**Chemical Demonstrations: A Compendium of Resources in Print and on the Internet**

by

**Jeannine E. Eddleton**

Thesis submitted to the Faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirement for the degree of

**Master of Science**

**in**

**Chemistry**

APPROVED:

Gary L. Long, Co-Chairman

Larry T. Taylor, Co-Chairman

James O. Glanville

Patricia G. Amateis

November 21, 1996
Blacksburg, Virginia

Keywords: chemical, lecture, demonstrations, laboratory, experiments, chemistry

CHEMICAL DEMONSTRATIONS:

A COMPENDIUM OF RESOURCES IN PRINT AND ON THE INTERNET

by

Jeannine E. Eddleton

Dr. Gary Long, Co-chairman

Dr. Larry Taylor, Co-chairman

Department of Chemistry

(ABSTRACT)

This masters report pulls together the body of resources available to assist the lecture demonstrator, professor, and teacher of chemistry in incorporating the very powerful teaching tools of chemical demonstrations. The lecture demonstration lies somewhere in the continuum between laboratory exercise and magic trick; but it is not my intention here to debate the pedagogical implications of a chemical demonstration's place in that continuum. I assume simply that the reader is in a position to motivate and excite students about chemistry and will benefit from the material contained herein. The most recent chemical demonstrations materials in print are listed and annotated in this report. The most useful chemical demonstrations-related sites on the internet are also listed and reviewed. The combination of a committed teacher and the following resources cannot but improve both the teaching and learning of chemistry at all levels of education.

# Acknowledgements

I am impossibly indebted to Dr. James Glanville for his consistent encouragement and for his dedication to my professional development for the past ten years.

I am sincerely thankful to Dr. Larry Taylor for his constant support, for his faith in my ability to determine my own path through graduate school, and for several Kleenex.

I am especially grateful to Dr. Gary Long for his efforts over the past several months. As a direct result of his time and dedication, this masters degree is finally completed.

I owe much to the entire faculty, staff, and student population of the Virginia Tech Chemistry Department for friendship and support and for the inspiration they have provided for my future studies.

Dedication

For Andy and Maggie

and especially

for

Craig

for his love and endless patience.

Science is like life itself; if we could foresee all the obstacles that lie in our path we would not attack even the first, but would settle down to self-centered contemplation. The average scientist unequipped with the powerful lenses of philosophy, is a nearsighted creature, and cheerfully attacks each difficulty in the hope that it may prove to be the last. He is not given to minute analysis of his own methods. Indeed, if he should become too self-conscious he might lose his power, like the famous centipede who, after too profound analysis of his own method of locomotion, found he could no longer walk.

G. N. Lewis

The Anatomy of Science

# I. INTRODUCTION

## A. Demonstrations? Yes!

- *Nihil intellectu quod non prius in sensu:* Nothing's in the mind that's not previously been in the senses (Latin proverb from Aristotle).
- All knowledge begins with observation (Roger Bacon).
- "Simultaneity!" Humpty Dumpty might say; else "Impenetrability!" Lectures Mondays, Wednesdays, and Fridays, labs Tuesdays or Thursdays, don't [entirely] do the trick.
- The unassisted eye [or merely text-book assisted eye] and unassisted mind [the merely lectured-to mind] have little power (Francis Bacon).
- Like Dodgson's dancing, there's no use trying to describe chemistry: chemistry has to be seen to be believed (Lewis Carroll, slightly paraphrased).[1]

These quotes are part of the exposition written by Henry E. Bent and Henry A. Bent on the occasion of the latter's receiving the American Chemical Society Award in Chemical Education in 1980. Of what significance are these statements regarding chemical demonstrations? They are of tremendous significance and it is of special importance that students get their first taste of chemistry by seeing, hearing, smelling, and feeling chemical phenomena by way of lecture demonstrations. How many of us who have chosen chemistry as a career remember the first time we saw the fire-ball produced by a hydrogen balloon explosion, heard that very violent chemical reaction taking place, and felt the shock wave produced as it passed to the very back of the lecture hall? Chemical demonstrations evolve a great quantity of charm; i.e. compelling attractiveness and appeal dispelling any possible reserved or antagonistic feeling.[2] Chemical demonstrations serve lecturers in that single most important purpose of communicating to students an appreciation of chemistry, its diversity and usefulness, its cohesiveness and value as a central science, its intellectual excitement and challenge.[3] Chemical demonstrations promote an atmosphere of interactive conversation in the classroom between the student and the teacher.[4] As borne out by attendance figures at demo presentations at conferences where all the attendees are teachers and chemists, *instructors* get excited about demos![5] Whatever the educational value of a demonstration, it is an opportunity for the instructor to show his or her excitement for, passion for, and love of chemistry.

**B. Purpose of This Document**

This masters report pulls together the body of resources available to assist the lecture demonstrator, professor, and teacher of chemistry in incorporating this powerful teaching technique in their own classrooms. The lecture demonstration lies somewhere in the continuum between laboratory exercise and magic trick. It is not my intention here to discuss the pedagogical implications of a chemical demonstration's place in this continuum. The most respected demonstrators of our time, Hubert Alyea and Don Herbert as examples, walk that fine line between educator and entertainer. I will not debate the safety of lecture demonstrations or their effectiveness in enhancing teaching and learning. I assume simply that the reader wants to motivate and excite students and improve student attitudes toward chemistry. I further assume that the reader understands the importance of incorporating the lecture demonstration safely and effectively into the lecture and is always searching for new ideas that do the job just a little bit better in preparation for the next lecture. The combination of a committed teacher and the following resources cannot but improve both the teaching and learning of chemistry at all levels of education.

### C. Work Done To Date

David Katz's *Science Demonstrations, Experiments, and Resources: A Reference List for Elementary through College Teachers Emphasizing Chemistry with Some Physics and Life Science* [6] published in the Journal of Chemical Education in 1991 is a most complete bibliography of lecture demonstrations. His collection of journals and formula, craft, and information books encompass basic and advanced science and chemistry: bubbles, magic, cosmetics, dyeing, soap, candles, and balloons to name a few. Katz's list of over 220 items is the most complete bibliography this author could find and the only one published in a chemistry journal. This report serves to update and expand Katz's collection. An annotated update of works not included in Katz's list and books that have been published since 1991 comprises a section of this chemical demonstrations compendium.

The next section contains the results of a Chemical Abstracts literature search on both *chemical* demonstrations and *lecture* demonstrations, the specifics of which are discussed in the experimental section of this report. As the pressure to cover more material and more special topics in general chemistry increases, the need to incorporate demonstrations on these topics increases. I have, therefore, included many demonstrations from polymer chemistry, materials science, and biochemistry.

A final section is a listing and commentary of internet sites that the lecture demonstrator or chemistry instructor may (or may not) find interesting and useful. This compendium is a collection to date and should not be viewed as a complete work; indeed, it can never be a complete work as many new wonderful (and some not so wonderful) publications continue to be published. Through annotation I hope to most efficiently direct the interested reader to the best sources currently available in lecture demonstrations. My ultimate goal is to make the general chemistry lecture the sensory experience it deserves to be.

## II. EXPERIMENTAL

Publications that are potential sources of chemical demonstrations are everywhere; but, finding them is a rather hit or miss proposition. The most recent publications can be purchased at conferences on chemical education. Flinn Scientific[7] is the most complete catalog source I have found; but, interesting documents can also be found in hobby shops and art and engineering supply retail outlets. Many of the most up-to-date books are reviewed in the **Books in Print** section of this report.

### A. In Print

An initial query on the Virginia Tech Library System revealed no responses for the topic chemical demonstrations and only one item under chemistry education-higher- a masters thesis written in our own department[8]. A search of Chemical Abstracts was similarly disappointing. Chemical demonstrations literature is available, as evidenced by many personal libraries, but the great majority of the publications listed in the bibliography review section of this report (the really useful compilations) were not found by the chemical abstracts search. An inquiry to the Chemical Abstracts Help Desk revealed that the titles of many such works simply didn't "sound chemical" enough to be included.[9] This is unfortunate since valuable resources like Lee Marek's *Be Cool to Your School: The Uses of Liquid Nitrogen* and Andy Sae's *Chemical Magic from the Grocery Store* are therefore not readily accessible through typical avenues of searching on chemistry topics.

Within the college teaching community, the Journal of Chemical Education (abbreviated as J. Chem Ed., and more recently as JCE) is the recognized authority on subjects in chemical education; it is my intention here to present useful information that supplements the very valuable information found in that journal. To that end, a

Chemical Abstracts search was done for "lecture" with "demonstration", excluding anything from JCE. The words "lecture" and "demonstration" were required to appear together in that order and in English. A second search was done in an identical manner but with the key words "chemical" and "demonstration." The only publication revealed on the second search that did not appear on the first search was Phillip Chen's *Entertaining and Educational Chemical Demonstrations* which is documented in David Katz's article.[10] Material from the very first issue of JCE to 1994 has been catalogued in Gilbert's *Tested Demonstrations in Chemistry Volumes 1 and 2.*[11,12] The online Chemical Abstracts database covers material from 1967 to the present. The results of these searches are listed in the **Literature Search** section of this report.

### B. On the Net

Searching the internet for chemical demonstrations materials proved difficult; there simply isn't any one organized or efficient way to search the topic. Ultimately the parameters of this internet search reduced to pursuing any and all reasonable looking leads and links via Netscape through the commonly available search engines, Lycos, Magellan, Infoseek, Alta Vista on topics that could be related to chemistry demonstrations. A similar technique was used on the list of all news groups available with Nuntius1.2. Any reasonable looking abbreviations were investigated, including ch, misc, sci, anything beginning or ending with u for university, and anything that looked to be college or "schoolish," like Princeton or Cornell. The search was deemed complete when links to useful resources then circled back to most of the same useful sources. An annotated list of relevant sites found on the internet comprises a section of this report.

# III. CHEMICAL DEMONSTRATIONS RESOURCES IN PRINT AND ON THE INTERNET

## A. An Updated, Annotated Bibliography

The following items are sources for experiments, activities, demonstrations, and information. It is rare to see original material; most publications duplicate activities found in other sources with variations in set-up and applications. The production of plastic sulfur, for example, can be found in at least fifty percent of available demonstration compilations. A demonstration and a lab activity are very different entities; nevertheless, many exercises can be either, depending on the set up. These activities can be modified to be applicable to any level; many substitutions can be made to materials and apparatus. Interested demonstrators should not neglect science laboratory manuals on all levels, and high school and introductory college chemistry and science textbooks. A footnote or photograph can certainly become the inspiration for any number of demonstrations; this cannot but help the textbook "come alive" for the introductory student.

### 1. Books in Print

Becker, Robert. Twenty Demonstrations Guaranteed to Knock Your Socks Off! Batavia, IL: Flinn Scientific, 1994.

> The most original variations of tried and true demonstrations and some original pieces. Bob Becker's presentations are not to missed; his publications belong in the personal library of every science teacher at every level. Clearly outlined materials and procedures, variations for every activity, tips for adapting the activity for different size groups, and easy to follow discussions of

the basic chemical principles involved. Safety is appropriately addressed; waste disposal is not, but most activities use readily available, non-hazardous supplies. All activities are properly acknowledged. Also available on CDRom.

Berger, Sue A.; Hill, Allen E.; Holmquist, Richard K.; Horsch, Elizabeth A. Element of the Week: A Descriptive Chemistry Technique. Batavia, IL: Flinn Scientific, 1989.

Describes demonstrations involving 14 different elements, unique in its organization in this respect. Teaching tips such as Adopt-An-Element, Getting Organized, and Homework make this book especially appropriate for middle school and early high school educators.

Cassidy, John. Explorabook: A Kid's Science Museum in a Book. Palo Alto, CF: Klutz Press, 1991.

A wonderful book from Klutz. John Cassidy, creator of many Klutz publications and the Exploratorium, a San Francisco-based museum of science, art, and human perception have collaborated on a book that they implore you to DO not READ. More than 50 activities, and the tools you need to do nearly all of them, are included on such topics as magnetism, light, bacteria, optical illusions, and Bernoulli's principle (or light wave craziness, hair dryer science, and ouchless physics in Klutz terms.) The book is written in a very engaging manner, typical of Klutz products, and the pictures, graphics, and general appearance are appealing to kids (and adults). Cassidy handles scientific priciples in a way that a general audience would find understandable.

Doherty, Paul; Cassidy, John. The Klutz Book of Magnetic Magic. Palo Alto, CF: Klutz Press, 1994.

Another wonderful Klutz offering, this time focusing on magnetism. These folks have an absolutely amazing ability to present real science in a completely appealing way. The phenomena are presented as magic tricks, and, while they could certainly be used effectively in the classroom that way, the activities could be easily adapted to more rigorous investigation. Klutz is clearly on the cutting edge of getting our kids excited about science.

Dunninger, Joseph. Dunninger's Complete Encyclopedia of Magic. New York: Gramercy Publishing Company, 1987.

Books of magic tricks are not to be overlooked as sources of science demonstrations. Most contain sections on "chemical entertainments" and at the discretion of the lecturer, many more of the tricks can be presented to emphasize their scientific bases, if desired.

Ealy, Julie B.; Ealy, James L. Jr. Visualizing Chemistry: Investigations for Teachers. Washington D.C.: American Chemical Society, 1995.

One hundred and one investigations presented by the well-known Ealy team. Unlike the collaborations with Summerlin (Chemical Demonstrations. A Sourcebook for Teachers, Volumes 1 and 2), explanations of chemical principles are offered as well as chemical reactions. Safety concerns are noted. Unfortunately, it is unclear as to exactly who this book is written for. The activities can be adapted for either the classroom or the demonstration bench, but in their present form are suitable for neither without extensive adaptation. The demonstrations for each topic are not simply repeats of commonly compiled material; novel presentations of oxidation and reduction, kinetics and equilibrium, and organic and biological reactions are included. A spiral binding and heavier duty page stock would make the book more lab ready.

Ealy, Julie B.; Ealy, James L., Jr. Close-Up on Chemistry VIDEOTAPE. Washington D. C.: American Chemical Society, 1991.

A truly excellent videotape of chemical demonstrations. Close-Up on Chemistry features 22 demonstrations that are either too dangerous or too expensive to be useful in most classrooms. The program student to view and for the teacher to integrate into the lecture. This is by far the most valuable videotape currently available.

Editors of Klutz Press. The Official Icky Poo Book. Palo Alto, CF: Klutz Press, 1990.

Much less (!) scientific emphasis in this Klutz book. Still, the Icky Poo is as interesting to budding polymer chemists as it is to kids. And what's wrong with having some fun with the results of chemistry? Slime (or Gak) production at public chemistry exhibitions is responsible for generating more than passing interest in chemistry by many thousands of young people. Why not Icky Poo?

Ellis, Arthur B.; Geselbracht, Margret J.; Johnson, Brian J.; Lisensky, George C.; Robinson, William R. Teaching General Chemistry: A Materials Science Companion. Washington D.C.: American Chemical Society, 1993.

The goal of these authors is to demystify materials chemistry so that its principles can be readily brought into the introductory chemistry course. They also want to refresh the general chemistry course by putting a new spin on the traditional material. Included are demonstrations of paramagnetism, ferromagnetism, ductility and fracturing, work hardening, annealing, hardening, and tempering, metallic reflectivity, photoconductivity, superelasticity, levitation, and shape-memory properties. Also helpful is the topic matrix that can be used to integrate the chapters of this book into the typical general chemistry syllabus. Many of these demonstrations would be difficult to present in the large lecture hall.

Epp, Dianne N. The Chemistry of Food Dyes. The Chemistry of Natural Dyes. The Chemistry of Vat Dyes. Middletown, OH Terrific Science Press, 1995.

A three-volume series of monographs entitled Palette of Color aimed at enabling high school chemistry teachers to introduce their students to dyes and colorants, an important area of industrial chemistry. Backround information on the history and chemistry of various dyes and colorants is included together with hands-on activities for producing, testing, and using these chemicals. These volumes are produced by Terrific Science Press and reviewed and tested by teachers in the Center for Chemical Education's Terrific Science Programs for accuracy, safety, and pedagogical effectiveness. The activities in these monographs would be a practical addition to an organic or introductory laboratory program and would have particular appeal to the non-major in chemistry.

Faculty Members from California Polytechnic State University at San Luis Obispo Chemistry Department, Organic Chemistry Experiments. Santa Maria, CF: CPSU, 1980.

Chemical demonstrations can be culled from countless sources. This organic chemistry manual has been used at Virginia Tech for many years; we scale the quantities of the soap making reagents up to make a large quantity for organic chemistry students in lecture.

Faraday, Michael. Faraday's Chemical History of a Candle. Chicago, IL: Chicago Review Press, 1988.

Faraday's classic lecture series on the chemistry of a burning candle has been updated with new illustrations, notes, and twenty-two experiments that allow young people, with adult supervision, to "enter into the study of natural philosophy by considering the phenomena of a candle." This discussion is important historically and unsurpassed as an introduction to the principles of combustion.

Gilbert, George L.; Alyea, Hubert N.; Dutton, Frederic B.; Dreisbach, Dale. Tested Demonstrations in Chemistry: Volume I & II. Washington D.C.: American Chemical Society, 1994.

Beginning with volume 1 of the Journal of Chemical Education in 1924, contributors have shared the lecture demonstrations they have found useful in presenting chemistry to their students. Hubert Alyea initiated the "Tested Demonstrations in General Chemistry" column during 1955-1956, and Tested Demonstrations has been part of the journal each issue since. These volumes are the collection of the materials published in the journal since its inception;

no rewriting was done. George Gilbert, the editor of this collection and current editor of the column, felt that this would allow the user the choice necessary in selecting the materials and equipment for any specific situation. As safety and disposal issues are a fairly recent development, little mention is made in most of the individual entries. The final section of these volumes is dedicated to articles written about safety, specifically detailing accidents that have taken place when demonstrations were being performed. These authors wrote for an educated, professional audience, hence little detail as to specific techniques is usually included. This book is a wonderfully useful distillation of the wealth of information available from JCE. The material is organized by topic, obviously useful for actually finding information, but it would be of historical interest to have the entries dated.

Gross, George R.; Bilash, Borislaw (II); Koob, John K. A Demo A Day: A Year of Chemical Demonstrations. Batavia, IL: Flinn Scientific, 1995.

Compilation of favorites of three high school teachers in an incredibly easy to handle spiral binding. Most demonstrations are the old favorites, but the Operations and Measurement in Chemistry section was particularly interesting. The illustration of scientific notation and logarithmic scales using a clothesline and distance to show relationships between powers of ten is wonderful. And just as useful in the general chemistry classroom as it is in high school. The construction of "A Rather Large Thermometer" is also an interesting addition.

Heiserman, David L. Exploring Chemical Elements and their Compounds. New York: TAB Books, 1992.

Not actually a demonstration book, but chock full of information for the interested chemistry student or curious person. The preparation/commercial production of the elements is particularly interesting, and all in one book. Written for ages 12 and up.

Hixson, B.K.; Kralik, M.S. Junior Boom Academy. Salt Lake City, UT: The Wild Goose Company, 1992.

I do not like or recommend this book. The Wild Goose Company could take some lessons from the Klutz folks on how to be funny and respectful of chemicals at the same time. The Oooh Aaah Chemistry section is particularly offensive. The Dramatic Color Changes described involve the production of lead(II) iodide and mercuric iodide with NO MENTION of the danger of heavy metal salts or their safe disposal. This book is written with a "kitchen chemistry" attitude which is obviously dangerous when "real chemicals" are, in fact, the reactants. *NO* mention of the carcinogenic properties of the chromic oxide produced from the ammonium dichromate volcano is made. In fact the authors state that, "You can handle the powder after the reaction without any side effects." The glycerine/potassium permanganate reaction is potentially much too dangerous to be safely done in a classroom full of children. The Smokescreen in a Cap is described as "the first of three socially redeeming experiments to finish out the book", since it falls into the life skills category of knowing how to make a smokescreen in James Bond-like circumstances. "Every good agent needs to know how to make a smokescreen so he or she can get away." Even if the Oklahoma City bombing had never occurred, this reaction is entirely too violent to be included in a book marketed to children and their parents, sold in an arts and crafts store, and presented as a fun time. The second of these three experiments is construction of a flashpaper cannon. "Flashpaper is commonly used by magicians to create the illusion of fire coming from their fingertips. Being the serious minded scientists that we are, we do not condone such trivial and superficial uses of said chemical, but rather will use it to create a cannon that shoots fire. Obviously, much more useful to society." No further comment necessary on this one. Finally, the simulated Grain Elevator Explosion which involves blowing cornstarch through a rolled up paper into the flame of a propane torch; the torch is held by a member of the class. Call me crazy; I don't like the thought of the fireball being produced over the head of an unsuspecting young person. The precautions listed involve low ceilings (the book's author melted one once) and the uncombusted cornstarch cloud which would settle onto the audience. The attitude of this publication is entirely inappropriate; this adds to its danger. No references included. Education and entertainment can (and should) be combined very effectively in certain instances. Unfortunately this publication is an example of how NOT to do it.

Hixson, B.K. Science Without Answers. Salt Lake City, UT: The Wild Goose Company, 1989.

Again, a little too irreverent a treatment of teaching science, but much less dangerous this time. The author presents 25 activities that are intended to get students to think creatively, some I'd like to try! Very simple materials required, lots of paper and straws. The activities are mostly more appropriate for a physics classroom or middle school level general science class, although the Superbubbles, Starch Tester, and Charcoal Crystals are suitable for chemistry.

Hixson, B.K.; Kralik, M.S.; Hutson, T.L.; Robertson, B.S. Zero to Einstein in 60. Salt Lake City, UT: The Wild Goose Company, 1989.

This one reminds me of the older science magic books for kids. Sixty activities with water, magnetism, air pressure, inertia, heat, and a little chemistry. Lots of really cool stuff. Not much new, but some interesting new twists on some old tricks. The balloon rocket is simple and leaves room for experimentation; the water magnifier is ingenious, and would make a great class activity. Hixson's illustrations are great. Some of this material should be referenced.

Iddon, Brian. The Magic of Chemistry. Letchworth, Hertfordshire, UK: The Garden City Press Limited, 1985.

Dr. Iddon presents his "Organic Chemistry at Work" program at the Royal Institute of Chemistry and at venues throughout the U.K. He presents 28 demonstrations in this small book; many are old favorites. Iddon places particular emphasis on polymers, illustrating, for example, poly(phenylethene)(polystyrene) expansion, self-siphoning Polyox, and drawn nylon from touching a nylon comb with a hot glass rod and quickly pulling it away. The book is difficult to read, but ends with a great reference list. Many of Iddon's references are from School Science Review, not readily available in the United States.

Marek, Lee. Be Cool To Your School: Uses of Liquid Nitrogen. Batavia, IL: Flinn Scientific, 1992.

Lee Marek has popularized science on the David Letterman show and around the country with his Weird Science troup. He's a wild man when presenting demonstrations and an excellent chemistry teacher. This short book is FULL OF SO MANY IDEAS for liquid nitrogen demonstrations...and you thought you had seen them all! Fry an egg and some bologna in a Teflon frying pan with liquid nitrogen. Do the old egg in a bottle trick by cooling the flask that has the egg sitting on its opening. Freeze a lead bell to discuss physical properties of metals at low temperatures. Cool the copper wire used as part of an electrical circuit to see the lightbulb brighten. Put a $10 bill into a dewar of liquid nitrogen and pull out the $1 bill you had put in previously to reinforce the concept of Charles' law...or to initiate a discussion of the shrinking dollar. Shrink a red balloon into a dewar and pull out the blue one you had previously put in to show that the balloon got cold! It's all pure Lee Marek, but presented properly, it'll sure drive the point home.

McDuffie, Thomas E. Jr.; Anderson, Jacqueline. Chemical Experiments From Daily Life. Portland, ME: J. Weston Walch, 1980.

Each one of these experiments has a "point to ponder" at the beginning, something to relate the activity to everyday life. Although the activities are written as laboratory exercises, many are easily adaptable as demonstrations. Antifreeze Is Also Anti-Boil and Milk and Its Sticky Step-Child were particularly interesting.

Sae, Andy. Chemical Magic from the Grocery Store. Portales, NM: Scopcraeft Press, 1995

Sae's goal is to remove the barriers of glassware, systems of units, and chemical calculations so that chemistry can become non-threatening and enjoyable and accessible for teachers and students alike. Sae's personal philosophy is that once chemistry has become useful and fun, then a more formal approach to various science disciplines can be pursued. Indeed, no scientific equipment is needed for any of the demonstrations in this book. Sae offers tables of contents both alphabetical and by subject area, a listing of selections that make good magic tricks, a list of chemical toys and their suppliers/manufacturer, an excerpt from his J. Chem. Ed. article on chemical problems and solutions which would be wonderful to share with students, and a supply list of EVERYTHING needed to do everything in the book. Every science teacher in America should own this book.

Sarquis, Jerry L.; Sarquis, Mickey; Williams, John P. Teaching Chemistry with TOYS. Middletown, OH: Terrific Science Press, 1995.

This book is written as a resource for teachers of grades K-9 who want to use toy-based physical science activities but are unable to attend the professional development workshops offered at Miami University. The activities are written so that a teacher or parent with no particular prior knowledge of physical science can complete them. The activities are divided into grade level groupings,

but any number of these activities could be adapted for the college chemistry classroom demonstration. Although the book is directed to instructors of K-9, it is a mistake to assume that college students have already seen these toys and experiments; many of the exercises can be brought effectively into the general chemistry lecture.

Shakhashiri, Bassam. Chemical Demonstrations: A Handbook for Teachers of Chemistry, Volume 4. Madison, WI: University of Wisconsin Press, 1992.

The fourth installment in THE authoritative publication for chemical demonstrations. Shakhashiri and his collaborators have put together another top-notch volume; this one includes clock reactions and electrochemistry: batteries, electrolytic cells, and plating. The author obviously understands that the primary purpose of chemical demonstrations is to educate students, that many general chemistry lectures necessarily are held in large lecture halls, and that an understanding of the chemical phenomenon is crucial to an effective presentation of the demonstration. Shakhashiri's explanations can be somewhat lengthy, but this makes the volumes suitable for all levels and the individual teacher can use what is needed for his intended audience. Although much of his material is not original, the Shakhashiri volumes have become a standard for chemical demonstrations texts. Most of the recipes for these demonstrations have appeared in other publications, but, until this series, have not been combined with such indepth explanations, variations on presentation, and attention to disposal of the resulting waste. Every instructor of college chemistry and every teacher of high school chemistry should be familiar with these volumes.

Tannenbaum, Ginger. Lessons in Chocolate. Batavia, IL: Flinn Scientific, 1993.

The development of this unit for high school students was funded by an STS Mini-Grant from the ACS, but aspects of the program are adaptable to the chemistry classroom on many levels. This volume is probably more suited to the laboratory, but anything involving chocolate (or any food) gets students attention and should be given a chance in the classroom. Did *you* know that chocolate has non-Newtonian properties?

Taylor, Beverley A.P.; Poth, James; Portman, Dwight J. Teaching Physics with TOYS. Middletown, OH: Terrific Science Press, 1995.

As per the description of Teaching Chemistry with TOYS, these activities can be adapted for any grade level; and, yes, physics demonstrations can (and should) certainly be adapted to the chemistry classroom!

**2. Books out of print**

The following volumes are interesting reading in that they contain many interesting demonstration ideas and they also discuss chemistry in a way that modern texts don't due to time and space limitations.

Benedict, Francis G. Chemical Lecture Experiments. New York: The MacMillan Company, 1901.

Elder, Albert L. Demonstrations and Experiments in General Chemistry. New York: Harper and Brothers, 1937.

Gilbert, A.C. Gilbert Chemical Magic: A Presentation of Original and Famous Tricks in Conjuring Accomplished by the Use of Chemicals. New Haven, CT: The A.C. Gilbert Company, 1920.

Morgan, Alfred. Simple Chemical Experiments. New York: Appleton-Century Co., 1941.

**3. Other print sources of chemical demonstrations**

Eastman Fine Chemicals NEWS. Eastman Fine Chemicals. Eastman Kodak Company.

I believe this is now out of print as I could not find a contact in the company who knew of the publication. I got my first slime recipe and a basic indigo dye recipe from here. Was also interesting reading on new products.

Flinn Scientific. FLINN FAX! and CHEM FAX! Batavia, IL: Flinn Scientific, 1994.

Flinn puts a couple of these in every package that leaves their headquarters. Lots of demo ideas, not usually new, but you never know what these folks will come up with. And they make it easy by providing all the ordering information you need at the conclusion of the demonstration write-up. Imagine that! Flinn Fax is published quarterly and also contains teaching tips, safety reminders, new products, tidbits of information that Flinn customers send in.

Sherman, Marie C. A Potpourri of Demonstrations and Labs: Some of My Favorite Things. Presented at the 14th Biennial Conference on Chemical Education, Clemson, S.C., August 1996.

Marie Sherman does amazing things with two cans of regular and diet soda. She also addresses nuclear radiation and Gore-Tex. Activities easily adapted to demonstration or lab.

Teachers Teaching Teachers: A Leadership Program in Science, History, and Mathematics.

The National Leadership Program for Teaching begun by the Woodrow Wilson Foundation in 1982 evolved into 120 one week institutes by 1991. The leaders of the institutes are award-winning high school teachers and present activities and demonstrations on topics like periodicity, gases, kinetics, and acid-base chemistry that have already proven successful in their own classrooms. The demonstrations aren't new but some of the methods of presentation are. Reactions from students make this an even more interesting document.

University of California Berkeley Institute for Chemical Education Summer 1991 Laboratory Activities.

This document is interesting in that it includes several organic and biochemical demonstrations: calcium and milk coagulation, pectin in fruit juices.

Virginia Tech Physics Instructor's Handbook. Compiled by D.D. Long.

The chemistry lecturer should never ignore physics as a source of demonstrations and activities. And it certainly never hurts to emphasize the interdisciplinary nature of the two fields.

## B. The Literature Search

Chemical Abstracts is regarded as comprehensive for all aspects of chemistry and related fields; it includes journal articles, individual papers, published books, technical reports, conferences, and patents in all languages.

### 1. Additional books located by Chemical Abstracts

The following volumes were unavailable for review, but are not listed in Katz's article and appear to warrant further investigation.

Kallard, T. Exploring Laser Light: Laboratory Exercises and Lecture Demonstrations Performed with Low-Power Helium-Neon Gas Lasers. New York: Optosonic Press, 1977.

Woodburn, John H.; Sanford, Lewis R.; Brawley, W. James, Jr. Demonstrations and Activities for High School Chemistry. West Nyack, NY: Parker, 1971.

## 2. Journal Articles by Topic

Individual journal articles are not discussed by Katz. The following are not commonly found in demonstration texts and are from journals other than J. Chem. Ed. Some of the journals are not readily available in the United States.

### -Introduction/Matter and Measurement

Ainley, D. The use of screened methyl orange in teaching chromatography. Sch. Sci. Rev. (1981), 63(223), 338-340.

### -Mass Relationships

Aronow Hoots, Rita. Dancing mothballs. J. Coll. Sci. Teach. (1988), 17(4), 296-297.

Greenslade, Thomas B., Jr. The maximum density of water. Phys. Teach. (1985), 23(8), 474-477.

Hopkins, David E. Relative densities of liquids. Sch. Sci. Rev. (1975), 57(198), 141-142.

### -Chemical Reactions

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### C. The Internet as a Resource

#### 1. Web Sites

Search engines are helpful for finding information on the internet; in this case they were of limited use. In November 1996, Lycos found 17,799 relevant documents to a chemical demonstrations query, Magellan located 62,525, some appearing to be completely unrelated to the topic. Yahoo and Alta Vista were also used as well as many links from one resource to another. Following is the annotated listing of the most valuable materials.

**-The Chemical Education Resource Shelf**

http://www.umsl.edu/divisions/artscience/chemistry/books/welcome.html.

This is an archive produced under the auspices of JCE Online; it contains some truly unique and useful material. Hal Harris at the University of Missouri-St. Louis maintains this site. Hal's Picks of the month spotlight publications written for teachers. They aren't all about chemistry and they aren't all about teaching; but they are all relevant and all impeccably reviewed. The Index to Chemistry Texts in Print is very complete (except that it could use some expansion in the chemical demonstrations area). The site also includes sections entitled Journals of Interest to Chemical Educators and References for Chemistry Teachers. This site has a scholarly appeal missing from many of the other sites and it has the REALLY useful material: the list of which good books to get and read! Every teacher of chemistry should consult this site periodically.

**-The Sheffield ChemDex: Chemistry Resources on the Internet**

http://www.shef.ac.uk/~chem/chemdex/

Many less than useful sites have as their only really useful aspect a link to Mark Winter's web offering from the University of Sheffield, South Yorkshire, England. It currently points to 2415 nodes, including all of the useful products regarding chemical education. WebELEMENTS at http://www2.shef.ac.uk/chemistry/web-elements/web-elements-home.html is an award-winning periodic table containing a wealth of information.

**-Chemistry Teaching Resources**

http://www.anachem.umu.sc/eks/pointers.htm.

Knut Irgum at Umea University (Sweden) maintains this site which is linked to many demonstration sites on the net.

**-The Chemical Demonstrations Page**

http://chemwww.byu.edu/chemed/hp.htm.

This page from Brigham Young University includes a very detailed listing of demonstrations and sources of materials contained within the BYU chemistry department and library/media center as well as write-ups of some individual demonstrations.

**-Amazing Science at the Roxy**

http://www.hood-consulting.com/amazing/index.html

Maintained by B. J. Hood, this site is impressively developed but of little real use as all information must be downloaded in the form of quick time movies; this severely limits its intended audience. The Demomania section includes The Amazing Diaper Absorbent, A Chicken-Based Insulation, Inks that Appear at Will, and Watching a Chemical Sunset, sure to be interesting if one's computer can successfully handle the files. Hood also offers How to Present an Effective Classroom Demonstration which is taken from the ACS video developed by the Public Outreach Office in 1990. The most interesting aspect of this particular site is the link it provides to the University of Northern Iowa College of Education Readings on Constructivist Education Site at http://iscssun.uni.edu/coe/regentsctr/biblio.html. This is the only link seen in this search to a strictly education site.

**-Science is Fun in the Lab of Shakhashiri**

http://scifun.chem.wisc.edu/

Maintained by the Shakhashiri group and containing the most useful piece of information found in this entire search: ordering information for the Chemical Demonstrations volumes written by Shakhashiri and colleagues.

**-Internet Chemistry Resources**

http://www.rpi.edu/dept/chem/cheminfo/chemres.html.

A site maintained at Rensselaer Polytechnic Institute. It contains many links to chemistry resources, but does not itself contain any demonstration information.

**-The Houghton Mifflin Resource Site for Instructors of Chemistry**

http://chemed.chem.binghamton.edu:2000/resource.htm

A site maintained at SUNY Binghamton and containing a most comprehensive Collections of Chemistry Links. As the purpose of each site seems to be to linking to other sites, this resource appears most useful.

**-Fisher Scientific Teacher Tips**

http://fisheredu.com/bin/sct221/fisher/v1/teacher_tips.html

or

http://fisheredu.com/bin/sct221/fisher/v1/chem_tips1.html.

It certainly is a good-looking site, and the demos are well-written and fully referenced for the most part. The total offering, however, is very small, maybe 6 demos. Of just six, though, one was an original demo (or lab activity) demonstrating fractals using petri dishes and acrylic paints.

**-Science Resource Center**

http://www.lapeer.lib.mi.us/Chem/

Patrick Gormely maintains this entry from the University of Michigan and , by internet standards, it contains a reasonably extensive list of demonstrations.

**-Tom Peregrin's Pyrotechnic Webbook**

http://mercury.aichem.arizona.edu/~tip/pyro.html

Touted as the best single source of high quality pyrotechnic information on the web by all lesser pyrotechnic web sites, Tom Peregrin offers a serious and complete source for every kind of information pertinent to this topic. He has imported complete sections of other references (properly documented) to supplement areas in which he is not an expert. The history of the discipline, the chemistry and physics theories behind fireworks, federal legalities of constructing display pyrotechnics, and links to all the related sites he has found are included. Juvenile requests for bomb instructions are clearly not invited. Mr. Peregrin's goal was to post decent information on this topic as he is fully aware of the quantity of what he terms "dangerous garbage" that is available. I located several other pyro sites that are linked to this pyrotechnic webbook and was quite impressed at their overall quality. Links to pyrotechnic organizations, selected articles, commercial sites, and some lovely photographs of exploding display pyrotechnics are available. Especially interesting were the time-lapse photograph sequences of exploding shells and the photographs of the ground equipment prior to a fireworks display. Very impressive was the commentary on safety that abounded on virtually every one of these sites.

**2. News Groups**

As demonstrations can be adapted from any discussion of chemical phenomena, the educated reader could glean information from any of the news groups: sci.chem, sci.engr.chem, sci.materials, sci.research. Sci.chem at ftp://rtfm.mit.edu/pub/usenet/sci.answers/sci/chem-faq/part4 contains, as Subject 15, a nine page listing of favorite demonstrations as informally posted from the group contributors. Subjects 16, 17, and 18 discuss laboratory procedures, chemical preparations, and sensory properties of chemicals and include several demos directly relevant to those topics. The sci.chem FAQ is quite useful as it serves as a directory to the best sites on many topics related to chemistry. Part 3 Subject 13 of the FAQ discusses illicit and government controlled substances under which drugs, explosives, and pyrotechnics fall. Many links to pyrotechnic sites are included. Some of these sites are wonderful, as discussed previously in this report. The comment is made in the FAQ that many serious pyrotechnic and explosives enthusiasts have fled to the mailing lists from the newsgroup rec.pyrotechnics due to the large number of juvenile "mad-bomber" type posts that abound. As many thermochemistry demonstrations are pyrotechnic in nature, demonstration ideas could certainly be culled from these discussions. The usefulness of newsgroups for chemical demonstrations is addressed as a conclusion of this report.

### 3. Listservs

A more useful aspect of the internet appears to be the interaction of professionals through listservs. CHEMED-L at listserv@uwf.bitnet aims to provide a forum for discussion of matters of interest to chemical educators at all levels. CHEMCOM at listserv@ubum.bitnet has been set up for discussion of chemistry in the community. Judging by the number of requests by individuals for interested responses, many listservs associated with schools and universities appear to be in planning stages. The quality of such lists and the degree of relevance to any one topic is obviously determined by the persons posting and replying to messages. Future investigation is warranted to determine the usefulness of listservs.

## IV. CONCLUSIONS

As a result of this effort to uncover chemical demonstrations resources in many forms, several major points developed.

### The Best Books

An abundance of chemical demonstration material is available to the interested science teacher. The best sources available in print are Shakhashiri's Chemical Demonstrations: A Handbook for Teachers of Chemistry Volumes 1-4 for their thoroughness and attention to detail, Summerlin's Chemical Demonstrations: A Sourcebook for Teachers, Volumes 1 and 2 for their conciseness, Gilbert's Tested Demonstrations in Chemistry Volumes 1 and 2 for the uniqueness that can only be contained in this original material and for the sheer quantity of original information, and Becker's 20 Demonstrations Guaranteed to Knock Your Socks Off and Sae's Chemical Magic from the Grocery Store for their originality. All of these works are annotated in either Katz's article or this report.

### Journal Articles

Material contained in this document as the result of the CA literature search is helpful especially in the area of special topics, most not addressed in available compiled form.

### The Internet

The true utility of most of these internet sites to the informed demonstrator or instructor is debatable. Every demo listed in the newsgroup FAQ, presented in a chemical demonstrations web site, and noted in the newsgroup postings is available in authoritative form in one of the aforementioned publications with appropriate safety and disposal information. A new twist on an old trick involving cycling saturated sodium chloride solution containing cobalt(II) chloride through a condenser from a distillation to illustrate that aspect of the distillation system was found to be worthwhile reading, but time invested in reading the postings to the newsgroup is ill-spent for this subject matter. It simply not an efficient way to convey the information and there is a very real danger in receiving this type of information from what are in reality unknown and possibly ill-advised sources. It is my intention to incorporate this information in the Virginia Tech chemistry department home page. There it will serve to screen and review chemical demonstrations offerings on the internet and to indicate their value to the chemistry teacher, at all levels of instruction. It will be continually updated with new sources of information and reviews of available sources. The page will expand to include science demonstrations available on videotape, videodisc, CDRom, and television.

**Further Work**

This listing of resources is valuable in that it can improve instruction and therefore improve learning. But what can be done to even further insure that my efforts improve learning or improve the ability of *the student* to further their knowledge of chemistry through chemical demonstrations? The intention of further work on this project will be to produce a CDRom of chemical demonstrations to parallel a chemistry text currently in use and to ascertain its value in improving learning at the general chemistry level. Efforts on this front have been made with videodisc technology.[13] This sort of technology may some day be workable on the web, but at the present time the numbers of interested parties who simply don't have access to the technology available and the limited bandwidth of the internet make this use unacceptable.

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## VI. RESUME

**Jeannine Stelmach Eddleton**

I. ADDRESS:

Business: Chemistry Department
Virginia Tech
Blacksburg, VA 24061-0212
(540)231-8228

Home: 1425 Cambria Street NE
Christiansburg, VA 24073
(540)382-6848

II. PERSONAL DATA:

| | |
|---|---|
| Born: | November 21, 1964, Baltimore, MD |
| Married: | Craig Douglas Eddleton |
| Children: | Andrew Christopher Eddleton (3/19/92) |
| | Margaret Alice Eddleton (9/10/95) |

III. EDUCATION:

| | |
|---|---|
| 1986 | B.S. Chemistry, Virginia Tech, Blacksburg, VA |
| 1991, 1995 | Virginia State Teacher Certification, Radford University, Radford, VA |
| 1996 | M.S. Chemistry, Virginia Tech, Blacksburg, VA |

IV. POSITIONS HELD:

9/84-12/84 Physical Science Aide, U.S. Department of the Interior, Patuxent Wildlife Research Center, Laurel, MD
Prepared biological samples for pesticide residue analysis.

1/85-8/86 Stockroom Assistant, Chemistry Department, Virginia Tech, Blacksburg, VA
Dispensed chemicals and apparatus, received inventory, removed chemical waste from research labs, duties as assigned.

8/86-8/89 Laboratory Specialist A/Lecture Demonstrator, Chemistry Department, Virginia Tech, Blacksburg, VA
Prepared and tested lecture demonstrations, provided administrative assistance as required by general chemistry faculty.

3/88-6/88 Chemistry Teacher, Cave Spring High School, Roanoke, VA
Taught five, junior level chemistry sections.

8/89-8/91 Chemistry Teacher, Northside High School, Roanoke,VA
Five junior and senior level advanced and general chemistry and physical science classes, introduced an environmental component to the science curriculum, organized an environmental club, science chairman of the ten-year self study,served on science fair, recycling, guidance, and honor society committees.

8/91- Instructor, Chemistry Department,Virginia Tech, Blacksburg, VA
Provide general administrative assistance to the Director of General Chemistry, prepare, set up, and present lecture demonstrations, present chemistry programs to classrooms and civic organizations, serve as a chemical activities resource for science teachers, conduct tours and present chemistry programs to visiting school groups, consult with Virginia Tech education majors.