A METHOD OF TEACHING CHEMISTRY

By

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PREFACE

I gratefully acknowledge the assistance of many professional educators in the preparation of this report.

Especially do I thank Dr. H. P. Johnston, Dr. James Zant, and Dr. Kenneth Crook. They have helped me immensely in developing a philosophy of teaching, and in techniques and procedures so vital to teaching.

Special thanks to my wife, Dorothy, for assistance in typing the report.

I am grateful to the National Science Foundation for giving me this opportunity to better prepare myself for teaching.

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CHAPTER I

INTRODUCTION

The writer of this paper has for eleven years taught in a small high school. In this situation the teacher if often faced with critical shortages of materials with which to work. After struggling along for these numbers of years, it became apparent that some method had to be devised in order to do justice to the students in science.

Another reason for writing this paper was that the writer realized his weakest field of preparation was in chemistry. Devoting the time to devise a method whereby one might teach chemistry under conditions far from ideal, and yet giving the student a good background for college work, seemed to be a worthwhile effort.

A statement made by George Rawlins and Alden Struble seemed to make it imperative for every school to offer chemistry. They said: "Because the products, methods, and objectives of chemistry have such a large influence on our daily lives, it would seem that no educated person could be considered truly educated without some knowledge of the subject." [1] We have only to look around us in our everyday life to have these facts driven home to us.

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[1] George Rawlins and Alden Struble, Chemistry in Action (Boston. 1956) p. v.

It seems that many students have been short changed in the educational set up of our modern day schools. There has been a general disregard for chemistry, because many feel that the cost is too great for the good obtained. There seems to be no department of our public schools that has all the money needed for operation. The sciences, especially chemistry, often bear the brunt of neglect. This teacher is attempting to off-set the feeling of not being needed by pointing out the values received from chemistry. A statement by Robert Carleton in Chemistry for the New Age, emphasizes the point. He said: "The first purpose of chemistry in high school is to contribute generously and effectively to the general education of all students enrolled."[2]

Much of the science teachers' woes have been due to the teachers themselves. James Harlow brought out some very pertinent thoughts about this in an article written in Science Education. He said: "High school science teachers have been inadequately trained to teach science. If the training of the teacher had been adequate, more students would be enrolled in science classes."[3]

Most teachers realize their shortcomings and work hard to overcome them. Consider the response to the National Science Foundation's program to improve the teachers of

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[2]Robert Carleton and Floyd F. Carpenter, Chemistry for the New Age (Chicago, 1949) p. iii

[3]James G. Harlow "The Secondary Science Problem", Science Education 41:114, March, 1957.

science. Teachers are literally swamping the institutions where these opportunities are being offered. This shows a great desire to do a better job on the part of the individual teachers of science.

One big question in the small high school is: Can I do the job with the limited resources which are available? Many people feel that a gifted teacher can perform a very excellent job by using originality, ingenuity, and personality. These may at a glance seem to be a poor substitute for a well equipped laboratory. Actually there have been outstanding jobs of teaching with very little more than these basic tools. Fredrich Dutton said: "Teachers of chemistry should keep in mind that truly effective teachers seldom, if ever, were born that way.[4]

One professor of chemistry said that the greatest wrong being done today in high school chemistry, is the substitution of demonstrations for general laboratory chemistry. This struck a tender spot for such a course had just been completed by this writer. The administration had been of the opinion that chemistry by demonstration was better than no chemistry. The class had been taught and was enthusiastic at the opportunity to take chemistry. Could this have been so wrong?

This particular class had five students taking the freshman chemistry test at a large university. The highest score made by a member of the class was in the 99 percentile. The

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[4]Fredrick B. Dutton "Editors Outlook", Journal of Chemical Education 34:365, August, 1958.

Oklahoma State University, a number of years ago, tried a similar approach at the college level. There seemed to be no published data as to the effectiveness of this method. Dr. Authur of the staff at Oklahoma State recalled this particular experiment in education. He felt that there was not a significant difference in the knowledge of fundamental chemistry between the two groups. The big difference was observed in the manipulation of laboratory equipment. The members of the demonstration class were not as proficient in the laboratory as those who had laboratory experience.

These two cases do not a revolution make. It would seem, however, there is room for investigation of this method of teaching. It would also seem that if the teacher used the students to actually perform the demonstrations that one might be able to overcome the lack of proficiency in laboratory procedures.

It seems that a teacher must look ahead to possible situations in the future. Studying this year made a project of reading and studying research reports a worthwhile endeavor. This will enable a teacher to do an acceptable job in teaching chemistry either with a laboratory or by the demonstration method.

CHAPTER II

OBJECTIVES OF THE COURSE

The study of chemistry can be a fascinating part of our educational system. It can be a frustrating as well as a rewarding area of study. These aspects of chemistry make it an area of promise and challenge for the teacher. One of the primary concerns of any teacher is the motivation of the pupil. The nature and challenge of a high school chemistry course provide the ideal situation in this respect.

In this report it is hoped that teachers may find an expression of philosophy and pedagogy that will help in the organization and development of the high school class.

The teacher of chemistry seeks to set forth an orderly array of facts that can be interpreted and used by the student throughout his life. The task is made more difficult by the fact that chemistry in the high school has been a broad area of study. Fredrick Dutton in an editorial said: "In the study of chemistry, facts can never be looked upon other than as statements of the present status of our knowledge".[5] This very clearly suggests to the teacher that there must be a considerable flexibility in the material presented to the student.

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[5]Fredrick B. Dutton, "Editors Outlook", _Journal of Chemical Education_, 34:2, January 1957

One of the big problems teachers have is in keeping up with the current advances in the teaching of science. Teachers must keep up with current advances in his field.[6] This means that a professional attitude must be developed toward the field in which he works. A professional attitude will encourage the teacher to keep up with changes in the field. The training of teachers for high school science has often been inadequate to the point where they develop no such professianal attitude. This may be seen in the general lack of interest in the fields of science before the advent of Sputnik I.[7] The chief area for retraining must be in the development of a professional attitude on the part of the teacher.

The chemistry teachers of Wisconsin through questionaires to the members of their organization have reached several conclusions that are especially meaningful today. Among the conclusions reached are the following:[8]

1. Teachers of chemistry should carefully examine the subject matter of their courses, and it should be kept up to date.

2. The teacher must continue to update his knowledge of chemistry in order to keep the course material up to date.

3. Qualitative rather than quantitative teaching is the most important single factor.

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[6]James G. Harlow, "The Secondary Science Problem", Science Education, 41:114, March, 1957

[7]Ibid.

[8]"High School Chemistry--Keeping the Course up to Date", The Science Teacher, 23:407-8, December, 1956

Many teachers have the common fault of trying to make the study of chemistry a "facts only" type of course. Good chemistry teaching extends beyond this. There is no cut and dried approach to the manner of presentation in high school classes. The yearbook of the National Society for the Study of Education expressed this thought in a very meaningful manner. The Quote: "Since the facts, concepts, and principles which we emphasize in our teaching, are only the raw materials needed for carrying on the intellectual processes which govern behavior, we should recognize the incompleteness of teaching methods which place almost exclusive emphasis upon memorization and recall.[9]

There is a wide area of disagreement among the teachers of chemistry, as to the purpose of teaching this subject in high school. Some feel that it is taught simply to provide a factual background to enable a student to get through the first year of college chemistry. While the teacher may feel that this is the primary purpose, many of them agree that much factual information is forgotten before the student gets to the place where he needs it. Then too, there is the idea among teachers that the first year college chemistry is a repetition of a good high school course.

Other teachers felt that high schools should teach chemistry because of future applications of the principles to the life of the student. In the high school, the teacher deals with individuals who will go into many divergent walks of life.

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[9] Yearbook for the National Society for the Study of Education, Volume 46, Part I, page 202

It will be extremely difficult to provide for all their needs with the one course in high school chemistry.

There is a feeling among many teachers that chemistry should be taught for its present applications. All teachers realize that to be really effective in their work, they have to present material that is interesting to the student. Students today are mostly interested in the very real present, not the obscure and distant future. What happens to a student in school is of vital importance to him, and it is over this part of his enviornment that the teacher has some measure of control. In teaching chemistry, we can have a hand in deciding with the student what things are of present importance to him; and hence, what course he may follow in the future.

In a careful consideration of the foregoing statements, it becomes possible to set up through a series of objectives a philosophy of teaching high school chemistry. There are at least three major objectives suggested. They are:

1. Solution of the students immediate problems, arising from the study of chemistry, which are related to and capable of solution by chemical methods and processes.

2. Development of insightful learning situations which can be transferred to situations in the present and in the future.

3. Learning that can induce and bring about future learning.

The major objectives listed are perhaps not as complete as could be expressed. They do, however, suggest a base upon which the teacher can set up specific objectives for the course This helps one to narrow the scope of the course to meet the needs of his class. Among the specific objectives in high scho chemistry, the teacher should include the following:

1. The student should develop an understanding of the basic concepts of chemistry. He should be given ample opportunities to apply these concepts.

2. The student should learn the techniques and learn proficiency in the use of the techniques of laboratory work which includes the following:

    (a) Identification and correct usage of apparatus.
    (b) Assembling apparatus for producing reactions and collecting the products.
    (c) Using balances correctly.
    (d) Adapting apparatus for experiments as needed.
    (e) Using the proper methods of handling chemicals.
    (f) Instruction in and observation of safety precautions.

The major objective calling for the development of insightful learning implies that the student should have many related experiences concerning each principle and concept. The student may be led from the experiences he has and to the discovery of the fundamental principle involved. The teacher must exercise care to keep from reaching conclusions for the students. The teacher should emphasize methods of approach to the problem rather than the solution. Teachers should encourag students to pursue problems which arise in each ones personal environment when it is feasible to do so.

In trying to facilitate future learning we should endeaver to give the student progressively more and more responsibility for directing his own efforts. This should allow him freedom to choose problems, and points of interest, carrying out his own investigations, and reaching the correct conclusior Every student should become proficient in certain areas of investigation. These are:

1. Identification of problem areas.
2. Clarification of the problem.
3. Location of pertinient information.
4. Observation of, and collecting of data.

5. Discrimination of data collected
6. Interpretation of this data.
7. Stating hypotheses.
8. Devising apparatus to carry out experiments.
9. Setting up experiments to test hypotheses.
10. Learning to generalize and reaching conclusions from experimental data.
11. Application of conclusions to new situation.

A good teacher will realize that the major, general and specific objectives do not provide in themselves for learning of large masses of descriptive materials and facts in an isolated manner. The student must of necessity learn the facts and descriptive material required to reach these objectives.

CHAPTER III

CONTENT OF THE COURSE

In a recent survey it was revealed that chemistry courses in high school varied widely the country over. The course content, order of introduction, and manner of presentation are very different in the various areas of our country. The teacher is forced to evaluate the courses he teaches; and, from his evaluation, devise a scheme that will enable him to reach the objectives set forth.

Bernard Faffee reported in 1953 that the trend was toward less coverage in favor of modern discoveries. A core of material, however, still remained in the high school classes.[10] This core included the following fundamentals.

1. Atomic structure
2. Bonding and Valence
3. Symbolism and equations
4. Oxidation and reduction
5. Solutions and related Phenomena
6. Ioniaztion and related phenomena
7. Equilibrium and rates of reaction
8. Gas behavior and gas laws
9. Periodism and the periodic table
10. Catalysis
11. Neutralization
12. Reactions among acids, bases, and salts

To the educator, experienced in the field, these will appear to be a logical order in the presentation of these

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[10] Bernard Jaffee, New World of Chemistry, New York: Silver Burdett Company, 1952.

fundamentals of chemistry. A students success is gaining a degree of proficiency in chemistry will in part depend upon the ability to present material in a logical order. Course content and logical order are hand in hand to the successful teacher.

The teacher often receives students that are not prepared for the study of chemistry. This is an age old problem of the college teacher, high school teacher, and grade teachers. Each seeks to shift the blame on the other instead of trying to do something about the situation.

The usual student enters high school chemistry with an inadequate concept of the metric system. This problem becomes apparent immediately. A suggestion to remedy this was made by Dr. H. P. Johnston, Professor of Chemistry, Oklahoma State University. He suggested that a sheet containing the material needed be passed out to each student with exercises to develop skill in handling these units. Such a table is presented in Table I of this report. The student may use the table to perform the required exercises and to familiarize himself with this system of weights and measures.

In order to become proficient in the study of chemistry or any subject, one must be able to locate pertinient information. An exercise to help the student locate material should be given early in the course. There are many ways to accomplish this and, Table II is offered as an example of an exercise designed to familiarize a student with the various aids available to him. The proper use of such an exercise will enable a teacher to make the class aware of the textbook, the library,

TABLE I

FOR USE IN EXERCISES ON THE METRIC SYSTEM

	1000 Dollars	1 Dollar	1 Dime	1 Cent	1 Mill
Prefix	Kilo 1000x		Deci 1/10, 0.1	Centi 1/100, 0.01	Milli 1/1000, 0.001
Linear	Kilometer	Meter (39.37 in.)	Decimeter	Centimeter	Millimeter
Abbreviation	km.	m.	dm.	cm.	mm.
Volume	Kiloliter	Liter (1.057 qts.)	Deciliter	Centiliter	Milliliter
Abbreviation	kl.	l.	dl.	cl.	ml. or cc.
Mass or Weight	Kilogram	Gram (453.6g = 1 lb.)	Decigram	Centigram	Milligram
Abbreviation	kg.	g.	dg.	cg.	mg.

This table can be used as a base for many exercises in metric system work. A sample exercise is submitted on the following page.

PROBLEMS, RELATING TO THE METRIC SYSTEM, TO BE SOLVED

1. Convert each of the linear measurements of the metric system to inches; to feet.

2. Convert each of the volume measures of the metric system to quarts; to gallons.

3. Convert the mass or weight units of the metric system to pounds.

4. Using the metric system measure the perimeter of this class room.

5. What volume would this room hold? express the answer in metric system units.

6. Express your weight as kilograms. How many centigrams would this be?

7. Podunk is twelve miles from _____. Express this as km, m dm, cm, and mm.

8. Using the metric system find the surface area of your text book. The volume. The weight.

9. Light travels 186,000 mi/sec. Convert this to km; to cm.

10. How many milliliters of gasoline will your car hold?

TABLE II

EXERCISE ON LOCATING INFORMATION NAME____________________

READ CAREFULLY:

This exercise is designed to help you gain experience in locating information. You may use your text, periodicals, "The Handbook of Chemistry" or any reliable source. Carefully note the page number, and be certain that the information called for has been supplied.

TITLE	PAGE	INFORMATION
1 Treatment for arsenic poisoning		
2 Removal of ink stain		
3 Definition of anion		
4 Atomic weight of barium in 1894		
5 Borax bead test for lead		
6 Flame test for lead		
7 How to store white phosphorous		
8 Composition of de-natured alcohol		
9 Melting point of helium		
10 Synonym for Jasper (mineral)		
11 Solubility of Calcium hydroxide		
12 Organic solvent with highest boiling point.		

The periodicals available, and the Handbook of Chemistry. One of the most essential things for high school students is a source of available material, and an ability to locate it. The method of approach to the teaching of chemistry is a big problem. Every teacher has variations peculiar to himself. These are due in part to the qualifications one possesses, the philosophy one has, and the objectives set up for the course. The objectives outlined earlier in this report suggests an organization of content for the course. This will determine to a great extent the manner of presentation.

To begin the presentation of a course one must, of necessity, define the subject. Chemistry deals with matter and energy and the changes that take place between them.

Using a simple definition such as the one proposed, one can immediatly see the opening presented for launching a study of chemistry. Since chemistry is concerned with the study of matter, we need to know a great deal about matter. Among the things to know are:

I. What is matter?

   A. The states of matter
   B. The particle concept of matter
      1. Particles--atoms, molecules, electrons, neutrons, protons

II. Compounds--two or more elements made a compound

   A. Mixtures
   B. Law of definite proportions
   C. Molecules
      1. Difference in the states of matter--Particle distance, energy involved, kinds of energy, absolute zero, and the fact that energy cannot be used unless associated with matter.

III. Atomic structure.
- A Nucleus--orbital electrons, valence
- B. Write simple reactions--first by word equations and then by symbols. Using elements that combine in a one to one ration.
- C. Stress the learning of valences, writing of formulas, and nomenclature of compounds.
  1. The types of compounds--
     - a. Oxides
     - b. Acids
     - c. Bases
     - d. Salts
     - e. Hydrides
- D. The types of Bonding
  1. Covalent
  2. Ionic
  3. Coordinate covalent
- E. Work out percentage of composition; work yield problems

IV. Study of gases
- A. The kinetic theory of gases
- B. The gas laws--perfect gases etc.
- C. Problems dealing with gas laws

V. Theories of solutions.
- A. Ionization
- B. Equilibria in solutions
  1. Effects of temperature, pressure, and catalysis
  2. Common ion effect
  3. Complex ions
- C. Problems in equilibrium reactions
- D. Acids and bases with theories of each
- E. Titrations to neutralize acids and bases.

VI. Study of the various families of elements.
- A. Industrial processes involved in the different groups.
- B. The meaning of the processes to the ordinary person.

VII. Organic compounds.
- A. Hydrocarbon substitutions products.
- B. Foods, vitamins, and medicine
- C. Textiles and paper
- D. Rubber and plastics
- E. Chemistry in Agriculture
- F. Problems in organic chemistry

VIII. Nuclear Fission.
- A. Radioactivity
- B. Nuclear Energy

Presentation of material in the foregoing order will enable one to build from one unit to the next. There will be many capable of progressing at a faster pace then others. This eventuality can be provided for by deepening the area of investigation for those of greater capabilities. Every student must be provided for, and he must have the chance to express his individual abilities as far as the schedule will permit.

The need for adequate instruction in the techniques of laboratory work is evident. The principles involved should be thoroughly taught to the student in laboratory. Perhaps they should be stressed even more in the demonstration type course.

CHAPTER IV

THE LABORATORY

Most people agree that it is best for every student to have laboratory experience for himself. The ideal situation is to have adequate facilities for the individual student. As was pointed out, the actual conditions are far from this. Perhaps the greatest discrepancy in the student's high school preparation for chemistry is in the area of the laboratory. He is often shorted on the fundamentals of good laboratory techniques and procedures.

Every student, whether in laboratory or in demonstration courses, should be taught the essentials of good laboratory practices. These will include proper handling of chemicals, safety precautions, accuracy of observations, and careful notation of results.

Before entering into the laboratory to begin work, every student should be instructed in safety precautions. He should be furnished with a copy of the rules of the laboratory and the safety precautions kept in his desk. . A good practice is to mimeograph a set of safety rules on half sheets. This may be done by folding ordinary mimeograph paper to form sheets eight and one half by five and one half inches. After the mimeograph ing, it should be bound in a manual, brightly colored, and issued to each student. The student should be responsible for the care and safe keeping of the manual. Usually a short question and answer session will be conducted on each section of the manual. This will impress upon the class the necessity of knowing what to do and how to do it.

One form of safety manual is suggested here.

SAFETY IN THE CHEMISTRY LABORATORY

Podunk High School

Podunk, Oklahoma

Many accidents can occur in the chemistry laboratory. Every student should be aware of the potential dangers, and he should know, both how to avoid accidents, and what to do if they occur. This manual suggests some rules of good conduct in the laboratory; warns of some specific dangers; and gives an outline of some first aid measures that every student in chemistry laboratory should know.

I. WHAT YOU DON'T KNOW CAN HURT YOU.

Students in the chemistry class are given instructions in proper methods of laboratory procedure and then permitted to work in the laboratory. The laboratory progresses from specific dittoed sheets, to co-operatively prepared directions, to individual investigations. Each student should be well prepared in laboratory techniques by the time he is on his own.

Non-chemistry students have not had such preparation and are not likely to be proficient in the laboratory. Even the experienced student may become confused and forget some detail if he is trying to engage in conversation as he works. One rule of the laboratory: No unauthorized person is permitte to be in chemistry laboratory. Authorization is by laboratory ticket. Any student must have one if he is to be allowed in the laboratory at any time besides the regular chemistry class hour.

There is a stock room for chemicals adjacent to the laboratory. Chemicals are moved from this room to the laboratory as they are needed for experiments, and then returned to the shelves. Our stock is fairly complete and varied, and we must take precautions to both keep it from becoming contaminated and to keep dangerous chemicals out of the laboratory. A second rule is: The only persons who may take chemicals from the stock room are the laboratory assistants.

Because of crowded conditions during laboratory sessions, stock bottles should be filled only in the stock room.

II. WE CAN'T ALL BE CHIEFS: THERE MUST BE A FEW INDIANS.

No matter what the source of the laboratory directions, the student performing the experiment ought to follow directions as closely as possible, and not improvise without asking the teacher as to the safety of the new procedure. Rule: Follow directions. Don't improvise after a set of directions have been decided upon. Do improvise plans for an experiment before deciding upon a final plan. Get these approved by the instructor.

In order to reduce breakage and resultant danger of cuts and punctures we have the rule: Keep all glassware out of reach of the instructors elbows.

III. JUST BECAUSE SOMETHING LOOKS HARMLESS---

A ring stand may be hot enough to burn the skin long after it looks cool.

A piece of glass tubing which you have just bent may look cool.

Add H_2SO_4 to water, never vise versa.

Dissolve NaOH in water in a pyrex container. It gives off a lot of heat.

The cans atop the reagent shelves are proper containers for matches, waste chemicals, used filter papers, and broken glass. They are not for waste paper. The waste paper cans are not for other wastes.

Never heat the bottom of a test tube. The vapors may drive the material above them out with a dangerous force.

Remove the delivery tube of a gas generator from the water before removing the heat. This will prevent water from being sucked back into the hot generator.

Take great care when inserting glass tubing, thistle tubes or funnels into a cork or rubber stopper. If they break, you can get a dangerous puncture wound.

Check gas generators and their connections for any constriction to avoid a pressure explosion.

Never light hydrogen in anything but an open test tube or bottle.

If experiments yield irritating odors such as SO_2, HCl vapor, Cl_2, NH_3 or H_2S, use a fume hood.

If the experiment results in inflammable vapors such as H_2, CS_2, ether, or alcohol, be sure that no flames are in the vicinity. If heat is necessary, use an electric heater.

If an experiment may result in a splattering of chemicals or an explosion, wear goggles, or use a protective shield.

If a reaction requiring ignition fails to proceed, wait before checking; it may begin while you are examining it.

A jagged edge of glass may not look sharp enough to cut deeply.

A colorless chemical may not look poisonous.

Hydrogen doesn't look explosive.

Test objects before touching them. Never taste a chemical Smell odors by carefully wafting toward the nose with the hand. Fire polish all glass edges that have been broken. Never heat a cracked beaker or test tube. If you want to save them, use them for temporary storage of solutions; not for heating or mixing materials.

IV. READ LABELS

It is easy to look at a bottle of KCN and think it is KCNS if you don't read carefully. The labels on stock bottles will not only warn you of poisonous and corrosive materials, but will also tell how to avoid danger and what to do in case of an accident.

If the label says poisonous, handle the chemical accordingly.

Be sure the bottle contains the chemical you want. (Double check your directions with the label)

Phosphorous is kept under water. The label will indicate that it must be cut under water to avoid igniting by friction.

Potassium, sodium, lithium or calcium carbide produce dangerous reactions with water. Rule: Li, Na, K are kept under kerosene. CaC_2 is kept in a dry container.

V. IF YOU SEE SOMEONE DOING SOMETHING POTENTIALLY DANGEROUS IN THE LABORATORY, <u>TELL</u> <u>HIM</u> -- OR ME.

VI. IN CASE OF FIRE.

The fire extinguishers in the laboratory are of the carbon dioxide snow type. They are suitable for any type fire in the laboratory. To use them, merely pull the pin and press the trigger.

Water from the faucets is suitable for fires <u>not</u> involving sodium, potassium, lithium, calcium, or calcium carbide, or oils that will float on water. <u>Never</u> use water on fires of electrical nature.

Useful for smothering small fires, expecially when a person's clothing is involved, is the blanket stored in the cabinet by the stock room.

The fire department is called by dialing Gr 6-3434.

VII. IT IS WHAT YOU DO WITH WHAT YOU HAVE.

There is a first aid cabinet on the east wall of the laboratory. If an accident does occur, many things can be done to lessen the injury or danger before calling the doctor.

<u>Cuts</u>: Clean them out; stop bleeding; apply merthiolate; and wrap. If it is a large cut, apply the usual first aid measures and call the doctor.

<u>Burns</u>: Cool with a gentle stream of water. Apply a soothing ointment. Do not wrap.

<u>Overcome by gas</u>: Get to fresh air, apply first aid measures.

Acid on skin: Wash immediately by flooding with water. Apply a paste of $NaHCO_3$. (Baking Soda)

Base on skin: Wash immediately by flooding with water. Apply vinegar.

Acid or base in the eyes: Wash immediately with plenty of water. (Use fountain at the hall door) Go immediately to the doctor.

Foreign object in the eye: Do not attempt to remove. Pad eye to avoid movement as much as possible. Go immediately to the doctor.

VIII. IF IN DOUBT, DON'T.

Don't proceed, that is, without first checking with the instructor and taking the proper precautions.

DETAILS OF SELECTED LABORATORY STORAGE TECHNIQUES

LITHIUM, SODIUM, POTASSIUM AND CALCIUM:

These four metals will react with water to form hydrogen. The first three will produce enough heat to ignite the hydrogen formed. They oxidize rapidly in air. For these reasons they should be stored under kerosene or mineral oil. It is best to use metal jacketed containers. Because of their ease of reaction and because of the corrosive nature of their hydroxides, they are never handled with the bare hand. Use tongs or tweezers. If the action of these metals are to be demonstrated use only small pieces, about the size of a pea, and react them only in an open container.

WHITE PHOSPHOROUS:

This material burns readily in air. It is very dangerour to human beings. Actually it should not be kept in the high school laboratory. Exercise extreme caution if you are using it. Do not touch with the hands. Handle it only with tongs or tweezers.

MERCURY AND ITS COMPOUNDS:

Mercury and its salts are poisonous when taken internally or inhaled. Care should be exercized in heating mercuric oxide to prevent mercury vapor being formed. Eggwhite is given as an antidote for mercury if swallowed. It is safe to handle mercury in the laboratory when necessary. Thoroughly clean the hands after using it.

ARSENIC AND ITS COMPOUNDS:

Arsenic and its compounds are poisonous when taken internally. A number of the compounds are used as insecticides, weed killers, and bactericides. Arsenic trioxide is sometimes kept in the stock room. It is quite dangerous because it sublimes. Keep it only in sealed containers.

FLUORIDES:

Hydrogen fluoride is used to etch glass. It is also corrosive to other silicon compounds. The acid is kept in the chemistry laboratory in wax or plastic containers. It is volatile and should be kept under seal. Contact of this acid with the skin produces sores that are slow to heal. The salts of fluorine are not too dangerous. Keep them from contact with acid solutions to prevent HF from being formed.

BROMINE:

Liquid bromine is stored in sealed containers. It is very volatile and quite corrosive to the skin and internal organs. Great care should be taken when liquid bromine is used, not to spill it or inhale the vapors. Never handle the containers without rubber gloves. Open the container only under the hood. The vapors are irritating to the mucous lining of the nose and throat, and to the eyes.

CHLORINE

Chlorine is not stored but is often used in the high school laboratory. It is a greenish colored heavy gas and poisonous if breathed or concentrated on the skin. its presence is easily recognized because of the acrid, irritating odor. When used the concentration should be kept down by using the hood. Chlorine may be used safely by using only small amounts.

CYANIDES:

Potassium and sodium cyanides have little use in the high school laboratory. They are used for insect killing and certain tests in qualitative analysis. The greatest danger from these compounds is from HCN. This is a deadly gas. Cyanides should never be allowed to come in contact with an acid.

ACIDS:

All of the strong acids and glacial acetic acid are corro sive and must be handled accordingly. HCl produces strong fumes which are corrosive. HNO_3 produces nitrogen dioxide which is irritating, and H_2SO_4 splatters dangerously when water is added to it. If any of these acids is spilled on the skin, it should be washed off immediately with water and a neutralizer such as becarbonate of soda added to the spot.

HYDROGEN SULFIDE:

H_2S is a poisonous gas commonly produced in the laboratory. Its offensive odor makes it difficult to stay in an area of dangerous concentration. It should be produced in small quanities only.

BASES:

The strong bases KOH and NaOH and the moderately strong base NH_4OH are corrosive. Like the strong acids, they should be washed off immediately. KOH and NaOH should not be handled with the bare hands since they absorb water and attact the skin. They should be handled with a porcelain spoon or a suitable glass tool. The bottles in which they are stored should be kept tightly sealed since moisture causes them to harden into a solid mass.

POTASSIUM CHLORATE, MANGANESE DIOXIDE, AND POTASSIUM NITRATE:

Both potassium chlorate and potassium nitrate can be used to make explosives. They can be dangerous when proper caution is not exercised.

$KClO_3$ and MnO_2 are used to prepare oxygen. In the generator these substances are heated to the melting point. If any impurities are present, there is danger of an explosion. Care should be taken to keep these chemicals free from impurities.

PEROXIDES:

the peroxides of metals are good oxidizing agents and should be handled with care. H_2O_2 is kept in brown bottles because it decomposes upon exposure to light. If it is in a clear bottle O_2 pressure may build up and explode the bottle.

Sodium peroxide liberates enough heat when water contacts it to start a fire in combustible materials. It should not be kept where it might be spilled on the floor or in the waste baskets. It should be disposed of carefully when necessary by adding water to it on a non-inflamable surface.

PHENOLS:

Carbolic acid is very corrosive to the skin, forming blisters almost immediately upon contact. Students should be cautioned about touching it. But if it is spilled on the skin, wash it off with plenty of water and then bathe the spot with alcohol or a very dilute solution of bromine.

OTHER ORGANIC COMPOUNDS:

Ether and chloroform obviously should be kept in sealed containers and used only under the hood. Benzene and other flamable and volatile organic compounds should be kept from open flames. If heat must be used in the vicinity of these compounds it should come from an electric heater. The fumes of benzene and carbon tetrachloride are poisonous if breathed over a prolonged period. Care should be taken to remove these fumes from the laboratory as quickly as possible.

Any fulminates or azides in the laboratory should be handled as explosives. They are used as detonators for dynamite.

CHAPTER V

IF YOU HAVE NO CHEMISTRY LABORATORY

This report has been based primarily upon the assumption that adequate laboratory facillities will be available. However, it was pointed out that many times this is not the case.

While a student should have a well equipped laboratory at his disposal in order to get the full benefits of chemistry, there are many things one can do that will bridge the gap. One need not sit back and wait for the school to build and equip a laboratory in order to teach chemistry.

Teaching kits are available at a nominal cost from any good scientific supply house. They may be used in a variety of ways to provide individual laboratory experience, plus the opportunity to watch teacher demonstration.

Kits may be constructed to supply equipment for set ups of one to four students. These setups may be used to provide experience for the whole class. Usually a group of students are assigned definite experiments to perform. The others of the class watch and record observed data. They are encouraged to be critical of procedures and techniques used by the other students. This is a good way to teach techniques. It enables a teacher with poor equipment to stretch it a long way.

One of the best kits that a teacher may build is one described by Paul Westmeyer.[11] Such a kit has been used to teach a class of twenty-four students. The room had only one sink and one gas outlet. One advantage of the kit was that it took up a comparatively small amount of space and provided real laboratory experience for the class. Such a kit is suggested on this and the following pages.

MATERIALS NECESSARY FOR THE KIT:

Metal pans are needed for washing equipment. These should be porcelain or aluminum. A bunsen burner or alcohol burner, tripod, six inch squares of wire gauze, test tube holders, burette clamps, triangular files, and test tube brushes.

Also needed is one balance, preferably a triple beam type of small size, at least one D.C. voltmeter, a DC ammeter, electric switch, copper wire, and a 6-volt battery.

Glassware needed: four each of porcelain spoons, 250 ml Erlemeyer flasks, thistle tubes, thermometers (-10 to 110° C), nests of beakers (250, 150, and 50 ml), funnels, watch glasses, medicine droppers, 10 ml graduated cylinders. Also needed are about 40 test tubes (10 x 80 mm) and twenty square bottles wi· dropper tops (four ounce size).

Miscellaneous items required include four boxes of filter paper, matches, a set of pH paper, assorted stoppers, rubber tubing, glass tubing, and glass rods and soap and towels.

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[11] Paul Westmeyer, Successful Devices in Teaching Chemistry J. Weston Walch, Publisher, Portland Maine, 1959.

THE FOLLOWING CHEMICALS ARE REQUIRED:

Concentrated acids (sulfuric, nitric, hydrochloric, and acetic), ammonium hydroxide, methanol, ethanol, and distilled water may be kept in quart bottles.

Glycerin, benzene, pentanol, acetone, carbon tetrachloride Carbon disulfide, and hydrogen peroxide may be kept in four ounce bottles.

Solids kept in one pound containers are potassium chlorate sodium carbonate, potassium nitrate, mossy zinc, potassium hydroxide, and sodium hydroxide. In addition you will need table salt and sucrose which can be purchased as needed.

Solids kept in small vials are aluminum powder, aluminum chloride, ammonium chloride, ammonium sulfate, antimony metal, antimony chloride, barium chloride, barium hydroxide, barium nitrate, busmuth metal, busmuth nitrate, cadmium nitrate, calcium carbide, calcium phosphate, calcium oxide, chinchonine powder, copper grains, cuprous chloride, copper nitrate, copper sulfate, dextrose, dimethyl glyoxime, iron filings, ferric chloride, ferric nitrate, ferric oxide, ferrous fulfate, lead grains, lead nitrate, plumbus oxide, plumbic oxide, manganese dioside, mercury metal, mercuric nitrate, nickle chloride, nickle nitrate, phenol, phenolphthalein, potassium metal, potassium bronide, potassium chloride, potassium dichromate, potassium permanganate, potassium sulfide, potassium sulfate, rachelle salts, salicylic acid, silver nitrate, sodium metal, sodium chloride (C.P.), sodium bicarbonate, sodium iodide, sodium nitrate, sodium phosphate, sodium sulfide, sodium sulfat sulfur, tin metal, stannous chloride, stannic chloride, zinc chloride, zinc nitrate, zinc sulfide.

An inexpensive wooden box can be made to store this material. One such box is thirty-six inches long, sixteen inches wide, and 12 inches deep. All the materials above may be stored in such a box. There will be a space for each item, but it must be carefully arranged. It is best to divide the depth by construction of trays making a layer four inches deep over a layer eight inches deep. Locks should be provided to safeguard materials.

This type of laboratory setup has its drawbacks, but it ca: really help students to gain laboratory experience where none has been available. The instructor can go as deeply into the procedures and techniques as he desires. Students usually plan their experiments, because they realize the shortcomings o the laboratory kit. This is a real advantage, because they learn to think objectively.

CHAPTER VI

SUMMARY AND CONCLUSIONS

There is no doubt that chemistry should be taught as a laboratory course. It is evident that the best method of teaching chemistry involves the use of individual laboratory experiences, to round out the course. In all the literature available, the recommendations stress this fact. Most people are aware of the ideal situations.

It is also evident that much can be done to develop a course where adequate facilities are unavailable. In such a situation careful planning, ingenuity, and teacher inspiration are important. The professional teacher will not bemoan the fact that the laboratory is not fully equipped, but will strive harder to make the course worth-while.

The professional teacher will not try to build up his department at the expense of others, but will by the results of his teaching show justification for the expenditures necessary to develop adequate facilities. School patrons will support a worth-while endeavor to the limit of their financial ability.

Organization and course content seem to be even more important to the teacher in the small schools. Much care should be taken to carefully organize the class. Content should be vital and up to date. It should have meaning to the student, and should help him decide further areas of study.

Even with poor facilities, laboratory techniques may be taught by demonstrations. These should be so organized that each student gains a personal experience with as many types of laboratory equipment as possible. In this type course, laboratory safety and procedures for handling chemicals should be stressed.

Careful thought is necessary to obtain the supplies needed for the demonstration laboratory. The teacher can, at very little expense, produce an entirely satisfactory kit which will enable the class to work with all the areas of chemistry.

A well rounded high school program will include chemistry. We cannot consider high school education that excludes chemistry as being complete. It is a timely and important subject. It prepares one for terminal education or to go on with his educational experiences at institutions of higher learning. Care must be exercised to develop worth-while objectives for the high school course. Here, as in any subject area, the teacher is the determinant for the quality of the course.

BIBLIOGRAPHY

Ames, Maurice U., and Bernard Jaffee. Laboratory and Workbook Units.

Brownlee, Raymond B., Robert Fuller, and Jesse E. Whitsitt. Elements of Chemistry. Boston: Allyn and Bacon Inc., 1954.

Carlton, Robert H., and Floyd F. Carpenter. Chemistry for the New Age. Chicago: J. B. Lippencott Company. 1949.

Carlton, Robert H., John Woodburn, and Thaddeus H. Elder, Jr., Chemistry Activities. Chicago: J. B. Lippencott Co. 1954.

Cragg, L. H., and R. P. Graham. An Introduction to the Principles of Chemistry. New York: Rinehart and Company, 195

Dull, Charles E., William O. Brooks, and H. Clark Metcalfe. Modern Chemistry. New York: Henry Holt and Company, 1954

Dutton, Fredrick B. "Editor's Outlook", Journal of Chemical Education, 34:2 January 1957.

Dutton, Fredrick B. "Editor's Outlook", Journal of Chemical Education, 34:365, August, 1958.

Ferris, Everett M. and Oscar Lanford. Laboratory Manual for Using Chemistry. New York: McGraw-Hill Book Company Inc. 1956.

Harlow, James G. "The Secondary Science Problem", Science Education, 41:114, March, 1957.

High School Chemistry. "Keeping the Course up to Date". The Science Teacher, 23:407-8, December, 1956

Jaffee, Bernard, New World of Chemistry. New York: Silver Burdett Company, 1952.

Mack, Edward, Alfred Garrett, Joseph Haskins and Frank Verhoek. Textbook of Chemistry. New York: Ginn and Company, 1956

Ravlins, George M. and Alden H. Strubble. Chemistry in Action In the Laboratory. Boston: D. C. Heath and Company 1954.

Weaver, Elbert C. and Laurence S. Foster. Chemistry for Our Times. New York: McGraw Hill Book Company Inc., 1954.

Westmeyer, Paul. Successful Devices in Teaching Chemistry. J. Weston Walch, Publisher, Portland Maine, 1959.

Yearbook for the National Society for the Study of Education Volume 46, Part I, page 202.

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