

THE NUCLEUS

February 1993

Of the Northeastern Section of the American Chemical Society

Vol. LXXI, No. 6

Monthly Meeting

*Ernest I. Becker on Teaching
Chemistry in the Public Schools*

Environmental Chemistry Column

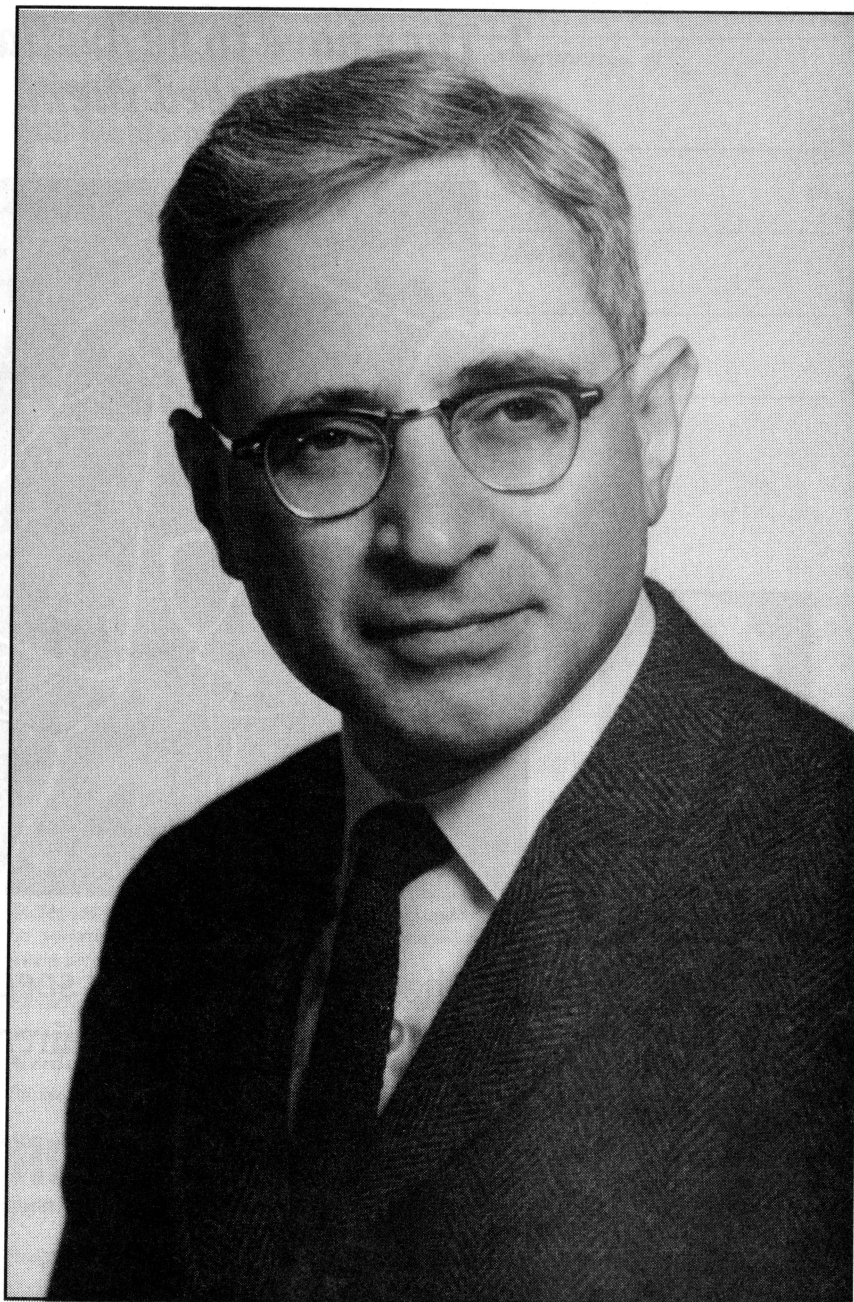
David Ham on CFC Replacement

Automotive Chemistry

*Joseph Lima on Physical Properties
of Automotive Engine Coolants*

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THE NUCLEUS



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Environmental Chemistry Column

CFC Replacements: Many Problems for Chemists to Solve

by David Ham, President
Envirochem, Inc.

Every few months we hear new reports that the ozone depletion in the stratosphere, especially over Antarctica, is worse than anticipated. The cause of the depletion and "ozone hole" is the release of manmade chlorofluorocarbons (CFC's) that are used for refrigeration, air conditioning, foam blowing and as solvents. (See the Dec. 1991 and Jan. 1992 issues of the Nucleus for C. Kolb's articles on the atmospheric chemistry of stratospheric ozone depletion.) Not all recent news has been bad; recent controversies over the ozone depletion effects of volcanic eruptions, especially Mount Pinatubo in the Philippines and Mount Hudson in Chile, are being resolved in favor of very small effects on the ozone layer. However, the observed depletions provide convincing evidence of the need to eliminate CFC production and find replacement chemicals.

Delegates from more than 80 countries met in Copenhagen at the end of November for the latest revision of the Montreal Protocol on Substances that Deplete the Ozone Layer. This was the latest in a series of meetings that have produced agreements for ever more stringent restrictions and accelerated phase-outs of CFC's since the treaty first was ratified in 1989. The most recent agreements require 75% reductions of CFC's from their 1986 production levels by Jan. 1, 1994 and 100% phase-out by Jan. 1, 1996. These agreements also require 100% phase-out of halons, which contain bromine, by Jan. 1, 1994 as well as accelerated reduction and phaseout dates for carbon tetrachloride and methyl bromide. The revised restrictions are very similar to the position the U.S. was pursuing under the Clean Air Act prior to the latest international meeting.

The accelerated schedules for compliance under the revised restrictions provide increased pressure for produc-

tion of CFC alternatives. The most highly developed CFC substitutes are hydrochlorofluorocarbons (HCFC's), CFC type molecules containing at least one hydrogen atom. The hydrogen provides a reactive site for oxidation in the troposphere that leads to reduced lifetimes of the molecules in the atmosphere and thus reduces their ozone removal potential. HCFC production is also under attack, because even though their ozone depletion potentials are less than those for CFC's, they are unacceptable in the long run. HCFC production will be frozen based upon the resulting ozone depletion potential being less than 3.1% of the equivalent 1989 CFC potential. HCFC's will be phased out altogether by Jan. 1, 2030. HCFC's are now considered as essential during development of better alternatives, but only as temporary CFC replacements.

CFC's are used in refrigeration both in the compressors and also as important contributors in the foam insulation of the walls and doors. Their contribution to the insulation is especially important as manufacturers try to comply simultaneously with the CFC restrictions and stringent federal energy efficiency requirements. Problems have been encountered with the HCFC replacements tested in the insulating foams. HCFC-123 (CHCl_2CF_3) and HCFC-141b ($\text{CH}_3\text{CCl}_2\text{F}$) have both been found to attack the plastic liners and elastomer gaskets used in refrigerators. These problems may be solved by using different plastics and elastomers.

A potentially more serious problem with HCFC substitutes, even as temporary substitutes, is coming from results of on-going toxicity tests on these compounds. HCFC-123 has been shown to cause benign tumors in rats. Tests are underway on other HCFC's. Several major air conditioner manufac-

turers have already refused to ask their employees to work with these compounds until they are proven safe. EPA restrictions may forbid many uses under safe alternative regulations in any case.

Electronics manufacturers have used CFC-113 ($\text{CCl}_2\text{FCClF}_2$) extensively as a solvent for cleaning printed circuit boards and other electronics components. They are now developing non-CFC alternatives including aqueous and terpene based solvents. They are also eliminating the need for any solvent in many cases and also saving money by developing soldering systems that require no cleaning.

Another major class of CFC substitutes are the HFC's, which contain no chlorine and thus will not contribute to ozone depletion. They must pass toxicity tests prior to most uses. The major disadvantage of these compounds is their cost. HFC's are currently about \$10 per lb. compared to about \$2 per pound for HCFC's and \$0.75 per pound, before increasing added taxes, for the CFC's. Computer models predict that HFC's could provide more efficient refrigerants than CFC's. However, these compounds have caused coking and caking in compressor tests that limit their useful-performance lifetimes to periods too short for refrigeration. Blends containing HFC-32 (CH_2F_2) are presently promising candidates for home air conditioners and commercial refrigerators.

A local company, Foster-Miller Inc., is working to develop refrigerants that may provide an alternative to CFC's. Their approach is to use non-azeotropic mixtures of non-CFC refrigerants. These mixtures are combinations of refrigerants with different volatilities which do not behave as pure liquids. While the mixture boils or condenses the composition changes as a temperature variation is achieved

in a constant pressure phase transition. Promising performance, compared with CFC-12 (CCl_2F_2), the most common refrigerator compressor fluid, has been achieved using such a mixture in a prototype heat pump. However, mixtures present problems. Due to the different densities of the mixture components, any leak is likely to cause selective loss of one component, requiring the system to be drained and refilled.

In spite of all of the chemical problems, perhaps the greatest long term problem in controlling the release of ozone depleting chemicals is political rather than chemical. As third world countries strive to attain higher standards of living, they need financial and technical help to avoid using chemicals that destroy the ozone layer. The parties to the Montreal Protocol set up a Multilateral Fund to help developing countries in these efforts. So far a major problem has been the failure of several of the donor nations to contribute to the fund. ◇

Automotive Chemistry

Automotive Engine Coolants - Part II, Specifications and Physical Properties

by Joseph A. Lima, Vice President, Houghton Chemical Corp.

In this part we will look at physical characteristics and tests required by ASTM Specification D3306, *Specification for Ethylene Glycol Base Engine Coolant for Automobile and Light Duty Service*, and ASTM Specification D4985, *Specification for, Low Silicate Ethylene Glycol Base Engine Coolant for Heavy Duty Engines Requiring an Initial Charge of Supplemental Coolant Additive (SCA)*¹.

These are not the only specifications for engine coolant. There are federal, military, state, automobile manufacturers, engine manufacturers, etc. specifications. These ASTM specifications are so widely used, however, that they will serve well to illustrate the important requirements which an engine coolant must meet to be functionally

and commercially acceptable. Generally, most other commercial coolant specifications refer to the ASTM Test Methods.

From a practical standpoint, especially for those of us living in cold areas, the freezing point is the most important property among the specifications. In both of the above specifications, the freezing point must be no higher than -34°F for a 50% (vol.) solution when it is measured using ASTM D1177.

ASTM D1177 *Test Method for Freezing Point of Aqueous Engine Coolant Solution*². This volume contains most of the specifications and test methods relevant to Engine Coolants. The test method requires careful cool-

continued on page 8

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Automotive Chemistry

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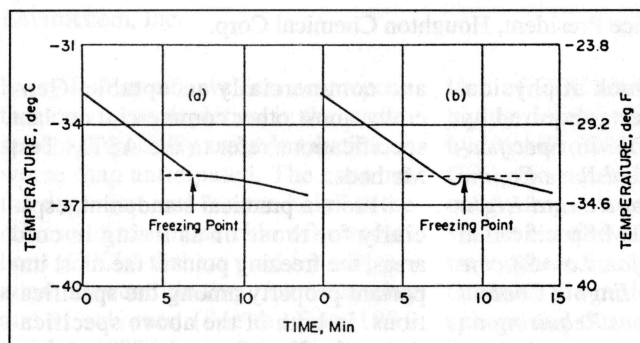


Fig. 1 Time-Temperature Cooling Curves for Determining the Freezing Point of an Engine Coolant

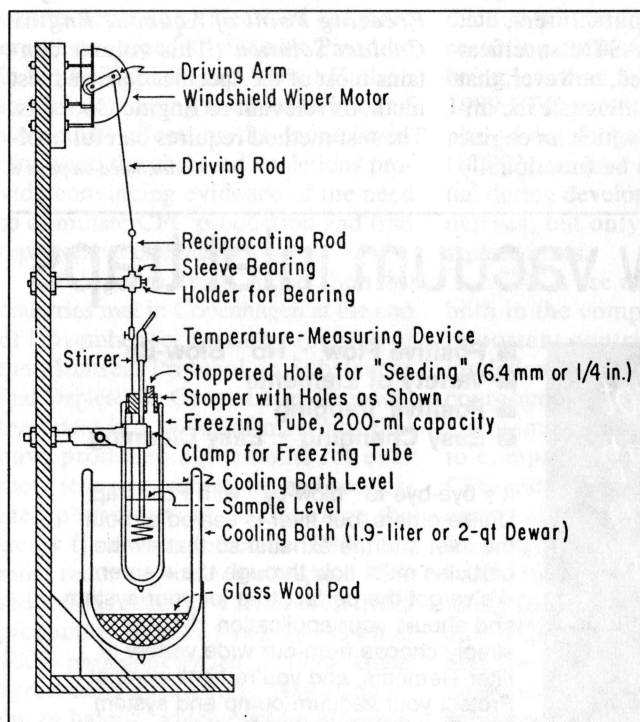


Fig. 2 The Freezing Point Apparatus

ing of the "glycol" solution for obtaining a time-temperature curve. The freezing point is the temperature where the cooling curve flattens as the rate of cooling changes while the phase change takes place. If supercooling occurs, the freezing point will be the highest temperature reached after supercooling (See Fig. 1).

Fig. 1 is a typical cooling curve obtained using the apparatus shown in Fig. 2. In practice, the driving rod is driven by a small constant speed electric motor, but some coolant testing laboratories (and the ASTM set-up) use a vacuum type windshield wiper motor (once commonly used on cars, but even J.C. Whitney in Chicago no longer lists them in their catalogs [ed.]).

Using the test method and equipment shown, freezing points found will be within 1°F of the actual freezing pint. In the field, however, "indicated" freezing points are determined by other methods, based on relative density, refractive index or test strips, rather than actual measurement of the freezing point.

Over many years of experience in the field, the most common quality complaints are about errors in the accurate determination of the freezing point.

In the typical repair garage, "freezing points" are determined using relative density. Values obtained are estimates: as any chemist will attest, the density of aqueous glycol solutions changes not only with dilution, but also with temperature. Most freezing point testers in the field do not allow adequately for the temperature of the coolant mixture. As an example, such devices use colored balls of varying density which float or sink to indicate approximate density and therefore freezing point. Until recently, an ASTM Field Test method for determining freezing points used a hydrometer. While relatively expensive versions include a thermometer, running this test under field conditions was found to be prone to error; consequently, the method has been rescinded. The only field tester for estimating freezing point currently listed in the ASTM manuals is ASTM D3321³. This method relies on a hand-held refractometer which has proven to be the most accurate field tester currently available. One version of this tester has a built-in temperature compensation and reads freezing points directly. In actual practice, the value found is within 2°F of the actual value. Freezing point is the only test commonly carried out in the field – it is usually termed "Checking protection" – strictly speaking, freeze protection.

Another relevant physical test which depends on the glycol content is the boiling point. ASTM D1120⁴ provides a method for determining the boiling point under equilibrium conditions. This laboratory method uses a 100 ml round bottom flask fitted with a thermometer and condenser. Engine coolant is heated to equilibrium boiling. After a short time the thermometer is read for the equilibrium boiling point. A table is used to correct for atmospheric pressure. Undiluted engine cooling concentrate must exhibit a boiling point of 325°F and a 50% aqueous solution must exhibit a minimum boiling point of 226°F to pass requirements of ASTM coolant specifications D3306 and D4985.

These are simple, though effective tests which have been

designed to enable virtually any lab to put together equipment to run these tests easily and inexpensively. Both freezing point depression and boiling point elevation of water are related to the molal (m) concentration of the solute. Specifications set density ranges and therefore glycol solution concentrations to ranges for which field test values for the freezing point do not differ significantly from actual values.

Check your engine coolant to be certain you have adequate freeze protection! A 50 volume % solution will give a freeze protection to -34°F, the level generally recommended for North America. ◇

- 1 American Society for Testing Materials, 1916 Race St., Philadelphia, PA 19103-1187.
- 2 ASTM Standards, Vol. 15.05 (annual).
- 3 ASTM D3321, *Use of the Refractometer for Field Test Determination of the Freezing Point of Aqueous Engine Coolants*.
- 4 ASTM D1120, *Standard Method for Boiling Point of Engine Coolants*

Research Experiences for Undergraduates

Tufts University Department of Chemistry

Description. Co-sponsored with the NSF, TUFTS-REU provides undergraduate summer research opportunities in the traditional areas of chemistry, plus bioorganic, environmental and materials science.

Format. TUFTS-REU will run from June 7-August 13, 1993, include a stipend of \$2,400, and subsidized dormitory housing.

Eligibility. Applicants must be U.S. citizens and full time college students. Women, minority and handicapped students are particularly encouraged to apply.

Applying. Application forms may be obtained by calling TUFTS-REU at (617) 627-3475. Complete applications are due March 12, 1993.

ACS Workforce Report

Foreign Scientists and Engineers in the Domestic Workforce

The ACS Office of Professional Services released a report with the above title, edited by Corinne A. Marasco. Copies of the 5-page report can be obtained from the American Chemical Society, Office of Professional Services, 1155 Sixteenth St., NW, Washington DC 20036.

The report is based on a paper presented at the April 1992 ACS Meeting by James D. Burke, Rohm and Haas Research Laboratories.

A summary of the report follows: Especially after the end of WWII US science benefited greatly from the immigration of West European scientists. Until about 1970 scientists could emigrate to the United States relatively easily, but by 1968 German and Japanese industry was again producing, competition increased and companies cut costs, i.e. research decreased and in-

stead of a scarcity of scientists there was a surplus. Consequently, US government policies on immigration became restrictive and remained so until the late eighties. Procedures for allowing immigration of foreign scientists and engineers required extensive documentation. As a consequence, most employers did not consider the effort of recruiting foreign nationals cost effective.

By the late eighties, opposition to immigration had decreased, jobs were plentiful and, for the long term, a shortage of technically trained people was forecast. As a result, an increasing number of foreign scientists immigrated, especially from the orient.

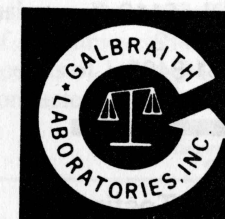
The rules requiring US trained foreign students to return to their country were seen as increasing the competi-

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ACS Workforce Report

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tiveness of these foreign countries even more. Therefore these rules were more easily waived and the 1990 Immigration Act nearly tripled the number of visas issued to managers, professionals and others with distinguished merit or ability.

Unfortunately, at that time the economy took a down-turn. Employers decreased the size of research staffs, and many state universities decreased their staff.

As a result, the competition for jobs became more intense. Despite this, it is unlikely that immigration policies will become more restrictive.

Looking at chemistry Ph.D.'s granted between 1981 and 1991, the total increased from just over 1500 to about 2200. The number granted to US citizens remained pretty much the

same at about 1200-1300, but those to foreign students on temporary visas increased from 239 to 659. During this period about half of the foreign students returned to their home land.

When a company hires a foreign citizen, up to \$4000 is spent in legal fees and expenses in order to obtain work permits for such foreign citizens. In addition, considerable managerial time is required with a total outlay of \$8,000-10,000. In addition, companies which hire foreign nationals have to provide information about salaries and wages to the Labor Department in order to satisfy the requirement that foreign employees are not used as cheap labor, displacing US residents.

Integrating foreign scientists into an American work environment requires a recognition of cultural differences. They should be made aware of their own responsibility for their advancement: they are expected to seek roles of leadership - both professionally and within their organization - in order to advance in their positions. ◇

High School News

Rindge and Latin High School and Worcester Polytech Institute to Cooperate

The New England Association of Schools and Colleges gave a joint grant to Dr. Angela B. Johnson, science teacher at Cambridge Rindge and Latin School (CRL) and Prof. Ladislav H. Berks at the Chemistry Department of the Worcester Polytechnic Institute for the improvement of science education programs at the school. CRL has a large Afro-American, Asian, and Hispanic student body and has great potential for providing some of the women and minority students needed in the sciences. Prof. Berks has found that, although the staff and science course program at CRL is very comprehen-

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Board of Directors

Condensed Minutes, Meeting of November 5, 1992

Officer's Reports:

Chairman's Report: K. Stygall reported on the programs in the Section during National Chemistry Week: "Fantastic Foods for the Future" at the Boston Museum of Science, "Undergraduate Chemistry Day" at Boston University, "An Evening of Chemistry" at Harvard University, the Norris Award meeting at Simmons College, a workshop on pollution prevention in academic, clinical and industrial research laboratories, and a symposium "College Chemistry: Future Directions" at Bradford College. The chair thanked all those who helped bring about the great success of the Chemistry Week programs. The Holiday Lecture Series has already elicited hundreds of ticket requests. Because of this, the Museum of Science has asked that there be no change in the highly successful format.

Treasurer's Report: J. Piper presented the report for October. Discretionary spending is somewhat behind budget estimates.

Archivist: M. Simon has agreed to accept this position. He requested space for the archives since Harvard has requested that the files be removed from Mallinckrodt, where they have been located.

Trustees: A. Dey reported that income from the trust funds is expected to reflect the economy. Some of the high-yielding bonds have been called in and income will be somewhat lower than previously.

Editor of the NUCLEUS: A. Heyn reported that the December issue was about to go to the printer. He thanked M. Simon for editing the November issue in his absence.

Committee Reports:

Hospitality: D. Howell reported that there will be 108 attendees at the Norris Award dinner that evening.

Publications: J. Lima announced that it is planned to distribute the Summer 1993 issue of the NUCLEUS to NERM

registrants. The publication schedule will be such that the issue is available in time and will contain appropriate information for registrants.

Professional Relations: M. Simon reported on the October meeting at which E.I. Becker received the Henry A. Hill Award and Dean Lester Thurow spoke about the economical challenges of the years ahead.

Other Committees:

Chemical Consultant's Group: D. Saez reported that 25 attended the first meeting of the group in October on the subject "Using a Patent Agent". A copy of the group's Newsletter is on file at the Section's office.

Continuing Education: A. Viola discussed the workshop on Experimental Design on November 21.

Esselen Award: T. Light reported that the award meeting in mid-April will be at Harvard University.

NERM Meeting: T. Gilbert stated that a request for volunteers to help at the June 1993 meeting was in the November NUCLEUS.

Retired Chemists' Group: E. Becker announced that draft bylaws of the group are expected to be available early in 1993.

New Business: Because of the resignation of J. Neumeyer from the Board of Trustees as of January 1, 1993, the Board conducted an election to fill the

continued on page 16

Historical Notes

The continuation of brief accounts of recently deceased chemists begun in the October 1992 issue follows.

by Edward R. Atkinson,
Amherst, MA

Ashworth N. Stull, 74, died on November 7, 1991. A Connecticut native, he received the B.S. from Georgia Tech and the M.S. from Columbia University. He was President of the American Resinous Products Corp. of Peabody, Mass. from 1942 to 1958. While a vice-president of Borden, Inc. he developed the water-based adhesive widely known as "Elmer's Glue." From 1965 until his retirement in 1985 he was President of the Linatex Corp. of Stafford Springs, Conn.

Gertrude Gray Sweeney, 91, died on October 7, 1991. She was a Nebraska native and received the B.S. in chemistry at the University there in 1920. She was employed as a teacher and then as a chemist for the Continental Baking Co. in Chicago until 1972, then made her home in Wakefield, Mass. One obituary I have seen stated that "she was the first woman member of the American Chemical Society." I have been unable to confirm that statement.

Arnold Torkelson, 69, died on February 21, 1992. He was a native of North Dakota and received the Ph.D.

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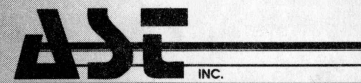
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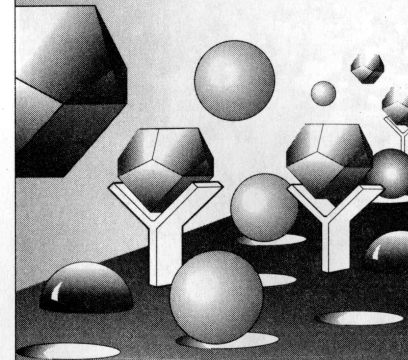
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Consulting & Clinical Labs		5%
Government		4%

One company that recruited through The Nucleus said: We received more qualified resumes from our ad in The Nucleus than we did from our newspaper ad.

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TSI Mason Laboratories, a high quality international testing laboratory serving the pharmaceutical and biotechnology industry, offers the following opportunity:

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Please donate your copies of the NUCLEUS to your local High School when you no longer need them.

Historical Notes

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in organic chemistry from Purdue University. He joined the research staff of the General Electric silicones plant in Waterford, N.Y. in 1950. At G.E. he held research management positions and was awarded several patents in the silicone field. In 1988 he retired to Plainfield, N.H. where he continued as a consultant to the industry and was also active in community affairs.

David Webster, 61, head of the science department of the Dexter School in Brookline, died on March 10, 1992. He was a native of Pennsylvania and was a graduate of Rutgers University. After service in Germany during World War II he obtained the M.Ed. degree from Harvard. He was a well-known teacher of science in secondary schools including Lincoln's Smith School, Wellesley High School, the Nashoba Brooke School in Concord, and the Dexter School. He developed a series of popular elementary science courses and wrote several

books, some of which are used abroad. He also founded two small science media businesses. According to the Boston Globe, Webster, when teaching at the Smith School, inadvertently allowed a boa constrictor to escape into the heating system of the school. The serpent was found only after it died and a strong odor developed.

Edgar Bright Wilson, 83, died on July 12, 1992 after a long battle with Parkinsonism. He was a native of Gallatin, Tenn. who received the B.S. (1930) and M.A. (1931) degrees from Princeton University and the Ph.D. from Caltech in 1933 following work with Linus Pauling. He also received several honorary degrees in later life.

Wilson joined the Harvard faculty as a Junior Fellow in 1934 and was promoted to tenure in 1937. He retired as the Theodore William Richards Professor in 1979. His book with Pauling in the 1930s was the standard text in the new subject of quantum mechanics. Later work in microwave spectroscopy gained him international recognition. He received many honors and awards including the 1976 National Medal of

Science. The Northeastern Section honored him with the Theodore William Richards Medal for Conspicuous Achievement in Chemistry (1978) and also the James Flack Norris Award for Outstanding Achievement in the Teaching of Chemistry (1966). In 1983 his son Kenneth, the 1982 winner of the Nobel Prize in physics, established a lecture series at Harvard to honor his father's support of young chemists.

Bright Wilson was a strong believer in the social responsibility of scientists. During World War II he directed underwater explosives research at Woods Hole and later spent a year at the Pentagon as a research director in the Weapons System Evaluation Group. In later years he was chairman of several committees of the National Research Council.

(I have always wondered whether Bright ever kept track of the frequent occasions when he and his work were confused with that of Edwin Bidwell Wilson, one time Presidential Administrator at M.I.T. and long a member of the Harvard Business School faculty.)

◇

Technical Product Manager

Millipore is the worldwide leader in the separation of liquids combining chromatographic and electrophoretic instrumentation, column and membrane chemistries and information processing. Millipore solves applications ranging from synthesis and sequencing of peptides to the assurance of product formulations in the chemical industry to assisting the search for new pharmaceuticals.

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MILLIPORE
Waters Chromatography

High School News

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sive, the equipment is woefully inadequate. Prof. Berks requested specific equipment donations from companies in the area, such as hot plates, electronic balances, simple spectrophotometers, pH meters, glass equipment, stereo microscopes and even a small astronomical telescope.

If your company has surplus items of equipment which might match the needs, call Sue O'Connor at the Section office, (800) 872-2054. ◇

Board of Directors

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vacancy until the next annual election. M. Green and G. Handrick had been nominated by the Nominating Committee. After hearing statements by both candidates, the Board elected G. Handrick and gave a rising vote of thanks to Dr. Neumeyer for his exceptional service on the Board of Trustees. ◇

Needed:

a room in a publicly accessible building for storage and use of the Section's archives.

*Please call M. Simon,
(617) 332-5273
for details.*

Calendar

For additional information, call:

Boston College – (617) 552-3625
Boston University – (617) 353-2537
Brandeis University – (617) 736-2500
Clark University – (508) 793-7116
Dartmouth College – (603) 646-2501
Harvard University – (617) 495-5333
MIT – (617) 253-4080
St. Anselm College – (603) 641-7148
Northeastern University – (617) 437-2822
Tufts University (Chemistry, Medford Campus) – (617) 627-3441
Tufts University (Chemical Eng., Medford Campus) – (617) 627-3900
Tufts University Health Science Campus – (617) 956-6867
UMass Dartmouth – (508) 999-8232
University of New Hampshire – (603) 862-1550

February 1

Prof. Andreas Vasella (ETH-Zurich)
“A New Look at the Synthesis of Glycosides”
Harvard University, 12 Oxford Street
Room Mb-23 at 4:15 pm

February 3

Dr. Ronald D. Archer (UMass Amherst)
“Metal Coordination Polymers – For Fun and For the Future”
UMass Dartmouth
Room 305 Science and Engineering Bldg. (Group II) at 4:00 pm

February 5

Dr. Marc d'Alarcao (Tufts University)
“The Design of Small Molecular Modulators of Signal Transduction”
St. Anselm College
Room 217 Perini Hall at 3:30 pm

February 8

Prof. Gerhard Wagner (Harv. Med. Sch.)
“Structural Studies by NMR of Proteins Involved in Cell Adhesion”
Harvard University, 12 Oxford Street
Room Mb-23 at 4:15 pm

February 10

Dr. Vernon Anderson (Case-Western Reserve University)
“Observation of Strained Intermediates in Enzyme Reactions”
UMass Dartmouth
Rm. 305 Science and Engineering Bldg. (Group II) at 4:00 pm

February 15

Prof. Stephen Lippard (MIT)
“Methane Monooxygenase, Models and Mechanism”
Harvard University, 12 Oxford Street
Room Mb-23 at 4:15 pm

February 17

Dr. T. Ross Kelly (Boston College)
“Studies Toward the Development of Artificial Enzymes”
UMass Dartmouth
Rm. 305 Science and Engineering Bldg. (Group II) at 4:00 pm

February 22

Dr. Kenneth Johnson (Moss Landing Marine Laboratories)
“Analytical Chemistry in Oceanography”
Tufts University
Room 104 Pearson Laboratory at 4:30 pm

February 24

Dr. Pradip Bhowmik (Univ. of Detroit)
“Liquid Crystalline Polymers”
UMass Dartmouth
Rm. 305 Science and Engineering Bldg. (Group II) at 4:00 pm

Notices for the Nucleus Calendar should be sent to:

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