SCOTTISH SCHOOLS EQUIPMENT RESEARCH CENTRE

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HAZARDOUS CHEMICALS

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My Computer

Science & Technology Bulletin

For: Teachers and Technicians in Technical Subjects and the Sciences

Science and Technology Bulletin

Number 195   Autumn 1998

INTRODUCTION

Thinks :"Here we go again then, blank screen. Autumn Bulletin already and still only August[1] - at least it feels like Autumn and it's better than marking internal assessments. You'd think the mince would come easier after a hundred and twenty odd Bulletins. You'd be wrong. Wonder if Editor's block is a recognised occupational disease?

Too jolly is it? I'll give 'em jolly."

Christmas closure

The Centre will be shut for Christmas and Hogmanay as from close of business on Wednesday 23rd December, 1998 until Monday 4th January 1999. Not being good at the maths, we've only just worked out that, with a measure of sanity and sobriety here, Bulletin 200 should be published at or around Hogmanay 2000. The smart money's probably already in paracetamol and orange-juice shares

Evaluation draw

The meteorologicals notwithstanding, three prize-winners have emerged triumphant in Grand Summer Draws. Given that all of them are council employees, we had best reassure you all that the process was S-word free. A student working over the Summer (analysing the returns) wrote a wee routine also to randomize them. They never felt a thing and vice-versa. Each will shortly receive a brown envelope with their share of a lantern slide of a fortune in ha'pennies[2]. Since none them ticked a "No publicity" box, on account of how there wasn't one, the winners were as follows (in reverse order) :

> *Third Prize (Ezirp Drith?) : Iain Mackenzie, Grangemouth High School.*
>
> *Second Prize : Joy Snape, Education Department, The Scottish Borders Council;*
>
> *First Prize : Brian Rookley, Stranraer Academy.*

Seriously folks[2] - many thanks again to all those who took the trouble to send in forms. We achieved an overall ten percent return which, without pre-paid replies, was gratifying. Many a commercial marketing department would be happy with a one or two percent reply level. The report is now more or less written. Courtesy and fear demand that it go first to our Steering Group and the SSERC Board before much more is written for these pages, except that the effect of taking respondents' advice should appear in this and future issues.

Footnotes: 1. Sorry this edition is actually a tad late. We had been ahead of the game until yours truly attempted to demonstrate Newtonian mechanics with two dogs and a Mitsubishi Shogun. Result dogs/parked vehicle combo one, Richardson nil 'cept for three cracked ribs and a popped collar bone. "Cest lavvy" as they say in Glasgow. 2. *The Goons.* A lantern slide of a fortune in ha'pennies was the prize in their "*First team to man- (sorry, 'person') handle a Grand Piano to the Summit of Everest*" Competition. Was this an early training session for *Higher Still?*

Interactive HazMan is here

The interactive web-style version of SSERC's *Hazardous Chemicals : A Manual for Science Education*, is now complete and available for purchase on CD.

Schools or authorities which have already bought the hard-copy folder are offered favourable, discounted terms for the CD which comes with a Site Licence as standard. See page 21 or our new Web Site for more information.

The CD format, which applies proprietary web browsers in an off-line mode, is ideal for accessing health and safety information quickly - generally within 2 or 3 mouse clicks.

The CD can be used on stand-alone, networked or intranet based PC, Apple or Acorn computers with CD drives and web browser software. Fife Council has already purchased an Authority Licence for its intranet. Therefore Fife schools linked to this closed network can access an on-line version of the Manual.

SSERC are also in negotiation with other Scottish EA's for the distribution of the Interactive Manual.

Reminder - ASE meeting

With any ordinary luck, and some simple synchronised desktop publishing to Olympic standards, this Bulletin should carry within it a copy of the programme for the ASE (Association for Science Education) Scotland, 1999 Annual General Meeting. That in turn should have in or on it, a booking form for the annual meeting in St Machar Academy, Aberdeen in March 1999. See me, see logistics - nae bother! Can I open my eyes now?

Meet the markers

We have had provisional notice of a series of science subject meetings for Higher Still, instigated through ASE Scotland and which have been agreed to by the SQA (Scottish Qualifications Authority). There will be twelve meetings in all, three sessions on each day, held at four different venues throughout Scotland. At each venue, teachers of each major science subject will have the chance to discuss Higher Still assessment arrangements with relevant SQA examiners. Dates and venues are as follows:

> Saturday 28th November 1998 : Robert Gordon's College Aberdeen.
>
> Tuesday 26th January, 1999 : Strathclyde University, Glasgow.
>
> Wednesday 10th February, 1999 : Moray House Institute of Education, Edinburgh.
>
> Monday 22nd February, 1999 : Northern College, Dundee Campus.

STOP PRESS - New SSERC Web Site

To tie in with the new improved *Scottish Virtual Teachers' Centre* (http://www.svtc.org.uk) we have revised the look of our Web Site therein. Take a peek at:

http://www.svtc.org.uk/resources/sserc

COMMENT

More beachcombings

Webs - strictly for arachnida and anoraks?

Probably not. Despite our comments in the last issue [1] we are not so daft as to see the Net and Web as entirely irrelevant educationally (see next piece). We judge that such ICT facilities may well become effective for learning and teaching, but only when more chalk-scarred veterans get wired-in. In the meantime, it is by no means all bad and there is at least some fun to be had. Surf doesn't just wash up electronic flotsam and jetsam. It also uncovers the odd gem. Witness the site with bits devoted to the seminal laws of cartoon physics - eg :

> "A body passing through a solid barrier always creates a shape exactly correspondent with its perimeter."

OK, some of the humour is feeble (nothing new there then). Apposite to the recent publication of the *New Oxford English Dictionary* is a bit of website devoted to:

> *"The 44 rules of writing good English"*

Lack of space precludes a full listing but here a few of our own favourites :

Rule 5	Don't use no double negatives.
Rule 10	About sentence fragments.
Rule 13	Its important to use apostrophe's right.
Rule 14	Don't abbrev.
Rule 15	Always check to see if you any words out.
Rule 17	Don't use a preposition to end a sentence with.
Rule 18	Never obfuscate documentation with archaic, pretentious, flowery or ostentatious language.
Rule 22	(a) Don't use a foreign term if there is a perfectly good English *quid pro quo.* (b) If you must use such a term it is *de rigor* to spell it correctly.
Rule 25	Avoid hyperbole. There isn't one writer in a million who can employ it correctly.
Rule 27	Mixed metaphors are a real pain in the bum which should be thrown out of the window.
Rule 40	Never use a long word when a more diminutive one will do.
Rule 44	Last but not least, avoid clichés like the plague. They are, without a shadow of doubt, old hat.

More firsts

Apropos le Nouveau Oxford Dictionary (and breaches of Rule 22) do, please, remember 'twas herein that you probably learned how to gaily split an infinitive [2]. And, who told you (in that same piece) that it was alright to start a sentence with a conjunction?

Single sentence paragraphs are also allowed, so stick with us to boldly go . . .

References
1. *Equipment matters*, Bulletin 194, SSERC, Summer 1998.
2. *Pedants revolt*, Bulletin 186, SSERC, Autumn 1995.

IT matters too

We are a bit concerned that the publication in the last issue of "Tae a moose" and of another related piece "Equipment matters" may have given the impression that we too suffer from what has been charmingly dubbed, in post-modern spinnese, *attitudinal conservatism.* Since that could be financially serious, possibly terminal, we think it prudent to redress the balance.

We are not alone. The Scottish Science Advisory Group (SSAG) is also worried about the twin issues of funding for apparatus or materials for science and technology courses and information and communications technology (ICT) equipment. These twin demands or concerns are not mutually incompatible. SSAG has taken the issue sufficiently seriously to have set up a special Task Group on ICT. We all need to get our act together, and quickly, if science and technology departments are not again to miss important opportunities to update, and trustfully improve, learning and teaching.

There are relevant sections of a briefing paper on "Baseline IT" written for Senior Managers by the Higher Still Development Unit. At best, however, these asserted much that is debatable and at worst have omissions which in some circles seem to raise questions of knowledge or competence. Neither has helped matters.

The SSAG Task Group has identified a number of points for action. These may be categorised as follows :

- The need to raise ICT awareness and aspirations so as to avoid acceptance by too many science and technology departments of yet more *hand-me downs* from computing or business studies. We might expect - very probably need - practical empiricists, like science and technology teachers, to be in the vanguard of current ICT provision not trailing behind merely picking up crumbs.

- Requirements of datalogging and interfacing for investigative practical work and control. These include updating standard apparatus to support such activities and the supply of more systems, each with a much smaller *footprint,* for pupil or student based practical activities.

- The need to update computers and software to improve capabilities for manipulating, analysing and displaying data.

- The necessity of access to advanced communications facilities. This is for a host of reasons, including better resourcing and co-ordinating of educational activities both in and outwith the formal school and college environment.

- The criticality of training, the lack of which was behind major failures and inefficiencies in some past provision, leading to equipment gathering dust or lying unused in its original boxes.

The Task Group is due to report back to the members of SSAG sometime before Christmas. We will keep the readership informed as to any policy statements or action plans which follow from the main advisory body.

SAFETY NOTES

Accidents

Real life examples can be powerfully persuasive in modifying or moderating careless behaviour. Instance the witnessing of a road accident, where subsequent reduction in the average driver's speed seems directly related to the degree of carnage.

The writer's first occupation, Polar survey work, was of a relatively hazardous nature followed largely in a hostile environment. There had been ten fatalities in the ten year period before I started. With a workforce of about 90, the fatality rate thus had been roughly one in one hundred a year. By modern occupational safety standards this is a level of risk so outrageously high as to appear fantastic.

Management responded by giving us a safety lecture. Each accident was analysed. In only one out of the ten fatalities could they show that death had not been the result of human error, but of factors outwith anyone's control. God did not play his hand often! This lecture had a suitably shocking effect on my subsequent behaviour at work, both in that employment and elsewhere.

In its guidance on industrial safety [1], HSE state:

It is now widely accepted that the majority of accidents in industry generally are in some measure attributable to human as well as technical factors in the sense that actions by people initiated or contributed to the accidents, or people might have acted better to avert them'.

The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995, known as RIDDOR, was put in place to generate reports to the Health and Safety Executive (HSE) and to local authorities. By analysing accident statistics, the enforcing authorities can see where and how the risks arise and spot trends. Appropriate, effective, responses then may help prevent further injuries, ill health and accidental loss.

An accident is an unplanned event causing harm to persons or property. Harm to persons includes physical injury, ill health, or a loss of business opportunity. (Criteria for deciding when to report an injury under RIDDOR are explained in the following safety note.)

Because accidents are so often the result of human error, there can be reluctance to report them - out of embarrassment, or fear of adverse publicity, or even of a criminal prosecution. A sense of proportion is called for. In the HSE's reporting year of 1995/96, the total number of court actions in the education sector brought by the HSE was four throughout the whole UK, and resulted in four convictions. Yet the number of injuries to students in the preceding four years averaged 4800 a year (Table 1). It is important to realise that the enforcing authorities try to improve safety or working conditions by persuasion and guidance rather than by litigation. The carrot is far, far more prominent than the stick! Data gathered under RIDDOR is used primarily to help the HSE decide where to strew carrots. It is a commendable scheme which has the protection of persons at work at its heart.

Process or environment	91/92	92/93	93/94	94/95
Teaching activities	379	287	270	253
Gyms, sports halls	1506	1295	1394	1371 /1
Swimming pools	28 /1	20	16 /2	30 /1
Playing fields	1371	1062 /1	1028 /1	1127 /2
Playground	733 /1	491 /1	548	638
Extramural activities	88	85 /5	114 /1	80 /1
Laboratories	42	32	43	31
Craft workshops	28	16	15	15
Art, pottery workshops	9	3	4	8
School gardens	12	4	4	5
Home economics	4	1	4	7
Play, including indoor play areas and playgrounds	682	423	410	601 /2
Events - theatre production, open day, assembly	34	35	28	30
Technical support services	4	3	1	2
Meal preparation	-	1	2	1
Administration	3	1	1	-
Amenities	71	45	42	59
Maintaining	1	2	-	2
Services	-	1	-	-
Packing	1	-	-	-
Loading/unloading	5	1	3	3
Transfer	405 /3	339	429 /1	495
Labouring	6	5	5	3
Training	1	2	-	-
Installing/dismantling	1	-	-	-
Handling	6	15	9	13
Travelling/delivering	11	6	6	14
Personnel services	1	-	1	1
Storing	-	-	-	1
Examine	-	-	-	-
Not known	16	17	15	17
Other	141	126	110	129
TOTAL (School sector)	5587 /5	4318 /7	4502 /5	4936 /7
Equivalents[1] for :				
Further Education	*214*	*155/1*	*119*	*150*
Higher Education	*110*	*126*	*131/2*	*145*

Table 1 Injuries to students. Number of fatalities shown after oblique stroke (source - HSE).
[1]Breakdowns for the FE and HE figures are available. Enquiries to the Executive Director, SSERC, please.

Reassuringly, reports made under RIDDOR cannot be used by the enforcing authorities as evidence for a prosecution.

One last root vegetable to chew on - the number of fatal or major accidents to teachers in the reporting year 1991-92 was 3289. This is only a little lower than the number of injuries to students. This begs the question : which group, the teachers or the students, is proportionately at greater risk of harm and in need of significantly better protection?

References
1 *Human factors in industrial safety* HS(G)48 HSE 1989 ISBN 0 11 885486 0

Reporting accidents

Some accidents that happen in schools and colleges, or during educational activities elsewhere, must be reported to the Health and Safety Executive (HSE). The law about accident reporting changed in 1996. In Scotland, HSE - with the support of COSLA - have established a telephone reporting service. The HSE have recently issued advice to schools on what to report and how to do it [1]. Here is a summary of what has to be done, including arrangements local to Scotland.

There are three main changes from previous reporting requirements :

1 The definition of accident now includes an act of non-consensual physical violence to staff (e.g. to a teacher, or support staff but not to a pupil).

2 The requirement to report certain accidents experienced by pupils or visitors has been simplified.

3 The accident report should be made by telephone; this supersedes making a written report.

Accidents to staff

There are two types of work-related accidents which must be reported to HSE if they injure either employees of self-employed people:

1 Accidents which result in a death or major injury (see text box).

2 Accidents which prevent the injured person from continuing at his/her normal work for more than three days.

You must notify HSE of fatal and major injuries without delay by telephoning the Scottish Accident Report Line Direct (0845 2770277). Other accidents should be reported to this number within ten days of occurrence.

Accidents to pupils and others

An accident that happens to a pupil or visitor should be reported if:

(a) the person is killed or taken to hospital; and

(b) the accident arises out of or in connection with work.

These accidents must be reported without delay by telephoning to HSE's Accident Direct Line. How do you decide whether an accident *arises out of or in connection with work*?

Major injuries

Any fracture other than to the fingers, thumbs or toes

Any amputation

Dislocation of the shoulder, hip, knee or spine

Loss of sight (whether temporary or permanent)

A chemical or hot metal burn to the eye or any penetrating injury to the eye

Any injury resulting from an electric shock or electrical burn (including any electrical burn caused by arcing or arcing products) leading to unconsciousness or requiring resuscitation or admittance to hospital for more than 24 hours

Any other injury:

   - leading to hypothermia, heat induced illness or to unconsciousness

   - requiring resuscitation or

   - requiring admittance to hospital for more than 24 hours

Loss of consciousness caused by asphyxia or by exposure to a harmful substance or biological agent

Either of the following conditions which result from the absorption of any substance by inhalation, ingestion or through the skin:

   - acute illness requiring medical treatment or

   - loss of consciousness

Acute illness which requires medical treatment where there is reason to believe that this resulted from exposure to a biological agent or its toxins or infected material

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An accident will be reportable if it is attributable to:

(a) work organisation (e.g. the supervision of a field trip);

(b) plant or substances (e.g. lifts, machinery, experiments, etc.) or,

(c) the condition of the premises.

Playground accidents due to collisions, slips and falls are not reportable unless they arise out of or in connection with work, e.g. the condition of the premises or equipment, or the level of supervision.

This information on reporting school accidents reproduces most of the contents of HSE's Education Sheet No 1. We have modified the information to incorporate details of the Scottish Accident Report Line Direct. Further information on accident reporting can be found in the references [2] [3].

References

1 *Reporting school accidents* Education Sheet No 1 HSE 1997.

2 *A guide to RIDDOR '95* L73 HSE ISBN 0 7176 1012 8.

3 *Everyone's guide to RIDDOR '95* HSE 31 (free leaflet).

Violence in education - Guidance

The Health and Safety Executive (HSE) recently has published an updated version of its guidance on this subject [1]. Violence is not just about physical force against individuals but includes verbal abuse and threats. HSE defines work-related violence as:

> . . any incident in which a person is abused, threatened or assaulted in circumstances relating to their work.

Studies have suggested that violence is one of the most important problems faced by many teachers and other educational staff. An 1989 survey of about two and half thousand teachers sampled across one week, showed that in that relatively short period about 15% (one in seven) had suffered significant verbal abuse. Overall 0.5%, or about one in two hundred, had experienced incidents of a clearly violent nature.

The guidance gives information on key parts of approaches to managing violence in the educational workplace. Information is also provided on employers' legal duties, what needs to be done to assess possible risks to staff, the need for appropriate training and how any victims of violence or serious verbal abuse should be treated.

Reference

1. *Violence in the education sector*, HSE, ISBN 0 7176 1293 (available from HSE Books at £6.95 per copy. See address list inside rear cover).

Oxy-fuel gas equipment

The British Compressed Gases Association (BCGA) have revised their Code of Practice 7, which has the snappy sub-title *The Safe Use of Oxy-Fuel Gas Equipment (Individual Portable or Mobile Cylinder Supply)*. The scope of the Code covers the use, inspection and maintenance of oxy-fuel gas welding, cutting and heating equipment incorporating individual portable or mobile cylinder gas supplies. The main points can be summarized thus :

> The Code lays down minimum safety standards for working practices, emphasising the importance of the skill and competence of operators, supervisors and management. It requires that operators shall be instructed in correct procedures for the safe use of equipment and in emergency procedures.
>
> Maintenance shall be carried out annually and each time the equipment is used. Written schemes of examination are not required. The competence of the person doing the annual maintenance is defined. Guidance on maintenance is provided.

Some schools have been sent details by BOC of a practical inspection course for all personnel who use oxy-fuel gas equipment. The BOC advertisement says, "The recent revision of the (BCGA) Code of Practice 7 requires oxy/fuel equipment such as regulators and hoses to be checked regularly. This course will enable delegates to carry out their own safety checks by training them in the inspection procedures for gas control equipment, avoiding the need to employ costly outside contractors to carry out these checks." The cost of this half day course is £140 per person. Before attending the BOC Inspection Course, you must have already attended a BOC Gas Safety Seminar.

Following consultation with various councils, we suggest that the following arrangements be made to comply with BCGA Code of Practice 7 :

1. Users of oxy-fuel gas equipment must be trained to be skilled and competent. Existing training run by councils is presumed to be adequate. Additionally, attending a BOC Gas Safety Seminar is recommended. We understand that these are run quite frequently.

2. Annual maintenance is perhaps best left to an outside specialist contractor because school staff do not normally operate this equipment sufficiently often to remain competent to carry out annual maintenance. The BOC Inspection course is therefore probably not required by school staff.

Fume cupboard advice revised

Design Note 29 was well established as a definitive source of advice on the design, installation testing and maintenance of fixed, permanently ducted, fume cupboards in schools. It has recently been extensively revised by the Architects and Buildings Branch of the Department for Education and Employment (DfEE) and re-issued as *Building Bulletin 88* [1].

The British Standard on this subject *BS7258* [2] is, for a number of reasons, an overspecification and inappropriate for schools. Bulletin 88 makes more reasonable and realistic demands than full compliance with BS7258.

Building Bulletin 88 extends some aspects of Design Note 29 to include testing and monitoring filter fume cupboards. The test methods are not dissimilar to those developed at SSERC some years ago for such purposes. We also have recently re-written our own guidance on the routine testing of fume cupboards - both ducted and recirculatory. This is currently available for comment in final draft form [3]. The SSERC paper deals especially with inspection and testing. It is thus shorter than Building Bulletin 88 and should be of direct interest to teachers and the technician service. The full DfEE document is more likely to be of interest to those in technical or property services or the advisorate, who may be responsible for buying, installing or upgrading fume cupboards in schools or, in some cases, further education or other colleges.

References

1. *Fume Cupboards in Schools (Revision of Design Note 29)*, Building Bulletin 88, Architects & Buildings Branch, DfEE, 1998, HMSO.
2. BS7258 : *Laboratory Fume Cupboards* (4 parts), 1994, British Standards Institution (BSI).
3. *Fume cupboards, routine testing - ducted and recirculatory*, SSERC, 1998.

Nicholl Conductivity Bars

This new product comprises of a set of four similar bars of different metals with attached thermochromic strips for showing the conduction of heat.

The set of four similar sized bars - 134 mm long - of copper, aluminium, brass and steel is embedded in an acrylic mould or cradle which has a suspension point at the top (Fig. 1). The materials are arranged in the order of their thermal conductivities. A thermochromic liquid crystal film strip, 80 mm long, is attached to each of the bars. The strips are recessed within the bars to give them some protection against accidental removal. Each is marked in eight 10 mm divisions so as to allow timing of the progression of heat along a bar.

In standard usage, the apparatus should be suspended over a beaker of freshly boiled water such that the exposed metal ends of the bars are immersed (Fig. 1). Neither the thermochromic strip, nor the acrylic cradle, should touch the water.

The strip appears to be black at room temperature, turns a rusty brown at 33 °C, then green at around 35 °C, reverting from green, through blue, to black as the temperature rises above 45 °C. If the apparatus is immersed in hot water, the coloured zones are seen to rise up the thermochromic strips on each of the bars. The differential rates are obvious. The green zone is more prominent than the others; it is typically about 1-2 cm long on the copper strip, and progressively lengthens as it moves up the bar, but shortens as you move across the materials from copper to steel.

The easiest zone to follow is the delineation between the black region and rusty brown zone. The uncertainty in determining the upper and lower positions of the green zone is ±2 mm by our reckoning.

Simple observations

Much can be deduced from watching the coloured zones move. If the apparatus is placed in a hot water bath, the different rates of heat conduction are obvious.

The top part of the bars has no liquid crystal strip. This is called the Touch Zone. Pupils should touch this to feel that the copper is hot, but the steel is cold, reinforcing their observations.

If the hot bars are then placed in cold water, the green zone is seen to descend with the colour order reversed. Therefore heat can be inferred to flow out of the hotter bars into the colder water. When the hot bars are removed from the hot water bath and allowed to cool in the air, then cooling takes place from every surface. This effect is observable from the spread of the green zone.

Graphs of the distance travelled by the green zone versus time can be plotted for each of the bars, one at a time, taking care to replicate the conditions.

We found that the optimum water temperature was about 60 °C. At a lower temperature, the green zone moved sluggishly and broadened out. At higher temperatures the movement was rather fast and steam condensed on the beaker obscuring the view.

If the apparatus was initially at a room temperature of 20 °C and the water bath was at 60 °C, then, depending on the depth of immersion, the rusty brown zone might take about 40 s to travel to the top of the copper bar. When the apparatus had been chilled beforehand, by placing in ice or a refrigerator, the same zone might take about 30% longer to rise up this bar. This reduction in speed made it easier to follow. Also the touch zones became more distinct. We therefore suggest that if you want to graph data as we have in Figure 2, this is made a little easier by chilling the bars below room temperature before immersing in warm water. However this improvement complicates the procedure and is not altogether necessary.
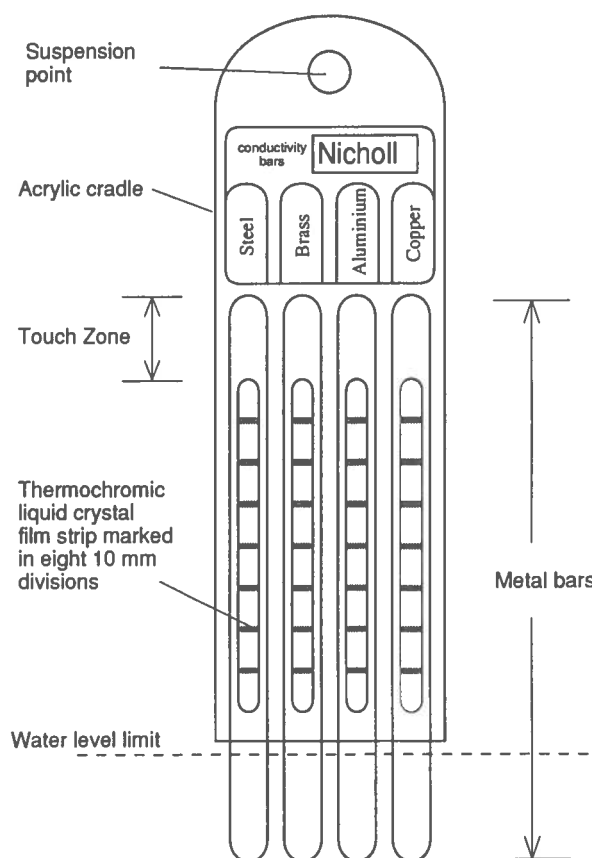

Figure 1   Nicholl Conductivity Bars.

The curves visible in the brass and, more particularly, the steel lines (Fig. 2) result from the loss of heat. With a poor conductor such as steel, the heat conducting into the bar barely keeps up with the heat being lost.

Two methods for getting data were tried. Having started a timer on immersion, the preferred method was to note the times when the rusty brown coloration preceding the green zone reached the relevant 10 mm mark. This method requires taking eight readings of time per bar (Fig. 2). The other method was to note the position of the top of the green zone every 10 s, which takes about six readings for copper, but about thirty readings for steel.

Advanced level observations

A value for thermal conductivity can be obtained by measuring : (1) the time taken for the green zone to pass a mark, and (2) the green zone length.

Finding difficulty in simultaneously noting the top and bottom limits of the green band by direct viewing, we made a colour movie with a digital camera recording at 1 frame per second. However since the digital images were only slightly easier to read, the movie clip was not worth the extra effort.

The value we got for copper was 350 W m^{-1} K^{-1} with an uncertainty of ±70 W m^{-1} K^{-1}. This is in agreement with the accepted value, 390 W m^{-1} K^{-1}.

Summary

The Nicholl Conductivity Bars are effective at showing that heat conducts through a material from hot to cold, that there is a temperature gradient across the material, and that the rate of conduction and temperature gradient depend on the type of material.

The apparatus is easy to work with, and can be set up and reused quickly. It is clean. Compared with the traditional experiment, there is no mess of wax to contend with.

There are hazards with hot water, Bunsens and kettles. But the risks are well understood and controlled by good training, handling and supervision.

The colour brightness of the liquid crystal indicators depend on incident light levels, viewing angle and contrast with other light sources. If viewed facing a bright window, they will look dull. Turn around and the brightness increases greatly. Several viewing angles should then be tried for the best effect.

It is a little disappointing that the colours are not vividly bright. If you think of the thrill of seeing a kingfisher in his brilliant plumage - forget it! The LCD colours are muted. This is a limitation of the display. Nevertheless it is a practicable indicator. The green zone is easily seen. Its length can be estimated to a tolerance of ±2.5 mm; the time to reach a mark to ±0.5 s. Data can be collected from which simple graphs can be drawn to illustrate the rates of conduction. At a more advanced level, values for thermal conductivity can be obtained.

The apparatus is available direct from Nicholl at £26 (single item), £120 (set of 5), or £220 (set of 10 including a Gratnell tray).

Assessment

The Nicholl Conductivity Bars are awarded an *A* assessment (*A* = most suitable for use in Scottish schools and non-advanced FE).
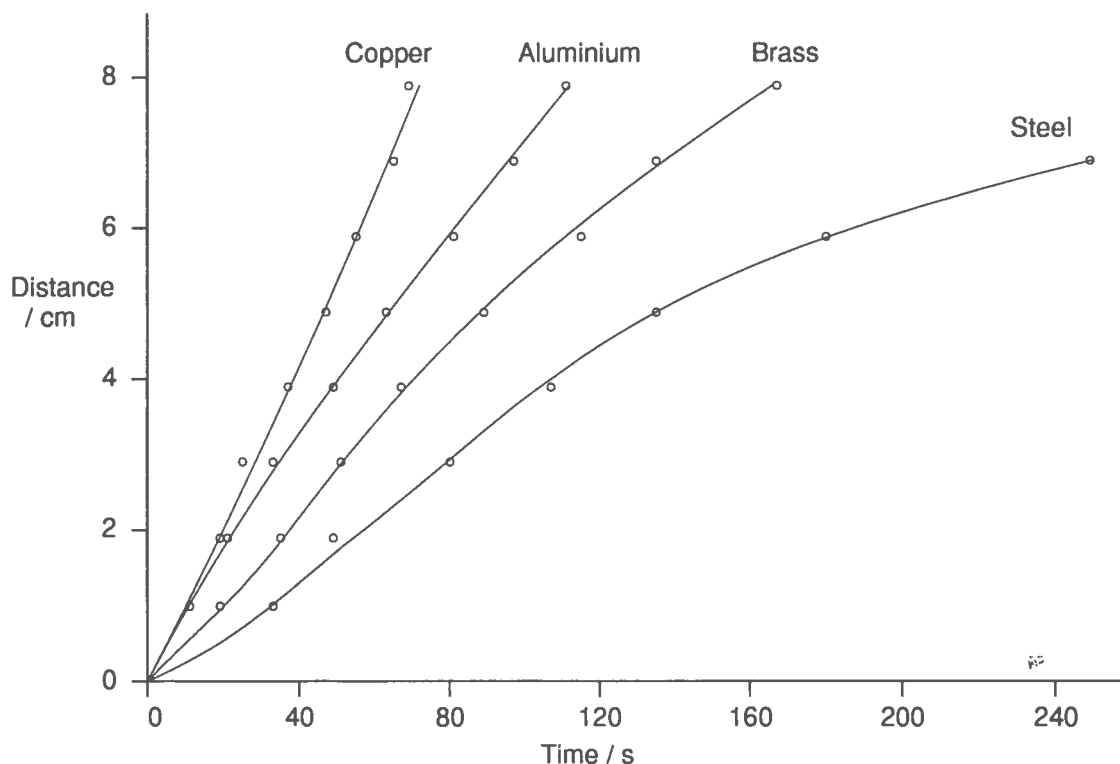

Figure 2 Graph of times taken by rusty brown zone to reach centimetre marks after immersion of previously chilled Conducting Bars in water at 60 °C.

EQUIPMENT NOTES
Nicholl Radiant Heat Source

This is a newly designed radiant heater which operates off the mains. Our tests show that it is electrically safe. An ancillary kit of radiation absorption discs is also reported on.

The critical part is the 300 W heating element. This comprises of a battery of six linear wire elements each enclosed within quartz insulation sleeves. The insulation resistance, even when red hot, is extremely high. Anyone silly enough to touch a hot element with a metallic probe is not at risk of getting an electric shock.

The heating elements form an extended source, measuring 100 mm by 60 mm, at a mean elevation of 160 mm above the bench. The rectangular enclosure is metallic and robust. The front and sides are in stainless steel. An array of square apertures has been punched out of the front panel to expose the elements. The apertures form a grid with a mean spacing of 10.5 mm, preventing accidental contact with the elements.

The enclosure has been mounted on a large steel base-plate. Such an extended area confers stability. There is an air gap between the baseplate and enclosure so that air can flow into the enclosure through inaccessible vents. This air leaves the enclosure through a pair of louvred vents at the top of the back panel, cooling the apparatus by convection.

The elements reach their maximum operating temperatures within a few minutes of being energized. Thus the apparatus can be used very soon after being switched on. The enclosure temperature continues to rise for 30 minutes. There is a small, very hot patch on the top panel which eventually reaches about 85 °C. This excessive temperature is quite localized. At the same time the temperature at the dead centre of this panel is 63 °C, which is not high enough to cause a skin burn.

Commenting on these findings, because the apparatus clearly functions as a heater, it is acceptable that the temperature on parts of the enclosure near to, or above, the element sometimes exceed the limiting value of 70 °C where skin burns can occur on touching. We were pleased to find that these excessively hot parts are small in extent. In fact the enclosure can be touched almost anywhere without getting a burn. A large handle is fitted to the rear panel to permit safe lifting.

Because of the baseplate, the heater cannot, in proper usage, topple forward to burn the benchtop.

The element is sufficiently high that any paper placed directly in front on the worktop does not char. The PVC insulated cable might start to perish if carelessly placed in front of the element and left in that position for an extended period. Supervision would prevent that occurrence.

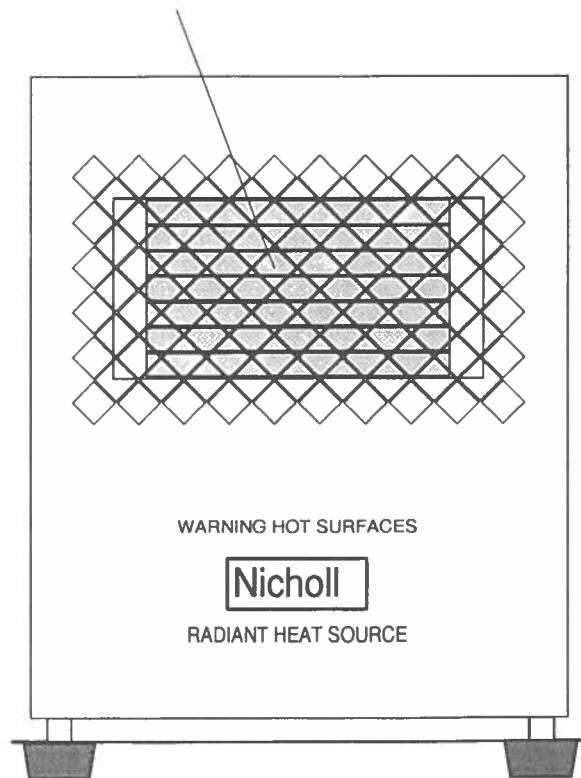Quartz insulated elements, six active, one dummy

WARNING HOT SURFACES

| Nicholl |

RADIANT HEAT SOURCE

Figure 1   Nicholl Radiant Heat Source : Front view.

Short term exposure to infrared radiation can cause skin burns. Long term exposure is not thought to represent a retinal hazard, but is associated with the formation of cataracts. The ceiling level proposed by the EC Physical Agents Directive is 100 W m^{-2}. This value of irradiance is exceeded at distances up to one metre directly in front of the source. Because the apparatus is intended for short term exposure in normal use, perhaps no warning need be given. However if a long term experiment was planned, it would be prudent to warn users not to view the source directly from within this distance and to minimize skin exposure at values above this ceiling level.

Note that there may be a conflict of interest. It is acceptable to allow children to feel the effect of infrared radiation on hands or cheeks for the educational experience, but prolonged exposure is not to be allowed.

Summary and assessment

The Nicholl Radiant Heat Source is an extended source of infrared radiation with electric elements operated at 230 V a.c. Its design complies with recognised standards of construction for electrical safety. It presents no foreseeable fire hazard if used sensibly. The risk of injury from burns to the skin is reasonably low. The apparatus is suitable for heat transfer studies in S1/S2 General Science and for other studies at first and second examination levels. It is a timely replacement for earlier, inadequately guarded designs which, on the advice of HSE and others, have been withdrawn from use.

The device is given an *A* assessment (*A* = most suitable for use in Scottish schools and non-advanced FE). It is available directly from Nicholl at £125 (product code NRHS-1).

Radiation Absorption Discs

These discs form an ancillary kit to show how the absorption of heat radiation depends on surface colour and texture.

There are four aluminium discs, each with a different anodised surface - matt black, polished black, matt silver and polished silver. They have little thermal mass, being about 2 g each. The diameter and thickness are about 43 mm and 0.5 mm respectively. Temperature is indicated by a thermochromic, liquid crystal display on the reverse surface. This is marked in eight settings, 5 °C apart, from 30 °C to 65 °C. At and above 70 °C a warning STOP sign appears in black, prompting the user to remove the disc from radiation. According to the specification, repeated exposure to 100 °C may damage the liquid crystal indicator.

The discs are designed to be used in the radiant flux from the Nicholl Radiant Heat Source, or other types of radiant heater. A perspex holder is supplied with the kit. It may be held by hand, or supported in a clamp stand.

An example of the performance of the discs is shown (Table 1). The Radiant Heat Source was switched on and allowed to warm up for 10 minutes. The disc holder was mounted in a clamp stand so that a disc would be 160 mm from the source.

Temperature (°C)	Matt black (s)	Polished black (s)	Matt silver (s)	Polished silver (s)
30	5	7	7	6
35	9	12	13	12
40	12	20	21	21
45	18	26	34	37
50	24	37	50	60
55	34	55	73	100
60	47	90	156	225

Table 1 Radiation Discs : Time taken to reach set temperature marks starting off from room temperature.

The flux was blocked temporarily with MMMF board, a disc at room temperature inserted in the holder and a timer started at the instant when the board was removed. The observer then noted down the time when each set temperature mark was reached. By taking temperatures to 60 °C, we were able to distinguish an order of heat absorption. The order was not clear until the discs had reached 50 °C.

Assessment : *A*. One set of four discs and holder costs £36 from Nicholl (product code NRAD-1). A set of five kits costs £150 (NRAD-5).

Inverse square law

A method was devised with the Nicholl Radiant Heat Source for showing that the radiation flux is inversely related to distance from the source (except at close range because it is an extended rather than a point source).

The bulb of a sensitive, mercury thermometer was painted with aquadag and placed in the radiation flux at different positions, noting the time taken for a 3.0 °C rise. The thermometer type does not greatly matter, but should be very sensitive, with a small range centred around room temperature. The one we used had a range from 12 °C to 30 °C and was marked in divisions of 0.05 °C.

The radiation source was left on throughout. The thermometer was held vertically in a clamp stand and positioned to the desired distance from the source. An ice bath containing a small, dry, inner vessel was held such that the bulb was enclosed by the inner vessel. Tissue paper inside the inner vessel prevented the bulb being wetted by beads of condensation. When the bulb temperature was about 2 °C below room temperature, the ice bath was removed, allowing the mercury to rise because of heating by the radiation flux. A stop watch was started when the reading was 1.5 °C below room temperature and stopped at 1.5 °C above. The time taken for this initial warming up was presumed to be inversely proportional to the rate of heating, or to the radiation intensity. If values of these heating times (Table 2) are plotted against the squares of the distances, a linear fit is obtained confirming the presumption and the inverse square relationship.

Distance (m)	Time (s)	(Distance)^2 (m^2)
0.10	6.3	0.010
0.20	19.5	0.040
0.25	27.9	0.063
0.30	37.1	0.090
0.35	45.1	0.123
0.40	56.9	0.160
0.50	108.1	0.250
0.60	149.6	0.360
0.70	174.4	0.490
0.80	215.1	0.640

Table 2 Inverse square law results : Time for black bulb thermometer to rise by 3 °C versus distance from source.

EQUIPMENT NOTES

Harris System SM : Part II

Comprising of a large range of *SensorMeters*, portable datalogger and software, the system may be used for measurement, data capture and analysis. In Part I (Bulletin 194) were reviewed the Temperature and Radioactive Count Rate sensors as components of that overall system. This part of our review examines the conductivity and pH sensors and how System SM performs within those contexts.

This article summarizes evaluation results for the conductivity and pH sensors and features of the data-logger and software relevant to their application to Scottish curricula. The Technical Notes section of this Bulletin includes some sample results and analyses of data for relevant experimental situations, thus illustrating how the equipment and software might be used. The pH sensor can also be used as a millivoltmeter and - over a limited temperature range - as a thermometer .

The two sensors were tested as individual stand-alone instruments (see Fig. 1 and text box opposite) and a summary of findings is given. Modes of data entry and several of the analysis tools available in the software were also trialled. This was done by using the overall system in several experiments and determinations. Data was logged and plotted in the following typical situations :

One variable logged against time : This was done for both pH and conductivity in the following:

● investigating the rate law for the hydrolysis of 2-bromo-2-methylpropane followed by the changing conductivity; and

● producing a quick titration curve in order to show the different shapes for strong and weak acids; here a reasonably constant flow rate from the burette is assumed and time plotted on the horizontal axis in place of volume of titrant added.

Two time-independent variables : Here for each point on the graph one variable, eg pH, is logged via the interface and the volume of titrant added is keyed in and both are recorded by a tap on the "spacebar". The two time independent variables are then plotted, one against the other (also termed an *X-Y plot*). This feature was evaluated in the determination of the dissociation constant of ethanoic acid by the half-neutralisation method.

Keyboard entry of two variables into a spreadsheet :
To test the ease and use of the spreadsheet entry facility, the conductivity for a series of different dilutions of strong and weak electrolytes were noted on paper and entered into the spreadsheet to prepare Onsager plots.
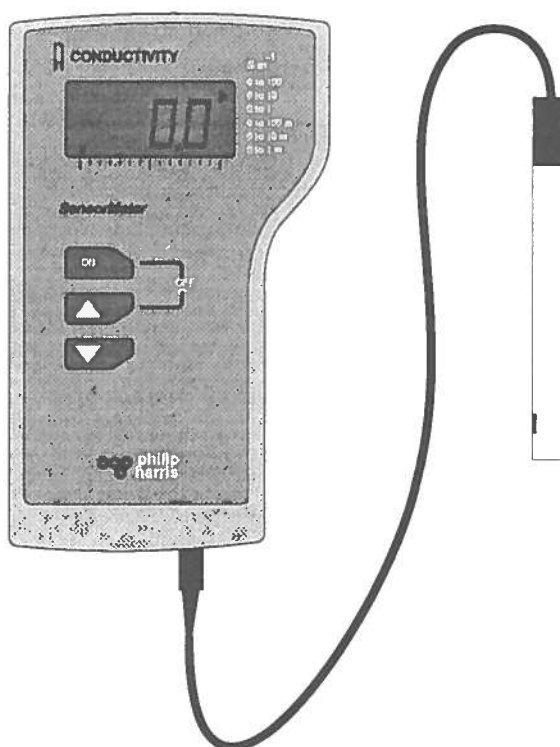

Figure 1 Typical *SensorMeter* and probe. Set-up illustrated is that for conductivity. Not to scale.

System SM Conductivity and pH Meters

Description	Catalogue number	Price (£)
DL plus 32 datalogger	E40000/8	399.00
SensorMeter leads	E30870 (1.2 m)	2.75
	E30872/4 (5 m)	2.75
Computer lead	See catalogue	15 or 20
Conductivity SensorMeter:	E30060/9	139.00
Conductivity cell	E30065	79.62
pH *SensorMeter*	E303980/8	149.00
pH probe	Y37200/4 (BNC)	45.00
temperature probe	E30662/4	30.00

Conductivity SensorMeter

General description

The meter has two sockets on the base, one for connection to the conductivity cell and the other for connection to the *DLplus* logger. A third socket at the rear allows a mains to low-voltage adaptor to be connected.

The on/off and range change functions are operated by waterproof membrane touch pads. A trimmer in the base, accessible by a small screwdriver, operates a gain on the read-out. This gain control can be used to adjust the reading to that of the known conductivity of a standard solution of potassium chloride in which the cell is placed. This removes the need for determining the cell constant and then applying it to every reading thereafter. This is useful if you are doing real time displays on screen and handy also, though not vital, if you want to process logged data in a data table before graphing it.

Linearity of response

A plot of the reading ($S\ m^{-1}$) against the known conductivities of a series of standard potassium chloride solutions is fairly linear (Fig. 2). The slope of this line gives a conversion factor. Onsager plots for hydrochloric acid and ethanoic acid also show good linearity (see Technical Notes).

If the cell is not well shaken, however, the instrument may misread. The plastic bodied cell is tough but somewhat poorly designed. The top of the electrode plates are situated above the air escape holes and are small. The result is that a small air bubble remains trapped in part of the path between the electrode plates even when the cell is well immersed. This lowers the conductivity reading. It may take several shakes with the cell under the surface to completely dislodge the bubble. When set in a solution of $78\ mS\ m^{-1}$, it first read 47 and by giving the cell a shake the reading increased through six steps 47, 52, 62, 73, 75 and finally to $78\ mS\ m^{-1}$. A single shake, if vigorous enough, will clear the air bubble.
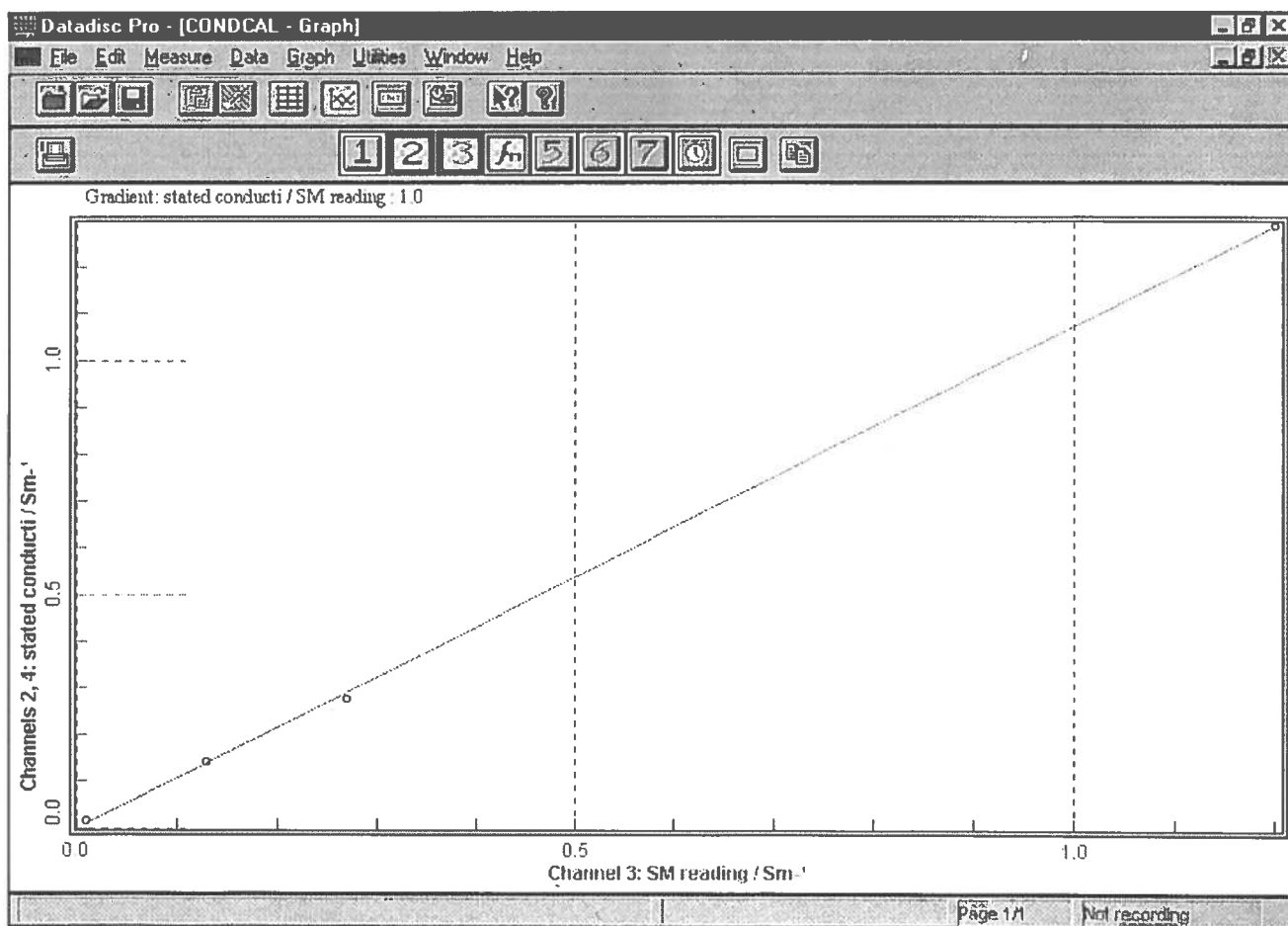

Figure 2 Linearity of response. Plot of published, theoretical conductance values against observed values. The software provides a best fit gradient value of 1.08. This calculation by the software is in fact in slight error, the conventionally calculated value was 1.075.

Ranges and ease of reading

The display has the advantage over older, six range, analogue meters in that the pointer is not "banged over hard" if someone accidentally starts on a more sensitive scale. Pupils may however experience two main difficulties in reading the display, namely, overscale readings and units.

If the conductivity of the solution being measured rises above the maximum of the range on which the *Sensor Meter* is set, the display ends up as 113 or 11.3. Unfortunately, this looks like a reading. Admittedly, if the instructions are carefully followed, the user should move up to a less sensitive range. This arrangement may be satisfactory for frequent usage, but many students may only use it once or twice. By this stage in their careers they may be used to multimeters which display a "1" or a flashing digit when out of range. With this display a student may easily make the mistake of thinking that the conductivity had reached a limiting value.

Some pupils may also be confused in reading the units, especially since there are two *m's* involved - one for "metres" and the other for "milli" (see Fig. 3). As with overscale problems, those who use the instrument a lot will sort things out and not be confused. It would have been ideal to have kept the same units, namely S m⁻¹, in
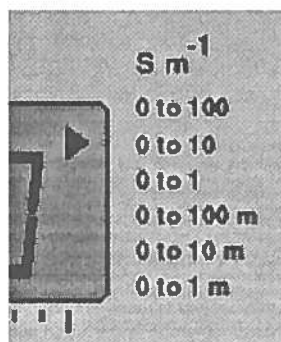

Figure 3 Conductivity scales as printed on meter casing.

all six ranges and simply moved the decimal point, but there are insufficient digits in the display. One simple way of removing any possible confusion is to bring the "S m⁻¹" on the labelling at the top of the casing to the end of every range. The top three would read in "..... S m⁻¹" and the bottom three as "..... mS m⁻¹".

Alternatively, the discontinuity of units could be pointed out more clearly in the instructions. Presently it is buried in the small print of the *Technical Specification* giving the accuracies of each range.

If, during datalogging, the conductivity rises sufficiently to necessitate a change to the next range, it is better to set the meter on that higher range before starting the recording. A trial run may be needed to find the maximum likely reading before hooking everything up.

The unusual feature of this conductivity meter noted above is that because of the way it operates the conductivity (S m⁻¹) is read off directly and the cell constant is not determined in the usual way.

Normally a meter readout provides the conductance (units S) and this is multiplied by the cell constant (units m⁻¹) to give the conductivity. However on this meter a trimmer control on the base is adjusted so that the meter reading coincides with the conductivity of a standard solution of potassium chloride being used for calibration. The instructions state that the value of the cell constant is read off from the position on the trimmer. This has a scale from 80 to 110. We found the supplied cell to have a constant very close to 100.

However this approach will upset us traditionalists. If your teaching syllabus requires pupils to know about the determining of cell constants and the subsequent use in calculations, then this meter is not for you. You could turn the trimmer to one extreme so that the two values differ and pretend to determine the cell constant in the usual way. But this will not be satisfactory as there is a gain in the meter of around 100. In general though, the instructions are clear.

pH SensorMeter

General description

The three-in-one *SensorMeter* (pH, mV and temperature) is housed in a casing like that of the conductivity meter (Figure 1) with similar sockets for connections to the *DLplus 32* datalogger, the pH probe, the temperature probe and a power adaptor or battery eliminator. With both probes together in the same solution, temperature compensation is automatic. In addition, the temperature probe can be used on its own to read or log temperature from 0 to 110 °C by 0.1 °C. The meter reads to 0.1 pH unit.

Performance aspects

The *pH SensorMeter* was subjected to our usual battery of tests for pH instruments. It was tested for drift, errors over varying spans of pH and at different

temperatures. To test both the pH and the millivolt function, accurately known voltages were fed in via the BNC socket and compared with both pH and millivolt read-outs. The meter performed satisfactorily in all of these tests.

Calibration is simple to carry out, but can only be done at pH7. Thus the normal good practice of calibrating with a buffer solution whose pH is close to the values being measured will not be possible with this meter. However with the pH probe supplied the long span error was negligible; though this might increase as the probe aged.

There is no slope control to compensate for the fall off in voltage output/pH unit as the probe ages and you will not be able to correct for this on the meter's own read-out. However a correction could be made as an additional step in any spreadsheet calculations. The multiplying factor for the number of pH units away from 7 in either direction could be found by dividing the expected change by that observed when you move the probe from pH7 to say pH3 or 4, or from 7 to 9 or 10.

The instructions are simple and clear and the meter was deemed most satisfactory for use in schools. The determination of the pK_a of ethanoic acid by the half-neutralisation method using the meter and software is described in the Technical Notes.

* * *

Datadisc Pro software

Overall, this is student friendly software, simpler to use than the standard spreadsheet packages such as *Excel*. In the interests of ease of use by younger pupils a number of simplifications have been made. Our main general comments are given here, but some matters are dealt with more naturally in describing certain curricular applications (see the Technical Notes section in this issue).

Calculations : are easy to perform on the data in the columns (or *channels*). A *Calculate Pad* (Fig. 4) provides most of the simple transformations likely to be needed. These facilities are easily used. Usually only one step can be done at a time with a channel used for each transformation; though sometimes it may be possible to combine two or more constants in one step. A plot of the rate of a reaction against concentration is easily derived - as $d(concentration)/dt$ - from the original concentration against time.
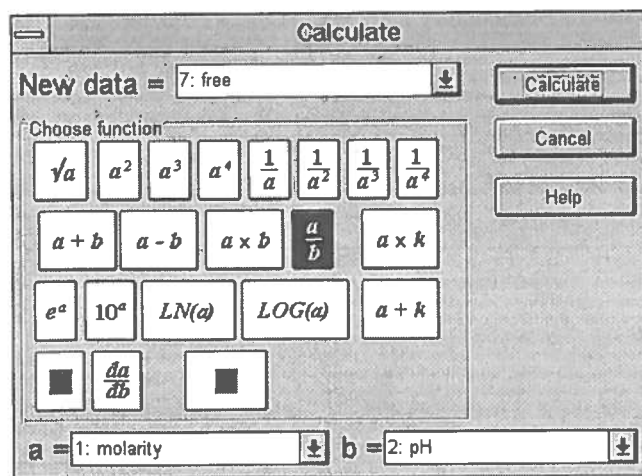

Figure 4 The *Datadisc PRO Calculate Pad* facility.

The inclusion of an antilog function would have been useful, though there is a way round its absence. An example of a requirement for this function came up when we wanted to calculate the hydrogen ion concentration from the logged pH. Some readers may have guessed already that one way round this problem is to use an alternative expression for defining pH, *viz* : $[H^+] = 10^{-pH}$. For the purposes of the calculation the various *channels* provided are designated as follows :

Channel 2 is designated as 10^{pH} and *Channel 3* as the reciprocal $1/_{Channel2}$ that is 10^{-pH} which, as defined above, is equivalent to the hydrogen ion concentration $[H^+]$ eg :

Channel 1	Channel 2	Channel 3
pH reading	$10^{(Channel\ 1)}$	$(Channel\ 2)^{-1}$
2.5	316	0.0032 (= $[H^+]$)

When a calculation step has finished the top of each table column (*channel*) holding calculated data carries the formula used to generate it. This makes it very easy for pupils to see later how they reached that stage in their calculation. The mode by which data in any column was derived from the previous one is also presented with any graph so produced.

Graphs : Information on the experiment and the labelling of axes is easily added to graphs. The software is friendly in this respect - anticipating the style of units and providing automatically the appropriate superscript, ie l^{-1} and in a point or two lower in size - not the ugly $l-1$ or $cm3$. Background information also can be added at this stage. On re-opening the file at a later date, such notes may then be read by pressing *control + i* or clicking on *Data /data information.* This facility removes the need for lots of paper records listing the details of particular experiments.

Merely clicking the relevant icon on the toolbar will switch instantly between table and graph. The *Graph/Set axes* dialogue box provides an easy way of choosing which variable is plotted on the X-axis and which one(s) is plotted vertically. Rescaling of the axes is done simply by dragging the cursor over the chosen part and cropping the rest. The selected part is then redrawn filling the original total area. The software also optimises the scale choosing only that small part of the vertical needed for the values obtained. This may mean that, by default, the zero for the vertical axis is not included, but this can be over-ridden easily and the zero added. A smoothing facility is also available.

Graph analyses : A *Graph/Cursor* placed on the graph gives the co-ordinates of the nearest point of data and a *Gradient Cursor* the gradient at the nearest data point at which a pair of cross-hairs is placed. This latter facility is very handy for quickly reading off the slope at several points on a curve. If the gradients of either an approximate straight line, or a curve with a few slight undulations in it, are so determined, one has to be careful to pick only those parts judged to be representative. Alternatively a line of best fit can be applied to data. The slope and intercept of that line is then given within a bar (box) at the top of the graph. This facility is illustrated in the Technical Notes Section of this Bulletin (Fig. 6 on page 20). Lines of best fit are available for :

linear functions $y = A + Bx$
binomial $y = A + Bx + Cx^2$
logarithmic $y = A\ log(Bx)$

as well as for several exponential forms :

$Y = Ae^{Bx}$
$Y = -Ae^{Bx}$

$Y = A(1 - Ae^{Bx})$ - This one is particularly useful for the classical saturation curve if B is negative.

Data can be copied from the *Datadisc Pro* table to a spreadsheet, eg *Excel*, or word processor by simply saving to a clipboard and then pasting into the other spreadsheet. Be warned that a single graph and table copied to any other software can easily add 1 or 2 Mb onto that document. This would make storage on floppies difficult for class scale usage. Pupils in S5 or S6 could use links to circumvent this problem.

The width of columns can be enlarged on screen by dragging the vertical line at the side of the column making data easier to view. However it prints with the original width of column so that the data in one column is partly overprinted on the next column. This problem was only found when both variables were entered from the keyboard in the spreadsheet entry mode. Unfortunately scientific notation is not available and small values with too many digits entered will be too long to be seen.

There is sometimes a need to reset the resolution from the default setting of 0.02. Unfortunately you cannot change this before making a recording or even be aware of it before entering data. As a result the display of the table on the screen can be very confusing because it is different from what you swear you typed in.

Compare the first two channels in Tables 1a and 1b with the same data entered. In the second (Table 1b) the resolution has been reset to 0.0001 after entry of the data. Also note the differences in the calculated values in later channels. In some instances the analysis software gave quite nonsensical answers until the resolution was reset.

With a reading every second the datalogger will record for 500 seconds with the period covered being inversely proportional to the inter-sample period. For example, with environmental measurements made every 34 minutes, logging will continue for nearly 12 days, or a lab experiment with readings every 4 seconds would last half an hour. There is a frugal recording mode which allows up to 1200 points to be recorded. In this mode the sensors and interface are continuously active, but data is only recorded when significant changes occur.

The projected new version of *Datadisc Pro* in 1999 is likely to have none of the minor problems mentioned above. Harris have told us about another useful feature we hadn't thought of. There will be a facility for pupils to put their names on a graph so that it can be identified from the pile of paper issuing from the single networked printer.

Datadisc data continuous

Ch 1 molarity (mol l⁻¹)	Ch 2 meter read	Ch 3 Ch 2 x 1.00 (S m⁻¹)	Ch 4 Sqr(1)	Ch 5 Ch 3 ÷ Ch1	Ch 6 Ch 5 x 0.00100
0.100	0.052	0.052	0.316	0.4	0.0004
0.050	0.034	0.034	0.224	0.8	0.0008
0.010	0.016	0.016	0.100	1.6	0.0016
0.004	0.008	0.008	0.072	1.6	0.0016
0.002	0.004	0.004	0.032	4.8	0.0048
0.000	0.002	0.002	0.024	4.8	0.0048
0.000	0.000	0.000	0.008	8.8	0.0092

Table 1a Keyed-in data with default resolution.

Datadisc data continuous

Ch 1 molarity (mol l⁻¹)	Ch 2 meter read	Ch 3 Ch 2 x 1.00 (S m⁻¹)	Ch 4 Sqr(1)	Ch 5 Ch 3 ÷ Ch1	Ch 6 Ch 5 x 0.00100
0.10000	0.0520	0.0559	0.31622	0.56	0.00056
0.05000	0.0350	0.0376	0.22360	0.76	0.00076
0.01000	0.0160	0.0172	0.10000	1.72	0.00172
0.00500	0.0084	0.0090	0.07072	1.80	0.00180
0.00100	0.0046	0.0049	0.03162	4.94	0.00494
0.00050	0.0023	0.0025	0.02236	4.94	0.00494
0.00010	0.0009	0.0010	0.01000	9.68	0.00968

Table 1b Same data as in Table 1a with resolution set to 0.0001 mol l⁻¹

Summary of conclusions

(a) datalogger and software

This datalogger and software is a great advance on the older *Datadisc* series. It is extremely easy to log data, to transfer it to a computer, and there to mathematically transform and present it graphically. In the past pupils have often lost their place in moving between all those menus in older software packages when carrying out mathematical treatment of the data. Taking one step in one channel at a time using a mathematical function on the Calculate pad should leave young pupils feeling in control. A few transformations, eg antilogarithm or divide by a constant are missing, but it is possible to get round both of these by use of extra steps. The cursor and gradient cursor facilities along with the best fit line giving intercept and gradient are extremely useful.

It is easy to be critical of the system and expect more features commonly only found on larger spreadsheets, eg the facility for entering a formula, which would replace many steps. However the *Datadisc Pro* system is more user-friendly and serves as an excellent introduction to the later use of full professional spreadsheets. For the software we would award an *A*.

(b) Instruments

The pH meter was excellent and would attract an *A*, though a gain or slope control would be useful.

The labelling of the units and the display on the conductivity meter are a little confusing and the meter would have considerable error if the conductivity cell was not carefully freed of trapped air. Once these problems are understood the meter will perform satisfactorily. We would give it a *B*.

Inexpensive pH measurement - the Turtle from Hanna

Appearance - The interface looks like a humped green shell with a long tail (RS232 connector) and a wee head (BNC socket for connecting a pH probe.) When connected to the serial port of a PC loaded with the software it can operate as a (i) pH meter with variable size (up to full) screen display or (ii) real time logger of pH against time.

Shown (Fig. 1) is a typical display of a logging of a *quick* titration curve where acid was run in from a burette and pH is plotted against time. Any of the three panels, ie the pH reading, the log (table of results) or the graph can be selected to fill the screen alone, thus working as a demonstration meter.

Software and datalogging - This is quite friendly and easy to use. The meter can be calibrated at one of three different pH values, pH4, 7 or 10. Temperature compensation can be applied by typing in the temperature of the sample. The system can log up to 5000 readings with sampling rates between 1 per second and 1 per 10 hours.

Exporting data - The software allows the data to be saved as an ASCII file, which can then be transported into a spreadsheet such as *Excel*. Before processing the data it was best to delete the columns containing superfluous data such as temperature, date and, strangely, time which is in the hours:minutes:seconds format. By choosing a sample time of 1 second the reading number (first column) can be plotted as time. For other sampling times the reading number can be multiplied by the sample period. The system could be used to follow any reaction where the pH changes, eg the saponification of an ester or in a fermenter. In the latter application the high or low pH alarm could be a most useful feature. Another interesting feature is the choice of six European languages - so you will be ready for those cultural exchanges!

Test results as pH meter - The meter reads 0 to 14 by 0.1 pH. The Turtle was subjected to our usual battery of tests and judged to be most satisfactory. The long range errors and drift were negligible and temperature compensation was perfect except for high temperatures in buffer pH10, where the reading was high by 0.4 pH.

Turtle, software, cable and pH probe (Cat. No. HI 9815) £49. *Spare pH probe* (HU 1333B) *with BNC connector* £26

Conclusion - This excellent little package costs less than many general purpose pH probes alone.
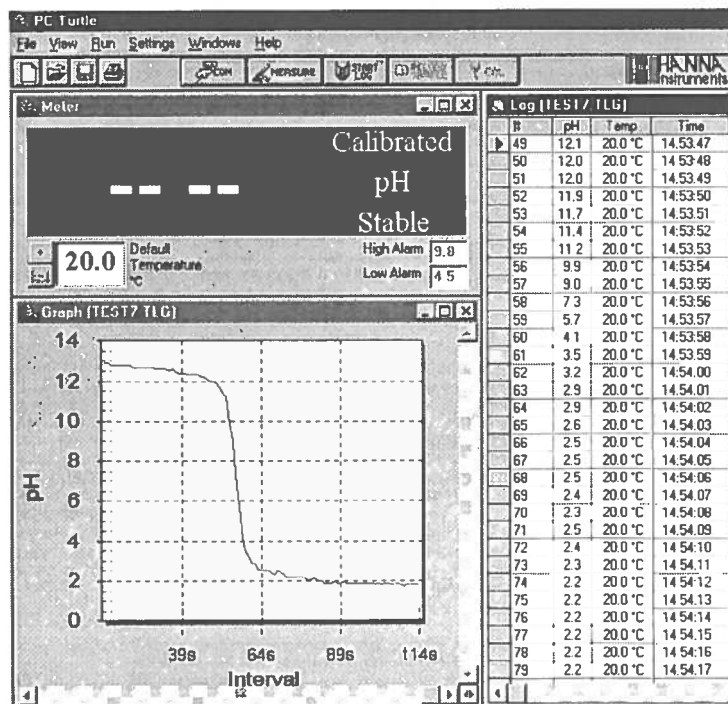

Figure 1 Hanna PC Turtle software on Windows 95.

Data capture and processing

The following examples illustrate the different methods of data capture and various aspects of processing the results using Datadisc Pro software.

Determination of the pK_a value for ethanoic acid by the half neutralisation method
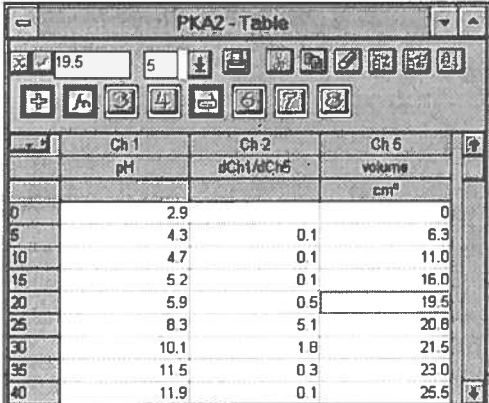
Here the pH is logged directly via the datalogger into the PC while the cumulative volume of sodium hydroxide added is keyed in. The spacebar is pressed to record each point on screen.

To get the pK_a for a weak acid all you need to do is to measure the pH at the half-neutralisation point. Plot the pH/volume graph and determine the end point. The end point can be read off more easily by using the *da/db* (ie *d(pH/dV)*) function and plotting a second graph of this against volume. With the cursor, read off the coordinates at the tip of the spike. Move the cross hair cursor along the original pH/ volume graph so that the volume reads half of the end-point titre and read off the pH (Fig 1).

An option with the spacebar entry mode is to choose in advance the intervals for entering the data, eg, if intervals of 1 cm³ had been chosen then after the addition of each 1 cm³ of sodium hydroxide from the burette, merely tapping the spacebar would enter the cumulated total volume. This facility would be timesaving.

However in this particular application readings are needed after smaller additions for certain parts of the graph.

A part of the table below shows how the data is calculated from channel to channel. In the interests of showing changes in slope, only every fifth reading is selected here (Fig. 2).

	Ch 1	Ch 2	Ch 5	
	pH	dCh1/dCh5	volume	
			cm³	
0	2.9		0	
5	4.3	0.1	6.3	
10	4.7	0.1	11.0	
15	5.2	0.1	16.0	
20	5.9	0.5	19.5	
25	8.3	5.1	20.8	
30	10.1	1.8	21.5	
35	11.5	0.3	23.0	
40	11.9	0.1	25.5	

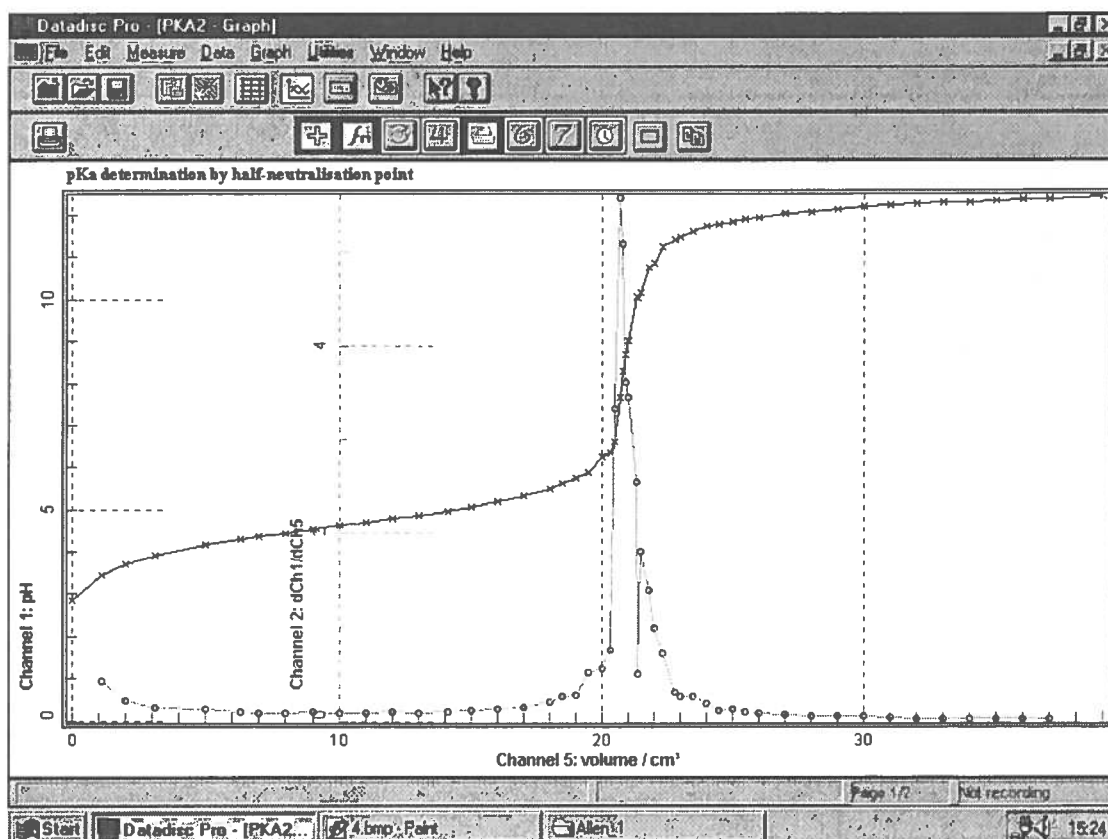**Figure 2** How data is calculated from channel to channel

Figure 1 Determination by half neutralisation point

For a weak acid such as ethanoic acid the reaction of the molecular species with water can be simplified as :-

$$CH_3COOH + H_2O \rightleftharpoons H^+_{(aq)} + CH_3COO^- \quad .... \, 1$$

$$K_a = \frac{[H^+][CH_3COO^-]}{[CH_3COOH]} \quad .... \, 2$$

$$[H^+] = \frac{K_a[CH_3COOH]}{[CH_3COO^-]}$$

$$pH = -\log_{10}K_a - \log_{10}\frac{[CH_3COOH]}{[CH_3COO^-]} \quad .... \, 3$$

This is known as the Henderson-Hasselbach equation.

As sodium hydroxide is gradually added to the acid, the number of moles of sodium ethanoate formed will equal the number of moles of ethanoic acid neutralised. Since the acid is a weak one its hydrolysis will be suppressed by the presence of the ethanoate ions of sodium ethanoate and hence the concentration of ethanoate ions will be entirely due to the salt with virtually zero contribution from the acid.

At the half neutralisation point :-

$$[CH_3COOH] = [CH_3COO^-]$$

$$\log_{10}\frac{[CH_3COOH]}{[CH_3COO^-]} = 0$$

$$Hence \quad pH = pK_a \quad .... \, 4$$

The end-point can be estimated more accurately from the peak of the $d(pH)/dV)$ / volume curve. The cursor placed there reads off the co-ordinates and shows the end point volume to be 20.7 cm³. It is simply a case of positioning the cursor control on the first graph (pH / volume) where the volume is half this quantity. When the x coordinate was 10 cm³ the pH read off as 4.6. At 11 cm³ the pH reads 4.7, so by interpolation the result would show the pKa to be slightly in excess of 4.6.

Unfortunately the cursor will only rest on an actual data point, so if you want to use the cursor to read off the values of co-ordinates along a curve, make sure you have plenty of points in the area of interest. The pH meter had been calibrated to pH 7 immediately before use, but read 6.9 on re-checking at the end. If it is permissible to make allowance for this small drift then the answer would come out at 4.7. The commonly accepted answer is 4.76 at the same temperature.

An interesting by-product of using this method of determining the pK_a is that it also reveals how the buffer action of a half neutralised acid works, showing the low rate of change of pH with addition of alkali or acid in this region and also that such buffer capacity is effective only over a range of 1 pH unit either side of the pK_a.

You can compare the answer obtained here with that obtained from the more usual method discussed below in which the pH of a dilute solution of ethanoic acid of known concentration is measured. [H+] is calculated from the recorded pH (antilogs needed) and then using a version of Equation 2.

$$K_a = \frac{[H^+]^2}{[CH_3COOH]} \quad \text{and since} \quad [H^+] = [CH_3COO^-] \quad :... \, 5$$

$$K_a = \frac{\alpha^2 C}{(1-\alpha)} \quad \text{where :}$$

α = degree of hydrolysis or fraction of acid hydrolysed.

C = concentration of acid as prepared, i.e. the initial concentration before any reaction.

The usual method

This is done by measuring the pH of solutions of known concentrations, calculating the [H+] and substituting this and concentration in Equation 2.

The hydrogen ion concentration will be αC and the concentration of ethanoic acid molecules remaining at equilibrium will be $(1 - \alpha)C$.

The justification for the commonly used simplification of equating [CH₃COOH] with the concentration of acid remaining at equilibrium is that since the acid is weak, α will be small in comparison with 1. This will not be true for more dilute solutions (higher concentration of water!) and calculations based on measurements made at very low concentrations will certainly show errors. On the other hand only at lower concentrations will the activity coefficients for the involved species approach unity and then the use of concentrations in place of activities will result only in very small error. A sample of the table for the calculation of K_a is shown below (Fig. 3).

Datadisc Pro
File Edit Measure Data Graph Utilities Window Help

DISSETH Table

0.001   1

	Ch.1 molarity mol⁻¹	Ch 2 pH	Ch 3 10^(Ch2)	Ch 4 Ch 3⁻¹	Ch 5 Ch 4²	Ch 6 Ch 5 + Ch1
0	0.001	4.000	9999	0.0001000	0.0000000100	0.0000099
1	0.005	3.500	3162	0.0003162	0.0000001000	0.0000201
2	0.010	3.300	1995	0.0005012	0.0000002512	0.0000252
3	0.050	3.000	999	0.0010000	0.0000010000	0.0000201
4	0.100	2.800	630	0.0015849	0.0000025118	0.0000252

Figure 3 Calculation of K_a

The best method might be to use dilute solutions where behaviour approaches the ideal. The simplified calculation without any assumptions is justifiable where α turns out to be small. Where α is larger than, say, 0.03 then the actual value can be used in the equation and a slightly better answer obtained. This neat trick, of iterative numerical approximation, avoids the need to solve a quadratic equation. You can always use a spreadsheet to calculate α. Other more sophisticated spreadsheets will even do the iteration for you, many times or until two successive answers differ by 0.001 or less. But you shouldn't need more than a few cycles.

On screen the columns widen out to contain all the data and this carries faithfully over to the word processor if the *select*, *copy* and *paste* procedure is used, but the columns are narrowed down on a direct print-out so that two adjacent columns of data overlap. So if you are relying on the print-out have a good look at the data on screen before you print it. We are informed that an updated version of the software, available in 1999, may have scientific notation and also the facility to keep the columns wide.

The column headings (Fig. 3) show the device used for obtaining the antilogarithm. *Channel 4* is the negative antilogarithm - the hydrogen ion concentration, [H+], and *Channel 6* the expression for K_a as defined in Equation 5.

Onsager plots for strong & weak acids

The effectiveness of ions in a solution to carry current is reduced by them being surrounded by "atmospheres" of ions of the opposite charge which they have to hump along on their backs! The two main factors operating are the:

● *assymetry effect*. This is the retarding drag exerted on the central ion by the atmosphere as the central ion starts moving in an electric field having to pull away from its oppositely charged companions and the

● *electrophoretic* effects. In an applied electric field the atmosphere tends to move in the opposite direction and drag the central ion backwards with it.

These effects both reduce the speed and the effective number of the ions and hence the conductivity. The decrease from both of these effects on molar conductivity, as the solution is progressively diluted and ions are further separated from each other, can be described by the Onsager equation:

$$\Lambda = \Lambda_o - (A + B\Lambda_o)\sqrt{C}$$

where Λ is the molar conductivity at concentration C

Λ_o is the molar conductivity at infinite dilution.

A and B are constants which include terms for the viscosity, dielectric constant of the particular solvent and its temperature.

At infinite dilution the assymetry and electrophoretic effects disappear altogether. The plot for a strong electrolyte like hydrochloric acid should over a range of concentrations be linear with a negative gradient and an intercept equal to Λ_o. This in fact turns out to be the case (Fig. 4).

The molar conductivity of ethanoic acid at infinite dilution (0.0391 S m^2 mol^{-1}) is comparable with that of hydrochloric acid (0.0426 S m^2 mol^{-1}) as the major contributor to the conductivity in both acids is the hydrogen ion. However the molar conductivity of the ethanoic acid (Fig. 5), unlike that of the hydrochloric acid (Fig. 4), falls away very rapidly as the concentration rises. This provides neat evidence for the fact that the proportion of ethanoic acid in the form of covalent molecules is extremely high unless in very dilute solution.
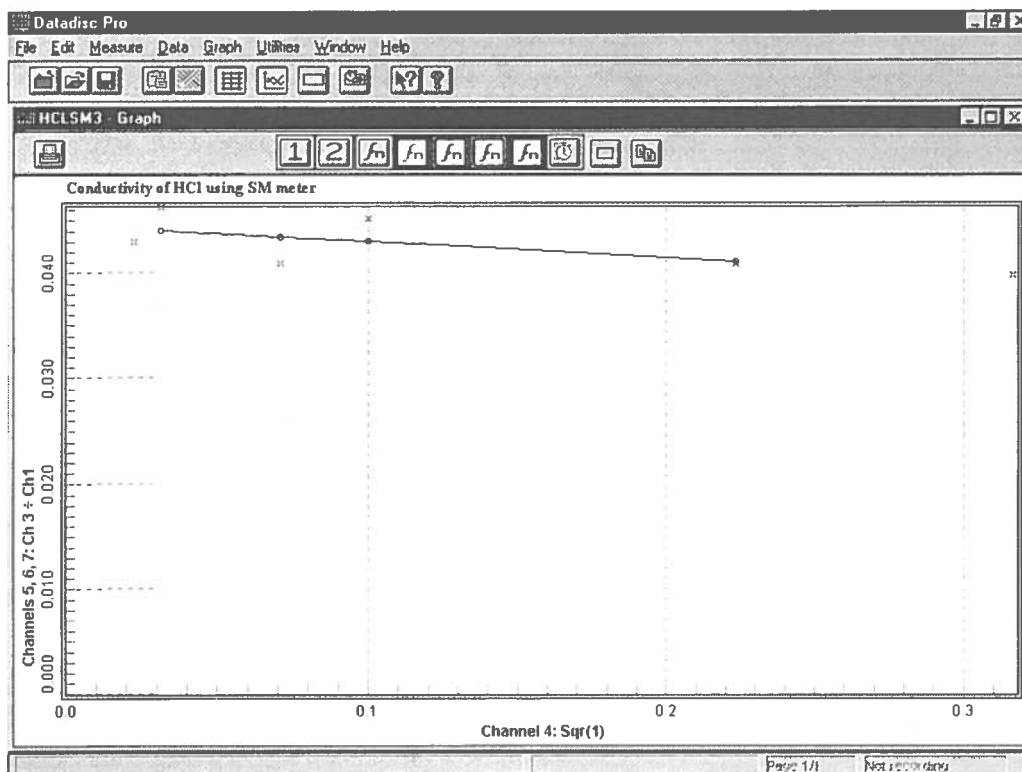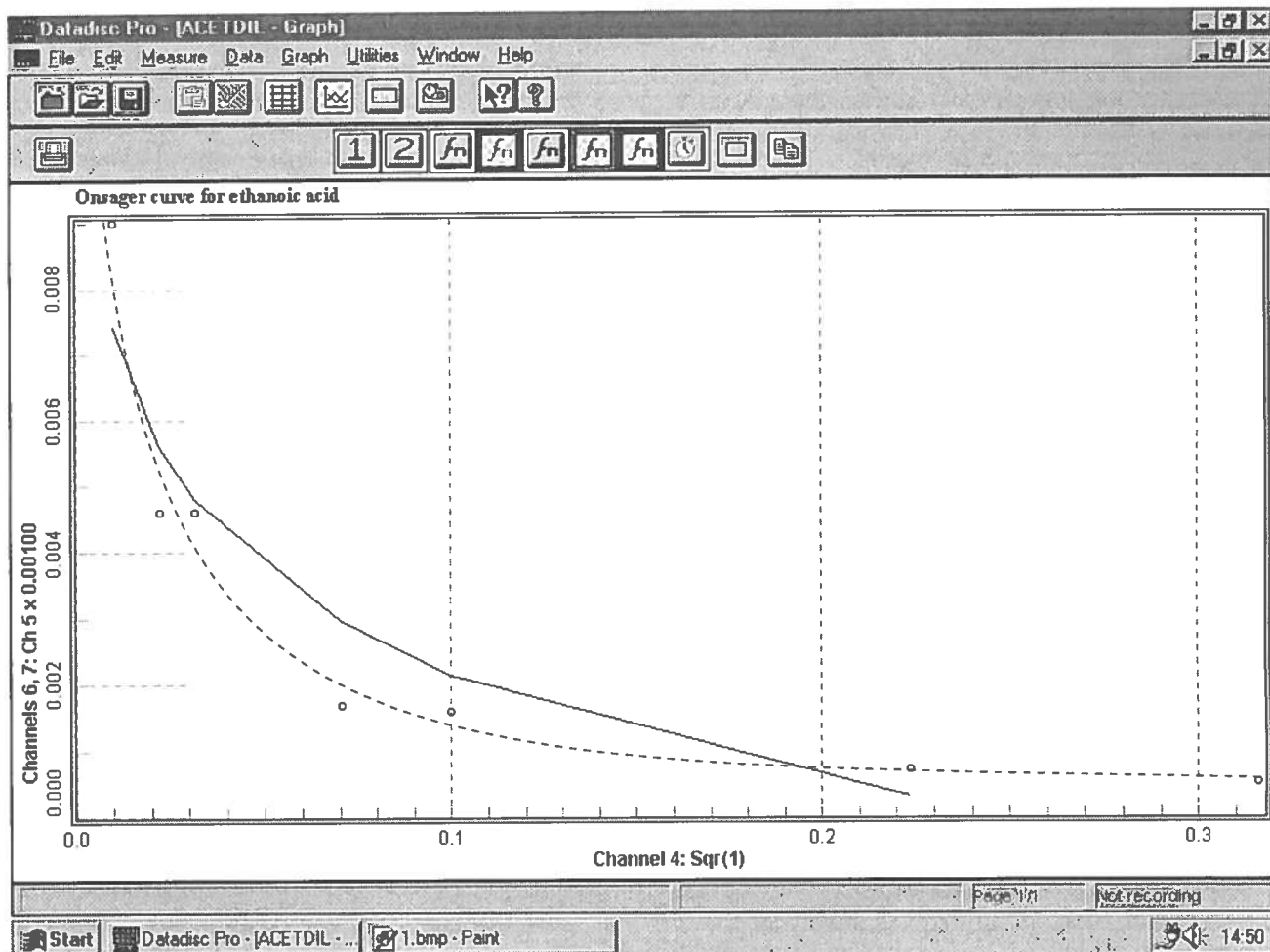

Figure 4 Onsager plot for HCl

Figure 5 Onsager plot for ethanoic acid

The mathematical transformations needed are fairly straightforward. Notice here in Figure 5 as in Figure 4 that when a best fit line (solid) is drawn it does not extend to the last point of the graph, which in fact was the first point in our table starting with high concentration. This is because of the way that the best fit line is calculated. It is an effect common to many spreadsheets.

The best fit facilities are useful for data approximating to one of the set forms provided. They are not generally useful for other data sets, as witnessed in the above example. There is still a place for the experienced eye and hand, which would almost certainly draw it along the dotted line shown (Fig. 5).

Both variables were entered into the spreadsheet facility by keyboard. The only difficulty found was that which was resolved by resetting the resolution of Channels 1 and 2. This was described in the comments on the software in the *Equipment Notes* in this issue.

Rate law for hydrolysis of 2-bromo-2-methylpropane

This classic measurement is greatly facilitated by the use of Harris *Datadisc Pro*, both in the ease of recording and in the post experiment analysis of the results. The log of concentration versus time is shown below (Fig .6) with the best fit line drawn over it. On screen the gradient is given on the top of the graph.

The gradient is also given on the information sheet accompanying any printout, but copy/paste does not carry this information onto other documents. On the data information sheet it reads :

$$y = 0.204 - 0.00017x$$

Therefore   Gradient $= -k/2.303 = -0.00017$

$$k = 2.303 \times 0.00017$$

$$k = 3.9 \times 10^{-4} \text{ s}^{-1} \text{ at } 20 \text{ °C}$$

Note that though the x- co-ordinate for this graph is in minutes, the gradient in the supplied equation is clearly in reciprocal seconds. This should not cause a problem as the discrepancy will be fairly obvious.

Pupil Investigations for chemistry

Harris provide teaching materials for Chemistry comprising of a teachers' guide and set of fifteen, A4-sized, protected worksheets for pupils. In each worksheet there is information about an experiment and instructions on setting up the apparatus and recording and analysing data. Once familiarised with this method and technique, pupils are encouraged to set up their own investigations.

The set of fifteen experiments includes all of the standard ones, such as acid-alkali titration, and some which are probably less well known, such as the determination of the iso-electric point of aminoethanoic acid.

The worksheets contain limited safety information. Generally the hazard warning labels for the chemicals used are included, but no direct safety instructions are given, leaving pupils and staff to prepare their own risk assessments. For most of the experiments the precautions needed are fairly obvious and of a type generally known as *simple assessments*. We think there should be some warning about the 2-chloro-2-methylpropane. It is a highly flammable, volatile liquid with a b.p. of 51 °C. There should be instructions to wear nitrile gloves and dispense it either in a fume cupboard or in a well ventilated place. All but three of the investigations include a goggles icon. The three exceptions use innocuous substances only.
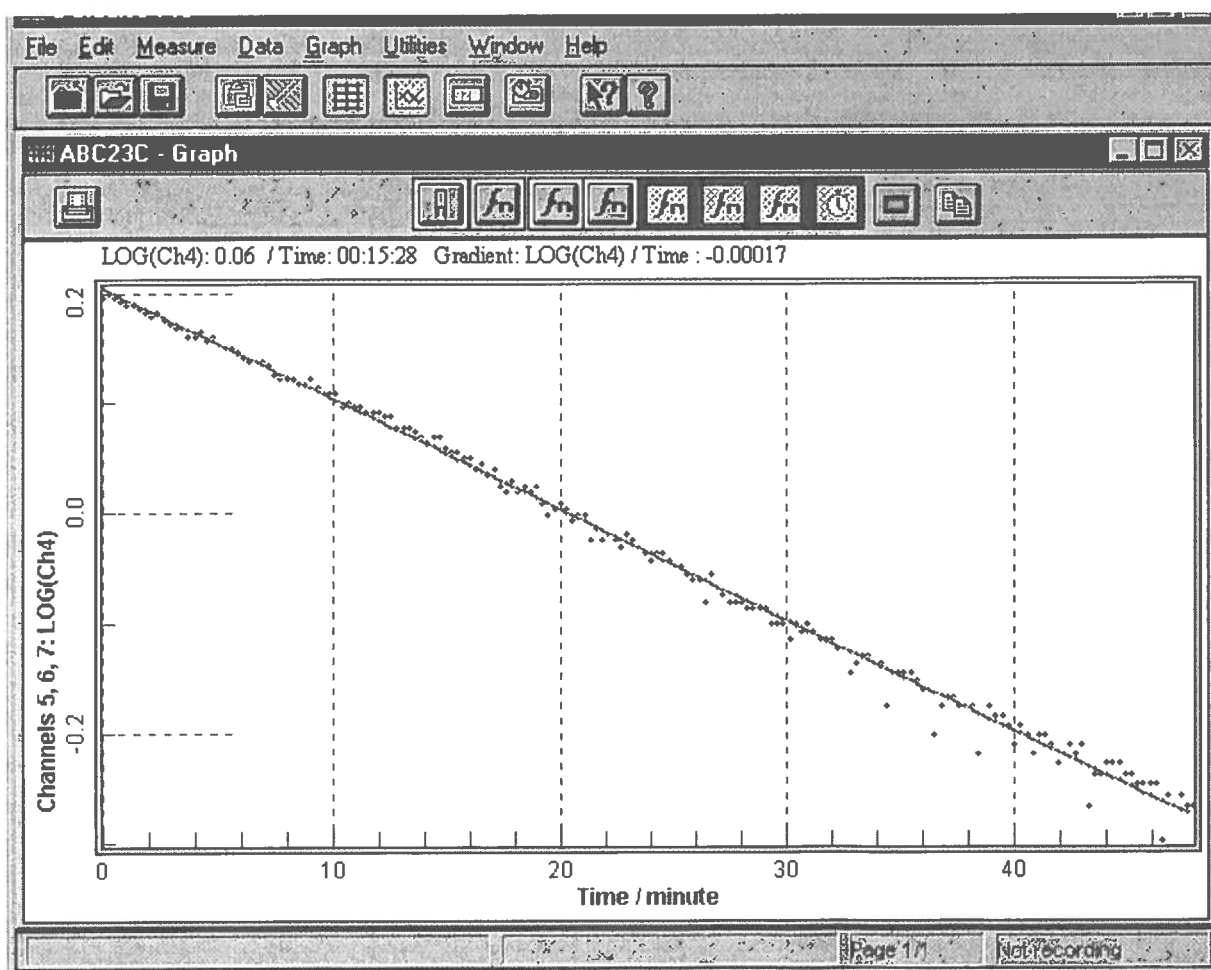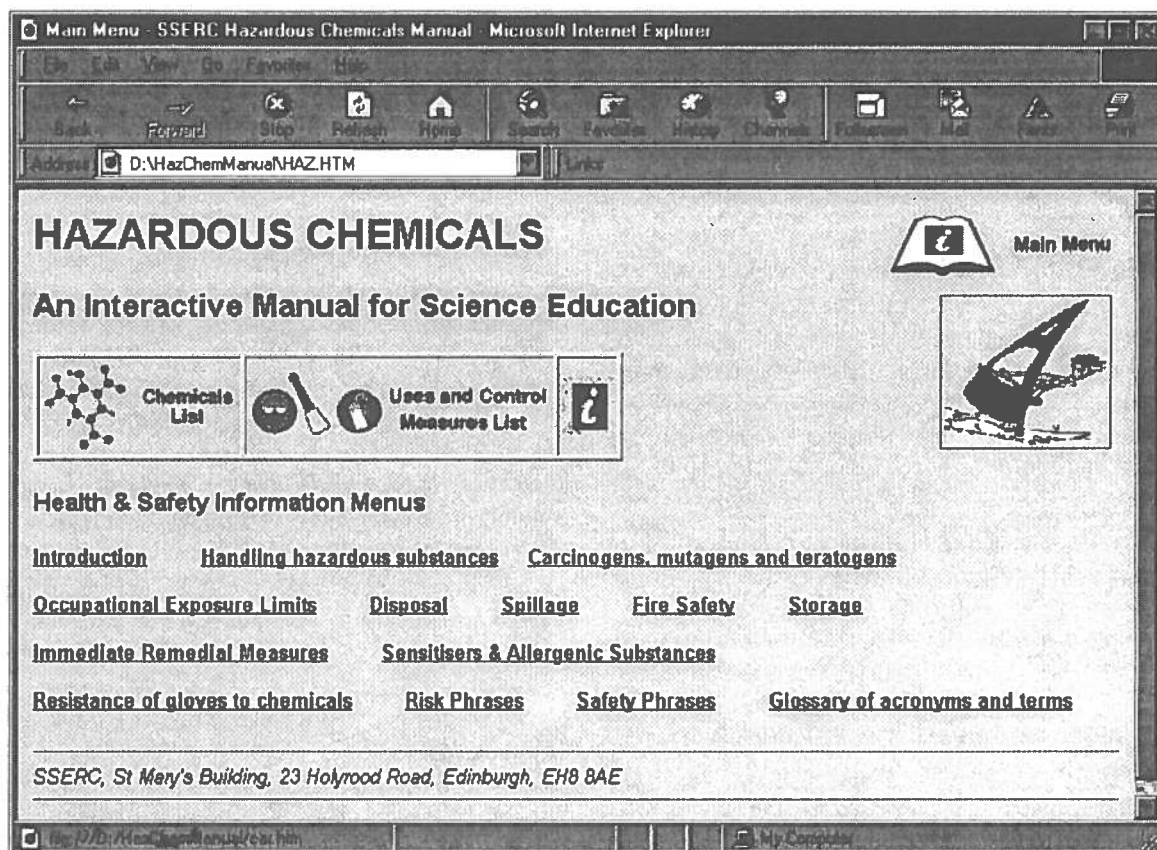

Figure 6   Hydrolysis of 2-bromo-2-methylpropane

Microcentrifuge applications

A demonstration of the Hill reaction with isolated chloroplasts makes use of a prototype microcentrifuge designed for the educational market.

Considerable interest was shown in our short review, in the last issue, discussing some features of a centrifuge developed through the Technology Enhancement Programme (TEP). In particular a number of readers have said they would like more information on the protocol for the Hill reaction. Some of the technical detail (mostly about centrifuge speeds for the two stage extraction) was given in Bulletin 183 [1]. There are also accounts in school texts, but more than one such source has to be consulted for a complete account and some of these are now out of print. A full description of the whole procedure would, it seems, be much appreciated.

Background

Curricular: This work is usually covered at Scottish Higher Grade or in A-level courses. It often follows on from a fairly simple treatment of the absorption and action spectra of chlorophyll, sometimes after a demonstration of the red fluorescence of a chlorophyll extract. This last is intended to show that chlorophyll(s) can *capture* light energy and that some of it is re-emitted at a different wavelength.

Theoretical : The ability of illuminated, isolated chloroplasts to reduce a suitable hydrogen acceptor, even in the absence of carbon dioxide, was first demonstrated by Hill and his colleagues in 1935. It is also possible, in suitable circumstances, to show that oxygen is evolved just as rapidly as in photosynthesis proper and that the process results in the conversion of ADP to ATP.

At this relatively elementary level, many teachers would perhaps content themselves with being able to show that, when they are illuminated, isolated chloroplasts will reduce a suitable redox dye such as DCPIP [dichlorophenolindophenol] (Figure 1).
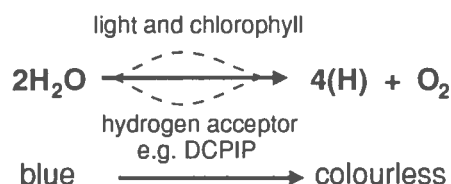
Technical considerations

Since crude leaf cell extracts may contain any number of enzymes or metabolites capable of reducing DCPIP a convincing demonstration relies on the use of isolated chloroplasts backed up with evidence from microscopic observations on a temporary mount of a sample of the extract. This means the use of a two stage centrifugation (see [1]). The first of these, at a relatively low speed, will spin down the larger general cell debris. A second centrifugation, of the supernatant resulting from the first, and at a higher speed, should then spin down organelles such as chloroplasts. Speeds and times for these two treatments depend to some extent on the source of the chloroplasts and thus their likely size.

A difficulty for some schools has been the availability of a suitable, affordable, centrifuge capable of the higher speeds needed to bring down chloroplasts or other organelles within acceptable times. Many of the less expensive, standard, laboratory centrifuges have *swing-out* rotors the air resistance of which effectively limits their speed of rotation. Whilst they are easily capable of spinning down cell debris they take far too long to pellet chloroplasts if they do so at all.

It is for such reasons that the TEP microcentrifuge has caused a stir. Not only will it have a low price but it seems more than capable of achieving such separations quickly and easily.

Procedure

The sequence is shown in the text box opposite. A list of apparatus and other technical details such as recipes for the reagents are provided in the Technical Appendices.

Note - all glassware and other apparatus as well as the solutions used for the various stages of the extraction are to be well chilled in a refrigerator.

Reference

1 *Hill reaction*, p28, Bulletin 183, SSERC, Winter 1994.

light and chlorophyll

$$2H_2O \rightleftharpoons 4(H) + O_2$$

hydrogen acceptor
e.g. DCPIP

blue $\longrightarrow$ colourless

Figure 1 Simplified equation for the photolysis of water as demonstrated in the Hill reaction.

Hill reaction - sequence of procedures.

1. 10 cm³ of ice-cold 0.5M sucrose solution were poured into a mortar and 5 g of freshly chopped spinach leaves or mustard cress cotyledons added and then ground with a pestle.

2. This extract was then strained through nylon mesh into a cooled test tube (100 x 16 mm).

3. 1 cm³ aliquots of the extract were dispensed by means of a pipettor into each of 8 Eppendorf tubes which were then centrifuged in the TEP device for 5 minutes using the internal 6 V supply. The supernatant in each tube was then transferred to a second set of 8 Eppendorf tubes and centrifuged. The centrifuge was now run at 12 V and thus a higher speed by connecting the device to the external mains to 12 V adaptor. The tubes were spun for 10 minutes.

4. The supernatant liquid was then pipetted off and discarded. 0.2 cm³ (200 µl) of cold 0.5M sucrose solution was added to the sedimented chloroplasts in each Eppendorf tube and mixed gently with a fine glass pipette tip. This resuspends the chloroplasts.

5. At this stage a little of the chloroplast suspension was transferred to a glass slide and the preparation checked under the microscope for the presence of isolated chloroplasts in adequate numbers (a successful preparation will be fairly dense with chloroplasts).

6. The chloroplast suspensions were transferred from the Eppendorf tubes into a test tube (150 x 20mm) and 15 cm³ of ice-cold phosphate buffer added mixing well.

7. Three 5 cm³ volumes of this mixture were pipetted into separate test tubes *A, B,* and *C,* and treated as follows:

   A. 1 cm³ of 1% DCPIP was added, tube inverted once to mix and left illuminated.

   B. As tube *A* but placed in the dark.

   C. The chloroplast suspension was boiled, cooled under a running tap, then treated as *A.*

Results :

Tube *A,* with live chloroplasts in the light, will lose its blueish tint, reverting to pale green, as the DCPIP is reduced (Fig. 1). When that happens examine and compare the other two tubes with the colourless (leuco) form. Neither *B* (without light) nor *C* (dead chloroplasts) should have changed colour from their original blue/green.

Technical appendices

Chemicals and reagents :

0.5M sucrose solution: (171.25 g l⁻¹ of solution).

Phosphate buffer: Mix equal volumes of 0.4M sucrose solution (136.92 g l⁻¹ of solution) and 0.1M potassium dihydrogen phosphate (KH_2PO_4). This gives a pH of 4.5.

Potassium hydroxide solution (1M) should then be added until the pH of the solution is 7, as indicated by a pH meter or Universal indicator / paper.

0.1% w:v DCPIP (dichlorophenolindophenol) redox indicator (0.1 g DCPIP made up to 100 cm³ with de-ionised water).

Apparatus :

TEP microcentrifuge	timer
knife or scissors	pasteur pipettes and teats
mortar and pestle	measuring cylinders
filter funnel	beakers
test tubes and rack	aluminium foil
Eppendorf tubes	microscope (x400)

microscope slides and coverslips
bench lamp (preferably a cool source such as a compact fluorescent lamp)
Bunsen burner
rubber bungs
micropipettors and tips (SSERC or NCBE type)
70 µm pore nylon mesh sieve (SSERC) or muslin

Thermal conductivity of gases

There are few, simple experiments showing that air is a poor conductor of heat. Most effects are confused by convection and other factors. Here we report on four experiments that may be suitable in general science courses. Three of these are pupil experiments; the fourth is a demonstration.

Although the poor thermal conductivity of air is a commonplace phenomenon, it is not easy to show by experiment. Despite it being an effect that is presumably taught in elementary science in every school, a search through two science education journals *Physics Education* and *The School Science Review* for the period 1966-85 yielded just one reference. Furthermore the SSERC *Bulletin* hasn't carried anything either! Other books searched that yielded nil returns were *The Science Masters Book* (1949 edition), which carries details of experiments published in early editions of *The School Science Review*, *Nuffield Physics Guide to Experiments*, *Practical Physics* by Llowarch (1952), *Experiments in Physics* by Siddons (1988), etc.

The only simple experiments we found initially were in *Physics is Fun* Book Two by Jardine (1964) [1]. The first is 'Experiment 3.18', in the sub-section *'Heat conduction in air'*, and was used in the Heinemann Worksheets Scottish S1/S2 Science series. The apparatus consists of a glass tube with rubber stoppers at either end, both fitted with thermometers. One stopper has a vent to allow for the expansion of air. The glass tube is tilted and its lower and upper ends heated by a Bunsen. Temperature changes are noted, allowing the tube to cool between different positions of the flame. The experiment is conceptually difficult and can produce confusing results if not set up carefully. For instance the Teachers' Guide [2] points out that the expected results do not occur with a glass tube eleven inches long and one inch in diameter. It recommends using a tube of fairly large diameter, at least two inches, and of length about 8 inches.

One of our four experiments is a modification of Jardine's Experiment 3.18. We substitute a plastic drink's bottle for the glass tube and an electric heater for the Bunsen. With this arrangement, air is heated directly rather than indirectly via the container wall, and there is a significant reduction in the thermal mass of the container, giving greater importance to the relative thermal mass of air.

Jardine's second experiment, 3.19, compares the rates of cooling of initially hot water in two calorimeters, one of which is lagged with cotton wool. In the Heinemann Worksheet version, the experiment compares the rates of cooling through different types of lagging - fur, feathers and felt - with an unlagged flask. It requires filling three flat-bottomed, round, glass flasks with hot water.

When properly set up, the experiment works fine. The effectiveness of thermal insulation and its dependence on trapped air is made clear. But the procedure has its drawbacks. Even given apparatus in good condition, it takes nearly half and hour of recording temperatures to differentiate between the types of insulation. This may be too tedious for some. Worse, in my experience, the apparatus never arrived in the classroom in good condition. The felt lagging resembled a seal in moult. The feathers were little more than you would get on a Tesco chicken. And as for the fur? Well it was worn in the manner of a Hollywood *arriviste* more interested in revealing their charms than keeping themselves warm. Compounding these problems, the classes who had previously worked with the equipment always seemed to be populated with vindictively handless children. The insulation would be sopping wet. Lagged calorimeters, or round glass flasks, make for a splendid thought experiment - but not one to actually do with a second year class!

Concluding this review, Jardine [1] suggests holding a finger on either side of a Bunsen flame, about half an inch from it, from which it can be inferred that air is a poor conductor of heat. Perhaps this simple example of tacit learning, backed up by experiences of using trapped air to insulate downies and sleeping bags, are sufficient to establish the point.

Nevertheless, to our experiments! One has already been introduced. The others resulted from a discussion with Iain MacInnes, formerly Head of Physics at Jordanhill College of Education, and now working part time in Langside College. Iain recalled trying and being impressed by Gaede's Water Vapour Insulation Experiment, having read about it in *The Physics Teacher* many years ago [3]. He also kindly looked up a publication of lectures given by John Tyndall, the nineteenth century science popularizer, from which he sent me a description of Leidenport's Experiment. This Tyndallic reference caused me to think of the Leidenfrost effect - which is surely the same experiment. Finally, with the assistance of Philip McGurk, a Langside College technician, Iain devised the Drinks' Can Experiment. We are grateful both for Iain's assistance and permission to describe the experiment.

THERMAL CONDUCTIVITY OF GASES :
Coke can pan experiment

Description

The experiment uses a standard, laboratory, electric hotplate rated at 400 W. It should be run on full setting giving a hotplate temperature of about 340 °C. Also required are two metal vessels with capacities of 100 cm³. One vessel should have a plane-surfaced, flat base, such as a copper calorimeter. The other should have a parabaloid recess, such as a coke can whose lid had been cut off. Two stirring thermometers and a timer are also needed.

The experiment compares the rates of temperature rise of water in the vessels when placed side by side on the hotplate (Fig. 1), concluding that the coke can's contents heat up more slowly because of the layer of air trapped between the base of this vessel and the hotplate.

The method is simple. The hotplate is switched on at its highest setting and allowed to warm up. 100 cm³ cold water is added to each vessel using a digital balance for accuracy. The vessels are then simultaneously placed side by side on the hot hotplate and water temperatures are recorded each minute until water in one of the vessels is boiling. We found that water in a 74 g, copper calorimeter came to the boil in 8 min 20 s, by which time the water in the 13 g, aluminium coke can had reached 72 °C. The coke can's temperature was consistently and significantly lower than that of the other vessel.
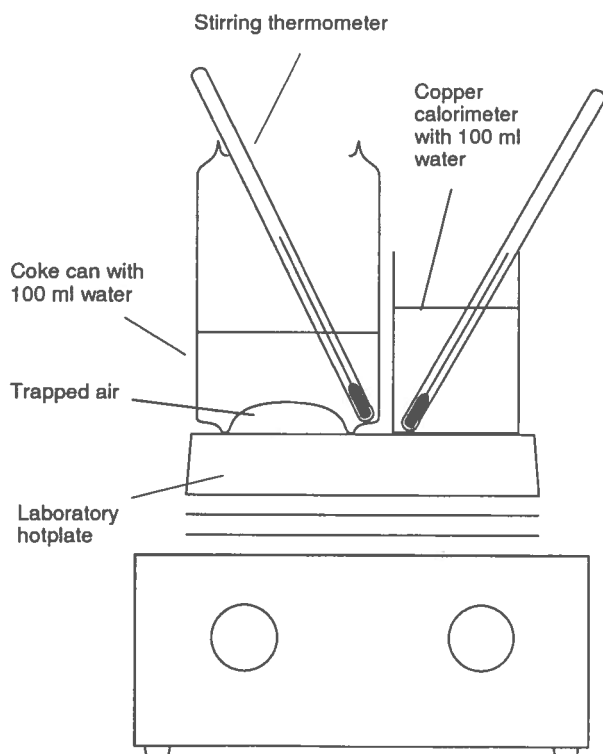

Figure 1   Arrangement for Coke Can Pan experiment.

Risk assessment

1. Skin burns : The hotplate is not obviously dangerous because it doesn't glow red, but is quite hot enough to give anyone touching it a nasty burn. After being switched off, it remains dangerously hot for quite a while. We advise leaving it at a fixed location throughout the lesson, Pupils should be warned orally several times at the beginning of the practical work by the teacher. The apparatus should be closely supervised and any careless behaviour checked. The benchtop around the hotplate should be marked off with strips of adhesive, hazard warning tape. A hazard sign should be errected behind.

   Hot metal cans should not be lifted without protecting the hand from burns. It is recommended that a thick leather glove should be provided for lifting hot cans. Failing that, a pair of lifting tongs would be satisfactory.

   Pupils should be given instructions on immediate remedial measures before starting practical work; *viz.* any skin burn should be bathed forthwith in cold water without any delay.

2. Scalding : Good laboratory practice and behaviour will minimise this risk.

3. Cuts : When a coke can lid is cut open, there are sharp edges round the rim which are probably impossible to remove. Warn pupils to be careful. (It is recognised that the apparatus is imperfect - see comment below.)

Discussion

This experiment would be suitable for pupils to carry out, taking about 15 min. The results seem fairly simple to interpret.

The vessels have more than one significant difference. The water equivalents for the copper calorimeter and aluminium coke can are respectively 7 g and 3 g. These values are small compared with the water contents. The disparity acts against the copper can heating faster, but can be discounted since the water in the copper can actually does warm up much more quickly.

Low values of the mercury level of the stirring thermometer in the coke can are hidden from view. The thermometer has to be removed from the water to be read.

We have approached an equipment manufacturer to ask that apparatus specifically for this experiment be produced.

Acknowledgement

THERMAL CONDUCTIVITY OF GASES :
PET bottle experiment

Description

The apparatus is illustrated (Fig. 2). The air chamber is a 1 litre bottle that had originally contained a carbonated drink. The bottle material is polyethylene terephthalate (PET) - hence the experiment's name. A 35 mm diameter hole was made in the base to accept a 33 mm diameter cork. This was achieved quite simply by heating a large diameter cork borer, which easily cuts through PET. Not having the right size of cork borer, we nibbled away at the hole until the requisite size was
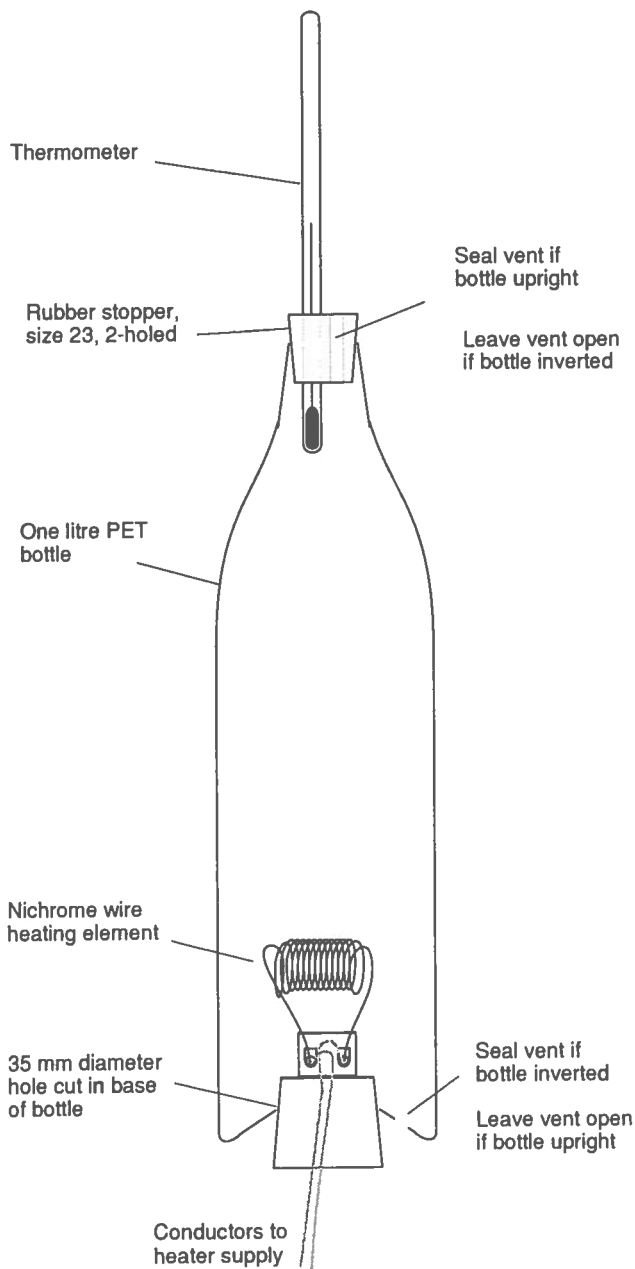

Nichrome wire
24 SWG, 15 turns,
750 mm overall
length,
16 mm coil diameter

Ceramic connector
block, 10 A, 2-way,
RS 425-156

Cork,
33 mm diameter

Figure 3   Heater.

Thermometer

Seal vent if
bottle upright

Rubber stopper,
size 23, 2-holed

Leave vent open
if bottle inverted

One litre PET
bottle

Nichrome wire
heating element

35 mm diameter
hole cut in base
of bottle

Seal vent if
bottle inverted

Leave vent open
if bottle upright

Conductors to
heater supply

Figure 2   Conductivity of air apparatus with PET bottle and electric heater element.
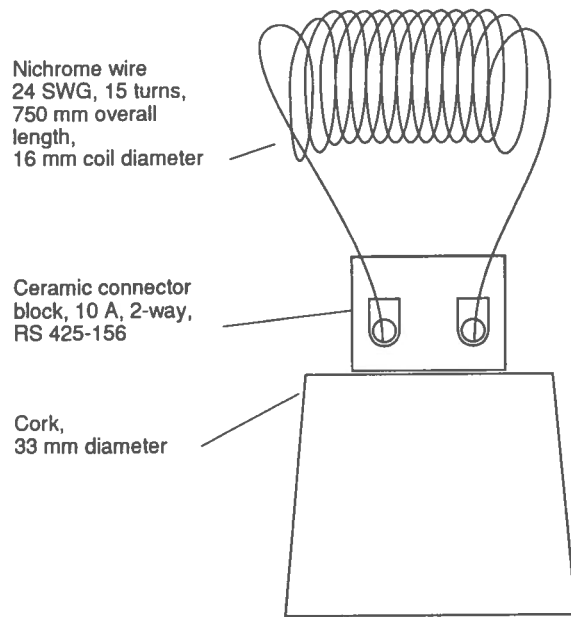
prepared. The resulting hole was imperfectly circular, but could be made airtight by wrapping two layers of tissue paper around the cork before fitment. Note that in one of the activities a small airflow through this hole is necessary. A perfectly circular hole can be made with a hole saw kit, which can be attached to either a hand or power drill.

The heater element (Fig. 3) was wound from a 75 cm length of 24 SWG (0.56 mm dia.) nichrome wire. This has a room temperature resistance of 1.8 Ω. The nichrome wire was fixed into a 10 A, 2-way, ceramic connector block (RS 425-156). This was secured to the cork with a woodscrew. A pair of insulated, copper, flexible leads terminated with 4 mm plugs linked the connector block to an LT laboratory supply. After trials, the heater was operated at 4 V a.c. It drew a current of 1.7 A and supplied power at 7 W.

A size 23 2-holed stopper was fitted to the mouth of the bottle. A stirring thermometer was fitted in one of the holes in the stopper to measure air temperature at the opposite end of the chamber from the heater. The other hole could be left open to allow for air to exhaust as the temperature of the chamber rose. The provision of a pressure release vent would seem to be essential. Two vent holes should be provided, one at each end. Only one should be open at any time to avoid a through draught. If the bottle is in a vertical position, the bottom vent should be open. If the bottle is in a horizontal position, the vent by the thermometer should be open. A 4 mm diameter vent aperture size is suggested. This can be plugged with a small diameter cork.

	Bottle vertical Heater at bottom	Bottle vertical Heater at top	Bottle horizontal
Time (s)	Air temp. (°C)	Air temp. (°C)	Air temp. (°C)
0	28.5	28	21.5
10	-	-	21.5
20	29.5	28	21.5
30	31	28	21.5
40	32.5	28	21.5
50	33.5	28	22
60	35	28	22
70	36	28	22
80	37	28	22
90	38	28	22
100	38.5	28	22.5
110	39.5	28	22.5
120	40.5	28	23

Table 1   Air temperatures for heating periods lasting 2 minutes.

The heater should be run for periods of 2 minutes. Sample results are given for temperature rises for three positions of the bottle (Table 1). With the bottle vertical and heater at the top, the air temperature at the bottom of the chamber does not rise during 2 minutes heating.

Risk assessment

1. Over-pressurization : It is good practice to leave an air vent open. Instruct pupils orally and by written notes and diagrams. Supervise practical activity.

    Under the specified electrical operating conditions and assuming that the vents were sealed, internal air pressure would rise to 4% above atmospheric. This is unlikely to cause the bottle to explode. We have tried this fault condition. We have also seen a report [4] of tests wherein soda bottles had been overpressurized to 6.5 times atmospheric pressure without rupturing. This suggests that an air vent is an unnecessary precaution in our application.

2. Evolution of toxic fumes : It was noted that when the heater was operated while the bottle was horizontal, the PET material directly above the element became hot. There would seem to be no risk of harm from this condition under the electrical conditions specified although the bottle may eventually embrittle and have to be replaced. Under a higher operating voltage, or in the event of the hot wire touching the bottle, harmful noxious gases might be evolved. The apparatus should be frequently inspected to ensure that it is in a safe condition.

Discussion

When discussing the results, children must be aware of convection. The upward transfer of heat is caused by convection entirely. Because there is no downward transfer of heat, conduction through air is seen to be ineffectual. Thus air is a poor conductor. The small amount of heat transferred horizontally is presumably entirely because of convection.

Analysing the thermal properties of this apparatus, all of its parts together have a thermal mass (Table 2) of about 65 J K^{-1}. By comparison, the litre of air within the bottle has a thermal mass of 1.3 J K^{-1}. Thus the thermal mass of air is 2% of the whole apparatus.

If the chamber were a glass tube measuring 300 mm long by 50 mm diameter, the volume of the enclosed air would be 500 cm^3. The thermal masses of air and apparatus are respectively 0.65 J K^{-1} and 215 J K^{-1}. In this case the thermal mass of air relative to the whole apparatus is only 0.3%. It would seem that this ratio is far too small. The influence of the thermal mass of the glass is too significant. Thus a chamber with lightweight plastic walls is preferable to one with glass walls from a consideration of their respective thermal masses.

Using either a 2 litre or 3 litre PET bottle would further increase the ratio of the thermal masses of air to apparatus.

It is interesting to note that supplying energy at a rate of 7 W for 120 s to a homogeneous system with a thermal inertia of 65 J K^{-1} results in a temperature rise of 13 K. The actual temperature rise of air at the top of the chamber is 12 K without allowing for the system to settle or considering losses to the surroundings.

Part	c (J kg^{-1} K^{-1})	m (g)	c m (J K^{-1})
Air	993	1.29	1.28
Bottle (PET)	(400)	43	17.2
Cork	2040	4	8.2
Wire	(400)	2	0.8
Ceramic connector	1000	8	8
Brass screws	370	3	1.1
Steel screw	420	2	0.8
Hg in thermometer	140	7	1.0
Glass of therm.	780	1	0.8
Rubber stopper	1600	16	25.6
Total (PET)			64.8
Glass tube	670	0.25	167
Air	993	0.65	0.65
Total (Glass tube)			215

Table 2   Thermal masses of constituent parts of PET bottle and glass tube apparatus.

THERMAL CONDUCTIVITY OF GASES :
Gaede's water vapour insulation experiment

Description

If a steel ball is suspended (Fig. 4) above a hot Bunsen flame and roasted until very hot (say about 850 °C), then immersed in water, it cools down causing water to evaporate. Differential rates of cooling occur depending on whether the water bath temperature is cold or hot. If the water is cold (say about 20 °C), the main form of heat transfer is directly from steel to water in its liquid state. A large number of minuscule bubbles evolve producing a low intensity fizzing sound. The ball cools down very quickly and very little evaporation occurs. However if the water is very hot (say about 99 °C), the ball is surrounded in an envelope of water vapour several millimetres thick. This reduces the rate of heat transfer tenfold because water vapour, being gaseous, has a low coefficient of thermal conductivity. Because of relative densities, the water vapour rises and evolves from the surface. However fresh vaporisation takes place and to all appearances the ball is continuously enclosed within its gaseous jacket. The top of the ball should be level with the water surface allowing vapour to evolve without causing water to bubble. If the ball is beneath the surface, large bubbles evolve which disturb the water and confuse the demonstration. This stable dynamic condition lasts for about 2 minutes. It is eventually broken when the gaseous envelope disintegrates. Violent boiling then occurs for about 15 s. A few seconds later both boiling and bubbling cease and the water becomes still, indicating that the steel sphere has equilibrated in temperature with the water bath.

Method

1. Fill a 1 litre glass beaker to the 800 cm³ mark with cold water, nominally at 20 °C. Fill a second glass beaker to the 800 cm³ mark with boiling water, place on a tripod and heat gently with a Bunsen such that the temperature is maintained at about 99 °C.

2. From a tall retort stand, suspend a 38 mm diameter steel ball in its nichrome wire cradle above a Bunsen and heat for about 6 minutes till very hot. A type-K temperature probe on the surface of the ball indicates that its temperature reaches about 840 °C.

3. Using pliers to grip the suspension wire, transfer the ball to the beaker of cold water. Simultaneously start a timer. Observe the evolution of minute bubbles and note the sounds of the water quietly fizzing. Stop the timer when bubbling ceases. At this stage the temperature of the sphere's surface has dropped below 100 °C. It takes about a further minute for the water temperature to stop rising, indicating that the system has equilibrated.

4. Reheat the ball for 6 minutes. During the final minute of heating, switch off the Bunsen supplying heat to the hot water. Using pliers to grip the suspension wire,

transfer the ball to the hot water and simultaneously start a timer. The ball should be totally immersed such that its top is level with the water surface. The reaction in the water is seen to be entirely different. The ball is encased within an envelope a gas several millimetres thick. The process is dynamic with gas being continuously produced and evolved. This condition remains for about 2 minutes. It eventually breaks down with violent boiling. Only then does the surface of the ball come into contact with liquid water. Cooling then proceeds rapidly. The violent boiling subsides and the water becomes still. The system has equilibrated.

Results

Immersion in cold water :

Period of boiling	= 15 s
Rate of heat transfer from ball to water during this period	= 7 kW

Immersion in hot water :

Period of gaseous envelope condition	= 108 s ± 29 s
Period of unstable boiling	= 20 s

We can estimate the rates of heat evolved by measuring the mass reduction of hot water during the two cooling phases using the relationship $P = (\Delta m \, l) / \Delta t$. However the estimate may be high because some water is lost by spurting.

Mass loss during envelope phase	= 25 g ± 7 g
Mass loss during violent boiling phase	= 15 g

Therefore energy transfer rate during envelope phase = 520 W ± 200 W (95% confidence)

Therefore energy transfer rate during boiling phase = 1700 W

We can conclude that the rate of energy loss during the gas envelope phase is about an order of magnitude lower than the rate during the cold water contact phase.

Discussion

The usual place in the curriculum for experiments on the thermal conductivity of air is Year S2. The experiment described here has conceptual difficulties. For one, the gas used is water vapour. The teacher would be expected to make the generalization that because water vapour is shown to be a poor conductor of heat, all gases are likely to be relatively poor conductors of heat, including air. Although this is a difficult inference to explain, much of what we understand in science is gleaned from indirect means. Where possible in science we try to observe directly, but where this is impossible
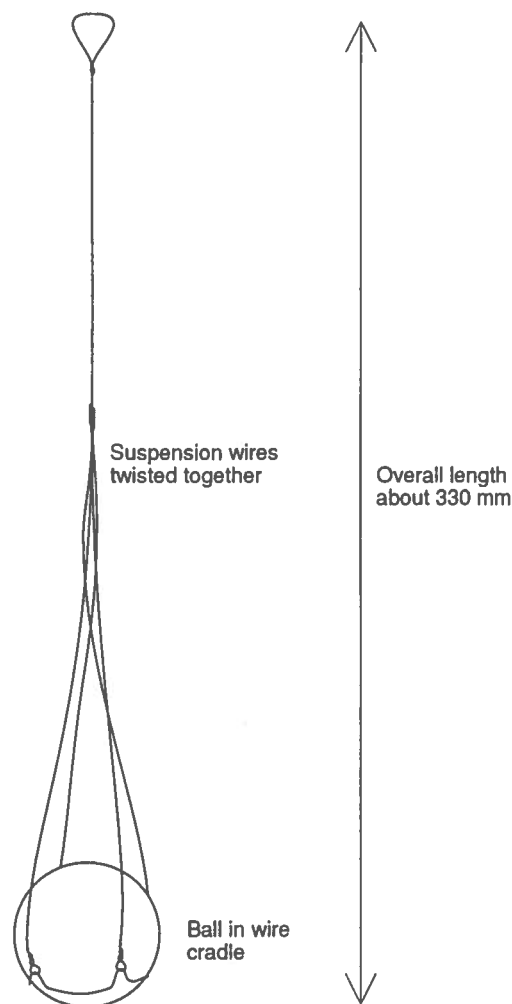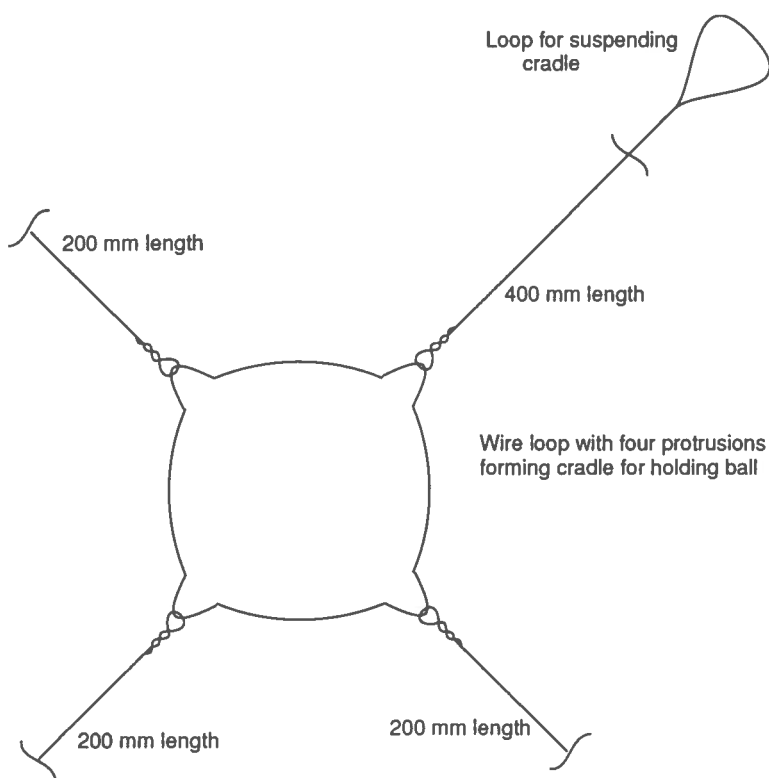
Figure 4   Showing ball suspended in cradle.

Labels in Figure 4:
- Suspension wires twisted together
- Overall length about 330 mm
- Ball in wire cradle

Figure 5   Construction of wire cradle for suspending ball.
Wire : 24 SWG nichrome.

Labels in Figure 5:
- Loop for suspending cradle
- 200 mm length
- 400 mm length
- Wire loop with four protrusions forming cradle for holding ball
- 200 mm length
- 200 mm length

we have to infer and deduce. The water vapour insulation experiment is such a one.

When demonstrating the experiment, pupils should be asked to concentrate on the relative times of cooling. From this, it should be clear that the water vapour envelope acts as an insulating jacket around the hot ball. Thus water vapour is shown to be a poor conductor of heat.

Apparatus

1. Steel ball : carbon chrome steel ball, 38 mm dia., available locally from ball bearing distributors, e.g. BSL or Wyko - see Yellow Pages. Prices quoted have varied to £10.

2. Nichrome wire cradle : 24 SWG (0.56 mm dia.) nichrome wire : Cut into five bits (Fig. 5). Two pairs of pliers required when twisting wire to make connections. Cut off straggling ends.

   Directions :

   a) Form a loop of wire about 50 mm diameter. Twist the ends together to secure the loop. Shape four small protuberances in the loop as per the sketch. The loop is suspended from these protrusions. The effective diameter of the loop should now be between 31 mm and 35 mm. Sit ball in loop.

   b) Cut three lengths of wire each 200 mm long. Cut one length 400 mm long. Neatly secure by a small loop one end of each of these four lengths of wire to the wire cradle. Position the loops such that each fits on a separate protrusion. Gather the four wires together above the ball and neatly twist together with about eight half turns. Trim any straggling tips off the shorter wires.

   c) Form a loop at the end of the 400 mm wire and twist tight. This loop should be sufficiently large to fit over a clamp stand support.

Risk assessment

1. Scalding and burning :

   Risk of scalding from beaker with 800 cm^3 boiling water breaking or couping. Never place hand under tripod. Move Bunsen away from tripod before adjusting flame. Ensure that children watching the demonstration are seated well over one metre distant. No spectator should be sitting with legs beneath the workbench. Experimenter should wear eye protection.

   Risk of scalds from drops of boiling water being projected from beaker. Stand away from beaker. Do not closely approach beaker to inspect the reaction.

   Risk of burns from hot sphere. Wear leather gloves. Have tongs ready with which to handle sphere. Lift suspension wire with pliers when hot. Protect workbench with MMMF board.

2. Demonstration experiment : Because of the risk of severe burns or scalds, this experiment should not be done by pupils under S6.

THERMAL CONDUCTIVITY OF GASES :
Leidenfrost effect

Description

If a drop of water falls on a hot plate with a surface temperature of about 150 °C, the water spreads out as a thin film 'wetting' the surface and evaporates in a few seconds. If the surface temperature is raised to about 200 °C and the experiment repeated, the water fizzes, prolonging the period of evaporation to about 10 s. This behaviour holds for surface temperatures up to about 250 °C. Hotter than this, a remarkable effect occurs - the water drop gathers together as a round bead and sits there for several minutes before completely disappearing by evaporation. What has happened is that the drop sits on a cushion of water vapour, which insulates the liquid water from the hot metal surface thereby prolonging evaporation. It is called the *Leidenfrost effect*, having been extensively investigated by Johann Gottlieb Leidenfrost in the eighteenth century. The transition temperature where the effect starts is known as the *Leidenfrost temperature.*

Tyndall's description is beautiful [5] : *'You hear no noise of ebullition; no hissing of the water; the drop rolls about on its own vapour - that is to say, it is sustained by the recoil of the molecular projectiles, discharging from its under surface.'*

The effect can be shown with a standard, electric hotplate. Use a dropping pipette to place about 0.5 cm³ cold water on the hotplate with a surface temperature above 250 °C. The water drop forms immediately and glides over the hotplate surface, the direction taken caused by the initial momentum imparted and gravity.

Temperature (° C)	Period (s)	
150	4 ± 1	95% confidence limits
200	11 ± 2	
210	11 ± 1	
220	10 ± 2	
230	11 ± 2	
240	17 ± 5	
250	27 ± 8	
260	205 ± 18	
270	238 ± 12	
280	235 ± 10	
290	229 ± 9	
300	219 ± 9	
320	209 ± 19	
370	181 ± 5	

Table 3   Duration of water in liquid state against surface temperature. Initial water volume was 0.5 cm³.

To prevent the drop wandering off the surface, build a perimeter fence out of four strips of metal laid flat on the hotplate, or cut a large diameter circular hole in a sheet of metal and place this on the surface. By using the first of these suggestions, you get a billiard table effect. The water drop resembles a billiard ball in constant motion, rebounding off the walls of a billiard table.

Here are some experimental values. The first table (Table 3) shows the duration of water in its liquid state versus surface temperature. The water quantity was 0.5 cm³. It indicates that the Leidenfrost point lay between 250 °C and 260 °C. The effect is best observed at a temperature of about 275 °C. The second table (Table 4) shows the duration of different quantities of water where the surface temperature was 370 °C.

Risk assessment

1   Skin burns : As for Coke Can Pan effect.

Discussion

The experiment would be suitable for pupils to carry out. If there is a shortage of laboratory hotplates, a small, thick-based girdle or skillet could be used sat on a tripod and heated by a Bunsen. Temperatures needn't be recorded. It is obvious when the hotplate is sufficiently hot. If a drop of water wets the surface and evaporates quickly, it isn't hot enough; if the drop glides over the surface, it is.

You may wish to show the different rates of evaporation off a cool hotplate at 150 °C and a hot hotplate at 275 °C.

When interpreting the results, a generalization is required that because this effect shows that water vapour conducts heat relatively very poorly, the same holds for other gases such as air.

The effect might also be used to illustrate principles of dynamics, or inter-molecular forces.

Volume (cm³)	Period (s)	
0.25	139 ± 6	95% confidence limits
0.5	181 ± 5	
0.75	209 ± 16	
1.0	267 ± 10	

Table 4   Duration of water in liquid state for different volumes. Surface temperature was 370 °C.

References

1   Jardine J *Physics is Fun* Book Two Heinemann London 1965

2   Tresise J Muir D McMahon D Barr J R *Teachers Guide to Physics is Fun* Books One and Two Heinemann London 1967

3   Gaede O F *The Physics Teacher* 1977 487

4   Malerich C Ruff P K *Chem 13 News* May 1998 26

5   Tyndall J *Heat - a mode of motion* 6th ed Longmans, Green & Co 1904 200

SAFETY NOTES

Electrical safety

DB2000 electrical service system

DB2000 is an electrical service system for furniture, racking or general use. It can be used for supplying mains electricity and is designed for rapid assembly. It may well be suitable for temporary installations to which the general public would not normally have access. These would have to be carried out out by a competent technician or tradesman. We do not think it suitable for use in classrooms and were concerned to find it on computer trolleys made by *Blindcraft* and installed in schools.

It comprises multiple gang socket outlets and jumper interconnections. The socket outlet enclosure is less robust than is typical of such devices. With relatively little effort we were able to prize open the enclosure. We are afraid that, if the device is installed in accessible situations in classrooms, some children might try to do this also. The socket outlets may be used individually, or in multiples linked in series with ST18 jumper leads. At each end there is a connector to accept such a lead. The live parts of sockets in these jumpers are recessed by 6 mm within a 7 mm insulated collar and, while they would not be accessible with a British Standard test finger, would be easy to touch with a test probe.

The DB2000 system is designed to several British Standards including BS 5733, which is a specification for accessories used in installations. There is no reference in this standard to limiting the usage of such accessories to areas where the public would normally not have access. There is therefore nothing in the standards to suggest that parts designed to them would be unsuitable for classroom fitments. We are thus left to make a judgement which we are unable to back up by referring to a standard. In our view, from the evidence we have so far, the DB2000 system should not be fitted into places in schools where children might have access.

The DB2000 system is stocked by RS Components.

Griffin Power Pack 300

A sample of this unit has been sent in to the Centre for comment. It has five independent outlets :

● 300 V DC, 30 mA, 100 mA fuse protection

● 0-30 V AC variable voltage, 6A, with 7 A fuse protection

● 0-30 V DC variable voltage, 6 A, with 7 A fuse protection

● 2 x 6.3 V AC, 1.5 A, unprotected

The Power Pack 300's enclosure measures 305 x 230 x 140 mm. Unlike Griffin power supplies of the 1970s, the controls and outlets are on the top panel. We think that the unit was made in the 1960s, but have been unable to recognise it in old catalogues.

The unit sent to us has had some renovations carried out to it. Remaining hazards are :

✗ 300 V outlet sockets are unshrouded

✗ 300 V outlet alongside LT outlets for general use

✗ No overcurrent protection on 6.3 V outlets such that an overload condition can destroy insulation

✗ HT and LT conductors bundled together

We recommend that any of these units still in service should be withdrawn and scrapped.

Netzgerat

Netzgerat is German for power supply. The specific one we are writing about was made by Elektro Automattic gmbh and sold in this country by Tait Components in the late 1980s and early 1990s. It is prominently marked with the maker's stock number, EA 3002, and NETZGERAT. The output voltage range is 10-15 V DC; it is voltage regulated, and can deliver up to 3.5 A.

Fault conditions may include :

✗ Inadequate overcurrent protection resulting in the transformer burning out on full load over continuous operation

✗ Deficient fuse holder insulation

✗ Fuse fitted on neutral rather than phase live conductor on 50% of units inspected

✗ Enclosure lid not earth bonded

✗ 6 mm dia. aperture for setting an internal pot poorly guarded and necessitates the interior being probed

✗ Insulation corrosion at cord entry

✗ Excessively high temperature rise

Tait submitted one to us for testing in 1989. We reported back to them by a letter dated 2/2/89 : *"All in all we cannot recommend the usage of this supply in schools . . . . . the transformer burns out under load 50 minutes after switch-on. This and some other adverse findings render the supply unsuitable."* We trusted that Tait would act on our findings and had no cause then to publish them in the Bulletin because we had understood that the product would not be marketed to schools given our adverse results. We were thus surprised to find that a Scottish school had been sold several of these *Netzgerat* in 1992.

Anyone else with one of these defective power supplies (of which there may be a number of variants) should contact SSERC for further advice and information.

Accidents with Mac 4400s

Two accidents have been reported to us. Both occurred with Apple Mac 4400 computers. We understand that at the rear of these machines there is an accessible voltage selector which changes over from 230 V to 115 V operation. One of the incidents happened in a school office when a member of staff operated the switch while trying to power down the computer. The other incident took place in a classroom while the computer had been de-energised. The cause was attributed to mischievous action by a pupil. Both accidents caused internal circuits to explode. No persons were harmed.

Electrical standards generally specify that voltage selectors should be designed so that changeover cannot occur accidentally. We occasionally have equipment in for testing where this is not so, but seldom get incidents reported to us related to this fault condition.

Voltage selectors can be rendered inoperative by covering with a plate, or unwiring. Any such renovating should be done by a suitably competent person. Please contact the Centre for advice on specific problems.

Van de Graaff problems

Griffin Junior enclosure

This note relates to the early version of the *Junior* model with the clear, plastic, cakebox lid [model number L81-275 (1972 and earlier), or XJE-300-K (around 1977)]. Because the lid can be lifted off, there is easy access to the 230 V motor with a risk of electric shock, or of injury from moving parts. The electric shock risk can be eliminated by replacing the motor with a low voltage version which has a reduction gearbox. A suitable type is in the *MFA/Como Drills 919D* series. The motor with pre-assembled, single ratio, 11:1 gearbox is supplied by Maplin (stock number WC70M at £16.161).

The replacement requires competence in fitting and access to workshop tools. The main difficulty is enlarging the axial hole in the drum on which the belt turns. This might be done on a lathe, or by hand, going in from either end to meet in the middle. A wooden baseplate to hold the motor also has to be fitted. Construction details are available from SSERC. We are grateful to Alan Wylie of Falkirk Council for supplying us with this information.

Griffin Senior motor speed controller

This second note is about the early version of the motor speed controller for the *Senior van de Graaff* generator (Griffin, stock numbers L81-280 and XJE-401-010Q). In its original state, the main hazard is the flexible, metallic, unearthed, ventilation grille which can be pressed down to make contact with an internal, hazardous live terminal on the rheostat.

One way of eliminating the hazard is to remount the rheostat by turning the frame which supports it through 90°. To do this, you will need to drill two extra holes in the enclosure and blank off the originals. Also a protective earth conductor should be bonded to both of the grilles and to the frame supporting the rheostat.

The power outlet to the van de Graaff is an obsolete Bulgin connector of a type which is hazardous because it is openable by hand and offers inadequate strain relief. However because the connector would not normally be used by pupils, the risk might be considered tolerable.

It could therefore be left as it is provided that it is regularly opened and inspected for secure connections, absence of frayed strands of wire, sound insulation and some form of strain relief, inadequate though it is. If however you decide to change this connector then we suggest that you fit a shuttered outlet, reverse configuration, power outlet socket (RS 489-245) to the enclosure and replace the motor lead with one having a reverse configuration moulded plug (RS 445-734). Additionally, a cable gland (RS 544-011) should be fitted to the cable entry where power is taken into the enclosure. The finger-turn nut should be placed inside the enclosure.

We have had a suggestion from Alan Wylie of Falkirk Council that the original Griffin box should be replaced by an ABS plastic enclosure, stock number ENMB4/B from CPC. With some 3 mm diameter ventilation apertures drilled in a part of the lid far away from internal fittings, there is no appreciable self heating reported.

It is a legal requirement that any person asked to carry out modifications of the sort described here is known to be sufficiently competent to do so. After the modification is complete a second competent person should inspect the work and the apparatus should be tested with a PAT meter.

Van de Graaff repairs

A company that specializes in repairing van de Graaff generators is Ideas for Education, whose address and telephone number are listed on the inside rear cover.

Philip Harris have produced a leaflet on the care and maintenance of van de Graaff generators. It offers very helpful advice and is well worth obtaining.

Exposure to ultrasound

An incident has ben reported to us wherein a pupil had been exposed to ultrasound by placing an ear directly to the bell of the horn on an *Ultrasonic Transmitter* (Philip Harris Catalogue reference Q50400/4) After being admonished by his teacher, the boy, who has behavioural problems, asserted that he was experiencing pain. The school contacted us to find out whether the apparatus is capable of causing harm. We understand from Harris that the transmitting sound level of the 40 kHz signal is 65 dB. The actual sound level at the bell of the horn might be about 10 dB less.

Under the Noise at Work Regulations, employers are required to take preventive action if employees are exposed to a peak sound pressure of 200 pascals, which is equivalent to a sound level of 140 dB. Because an actual, instantaneous exposure from the Harris Ultrasonic Transmitter is many orders of magnitude lower than this statutory action level, the chance of someone being injured by such an exposure is negligible. Moreover the peak sensitivity of the human ear is 8 kHz, with susceptibility to damage dropping away at lower and higher frequencies.

We discussed the incident with an occupational physician in the Employment Medical Advisory Service (EMAS) of HSE. He agreed that an exposure from this equipment was unlikely to cause damage. It might have caused tinnitus, or ringing in the ears, which would disappear after a short period. On the basis of the facts as presented, he thought that it would be unwise to send the boy for a medical examination.

Carbon dioxide cylinder accident

A laboratory worker was reportedly injured when using a carbon dioxide cylinder with a device designed to produce flaked dry ice [1]. The injured person had been using an attachment, called a *Frigimat Junior*, which screws directly to a cylinder containing liquid carbon dioxide. The apparatus works by allowing pressurized liquid to escape from the cylinder via a small orifice in a brass nozzle and expand into a cloth bag forming solid carbon dioxide.

The accident occurred because the experimenter apparently mistook the instructions to open the cylinder valve by 3/4 of a turn and made three or four turns instead. The cylinder valve popped, causing the polypropylene cone attached to the brass nozzle to crack and releasing a mixture of gaseous and solid CO_2 at high pressure into the experimenter's face knocking off his safety glasses. He was treated for traumatic injury, corneal abrasion and cold burn.

The Frigimat Junior is made by Bel-Art and supplied by Radleys. The report concludes, "*Though the accident must be attributed to the researcher's poor judgement in opening the valve so far so fast, the device is also not designed for optimal safety. Be careful in using it.*"

Reference

1 *Laboratory Safety and Environmental Management* Jan-Feb 1998 6(1) 4.

Ionising Radiations Regulations

The Health and Safety Commission (HSC) are revising the Ionising Radiations Regulations 1985, which control work with radioactive substances and x-rays. Earlier this year the HSC issued a Consultative Document containing their proposals. The deadline for consultation has passed and the new regulations are now being finalised. Revised regulations (IRRrev) are due to be published by the end of this year, enacted by Parliament next Summer and brought into force no later than Year 2000.

Reasons for the revision include :

- Responding to several new European Union Directives, chiefly the revised Euratom Basic Safety Standards (BSS) Directive.

- Incorporating new internationally agreed principles on radiation protection.

- The setting of lower dose limits.

- The influence of the Management of Health and Safety at Work Regulations (MHSWR)1992.

- Recasting and resystematising the regulations to bring out more clearly the concepts of radiation protection.

- General acceptance that a radiation protection adviser (RPA) should be professionally qualified.

Whilst at this stage we can only speculate on which of the ideas so far proposed will be taken up, the main effects on schools may be the disappearance of the radiation protection supervisor (RPS) post and the need for a radiological protection adviser (RPA) to be professionally qualified. Under IRR85, schools do not need to appoint an RPA, but do need under Regulation 6 of the Management of Health and Safety at Work Regulations (MHSWR) to appoint a competent person to advise on work with radioactive substances.

The proposals within IRRrev indicate that schools would in future need to appoint an RPA. Such an Adviser appointed under IRR85 has a five year period of grace before becoming professionally qualified. An RPA appointed under IRRrev, however, would have to be already so qualified.

It would therefore seem to be in schools' and councils' interests to ensure that they have RPAs in post under the existing legislation. That would give them a five year breathing space to appoint qualified persons. When appropriate we shall write to Councils and SCIS to offer further advice on this matter.

*   *   *

SAFETY AND ENVIRONMENTAL NEWS

New or revised HSE guidance

For schools and school boards : Health and Safety Executive (HSE) revised guidance on health and safety, principally for third parties involved in the governance of schools, has been published recently. Originally issued in 1992 and aimed mainly at school governors in England and Wales the guidance is now extended to cover school boards in Scotland [1]. Revisions include those taking account of changes in health and safety law since publication of the first edition. The guidance now clearly differentiates the various roles of bodies involved in school governance in different kinds of schools, whether state funded or independent. In addition to extending the advice to cover Scotland and the provision of much practical advice, the booklet also provides gentle, plain English, guidance on health and safety management.

Occupational asthma, skin disease: Two new Medical Guidance Notes have just been published by HSE. Although not intended for a general readership, they may well be of interest to health and safety officers, health care professionals and safety representatives. They are entitled : *Medical aspects of occupational asthma* [2], which discusses problems that may arise from the use of asthmagens at work, and *Medical aspects of occupational skin disease* [3], which considers substances that can cause allergenic reactions and other skin disorders.

Noise at work: HSE has launched a major revision of its guidance on the Noise at Work Regulations 1989. One volume now replaces the 1989 and 1990 Noise Guides (parts 1-2 and 3-8). The new guidance [4] is entitled: *Reducing noise at Work : Guidance on the Noise at Work Regulations 1989.* It is divided into six parts, with each section having a specific audience such as: employers, manufacturers, designers and importers, engineers and competent persons appointed to carry out noise measurements or risk assessments. Again this guidance is more likely to have relevance for persons with specific professional, technical or other interests in health and safety issues.

More COSHH amendments

The 1994 version of COSHH has again been amended by Regulations laid before Parliament in June [5]. The amendments are mainly concerned with implementing European Directive 96/55/EC. The major change has been amendment of Schedule 2 of COSHH which will prohibit the supply, for use in "diffusive" applications, of eight chlorinated hydrocarbon solvents including : 1,1,1-trichloroethane (methyl chloroform); tetrachloromethane (carbon tetrachloride) and trichloromethane (chloroform).

Diffusive applications include cleaning surfaces, degreasing metal parts and cleaning fabrics etc. whereby ozone-unfriendly solvent vapours may be released into the atmosphere. The prohibition does not cover medicinal or cosmetic products nor does it extend to uses in research and development or analyses. These amendments will probably have little or no significant, practical, effect in educational contexts. This is because in science and technology departments, usage of most or all of these solvents has already been abandoned in favour of less harmful substitutes. Some schools may well hold stocks of 1,1,1-trichloroethane, which has a number of non-diffusive applications in chemistry courses. Its application can continue but since supply is now problematical it will have to be recycled for further use [6].

SEPA guidance

The Scottish Environmental Protection Agency (SEPA) as a single agency, has for some time been carrying out a number of functions and enforcing legislation previously overseen by several disparate agencies. SEPA has also been busy of late publishing new or revised guidance on pollution control and related environmental matters. One such publication is *A Guide to the Special Waste Regulations 1996* [7]. This gives general guidance and whilst useful is not education sector specific. At the time writing, more advice - a set of pollution prevention guidelines - for schools and other educational establishments, is out for consultation [8].

As indicated in our Hazardous Chemicals Manual, the 'domestic' activities of schools or other educational premises are deemed exempt from the Special Waste Regulations 1996, as amended. Any laboratories therein, however, are not so exempt. Detailed consideration of the implications of this partial exemption has thrown up a number of interesting anomalies. Discussions with SEPA, their English equivalent EPA, CLEAPSS and ASE are, as they say, "ongoing" as to how these practical problems might best be resolved. Of which, more, anon.

Meantime we have also had news of a book for schools on environmental chemistry, written by a SEPA staff member. We hope soon to obtain a copy for review.

References
1. *Health and safety guidance for school governors and members of school boards*, HSE Books, 1998, ISBN 0 7176 1298 8. (£5.95)
2. *Medical aspects of occupational asthma*, MS25, HSE Books, 1998, ISBN 07176 1547 2, (£6.00).
3. *Medical aspects of occupational skin disease*, MS24, HSE Books, 1998, ISBN 0 7176 1545 6, (£5.50).
4. *Reducing noise at work - Guidance on the Noise at Work Regulations 1989*, ISBN 0 7176 1511 1, (£9.75).
5. *The Control of Substances Hazardous to Health (Amendment) Regulations, 1998* (SI 1998 No.1357), ISBN 0 11 079109 6. HMSO.
6. *Hazardous Chemicals : A Manual for Science Education*, SSERC, 1997, ISBN 0 9531776 0 2 (see entries for relevant solvents, particularly under "Uses and Control Measures").
7. *A Guide to the Special Waste Regulations 1996*, SEPA.
8. *Pollution Prevention Guidelines, Schools and Educational Establishments*, PPG16, SEPA, draft edition, 1998.

Machinery safety : BS 5304 obsolescent

This standard code of practice has been the basic text on machine safety. Its scope covers the identification of the hazards arising from the use of machinery and it describes methods for the elimination or reduction of these hazards, for the safeguarding of machinery and for the use of safe working practices. It also refers, but does not give full coverage, to non-mechanical hazards.

Like the Good Book itself, this 'Bible' on machinery safety is a good read. Several SSERC staff have read it from cover to cover - all 158 pages - and return to it routinely for guidance. Few other standards, even those one tenth its size, were consulted so thoroughly, far less read in entirety. It will be missed.

The term *obsolescent* needs explaining. It does not mean that the standard is obsolete, or no longer of current use, but rather that it is becoming obsolete. Thus it is not recommended for use in designing new equipment, but needs to be retained to provide for the servicing of existing equipment that is expected to have a long working life. So although BS 5304 will still be available, it no longer applies to today's new machinery.

Confusingly, there is no single replacement - just lots of EN equivalents (see list below). This is alarming! If something as important as machinery safety becomes hidden within a fog of dozens of standards, those of us who need to know about this matter may have no ready access to the information. It is too expensive!

Many teachers would have been familiar with BS 5304 and be accustomed to pass on information and ideas from it to their junior colleagues and pupils. Now, because this holistic code of practice is obsolescent, the chain of expert advice is in danger of being broken. There is surely a need for BSI to produce a single document whose scope matches that of BS 5304.

Safety of machinery standards

BS EN 292	Safety of machinery. Basic concepts, general principles for design :-	
BS EN 292-1:1991	Basic terminology, methodology	£50
BS EN 292-2:1991	Technical principles and specifications	£80
BS EN 294:1994	Safety of machinery. Safety distances to prevent danger zones being reached by the upper limbs	£36
BS EN 349:1993	Safety of machinery. Minimum gaps to avoid crushing of parts of the human body	£26
BS EN 414:1992	Safety of machinery. Rules for the drafting and presentation of safety standards	£50
BS EN 418:1992	Safety of machinery. Emergency stop equipment, functional aspects. Principles for design	£36
BS EN 457:1992	Safety of machinery. Auditory danger signals. General requirements, design and testing	£50
BS EN 547	Safety of machinery. Human body measurements :-	
BS EN 547-1:1997	Principles for determining the dimensions required for openings for whole body access into machinery	£36
BS EN 547-2:1997	Principles for determining the dimensions required for access openings	£50
BS EN 547-3:1997	Anthropometric data	£36
BS EN 563:1994	Safety of machinery. Temperatures of touchable surfaces. Ergonomics data to establish temperature limit values for hot surfaces	£50
BS EN 574:1997	Safety of machinery. Two-hand control devices. Functional aspects. Principles for design	£50
BS EN 614	Safety of machinery. Ergonomic design :-	
BS EN 614-1: 1995	Terminology and general principles	£50
BS EN 626	Safety of machinery. Reduction of risks to health from hazardous substances emitted by machinery :-	
BS EN 626-1:1995	Principles and specifications for machinery manufacturers	£26
BS EN 626-2:1996	Methodology leading to verification procedures	£36
BS EN 811:1997	Safety of machinery. Safety distances to prevent danger zones being reached by the lower limbs	£50
BS EN 842:1996	Safety of machinery. Visual danger signals. General requirements, design and testing	£50
BS EN 953:1998	Safety of machinery. Guards. General requirements for the design and construction of fixed and movable guards	£50
BS EN 954	Safety related parts of control systems :-	
BS EN 954-1:1997	General principles for design	£50
BS EN 982:1996	Safety of machinery. Safety requirements for fluid power systems and their components. Hydraulics	£50
BS EN 983:1996	Safety of machinery. Safety requirements for fluid power systems and their components. Pneumatics	£50
BS EN 1037:1996	Safety of machinery. Prevention of unexpected start-up	£50
BS EN 1050:1997	Safety of machinery. Principles for risk assessment	£50
BS EN 1070:1993	Safety of machinery. Terminology	£26
BS EN 1088:1996	Safety of machinery. Interlocking devices associated with guards. Principles for design and selection	£66
BS EN 1760	Safety of machinery. Pressure sensitive protective devices :-	
BS EN 1760-1:1998	General principles for the design and testing of pressure sensitive mats and pressure sensitive floors	£66
BS EN 60204	Safety of machinery. Electrical equipment of machines :-	
BS EN 60204-1:1993	General requirements	£100

NEWS AND RESOURCES

Scottish technicians' group

We are very pleased to announce the formation of a Scottish Technicians' Advisory Group. Following a number of exploratory meetings, the new group was formally constituted this September. The advisory group is made up representatives from : the technical support services of several Scottish Unitary Authorities, ASE Scotland and the independent sector. The membership has a wide geographical spread although a number of areas are not yet represented. The next step will be for the advisory group to draw up a set of priorities and a work programme. The intention is also to develop mechanisms for liaison with other groups and parties with an interest in professional support and development for educational technicians. Such other parties would include the ASE, other professional or learned societies, possibly FE and HE, the Scottish Science Advisory Group and the parallel body for Technology Education as well as the Scottish Local Authorities' Health and Safety Group, another recently constituted and potentially important body. The office bearers of the new technicians' group are :

Chairperson : Mr Sam McFarlane, Manager of the Glasgow City educational technical support services;

Secretary : Mrs Pauline Anderson, Earlston High School, Scottish Borders Council and ASE Technicians' Task Group.

Minute Secretary : Mr Alan Wyllie, Falkirk Council.

SSERC has agreed, meantime, to provide an accommodation address for the Technicians' Advisory Group and further information may be obtained via Mr Ian Buchanan here at SSERC.

Field Studies : New Code of Practice

In recent years there have been a number of high profile accidents and incidents which have drawn attention to a need to tighten supervision of some providers in the outdoor education sector. Whilst the majority of field studies centres and other outdoor education sites exhibit good practice, there has been a need to bring others up to the same high standards. To that end the National Association of Field Studies Officers (NAFSO) has published a Code of Practice on quality, safety and sustainability [1]. This new code has the support of the Geographical Association, Institute of Biology; the Field Studies Council and the Council for Environmental Education. Whilst the code, on occasion, begs some questions - in general it is a worthwhile and useful document. It is also reasonably succinct and thus, mercifully, short. It also has a useful list of references for those who wish to pursue the matter in more depth.

Reference

1. *Field Studies Centres : A Code of Practice, Quality, Safety and Sustainability*, NAFSO, 1998, ISBN 1 901642 01 1

Chemistry teachers' meeting

The date has already been set for the 1999 University of St. Andrews and Royal Society of Chemistry National Scottish Meeting for Teachers of Chemistry. The date for your diaries is Thursday the 20th of May 1999. The venue, we imagine, will be St. Andrews. In due course a programme will be publicised by the joint organisers through Drs Botting and Flood.

Biology education events

The Institute of Biology's (IoB) third annual Biology Education Meeting at Stirling University - *Taking Biology Forward* was well attended with an excellent, relevant programme. Participants seem to appreciate the mix of topics and speakers which cover both matters directly applicable to learning and teaching with items of more general educational and biological interest. Just one of the 'stars' of the show was Dr Elizabeth Fisher of Saint Mary's Hospital Medical School who gave a talk on the Human Genome Project. (A summary of Dr Fisher's lecture has been produced by Morag Barnes of the IoB Scottish Council. Copies are available from Peter Anderson (see Address List). The date for the fourth annual gathering is provisionally set for Thursday the 13th of May 1999.

The week-long, 1998, *Biotechnology Summer School* at Edinburgh University was also, by all accounts, a runaway success, even though it took up the first week of most of the teacher participant's well deserved Summer break. Possibly hard to believe of, allegedly idle, teachers but the event was over-subscribed. The lists had first to be extended and then closed at 55 or so. Participants were worked very hard (too hard at times according to not a few) and packed a lot in to their week. Fuller accounts from participants may well appear in other journals such as Scottish Science Issues. Already, the Planning Group are girding their whatsits for 1999. There is a rumour that funding may be forthcoming for two events next year - a repeat, more or less, of this year's event together with a second - more advanced programme - for anyone sufficiently masochistic from the 1998 cohort wishing to return for yet more demanding punishment.

SAPS update

Having gained another appointment, Dr Mary McDonald has resigned from her part-time post at SAPS (Science and Plants for Schools Project). She may be available on a broad consultancy basis early next year. This would provide further support for the ELISA project with which Dr MacDonald has been closely involved. This ELISA protocol is currently undergoing trials and is to be evaluated here in Scotland as well as furth of the border. Mrs Erica Clark joins the SAPS Cambridge office in January 1999 and Maggie Bolt has been confirmed as Programme Administrator for SAPS.

Resources for microbiology

The Society for General Microbiology (SGM) has announced a number of initiatives and low-cost resources to increase yet further support for teachers in the teaching of microbiology and biotechnology. They have either been produced or are under active development at the SGM and, or, NCBE and include : computer based learning materials for the first examination stage and post 16 courses, and a range of posters (posters have gone out of fashion apparently but we have samples of these and they are excellent covering contemporary issues such as food poisoning).

There is also a pack on fermentation experiments from NCBE and an overhauled and updated MISAC (Microbiology in Schools Advisory Committee) service. Curricular references are solely to English/Welsh and Northern Irish courses but, for once, don't let that put you off! The equivalent Scottish contexts are quite obvious. Further information on these resources and details of the MISAC service are available from the SGM. If you have access to the Internet you can also look at the NCBE site (see Address List) which is hot linked to other sites run by some of the other supporters of MISAC such as the Science and Plants for Schools Project (SAPS). Another, related, site well worth a visit is *The World of Microbes* produced by the Biology Teaching Organisation at Edinburgh University.

Changes to DNA kit

NCBE/SAPS have produced a new *Technical Guide* and a revised edition of the *Student's Guides* to their Plant DNA Kit. The kit itself has also been modified with the provision of a new 6-tooth gel comb and the price increased slightly (by £2 to £130.00). Class sets of the Student's Guide are now available at a reduced price and those ordering such class sets will receive the new Technical Guide free of charge. The original NCBE Lambda DNA kit is also still available at £115 and contains sufficient material to allow 16 runs of the Lambda protocol.   /next col.

A revised NCBE price list has been produced listing these products and many more. Visit the NCBE Website for details or write to NCBE at the address on the inside back cover of this bulletin.

Higher Still Sciences : R.I.S.E.

Over the Summer and the early part of this term, we had a number of enquiries on the whereabouts of 'R.I.S.E. Publishing'. The full name of this small, independent publisher is 'Resources in Science Education'. R.I.S.E. Publishing is run by a partnership of three practising teachers. Their copymaster materials for Higher Still courses are being marketed as *Challenge Products*. As of August this year the range included :

Challenge Biology - Intermediate 2;

Challenge Chemistry - Intermediate 2;

Challenge Chemistry - Higher and

Challenge Physics - Intermediate 2.

Each course has been divided into 3 Units and each Unit into 4 Sections. The materials may be purchased as individual sections, units of four sections or as whole courses. Prices are either for copymasters (£22 per section, £80 per unit and £220 per course) or on a library/reference basis only (£5.50; £20.00 and £55.00 respectively). An address for R.I.S.E. and an evening telephone number are provided on the inside rear cover of this issue.

We would point out that the above piece is neutral and is provided for information only as to the source of these publications. We have not had sight of the materials and this note is thus not to be taken as any kind of a SSERC endorsement of these resources.

On-line booksales

Both the Association for Science Education (ASE) and the publications agency of the Health and Safety Executive (HSE Books) have recently launched on-line access to their booksales departments. (See Address List - inside rear cover).

TRADE NEWS

Specialist waste disposal

Under the revised Special Waste Regulations 'producers of waste' have to take even more care to satisfy themselves as to the bona-fides of any disposal contractors they may engage. SSERC has compiled a short list of eight or so specialist disposal contractors with operations based in Scotland or the Northern airts of England.

Use of the SSERC list will not relieve the 'producer' of special waste of any of their legal obligations to carry out checks for themselves but it will at least provide a basis on which to proceed in selecting a suitable contractor, obtaining quotes etc. If you wish to receive a copy of our most recent list please send us a self-addressed, stamped, envelope. SSERC staff can also provide advice and guidance on packaging requirements and other arrangements necessary in organising for and managing disposals.

Fridges for flammables

Occasionally schools and, more often, colleges need to store materials made up in flammable solvents. A well documented accident history, with destructive explosions, in domestic type fridges means that a properly designed model must be used for such storage. Usually as a minimum the pump motor and any door operated or other light switches have to be suitably sparkproofed. New to us as a source of such devices is the Edinburgh based firm of *Swan Refrigeration Technology*. Obviously these specially constructed fridges are significantly dearer than normal domestic types (but not as expensive as a fridge explosion). Swan's prices start at about £255 and range up to over £400 depending on the fridge capacity and the provision or otherwise of a freezer compartment. Sparkproofed freezers are even more expensive and may cost thousands rather than a couple of hundreds of pounds. FE colleges may have unavoidable needs for such freezers but they are probably prohibitive for schools where operational means may have to be found to avoid the problem of storing flammables in a frozen state.

Kyowa microscope spares

A number of schools and colleges have stocks of Kyowa microsopes. Quite often these have been inherited second-hand from University departments. We have had a number of enquiries on sources of spares for these Kyowa models. Such spares should be available from the successor to the firm which probably originally sold the microscopes to the Universities in Scotland - then known as Finlay Microvision. This concern no longer trades out of Scotland. Its succesors are located in the Midlands and trade as *Euromicrovision Co. Ltd*.

Euromicrovision is said to be the UK's sole importer and distributor of Kyowa microscopes and accessories. They have indicated that they would be pleased to assist, where they can, with the provision of spares for older models. They also carry out servicing and repairs but because of their location and the costs of travelling time etc. it would be wise to obtain a firm quote before agreeing on a service contract or repairs (this is true of all such arrangements not just this one firm).

Microscope servicing

It's some time now since Watson Easson, everyone's favourite Scots microscope man, finally retired. We regularly get enquiries on microscope repairs, servicing and servicing contracts. We can sometimes assist directly with such matters and we offer training on routine maintenance and servicing. Thanks to Ian Helmsley of Fife Council, we now also know of a sole trader in Scotland who still carries out such work. He is *James Lansdown* of Bo'ness and his contact details are provided in the Address List.

Balances - servicing and repairs

A firm which will repair and, or, service many makes and models of electronic balances held in schools is *S.M.K. Balances* in Gateshead. See Address List for details.

SURPLUS SALE
Oscillocope offer

A sale by ballot of second hand, dual trace oscilloscopes is announced.

Following the closure of the Mitsubishi factory in Haddington, we bought at auction a large batch of Hitachi *V-212* and two Kenwood *CS-4125* oscilloscopes for resale to schools. All of this equipment had been tested annually for electrical safety. About 75% had also been tested for calibration recently. We understand from discussions with a Mitsubishi engineer that most of the 'scopes would have been in service for less than two years. Because they had been used mainly for single function tests or inspections, the switches generally are not worn and are in good condition. The only significant defects are minor screen burn and marks or scratches on the exterior. A few have lost their stands.

The Hitachi *V-212* was a top-selling, industry standard 'scope throughout the 1980s and early 90s. It has a high quality, 6" screen, giving a sharply defined trace. It is a 'scope from which accurate measurements may be made. We find that it performs better than its specification indicates. The *V-212* came off the market in 1995, at which time it was selling for £360. The model was tested by SSERC in 1993 and given an *A* assessment (*Bull.*176).

The Kenwood *CS-4125* is a relatively new model selling at £299. We reviewed its predecessor, *CS-4025*, in 1993. It also got an *A* assessment from us.

All of the oscilloscopes have been cleaned, inspected and tested for safety and performance. We are satisfied that they are in good condition. The sale offer gives you the opportunity to obtain good quality instruments at a remarkably low price.

The sale of the oscilloscopes will be by ballot, giving all readers an equal opportunity for reasonable delays in receipt of this Bulletin issue. The draw will be made on 14th December. To enter the ballot, please photocopy the Ballot Slip below, complete and send it to us a.s.a.p.

SPECIFICATIONS

Model	Hitachi V-212	Kenwood CS-4125
CRT	6 inch screen	6 inch screen
Effective area	8 cm x 10 cm	8 cm x 10 cm
No. of channels	2	2
Input terminals	BNC	BNC
Vertical sensitivity	5 mV/div - 5 V/div	1 mV/div - 5 V/div
Variable gain	Yes	Yes
x5 Magnification	Yes	No
Input impedance	1 MΩ 25 pF	1 MΩ 35 pF
Freq. bandwidth	DC to 20 MHz	DC to 20 MHz
Input coupling	AC, GND, DC	AC, GND, DC
Operating modes	CH1, CH2, ALT, CHOP, ADD	CH1, CH2, ALT, CHOP, ADD
Polarity changing	CH2	CH2
X-Y operation	CH1 : X, CH2 : Y	CH1 : Y, CH2 : X
EXT trigger	Yes	Yes
Trigger modes	AUTO, NORM, TV-V, TV-H	AUTO, NORM, FIX, TV-V, TV-H
Trigger source	INT, LINE, EXT	INT, LINE, EXT
Trigger level	Yes	Yes
Trigger slope	+/-	+/-
Sweep time	0.2 µs/div - 0.2 s/div	0.2 µs/div - 0.5 s/d
Variable sweep	Yes	Yes
Sweep magn.	x5	x10
Calibrator	1 kHz, 0.5 V	1 kHz, 1 V
Dimensions, (W x H x D)		
(mm)	310 x 130 x 370	310 x 140 x 415

Schools may bid for as many instruments as they want. The ballot will be arranged to distribute the equipment as widely as possible. Anyone bidding for two or more is allocated one instrument per draw from the hat. If there is still stock remaining after all of the bids have been removed from the hat, bids for multiple requests will be allocated in the order in which they were drawn.

BALLOT SLIP
SSERC OSCILLOSCOPE SALE - Price : £100 + VAT
(carriage extra)

Applicant's name _____

Department _____

School _____

Address _____

_____

_____

Number of oscilloscopes wanted _____

Preference   HITACHI / KENWOOD

Please photocopy ballot form and post or fax to :

SSERC
St Mary's Building
23 Holyrood Road
Edinburgh
EH8 8AE

Tel. 0131 558 8180
Fax. 0131 558 8191

Entries to be received no later than Friday 11th December 1998.

ADDRESS LIST

SSERC, St Mary's Building, 23 Holyrood Road, Edinburgh, EH8 8AE. Tel: 0131 558 8180, Fax: 0131 558 8191, Email: sserc@mhie.ac.uk Web site: http://www.svtc.org.uk/resources/sserc/

ASE (UK, HQ), College Lane, Hatfield, Herts., AL10 9AA. Tel: 01707 267411, Fax: 01707 266532. Website : http://www.ase.org.uk/ On-line booksales : as for website but add "products/" at the end (without the quotes, obviously).

ASE (Scottish Meeting) Organiser : Margaret Barr, 9 Hillside Gardens, Westhill, Aberdeen, AB32 6PB; Tel. 01224 741426. Bookings : Wendy MacGregor, 76 Donbank Terrace, Woodside, Aberdeen, AB24 2SD; Tel. 01224 493659.

BOC Gases, Priestley Road, Worsley, Manchester, M28 5JU. Tel: 0161 728 4308, Fax: 0161 728 4309.

BSI Standards, 389 Chiswick High Road, London, W4 4AL. Tel: 0181 996 7000, Fax: 0181 996 7001.

BSL Limited, Bearing and Power Transmission Distributors, 41 West Bowling Green Street, Edinburgh, EH6. Tel: 0131 554 1437, Fax: 0131 553 4243.

Blindcraft Scotland, Craigmillar Works, 2 Peffer Place, Edinburgh, EH16. Tel: 0131 661 1205.

British Compressed Gases Association, 14 Tollgate, Eastleigh, Hampshire, SO53 3TG. Tel: 01703 641488, Fax: 01703 641477.

DfEE : Buildings Bulletins from the Architects and Building Division are available from : DfEE Publications Centre, PO Box 5050, Sudbury, Suffolk, CO10 6ZQ.

Euromicrovision Co.Ltd., Finlay House, Southfields Road, Kineton Road Industrial Estate, Southam, Warwickshire, CV33 OFB ; Tel. 01926 813043, Fax 01926 817186 Email: sales@euromicrovision.co.uk

Griffin & George, Bishop Meadow Road, Loughborough, Leicestershire, LE11 5RG. Tel: 01509 233344, Fax: 01509 231893, Email: griffin@fisher.co.uk

Philip Harris Education:
E6 North Caldeen Road, Calder Street, Coatbridge, Lanarkshire, ML5 4EF; Tel. 01236 437716 Fax 01236 435183. Email : sales@education.philipharris.co.uk
Lynn Lane, Shenstone, Lichfield, Staffordshire, WS14 0EE. Tel: 01543 480077, Fax: 01543 480068.

HMSO: The Stationery Office Ltd., 51 Nine Elms Lane, Vauxhall, London, SW8 5DR. Tel: 0171 873 0011, Fax: 0171 873 8247.

Hanna Instruments Limited, Eden Way, Pages Industrial Park, Leighton Buzzard, Bedfordshire, LU7 8TZ. Tel: 01525 850855, Fax: 01525 853668, Email: sales@hannainst.co.uk

HSE Booksales, PO Box 1999, Sudbury, Suffolk, CO10 6FS; Tel. 01787 881165 Fax 01787 313995.

On-line sales : http://www.hsebooks.co.uk Contact : Sandy Brown, Helpline : 0151 951 3608.

Ideas for Education, Dromard House, Kesk, Co. Fermanagh, Northern Ireland, BT93 1RW. Tel: 01365 631209.

Institute of Biology, Education Meeting Copies of Dr Fisher's Lecture on the Human Genome Project : Mr Peter S. Anderson, c/o ASDARC, Woodend Road, Cardenden, Fife, KY5 0NE. Tel. 01592414676 Fax. 01592 414641.

Maplin Electronics, FREEPOST SMU 94, PO Box 777, Rayleigh, Essex, SS6 8LU. Tel: 01702 554000, Fax: 01702 554001.

Microscope servicing and repairs : James F. Lansdown, Esq., 54 Pennelton Place, Bo'ness, West Lothian, EH51 0PE. Tel. 01506 826291.

Microbial World Website : http://helios.bto.ed.ac.uk./bto/microbes/microbes.htm

NAFSO, c/o Stibbington Centre for Environmental Education, Great North Road, Stibbington, Peterborough, PE8 6LP. Tel. 01780 782386; Fax 01780 783835).

National Centre for Biotechnology Education (NCBE), Department of Microbiology, University of Reading, Whiteknights Road, Reading, RG6 2AJ. Tel: 01734 873743, Fax: 01734 750140, Web site: http://www.reading.ac.uk/NCBE

Nicholl Education Limited, Block 1, Nortonthorpe Mills, Scissett, Huddersfield, HD8 9LA. Tel: 01484 860006, Fax: 01484 860008, Email: nicholl.education@BTinternet.com

RS Components, PO Box 99, Corby, Northants., NN17 9RS. Tel: 01536 201201, Fax: 01536 201501.

Radleys, Shire Hill, Saffron Walden, Essex, CB11 3AZ. Tel: 01799 513320, Fax: 01799 513283.

R.I.S.E. Publishing, 25 Spring Gardens, Edinburgh EH8 8HU; Tel. 0131 661 2598 (Evenings).

RSC/St Andrews Chemistry Teachers' Meeting Organisers :

Dr Nigel Botting, Chemistry Department, University of St. Andrews, North Haugh, St. Andrews, Fife. Tel. 01334 463856. Dr. Wilson W. Flood, Educational Consultant, 68 Rowanbank Road, Dumfries, DG1 4QE; Tel./Fax 01387 269571 Email: wflood@btinternet.com

SAPS, Homerton College, Cambridge, CB2 2PH

Tel. 01223 507168, Fax 01223 215004, Website http://www-saps.plantsci.cam.ac.uk

Scottish Accident Report Line Direct (RIDDOR telephone reporting service): 0845 2770277.

SMK Balances, Greenesfield Business Park, Mulgrave Terrace, Gateshead, NE8 1PQ; Tel. 0191 477 6165.

Society for General Microbiology, Marlborough House, Basingstoke Road, Spencers Wood, Reading RG7 1AE; Tel.0118 988 5577, Fax 0118 988 5656. Email: admin@socgenmicrobiol.org.uk

Swan Refrigeration Technology, Peter Swan & Sons Ltd., Block 4 UNit 2, Peffermill Industrial Estate, Edinburgh EH16 5UY; Tel. 0131 667 5596 or 0131 652 1427, Fax 0131 659 6541.

Tait Components Limited, 20 Couper Street, Glasgow, G4 0DL. Tel: 0141 552 5043, Fax: 0141 552 8826.

Technology Enhancement Programme (TEP), Middlesex University, E Block, Bramley Road, Oakwood, London, N14 4YZ. Tel: 0181 447 0342, Fax: 0181 447 0340.

Wyko-EWB Limited, Unit 1a, West Craigs Industrial Estate, Turnhouse Road, Edinburgh, EH12. Tel: 0131 317 9988, Fax: 0131 317 7660.