4[(4-nitrophenyl) azo] O
naphthalen-1-ol solution
(Magneson II)
Nitrosamines X
Nitrosophenols, 2- and 3- isomers X
4-nitrosophenol R, St
Octane R, O, (F)
Oct-1-ene R, S, (F)
Oleum N
Orthophosphoric acid S
Orthophosphoric acid, dilute O
Osmic acid N alternative stains for microscope work are the Sudan dyes
Oxygen mixture (potassium N alternative preparation is decomposition of
chlorate(V)/manganese(IV) oxide) 20 vol hydrogen peroxide catalysed by
manganese (IV) oxide
Paraffin oil O

Paraquat R, T
Pentane O, (F)
Pentan-1-ol and 2-ol O, (F)
(n- and sec-amyl alcohol)
Pentan-3-one (diethyl ketone) O, (F)
Pentyl ethanoate (amyl acetate) R, O, (F)
Peroxides, inorganic S
(excluding H2O2)
Peroxodisulphates(VI) St
(persulphates)
Petroleum ether, BP below 80ºC S, (F)
Petroleum ether, BP above 80ºC Ot, (F)
Phenols St
Phenols, dilute solutions O
e.g. indicators
Phenylamine (aniline) R, St, F
Phenylammonium salts R, S, (F)
(anilinium salts)
Phenylethene (styrene) R, S, F
Phenylhydrazine and salts R, S
Phenylthiorea (P.T.U) Ot see Education in Science,
also phenylthiocarbamide (P.T.C.) September 1979, page 17.
Phosphides, metal N
Phosphorus, red R, Ot, F
Phosphorus, white R, T, F, L
Phosphorus(V) oxide R, St, F, L
Phosphorus pentabromide R, St, F, L
Phosphorus tribromide R, St, F, L
Phosphorus trichloride R, St, F, L
Phosphorus trichloride oxide R, St, F, L
Photographic developer t
Potassium R, T, L
Potassium amide (potassamide) N, L
Potassium hydrogen-sulphate O
(potassium bisulphate)

Potassium hydroxide, Ot
solution <2 molar
Potassium hydroxide, solid, melt, St
or concentrated solution
Potassium manganate(VII) t
(potassium permanganate)
Potassium nitrate t
Potassium nitrite R, S
Potassium sulphide R, Ot
Propanal (propionaldehyde) O, (F)
Propanoic acid (propionic acid) O, (F)
propan-1-ol and –2-ol
(n-propyl and iso-propyl alcohols) O, (F)
Propanone (acetone) O, below O if t, (F)
Propylamine S, F
Propylamine, dilute solution O
Propyl ethanoate (propyl acetate) O, (F)
Pyridine R, St, F
Quinine R, T cold tea is alternative for taste bud experiments
Selenium and compounds R, S, F
Silicon tetrachloride R, St, F, L
Silver nitrate R, S
Silver nitrate solution Ot
Sodamide (sodium amide) N, L
Sodium R, St
Sodium amalgam R, S
Sodium azide R, S
Sodium chlorate(I) solution Ot Ensure container is vented
(hypochlorite)
Sodium hydroxide, Ot
solution <2 molar
Sodium hydroxide, solid, St
melt or concentrated solution
Sodium hydrogen sulphate O
(bisulphate)
Sodium nitrate t
Sodium nitrite R, S
Sodium pentacyano- S
nitrosylferrate(II)
(sodium nitroprusside)
Sodium peroxide R, St, L
Sodium sulphide R, Ot
Strontium R, T
Sulphides, heavy metal Ot
Sulphur chlorides R, St, F
Sulphur dioxide canister St, F
Sulphuric acid, conc Ot
Sulphuric acid, dilute t
Tellurium metal and compounds E
Tellurium compounds X
Tetrachloromethane R, St, F 1,1,1-trichloroethane is less harmful (carbon tetrachloride) substitute for solvent applications
Thallium and compounds X
Thermite mixture T Do not store
Thiocyanates, solid S Do not heat to decomposition
or add strong acids
Thiourea (also thiocarbamide) R, S See Education in Science,
September 1976, Page 17
Tin(II) chloride (stannous chloride) O
Tin(IV) chloride (stannic chloride) R, S, F, L
Titanium(IV) chloride R, T, F
(titanium tetrachloride)
1,1,1-trichloroethane as solvent t, (F)
Trichloroethanoic acid S
(trichloroacetic acid)
Trichloroethene N 1,1,1-trichloroethane is a less harmful (trichloroethylene) substitute for solvent applications
2,2,2-trichloroethanediol R, S, F
(chloral hydrate)

Trichloromethane (chloroform) R, St, F 1,1,1-trichloroethane is a less harmful substitute for solvent applications
3,4,5-trinitrobenzoic acid R, S
(gallic acid)
2,4,6-trinitrophenol (picric acid) R, S
Turpentine R, t, F
Uranium compounds, solid R, T
Uranium compounds; solution S
Vanadium(V) oxide T
(vanadium pentoxide)
Vanadates(V) S
Xylene cyanol solid R, S
Zinc powder R, t
Zinc chloride S
Zinc chromate(VI) X

Safety in School Science

The article above is one of a series on “Safety in School Science” published by the Association for science Education in “Education in Science” as follows:

The labelling of chemicals April 1979
Blood sampling April 1979
Electrical safety June 1979
Possible carcinogenic hazards Sept. 1979
Safety bibliography Sept. 1979
The use of pesticides in schools Nov. 1979
Chemistry experiments:
advice on safety April 1980
Restricted chemicals April 1980 (see above)
Management and organisation
of chemical storage Sept. 1980
The storage and handling of
flammable liquids Sept. 1980

This is an important and authoritative series of articles prepared by the Laboratory Safeguards Sub-Committee of the A.S.E. in consultation with a wide range of organisations. The articles of interest to l.c. chemistry teachers will be reprinted in “Chemistry in Action”. You should detach the centre-pages of this issue or photocopy them and put them in a “Laboratory Safety File” for ready reference.

THE SAFE PREPARATION OF HYDROGEN

by H.G.Andrew

(reprinted from School Science Review 61 (215) Dec.1979)

The unique properties of hydrogen render it both the cause of most of the explosions and some of the more serious accidents in schools, but also permit it to be used safely even if it is allowed to escape.

The dangers are that hydrogen-air mixtures are potentially explosive over the range of 4 to 74 per cent of hydrogen; (c.f. 5 to 15 percent for CH4). The ignition temperature of the mixtures is relatively low, about 500 ºC, well below this temperature in the presence of many transition metals or their oxides.

The very low density of hydrogen enables it to diffuse rapidly out of any leaks in an apparatus, the resulting fall of pressure inside causing air to be drawn in. On the other hand its extreme lightness and rapidity of diffusion mean that any that escapes into the air can scarcely form an explosive mixture with the air in a room. If the whole contents of a 20 cu ft (0·57cm^3) cylinder are discharged into an average laboratory as quickly as possible it should be possible to strike a light quite safely ten seconds afterwards. (When I proposed to demonstrate this at a safety lecture, I did not conclude the experiment as my audience started to disperse almost as fast as the hydrogen!) If all this hydrogen mixed uniformly with the laboratory air the concentration would be only about 0·1 per cent. Its extreme lightness would prevent uniform mixing and cause it to rise rapidly to higher levels where it would quickly diffuse away through ceilings, walls and window cracks. There is therefore no danger of a major explosion from a leaking hydrogen cylinder.
The generation of hydrogen is traditionally from granulated zinc and dilute sulphuric acid. The acid can conveniently be about 3 M. The final solution will then be warm enough and concentrated enough after filtering to give good crystals of zinc sulphate-7-water as it cools. If a more dilute acid is used the resulting solution requires concentrating to give crystals and if solid is deposited above 40ºC unsatisfactory basic salts and lower hydrates are produced.

Alternatively 3M hydrochloric acid may be used. This is less corrosive than sulphuric acid but nice crystals of zinc chloride will not be obtained since these are deliquescent and very soluble.

A small quantity of copper(II) sulphate is usually added, preferably to the acid before it is run in, but the quantity should be very small. Too much defeats its object which is to form tiny sites of copper on the zinc so that the hydrogen bubbles form on these, leaving most of the zinc freely exposed to the acid. In preparing hydrogen for reductions it is a good plan to place a few inches of magnesium ribbon under the zinc before starting. The initial vigorous action helps quickly to purge the apparatus of air.

It is when explosion occurs in a drying bottle containing concentrated sulphuric acid that most of the damage is done, both by flying glass splinters and dispersed acid. It is often convenient to have some kind of wash bottle containing liquid in a train of apparatus in order to monitor the rate of gas flow, but there are ways of doing this safely.

Concentrated calcium chloride solution will dry hydrogen sufficiently for most purposes and will also indicate flow rate. If sulphuric is needed for more complete drying, it should be soaked up in small lumps of pumice and used in a tower or U-tube. These could be followed by a small monitoring tube containing only a few cubic cm of acid. Or concentrated phosphoric(V) acid (H_3PO_4, S.G. 1·75) is a good desiccant and so is glycerol (propane-1,2,3-triol). Both these liquids have viscosities greater than sulphuric acid but this is no problem if they are dispersed on pumice. For monitoring, a low viscosity and low vapour pressure liquid such as dibutyl benzenedicarboxylate (phthalate) may be used with advantage. Hydrogen dried with sulphuric acid usually contains traces of hydrogen sulphide.

The safest way of showing that an apparatus through which hydrogen is passing is free from explosive mixture is to collect gas at the exit in a test-tube by upward delivery. If this burns quietly when ignited at a distant flame all is well.

If a thistle tunnel is used in the generator a small quantity of air may be entrained when further acid is added but this does not involve additional risk since it would be necessary to entrain a volume of air equal to at least a quarter of the volume of the gas in the generator to obtain the minimum explosive concentration (24 per cent of air). The back-pressure when a considerable train of apparatus is used makes the normal use of a funnel inconvenient. A good method is to have a tube from the laboratory gas supply connected to a cork which can be inserted into the top of the thistle funnel (Figure1). The gas can then be used to flush air from the apparatus to start with, and if required, to act as a carrier gas at the end of a reduction experiment when hydrogen production is slowing down. The covered thistle funnel also overcomes back pressure.

Alternatively a tap funnel can be used and the pressure in the apparatus communicated to the top of the funnel (Figure 2). This device is useful in any apparatus in which gas is produced by dripping a liquid into a flask, as a very steady supply can be maintained.

Conical-shaped pyrex flasks should be used. The dead space in these is much less than in the normal flasks used at one time. Plastic bottles are also suitable.

Methods of preparing hydrogen other than the use of zinc and acid are not attractive. Dropping water onto calcium turnings, or, better, technical grade calcium hydride, is expensive but could be considered for special purposes. The hydrogen will be reasonably dry and the use of corrosive liquids is avoided.

Magnesium acts inconveniently fast with acids unless pieces of cut rod are used or the acid is dripped onto the turnings. Aluminium reacts too slowly with acids and froths unpleasantly with alkalis.

Approximate current costs for making a mole of hydrogen molecules using various substances are (in pence): aluminium 15, zinc 15, magnesium turnings 25, calcium hydride 100, calcium 150. This excludes the cost of any acids used.

Some form of automatic generator, with a small dead space, such as can be made from an inverted long-bodied tap funnel, is convenient for providing occasional supplies of hydrogen (Figure 3).

Now that power packs and battery chargers are readily available the design of electrolytic generators for hydrogen or other gases is worth considering. For chlorine, titanium anodes have now replaced carbon in both mercury and diaphragm cells commercially.

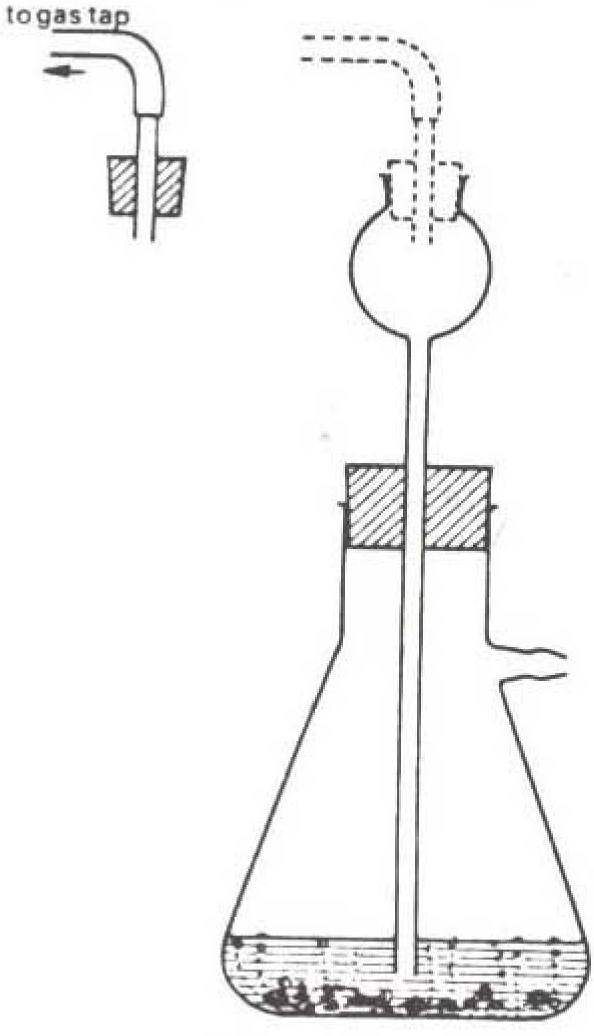
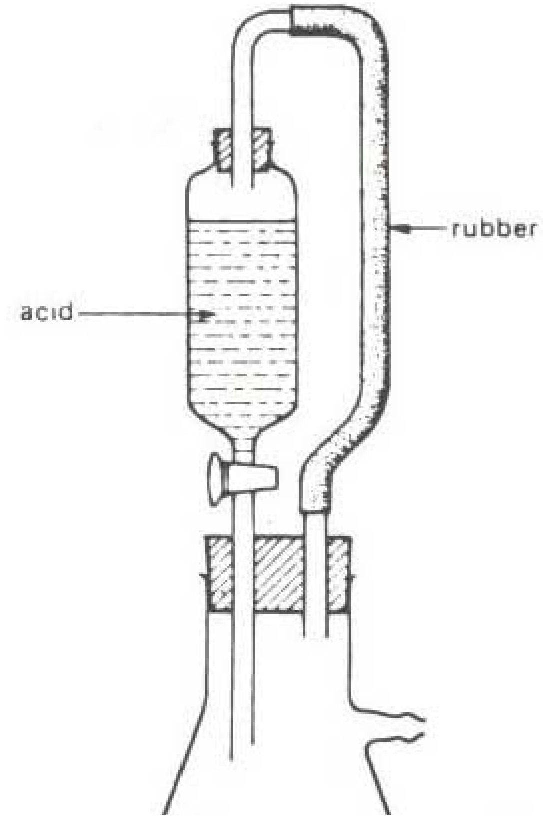


Figure 1

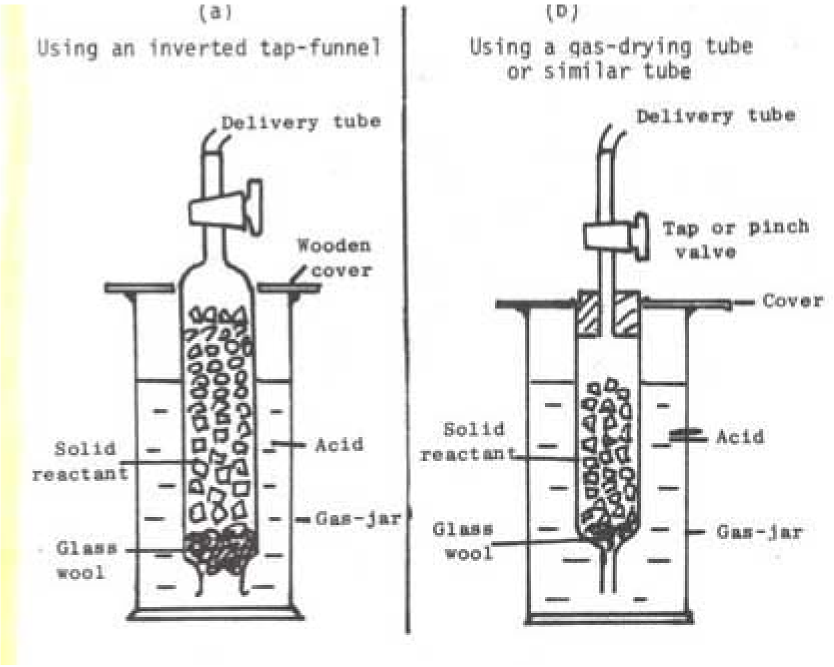


Chem Tips

A Simple Gas Generator

Getting a regular and reliable supply of common gases e.g. Hydrogen, Carbon Dioxide, Hydrogen Sulphide etc. often present problems at school. The conventional apparatus is large and inconvenient and takes up valuable space.

A simple gas generator can easily be set up as described below. It works on the same principle as the Kipps apparatus. It can be adapted to produce several different gases. Two designs are shown below: use whatever apparatus you have available.



(a) Using an inverted tap-funnel (b) Using a gas-drying tube or similar tube

(Mount the whole assembly, well clamped, on a stand.)

Put a charge of solid chemical in the tap-funnel and loosely block the exit with glass wool. Clamp upside down in a gas jar (or other container) and fill the gas-jar with acid.

The tube should be fitted with a rubber stopper and either a glass tap with a rubber delivery tube or a glass tube and rubber pinch valve. Insert as shown in a gas jar, and fill with acid.

When the tap or pinch valve are opened the acid can move up the apparatus, reacting with the solid and generating gas. The gas will be evolved in a steady stream until the acid or solid is used up. Try and ensure enough acid to cover the solid and thus get maximum gas generation.

To stop production, close the tap or valve. The gas pressure now pushes down the acid in the apparatus, stopping the production of gas automatically. When the tap is opened again the acid can rise again and gas generation resumes. The apparatus is safe because it is always open to the atmosphere at the bottom and any excess pressure can be relieved. The apparatus is always full of gas (kept in by the acid) and is ready for immediate use. Only the delivery tube needs flushing out to give pure gas. A washing bottle can be included if desired: this also gives a visible gas flow indication. When I saw this idea I immediately went & made one: it works beautifully. When the chemicals are exhausted they can be replaced very quickly. 50g marble chips, for example will give about 11L of carbon dioxide, & requires 100mL conc. HCl.

GAS	SOLID CHEMICAL IN GENERATOR	ACID
Hydrogen	Granulated zinc	Dilute HCl (6M) + little $CuSO_4$

Carbon dioxide	Marble chips	Dilute HCl (6M)
Hydrogen sulphide	Iron(II) sulphide lumps	Dilute HCl (6M)

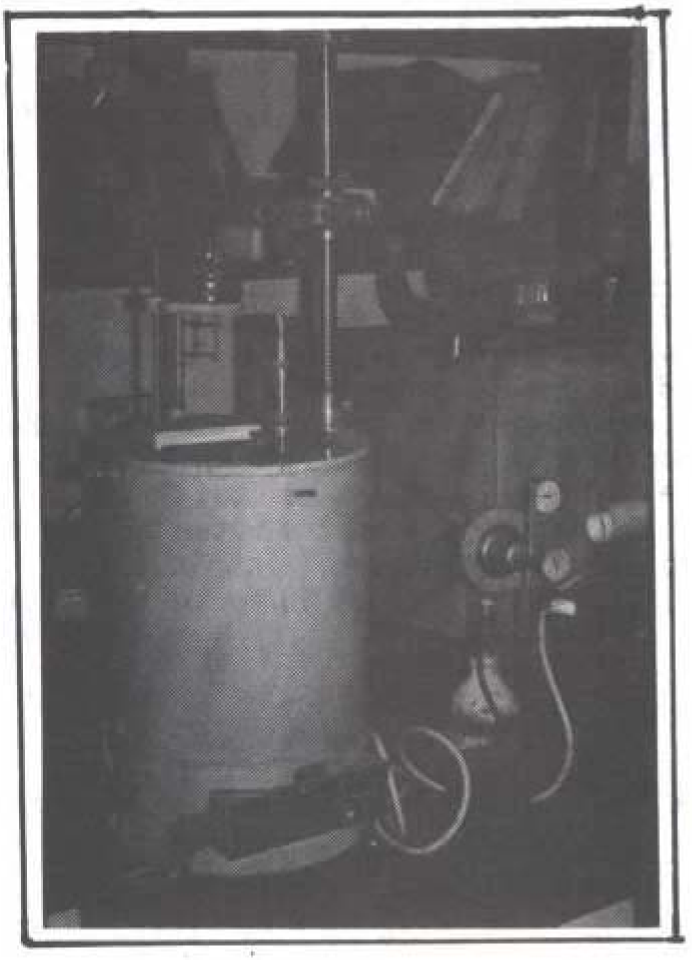
This generator can be used for other gases where the reaction involves the reaction of an insoluble solid with water or an aqueous solution, and heating is not required e.g. ethyne (acetylene) from calcium carbide and water.

A Hydrogen Generator set up for use
N.B. the Zinc is blackened from the use of the copper ions as catalyst

The Hydrogen Generator in action

WHAT DOES A BOMB CALORIMETER LOOK LIKE?

The photo below shows a bomb calorimeter in use at Irish Cement Ltd. (Limerick Works), where it is used to measure the fuel value of the coal used for firing the cement kilns. The oxygen supply can be seen at the right and the actual bomb is dismounted on top of the main calorimeter body.



THERMOMETERS: need they be mercury-in-glass?

Mercury thermometers are expensive and are dangerous because they are easily broken, releasing mercury into the laboratory. Do we have to use mercury-in-glass? Looking through a catalogue of science equipment reveals that one can buy alcohol-in-glass thermometers (up to 110ºC x1ºC) for less money than the equivalent mercury-in-glass thermometers. Alcohol thermometers are much safer, as well as being cheaper, and this temperature range covers most laboratory needs. Mercury thermometers would be needed above 110ºC e.g. 0-360º thermometers for m.pt. determination.

Other alternatives are the use of electronic thermometers (using thermocouples or thermistors as sensing elements). These are too expensive at present for widespread use, but the digital models are ideal for demonstrations. The expanded scale demonstration meters with temperature probes and scales are also useful.

Stop the rolling thermometer!

Most breakages of thermometers are due to them rolling off benches or when they are being inserted (or removed) from stoppers (see p.8). Some brands of thermometers now come with anti-roll caps that fit on the end of the thermometer and simply stop them rolling. You can do this yourself by putting a small cork or rubber stopper on the end of the thermometer, with one flat face cut on the stopper. This will stop the thermometer rolling.

Thermometers should, anyway, be placed down perpendicular to the edge of the bench (not parallel) and returned to a safe storage place after use. A tray with spaces, similar to that used for pipettes (see issue 2, p.24), made from expanded polystyrene makes a safe store. It also gives a see-at-a-glance check if any are missing, presumed broken.

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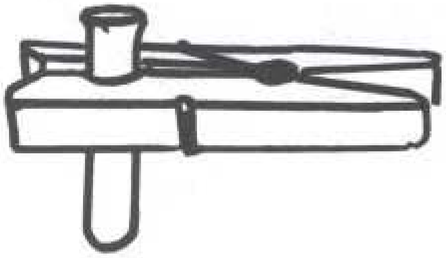
CHEAP TEST-TUBE HOLDERS

A cheap, convenient test-tube holder can be made using wooden spring clothes-pegs. 3 dozen of the smaller type cost about 50p. The plastic variety are NOT suitable. The small clothes-pegs can be used directly to hold small test-tubes. They give a firm grip, unlike some metal tongs, and are poor conductors. Fingers may be too close to the flame, and screwing on a longer strip of thin wood to one side makes them safer. (You can buy a version similar to this – but its cheaper and more fun to make your own.) A larger version of the wooden spring peg is available in some shops and enables larger test-tubes to be held securely.



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MICROWAVES REVISITED (see Chemistry in Action, May 1980, p.20)

“The penetration of microwaves and their loss of energy is different for different substances and even for a given substance depends on its physical state. As I have said before, water is a good absorber of microwaves, and this is because under the influence of the microwave electric field the water molecules rotate or oscillate and then through friction their kinetic energy is converted into heat. In ice, on the other hand, the water molecules are rigidly anchored in the crystal lattice and are hardly affected by the microwaves, which therefore pass through ice almost unhindered. The following simple demonstration can illustrate this. A cup of water is placed in a hollowed-out block of ice, and after about 30 seconds in the microwave oven the water boils while the surrounding ice remains frozen.”
N.Kurti New Scientist
18/25 Dec. 1980

WEAR SAFETY GLASSES ALWAYS - YOUR SIGHT IS TOO PRECIOUS

With issue 2 I sent out a safety poster. I said then, and I repeat, you can’t display that poster until you make safety spectacles or goggles available. If you, the teacher, don’t wear them routinely for preparing classes and doing demonstrations, then you’ll never get the message over to your pupils. In fact, you are more likely to have an accident than them!

I heard of a case recently of a technician making up sodium hydroxide solution from pellets, WITHOUT eye protection. The unforeseen accident happened – they are usually unforeseen. A pellet jumped out into his eye and began to eat it away. Solid sodium hydroxide is extremely caustic with a strong, exothermic affinity for water. He lost his eye. Even dilute alkali splashes in the eye have been known to produce fogging of the cornea. It does not pay to take chances.

Can I make a stronger case for you and your pupils to wear safety glasses/goggles at all times in the laboratory when practical work is being done? Eye protection is cheap – about £1·50 - £2·00 per pupil, and well worth it to prevent even one accident in ten years. You and/or the school are likely to be sued if an accident does happen and you haven't taken 'reasonable precautions'. Most laboratory suppliers will supply safety glasses or goggles, at a price. You are better to try a supplier of industrial safety equipment, even a local hardware shop stocks them, for a better price since you will need at least 30 pairs for an inter-cert class.

A GOOD WORD FOR CHEMISTS – FROM A PHYSICIST

"The contributions of the chemist to culinary art and to many other activities designed to increase out sensual pleasures are well-known. The chemists analyse and explain fragrances and flavours and often invent new ones; a vast chemical industry is concerned with producing dyes to please our eyes. Physicists, on the other hand, either alone or in the company of engineers, are, in the public mind, usually associated with all the nasty and unpleasant things: supersonic bangs, hydrogen bombs, our transport problems caused by internal combustion engines..."
N. Kurti in New Scientist 18/25 Dec. 1980

USE PIPETTE FILLERS ROUTINELY

Miscellany

Chemical Jubilees 1981

The jubilees of the births and deaths of 13 notable contributors to chemistry occur during 1981. The following brief biographies are based on entries in the Biographical Dictionary of Scientists, edited by Dr T I Williams and published by A and C Black Ltd.

17 January – bicentenary of the birth of the American Robert Hare who invented the oxyhydrogen blowpipe. At the age of only 20, Hare first demonstrated his blowpipe to Joseph Priestley. The intensely hot flame was capable of melting a two-pound block of platinum. He obtained the hydrogen and oxygen by electrolysis of water.

30 January – centenary of the birth of Irving Langmuir who was also an American and also interested in blowpipes. He patented the atomic hydrogen blowpipe in 1934.

Langmuir observed that the blackening of an incandescent filament lamp was caused by the evaporation of the filament and this could be reduced by introducing nitrogen into the bulb instead of using high vacuum. The consequent increased heat losses, however, caused a decrease in efficiency. The answer was to produce a new filament coiled in a tight helix to produce an efficient gas-filled lamp.

Langmuir is best known for his investigations on the properties of liquid surfaces. He recognised the concept of mono-molecular layers and used this to gain approximate shapes and sizes of molecules. The idea of monolayer adsorption on solids came next, closely followed by the general theory that chemical reactions occurred between substances adsorbed adjacently on a surface eg of a catalyst. Langmuir received the 1932 Nobel prize for this work.

23 March – centenary of the birth of Hermann Staudinger who was awarded the 1953 Nobel prize for chemistry. He is considered by many to have been the founder of polymer chemistry. His studies on the structure of rubber quickly made him an advocate of the view that high polymers are truly ‘giant molecules’ held together by ordinary valency bonds. Although the theory is now undisputed, the majority of chemists of the day preferred to think of polymers as aggregates of monomer molecules (micelles) loosely bound by ‘partial valencies’ or even van der Waals’ forces. The Staudinger equation, which relates viscosity of a polymer solution to molecular weight, is still generally applied, with reservations, in the polymer industry.

31 March – sesquicentenary of the birth of Archibald Scott Couper. This Scottish organic chemist was the first to recognise the quadrivalency of carbon and its power of combining with itself. Early in 1858, he asked Wurtz to present to the French Academy a paper which he had written On a New Chemical Theory. Unfortunately Wurtz procrastinated and Kekulé put forward identical views first.

19 April – 75th anniversary of the death of Pierre Curie, killed tragically by a wagon in a Paris street. Pierre is famous as the co-worker of his wife Marie on radioactivity but he should be recognised also for his own discoveries of piezoelectricity and Curie’s Law. He observed the piezoelectric effect with his brother Jacques when opposite sides of asymmetric crystals of quartz became electrified under the influence of pressure. His investigations into magnetism led him to observe that magnetic susceptibility is inversely proportional to absolute temperature – Curie’s Law. At a critical temperature (the Curie point), the substance changes from paramagnetism to ferromagnetism.

19 June - 75th anniversary of the birth in Berlin of Ernst Chain who came to England as a refugee from the Nazis. The penicillin which he isolated (with Florey) in Oxford, healed many wounds during World War 2. After the War, Chain was called on to set up the production of penicillin for clinical use in many countries. A fuller appreciation of his work appeared last year (Chem.Brit. 1980 page 267). He received the 1945 Nobel prize for medicine with Fleming and Florey (see next page).

1 July – centenary of the death of Henri Deville. He is best known for his work on the production of aluminium and for his studies of dissociation. Deville was the first to prepare the pure metal in bulk by the reduction of the chloride with potassium and later sodium. His experiences led to many other important developments such as the large-scale production of sodium, silicon, boron and titanium and the separation of the platinum metals. To him can also be attributed the design of high-temperature furnaces and the consequent synthesis of artificial minerals. His high-temperature measurements of vapour density led to the realization that many compounds undergo reversible dissociation.

2 July – 50th anniversary of the death of Stephen Babcock. This American agricultural chemist was a pioneer of research on nutrition. He developed a gravimetric method for milk analysis, a viscometer to detect adulterants in liquids and a method for accurately assessing the fat content of milk. The method was used widely because of its simplicity and accuracy. One of his most important investigations was connected with the nutritional value of animal foodstuffs.

6 July – 50th anniversary of the death of Edward Acheson. This American industrial chemist discovered silicon carbide (‘carborundum’) and set up a company to manufacture it. His electric furnace was also used to make synthetic graphite from coke. He later learned how to disperse colloidal graphite to make high-temperature lubricants for industry.

27 July – centenary of the birth of Hans Fischer who is notable for his work in Germany on the pyrrole pigments. The work began with investigations on bilirubin, the main colouring matter of bile, however his first major success was in the study of haemin – the non-protein moiety of haemoglobin. He showed that haemin has a macrocyclic structure (the ‘porphin’ ring) containing four joined pyrroles with an atom of iron at the centre. Later, he showed that the bile pigments were linear tetrapyrroles formed by oxidative degradation of porphins. Fischer also studied the chorophylls and demonstrated that they too were substituted porphins with an atom of magnesium at the centre. He won the Nobel prize for chemistry in 1930.

6 August – centenary of the birth of Alexander Fleming whose discovery of penicillin is well known. The exploitation of his discovery was carried out later by Chain and Florey. It is perhaps less well known that the discovery was part of a general search for antibacterial substances that might be therapeutically useful. Fleming had previously discovered in 1922 that lysozyme from nasal secretion had the power of dissolving (or lysing) certain kinds of bacteria. Lysozyme is present in many tissues of the body but its activity is unfortunately limited so far as the pathogenic organisms that cause disease are concerned. Thus lysozyme demonstrated the existence of substances harmless to the cells of the body but lethal to bacteria – the ‘magic bullets’ sought initially by Paul Ehrlich and realised in penicillin.

18 September – centenary of the death of David Alter. Although more a physicist than a chemist, this American contributed to spectrum analysis which proved to be of great value to chemists. He put forward the idea (later proved by Bunsen and Kirchoff) that each element has a characteristic spectrum in its vapour state.

22 September – 25th anniversary of the death of Englishman Frederick Soddy who originated the concept of isotopes. He advanced the idea that atoms could be chemically identical, yet have different weights. For such elements, he proposed the name isotope because they occupied the same place (Greek, isos topos) in the periodic Table. As a result of this strict classical derivation, the word isotope has passed unchanged into almost every language. He was awarded the Nobel prize in 1921.

Major Overseas Healthcare and Chemical Companies in Ireland

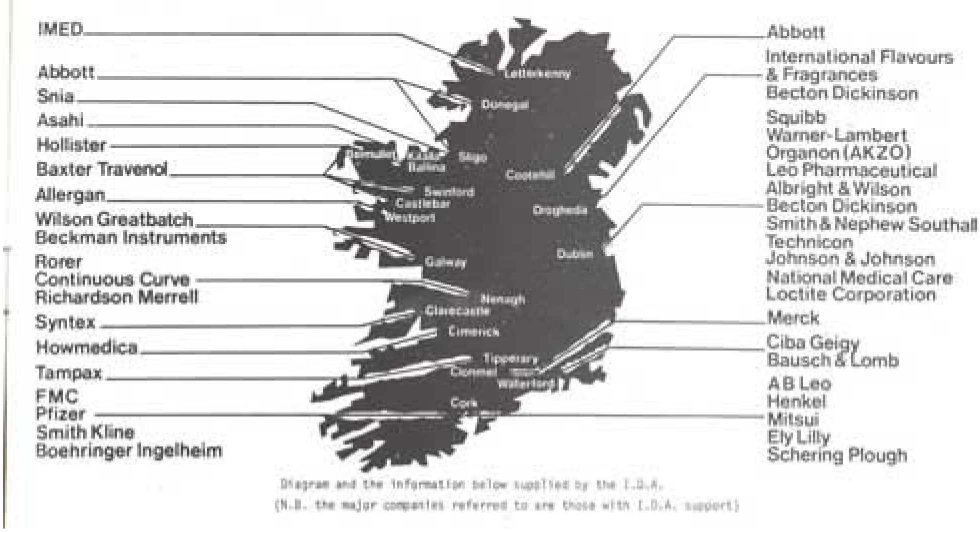

Diagram and the information below supplied by the I.D.A.
(N.B. the major companies referred to are those with I.D.A. support)

WHAT DO THEY MAKE? (name of Irish subsidiary)

IMED Ltd.	Intravenous blood systems
Abbott (Ireland) Ltd.	Disposable hospital products
Snia (Ireland) Ltd.	Nylon continuous filament yarn
Asahi Synthetic Fibre (Ire) Ltd	Acrylic yarns
Hollister Overseas Ltd.	Plastic medical products
Baxter Travenol (Travenol Labs.)	Healthcare products
Allergan	Contact lens solution
Wilson Greatbatch (Gwydd Ltd.)	Cardiac pacemaker batteries
Beckman Instruments	Electromedical instruments
Rorer	Pharmaceuticals
Continuous Curve (Hydrocurve Ltd.)	Soft contact lenses
Richardson Merrell (RM Chemicals)	Skin cream
Syntex	Naproxen and dental instruments
Howmedica	Orthopaedic implants
Tampax	Sanitary tampons
FMC (Ireland) Ltd.	Microcrystalline cellulose
Pfizer Chemical Corporation	Citric and gluconic acids
Smith Kline (Penn Chemicals BV)	Cimetidine
Boehringer Ingelheim (Irish Fher Labs)	Pharmeceuticals
Abbott (Ireland) Ltd.	Baby foods
International Flavours	Fragrances and aroma chemicals
Becton Dickinson & Co.	Disposable hypodermic syringes
Squibb (Linson Ltd.)	Pharmaceuticals
Warner-Lambert (Irl.) Ltd.	Diagnostic reagents

Organon (AKZO)	Pharmaceuticals and diagnostics
Leo Pharmaceutical (Leo Labs. Ltd)	Pharmaceuticals
Albright & Wilson (Irl) Ltd.	Chemicals
Smith & Nephew Southall	Healthcare products
Technicon (Ireland) Ltd.	Automatic chemical analysers
Johnson and Johnson	Baby powders
National Medical Care (Erika Ltd.)	Dialysers
Loctite Corp. (Loctite (Ireland) Ltd.)	Adhesives and sealants
Merck, Sharpe and Dohme	Pharmaceuticals
Ciba Geigy (Agro) Ltd.	Agricultural & general disinfectants
Bausch and Lomb (Irl) Ltd.	Soft contact lenses
AB Leo (Gaeleo)	Pharmaceuticals
Henkel Ireland Ltd.	Ion-exchange reagents
Mitsui Denman	Electrolytic manganese dioxide
Ely Lilly (Elanco SA)	Antibiotics and fine chemicals
Schering Plough (Chembiotic Ltd.)	Pharmaceuticals

"*The point, however, is that the problem-solving technological method includes the academic approach. It uses academic principles, solutions and established knowledge if these are appropriate. If they are not, it invents new ones.*"
P.Coggin TES 19/12/80

"*Chemistry is an empirical science. Without one's own experience and that of others it is impossible to pursue the study of chemistry. Experience, however, particularly when it is encoded in formulae and equations, can resemble a chitin shell, and the stronger it becomes the more difficult it will be to shed in order to permit further growth i.e. to recognise and experience something for what it is.*"
R.Hoppe Agnew Chem. I.E. 19 110-125 1980

NOMENCLATURE Part 1 METAL CATIONS

<u>Systematic names are best</u>
Let us work for the old names' demise.
Use correct names and set me at ease,
Not ferrous or ferric!
Those names drive me frantic.
Iron (II), iron (III); if you please.

Many books, chemical labels and teachers (above all) still cling to old, unsystematic names such as ferrous, ferric; cuprous, cupric; cerous, ceric; manganous, manganic etc. It is not clear from these names what oxidation state is referred to and thus there are no clues to the formulae of compounds, stoichiometry of equations etc. The systematic Inorganic nomenclature for metal cations, recommended by I.U.P.A.C. for many decades now, is easy to learn and use, and avoids ambiguity.

Rule: The oxidation state of a metal in an ion or compound is indicated in Roman numerals in brackets after the element.

Examples:
New name Old name Formula
Iron (II) Ferrous Fe2+ or FeII
Iron (III) Ferric Fe3+ or FeIII
Copper (I) Cuprous Cu+ or CuII
Copper (II) Cupric Cu2+ or CuII

Cerium (III) Cerous Ce3+ or CeIII
Cerium (IV) Ceric Ce4+ or CeIV
Manganese (II) Manganous Mn2+ or MnII
Manganese (III) Manganic Mn3+ or MnIII
Chromium (II) Chromous Cr2+ or CrII
Chromium (III) Chromic Cr3+ or CrIII

The endings -ous and -ic in olden times referred to the lower and higher oxidation states commonly found in aqueous solution and in stable compounds. Consequently -ous could refer to +1, +2 or +3 oxidation states depending on the element; -ic could refer to +2, +3 or +5. There was no system: every element had to be memorised separately. Some elements form compounds (mixed-valency compounds) with two or more oxidation states of the same element and a more systematic method of naming is vital here.

The old names do have a place – in history, in older textbooks and unfortunately in the world of commerce and industry. So our pupils need to know the old names – but they should start by learning the systematic names. We should teach and build understanding first through the systematic names, and the trivial names should be in brackets.

A final plea
Let us hear no more of manganic,
Cerous, cupric or even chromic.
Old cuprous has had its day,
Chromous too must fade away.
Resolve TODAY to sink titanic!

Bring on the names more systematic,
Cerium (IV) and never ceric,
Copper (I) and copper (II),
These are now the names for you,
It's just the same with copper (III) (sic).
P.E.C.

SOME EXPERIMENTS IN CHEMISTRY

by Pat Browne, North Monastery, Cork.

1. Activity series for non-metals

To impress the fact that non-metals also take part in the activity series use chlorine gas to displace bromide and iodide from their solutions.

In the preparation of chlorine (N.B. in a fume cupboard) bubble the gas through wash-bottles of potassium bromide or potassium iodide and watch the colour of bromine or iodine appear.

$$\tfrac{1}{2}Cl_2(aq) + Br^-(aq) \longrightarrow Cl^-(aq) + \tfrac{1}{2}Br_2(aq)$$

$$\text{or } \tfrac{1}{2}Cl_2(aq) + I^-(aq) \longrightarrow Cl^-(aq) + \tfrac{1}{2}I_2(aq)$$

2. Reducing action of ethanal (acetaldehyde) vapour

Boil some ethanal in an evaporating basin. Heat a copper coin to red heat in a bunsen flame and hold the hot coin in the ethanal vapour. It is 'cleaned' immediately and re- oxidises at once when removed from the reducing vapour.

3. Molecular mass of sulphur by f.pt. depression

Use a wide test-tube (boiling tube) and half-fill with naphthalene. Weigh the naphthalene carefully to 0·01g or better.

Heat carefully over a small flame and note the m.pt. Dissolve in a small, weighed mass of sulphur and note the new m.pt.

Freezing point of naphthalene depression constant, Kf = 6·851º mol-1 kg^{-1}

R.M.M. of sulphur = $\frac{Kf \times W}{DT}$ (W = mass sulphur/kg naphthalene)

(f.pt. depression)

e.g. R.M.M obtained = 250 i.e. sulphur exists as S8 molecules in solution (8 x 32 = 256).

N.B. remove the thermometer before the mixture sets. Naphthalene is a safer solvent than benzene, which is too toxic.

4. Rates of reaction

You need five beakers, stop-clock, bunsen, measuring cylinder. Solutions of potassium permanganate, oxalic acid, manganese (II) sulphate and iron (II) sulphate. The five beakers contain A. cold oxalic acid solution, B. hot oxalic acid solution, C. oxalic acid solution diluted by half and heated, D. cold oxalic acid plus manganese (II) sulphate solution, E. iron (II) sulphate solution.

A small volume of potassium permanganate solution is added to each beaker and the relative rates of bleaching compared.

Note: The difference between A. and B. shows the effect of temperature on rate – the reaction between oxalic acid and permanganate is slow in the cold. The difference between B. and C. shows the effect of concentration on rate. Comparing A. and D. shows the effect of a catalyst (Mn2+ ions) on the reaction rate. Comparing A. and E. shows the effect of changing the reactant completely – iron (II) is oxidised quickly by permanganate in the cold, unlike oxalic acid.

5. Thermite reduction of iron oxide

THIS EXPERIMENT IS HAZARDOUS. It should be done outdoors preferably or behind a safety screen. Wear eye protection.

You need a crucible (or tin lid), iron oxide (rust), aluminium powder, and magnesium ribbon.

Mix equal parts of Al powder and iron oxide. Insert a piece of magnesium ribbon (10cm) as a fuse, with the mixture in a crucible standing on a heat-proof tray. Light the fuse and stand back. The mixture may ignite slowly but then goes off violently. The reaction is strongly exothermic as the more reactive Al strips the oxygen from the iron oxide, leaving red-hot iron, and vaporising the aluminium oxide formed.

Historically this method was used for in situ welding of railway and tram rails, but it is a dramatic illustration of the reactivity series.

$$2Al(s) + Fe_2O_3(s) \longrightarrow Al_2O_3(s) + 2Fe(s)$$

Reprinted from: May 1979/CHEM 13 NEWS

A simple test for lead-based paints.

Lead-based paints used to be very common until the toxicity hazard was recognised. Young children were particularly at risk since they commonly chew painted objects and have low body weights. There is strong evidence that lead accumulates in the body (from various sources) and affects brain function and development. Most lead-based paints have now been withdrawn, except for specific industrial use e.g. anti-corrosion paints. A simple test can be used to show whether a sample of old paint contains lead or not. Scrape some flakes of paint into a small test-tube or specimen tube. Add a few mL of sodium sulphide, stopper and shake. The solution will darken if lead is present in the paint, though this may take some time. This is due to the formation of the black and very insoluble lead (II) sulphide.

$$\text{Paint} \longrightarrow Pb^{2+}(aq) + S^{2-}(aq)\ PbS(s)$$
$$(K_{sp} = 1{\cdot}25 \times 10^{-28})$$

NOTE: you could do this as a demonstration (having located some lead-based paint) or as the basis of a project on lead pollution: get pupils to bring in samples of old paint from various sources and test them for lead. To find the actual amount of lead present is more difficult. It can be done by E.D.T.A. titration for larger concentrations or by atomic absorption spectrometry (AAS*) down to very low levels.

*see p.21 for a quiz on other chemical acronyms.

ACKNOWLEDGEMENTS
The Editor thanks the Director of Thomond College for the use of college facilities and Ann Boardman for some of the typing.