SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 78.   March, 1975.

Contents

Introduction

One or two teachers have approached us recently with a query arising out of the effects of regionalisation; they have been commanded by their local authority to spend what remains in the kitty so that the regional authority which takes over in May shall not get its hands on it. At one time we would have deplored this hasty and needless spending, resulting as it sometimes does in the teacher rifling the pages of a catalogue and picking the items which look best in the photographs.

Not now. We live in inflationary times, and if Mrs. Thatcher sees it as common sense to stock up with a few months' supply of tinned goods, the teacher would do well to follow her example. To any teacher given a windfall like the above, I would say buy those consumibles which will not deteriorate on the shelf and put them into your attics; they will prove a good investment. Buy thermometers by the gross, Japanese meters by the score, ticker-tape by the km. In April, 1973 an MR38P meter cost £1.75, a year later it was £2.50, today it is £2.80.

Spiralling costs like these mean that there is a real need for principal teachers, and headmasters, to know from year to year how much more it is going to cost them to buy the same replacements for stock used or broken. Hence we propose to establish a cost index, similar to the government's cost of living index, which will be given a value of 100 at some arbitrary date and will thereafter be reviewed every six months. It will be based on a shopping basket of 30 - 50 items, spread over biology, chemistry and physics, which are commonly required to be replaced each year, items like thermometers, test-tubes, filter paper and crocodile clips. It is intended that the index shall be weighted, i.e. we will not simply price one of each of the selected items, but rather that the quantity of an item should be representative of the schools' needs.

It is obviously going to be difficult to establish which and how many of each item should go into the index. We have asked our Development Committee, and the main schools' suppliers for their views. We would also like the views of the general body of readers of this bulletin. If at any time you have been exasperated by the failure of your per capita requisition to stretch as far as it once did, tell us where the shoe pinches most. If you feel that any one item may escape our notice and deserves to be included, please write to us. Most of all we will be grateful if anyone cares to take the time and trouble to send us a list of quantities and costs of the 30 - 50 items forming the major part of his current requisition. Such information will be very helpful.

Opinion

In the writer's teaching days there was some difference of opinion over how to formulate Newton's second law. If memory serves,

the engineer teaching for Applied Mechanics wanted to write $F/W = a/g$, the physicist wanted $F = ma$, and the mathematician teaching for dynamics wanted $P = mf$. All three peered out from solidly entrenched positions, and the poor pupil was pig-in-the-middle. Perhaps it was thought that few pupils would have to suffer such trichotomy, and those that did should be sufficiently versatile to rise above it.

The coming of s.i. was supposed to rationalise (no pun intended) such problems. The International Union of Pure and Applied Chemistry (i.u.p.a.c.), the British Standards Institution (b.s.i.), and our own Scottish Centre for Mathematics, Science and Technical Education (s.c.m.s.t.e.?), have all gone to print to advise us on what symbols we should use. In Memorandum No. 5 of the Scottish Centre, we are told that refractive index should be represented by n. The former symbol μ was presumably overworked, having to represent the prefix micro-, and the coefficient of friction. But n has to represent the prefix nano-, the rotational frequency, the amount of substance (Heat), as well as a generalised number and the filling in a pnp sandwich. It is little wonder that we find in Memorandum No. 14, Oscillations and Waves for the Certificate of Sixth Year Studies, the thin film interference formula written as

$$2 \mu t = n\lambda$$

Can anyone quote me an authority stating how this should be expressed, using n for refractive index? I am sure many teachers of s.y.s. physics would also like to know.

Again, if you are puzzled by the lower case abbreviations which have appeared here, read your Memorandum No. 5. Lower case letters should be used for abbreviations except when one or more of the words is a proper noun, or at the beginning of a sentence. Abbreviated words should have stops, but no spaces between them, such as p.d., or a.c. Why then has the transistor escaped this net? There seems no uniformity in the way in which the transistor type should be written. One finds lower case upright or italic script, with or without hyphens, with or without spaces with equal frequency. Biologists and Americans seem to prefer the upper case PNP and NPN. What one does not find, but which I feel ought to be there, are stops between the letters, viz. p.n.p. The field effect transistor usually gets f.e.t. Oh, no, you say, lower case abbreviations are for scientific terms only, not for every day usage. There are two points to be made here. Who is persuading the biologist to write d.n.a. and a.t.p.? Or have they an exemption licence? The second is that the child is a child is a child, not a compartmented mind with so many pigeon-holes for conflicting conventions that he must sometimes feel like the American tourist - 'if today is Tuesday, this is Paris, France'.

It has not been my intention here merely to poke fun at the innovators; seriously, it is to point out that perhaps they have not given enough thought to the possibility that their new conventions may be creating as many, though different, anomalies as existed in the old, and that if they have given thought they have not been honest and said so, but appear to have swept the problems under the carpet. It seems to be an unfortunate necessity of any growth point of knowledge to create its own conventions in order to clarify its thinking. This gives it status, at the expense of making it less understandable to its sympathisers who may not be devotees or actively concerned in its promotion. It is noteworthy that the bible of the curriculum developers calls itself a taxonomy, and makes liberal use of words not found in the Oxford Dictionary. This trend may be a

necessary evil in an adult world.   When we introduce it into school
science, we seem to be more concerned to smooth the path of those
few pupils who will pursue the subject beyond the school stage, than
with its effect on the great majority who will be the laymen and
women of tomorrow.   Most of them instinctively feel that life is
more important than having to worry about whether to write ml or cm^3.
If we scientists fuss about such things, they dismiss us as small-
minded, with justification.

Biology Notes

There has been considerable interest lately in methods for
measuring dissolved oxygen content.   Several methods are available,
from the relatively involved Winkler method and its modifications
such as the Whitney syringe pipette/burette, to polarography and
oxygen meters.   One of the simplest methods is the iron sulphate/
phenosafranine or methylene blue titration method used in the
Nuffield 'A' level course.   In this analysis a sample of water has
a 'redox' dye added to it.   A solution containing iron(II) ions is
then added to the water.   Until all the oxygen present has been
used up in converting iron(II) to the iron(III) state, the dye will
retain its colour.   As soon as the oxygen is exhausted any iron(II)
present in excess will reduce the dye to its leuco form.   Thus the
amount of iron(II) solution added to the sample until the dye is
just decolourised is a measure of the amount of oxygen in the water
sample.   However it is likely that atmospheric oxygen will enter the
water when the sample is taken and when the analysis is being carried
out.

We have developed a piece of apparatus which may be more
efficient in minimising errors from these sources than the apparatus
usually recommended.   To prevent oxygen entering the sample the water
is taken up into a 50 ml disposable syringe.   The dye is injected
into this syringe as is the solution containing the iron(II) ions.
This prevents contact with the air and the addition of atmospheric
oxygen but necessitates the provision of special arrangements for
stirring the sample, as thorough mixing is a pre-requisite for an
accurate determination.   A diagram of the apparatus is shown below.
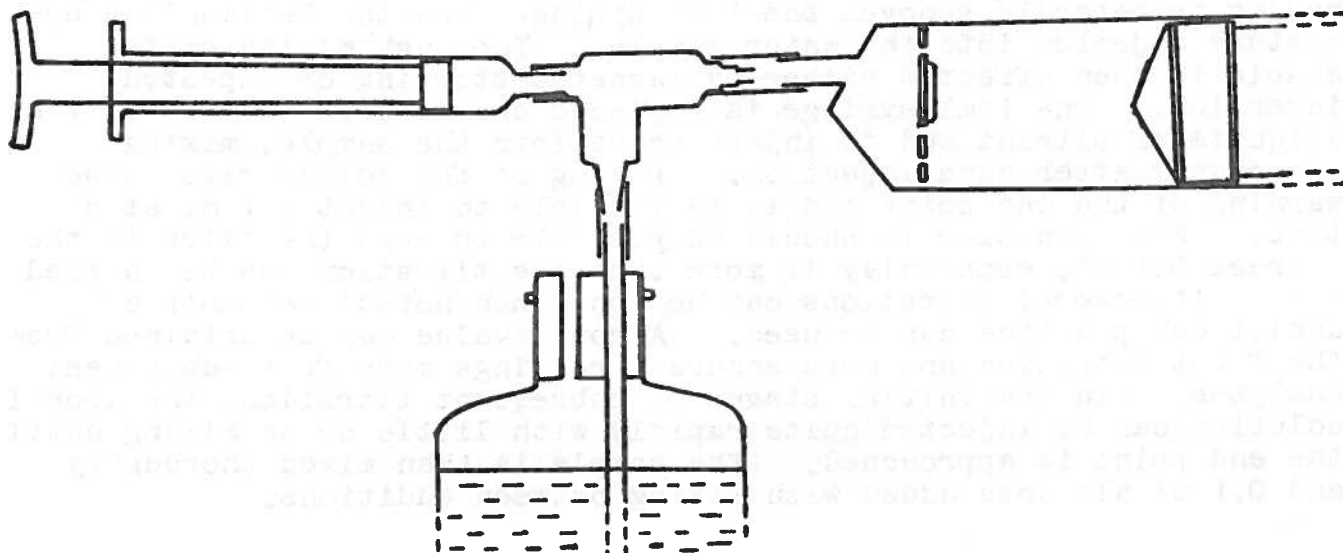
The reagent bottle is used as a reservoir for the titrant which should contain 0.5 mg of iron(II) per ml. (see recipes on p. 5) This bottle can be fairly small, 250 ml would give over 25 determinations, and can be of polythene or other plastic material so reducing the risk of breakages in fieldwork. The syringe valve, from Gordon-Keeble at £1.50 allows small aliquots of titrant to be drawn up into the 1 ml syringe and injected into the sample. A 5 ml syringe is used to inject a mixture of Fehling's B (which provides the necessary alkaline conditions for the reaction) and dye into the sample, prior to titration. The 50 ml syringe contains a piece of plastic as a stirrer. We used a white plastic disc - tiddleywink or ludo counter - obtainable from E.J. Arnold. A number of holes were drilled in this disc and a piece of magnetic rubber strip (also from Arnold) approximately 20 mm long was glued across the centre using 'Evo-Stik'. A magnet stroked up and down the outside of the syringe produces movement of the disc and allows thorough mixing. The magnet is not essential, and if one is prepared to accept that mixing will take more time, the syringe can be repeatedly inverted when movement of the disc within the syringe will mix the contents. A 2-3 cm length of flexible polythene between syringe and valve allows easy inversion. The disc occupies a significant volume of the syringe and recalibration must be carried out. The piston of the syringe is removed and the barrel held upright, nozzle down, with a finger over the nozzle. The barrel is filled with water up to the 50 ml mark. The stirrer is then added and a mark made at the new level. We wrapped plastic tape around the syringe to mark the corrected level.

The actual analysis is straightforward and fairly quick. The reagent bottle is filled with the iron(II) solution and the bung with the glass tube and syringe valve fitted. The 1 ml syringe is then used to 'prime' the apparatus, filling the glass tube and valve with titrant and expelling all air. The next step is to obtain a sample of the water to be tested. The stirrer in the 50 ml syringe prevents full travel of the piston. If a full sample were immediately taken up it would inevitably be mixed with air present in the syringe. However this source of error is easily avoided. Initially enough water to cover the stirrer adequately is taken up. The syringe is then held nozzle upwards and all air expelled. It is then used to draw up the rest of the sample, and is then connected to the valve.

5 ml of Fehling's B solution is measured into a small beaker, 2 drops of 1% aqueous phenosafranine or 1 drop of 0.25% aqueous methylene blue added and the resulting mixture carefully taken up into a 5 ml syringe. This syringe is connected to the syringe valve, having temporarily removed the 1 ml syringe, and the Fehling's B/dye mixture injected into the water sample. Thorough mixing of the sample is then effected either by magnetic stirring or repeated inversion. The 1 ml syringe is replaced and is used to draw up 1 ml aliquots of titrant and to inject these into the sample, mixing thoroughly after each injection. Paling of the colour gives some warning of the end point and it is possible to inject 0.1 ml at a time. With practice it should be possible to read the titre to the nearest 0.1 ml, especially if more than one titration can be carried out. If several titrations can be done then normal volumetric analytical practice can be used. A rough value can be obtained from the first titration and more accurate readings made from subsequent analyses. In the initial stages of subsequent titrations the iron(II) solution can be injected quite rapidly with little or no mixing until the end point is approached. The sample is then mixed thoroughly and 0.1 ml aliquots added with mixing between additions.

If the recipes given below are used then the number of ml of iron(II) solution required to decolourise the dye is approximately equivalent to the number of ml of oxygen per litre of water sample. If required the figure can be converted to ppm (by weight) by multiplying by 1.43 (the approximate weight in grams of one litre of oxygen). Typical results are shown below together with published results for comparison. The analyses were carried out on water saturated with oxygen at the temperatures shown.

Temp $^{\circ}C$	Titre, ml	Mean value	Published figure ml O_2/l
0	1. 10.6 2. 10.7 3. 10.8	10.7	10.2
10	1. 8.2 2. 8.5 3. 8.3	8.3	7.9
15	1. 7.4 2. 7.3 3. 7.5	7.4	7.0
30	1. 5.5 2. 5.4 3. 5.3	5.4	5.3

The manufacturers claim the valve to be gas and water tight up to 80 psi (sic) pressure. The large syringe must be regularly lubricated with silicone grease so that it is free moving. Sticking of the syringe can lead to a build-up of back pressure which will cause failure of the valve and result in serious errors in analyses. Warning is given of development of back pressure as the syringe is removed after a titration when spurting of the liquid will occur. Since there is always a possibility of some liquid spurting from the syringe when the connection to the valve is broken, this operation should be performed with care. Although the Fehling's B is greatly diluted by the water sample the mixture is still alkaline and some-what caustic.

Some error will arise from the fact that when the Fehling's B solution is injected into the sample, the valve and its connection to the large syringe have already been primed with iron(II) solution. This amount of solution will not be registered when the aliquot injections are summed. Obviously one could do a preliminary test to determine what this volume amounts to, but the error will usually be small, and if one is interested only in comparisons between water samples and not in absolute determinations it is not significant.

Iron(II) solution.

a) Dissolve 2.2 g Analar hydrated iron(II) sulphate in a few ml of 1% sulphuric acid and make up to a litre with deionised water.

b) As above, using 3.1 g hydrated ammonium iron(II) sulphate. This latter is preferable because it does not decompose so readily in storage.

Physics Notes

The arrival of rotary vacuum pumps in schools meant that the collapsed can experiment became a more successful demonstration than it had been in the days when it was necessary to boil water in it in order to get adequate pressure reduction. Then the preliminaries and their explanation often obscured the object of the experiment. But cans with a suitably small opening which could be easily stoppered have always been difficult to find, and many teachers must have found their usual source disappeared as packaging firms changed from metal to plastic. Hence we think we have a winner in this idea from St. Aloysius College, Glasgow, which uses a package which is proliferating rather than the reverse, the ring-pull can.
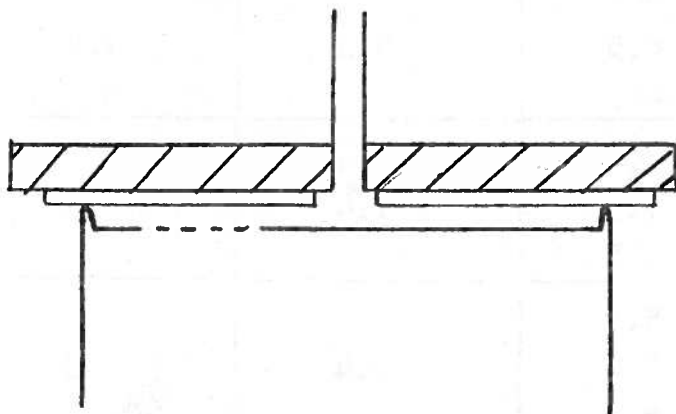
A plywood block, 100 x 100 x 10 mm, is drilled centrally to take a 7 mm diameter copper tube. The hole is drilled slightly undersize so that the tube is an air-tight push fit. A thick rubber disc, 90 mm diameter, which has a 10 mm central hole in it, is cemented to the wood with Evostik. We obtained our rubber from the inner tube of a commercial vehicle tyre, which can usually be obtained as scrap from a garage. The fitting, connected to a vacuum pump via the copper tube, is pressed onto the top of an empty ring-pull can standing on the bench, and the can collapses quite quickly. Then the top rim of the can distorts and breaks the air-tight seal.

The apparatus can also be used upside down, clamping it in a retort stand and pressing the inverted can onto the rubber pad. Then it is more essential to see that the can is empty, to prevent liquid from entering the vacuum pump. The experiment works well with the standard 440 ml beer-can; the smaller 327 ml soft drinks can, due to its shorter length will sometimes refuse to collapse.

Chemistry Notes

In Bulletin 75 we discussed the pros and cons of wooden and metal flameproof cabinets, gave an account of a test on a wooden cupboard carried out by the Fire Research Station, and promised to

give the results of a similar test on a metal cabinet. These are now to hand, and what follows is a selection of quotes from Fire Research Note No. 998 (amended). A caveat to the note states that "This report has not been published and should be considered advance research information".

"Summary. A steel cupboard of a design proposed for the storage of flammable liquids has been subjected to an all-enveloping kerosine fire. The interior and contents of the cupboard rapidly reached high temperatures leading to the collapse of one of the shelves, destruction of gauze vents, fracture of glass bottles and the ignition of their contents, and general distortion of the cupboard.

Comparison with the results of earlier tests on wooden cupboards for solvents indicates that the steel cupboard tested afforded much less protection from fire to its contents.

It must be expected that any simple steel cupboard even if it were of acceptable integrity would, when exposed to a similar fire, permit its contents to be heated sufficiently for flammable liquids in bottles to escape and ignite.

The cupboard was designed before the issue of the Highly Flammable Liquids and Liquefied Petroleum Gases Regulations, 1972, under the Factories Act, 1961 and does not satisfy the requirements for Certificate of Approval No. 1 Schedule Part 4 under those Regulations.

Experiment. The cupboard was constructed from panels of 18 SWG mild steel sheet. The full width double doors were each fitted with upper and lower hinges and closed by a ganged catch and lock on one door, bolting the doors at top, middle and base. A plastic foam sealing strip had been fitted to the closing edges of the doors. Two gauze vents were fitted, one at the top of one side panel of the cupboard and one at the bottom of the other. These consisted of 0.12 m diameter discs of about 1 mm mesh gauze secured against a hole in the panel by a steel ring with light alloy rivets, on the inside of the cupboard. There were gaps between the back and side panels, which in some places exceeded 2 mm width. Two shelves, fabricated from 25 mm wide 3 mm thick galvanised steel strip and welded to form an open structured decking, were fitted, one just above a liquid-tight base and one just below the centre-line. Each shelf rested on "L" shaped brackets of similar gauge to the panelling, secured by light alloy rivets. The unpainted liquid-tight base was about 200 mm high and of sufficient capacity to contain liquid from the entire contents in the event of spillage.

The cupboard was loaded with a Winchester bottle and a 250 ml bottle on each shelf. These contained either a mineral hydraulic oil or dibutyl phthalate to half their capacity. Fluids of high boiling point were chosen to lessen the risk of explosion of released vapours, but to have a similar specific heat to more volatile flammable liquids. Thermocouples were positioned in the liquid in three of the bottles and a further three thermocouples were brazed to the top shelf and the inside and outside of the back panel.

The cupboard was positioned centrally in a steel tray containing $12\frac{1}{2}$ gallons of kerosene floating on water. The kerosene was ignited by pouring quickly 50 ml of petrol on to its surface and applying a lighted match.

The fire developed rapidly and after one minute the cupboard was enveloped in flames. The sound of breaking glass at two and a half minutes was followed by flaming from the top of the doors. After four and a half minutes two dull explosions were heard followed by falling glass, and at five minutes by a crash, assumed to be the collapse of the top shelf. This resulted in more vigorous flaming from the top of the doors at five and a half minutes of test. The fluorinated chemical foam was applied at eight minutes, the complete extinction process taking about forty seconds although the fire was well controlled after ten seconds. The surface of the cupboard was cooled with a fine, gentle spray of water before investigation for damage.
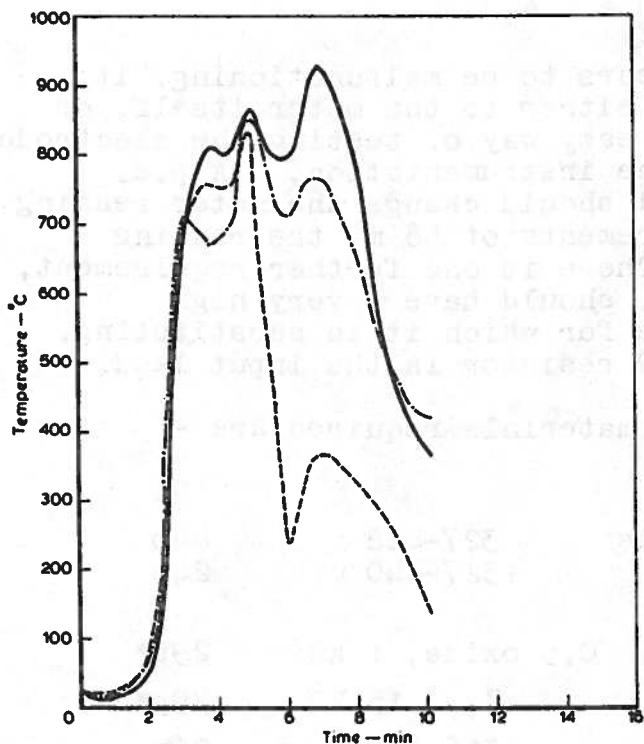
The doors, the locking handle of which had melted, leaving a hole, fell out on attempting to open them, the hinges also having become detached from the cupboard. The plastic foam sealing strip was totally consumed. The securing ring and gauze of the upper vent had fallen into the base of the cupboard, the alloy rivets having failed. The lower gauze had buckled and would no longer have been able to function as a flame trap. Alloy rivets had also been used to secure the top shelf brackets and probably led to their collapse. The Winchester bottle on the bottom shelf was still standing but was badly cracked and shattered when touched. The back panel had become detached from the side member near the base, resulting in a tapering gap 10 mm wide at its widest point.

Discussion. The temperatures (of the cupboard surfaces) reached the Curie point of steel, about $550^{o}C$, in 2 min. 50s, at which distortion of the folded steel panels of the cupboard would be expected. The almost equally rapid rises in temperature recorded by the thermocouples in the bottles of liquids, were probably due to the thermocouples being exposed to air on the breaking of the bottles, except for the Winchester on the lower shelf, for which the reason would appear to be disturbance of the thermocouple, possibly by the falling shelf. As the boiling points of the oil and dibutyl phthalate were both about $360^{o}C$, temperatures registered by the thermocouple in the lower Winchester bottle after 6 min were probably due to the liquid or its vapour at boiling point. If it is assumed that the temperature of the liquids rose gradually between 2 and 6 min to that indicated for the lower Winchester, then diethyl ether, b.pt $35^{o}C$, would have boiled less than 2 min after ignition of the kerosine fire, and hexane, b.pt $68^{o}C$, in less than 5 min. Thus there could have been an explosive atmosphere within the cupboard containing low boiling solvents under the conditions of test, and as the surfaces of the cupboard reached temperatures exceeding the self-ignition temperatures of such liquids (for example, diethyl ether, $180^{o}C$) in less than 3 min, an explosion could well have occurred in this time. The gaps existing before test between the back and side panels, the destruction of the plastic foam strip around the doors during test and the distortion of the steel sheet panels by heat would each have presented gaps through which flames could have passed. The loss of the light alloy handle by melting, and the failure of the alloy rivets securing the hinges also produced holes or gaps through which vapours could escape or flames could enter the cupboard. Each of these conditions would have added to the risk of ignition or explosion of solvents vapours within the cupboard.

A comparison of the temperature curves for the steel cupboard, with those for the wooden cupboard tested previously indicates that although the wooden cupboard was subjected to fire conditions raising the outer surface to similar high temperatures, but for a longer time,

neither the internal surfaces nor the contents of a Winchester bottle reached as high temperatures as in the steel cupboard. Indeed the temperature of the liquids in the wooden cupboard did not reach the boiling point of ether for 7 min, or hexane during the effective period of test, 10 min. Also, none of the four bottles, similar to those in the steel cupboard, failed in any way, although some of the low boiling solvents contained in the smaller bottles were lost by evaporation.

It seems reasonable to suggest that the protection required by solvents cupboards within a laboratory or store containing other combustibles need extend only for the time during which first aid fire fighting could be attempted. If there were a spillage or general fire which continued to burn for a longer period of time, there would be the likelihood that the room and its contents would be destroyed. In respect of resistance to fire for the short period for first aid fighting, estimated at about 5 min, the wooden cupboard is clearly superior to the steel one.

Figure 2 Fire test of steel solvent cupboard—temperatures measured in liquids in bottles on the shelves

Note:- These thermocouples were not in the liquids at the end of the test

— Top shelf Winchester
— — — Bottom shelf Winchester
— ·— ·— Bottom shelf 250 ml

Figure 3 Temperatures measured during a test on a wooden cupboard
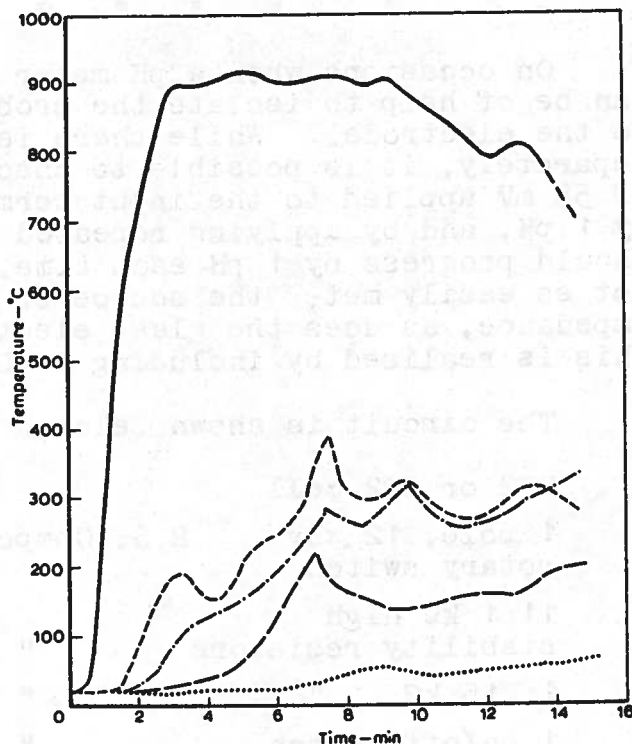
— Outer surface
— — — Inner surface
— ·— ·— Top air space
— — — Bottom air space
·········· Bottom Winchester containing solvent

Conclusions. The tests conducted by the Fire Research Station on a wooden and a steel solvents cupboard indicate that a well designed wooden cupboard provides greater protection from a surrounding spillage fire than a steel office type cupboard to store flammable liquids during the early stages of a fire. Although the wood of the cupboard contributed some fuel to the fire, and accordingly departed from the requirements for issue of a Certificate of Approval, the insulation it provided protected the contents from a rapid rise

in temperature.

The steel cupboard tested allowed rapid heat transfer from the surrounding flames and hot gases to the contents, resulting in rapid heating and cracking of glass bottles, and, because of the construction with light alloy rivets and handles, rapid failure of such items. Heat distortion was also greater with the steel cupboard than with the wooden cupboard.

A 2-gallon fluorinated chemical foam extinguisher is likely to be effective for the first aid extinction of solvent spillage fires.

There are a number of establishments using flammable solvents to which the Factories Act does not apply, but where it would be advisable for appropriate precautions to be taken to minimise the risk of serious fires in order to protect both lives and property. The tests reported on here should enable decisions to be taken as to the type of solvents cupboard suitable for installation in laboratories and stores in such establishments."

* * * * * * *

On occasions when a pH meter appears to be malfunctioning, it can be of help to isolate the problem either to the meter itself, or to the electrode. While there is no easy way of testing the electrode separately, it is possible to check the instrumentation. A p.d. of 58 mV applied to the input terminal should change the meter reading by 1 pH, and by applying repeated increments of 58 mV the reading should progress by 1 pH each time. There is one further requirement, not so easily met; the source of p.d. should have a very high impedance, as does the glass electrode for which it is substituting. This is realised by including a 100 MΩ resistor in the input lead.

The circuit is shown below; the materials required are –

|			
HP2 or SP2 cell			9p
1 pole, 12 way rotary switch	R.S. Components	327–428 +327–440	44p 24p
11 1 kΩ high stability resistors	"	0.5 oxide, 1 kΩ	29p*
1 15 kΩ "	"	" 15 kΩ	29p*
1 on/off switch	"	316–850	26p
1 100 MΩ resistor (see text)		–	(60p)
Connecting wire, switch knob, etc.			

* Price for pack of 10 resistors.

The total resistance in the cell circuit is 26 kΩ, and if we assume a cell p.d. of 1.5 V this gives 57.7 μA current, and a p.d. of 57.7 mV per switch step. This is near enough the required 58 mV, particularly as the 1.5 V for the cell is somewhat nominal, depending as it does on the state of the cell. We believe it to be sufficiently accurate to indicate the presence of a fault in the meter circuit.

The 100 MΩ resistor is not supplied by R.S. Components. We have a very limited number (single figures) in our surplus stock which we will supply on a first come, first served basis at 10p each. Thereafter, if demand is sufficiently great, we will supply resistors which we will have to buy in, at 60p each.

We have not given details of wiring, boxing of components etc this being left to the individual constructor. The output could be in the form of a length of cable, terminating in the same type of socket as the electrode, for direct plugging into the pH meter.

11 × 1 kΩ

15 kΩ

100 MΩ

1.5 V

* * * * * * *
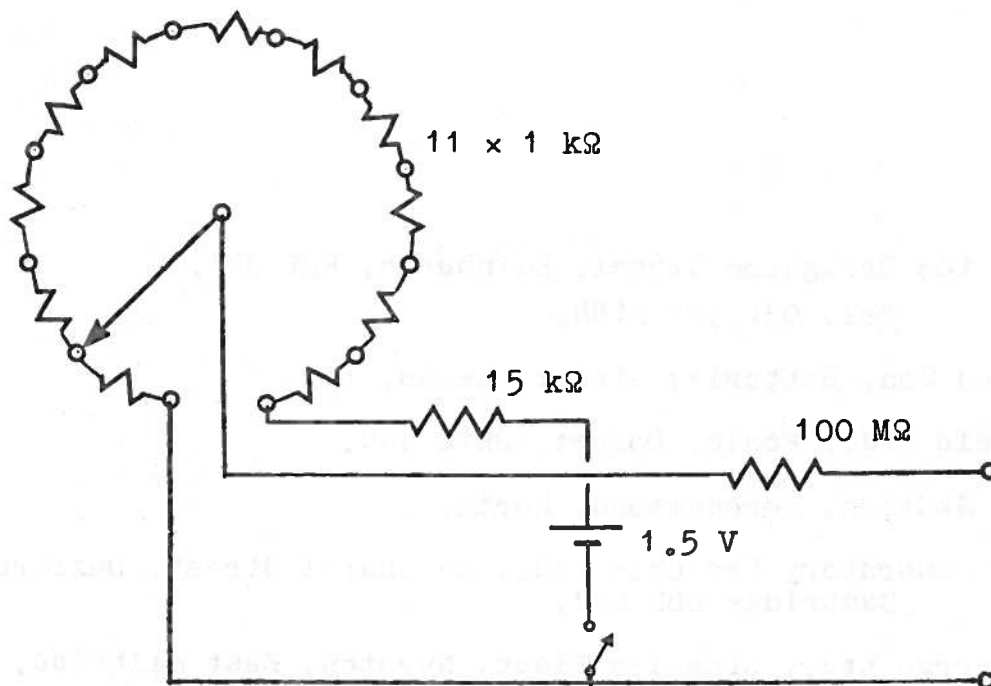
Lead sulphate as at present supplied by <u>Griffin and George</u> and <u>Philip Harris</u> gives unsatisfactory results for the equilibrium constant of lead sulphate and sodium iodide solution in the experiment described on page 6 of Memorandum Number 16, "Practical Work in Sixth Year Studies Chemistry". This was pointed out to us by the Chemistry Department of Jordanhill College of Education. Using lead sulphate from various sources we did the experiment as described in the memorandum. Our results confirmed those obtained at Jordanhill, satisfactory results being obtained with lead sulphate from <u>B.D.H.</u>, <u>Hopkins and Williams</u>, and a sample prepared from lead nitrate by precipitation with sulphuric acid. Analysis of the unsatisfactory lead sulphate showed that 16% lead(II) oxide was present as impurity, indicating that it was technical grade.

Analar lead sulphate is not available. The maximum limits of impurities in the B.D.H. chemical are 0.1% moisture and 0.1% soluble matter. The analysis of the Hopkins and Williams chemical is assay 98.5% and 0.04% chloride. We have requested Griffin and George and Philip Harris to supply material of the necessary purity and have now received their replies. Griffin and George have promised to obtain a reagent grade for inclusion in their next Chemicals Catalogue. Philip Harris have promised to include lead sulphate of minimum assay 99% in their next catalogue, but until that is issued teachers can obtain the chemical by using the reference "Lead(II) Sulphate 99% assay (SSSERC)." Price for this will be 85p for 100 g, or £1.70 for 250 g. Obviously it will be much cheaper, and may also be instructive, to have the pupil prepare his own, as we did.

S.S.S.E.R.C., 103 Broughton Street, Edinburgh, EH1 3RZ.
                Tel. 031 556 2184.

E.J. Arnold and Son, Butterley Street, Leeds, 10.

B.D.H. Chemicals Ltd., Poole, Dorset, BH12 4NN.

Fire Research Station, Borehamwood, Herts.

Gordon Keeble Laboratory Products Ltd., 8a Chapel Street, Duxford,
                Cambridge CB2 4RJ.

Griffin and George Ltd., Braeview Place, Nerston, East Kilbride,
                Glasgow G74 3XJ.

Philip Harris Ltd., 30 Carron Place, Kelvin Industrial Estate,
                East Kilbride, Glasgow G75 OTL.

Hopkins and Williams Ltd., P.O. Box 1, Romford, Essex, RM1 1HA.