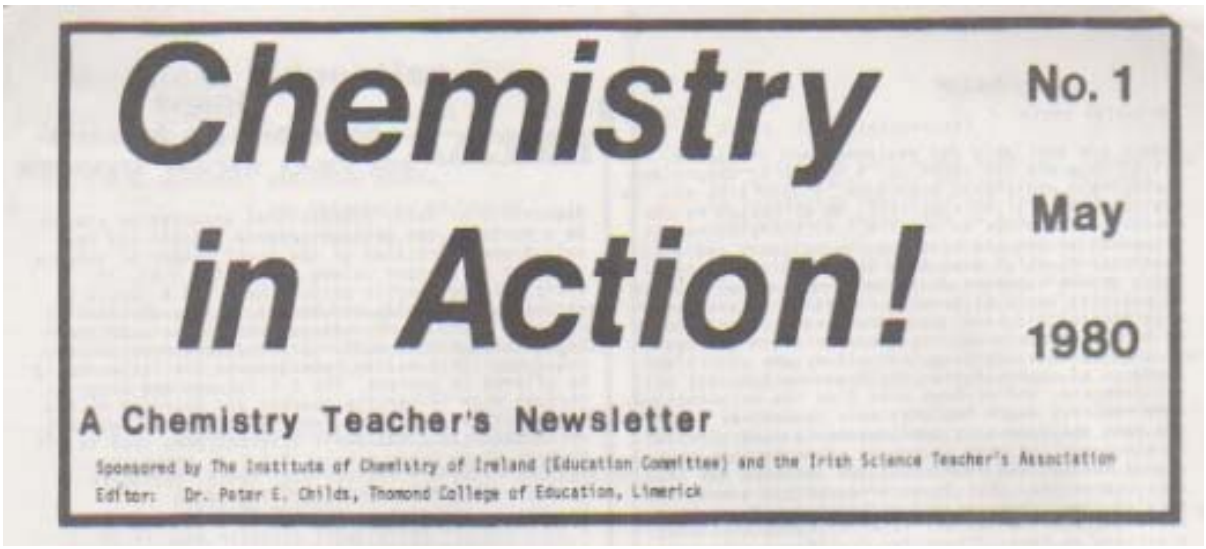
Chemistry
in Action!
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A Chemistry Teacher's Newsletter
Sponsored by The Institute of Chemistry of Ireland (Education Committee) and the Irish Science Teacher's Association
Editor: Dr. Peter E. Childs, Thomond College of Education, Limerick

Editorial

Change for the better?

Matter at the microscopic level is in a state of molecular chaos, of rapid, continual change. There are many parallels with the state of the world in 1980 where an increasing rate of change is a common feature of different countries. Chemical education in Ireland in the 1980's is no exception and cannot escape the pressures to change. Many dissatisfactions have been expressed about the teaching of science and maths in Irish schools – from pupils, teachers, third-level institutions, professional bodies and employers. They are signs of the winds of change blowing through the educational system, and for chemists and chemistry teachers our main concern is the teaching of chemistry in schools. Chemistry, along with physics, is one of the most useful subjects at school in relation to the development of the Irish economy and the needs of industry, both in its own right and as a basis for other careers in science and technology. This is just where the jobs of the 1980's will be found and common-sense alone would dictate that schools should be encouraging pupils to take the physical sciences at leaving certificate level. This should be evidenced by increasing numbers of boys and girls taking chemistry and physics at school, but the actual situation is rather discouraging.

1978 Leaving Certificate Numbers as % total

Chemistry	Biology	Physics
19·0	48·5	13·0
(20·5)	(22·0)	(13·1)

(1972 figures in brackets: D. of E. statistics)

Chemistry and physics are barely managing to hold their own, despite a steady increase in the total numbers doing the leaving certificate, whereas biology has shown a dramatic growth. The more people who do some science at school the better, but we should all be concerned at the small numbers doing the physical sciences, given the changes in the Irish economy over the past decade.

What is wrong?

What can be done to improve the image and enhance the status of chemistry in Irish schools? This question should concern all of us involved in chemical education and we should remember that the choice is made after the inter-certificate and that in some schools there is no choice! The present syllabus and the examination are usually cited as the main problem areas, followed by the inadequacy of the teacher-training process and the lack of facilities in schools. The syllabus and the examination are imposed from above and teachers have traditionally had little or no say in them, although all teachers are constrained by them.
The present syllabus is widely agreed to be overloaded with material, to be too academic and conceptual, to require no practical work, and to contain very little applied chemistry. The examination, on the other hand, favours rote-learning, it is predictable (encouraging 'question-spotting'), it tests mainly recall, and high marks can be obtained without ever doing any practical work. These are all major indictments and it is good to be able to record that the Department of Education has set up a syllabus revision committee for leaving certificate chemistry, which is to start meeting about now. Submissions have been made by the Irish Science Teacher's Association (I.S.T.A.) and the Institute of Chemistry of Ireland (I.C.I.). However, it will be at least 1982 (or later) before the new syllabus is actually introduced in schools, and many would argue that changes are needed NOW!

The Role of "Chemistry in Action"

"Chemistry in Action" is a new publication for chemistry teachers which has been initiated by the Education Committee of the I.C.I., with the support of the I.S.T.A. It is an attempt to bridge the gap by helping teachers to understand their subject better, to realise its applications and to provide ideas and advice on practical work, with the hope that this will improve the teaching of chemistry.

Curriculum reform and change must always start with the teacher. In-Service Education is widely recognised as one of the most effective and the cheapest ways of improving the quality of the teaching profession and keeping it up-to-date. The current level of support for In-Service Education in Ireland, for all subjects, is totally inadequate and lacking any clear policy or direction. A strong case could be made for the special needs of science and maths, both from the deficiencies of the present situation and the future needs of the country. "Chemistry in Action" will try to place useful material in the hands of chemistry teachers on a regular basis, for them to use as they think fit, as a sort of school-based, individualised In-Service education available to all on a continuous basis.

Chemistry is a practical subject

Chemistry is first and foremost a practical subject which cannot be taught properly without providing the pupils with experiences in a laboratory. There is no real learning without doing. In too many Irish schools it appears that chemistry (and other sciences) is taught mainly, if not exclusively, from the textbook and in the classroom. In this, Ireland is out of line with most of the world in regards to science education at second level. Grants are available for equipment and chemicals, but all of them are not taken up. A wealth of modern and appropriate equipment, apparatus, visual aids etc. is available from Irish suppliers, as witnessed by the exhibition displays at the I.S.T.A. conferences. It is common to put the blame on the syllabus and the examination, which must take their share, but many Irish teachers manage to include substantial amounts of practical work at leaving certificate (and Inter-certificate) and still get good results. There needs to be a change of attitude and approach on the part of many science teachers (not all by any means) and a change of emphasis from the Department in its requirements, and perhaps also from the universities. Many teachers teach "as they were themselves taught" and lack the necessary confidence and expertise to tackle practical work at school, often because this aspect was omitted from their own training and in their schooling. This is an area where the need for regular, comprehensive and perhaps compulsory In-Service Education for all science teachers is most glaringly obvious. "Chemistry in Action" will stress a practical approach to the teaching of chemistry and it is hoped that this will be a help to many teachers.

Applied chemistry is essential

The second major area of concern which "Chemistry in Action" will try to tackle is the importance of an awareness of the role of chemistry in everyday life, in society, in industry and in the Irish economy of the 1980's. The usefulness of chemistry when applied to solve problems e.g. in agriculture, medicine, and industry in general, is one of the main reasons for including chemistry on the school curriculum. It has been said that we live in a chemical world and the applications of chemistry are all around us, and indeed we depend on chemistry everyday in many ways. The importance of applied chemistry could not be gathered by studying the present l.c. syllabus or the way chemistry is taught in most schools, or indeed at third-level institutions. Chemistry which is unrelated either to personal experience in a laboratory or to its applications in everyday life, can only be a superficial part of a child's education. Knowledge which is crammed for regurgitation in a short examination usually evaporates overnight, leaving little trace in later life. Education in and through chemistry should surely be more than this! "Chemistry in Action" will be trying to make us all more aware of the applied nature of chemistry in the real world, and this must surely enrich our teaching.

Everyone's support is needed

"Chemistry in Action" is a new venture and will need all the support it can get. It is hoped to produce the newsletter 2 or 3 times a year, with free circulation to at least all second-level schools in the Republic, and eventually to all individual teachers of chemistry. The size of the newsletter, the frequency and the free circulation will be critically dependent on the level of financial support from the chemical and related industries in Ireland, who are interested in improving chemical education. In order to make sure every teacher sees the newsletter (making you read it is a different matter!) it has to go to every school. We want to reach the whole set of chemistry teachers not just those in the I.S.T.A. or the few in the I.C.I., and this requires a subsidised publication. So far the response of Irish industry has been very encouraging (see sponsors on the back page) and I hope that many other firms will follow suit once the newsletter is launched.

We also need the contributions of practising teachers to make “Chemistry in Action” successful and useful: not in money but in kind – articles, experiments, ideas for teaching, your personal views etc. I hope you will feel that this is your newsletter and that it contains something of interest and of use to you in your teaching. Your comments on “Chemistry in Action” as well as your contributions will be welcome. Please make sure all your science/chemistry colleagues see this issue and get them to send their names in for their own copies.

P.E.Childs
Hon.Editor

Chemical Education

Teaching Strategies And Definitions Of Chemsitry

Dr. J.E.B. McGarvey, Education Centre,
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Some of the aims of science teaching are derived from the nature of science itself. The Schools Council Curriculum Bulletin No.3, 'Changes in school science teaching', 1970, summarises the nature of science in three statements:

a. Science involves methods of inquiry.
b. This inquiry results in an evolving body of knowledge containing underlying and unifying patterns.
c. This knowledge encompasses man and his environment and enables changes to be made in their relationships; science is therefore a social influence and an essential part of culture.

i.e. Science = method + knowledge + influence

If we want to present these three components in the school chemistry curriculum then the types of learning experience provided must encompass all these aspects of science. Different teaching methods lend themselves best to the separate components and so overall a wide variety of teaching methods needs to be used.

In science teaching a tremendously wide range of strategies is available. Do teachers vary their approach? What do chemistry teachers actually do during their lessons? Surprisingly, we know very little about the processes of science teaching. There has been only one major research study in Britain which has observed science teachers at work. This was a Schools Council sponsored project 'The Evaluation of Science Teaching Methods' reported in Eggleston, J.F., Galton, M.J. and Jones, M.E.; 'Processes and Products of Science Teaching', MacMillan Education, 1976.

The researchers observed 95 science teachers (including 34 chemists) on 4 occasions, classified different styles of teaching and also measured the outcomes of this teaching in terms of intellectual attainment and attitude improvement of the pupils. The research identified three styles of teaching and found that teachers could be characterised as they consistently used the one style.

Style I (problem solving)
The initiative is held by the teacher who challenges his pupils with a comprehensive array of questions observational, problem solving, and speculative in both practical and theoretical contexts. The teachers' statements reflect an orientation towards science as a problem solving activity.

Style II (informing)
There is relatively infrequent use of teachers' questions excepting those requiring recall and application of facts and principles to problem solving. There is a relatively high incidence of teacher's statements of fact and teachers' directions to sources of information for fact-finding. There is a non-practical bias and fewer transactions are inferential or speculative.

Style III (inquiring)
This style is more pupil centred; initiatives by pupils occur more frequently. The work is relatively practical and the level of intellectual engagement is high.'

Clearly, these three styles give pupils different views of the nature of science and, since teachers were found to adhere to the one style, pupils were experiencing a rather narrow definition of science. Chemistry pupils were three times as likely to be taught by Style I than by either Style II or Style III. The research report goes on to summarise its findings on the relative effectiveness of these styles.

Thus the partial picture that the research presents of science teachers reveals a problem. On the one hand the evidence suggests that individual teachers use a very stable and strongly stereotyped approach, whereas a broad definition of

science requires a very varied approach.

This problem has been overlooked by curriculum developers. They have assumed that it is possible simply to present teachers with a new approach, as in the Nuffield Foundation Science Teaching Projects, and then its adoption will follow. There is strong resistance to change because teachers have a strong preference for a particular style of teaching with which they feel comfortable and which they use habitually.

(Summary of a talk given at the 24th Teachers' Refresher Course, 3rd – 4th January, 1980)

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A MODEL OF CHEMICAL EDUCATION

The preparation, cooking, consumption and digestion of food can provide a useful model for effective chemical education.

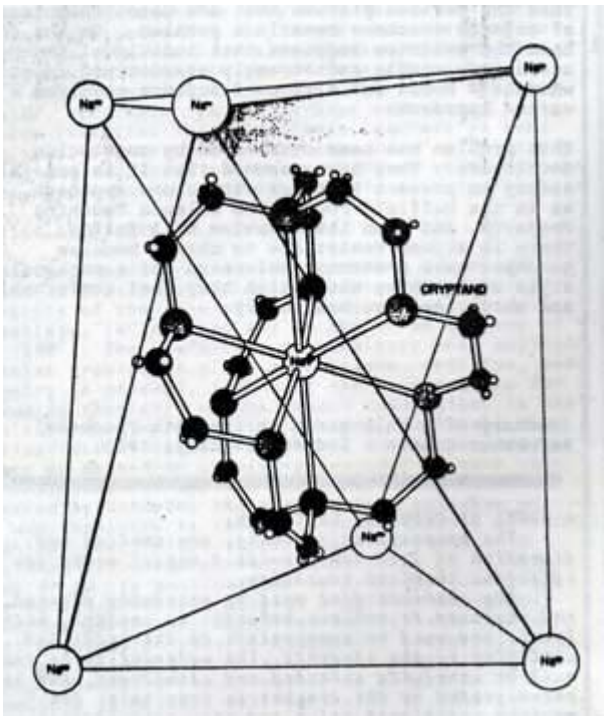
Any chemical diet must be carefully planned and prepared to achieve balance; in content, methods, level, and must be appropriate to the needs and abilities of the students. The material to be taught must be carefully selected and structured, and be pre-digested by the teacher in some cases for maximum nutritional value and easy assimilation. Chemistry, like food, must be presented in a carefully structured and attractive way to make it both appetising and digestible. Small portions are to be recommended, especially for children, with adequate instruction in and time for chewing; eating too quickly tends to produce indigestion. The student should be given opportunity to use his ingested knowledge and acquired skills; exercise after meals is a good prescription. In this way we can develop mental muscles and avoid running to fat. Exercise is as essential for the mind as it is for the body, and little and often is a good maxim.

A balanced diet is neither all convenience foods nor all protein or vitamins, nor indeed all desserts. Let us beware of chemistry courses which are undercooked, poorly presented and too stodgy! Let us not fall into the trap of too much theory (high protein diet) or always using exciting examples or stressing relevance at all costs; we don't want a menu with only starters and desserts, with no main courses. Nor let us forget that our students are supposed to be actively involved; too many chemistry classes involve the pupils reading the menu and then watching the teacher eat the food!

The good teacher must always be on the lookout for the slow eaters, those with nutritional deficiencies and those with special dietary requirements. He must also be prepared to try out new menus, new dishes and new ways with the old food. The teacher can learn a lot from the chef in many ways, where constant practice, a willingness to experiment and consistency are some of the culinary virtues.
P.E.Childs

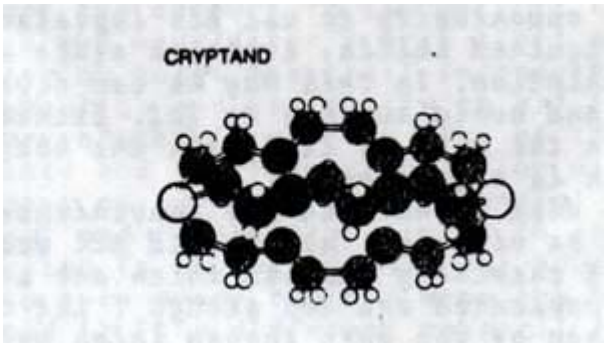
Frontiers of Chemistry
Of Alkalides and Electrides – new types of compound

One basic belief of chemists is the ability of alkali metals only to donate electrons forming cations and never to accept electrons. This now has to be revived since a series of compounds with alkali anions, or alkalides, have been known since 1974. A colourful article in Scientific American, July 1977 “Anions of the alkali metals” by J.L.Dye describes this work very clearly. These compounds contain the cation and anion of the same metal, e.g. Na+ and Na-, and their structure is shown in the diagram.



Diag. p.4

The cation is trapped inside a cage-forming ligand or cryptand, which makes it more soluble in polar organic solvents and separates it from the anion. If allowed in contact the anion and cation would recombine to form the metal. Such a compound can be termed a sodium sodide.



Diag. of cryptand

Solutions of gp.I and gp.II metals in liquid ammonia have been known for a long time. They are deep blue in colour and contain free, solvated electrons. The blue colour is characteristic of the free electrons. This can happen in liquid ammonia, though not in water, because ammonia is less easily reduced. In water the electrons immediately reduce water to give hydrogen and hydroxide ions.

$Na(s) + H_2O(l) \longrightarrow Na^+(aq) + OH^-(aq) + \frac{1}{2}H_2(g)$

The addition of cryptands makes the metals even more soluble in liquid

ammonia. If excess metal is added and the solvent is removed then alkalides of sodium, potassium, rubidium and caesium can be made (but not of lithium).

As an extension of this work Prof.Dye and co-workers have now made electrides where the electron acts as the anion. The electrides are less stable than alkalides and haven't yet been crystallised. They have been made for lithium, potassium, caesium and rubidium. They are deep blue in solution and the solid (due to absorption of red light by the electrons) and lithium electride has been most studied.

Both alkalides and electrides are fairly unstable and decompose on warming. Electrides are closely related to expanded metals e.g. $Li(NH_3)4^{e-}$, where ammonia is evaporated from a metal-ammonia solution to give a metal with dissolved ammonia. In a metal the valence electrons are essentially free to move in a sea of cations. In an expanded metal ammonia is also present, solvating and stabilising the cation and electron. Lithium tetramine looks like gold and floats on liquid nitrogen, and behaves a little like mercury.

Professor J.Lagowski from the University of Texas has also made a caesium auride by dissolving gold in caesium electride, $Cs(NH_3)_ne$-.

An exciting new area of chemistry has been opened up and textbooks will need to be rewritten, just as they did after the discovery of noble gas compounds in 1962.

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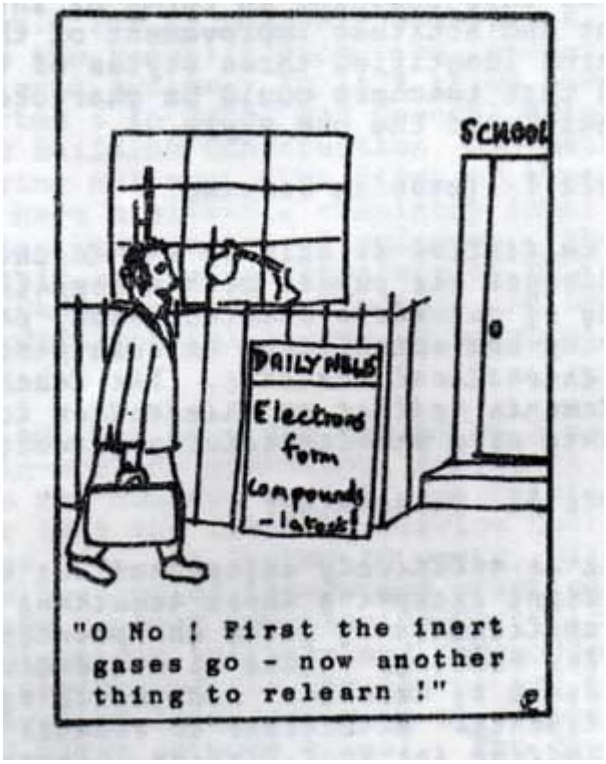


Cartoon

"There is nothing more difficult to carry out, nor more dangerous to handle, than to initiate a new order of things. For the reformer has enemies in all those who profit by the old order, and only lukewarm defenders in all those who would profit by the new."
Machiavelli
"Theories change – the facts remain.

Silver

HIGH-HO SILVER: increase in silver prices aggravates the problems of teaching chemistry

With all the coverage in the press no-one can have escaped noticing that the price of gold (Au) has gone up. Gold is an element of only academic interest in the classroom but silver is not. Many people seem to have overlooked the fact that the price of silver has gone up from $6 an ounce to around $41 in a year, an increase of nearly 700%. Gold increased by 2-300% in the same period.

The major effect of the silver cost-increase will be felt in photography, which uses a third of the 450m oz of silver consumed each year. The cost of films and prints will increase dramatically this year, despite attempts by the photographic manufacturers to reduce costs. "Fuji is searching for the photographer's equivalent of the philosopher's stone: the substance that will replace silver."

Silver salts, mainly silver nitrate ($AgNO_3$), are important in school chemistry; in argentometric titrations for halides or as a test for halogens. The use of silver in schools may have to be curtailed in view of the huge price rise. 500 cm^3 of 1M $AgNO_3$ now costs about £25! What can be done?

First of all use much lower concentrations of silver nitrate: reactions still work and waste is much reduced if 0·01M solutions are used. The 500cm^3 of 1M solution above (containing 71·5g $AgNO_3$) will make 50 litres of 0·01M solution – enough for a lot of tests and several years of titrations.

Secondly never throw any silver wastes away – whether solids or solutions – the silver in them can be recovered since silver salts can easily be converted back to silver (see below).

Thirdly, if you want to use silver next year – buy now before prices go up.
Fourthly, if you can substitute for silver salts do so: the lead (II) halides show the insolubility of a series of halides, the iodide being yellow, although the variation in Ksp is not as regular as for silver halides.
(See Irish Times 28/1/80, business section.)

RECOVERY OF SILVER FROM WASTES
Silver is too valuable to be thrown down the sink and it can easily be recovered. The process also illustrates some interesting chemistry. Silver recovery from photographic wastes e.g. fixer solution or waste film is also done commercially e.g. by IMEA Ltd., St.Brigids, Kilcock Rd., Maynooth.

Make it a policy to have a silver residues bottle in the laboratory and every time silver is used pour all the residues into the bottle, including solids. Insoluble silver salts will settle out and the liquid can be decanted off. Check by adding some sodium chloride solution to ensure that all silver is precipitated. Collect all used fixer solutions if you, your colleagues or the school do photographic processing.

The basic chemical process in fixing is the solution of silver bromide from the film i.e. the unexposed areas, by treatment with sodium thiosulphate to form the soluble complex ion $Ag(S_2O_3)^{2-}$. Consequently a mixture of insoluble silver salts (10g) can be dissolved in 200 cm^3 20% sodium thiosulphate or in excess used fixer solution. This solution is filtered to remove undissolved impurities, heated to 60ºC and mixed with 6g powdered zinc (a 20% molar excess) and allowed to stand for 24 hours. Zinc displaces silver from solution and a precipitate of silver settles out as a sludge. The liquid is decanted off, the solid filtered off and washed with water, hot dilute hydrochloric acid and again with water. The acid removes the unreacted zinc. With used fixer the same procedure is used except that 5–10g of zinc per 4 litres of used fixer solution is required.

The silver powder can be dissolved in nitric acid to give silver nitrate solution or used for analysis or melted to give a silver button.

(This method is due to D.H.Wakeford, S.S.R., **59** (209) June 1978.)

Silver can also be recovered from solution by electrolysis and this is the commercial method. There is no reason why the recovery process cannot be done by 5th/6th year students as an illustration of silver chemistry and the reactivity series.

STOP PRESS: Since the above article was written the price of silver has plummeted more rapidly than it rose and is back to about a quarter of its maximum price. The increase was due to speculators buying up silver and they have now had their fingers badly burnt. Let us hope that the prices of silver compounds from the chemical suppliers follows suit. Silver is still expensive and the comments about economy still apply.

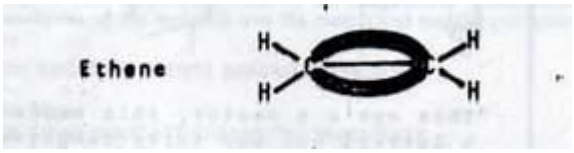
It's all been said before:
"Those who are eager to be rich fall into temptation and a snare, and into numerous thoughtless and hurtful cravings that plunge people into destruction and ruin."
1 Tim. 6:9

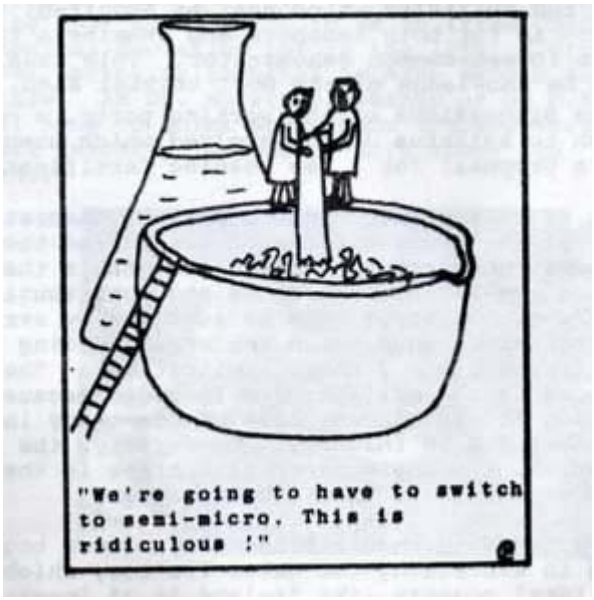
"One bad apple spoils a barrel"
This common quotation is not only true, as anyone who has stored apples will know, but it has an interesting biochemical explanation. Ripening fruit gives out ethene gas (ethylene) and the gas is produced by and triggers off the ripening process. One over-ripe apple will thus stimulate all the other apples to ripen faster by increasing the ethene concentration in the air. Ripening can be prevented by storing the fruit in an inert atmosphere e.g. nitrogen, which is flushed out regularly to remove ethene.

Bananas are shipped green from the West Indies and other producing countries in an inert atmosphere and are stored in warehouses until needed. Ripening can be induced by adding ethene to the atmosphere when the fruit is required. The ripening process can thus be controlled chemically unlike the natural process which depends on the weather.

Analysis of the flavour chemicals in the natural and ethene-ripened fruit has shown significant differences. Natural ripening produces a more complex mixture of flavour chemicals so that the sensitive nose can probably tell the difference.

This example illustrates an interesting commercial use of ethene and also shows one process by which an unsaturated hydrocarbon is produced in nature. The biochemistry of this process provides a link with biology. This example of applied chemistry also perhaps puts the common phrase 'banana bonds in ethene' in a different perspective!




"We're going to have to switch
to semi-micro. This is
ridiculous !"

Cartoon

Personal view

A New Approach To The Leaving Certificate Syllabus

Joseph P.Chester, Colaiste Choilm, Swords.

In January 1978, the Institute of Chemistry of Ireland organised a one day seminar on the current leaving certificate Chemistry syllabus. The seminar was attended by nearly 100 teachers, industrialists, and academics, who agreed that the current syllabus was in urgent need of review.

The principal point made by the participants was the need for a complete review of the aims, content, and assessment techniques of Chemistry for Leaving Certificate, because the present syllabus was completely at variance with current educational philosophy. A working party was set up from among the participants in order to present the views expressed at the seminar to the Minister.

For instance, the present syllabus is dominated by an inward view of the subject, which pays insufficient attention to the impact of chemistry on life and modern civilisation. The need for an informed and balanced public opinion on the social advantages and disadvantages of chemistry has never been greater. The recognition of this point alone led to the introduction of an alternative syllabus by the UK Joint Matriculation Board with an applied emphasis.

The problem of assessment has been the subject of much study. In one study, analysis of the questions on an honours paper showed that 83% of the marks were awarded for recall of knowledge, 2% for comprehension, 15% for application and no marks at all for the higher educational objectives (such as analysis, synthesis, evaluation). When a syllabus fails to specify not only the content but also the related skills and abilities which must be acquired, the tendency is for both teachers and examiners to settle for the lowest common denominator. This usually turns out to be knowledge of the most trivial kind. From the discussions of the working party a new approach to syllabus design evolved which eventually led to a proposal for a new Leaving Certificate Syllabus.

The aim of this syllabus is to present Chemistry as the science of the various forms of matter and their transformation, and in addition to enable the student to assess the social importance and contribution of Chemistry to society. This is achieved by stressing a two way interaction between the understanding of chemical concepts and their applications. The chemical principles in the syllabus are included because they are needed to explain the role of chemistry in the environment and in industry. Conversely, the applications are designed to illustrate in the most graphic manner the concepts being taught.

Thus, for example, equilibrium is included because it is used in explaining the Haber Process, which in an agricultural country like Ireland is of importance in the manufacture of fertilisers. The Haber process is included because it is a clear illustration of the application of the principles of equilibrium.

Furthermore, extensive topics, such as chemical-bonding, are not treated as one large block of material divorced from useful applications, but rather the basic theories are explained in the context in which they are most needed. Covalent bonding, for example, appears in conjunction with the properties of simple diatomic gases, which in turn are used in discussion of air pollution, and when dealing with water pollution and its treatment, the properties of ionic compounds are taught.

Assessment of any syllabus must be in terms of the initial aims and objectives. Examination of this proposed syllabus will thus require two changes. The written questions must require activities of the student other than recall. In addition, for completion of practical work, the teacher will assign a mark, based on a completed practical note book. This book must be available for external moderation by Departmental Inspectors.

The syllabus is divided into four main topics – environment, energy, industry, comparative chemistry. In a short article, it is not feasible to describe the syllabus. Copies are available from the author.

At the 3rd International Conference on Chemical Education held in Dublin (August 1979), this syllabus was discussed, both in plenary session and at various group meetings. The new approach was welcomed by teachers, and many useful suggestions were made. The final draft has been submitted by the Institute of Chemistry of Ireland to the Minister of Education, for consideration by the Syllabus Revision Committee for Leaving Certificate Chemistry. This Committee is due to meet just after Easter 1980 and it is hoped that a new syllabus should be agreed by March 1981.

THE FIRST YEARS OF TEACHING
Michelle Harrison, Salesian Convent, Limerick

The biggest problem I came up against in the past two years, since I started teaching, was in the running of the practical laboratory sessions. I consider that the best way to learn and understand Science is by first-hand practical discovery. This can be a major problem area for the young teacher, particularly in a large school such as mine, where several teachers use the same laboratory. This means that the laboratory is in constant use, allowing no time for the teacher to prepare and set up apparatus or to measure out quantities of chemicals. It can often be difficult to control a class while setting up things at the beginning of a session and also the lost time can result in the experiment not being finished when the session ends.

However, this problem can be resolved by finding experiments which demonstrate the principles in the simplest way and in the shortest time.
A further problem arises in choosing a textbook as there are so many available on all the different aspects of science. It is necessary to choose a book with an interesting and yet not too superficial an approach. However, I find that by using a combination of several books myself I can supplement the textbooks used by the pupils with extra notes where necessary.

(Problems of laboratory organisation, tips on running practicals and ideas for simple apparatus or experiments will be covered in “Chemistry in Action”. See ChemTips on p.19 for some ideas in this issue. Please send in your own favourite tip or idea or experiment for the Newsletter.)

Cartoon p.6

Inter-Cert. Science Notes

THE BOG-GAS EXPERIMENT

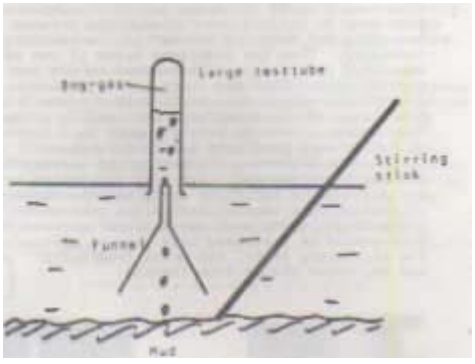
An interesting open-ended, discovery-type experiment that could easily be done at school after the preparation and properties of the common gases is the collection and identification of "bog-gas". This is the gas produced by the anaerobic fermentation of organic matter at the bottom of stagnant waters e.g. bogs, ponds or slow-moving streams. Most schools in Ireland should be within reach of adequate supplies of this natural chemical! The experiment is a good way of introducing the scientific method, experimental design and a revision of the properties of the common gases. The amount of help and information given to the pupils can be decided by the teacher, but it is a help if they don't know the answer before they start.

Bog-gas is a mixture of methane and carbon dioxide (roughly 70:30) and is combustible, colourless and usually odourless. (It may be contaminated e.g. by hydrogen sulphide, depending on your source.)

Statement of the problem: When the bottom of a stream or pond or bog is stirred, bubbles of gas come up to the surface. You should devise a method of collecting a number of small samples of this gas (working in small groups), and then back in the laboratory try to identify it as conclusively as you can by doing simple chemical tests. Write up everything as you go along and try to come to some conclusion at the end. Even if you think you know the answer, remember that you must have evidence to support your conclusion.
Before you start the experiment, look up and fill in characteristic tests for the common gases listed below and try to make up a key or flow diagram to help you test your samples in the most logical way.
Common gases most likely to be found: carbon dioxide, oxygen, hydrogen, sulphur dioxide, hydrogen sulphide, ammonia, carbon monoxide, methane, nitrogen.

To the teacher: You may like to add some gases to the list above that you have studied at school and to delete some that you haven't done. If you don't do it, running some tests on bottled gas i.e. propane or butane, is a good introduction to this experiment. For that reason you might want to leave it to the 5th year as a lead-in to organic chemistry and a revision of some of the chemistry done at Inter-Cert.

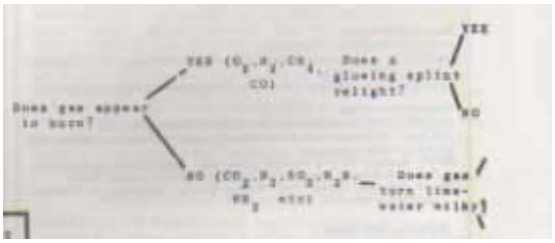
A suitable method of collection is illustrated below: use a funnel to channel the gas bubbles up into large test-tubes. Collect by displacement of water and several small samples are better than one large one, since many more tests can be done or tests repeated.



One of the problems is to distinguish between the common combustible gases: H_2, CO and CH_4. This could be discussed in class to come up with some ideas and even tested on pure samples, before tackling the bog-gas problem. When writing down tests for gases stress that useful test(s) should be unambiguous and that for most gases confirmatory tests are needed. The gas may of course be a mixture (like air) and this is quite likely for a natural sample. In this case the gas would give positive tests for more than one gas and this possibility should be made clear to pupils.

The use of a key to help in identifying the gas with the minimum of tests is a good idea to pinch from biology (thanks to Michael Moloney of TCE for this idea). A complete key is not given as you might have different gases but the sample below indicates what I mean:

Key for identifying some common gases



(N.B. Many pupils find it difficult to distinguish between burning and supporting combustion – hence the meaning of the first statement "appear to burn".)

Will-o'-the-wisp, Jack-o'-lantern, Ignis Fatuus, Elf-fire

A recent article in Chemistry in Britain (**16**, 69-72, 1980) by A.A.Mills reviews what is known about this elusive subject, "Will-o'-the-wisp", and his conclusion is: nothing much! It is usually identified with the spontaneous combustion of marsh gas in some undetermined way, but there is no evidence to support this. The actual origin of these strange, flickering lights seen at night in boggy places seems to be a mystery, and doesn't seem to be common today – perhaps too many people travel by car and not enough walk or ride through the countryside at night? Mills makes the suggestion that it may be some form of chemiluminescence which could produce cold light typical of reported observations of will-o'-the-wisp. However, this is only another hypothesis and remains to be tested. Can any Irish reader supply any recent information or examples on this fascinating but ephemeral topic? The article makes an interesting, if inconclusive, read.

Chemistry in Ireland

AMMONIA SYNTHESIS AT NET'S MARINO POINT PLANT

by T.MacSweeney, NET, Marino Point, Cork.

Introduction

NET, Nitrigin Eireann Teoranta, is the sole manufacturer of basic heavy chemicals in Ireland. This gives the company a unique place in the Irish chemical industry and makes it difficult to compare with other chemical producers in Ireland, where the growth essentially has been in pharmaceuticals, fine chemicals and in speciality products.

NET is also unique in exploiting two important native raw materials – natural Gas for the Kinsale Head Field to make Ammonia at Marino Point in Cork and Avoca Pyrites to make Sulphuric Acid in Arklow.

With the completion of the Marino Point project NET has joined the international league of big fertiliser companies and is uniquely positioned to lead the future development of the chemical industry in Ireland.

The company has had a very rapid growth since it first went into production in 1965, following a decision taken by the Irish Government four years before to establish NET with the task of setting up a native nitrogenous fertiliser industry.

NET's original factory went into production at Arklow, County Wicklow, in 1965 with a capacity of 120 tons of ammonia and 460 tons of nitrogenous fertilisers daily, initially calcium ammonium nitrate (C.A.N., NET Nitrate) and ammonium sulphate. Subsequently, the Arklow factory was extended to manufacture other intermediate chemical products and concentrated compound fertilisers, as well as additional C.A.N.

In 1975 the Government approved the construction of Ireland's biggest chemical plant at Marino Point in Cork Harbour, using the nation's first natural gasfield to make ammonia and urea.

In 1979 Marino Point, one of the world's largest and technologically most advanced fertiliser plants went into production, with a capacity of 1,350 tonnes of ammonia and 1,000 tonnes of urea per day. NET employs 1,500 people.

Ammonia and urea production at Marino Point

Ammonia is the basis for all nitrogen fertilisers and is manufactured at Marino Point by the synthesis from nitrogen and hydrogen, with natural gas as the basic raw material.

The gas comes from Ireland's first offshore field at Kinsale Head, discovered and developed by Marathon Petroleum and with a reserve of 1 trillion cubic feet. Piped underwater to Inch Beach in East Cork, it is supplied to NET by underground pipeline through an Irish Gas Board installation. Natural gas is mainly methane.

Fertiliser production, in helping to manufacture the food for the land which provides the food for the people, is a most efficient use of natural gas, adding considerably to the value of this national resource.

NET will use 40% of the gas field at the rate of 52 million cubic feet per day and its decision to opt for gas gave a considerable boost to the development of the Kinsale Head Field.

At Marino Point, natural gas, air and water are reacted together to produce ammonia in liquid form and carbon dioxide as a by-product. Some of the ammonia and carbon dioxide subsequently react together to produce urea in the form of small white particles or prills.

In engineering and construction terms, the NET complex at Marino Point represented the kind of challenge that is to be expected in organising a major petrochemical project. By world industry standards it is a major operation while, by Irish standards, it is probably the largest, technologically most diverse and complex construction project yet to be undertaken.

Taking advantage of the efficiencies of large scale, the ammonia and urea plants are quite enormous, covering many acres of site and extending high into the sky (see Figure 1). These plants incorporate the highest levels of chemical technology and presented many design and construction problems, which the international process contracting industry has learned to cope with. The ancillary facilities serving the production complex, such as marine jetty, cooling water pump house, product handling and storage facilities, railways and associated bridges, engineering and administration buildings, have also required many innovations in their construction. That this complex has been constructed almost exclusively by Irish workers is a tribute to their skills and abilities.

By-products

Associated with fertiliser production, NET makes use of by-product materials wherever possible. CO_2 from NET provides the bubbles in beers, lagers and minerals. NET is the largest supplier of CO_2 in Ireland.

The company is also involved in the manufacture of a very valuable substance, carbon black, which is used to provide anti-static qualities in underground electrical cables, on records, tapes and in other ways.

As well it uses gypsum, a by-product in the fertiliser manufacturing process at Arklow, to make plasterboard and associated products for the building industry. The sulphur component of the gypsum is mined in Avoca as sulphur pyrites. It is processed by NET into sulphuric acid, which in turn is combined with phosphate rock to form phosphoric acid and by-product gypsum.

To conduct this business, NET employs skilled personnel at all levels, from graduate engineers, and chemists, to technicians and craftsmen, to plant operatives who are provided with training to operate the complex sophisticated process, to clerical staff.

A future article will deal in detail with the NET Arklow plant.

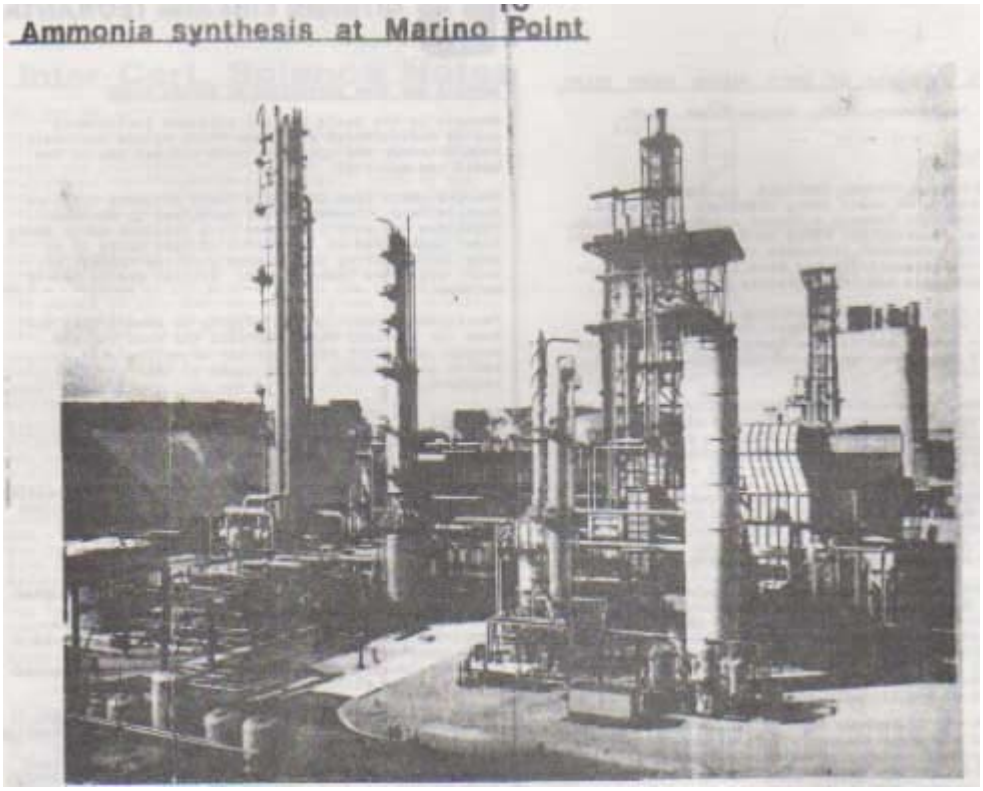


Figure 1 A general view of the ammonia/urea plant complex at N.E.T., Marino Point, Cobh, Co.Cork (Photo: N.E.T.)

The ammonia synthesis plant

NET's Marino Point project is basically about turning gas into grass, a simple statement covering a massive technological and engineering task of vital importance to Ireland's major industry – agriculture – which underpins the economic future of the nation and provides the food for its people.

There are three major elements in the ammonia plant:

1. the separation of the two components of the natural gas; carbon and hydrogen,
2. the removal of carbon in the form of by-product gaseous carbon dioxide and,
3. the combination of hydrogen with nitrogen from the air to form ammonia.

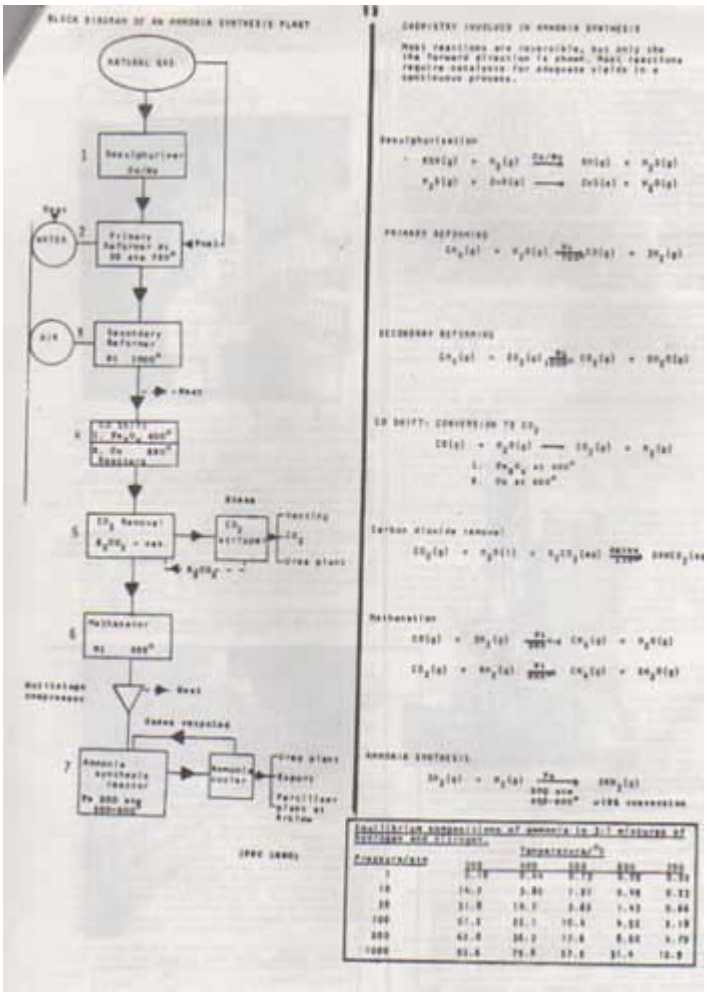
Initial separation of the gas takes place in a reforming furnace where the gas is "cracked" at a pressure of 35 atm. at 900ºC over a catalyst, with the reforming taking place in 520 catalyst-filled tubes and fired by 198 burners. The residual gas is burned with air, and nitrogen, which is contained in the air, is one of the requirements for the ammonia synthesis.

The plant incorporates five catalytic reaction vessels for removal of sulphur and for the conversion of carbon monoxide to the more readily removable carbon dioxide. Complete removal of carbon dioxide is achieved by scrubbing the gas stream with hot potassium carbonate solution under pressure at 100ºC. This solution is regenerated and continuously recycled.

To achieve conversion to ammonia from the pure gas now derived, now mainly hydrogen, the pressure must be raised to over 200 atm., which is done in a centrifugal compressor. Large centrifugal machines are a feature of the plant. Four are used: for air compression, synthesis gas compression, refrigeration and compression of carbon dioxide for the urea plant.

The final synthesis of ammonia (using the hydrogen and nitrogen) takes place over an iron catalyst at 200 atm. pressure and 400-500ºC.

A major feature of the ammonia plant is the very high utilisation of waste heat, partly through direct interchange but mainly to generate high pressure steam which is used in the process and for driving steam turbines which drive the compressors. Of a total energy demand of over 60 megawatts, for turbines, pumps etc., only 20% is derived from electric power. The scope for waste heat recovery is illustrated by the fact that the reforming process is carried out at 900-1,000ºC whereas the final ammonia is condensed out as a liquid at –33ºC. As a result, Marino Point has virtually a complete power station-type high pressure steam and cooling system with 300T per hour of steam being generated at 110 atm. and 500ºC, and a sea-water cooling utilisation of 5·5 million gallons per hour.



Manufactured ammonia is stored in two tanks, each of 15,000 tonnes capacity under refrigeration at –33ºC. These tanks have their own refrigeration plant. From Marino Point the liquid ammonia goes to NET's Arklow factory by sea and rail for processing into the company's well-known range of fertiliser products, including NET Nitrate and concentrated compounds (N.P.K's). The ammonia also feeds Marino Point's own urea plant producing 1,000 tonnes of urea daily both for the home market and for export. There is a growing world market for urea, while at home it will provide Irish farmers with the cheapest nitrogen in Europe.

While the entire production of ammonia is destined to be sold eventually on the home market, surplus production in the initial years of operation will be exported, bringing a multi-million pound boost to the Irish economy. Surplus production also provides supplies for other Irish users, including chemical and fertiliser concerns.

Ammonia from Marino Point is sought by many countries for use in the manufacture of Ammonium Sulphate, Nitric Acid, Ammonium Phosphate and Ammonium Nitrate, just a few products in which ammonia is the main raw material. Exports of ammonia and urea go direct from the Marino Point jetty where ships up to 25,000 tonnes dock.

The urea synthesis plant

The urea process consists of four principal steps:

1. the synthesis of aqueous urea solution,
2. recovery and recycle of unconverted reactants,
3. the concentration of the aqueous urea to a melt,
4. the prilling of the urea melt.

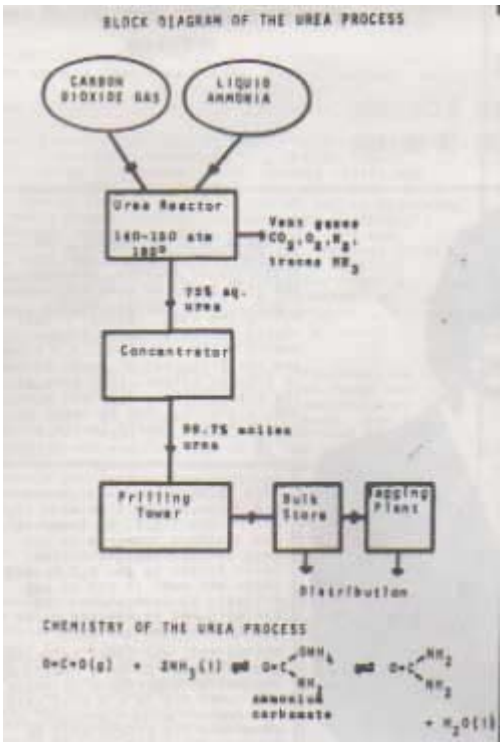
A flowsheet for the urea process is given alongside, and Figures 2-4 illustrate aspects of the plant.
(All photos: N.E.T.)

Anhydrous ammonia and pure carbon dioxide combine at high pressure (140-150 atm.) to produce ammonium carbamate (NH_4 (CO_2) NH_2) with the release of heat. This heat is used to produce steam which is consumed later in the plant. The ammonium carbamate is decomposed to produce aqueous urea solution. The unconverted carbamate is recovered in multi-stage decompression and condensation steps and recycled to the synthesis section.

After these steps, a 75% solution of urea in water is obtained. This is concentrated in a two-stage evaporation unit under vacuum to a 99·7% urea melt.

The molten urea is prilled, producing droplets, by spraying downwards in a rising current of air in the prilling tower. The droplets solidify as they cool and are removed from the base of the tower as white spherical particles or prills between 1 - 2·4mm. in diameter.

The urea bagging operation is completely automated, starting with a roll of printed plastic and finishing with neatly-stacked pallets of fertiliser for movement by road and rail, while automatic equipment also delivers bagged or bulk product to ships at the factory's jetty.



Unconverted carbamate and gases can be recycled.

USES

Urea is used as a fertiliser (46% N) particularly in the tropics. It is the most concentrated straight fertiliser.

Urea is also used to produce urea-formaldehyde resins and to produce melamine for the production of melamine-formaldehyde resins.

USING THE AMMONIA SYNTHESIS PROCESS AT SCHOOL

The ammonia synthesis process is one of the most important industrial syntheses, and NET's plant is the largest chemical plant in Ireland. It fixes the nitrogen in the air as ammonia (gas into grass) for use in making fertilisers, explosives, plastics, dyes etc. The raw materials of the process: air, water, and natural gas, are all indigenous materials. (Coal and naphtha from oil can also be produced electrolytically.) Ammonia is the second most important industrial inorganic chemical after sulphuric acid: about 50 million tons are used each year for fertilisers, and another 10 million tons for other uses. The modern process is essentially the same as that developed by Haber and Bosch in 1916, whose main achievement was to identify a cheap and effective catalyst. The thermal efficiency of the process has been increased from 20% to 60% by conserving

waste heat, the catalyst has been improved by using promoters and the cost/ton has been reduced ten-fold. It is now only economic to produce ammonia in large (~1200 ton/day) plants as at Marino Point, and only then if a cheap feedstock is available.

The ammonia synthesis process is a good example of chemistry in action which also illustrates the basic chemical theories done at school. The synthesis reaction:

is an exothermic, reversible reaction. It gives an excellent illustration of the factors affecting equilibrium (Le Chatelier's principle) and also shows the interplay of thermodynamic (energetic) and kinetic (rate) factors in determining reaction conditions for an economic process.

Effect of temperature

The reaction is exothermic and so increasing the temperature favours the backward reaction: the yield of ammonia falls as the temperature is raised. The data in the table on p.11 show that increasing pressure at constant temperature increases the yield of ammonia.

It would thus appear that we would choose a high pressure and a low temperature to get maximum yield from the reaction e.g. 1000 atm and 300ºC. In practice this does not work. The reaction is too slow at low temperatures, even with a catalyst, to achieve equilibrium in a reasonable time. A higher temperature and a catalyst must be used to make the reaction fast enough: the yield of ammonia thus drops.

High temperatures and pressures are costly in energy and require more expensive equipment to withstand the extreme conditions.

In practice pressures in the range 150-200 atm and temperatures of 400-500ºC are chosen, with an iron catalyst promoted with potassium hydroxide and other metal oxides. This gives an equilibrium yield of ~15%. The process is made to operate continuously by removing the ammonia product by refrigeration as liquid, and recycling the unreacted gases. A 1:3 mole ratio of nitrogen:hydrogen is kept throughout, and is adjusted by varying the amount of air added to the Secondary Reformer.

The importance of catalysts in industry can be seen from the number used at different stages in this process. Sulphur must be removed right at the beginning because it poisons the catalyst in later stages. Similarly all carbon monoxide must be removed in the Methanator stage as it poisons the ammonia catalyst.

Institiuid Ceimice na hEireann
THE INSTITUTE OF CHEMISTRY OF IRELAND

Photograph – Presentation of the Institute's medal for the best performance in the 1979 leaving certificate chemistry examination, p.14

24th TEACHER'S REFRESHER COURSE

The 24th Annual Teacher's Refresher Course was held this year from 3rd.-4th. January at the College of Technology, Kevin Street, Dublin. This year's course kept up the high standard of previous years and was attended by over 50 teachers. The course is recognised by the Department of Education as an in-service course.

The course opened with "Inorganic Chemistry – an integrated approach" by Henry Lyons (now at Tralee R.T.C.) who stressed the need to make the Inorganic chemistry relevant by including examples from Irish chemical industry e.g. ammonia synthesis at N.E.T., Marino Point. A new and welcome feature of the 1980 course was the introduction of lectures on chemical education, as distinct from chemistry alone. Brian McGarvey gave a fascinating introduction to the mismatch between what we teach and how we teach it. His talk, entitled "Teaching strategies and definitions of chemistry", is summarised on p.3 of this Newsletter.

As in previous courses, the high spot for many came in the afternoon of the first day when four teachers gave examples from their own teaching. Randel Henly rushed in, demonstrated several dramatic kinetics experiments, and rushed out to spend a sabbatical term at York University, on their Chemical Education course. Adrian Somerfield delighted everyone with his advice on cocktail mixing: that is doing the thermochemistry experiments in a corked thermos flask. The microchip was not forgotten as Joe Chester tried to persuade us that computer chemistry was possible at school. (An account of his work done with a Colaiste Choilm pupil has appeared in Education in Chemistry, 16, 5 (1979)). Finally Dick O'Connor enthused over the beauty and usefulness of gas syringes for experiments involving gases. There were plenty of ideas thrown out so that everyone could take some new ideas home to try in their school. But there is obviously a need for some enthusiastic women chemistry teachers to show off their ideas in this forum. Any volunteers for the 25th course?

The second day started well with Dr.Melody getting stuck into a brief, but illuminating account of the range of modern "Adhesives": their uses, chemistry and properties. Roy Brown then attempted to clear up our misconceptions with "A balanced treatment of equilibrium", including many demonstrations and a

useful article to take away and digest. On both days there was time for discussion, in two groups, with a general session on the last day; with much discussion of the syllabus revision, the 'examination problem' and the swing towards biology. Some of these points were taken up and amplified by Peter Childs in the final lecture, "Trends in chemical education." In another new departure for the Refresher Course this lecture was held at the R.D.S. in conjunction with the Aer Lingus Y.S.E. Workshop. A few teachers appeared to get lost in the transition from Kevin Street to the R.D.S., but those who made it had an opportunity to look around the exhibits and to see the presentation of the awards.

All in all, the 24th Refresher Course seemed to be a rewarding and useful experience to those who came, but it's a pity that the numbers weren't greater. All those who did attend will be looking forward to the Silver Jubilee of the Teacher's Refresher course in 1981. If anyone reading this didn't make it this year, why not make a date for next year?

Our thanks are also due to all those who organised this year's course, particularly Noel Fitzpatrick of U.C.D.

It is hoped to publish more of the lectures and ideas for experiments given at the 24th Refresher Course in "Chemistry in Action", in order to make them more widely available to chemistry teachers.

In-Service Education

IN-SERVICE COURSES: what use are they?
Some answers from Anne Mulroy, Loreto College, Stephen's Green, Dublin.

What courses or conferences have you attended?

Since entering teaching in 1977 I've attended quite a few courses and conferences: I.S.T.A. annual conferences in Dundalk (1978), Dublin (1979) and Kilkenny (1980), and I.S.T.A. sponsored evening courses in Biology at T.C.D. (1978) and in Chemistry at Kevin Street (1979): Institute of Chemistry's refresher courses at Kevin Street in 1979 and 1980: A.S.E. Annual Conference in Liverpool 1978: the Third International Conference in Chemical Education, Dublin 1979. I'm currently doing a Diploma Course on "Computers in Education" at T.C.D., part-time in the evenings.

What value did you get from them?

The first thing they gave me was confidence, in that I picked up ideas for practicals that would work in a school. I also got ideas for presentation as I needed exact guidelines of how to teach. Now I still go to learn new ideas, but now they are for extension and modification of my own ideas. I enjoy the dialogues between teachers and the mental stimulus provided by the lectures. I'm more interested now in education, as distinct from the subject content, and I need a wealth of experience to draw on.

What general use are in-service courses to science teachers?

I think that many teachers feel that our subject may be getting ahead of us and unless we keep up-to-date we may be left behind. This is one reason for going on in-service courses. They also provide a medium for evaluating our system of teaching, and for the exchange of ideas that allows us to extend our own. There is also an important social element, and a sense of unity in meeting colleagues in the same field. There is also an indefinable residue that remains after a conference – maybe a sentence, an idea, a demonstration, but it keeps us going until the next one!

How do teachers find out about courses?

Finding out is a problem. Teachers hear about courses through friends, through circulars from active I.S.T.A. branches and by publicity from bodies running courses like the Institute of Chemistry. Not everyone does hear about courses and that undoubtedly affects attendance.

Why didn't you find out about the I.S.T.A. until 2 years ago?

I just didn't hear about it, and I think many science teachers must be the same. In fact, I had to go to an A.S.E. conference in Liverpool to find out about our own I.S.T.A.!

Would you advise science teachers, especially new ones, to get involved with I.S.T.A.?

Certainly, but the help young teachers need isn't the same as that needed by experienced teachers. Young teachers need exact guidelines as to what and how to teach, run practicals, etc., whereas more experienced teachers need the broad ideas. The I.S.T.A. is good but full of experienced and keen teachers, and not many new teachers seem to be members. The British equivalent, the Association for Science Education, A.S.E., is a very efficient organisation but has limited application to the Irish scene. Their publications are very comprehensive and very useful, and I can recommend them strongly.

What can be done to improve existing in-service courses in Ireland?

I can't see much wrong with the ones we have now. Courses must be relevant to what is actually taught in the schools and be of direct practical use in order to encourage teachers to attend.

Why don't more teachers attend the courses that are available?

One main reason is the lack of financial help from the Department of Education

which means that only the keenest and most active teachers go to courses. We need more support and encouragement from the Department for In-Service course in Ireland.

(Anne Mulroy teaches Inter-Cert. Science, Leaving Cert. Chemistry, and Leaving Cert. Mathematics at a fee-paying girls secondary school in Dublin.)

Molecules in the news:

2,4,5-T or 2,4,5-trichlorophenoxyacetic acid.
This apparently innocuous molecule is a potent herbicide better known as 'Agent Orange', as used in Vietnam. It often (if not always) contains dioxin as an impurity, one of the most poisonous chemicals known. This is the chemical notorious from Seveso and now thought to be responsible for birth defects in the children of Vietnam veterans, as well as many serious symptoms amongst the veterans themselves. (N.B. it is the impurity not 2,4,5–T itself that is the main problem.)

"Experience is as to intensity, not to duration."
Thomas Hardy

"Not only does science begin in wonder, it also ends in wonder."
A.Maslow

Leaving Certificate Chemistry Notes

THE ELECTROCHEMICAL SERIES

Pat Browne, North Monastery C.B.S., Cork.

The following is a series of simple demonstrations used in the early stages of study of the Electrochemical Series for the Leaving Certificate course.

1. Metals Displace Lower Metals from Solutions of their Ions

The usual demonstration for this is to dip an iron nail into a solution of Copper (II) Sulphate (VI). The copper formed is usually either non-crystalline or the crystals are very small. Various other combinations may be tried but most of them tend to be messy and lack excitement.

My favourite combination which is clean and beautiful to look at is Copper and Silver Nitrate (V). There are three equally satisfactory ways to do the experiment.

(a) Prepare about 50 cm^3 of Silver Nitrate (V) (0·05 M) per student. Place this in a beaker and stand a piece of thick copper wire (0·5mm diam. or larger) into it. (I have used several thin wires twisted together quite satisfactorily).

Left overnight a beautiful growth of crystals of silver appears which may be examined with a hand lens or better still a binocular microscope at 40X. Pupils almost invariably describe the result as like a “forest of Christmas trees.”

(b) If you can get a small glass cell to fit a slide projector (2” x 2”) a very small volume of solution and a very fine copper wire will give the same effect very quickly and the crystals can be seen to grow. (It is possible to make such a cell and I hope in a future note to give details since it is a generally very useful item.)

(c) My good friend Mr.D.P. MacCann has devised a variation using an Overhead Projector. The solution is contained in a petri-dish on the O.H.P. The copper wire is placed therein and again the crystals of silver grow visibly.

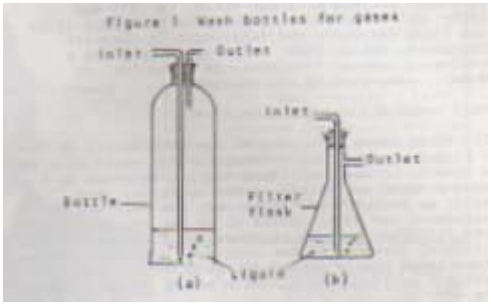
2. Non-Metals Displace Higher Non-Metals from Solutions of their Ions

It is useful to emphasise that the non-metals also fit into the series.

Set up a standard chlorine generation apparatus to produce pure chlorine. It is essential that HCl be removed by bubbling the gas through a Dreschel bottle of water. It is pointless to dry the gas.

In a second Dreschel bottle place a solution of iodide or a bromide to a depth of 5-6 cm. Bubble the chlorine through the solution. The Iodine or Bromine appear quickly and with iodine will quickly reach a concentration at which crystals appear.
(This reaction should only be done in a fume cupboard).

Dreschel bottles are sometimes called gas washing bottles. It is possible to make them up as follows (see Figure 1 (a)).
Fit a two holed rubber stopper with two L-shaped pieces of glass tube, one long and one short. Place the stopper in a glass bottle so that the long tube is about 0·5 cm. from the bottom and the short one projects only 0·5 cm. from the base of the stopper.
(An alternative is to use a filter flask with one glass tube dipping to the bottom as the inlet, see Figure 1 (b). Ed.)



REMEMBER the long tube is the inlet. Reversal of the tube functions could be

dangerous.

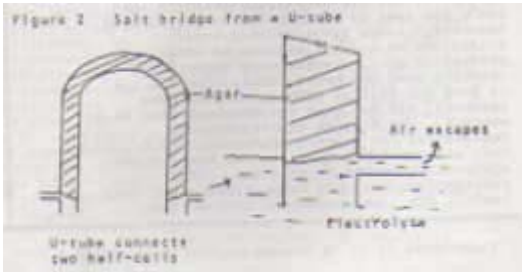
3. Electrical Half-Cells and Salt Bridges

The electrical potentials of various metals can be compared to a standard quite easily. A possible standard, in the absence of a Hydrogen electrode (Which will almost certainly be absent!) is a carbon rod in an acid solution.

Prepare a beaker for each metal rod available, (Zinc, Copper, Iron, Magnesium, Aluminium and Lead can be tried), and fill it with a solution of a salt of the metal (0·1 M). Prepare a beaker of 0·1 M HCl for the carbon rod also. Each beaker with the appropriate rod standing in it forms a half-cell.

Melt enough Agar in water to produce a good stiff gel, in volume sufficient to fill a U-tube completely and dissolve some Sodium Chloride or Iron (II) Sulphate (VI) in it. Fill the U-tube and allow to cool and solidify, (5g Agar/100 cm^3 water should be more than ample).

The U-tube can now be inverted and used as a salt bridge between the beakers. It is essential that there is contact between the liquid and the jel. Using U-tubes with side arms I find the ideal situation is to allow the molten jel to rise until it just begins to pour out. When the jel is solid the side tube is cleared so that air can escape as shown. (Figure 2)



The carbon and metal rods can be connected to a sensitive voltmeter (F.S.D. 2-3V) or pH/mV meter and when the salt bridge connects the two solutions the appropriate reading will be obtained on the meter e.g. Zn vs. C. 1·5V approx.

Safety

SAFETY

Safety should be of paramount importance in conducting science lessons. The science teacher has the main responsibility for safety in his/her laboratory. The teacher should both teach and practise good safety habits, and should instil these into the pupils. The potential dangers inherent in handling any chemicals or apparatus should not be used as an excuse for avoiding practical work. Learning to work safely with chemicals and apparatus is an important part of any chemistry course. Going to and from schools, and playing games, are in fact much more hazardous than doing practical work in science. In the U.K. there is a long tradition of doing practical work at second-level, from 11 upwards, and the school laboratory is still one of the safest places to be! One cannot eliminate all hazards or accidents in any aspect of life. An intelligent approach to safety, and constant attention to the safety aspects of every practical lesson, can avoid most accidents. I have heard of more than one Irish school which does not do practical work in chemistry because of the 'problems' of safety. This is no excuse, as many other Irish chemistry teachers in other schools would tell them. In fact, there are strong indications from the leaving certificate results that the best results are obtained consistently in schools where lots of practical work is done. Perhaps there is a lesson to learn there?

Training in safety should be part of every science teacher's training, and every laboratory should contain a suitable book on laboratory safety for reference and revision. Some suitable books are listed below. Similarly every student doing science must receive some general instruction in safety procedures, in addition to instruction before every practical session on the appropriate safety precautions.

"Chemistry in Action" will have material on Laboratory Safety in every issue. It may be that there is a need for a booklet or short in-service course in Ireland on general safety procedures, and on safe ways for handling dangerous chemicals. Your comments and contributions on this subject will be welcome, including accounts of accidents in your laboratory in order to help others avoid them.

Books on safety in the laboratory

'A safety handbook for science teachers', K.Everett and E.W.Jenkins, Murray, 1976

'Laboratory safety', P.Armitage and J.Fasemore, Heinemann, 1977

'School science laboratories', Archenhold, Jenkins and Wood-Robinson, Murray, 1978 (see Reviews) ch.3

'Hazards in the chemical laboratory', Muir, Chemical Society, London, 1977 (the most comprehensive listing of hazards)

'Safety in the chemical laboratory', May and Baker, 1977, free

MERCURY POISONING

There is widespread awareness of the dangers of mercury compounds in the environment, particularly since the disaster at Minamata, Japan, in 1950. (1). However, even quite small spillages of elemental mercury will quickly generate

toxic levels of mercury vapour in poorly ventilated laboratories. Confined in a closed room at 20ºC, mercury will evaporate to its equilibrium vapour pressure of 13·2 mg m-3, which is 265 times the 0·05 mg m-3 limit established for occupational exposure by an international committee (2).

In a recent study under real laboratory conditions (3), mercury levels of 0·3 mg m-3 were found in a laboratory with open doors, and in closed cupboards and storerooms the level approached the equilibrium vapour pressure.

The hazard of spilled mercury can be greatly reduced by thorough clean up of mercury droplets. Perhaps the most common method is to suction the droplets through a pipette into a reservoir connected to a vacuum pump. Once larger drops have been recovered, sulphur can be sprinkled on the area, converting remaining droplets to the non-volatile sulphide.

In school laboratories complex monitoring systems are unlikely to be used. It is therefore important to anticipate spillages when planning and conducting experiments. Perhaps the best precaution is not to use mercury at all unless no alternative experiments or materials may be substituted (2). All mercury should be kept in closed containers and open surfaces e.g. in manometers, covered with a thin layer of oil.

JBC

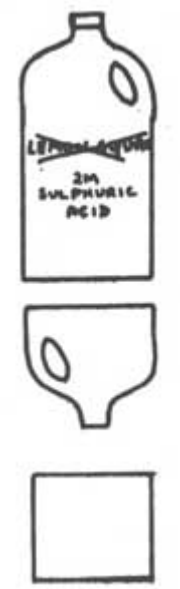
REFERENCES

(1) D.H.Klein, J.Chem.Ed., **49** (1972), 7
(2) Pure and App.Chem., 1979 (2), 4
(3) T.M.Letcher, Chem. SA, 1978 (12), 54

ChemTips

PLASTIC BOTTLES IN THE LABORATORY

Glassware is breakable, expensive and has to be obtained from laboratory suppliers. Many items of laboratory glassware can be replaced by plastic items, providing that heat is not involved. Also in some cases organic solvents may dissolve some types of plastic.
What are the advantages of plastic labware? Plastic items are unbreakable in normal use and are much safer from this aspect alone. Many items of use in the laboratory can be obtained from local suppliers or even scavenged from throw-away items, and are inexpensive.
Storage of laboratory solutions often presents a problem and glass stoppers invariably get stuck on standing. Most bottles in school laboratories are also too small to store large quantities of solution e.g. enough for a class or to store left-over solutions. The 2 litre or 4 litre plastic squash bottles are ideal for storing most aqueous solutions in the laboratory. They are light, unbreakable and have handles, making them easy to pour, and are free – ask your pupils to bring in empty bottles and you'll be overwhelmed.
The bottles are blow moulded in one piece and have no seams to leak, and are probably made from high density polythene (HDPE). This is chemically inert and is actually better for storing many solutions than glass.
A recent note in Chem13 News (February, 1980, no.111) suggested using the new 2 litre soft drink bottles (Coca-cola etc.) for the same purposes. These bottles are taller and not as stable, have no handles and have a seam at the bottom which can leak. The bottles available in Ireland with fruit squashes (Robinsons, St.Bernards etc.) are much more suitable. Cut in half the bottles can be used as beakers, stands for round-bottomed flasks and pouring funnels.
The article in Chem13News also suggested that the bottles could be used to determine the molecular masses of gases very quickly and easily. I have tried this and it works well.



CAN YOU THINK OF ANY MORE USES FOR THESE PLASTIC BOTTLES?

MOLECULAR MASSES USING PLASTIC BOTTLES

The experiment consists of weighing a given volume of air (in a 2 L plastic bottle) and then weighing the same bottle full of air. From room temperature and pressure the density of the air can be obtained from a Book of Physiochemical Data. Hence the mass of the unknown gas with a volume of 2 L at room temperature and pressure can be found and this is converted to the volume this mass of gas would have at S.T.P. 1 mole of an ideal gas at S.T.P. has a volume of 22·4 L and hence we can find the molecular mass of our gas.

Sample result using Kosangas

Weight of bottle + lid + air = 75·46g

At 20ºC and 1 atm, density of dry air is 1·205 x 10-3 g cm^{-3} (from tables)
2 L of air thus weigh 1·205 x 10-3 x 2000 = 2·41g
Bottle + lid thus weighs 75·46 – 2·41 = 73·05g

Bottle was flushed well with gas from the tap using rubber tubing going to the bottom of the bottle.

Weight of bottle + lid + Kosangas = 76.68g at 20ºC
N.B. Kosangas is obviously heavier than air.
2 L of Kosangas at 20ºC thus weigh 76·68 – 73·05 = 3·63g

What volume would this weight of gas occupy at S.T.P. i.e. 0ºC and 1 atm pressure?
Volume at S.T.P. = 2 x 273/293 = 1·86L
22·4 L of gas at S.T.P. contains 1 mole

Thus molecular mass of Kosangas = 3·63 x 22·4/1·86 = 43·7 g mol^{-1}

N.B. I didn't know what the atmospheric pressure was and I should have corrected for this.

Kosangas is quite clearly propane, molecular mass = 44 g mol^{-1}, not methane or butane.

This experiment is quick, easy to perform and fairly accurate – enough to distinguish between common hydrocarbons. Camping gas cylinders (blue) are a convenient source of butane. Oxygen, ethyne (acetylene), carbon dioxide, nitrogen and sulphur dioxide are fairly easily obtained in cylinders, or gases can be prepared and dried in the laboratory.

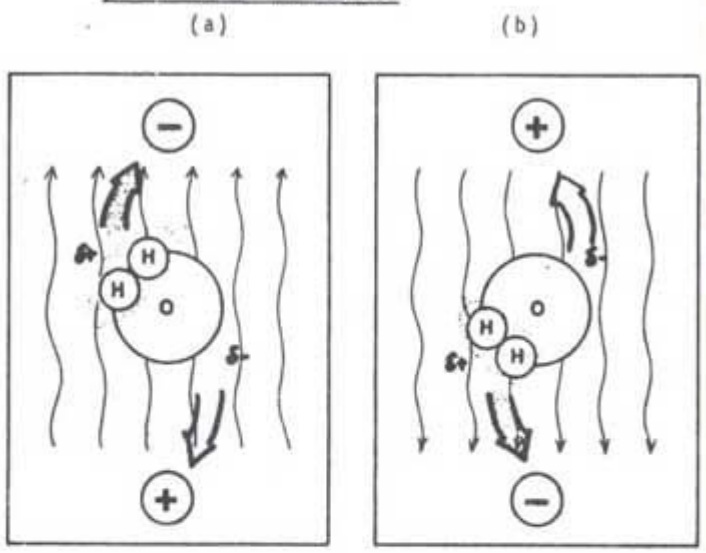
SAFETY GLASSES: EXCESSIVE OR ESSENTIAL?

It has become widely accepted in most countries that proper eye-protection is necessary for school students doing experimental work, particularly using chemicals. In the U.S.A. and the U.K. this is now a legal requirement. Very few Irish schools where practical work is done appear to use safety glasses as a routine procedure for all pupils doing practicals. The use of safety glasses or goggles makes practical work safer and would have prevented many serious accidents. It is worth remembering that skin tissue regenerates, but eye tissue does not. The financial investment to equip every pupil with eye protection is well worth it if one eye accident is prevented.

WATER POLARITY AND MICROWAVES

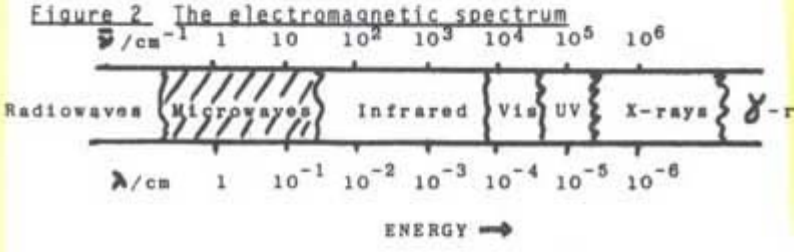
What do microwave ovens have to do with the polarity of water molecules? The answer lies in the oscillating electric field set up by the microwave field. Polar molecules, such as water which is present in all foods, have a positive and a negative end. This dipole tries to line up with the electric field (see Figure 1(a)). Unfortunately the microwave field changes polarity 5 billion times per sec at the frequency usually employed (2450 MHz). The water molecules reverse their direction to try and follow this change (Figure 1(b)) and end up oscillating madly 5 billion times per sec, generating heat by friction all through the food. The microwave energy is only absorbed by the cooking food and cooks uniformly all through the food, taking a few minutes instead of hours to cook a joint, for example, and consuming much less energy. The microwave oven must of course be shielded to prevent leakage of radiation into the kitchen since we also contain water!

Figure 1 Interaction of microwave radiation with polar water molecules



(Adapted from a diagram in Science Dimension, 1979/3)

Figure 2 The electromagnetic spectrum



The property of microwaves to interact with polar molecules is also used in microwave spectroscopy. The microwave region of the electromagnetic spectrum (Figure 2) occurs between the infrared and the radio frequency regions. Molecules possess rotational energy and a set of rotational energy levels whose spacings correspond to energies in the microwave radiation of the correct frequency, absorbing energy and increasing its rotational energy. The spectrum can be interpreted to yield very precise molecular parameters and the resolution is high enough to distinguish isotopic species. Every polar molecule has a characteristic microwave spectrum which can be used as a molecular fingerprint, though non-polar molecules cannot absorb microwave radiation. The ability of microwaves to travel long distances and their highly specific molecular fingerprints are the reasons why microwave spectroscopy has been used to identify molecules in interstellar space. Over 40 different molecular species (some of them isotopic isomers) have so far been identified in this way out among the stars.