AN ABSTRACT OF THE THESIS OF

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Title A Course of Study in Chemistry Which Meets Adolescent Needs

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This course of study has been developed for two major purposes: First, to organize a functional course in chemistry that meets the needs, interests, and capacities of students. Second, to be used as a guide, either in part or as a whole, for a course of study for Oregon secondary schools.

Great emphasis is placed on the fact that adolescents learn easier and with more thoroughness when chemistry is taught by the association of ideas from actual experience. This study recognizes the student as an individual, deals with his problems and issues of practical interest, and is so arranged as to help him grow in his powers of reflective thinking.

The course of study is set up on a unit basis with each unit built around one or more major chemical principles. The first seven units are concerned with the basic fundamentals that pupils need in order to understand and apply their chemical knowledge to the world in which they live.

The remainder of the course consists of a series of independent investigations and research conducted by the pupils. The methods employed in conducting this portion of the course are: the use of committees, individual projects, small group projects, reports, and student leadership. These methods tend to encourage the development of cooperativeness, self-assurance, intelligent self-direction, and wider personal interests.

Each unit consists of the following:

1. Suggestions to teachers.
2. Objectives of the unit.
3. Suggested approach.
4. Unit analysis.
5. Laboratory suggestions.
6. Evaluation of the unit.
7. Materials for the unit.

The unit analysis is written in such a manner that the subject content is in the left hand column and immediately opposite is the corresponding suggested activity. This method makes it very easy for a teacher to follow and use the course of study.

Many interest-getting devices have been used throughout the study, such as: stimulating approaches to each unit, thought-provoking problems, games, many demonstrations, and other instruments that have been proved by modern psychology to be effective teaching methods.

Throughout this course of study the student is encouraged to adventure actively on his own by recognizing and solving his problems and doing research. This means the pupil is living chemistry not just learning about chemistry.

In order to attain the most from this course several textbooks should be used rather than adhering to a single volume. At the end of each unit there is a list of reference books, including textbooks with page references. Suggested films and free and inexpensive materials are provided that will prove useful in supplying supporting data for each unit.

Students themselves have expressed a desire for a course in chemistry that will be practical and functional to them in their daily life situations. Chemistry is functional if it increases pupils' appreciation for the cultural aspects of the course; if it provides useful applications related to his personal, social, and community life; if it enables him to acquire techniques which are useful to him; and finally, if it provides useful work experience. This course of study endeavors to satisfy the students' needs by being functional.

A COURSE OF STUDY IN CHEMISTRY WHICH MEETS
ADOLESCENT NEEDS

by

ALONZO BERT COLBURN

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A COURSE OF STUDY IN CHEMISTRY WHICH MEETS ADOLESCENT NEEDS

CHAPTER I

INTRODUCTION

The current trend of teaching chemistry is turning from the traditional memorization of subject matter to the more logical understanding and use of the major generalizations and principles in the subject. Most workers in the field of education feel that this newer development is a step in the right direction toward solving the problems of the student in learning to understand and use chemistry in everyday life.

The aim of education has been expressed as life enrichment through participation in a democratic social order. This, in large part, is developed from the understanding of principles and generalizations that ramify every branch of human achievement. The understanding of these concepts is brought about by the association of ideas from actual experience. Chemistry can offer a large contribution toward pupils life enrichment by making functional use of principles and generalizations important in the field.

It is the function of the high school chemistry course to prepare the adolescent for life, so that he may be a more intelligent consumer and be able to take his place in his environment, understanding the major chemical principles and using these principles to make his life fuller and richer.

Statement and Purpose of the Problem

This course of study has been developed for two major purposes:

First, to organize a functional course in chemistry that meets the needs, interests, and capacities of students. Great emphasis is placed on the fact that adolescents learn easier and with more thoroughness when chemistry is taught by the association of ideas from actual experience. This study recognizes the student as an individual, deals with his problems and issues of practical interest, and is so arranged as to help him grow in his powers of reflective thinking.

Second, to be used as a guide, either in part or as a whole, for a course of study for Oregon secondary schools.

Need of the Study

The need of a study such as this, is apparent to all science teachers. Chemistry has been taught in the same uninteresting manner year after year with little regard for the student or his interests. Dr. Gerard, of the University of Chicago, in a lecture delivered to the New England

Association of Chemistry Teachers, has this to say concerning the need of a new course of study in chemistry.

To quote from Dr. Gerard:

> Perhaps one or two percent of the high-school students taking chemistry courses will become chemists or will ever use chemistry in any true professional sense. Yet they are taught in preparation for taking college courses in chemistry which in turn largely prepare for advance courses in chemistry. Our youngsters are taught this subject as if it were to be their vocation: it should be taught for its avocational value.
>
> . . . .
>
> . . . The student must live science not learn about it, in his formative years, if he is to act scientifically later. To live science he must actively adventure on his own, must recognize and solve his own problems, must do "research." And the laboratory is the boat which fares into this world of exploration, which excites yet restrains the imagination of its pilot. (20:47, 50)*

In an article in the "Journal of Chemical Education," Reed (36:496-97) stressed a change of emphasis from traditional factual chemistry to practical applied chemistry. Courses should include many experiments with common household chemicals, testing of soaps, dyes, fabrics, spot removers, cleaners, investigations of the corroding of metals, and many others. The chemistry laboratory should be used more by the student in working out practical everyday problems that are found in his everyday living.

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*The numbers refer to references in the bibliography. A number following a colon indicates the exact page or pages in the reference where the quotation or data may be found.

Professor Glasoe of St. Olaf College has this to say in reference to a new course in chemistry.

Glasoe says:

> Such a course should be cultured rather than purely scientific. It should be an appreciation course, a humanized course in which the relation of chemistry to the daily life of men should be stressed rather than the relation of atoms and molecules to composition and reactions. It goes without saying that this will be a course about chemistry. The course about chemistry can be made so romantic, so thrilling, so vitally sympathetic with life and with science that boys and girls will carry with them a real knowledge of what chemistry is and a friendliness for it that will rebound greatly to the popularity of the subject among our people. (22:367)

The need for a course of study in chemistry is clearly stated in the Report of the Committee on the Function of Science in General Education. (8:465) Illustrated in the appendices of the report is a description of a functional course in chemistry that is being taught in the Denver Public Schools. This course written by Ahrens, Bush and Easley, resulted in a new chemistry text called, "Living Chemistry" (1). It is this course of study that the committee illustrates as satisfying the principles of the report of "Science in General Education" (8).

The committee goes further, stating that new courses should exemplify a useful and suggestive adaptation of the materials of chemistry to the purpose of general education. Use of committees, group projects, reports, and student leadership encourage the development of intelligent self-direction, self-assurance, wider personal interests and reflective thinking. Functional studies such as the Denver course and the course presented in this thesis satisfies the requirements of what the Committee on the Function of Science in General Education has stated must be done to integrate chemistry teaching more closely with the entire educational program.

A sound course of study is needed more than ever according to Professor Ashford of the University of Chicago. Ashford writes:

> Another problem is that of providing instructional material for courses in general education. Those who have attempted to give such courses are painfully aware of the lack not only of basic texts but of collateral readings. The texts on the whole have been slight modifications on the traditional type. Wherever the texts have departed considerably from tradition, they have tended to become superficial. The collateral reading available is even less satisfactory. The available material is either too technical and incomprehensible or too "popular." There is a need for material written specifically for this purpose. We are laboring under the misconception that courses for general education may be devised by simply omitting the difficult material from the traditional courses. We have not yet grasped the idea that the functions of the two types of courses are different, that the course for general education can be made just as intensive and difficult as the traditional courses, with its emphasis, however, on different aspects of chemistry (2:262).

In an article in "Science Education," Kowald (29: 22-24), of Drew University, points out the fact that in 1900, according to the U. S. Office of Education, 75 per cent of the high school graduates went to college. At the present time, according to the same source, not more than 15 per cent of the total secondary population goes beyond the twelfth grade. In recognition of this fact we need a functional course of study in chemistry for the 85 per cent of the high school students that will never attend an institution of higher learning.

There is no logical reason why the high school chemistry course should be patterned after the college course. Professor Glasoe (22:364) of St. Olaf College says, "Judging by the textbooks in use, the standard high school course in chemistry and first year college or university course are still one and the same, with such modifications as a one-to-two year difference in age of the students seem to impose."

In the Progressive Education report, "Science in General Education" (8) the needs and interests of students determine what is to be taught. What is needed is a child-centered school, not a subject matter school. Almost every student that enrolls in high school chemistry is fascinated with the subject. This enthusiasm is a tremendous compliment to the course itself, and the question arises as to why this ambition for information should decline so rapidly after the first few weeks of school.

We, as teachers, very often answer this question by saying the student loses his ambition and interest just as soon as chemistry requires the pupil to memorize chemical formulas, work problems, do experiments, or study the material as it appears in the course of study or in the textbook. We imply that the fault is with the student. Seldom do we ask ourselves if there is perhaps some fault in the manner of presenting this chemical information. We should not only hold their interest but also increase their enthusiasm for chemistry.

Chemistry offers every opportunity to proceed from the pupils interest, but this will require an entirely new point of view for the average chemistry teacher, as well as, a recognized up-to-date course of study.

The need of a functional course of study in chemistry that meets the requirements of science in general education has been felt for many years by educators in the State of Oregon. The present course of study in this state is almost ten years old, the need is great, and this study is offered as a contribution to the improvement of chemistry instruction in Oregon.

Limitations of the Study

This course of study would be greatly handicapped by lack of sufficient reference materials for student use. In Unit VIII of this study, a minimum list of reference material required for the completion of this course is provided.

The fact that there are so few chemistry texts written for general education constitutes a serious hindrance to a modern course of study in chemistry.

Most high schools teach the entire course from one chemistry book. This habit would establish a serious limit on the use of this course of study. Ten copies each of four or five of the better chemistry texts would aid greatly in teaching the subject from the needs and interests of the pupils.

The fact that this course of study as presented has not been used in its entirety constitutes a limitation to the study.

This study limits itself to a functional course in chemistry which presents a point of view that is different from the traditional course. It is concerned primarily with the use of modern psychological teaching methods as applied to high school chemistry instruction.

CHAPTER II

HISTORICAL BACKGROUND

A brief examination of the history of science teaching will bring about a clearer understanding of the necessity for a course of study in chemistry that will meet the needs of the adolescent.

Development of Science Instruction

There has been a great deal of confusion concerning the purposes which science instruction should serve, and the most effective procedures for realizing these purposes. Scientific training has been emphasized for a number of years and there is a question whether the scientific method, and other methods of science, are carrying over into life situations.

The history of science instruction is divided into three periods. The first starting with the establishment of the academy in 1751, extending up to 1880, with the aims of this period being religious, descriptive, and utilitarian. The sciences taught during this period consisted of natural philosophy, chemistry, astronomy, geography, and some emphasis on zoology and geology. The usual method of presenting subject matter was assigning passages to be learned and hearing recitations on the assignment. There was little in the aims of this period to develop independent thinking.

The second period from 1880 to 1910 ushered in the faculty psychology, the doctrine of formal discipline, and the laboratory method of teaching science.

There is a distinct carry over from this period of assigning problems selected primarily for their difficulty, the memorization of much factual data, and attention to abstract reasoning -- which is all out of relationship to life situations and has been experimentally proven inadequate by modern psychology.

The third period from 1910 to the present reacted against formal discipline and against college preparation as the chief function of science teaching. There was an attempt to meet the demands of modern industrial society by emphasizing newer developments in science and seeking to make science play a more active role in the lives of students.

There is less agreement now as to the purposes of science instruction than there was in the two previous periods. Shifts in the psychological theory during recent years has led to this non-agreement. So there is a real need for a re-examination of the basic principles of instruction and more particularly -- instruction in chemistry.

The Commission on the Reorganization of Secondary Education, appointed by the National Education Association, in its report, "Cardinal Principles of Secondary Education," (4) was one of the first attempts to create a more functional approach to science instruction

Later, in 1920, the Commission, in its bulletin, "Reorganization of Science in Secondary Schools," (5) urged that the sciences be taught in such a fashion as to contribute to all the "cardinal principles," except the second, the command of fundamental processes. The project method resulted from this era.

In 1926, the North Central Association of Colleges and Secondary Schools (37:428-444) reported that all subjects should contribute to achievement in terms of four objectives: health, vocation, social relationships, and leisure time. This report awakened many science teachers to the fact that they could and should use a much wider range of material, and give more importance to teaching science so as to meet the needs of their students.

Another report that did a great deal in developing functional science courses, was published by the National Society for the Study of Education in 1932: "A Program for Teaching Science." (31) This report developed the plan for organizing subject matter and learning experiences around "generalizations" or "big ideas" which are significant for a liberal education.

The most recent report in this development of functional science education is the book, "Science in General

Education." (8) This book was developed by the Committee on Function of Science in General Education of the Commission on Secondary School Curriculum. This commission was established by the Progressive Education Association. The report tackled the problem from the standpoint of the student himself. In order to have a functional course, teachers should discover the needs and interests of their pupils and build the science course around these needs. The units of work as developed by the students would be built around major generalizations or principles of science. This is the method employed in the development of the course of study for this thesis.

As mentioned in chapter one of this study, a text book, "Living Chemistry," (1) by Ahrens, Bush, and Easley represents the first attempt to organize a chemistry book around the needs of the students. This book is a departure from the traditional chemistry text and is a step in the right direction according to the Committee on the Function of Science in General Education.

Of all the science subjects there is little doubt that the methods of teaching of chemistry have been neglected. It is true that a good many chemistry teachers have altered their courses, have adopted newer textbooks, and have made an attempt to modernize their subject matter on a unit basis. However, too many chemistry teachers are still requiring students to learn volumes of unrelated factual material. This fact is well brought out in the report of the Committee on the Function of Science in General Education.

The Committee says:

> The present status of science teaching is difficult to determine. One of the most recent pertinent studies, "Instruction in Science," was made in 1932 by Wilbur L. Beauchamp, who analyzed fifty-eight courses of study in general science, forty-five in biology, twenty-seven in physics, and thirty in chemistry, all of which had been revised since 1925.
>
> . . . .
>
> This study revealed that science teaching at present is a mixture of the orthodox practices of the period 1880-1910 and the emerging practices of the last two decades. It thus combines much of the aim of mental discipline (presumably to be achieved through the study of a systematic organization of facts) with the aim showing the importance of pure and applied science in modern life. In addition it seeks to meet the needs of the individual in everyday life by imparting useful scientific information.
>
> . . . The older courses, physics and chemistry show greater emphasis upon mental discipline, although many high-school and college courses in these subjects exhibit the emphases of more recent years (8:13).

Science education has undergone many changes since 1932. The same is true of instruction in chemistry. The trends are in the right direction, but these trends are misleading; chemistry instruction is not improving rapidly enough from the psychological point of view. Parsons (34: 341) says, "Many new chemistry books are printed with the unit organization, having better pictures, more attractive covers, but most of them are still highly abstract, factual, and decidedly logical than psychological in organization."

The author analyzed several chemistry textbooks that have been widely used in secondary schools in the past twenty-five or thirty years and still are being used today. These books were checked to determine whether or not they were keeping in step with sound modern psychological teaching methods.

Table I, illustrates the inadequacies of chemistry textbooks in meeting the needs of high school students. They still emphasize facts and logical presentation, showing little improvement in psychological presentation and the use of principles and generalizations.

TABLE I

Text Book Analysis

Period	Books by Author & Publishing Date	Facts	Logical Presentation	Principles	Generalizations	Psychological Presentation
	Black-Conant, 1921	I	I	III	III	III
----	Emery-Downey-Davis-Boynton, 1924	I	I	III	III	III
1924	McPherson-Henderson-1917	I	I	III	III	III
	Black-Conant, 1934	I	I	III	III	III
1925	Brownlee-Fuller and Others, 1934	I	I	III	III	III
1934	Emery-Downey-Davis-Boynton, 1928	I	I	III	III	III
	Gordon, 1930	I	I	III	III	III
	McPherson-Henderson-Fowler, 1930	I	I	III	III	III
	Ahrens-Bush-Easley,1942	I	III	I	I	I
1935	Biddle-Bush, 1937	I	I	I	I	III
	Black-Conant, 1936	I	I	III	III	III
	Brownlee & Others,1940	I	I	II	II	III
1944	Dull, 1942	I	I	II	II	III
	Hopkins & Others,1939	I	I	I	I	III
	Jaffe, 1940	I	I	II	II	III

I - Well-developed; II - Mentioned, not developed; III - Not mentioned, not developed.

Review of Previous Studies

A thorough search has been made of recent periodicals, books, and abstracts of theses from colleges and universities to discover and review those investigations which have a direct bearing on this thesis. The more important are discussed in the following pages.

In 1924, the Committee of Chemical Education of the American Chemical Society (9:87-93) constructed a standard minimum high school course in chemistry to be used as a guide for teachers of such courses. This outline had as a major objective proper preparation for college entrance examinations.

A study by Koos (28:798-802) in 1925, determined that the average high school chemistry course is repeated in college with little modifications. If a student takes a course in general inorganic chemistry in college after having had a high school course he would be repeating nearly all of it.

In 1926, an investigation by Schwartz (38:817-23) of the methods and materials used in the high schools of Oregon was undertaken in cooperation with the Chemistry and Education departments of Oregon State Agriculture College. The following conditions governing the teaching of chemistry courses in Oregon were found to exist.

1. Chemistry is a text book subject, according to the course of study.
2. The text is an abbreviated college book.
3. Teachers are required to present a course of study emphasizing the standards set by the college entrance requirements.
4. The students viewpoint cannot be reached by this type of course and as a result chemistry remains largely unrelated to the students' experience, needs, environment, and capacity.

A course of study presented by Collier (6:2214-26) in 1931, emphasizes all the minimum essentials of high school chemistry as outlined by the Committee on Chemical Education of the American Chemical Society, with stress on the practical rather than the theoretical side of chemistry.

This study is the beginning of a consumer course in chemistry, which fulfills all the requirements of the college preparation courses. After a study of the fundamentals, the following subjects were studied; chemistry of food, clothing, shelter, health, automobile, radio, and motion pictures. The approach is different but the course is quite traditional.

An important investigation was made in 1937, by Dr. Gillson (13:171-173) to determine what knowledge of chemistry will prove most useful in adult life. Some of the conclusions of this study are summarized here.

1. The beginning of a course in chemistry should be practical not theoretical.
2. Laboratory work should be closely associated with the classroom discussion and should be used to acquire information first-hand.
3. The use of a single text should give way to gathering data from many sources.
4. The traditional course in chemistry will have to be changed if beginning students are to receive material that will be vital to them.
5. Chemistry teachers should be broadly trained.
6. There should be a change in the course in the second semester to allow for studies that are related to the daily lives of boys and girls. Let them analyze or study materials brought from home.
7. A great deal of chemistry taught in high school doesn't function in the later lives of students.
8. The amount of factual material the pupils are asked to learn is too much.
9. The relationship between the subject matter presented and the activities of pupils' daily lives is not developed sufficiently.
10. Principles which are of most use to laymen are:
    a. Composition of matter.

b. Nature of chemical action.

c. Chemical theory of solutions.

d. Properties of carbon compounds.

e. Acids - bases - salts.

f. Nature of metals.

An experimental study of two methods of teaching chemistry was completed in the Fort Worth Public Schools in 1942. This investigation was conducted by Ward (41:69-80) for his doctors dissertation. A new course in chemistry was installed and the traditional course was compared with this new modern course.

The traditional method consisted of;

1. Assignment of the lesson.
2. The recitation of the lesson.
3. Laboratory experiments.
4. Testing.

The modern method consisted of;

1. Using the pupils interests and needs to facilitate the students development.
2. Course built around major generalizations.
3. Experience of chemistry in life for the pupil.
4. The teacher is concerned primarily with "what" to teach and "how" to teach it.
5. The "what" is to be determined from the needs,

interests, previous experiences, and abilities of the students.

The modern method proved superior to the traditional method of teaching chemistry. Some important implications of the study were: texts should be used to obtain information -- not determine what is to be studied; teachers should locate already present interests and take the child as far along toward maximum growth and development as can be accomplished; use many illustrations and relate them to the student's life; emphasis should be on basic principles, generalizations, and concepts; and finally, teachers should discontinue the use of the traditional method of teaching chemistry in favor of a plan similar to the modern method.

In 1944, a study was made by Weaver (42:299-300), with emphasis placed on natural phenomena, local industries, and the chemical occurrences of everyday life. Just how these were to be accomplished wasn't clearly indicated.

These numerous authoritive studies indicate clearly that courses of study in chemistry must be devised that will begin with the student and work out a functional chemistry course that will meet the needs of every boy and girl enrolled in the class.

Courses of Study in Oregon

The state course of study in chemistry for Oregon published in 1937, follows the logical organization of the mental discipline era of 1880-1910. This course of study is obsolete, and during the past few years there has been a committee working on a new course of study in chemistry for the Oregon schools.

In the elementary and junior high school sciences, the state department of public instruction has developed outstanding courses of study from the lower grades up to and including ninth grade general science. These courses have the psychological approach and tend to develop independent thinking.

It has already been shown that students like this new approach to the field of science and when they reach the senior high school they will expect their chemistry course to be just as stimulating and interesting as their lower grade sciences.

Already a tentative course of study in applied physical science has been adopted by the state department of public instruction. This course also used the psychological approach and is organized around certain major physical and chemical principles. In order to keep pace with elementary, junior high, and applied sciences, the high school physics and chemistry courses of study need revision and stimulation.

CHAPTER III

THE STUDY

The purpose of this study is the preparation of a course of study in chemistry that will meet the needs of adolescent, and at the same time be consistent with the purposes of general education as set forth by the Progressive Education Committee on the Function of Science in General Education.

To quote from the Committee:

> The purpose of general education is to meet the needs of individuals in the basic aspects of living in such a way as to promote the fullest possible realization of personal potentialities and the most effective participation in a democratic society. (8:23)

In the past, courses in chemistry have been logically organized with internal consistency and maximum possibility of deduction. For a great number of students, courses of this type have not dealt with problems or issues of practical interest, and they have not been taught so as to help students grow in their powers of reflective thinking, as well as not being consistent with the purposes of general education. Chemistry teachers cannot isolate themselves and their subjects from education in general. In order to receive maximum understanding and cooperation from pupils, it will be necessary to use the psychological approach in chemistry.

In his article, "Making High School Chemistry Practical," Curtis suggests ways of supplying supplementary material as an aid to a proper approach.

To quote from Curtis:

> Chemistry should include subject matter that is essential to an understanding of chemistry, together with adequate provision for supplementary material which will be of value to students in later life. The supplementary material should be dictated by the local conditions. In agriculture country applications of chemistry to agriculture should be made. In larger communities applications of chemistry to the industries characteristic of the community. In communities that are neither agriculture nor industrial application should be made of chemistry to everyday vocations. (15:234)

From the standpoint of psychology, the most capable and well meaning teacher can be effective only if he approaches the pupil through his needs and interests.

Criteria for the Study

A careful study to ascertain as nearly as possible what phases of chemical knowledge adults considered of service to them, was made by Dr. Gillson of Columbia University Teachers College. A study of the data resulted in the setting up of certain criteria for the selection of content for beginning chemistry courses adapted to life needs.

To quote from Dr. Gillson:

> These criteria are threefold.

1. Psychological, those which consider the pupil's interest and abilities.

2. Professional, those concerned with the selection of subject matter which will include only the truly fundamental principles and generalizations.

3. "Practical," those concerned with the tie-up between the life of the indivicual and the use of chemical principles and generalizations. (21:246)

The above criteria are interesting for they had their origin from adults, not from a member of the teaching profession. It is true an educator worked out the criteria, but the parents of children stated the phases of chemistry that were of use to them in life, hence these criteria carry weight because they are practical and will result in the formation of a usable chemistry course for the adolescent.

It is interesting to note the similarity of the above criteria with those stated by George I. Linn in his article, "A Sound Approach to Chemistry Teaching."

Linn says:

> Guiding principles to be used as a criteria in developing a chemistry curriculum.
>
> 1. It must be kept within the interests of the pupils.
>
> 2. It must be kept within the ability and understanding of the pupils.
>
> 3. It must deal with common life experiences of a chemical nature. (30:493)

The course of study in chemistry presented in this thesis is in full agreement with the above criteria.

Parsons, in an article, "A Plan for a New High School Chemistry," (34:341-343) has stated that in order to overcome the evils of the past in chemistry each unit should be broken down into its most important divisions. Woven into these units, in a minor way, such fundamentals as balancing equations, laws of energy and matter, oxidation- reduction, atomic and molecular theories, and other important concepts stressed in present day high school chemistry courses. The stress would go from inorganic to organic chemistry with experiments adapted to specific needs of the student and community needs. There would be a repetition of a few simple working principles brought out in connection with each major unit, and finally, use many textbooks as references.

To quote from Parsons:

> As a result of reorganization the new chemistry would:
>
> 1. Avoid putting a premium on memorized work and facts never to be used again and would use formulae, equations, symbols, and properties of elements and compounds only in connection with the understanding of numerous problems arising from a study of such units as Life Processes and Medicine.
>
> 2. Be taught psychologically instead of logically.
>
> 3. Enable the terminal as well as the college preparatory student to understand the combating of alkali on farm lands, the technique of a police chemist in helping to solve a crime, the actions which antidotes for poisons have, how

"plastics" can be made from wood and coal, and how tannic acid prevents scarring from burns.

4. Stimulate interest at an early age for both terminal and college preparatory students.

5. Not possess the mysterious and supernatural aspects of traditional chemistry.

6. Help to make educated consumers of students and future citizens.

7. Function in a "streamlined" manner in the life of each student without being merely a college preparatory subject.

8. Make future citizens "chemistry and and science conscious," and interested in all phases of everyday science. (34:343)

In the conclusion of, "An Experimental Study of Two Methods of Teaching Chemistry in Senior High School," by Ward, it was found that the modern method was superior in some ways to the traditional method of teaching chemistry.

To quote from Ward:

Conclusions and implications:

1. The modern method seems to be superior to the traditional method for general class work with heterogenous groups.

2. Selection of learning materials on the basis of interest, needs, and capacities is superior to the use of subject matter on the traditional basis.

3. With regard to intelligence, evidence obtained in this study seems to show that the modern method is equal to the traditional method for pupils of high I.Q.'s and is superior to the traditional

method for pupils of lower levels of intelligence.

4. Pupils of high I.Q.'s learn equally well by either method, as measured by both chemistry informational and the functional tests.

5. Pupils of lower I.Q.'s learn equally well by either method, as measured by both chemistry informational and the functional tests.

6. Pupils learn not only the facts and principles of chemistry better by the modern method, but also learn to appreciate the social significance of chemistry better when taught by this method.

7. In general, more transfer is obtained by the modern method, as indicated by the application of chemistry to practical life situations.

8. In general, the scientific attitude is developed better by the modern method than by the traditional method.

9. The modern method is superior to the traditional method as these methods relate to disciplinary problems. (41: 69-80)

For two years the writer has asked his beginning chemistry students what they expected to get out of their study of chemistry. Their answers are summarized below:

1. They want to understand about plastics, how they are made and where the materials come from.
2. They want to learn about synthetic fibers, such as rayon, and nylon.
3. They would like to apply their learned chemical principles to the understanding of different types

of gasoline, and why one type is better than the other.

4. They want to be a more intelligent consumer because of their knowledge of chemistry.

5. They would like to be able to experiment and discover many interesting things.

6. They stressed the fact that they hoped their chemistry course would be practical.

In a great many chemistry classes very little time is spent on the above subjects. The stress is on the factual matter that the colleges require in their chemistry courses. What good will the knowledge a student may possess on the balancing of an oxidation-reduction reaction by the electron method carry over into life? The student may know these things on the completion of his course, he may know how to write equations, balance them correctly, prepare oxygen, hydrogen, nitrogen, etc., but how long will he retain this information? He will retain it just as long as he has use for it -- and for the average high school student there will be no use for this type of information because he does not go on to college or into advanced chemistry.

This information will help him to understand and appreciate chemistry, but if the student cannot use this great mass of detailed information, then he has wasted his time and effort in school, because chemistry should certainly be more than just an appreciation course. In other words, some chemistry instructors have gone back to the old and obsolete idea of mental discipline, requiring the pupil to master something that will have no bearing on his future welfare, and may, by demanding this sort of unrelated information, have killed the interest for chemistry of many intelligent students.

Too often chemistry teachers ask their students to learn many chemical processes, not because the knowledge would be useful to the pupil in life, but because the chemistry text, or the course of study in use at the time, had a unit covering this material.

The "Principle" Method of Teaching Chemistry

This course of study in high school chemistry is organized on a unit basis with each unit built around one or more major chemical principles.

Downing, (17:39-41) in his book, "An Introduction to the Teaching of Science," has listed fifteen major chemical principles that are essential to the complete understanding of high school chemistry. His list of principles is found below in condensed form.

1. Atoms of all elements are made up of equal numbers of positive and negative electrons.
2. The atoms of all radioactive elements are constantly

disintegrating by giving off various rays, changing into isotopes or into different elements.

3. The molecules of nearly all substances are composed of atoms of relatively few elements which, in a chemical change, separate and recombine so as to produce new substances with different properties.
4. The name of every organic compound is derived from the various type combinations of atoms found in the molecule of the substance.
5. Every element when incandescent gives off light of definite wave lengths which can be detected from those of other elements by means of a spectroscope.
6. All inorganic compounds can be placed within three general groups of substances, acids, bases, and salts.
7. During a chemical reaction an element may lose or gain electrons.
8. When an electric current is passed through a solution containing an electrolyte, the ions lose their electric charges and are set free at the anode and the cathode.
9. Every substance has definite chemical composition.
10. The physical and chemical properties of elements are functions of their atomic numbers.

11. The rate of chemical change is increased by the presence of a catalyzer.
12. Every element displays an attraction for other elements, the strength of which varies with the element.
13. Acids, bases, and salts dissociate in aqueous solution into atoms or groups of atoms called "ions," which carry electric charges.
14. Energy can be neither created or destroyed.
15. When an acid and a base come together, the hydrogen of the acid and the hydroxyl of the base have a tendency to unite to form water.

In this study the term "generalizations" is used to represent understandings. The Committee on the Function of Science in General Education defines the term as follows; "Understanding, is here used to denote a major conception so grasped as to illuminate its connections with related conceptions and to result in significant changes in the individuals behavior." (8:55)

The Committee goes on to say, "A principle becomes an understanding for an individual only when and as it throws new light for him on a group of relationships not previously sensed and so brings about a reorganization of his behavior." (8:55)

The principles around which each unit in this study is developed are listed below:

Unit I Introduction

This is an overview of the course in chemistry and no particular principle is to be developed here.

Unit II Matter and Its Composition

1. Every substance has definite chemical composition.

2. The physical and chemical properties of elements are functions of their atomic numbers.

3. Energy can be neither created nor destroyed.

Unit III The Structure of Matter

1. Atoms of all elements are made up of equal numbers of positive and negative electrons.

2. The molecules of nearly all substances are composed of atoms of relatively few elements which in a chemical change separate and recombine so as to produce new substances with different properties.

3. The physical and chemical properties of elements are functions of their atomic numbers.

4. Every element displays an attraction for other elements, the strength of which varies with the element.

Unit IV The Atmosphere

1. During a chemical reaction, an element may lose or gain electrons.

2. When an electric current is passed through a solution containing an electrolyte, the ions lose their electric charges and are set free at the anode and cathode.

3. The physical and chemical properties of elements are functions of their atomic numbers.

4. The rate of chemical change is increased by the presence of a catalyzer.

5. Acids, bases, and salts dissociate in aqueous solution into atoms or groups of atoms called, "ions," which carry electric charges.

Unit V The Shorthand of Chemistry

1. All inorganic compounds can be placed within three general groups of substances, acids, bases, and salts.

2. During a chemical reaction an element may lose or gain electrons.

3. Every substance has definite chemical composition.

4. The physical and chemical properties of elements are functions of their atomic numbers.

5. Every element displays an attraction for other elements, the strength of which varies with the element.

6. Energy can be neither created nor destroyed.

Unit VI Acids - Bases - Salts

1. The atoms of all radioactive elements are constantly disintegrating by giving off various rays, changing into isotopes or into different elements.

2. All inorganic compounds can be placed within three general groups of substances, acids, bases, and salts.

3. The physical and chemical properties of elements are functions of their atomic numbers.

4. Acids, bases, and salts dissociate in aqueous solution into atoms or groups of atoms called "ions" which carry electric charges.

5. When an acid and a base come together, the hydrogen of the acid and the hydroxyl of the base have a tendency to unite to form water.

Unit VII Organic Compounds

1. The name of every organic compound is derived from the various type combinations of atoms found in the molecule of the substance.

2. The physical and chemical properties of elements are functions of their atomic numbers.

3. The rate of chemical change is increased by the presence of a catalyzer.

4. Every element displays an attraction for other elements the strength of which varies with the element.

Unit VIII Applying Chemistry to Life

All the major chemical principles will be developed in this unit at one time or another, depending upon what the students are investigating.

General Objectives of the Course of Study

What students can expect to get from a course in chemistry depends upon the general objectives of the course. The general objectives do not represent fixed points to be reached by all the students, but rather directions in which all students may profitably progress. The general objectives of this course of study are:

1. To develop an understanding of major chemical principles so that they may be applied to everyday problems.
2. To develop the desire and ability to investigate intelligently problems of everyday interest and living.
3. To help in discovering wholesome leisure activities or hobbies.
4. To give the individual scientific knowledge in selecting, buying, and using goods and services.

5. To gain knowledge in choosing and exploring the scientific vocations so that knowledge may be used intelligently in planning for their future.
6. To gain knowledge of health so as to aid in correct habits and maintain healthful living.
7. To help the student develop a scientific attitude that will carry over into all fields of thinking.
8. To develop through chemistry the relationship of industry to society and ordinary living.
9. To teach pupils how to gain useful information for themselves.
10. To develop an understanding and appreciation of the relation of chemistry to other subjects and to the world about him.

All adolescents have certain specific needs. It is the job of the school to meet these needs, and particularly each course should contribute toward the realization of these needs. The National Association of Secondary-School Principals, in their publication, "Planning for American Youth," have listed ten common educational needs of all youth.

To quote from the Association:

1. All youth need to develop salable skills.
2. All youth need to develop and maintain good health and physical fitness.
3. All youth need to understand the rights and duties of the citizen of a democratic society.

4. All youth need to understand the significance of the family for the individual and society.

5. All youth need to know how to purchase and use goods and services intelligently.

6. All youth need to understand the influence of science on human life.

7. All youth need an appreciation of literature, art, music, and nature.

8. All youth need to be able to use their leisure time well and to budget it wisely.

9. All youth need to develop respect for other persons.

10. All youth need to grow in their ability to think rationally. (7:10)

This course of study in chemistry contributes to many of the needs mentioned above as evidenced in the statement of the general objectives of this course.

Evaluation in Chemistry

An adequate program of evaluation is invaluable in helping the student, his parents and his teachers to measure a pupil's acievements and direct his progress.

To quote from Heiss, Obourn, and Hoffman:

> An evaluation program which would attempt a complete appraisal of a student's growth in science or any other subject area has several obligations; first, to devise tests and measures that will reveal not only the mastery of facts and principles of a given area, but a functional understanding of the concepts and generalizations involved; and secondly, to devise techniques for revealing growth in certain other outcomes such as the elements of reflective thinking, attitudes,

creativeness, personal interest, and social sensitivity.

A further obligation of an adequate evaluation program, equally as important as the appraisal of achievement, is that of detecting as early as possible the strengths and weaknesses of students with respect to the objectives or goals of the course. Evaluation instruments must have the property of diagnosis, if there is to be any effort made to have students proceed at a rate commensurate with their ability. (24: 95-96)

The best protection against vague and irresponsible theorizing in chemistry is an adequate program of evaluation. The committee on the Function of Science in General Education has this to say:

To quote from the Committee:

First, to be at all acceptable from the point of view of this report, evaluation must be a continuing process. Most significant changes in behavior -- surely those which indicate development in desirable characteristics of the personality -- take place slowly and need to be observed over long periods of time. Too often it is assumed that the work of each year, or each semester, is to be judged solely in terms of the outcomes at the end of that period. The fact that the student's development continues throughout life is disregarded. A complete evaluation of the effects that experiences in science have had on a student would involve a continuous study of his personality and conduct and a cumulative record of his development through the years of formal schooling and on into adult life. Though such a program may not be practicable, a close approach to it during the years of formal education can be made.

Second, in as far as possible, the whole and functioning person must be taken into account. Evaluation inevitably consists in taking samples of student behavior and synthesizing them into a picture of the whole personality of a student and the ways in which it is developing. (8:390)

A general technique for the construction of instruments of evaluation is suggested by Tyler in the book, "Science in General Education," by the Committee on the Function of Science in General Education.

To quote from the Committee:

1. Statement by the teacher of his objectives. This is necessary in order to indicate what is to be evaluated and to define the variety of instruments of evaluation necessary for comprehensive measurement of student achievement.

2. Description of the kinds of student behavior that indicate growth toward achievement of these objectives. This requires the definition of specific types of situations in which students will reveal achievement or lack of it.

3. Invention of methods of observing and recording the behavior that indicates progress toward achievement of objectives. (8:393)

It is quite evident that written examinations of the essay type or the objective type are not adequate for an evaluation program. Too many teachers base all their grades on the result their pupils achieve in essay or objective tests. If an evaluation program is to get information concerning student progress toward the objectives of the chemistry course as well as the objectives of general education, there will be many types of evaluation some of the so-called "intangibles" of education.

Other than written essay and objective types of examinations, a complete testing program in chemistry should include some of the following:

1. Questionnaires.
2. Anecdotal records.
3. Interviews.
4. Student's diaries.
5. Problem solving situations.
6. Testing student's creative ability.

In the study of chemistry there undoubtedly should be more universal use of the above additional methods of evaluation. The anecdotal record is an excellent tool to determine some of the less dominate characteristics of a student that may shed great light on his behavior patterns.

A successful chemistry teacher must assume responsibility for remedial instruction in reading skills when they do not involve the consultation of specialists. Many students have trouble with chemistry, not so much because the work is too difficult, but due to the fact they lack ability to read successfully. They experience great difficulty with the vocabulary of chemistry. Tests on definitions of new words will keep the student well acquainted with glossaries and the dictionary. Troublesome words may then be brought to the attention of both teacher and pupil.

In the book, "Appraising and Recording Student Progress," by Smith and Tyler, it became clear to committees working on evaluation programs that teachers benefited greatly by the construction of modern evaluation programs for their classes.

To quote from Smith and Tyler:

> The recurring demand for the formulation and clarification of objectives, the continuing study of the reactions of the students in terms of these objectives, and the persistent attempt to relate the results obtained from various sorts of measurement are all means for focusing the interests and efforts of teachers upon the most vital parts of the educational process. The results in several schools indicate that evaluation provides a means for the continued improvement of the educational program, for an ever deepening understanding of students with a consequent increase in the effectiveness of the school (39:30)

To aid the teacher in developing new type examinations in chemistry, examples of newer types of evaluation will be found throughout this course of study.

Construction of the Units

The first seven units of this course of study in chemistry are concerned with the fundamentals that pupils need in order to understand and apply their chemical knowledge to the world in which they live.

What is called unit VIII of this study is really a series of units for each student. It is believed that pupils, upon completion of the first seven units, will have a good foundation for further investigation into the problems of their own choosing. This portion of chemistry is most interesting to pupils for here they may make their chemistry really practical by having their course meet their needs directly.

The class is organized with student committees in charge of various sections of the study. It is the function of these committees to check the investigations with the help of the instructor, and to arrange the time for the various individuals in the class to present their investigations with their conclusions and recommendations for further study.

Each unit is constructed around major chemical principles which were stated earlier in this chapter. The content of each unit is listed below:

1. Suggestions to teachers.
2. Objectives of the unit.
3. Suggested approach.
4. Unit analysis.
5. Laboratory suggestions.
6. Evaluation of the unit.
7. Materials
    a. Chemistry texts with page references.
    b. Other references.
    c. List of suggested films.
    d. List of free and inexpensive materials.

The unit analysis is written in such a manner that the subject matter content is in the left hand column and immediately opposite is the corresponding suggested activity. This method makes it very easy for a teacher to follow and use the course of study.

CHAPTER IV

THE COURSE OF STUDY

Unit I -- A New Life Through Chemistry

It is assumed that beginning students in chemistry have had at least a one-year course or its equivalent in general science. Since this will be true in most cases, the pupil will be able to begin immediately the study of chemistry in an interesting and stimulating manner. There is not need to spend the first few periods explaining and discussing what chemistry is, and with what it is concerned. Most students enrolled have an adequate picture of the field of chemistry. At least the pupil knows that in its study he will be able to experiment with chemicals, make many interesting substances from a few ingredients mixed in a test tube, and most of all, the student feels he will have to really do some earnest studying in order to meet the standards of the ordinary chemistry class.

Here then, we find a group of pupils with an almost ideal mind-set, eager and enthusiastic, and very anxious to begin a course they feel will be practical and interesting.

In view of these facts, it is essential that the chemistry teacher make the first class most stimulating. Nothing will arouse more, the full cooperation for learning chemistry, than a few exciting experiments on the very first day. However, these demonstrations and experiments should serve as a logical introduction to the course, and bear definite relationship and reference to unit two.

These stimulating periods must continue all the way through the course. In each unit of this study will be found interest-getting devices to keep the study lively and inspirational.

Once the introductory unit has been completed, make it clear that everything the pupil learns has relationship. If this is done well, the study of chemistry will be much easier for most students.

Suggestions to Teachers

1. During the first week of school classes are always disorganized by the students entering late, changing of classes, and organizing schedules. Do not, however, allow these interruptions to interfere with the forward progress of the class. Late students may easily catch up with the rest of the class in this first introductive and interest-getting unit. If the first regular chemistry class is stimulating, new, and different, the late students will hear about it at great lengths, and it won't be necessary to repeat demonstrations or experiments conducted the first day or two.

2. Remember that this first unit is extremely important, and should be very well worked out to insure proper stimulation and interest for chemistry.
3. In every class period during the first week there should be at least one interesting experiment or demonstration. It is better if these demonstrations show a connected relationship with the first unit and serve as a logical introduction to the course of chemistry.
4. During the first week there should be at least one laboratory period in which the student is allowed to perform some spectacular experiments for his own pleasure and enjoyment. A suggested laboratory period of this type has been outlined in the first unit.
5. Be enthusiastic about chemistry! Show your pupils that you enjoy teaching the subject, and make it clear by your actions that you understand their viewpoint. Do not stress theory and factual matter unduly. Make every effort to teach fundamentals from the psychological point of view.
6. Finally, it is important to keep in mind that everything in the first unit should constitute a logical and organized series of events that lead the student up and into unit two, "Matter and its Composition."

Objectives of Unit I

1. To arouse enthusiasm and stimulate interest in chemistry.
2. To introduce the student to the vast field of chemistry.
3. To survey the background of the individuals in the class.

Suggested Approach

On a table or side shelf have a complete display of all the chemical apparatus that will be used in the year's course. In front of each piece of equipment have a neatly printed label giving its name and use. Do not display glassware that has been unduly scratched, and be sure that every piece of equipment is clean and shining. A display of this nature is a good interest-getting device, which can be observed by the pupils during the first week of school.

A stimulating display can be arranged on the demonstration desk or table near the front of the room. Place on the desk as many complicated sets of apparatus in full operation as desired. The following have been used successfully; a complete distilling apparatus with colored or muddy water in the distilling flask or retort, with the clear colorless water coming out into the receiving flask at the lower end of the condenser; colored water in capillary tubes; the sound of a hydrogen generator bubbling gas into a bell jar of water; a titration set-up with burettes, one containing a basic solution, the other an acid solution with beakers below containing the usual indicators to demonstrate color changes; an electrolysis of water apparatus to show proportionate breaking up of common water to hydrogen and oxygen; retorts, erlenmeyer flasks, condensing tubes, beakers, mortar and pestles. All apparatus on display should be neatly and thoroughly labelled.

It is important that all the demonstrations are working when the students enter the classroom.

Unit Analysis

It is the purpose of this unit to illustrate that through the study of chemistry the student will be able to see more clearly how a new life is being created through developments in chemistry.

Suggested time: one to three weeks.

Content	Suggested Activities
1. Coal (black gold) is the leading substance in the betterment of civilization through chemistry. Four main sub-divisions for	1. Divide the class into groups and assign the topics in the left column for investigation. For example, one group may take the mineral and work

suggested study are:

a. Coke

b. Coal tar

c. Aniline dyes

d. Sulfa drugs

out a complete report on new things developed from coal and its products.

A good demonstration can be performed with the sulfa drugs showing how they are made from coal. All of these reports should be illustrated and demonstrated, if possible.

2. Plant fiber. Cellulose chemically treated in different ways may be studied as:
   a. Paper
   b. Linen
   c. Artificial silk
   d. Cellophane

2. Very attractive displays can be developed from these investigations and the best can be placed in a show case in the school's front hall. Pupils take great pride in recognition of their work.

3. Synthetic chemistry
   a. Rubber
   b. Plastics

3. In cases where it is impractical to have demonstrations, the following method can be used. For example, in making a display of the sulfa drugs showing their preparation

from coal and acids, the student can acquire all the ingredients from the laborotory, place them in labelled bottles and retorts and connect with ribbons or string to illustrate the direction and steps of the reactions to produce the various sulfa drugs from these familiar substances.

4. Foods.
   a. Dehydrated
   b. Vitamins
   c. Refrigeration
   d. Improvement of foods.

4. A display like the one mentioned above is easy to prepare, and once completed, is easily understood so that anyone could appreciate the method of preparation.

5. Steel.
   a. Heat treatment
   b. Alloys
   c. Rust

5. The purpose of these reports and investigations is to stimulate interest for a study of chemistry.

6. Clothing.
   a. Cleaning
   b. Dying

6. Point out the fact that the the subject matter of these reports will be taken up in

c. New developments
   (1) Glass
   (2) Steel

greater detail as the course progresses.

Laboratory Suggestions

Many variations are possible for this first laboratory period, however, the real purpose of the period is one of enjoyment for the students. Although the experiments are primarily for pleasure, the instructor must not fail to begin his instruction of correct laboratory technique. This can be done in an easy and informal way so the students will start correct learning processes in their first laboratory period. These experiments will offer excellent discussion material for the next unit and should be used in such a manner that pupils will have an interesting time as well as learn some fundamental chemistry.

If the instructor wishes certain students to perform these experiments, or have them done in groups in order to save materials, he may do so. It is better, however, to have the students work individually or in groups of two. The following are a few of the many types of short experiments that will arouse enthusiasm.

1. A brilliant flash! A piece of magnesium ribbon one inch long held in a flame produces a blinding flash of light.

2. A magicians trick! Into three beakers before you put three drops of phenolphthalein in the first one, in the second put 1 cc. of dilute hydrocholoric acid. Add 50 cc. of water to each beaker and stir. Add the contents of the first beaker to the second beaker and stir. Then add the contents of the second to the third and stir. Water changed into wine!
3. Invisible ink! Dissolve a small crystal of cobalt nitrate to a half test tube of water. With a clean pen or a pin write you name on a piece of glazed paper. Allow to dry and then hold the writing over a flame and note what happens.
4. If the materials for the above experiment are not available, the following may be substituted. Make a concentrated solution of table salt in hot water and let it cool. Write your name with this salt solution with a new clean pen which has never touch ink. Let the writing dry and it will be almost invisible. Rub across it with a lead pencil and your name will appear.
5. Spontaneous combustion! On an asbestos mat arrange in the form of a cone, a quantity of powdered potassium permanganate equal to the size of a bean. With a pencil point make a small hole in the tip of the cone and put a drop of glycerin in the hole. Step back and wait for a reaction!

6. Fire writing! Dissolve as much powdered potassium nitrate as possible in a test tube one-fourth full of water. Use a frayed end of a match to act as a brush, and dip it into the solution and write your name on a piece of absorbent paper and allow to dry thoroughly. After drying set fire to the place where you first started to write.
7. Self-inflating balloon! Fill a small vial (about 4 cc. capacity) full of water and close tightly with a cork stopper. Wipe off any water which may adhere to the vial. Obtain two pieces of calcium carbide about the size of a pea and place both the vial and the calcium carbide in a balloon. Tie the balloon opening with a thread or string so that no air can enter or leave it. Take the balloon in your hands and remove the cork from the vial, shake the contents and immediately place the balloon on the desk. The balloon is inflated with acetylene gas which is very explosive so keep away from fire!

Evaluation of Unit I

The methods of evaluation that are to be used in a chemistry course should be carefully explained to the class at the beginning of the course. Many misunderstandings are often prevented by a careful explanation of the evaluation program during the first week of school.

Perhaps the best method to follow in evaluating this first week of work is the anecdotal record. A short and convenient method of recording behavior characteristics can be devised in which the names of the students are placed down one side of a sheet and the abilities under observation across the top. The paper is then divided into squares by lines. This provides a square for each ability opposite each name. The presence or absence of the desired response may be recorded by means of a plus and minus sign.
For example:

Observational Record

Name	Tolerance	Curiosity	Reserve Judgment	Seeing a Problem through to Completion
Mary Smith	+	-	+	-
Bill Brown	-	+	+	+
Others				

This form can be added to and should be used through the entire course. Improvement or lack of improvement can be indicated by the accumulation of plus and minus marks.

A simple case history of each student should be prepared during this introductory unit. A form similar to the one below will be sufficient.

Case History

Name - Bill Brown	Age - 17	Date

1. Achievement (grades or I.Q.) - "C" average
2. Social economic background - Delivers papers in town, etc.
3. Reading ability - Poor
4. Testing record - No record

The information gained from such a form can prove invaluable in understanding student behavior. Vocabulary and reading weakness can be noted and checked at an early stage. The fact that a student is working five or six hours after school might account for lowered grades or a lack of interest in chemistry. The more information a teacher can gain concerning individuals the easier it is to understand and interest his students.

Materials

References:

In addition to the following references use all the chemistry texts, encyclopedias, and science periodicals that are available.

Borth, Christy. Pioneers of Plenty. Bobbs-Merril Co., New York, 1939.

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Furnas, C. C. The Next Hundred Years. The Williams and Wilkins Company, Baltimore, 1936.

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Jaffe, Bernard. Crucibles. Tudor Publishing Co., New York, 1934.

Kendal, James. At Home Among the Atoms. D. Appleton-Century Co., New York, 1929.

Lynde, C. J. Science Experiences with Home Equipment. International Textbook Company, Scranton, Pa., 1937.

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Lynde, C. J. Science Experiences with Ten-Cent Store Equipment. International Textbook Company, Scranton, Pa., 1941.

Slosson, Edwin E. Creative Chemistry. D. Appleton-Century Co., New York, 1930.

Weeks, Mary E. The Discovery of the Elements. Journal of Chemical Education, Easton, Pa., 1939.

Films: (16 mm.)

Chemistry, Historical Introduction to the Study of. 10 min. Sound. $1.00. #817. Dept. of Visual Instruction, University Extension Division Building, Berkeley 4, California.

New World Through Chemistry. 20 min. $0.50. Sound. Dept. of Visual Instruction, Extension Service, Oregon State System of Higher Education, Corvallis, Oregon.

Synthetic Rubber. 2 reels. Sound. $0.50. Division of General College Extension, Bureau of Visual Teaching, Washington State College, Pullman, Washington.

Wonder World of Chemistry. 25 min. Sound. $0.50. Corvallis, Oregon.

Free and Inexpensive Materials:

A Wonder Book of Rubber. The B. F. Goodrich C., Akron, Ohio. 40 p. Free to teachers.

Bakelite Review. Bakelite Corporation. 247 Park Avenue, New York City. Quarterly. 15 p. Free.

Buried Sunlight. 36 p. 1941. Row, Peterson and Company, Evanston, Illinois. $0.28. Coal.

Educational Exhibit. Hood Rubber Products Company, Watertown, Mass. $0.60. Samples of crude rubber and the ingredients to refine and manufacture rubber boots and shoes.

From the Far Corners of the Earth. Weston Electric Company, 105 Broadway, New York City. 70 p. Free. Metals used in the construction of the telephone.

History of Glass. G. D. Sailer. 5 p. 1941. American Glassware Association, 19 West 44th. Street, New York City. Free.

Information Regarding Rayon. 20 p. 1940. American Viscose Corporation, 350 Fifth Avenue, New York City. Free.

Metallurgy and Wheels. Revised edition. 47 p. 1938. General Motors Corporation, Dept. of Public Relations, Detroit, Michigan. Free.

Parade of Plastics. 7 p. E. I. du Pont de Nemous and Company, Wilmington, Delaware. Free. Also:

Cellulose and Civilization. Dr. Frederick C. Hahn. 8 p. 1938. Free.

Blazing the Trail to New Frontiers Through Chemistry. 31 p. 1940. Free.

Chemistry and You. Free.

Du Pont Rayon Reaches New Peak in Fashion Fabrics, Du Pont Style News Service. 37 p. Free with samples.

Science in Everyday Life. C.M.A. Stine. 19 p. Free.

The Kinship of Du Pont Products. Free.

Things are not What They Seem. Free.

Wonder World of Chemistry. Free.

Products Derived From Coal. The Barrett Company, 40 Rector Street, New York City. A chart 14 by 17 inches. Free.

Stainless Steels. 32 p. 1941. Allegheny Ludlum Steel Corporation, Sales Promotion Dept., Brackenridge, Penn. Free.

Steel and Its Use. Bethlehem Steel Co., Bethlehem, Pa. 31 p. Free to teachers only.

Story of Nylon. 20 p. 1941. Cooper Wells and Company, St. Joseph, Michigan. Free.

In this unit the student begins his study of the many properties of matter which determines its usefulness in the home and in the world about him.

Suggestions to Teachers

1. The periodic chart should be referred to the class in an informal way, briefly explaining how it is used when the first element is discussed. As the class progresses, the chart will take on meaning and before the end of the first semester students will be using the chart to simplify and clarify their chemical problems. Under no circumstances should the periodic classification of elements be presented to the class with the idea of the pupils' mastering it during these first three units. It is surprising how quickly and easily students can acquire this information when the chart is mentioned frequently as occasions present themselves for its use.

   If the school does not own a chart, one can be easily made as a student project. Two pieces of butcher paper about five feet long can be pasted together and the chart copied from any standard chemistry text book. The chart should be placed at a convenient height so that students can examine it closely and read the fine printing with little difficulty. Many charts are placed above a blackboard which makes it hard to read and very inconvenient for reference.

2. Use many simple demonstrations in explaining chemistry to students. Startle them, and keep them on their toes so they will wonder what is coming next.
3. Remember the nature of your student! He is still an adolescent. He likes games and competition.
4. Have a chemistry question box in the room. Explain to the students that any question they wish to ask about the subject matter or other related material may be placed in the box. No names need to be on the questions.

Objectives of Unit II

1. To develop an understanding of the nature of matter and how to identify matter.
2. To awaken an appreciation of the definiteness and orderliness of matter.
3. To understand how the scientific method of thinking has been used in gaining a better knowledge of the nature of matter.
4. To cultivate a general understanding of the importance of chemical change in the transition of one substance into another.
5. To develop an understanding of the composition of matter, including solutions.

Suggested Approach

Have ready for the first day this unit is to be presented, two flash bulbs, large ones if available. On the demonstration desk have the two bulbs balanced on scales showing that they weigh the same. If there is a student that has a flash camera, have him take a picture of the class busy studying in the room. After the picture place the bulb back on the pan balance and it will be clearly seen that the bulb weighs just as much as it did before it was burned. Why? You wouldn't expect it to weigh the same after all the metal had been burned in the bulb, would you? From the discussion that will follow the students will be aware of the Law of Conservation of Energy.

Another excellent demonstration that can be used to introduce the unit of physical and chemical properties of matter is as follows: Make a paper box out of smooth wrapping paper about one foot square. Pin the corners, fill it half full of water, and place it over the burner. The students will be very much interested to see that the paper does not burn, instead the water will soon be boiling. After the water has boiled for a time, remove the water and place the box over the flame again. This time the box quickly catches on fire. Why?

Here, again, is an excellent opportunity to develop active interest in physical and chemical properties of matter. There are many other simple demonstrations that might be used in this same manner, the type and extent of these depending upon the experience and initiative of the instructor. Experiments of this sort will be successful because they not only stimulate interest in the new unit, but also, lead the group quickly into the real issues of the unit. From this point the class is ready to continue the study of Unit II.

Unit Analysis

Suggested time: four to five weeks.

Content	Suggested Activities
1. The nature of matter.	1. The nature of matter can be explained by a simple discussion expressing the idea that anything that occupies space and has weight is known as matter. This discussion will bring out the fact that all matter has certain properties, physical and chemical, and may exist in three states; gas, liquid, and solid. Use water as an example.
2. Physical properties of matter	2. Refer to the experiments done on the first day of

a. Color
b. Odor
c. Taste
d. Hardness
e. Density
f. Specific gravity
g. Solubility
h. Conduction of heat
i. Physical changes

this unit. The reason the paper didn't burn was due to its property to transmit heat rapidly from the burner to the water.

The common physical properties of matter can successfully be explained by the use of sulfur and iron powder, illustrating their color, odor, taste, density, and solubility. These two substances are good because they are colorful and can clearly illustrate a physical change by the use of magnets and carbon bi-sulfide. Later on these substances can be used to illustrate a chemical change.

3. Chemical properties of matter
   a. Acid - base
   b. Active - inactive

3. The sulfur and iron can be used again to illustrate a chemical change.

Refer to the first

c. Combining with oxygen
d. Reactions with water
e. Reactions with other reagents

demonstration of the unit and show how chemical changes occurred in the burning of the flash bulb and the paper box.

During a period when observation has been stressed as an important requirement of chemistry perform this demonstration.

Place your finger in a bottle and give the impression that the material tastes extremely good. Pass the bottle to all members of the class requesting they hide their reactions of the taste so that each pupil can observe on the basis of their own reactions.

Did you enjoy the taste? No! Why not? Now watch me again. Place one finger in the soluble saccharine and put another finger into your mouth. Students like demonstrations like this and they help their powers of observation.

4. Composition of matter
    a. Elements
        (1) Metal
        (2) Non-metal

4. Discuss the development of new elements through atomic research.

Refer to the periodic chart at this point, and illustrate how the various elements are related to one another. Point out the difference between a metal and a non-metal. Mention how the metals and the non-metals are named. Symbols should be introduced at this time.

Many interesting reports can be made on elements of special significance to our post-war world. i.e. Iron, aluminum berillium, antimony, chromium, tin, magnesium, copper, silver, uranium, and others.

b. Atoms

(1) Size

(2) Weight

(3) Molecules

Illustrate the size of atoms by stories; i.e. there are so many atoms of hydrogen in one drop of water that if the atoms were as big as the drop they would cover the whole earth with one foot of water. Illustrations of this sort stimulate imagination and create enthusiasm for more knowledge.

Reports on the atom bomb and recent developments with uranium.

c. Compounds and mixtures

Using sulfur and iron powder, repeat the experiments above to illustrate again the difference between a compound and a mixture.

At this time it would be well if formulas of the reactions were written on the

	board, but not required for memorization.
	For review of the terms learned so far, play the twenty question game. A student decides to be a molecule and the rest of the class asks questions to determine what the pupil is thinking. The only answer the person who is "it" can give is yes or no.
5. Solutions a. Water b. Distillation c. Solubility d. Water of crystallization e. Hydrates	5. A challenging demonstration can be executed by having a cup of hot, steaming coffee on the table with sugar and cream in containers near by. Ask the students which they would place in the coffee first and why. Which would be most patriotic in post-war times since sugar is scarce? Ask the pupils to figure out their reasons and present them to the class the next day. A great deal of

chemistry can be learned by this simple experiment and certainly solubility will be a term that will be remembered.

To illustrate the construction of the universal solvent, perform the electrolysis of water demonstration.

Test the local water for hardness. What makes it hard?

Reports on heavy water, and the local water purification methods.

Demonstrate to the class that the boiling point of water changes with changes in pressure.

To illustrate immiscible liquids. Dissolve a small speck of oil soluble dye in 10 ml. of carbon disulfide. Dissolve a speck of some water soluble dye of another color in 10 ml. of water. Pour the two liquids into a large test tube, cork tightly, and shake well. The liquids will separate on standing, each with its own color.

Illustrate diffusion of potassium permanganate crystals in a large cylinder of water.

Discuss how salt may be reclaimed from sea water by crystallization.

6. Purity of substances	6. A discussion of the various types of chemicals that may be purchased at a drug store. i.e. "Tech," "U.S.P.," and "C.P."

Laboratory Suggestions

The first laboratory period of Unit II should be spent learning laboratory methods, and bending glass tubing for future use.

The following experiments are recommended for study in Unit II. These experiments were taken from, "Chemistry and You in the Laboratory," by Hopkins and others, but any of the later laboratory manuals will do just as well.

1. Laboratory Methods.
2. Physical and Chemical Change.
3. Elements, Compounds, and Mixtures.
4. Separating a Mixture into its Components.
5. Distillation.
6. Water Purification.
7. Solutions.
8. Solubility of Sodium Chloride.
9. Hydrates.
10. Quantitative Determination of Water of Hydration.

It is important that the laboratory and the classwork go hand in hand. In fact, the laboratory work must be determined by the progress in classwork. There should never be a laboratory period until the class work warrants experimental evidence to support it.

Evaluation of Unit II

Give frequent examinations throughout the course in chemistry. At least one each week. The anecdotal record should be checked several times each week. During these first units it is well to give a short vocabulary quiz frequently. The vocabulary of chemistry is one of the greatest stumbling blocks for students in the early weeks of the course.

Try this modified True-False test.

Directions: In column I, mark the items true or false using + for true and O for false. If in column I, the item has been marked False, place in Column II the correct word, phrase, formula, or number replacing the incorrect underlined word, phrase, formula, or number.

Example:

Column I	Column II		
O	compounds	1.	Most elements are found in nature as liquids.
+		2.	A substance that can be separated by physical means is a mixture.

If you wish to make the test harder, do not underline the key words.

Materials

Text references:

Ahrens, M. R., N. F. Bush, and R. K. Easley. Living Chemistry. Ginn and Company, Boston, 1942. pp. 17-22, 70-74.

Biddle, H. C., and G. L. Bush. Dynamic Chemistry. Rand McNally and Co., Chicago, 1937. pp. 1-22, 70-85.

Hopkins, B. S. and others. Chemistry and You. Lyons and Carnahan, Chicago, 1939. pp. 1-21, 89-137.

Other references:

Fisk, Dorothy M. Modern Alchemy. D. Appleton-Century Company, Inc., New York, 1936.

Foster, William, The Romance of Chemistry. D. Appleton-Century Company, Inc., New York, 1936.

Jaffe, Bernard. Crucibles. Simon and Schuster, Inc., New York, 1930.

Kendall, James. At Home among the Atoms. D. Appleton-Century Co., Inc., New York, 1929.

Films: (16mm.)

Crystallization. 18 min. Silent. $2.00. #67. Berkeley, California.

Energy and Its Transformation. 11 Min. Sound. $1.50. Corvallis, Oregon.

Oxidation-Reduction. 11 min. Sound. $1.50. Corvallis, Oregon.

Surface Chemistry. 12 min. Sound. $1.50. #3021. Berkeley, California.

Free and Inexpensive Materials:

A Drop of Mercury. A Tube of Glass. Taylor Instrument Company, Rochester, New York. Pamphlet telling the story of the manufacture of the thermometer.

A Short Story of Technical Glassware. Corning Glass Works, Corning, New York. 32 p. Free.

Aluminum Exhibit. Aluminum Cooking Utensil Company, New Kensignton, Pa., or Oakland, California. 21 p. booklet and samples. Free.

In order for pupils to understand chemical reactions and to appreciate why some elements have combining power and some do not, they will need to learn the structure of the atoms.

Suggestions to Teachers

1. This unit requires careful teaching. The student must have a clear understanding of the structure of matter before he can begin to understand chemistry. Do not hurry through this unit. Be sure the material is being understood by your pupils. If this unit is well presented and the students really understand it, they will find the remaining weeks of chemistry easy.
2. Since this unit is mostly theory the teacher will need to use as many interest-getting devices as possible. Keep your pupils stimulated and show them that the study of atoms, ions, electrons, protons, can be fun and is lively and interesting.
3. Be sure you convey to the class that you enjoy teaching chemistry, and especially you enjoy teaching these particular students before you.

Objectives of Unit III

1. To develop within the student a functional understanding of the structure of molecules and atoms.

2. To be able to understand and use molecular and atomic weights as they apply to every day chemistry.
3. To develop an understanding of valence and how atoms combine to form compounds.
4. To be able to work simple problems that are necessary in applying chemistry to everyday situations.

Suggested Approach

On the demonstration desk have a clean large battery jar full of water. With the class watching, place one drop of red dye in the jar of clean water and note what happens. As the coloring matter distributes itself around the jar ask the students to explain how this could be when there are no currents within the jar to move the color around.

There will be several theories presented, but do not give the class a true explanation at the moment. Have all the students that think Jack's explanation is correct get together and prepare their reasons for their theory. Those students that believe John's answer is better, go with John to another corner of the room and work out their list of reasons to support their view. There may be only two groups or there may be six. Encourage them to work out their explanations and present their reasons to the class at the end of the period if there is time, or the next day.

A great deal of interest and enthusiasm will immediately be created by this simple demonstration. It provides an excellent approach to the discussion of the theory of moving molecules.

A bottle of ammonia may be uncorked and soon the odor is at the rear of the room. Why? The table looks solid, and it is very stationary, is it?

<u>Unit Analysis</u>

Suggested time: two to three weeks.

Content	Suggested Activities
1. The theory of moving molecules.	1. Inflate two ballons until they are the same size. Hold one over a source of hear and note that it increases in size. Why? Recall the discussion developed in the approach to this unit.
2. Structure of the atom.	2. Have students make models of the atoms. Toothpicks and squares of colored paper may be used to make atomic models. Many diagrams of the atoms should be made on the blackboard showing how the

electrons appear in their outer orbit.

A great many interesting reports can be made about this material. Refer to, Kendall, "At Home Among The Atoms."

3. Atomic numbers

3. Drill will be required to learn the arrangement of the electrons around the nucleus of the atom, and learn the atomic numbers of some elements.

4. Atoms may form compounds
   a. Valence
   b. Electron theory explains valence.
   c. Formula writing.

4. Use the periodic chart in these explanations.

Point out that a knowledge of a few valences will aid in learning others.

Drill in formula writing is very necessary. Make a game of this drill. Divide the class in groups and pit one against the other. If the class is evenly divided, have the boys compete against the girls.

Play the game called, "Valence," it is lots of fun and a great deal of chemistry can be learned in a pleasant way.

5. Determining molecular weights
   a. Gay-Lussac's Law
   b. Avogadro's Law
   c. G.M.W.
   d. G.M.V.
   e. Percentage composition

5. Have students visit the local drug stores and chemical houses and see if the chemist has any use for this type of calculation.

Furnish many problems for the students to work so the mathematics and the terms G.M.W. and G.M.V. will be clearly understood.

Make it clear to the student that he will have need of this type of work later on in the course as well as right now. How can you determine a good buy in household ammonia? You will need to know how to do simple calculations as illustrated in this unit in order to answer questions like the one above.

Make a game for the drill as often as possible. There is another good chemistry game called, "Kem-Check," which will give drill in learning atomic weights, valences, grouping of elements according to families, combinations of elements in formulas, the displacement series, and chemical reactions.

This game may be had for fifty-cents by writing to, Sister Cecilia Louise, Notre Dame High School, Wellington and Mango Avenue, Chicago, Illinois.

Laboratory Suggestions

The following experiments are recommended for study in Unit IV. These experiments were taken from, "Chemistry and You in the Laboratory."

1. Molecular Weight of Oxygen.
2. Experimental Determination of a Formula.

3. Percentage Composition.

4. Finding the Valence of a Metal.

Evaluation of Unit III

Give frequent vocabulary quizzes during the study of this unit.

A game that can serve as a testing device as well as excellent review, can be played in the following manner. A student is chosen who thinks of an element or a chemical term and the rest of the class ask questions that can be aswered by the person who is "it" by "yes" or "no." This game requires a great deal of knowledge by the pupils taking part. Grades can be recorded on the basis of the questions asked and answered.

Give at least one test in each unit on applying principles. An example of this type of examination is found in Unit IV.

Make a check list to determine students creativeness in action. Place a check mark in the column opposite the student's name when the behavior is noted.

Creativeness Check Sheet

Student	Design of Apparatus	Outline of Experiment	Organization of material	Originality
A.				
B.				

The list of traits may be expanded to suit the instructor. Laboratory work is an important part of the course and this form offers a convenient wat to check students' creativeness.

Materials

Text references:

Living Chemistry. pp. 39-45.

Dynamic Chemistry. pp. 23-29, 116-151.

Chemistry and You. pp. 139-175.

Other references:

Foster, William. The Romance of Chemistry. D. Appleton-Century Company, Inc., New York, 1936.

Harrow, Benjamin, The Romance of the Atom. Boni and Liveright, New York, 1927.

Langdon-Davies, John. Inside the Atom. Harper and Brothers, New York, 1933.

Thomson, J. Arthur, The Outline of Science. G. P. Putman's Sons, New York, 1922.

Films: (16 mm.)

Electrochemistry. 11 min. Sound. $1.50. Corvallis, Oregon.

Electrons. 11 min. Sound. $1.50. Corvallis, Oregon.

Molecular Theory of Matter. 11 min. Sound. $1.50. Corvallis, Oregon.

Free and inexpensive materials:

Chemical Products in the United States. 1936. Silver, Burdett Co., 45 East 17th Street, New York City. Free. Outline map of the United States showing chemical products and mineral resources in each state.

The atmosphere contains many gases that are indispensable to man. In this unit these important gases are studied showing their relationship to man and his world.

Suggestions to Teachers

1. There is a tendency to settle down to a "cut and dried" routine after the students have come this far. Guard against this!
2. Use many interest-getting devices. This unit offers offers excellent opportunity to use stimulating experiments and demonstrations.
3. Games used in your presentation, in reviews, and in examinations are very successful.
4. Have a large chart of the activities series made, and introduce it early in this unit.

Objectives of Unit IV

1. To understand the part that oxygen plays in maintaining life.
2. To gain a knowledge of the preparation of oxygen and hydrogen.
3. To understand how hydrogen serves in our daily life needs.
4. To discover the practical uses of hydrogen and oxygen.

5. To understand how ionization aids in explaining chemical reactions.

Suggested Approach

Place on the demonstration desk an empty milk bottle, a spoon, two matches, and a hard boiled egg with the shell removed. Ignore the bottle and egg until you think the class is sufficiently curious, then ask for volunteers to put the egg into the bottle without breaking it. Be sure to ask if anyone knows how to do the trick. The ones that know how will please keep silent. If a student does the experiment correctly, have him explain how and why the egg went into the bottle.

As soon as the egg is in the bottle someone is sure to ask how can one get it out without breaking the egg. This seems to be a greater problem. If no one can figure the solution, give the class until the next day to work out methods for removing the egg without breaking. When the egg is removed be sure the student explains how and why he was able to cause it to come out of the bottle.

Place the egg in the neck of the bottle after inserting a lighted match. When the match goes out the egg will slowly pop in. Atmospheric pressure forced the egg in after the oxygen had been used up by the burning of the match. If one match won't work light a piece of paper and drop it in. Mention the expansion of gases as a possible answer as to why the egg entered the bottle.

To remove the egg: first work the match out and then turn the bottle upside down until the egg is resting firmly in the neck. Press the opening of the bottle firmly over your mouth and puff hard. The increased air pressure inside the bottle will force the egg out. Be sure to catch it.

This demonstration offers an excellent introduction to the subject of air pressure, oxygen content of the atmosphere, etc.

Another successful demonstration that will stimulate interest can be done by filling a glass full of water, covering it with a piece of paper, and inverting over the sink. After removing the hand the paper will hold the water in the glass. Ask for volunteers. If they can do the trick, have them explain why the water remains in the glass.

Even if the students know how to do these tricks before they come to class, they enjoy doing them, and the demonstrations still retain their teaching value.

Unit Analysis

Suggested time: four to five weeks.

Content	Suggested Activities
1. Air and its composition	1. Student reports on the uses of carbon dioxide, argon, neon, helium, krypton, and xenon. Have a student prove to the class that air is a true mixture that has very definite properties. Student reports on stratosphere flights, why some were successful and some failures. Illustrate atmospheric pressure by boiling a small amount of water in a gallon can, and then quickly put the cover on the can after removing from the heat. The can is flattened as soon as the air cools inside. If possible, have a liquid air demonstration.
2. Oxygen a. Discovery	2. Reports on the discovery of Oxygen, Priestley and

b. Hideouts

c. Preparation

d. Properties

e. Uses

f. Reactions in life

(1) Burning

(2) Oxidation

Lavoisier offer a good introduction to this study.

A problem: Who can pour air up hill? This question constitutes quite a problem and demonstrates the fact that air occupies space. Give the class overnight to figure out a method.

Solution: Invert a glass full of water in a large pan, and a glass full of air inverted along side of the one filled with water. Tilt the air tumbler down under the water tumbler and the air will pour up hill into the glass filled with water.

Ask a student to demonstrate whether or not dioxides, other than manganese dioxide, are catalysts with potassium chlorate in the preparation of oxygen. Use barium dioxide, lead dioxide, silicon dioxide, and tin dioxide.

A demonstration! The class has prepared oxygen in the laboratory by heating mercuric oxide. Ask a student if other simple oxides do the same, such as, copper oxide, lead oxide, iron oxide, and magnesium oxide. Have a pupil come to the desk and try one of the oxides and other pupils try the other oxides. Why didn't all the oxides give off oxygen? Ask another student to point out the location of mercury in the displacement series. The students will now be able to answer the original question. A good teaching method!

Use the displacement series to make chemistry easier, that is what the series is for.

Ask a student to demonstrate oxidation and prove the approximate amount of oxygen in the air.

Reports on dust explosions, spontaneous combustion, and fire fighting in the city, and in the woods.

A display of the results of oxidation, such as, a rusted piece of pipe, an unpainted board, etc..

3. Hydrogen
   a. Discovery
   b. Hideouts
   c. Preparation
   d. Properties
   e. Uses
   f. Activities series

3. Report on the difference between helium and hydrogen in dirigibles.

An investigation: Ask a student to demonstrate the following. In the reaction between zinc and sulfuric acid, do other metals act as well as zinc? In which case, using iron, copper, tin, magnesium, or lead, is hydrogen produced? Which metals fail to react? What is the position of the reacting and the non-reacting metals in the displacement series?

A good teaching device. Requires student to think, and it illustrates the practical value of knowing how to use the displacement series.

4. Ionization
   a. Theory of
   b. Electrolytes
   c. Non-electrolytes
   d. Strength of solutions determined by degree of ionization

4. Demonstrate the electrolysis of water.

Use a conductivity apparatus to test difference between an electrolyte and a non-electrolyte.

Have a review of vocabulary and chemical terms by use of this game. Write on the blackboard an arrangement of letters like this:

1. nori
2. reppoc
3. lversi
4. trolecelyte
5. etc.

The student is to name element or chemical term, define,the term, or give a physical or chemical property of the element named. The answers of the above are: iron, copper, silver and electrolyte. The words are arranged in almost any way you wish, and the students enjoy deciphering the words, making pleasure out of a drill period.

Laboratory Suggestions

The following experiments are recommended for study in Unit III. These experiments were taken from "Chemistry and You in the Laboratory."

1. The Gases of the Air
2. The Percentage of Oxygen in Air
3. Oxygen from Compounds
4. The Properties of Oxygen
5. Hydrogen from Compounds
6. The Properties of Hydrogen

Insist that your students be neat and orderly in their laboratory work. Expect them to know what they are doing at all times. Close supervision must be given each student in these first weeks of their study of chemistry so that bad habits are corrected and good laboratory technique developed.

Evaluation of Unit IV

Do not rely too much on the conventional type examinations. We overwork true-false, completion, and essay type examinations. There are other good ways of testing that we should use along with the conventional type examinations.

Testing application of principles:

Make an examination consisting of situations on one side of the page and principles that could apply on the other side.

For example:

1. Manganese dioxide is mixed with potassium chlorate in the preparation of oxygen.	1. The rate of chemical change is increased by presence of a catalyzer.
2. A photo-flash bulb weighs the same before and after burning.	2. Energy can be neither created or destroyed.
3. etc.	3. During a chemical reaction an element may lose or gain electrons.

Use the game "arrangement of letters" that was suggested in this unit as a means of learning vocabulary.

Materials

Text references:

Living Chemistry. pp. 52-69.

Dynamic Chemistry. pp. 37-70.

Chemistry and You. pp. 22-87.

Other references:

Berry, Pauline G. Stuff. D. Appleton-Century Co., New York, 1930.

Foster, William. The Romance of Chemistry. D. Appleton-Century Co., New York, 1936.

Holmes, Harry N. Out of the Test Tube. Ray Long and Richard R. Smith, Inc., New York, 1934.

Kendall, James. At Home Among the Atoms. D. Appleton-Century Co., Inc., New York, 1929.

Films: (16 mm.)

Carbon - Oxygen Cycle. 10 min. Silent. $1.00. #816. Berkeley, California.

Catalysis. 11 min. Sound. $1.50. Corvallis, Oregon.

Dangerous Dusts. 11 min. Sound. $0.50. Terrific explosions caused by dust. Corvallis, Oregon.

Oxidation - Reduction. 11 min. Sound. $1.50. Corvallis, Oregon.

Velocity of Chemical Reactions. 11 min. Sound. $1.50. Corvallis, Oregon.

Free and inexpensive materials:

Carbon Dioxide. Liquid Carbonic Corporation, 3100 Kedzie Avenue, Chicago, Illinois, Free.

a. Folder describing the production of carbon dioxide and its uses.
b. The uses of Carbon dioxide. 8 p.
c. A glimpse of the liquid carbon dioxide industry. 7 p.

Our Ocean of Air. B. M. Parker. 36 p. 1941. Row, Peterson and Company, Evanston, Illinois. $0.28.

The Zinc Industry. Earnest V. Gent. 30 p. 1940. The American Zinc Institute, Inc., New York City. Free.

Many students have the impression that formulas and equations complicate the study of chemistry making it dull and harder to understand. On the contrary, if presented correctly, their study will be far easier because of their knowledge of formula and equation writing.

<u>Suggestions to Teachers</u>

1. By this time the students already know a great many symbols, formulas, and perhaps a few equations. Make every effort to recall this knowledge as this unit is studied.
2. Keep the students' viewpoint! Refrain from using technical words beyond their comprehension.
3. Give your pupils as much individual help and encouragement as possible. Don't allow this unit to become a week or two of dull drill.
4. Stimulate their thinking with several thought provoking questions. Keep them on their toes!

<u>Objectives of Unit V</u>

1. To develop the ability to write balanced equations correctly.
2. To develop an understanding and use of the different types of chemical reactions.

3. To be able to determine how much you will get from reactions.

Suggested Approach

Have written on the blackboard when the class enters, a description of a chemical reaction. On the opposite side, have the equation written. This offers an excellent contrast and clearly illustrates the need for formulas and the writing of equations. For example:

Carbon burns by uniting with oxygen. Carbon dioxide, a gas, is formed. In order to burn 12 pounds of carbon 32 pounds of oxygen are needed, 44 pounds of carbon dioxide are formed by the combination.

$$C + O_2 \rightarrow CO_2\uparrow$$

To illustrate how a formula may simplify matters, use water as an example. The composition of water consists of two parts of the element hydrogen, by volume, united with one part of oxygen, by volume, or 88.11 per cent oxygen, by weight, combined with 11.19 per cent hydrogen, by weight.

The two illustrations above will certainly make it clear to the student that formulas and equations do make his work much easier.

Unit Analysis

Suggested time: two to three weeks.

Content	Suggested Activities
1. The law of conservation of matter	1. Recall to the class their knowledge of the law of conservation of matter, and illustrate how it is applied to the writing of equations.
2. What must be known in o order to write equations?	2. After discussing this problem, present the class with a thought-provoking problem such as this: Place one-quarter pound of salt on the demonstration desk, along with several sheets of large notebook paper, and a balance with no weights. The ten-gram scale cannot be used. Determine accurately how much salt will weigh one

ounce. Students like problems of this type. These demonstrations stimulate thinking and arouse interest for more chemistry.

Try it. You will find it works.

3. Writing balanced equations

3. Make use of equations that have been presented earlier in the course. Review them and have the pupils practice writing equations.

4. Types of chemical reactions
   a. Synthesis
   b. Decomposition
   c. Displacement
   d. Double decomposition
   e. Oxidation - reduction reactions

4. The basic principles of writing these equations are simple, but the students will need plenty of drill.

Some students will need more help than others so be sure to give as much personal aid to the slower pupils as is practical.

5. Equilibrium - What is going to happen?
   a. Reversible reaction
   b. Completion reactions

5. Equilibrium will require careful instruction and pupils will need lots of practice with this type of reaction.

6. How much will you get? a. Weights of chemicals b. Volume of gases	6. Do many drill exercises on simple problems involving gram molecular weight and gram molecular volume.

Laboratory Suggestions

The following experiments are recommended for study in Unit V. These experiments were taken from "Chemistry and You in the Laboratory."

1. Using Equations
2. Titration
3. Double-Decomposition Reactions
4. Combinations and Decompositions
5. Simple Displacements

Experiments like these will help the student see the practical value of knowing how to use equations and be able to write balanced equations.

Evaluation of Unit V

The evaluation in this unit will have to be predominantly working problems and writing formulas and equations. However, the use of check sheets for attitudes and creativeness should be used during this unit.

As another means of evaluation, encourage your students to keep diaries of reading and research they are doing out-side of class. This record is valuable for student self-evaluation and illustrates cooperation between teacher and student.

Materials

Text references:

Living Chemistry. pp. 46-51, 78-92.

Dynamic Chemistry. pp. 107-122.

Chemistry and You. pp. 228-259.

Other references:

Caven and Cranston. Symbols and Formulas in Chemistry. Blackie and Son, Ltd., London, 1928.

Jaffe, Bernard. Chemical Calculations. World Book Company, Yonkers-on-Hudson, New York, 1931.

Kendal, James. At Home Among the Atoms. D. Appleton-Century Company, Inc., New York, 1929.

Films: (16 mm.)

Chemistry in a Changing World. 11 min. Sound. $1.50. Corvallis, Oregon

Energy and Its Transformation. 11 min. Sound. $1.50 Corvallis, Oregon.

Story of a Storage Battery. 22 min. Silent. $0.50. Corvallis, Oregon

Velocity of Chemical Reactions. 11 min. Sound. $1.50. Corvallis, Oregon.

Free and inexpensive materials:

Aluminum: Its Story. 45 p. 1940. Aluminum Company of America, Gulf Building, Pittsburg, Pennsylvania. Free. Also ask for, "Outline of Aluminum." 50 p. 1940.

In the study of this unit the student will realize how the chemist classifies the thousands of different chemical compounds found in inorganic chemistry.

Suggestions to Teachers

1. Take every opportunity available to apply the material being studied to the world in which the student is familiar. When studying acids use illustrations that will be meaningful to students, refer to acid spot removers that can be found and used at home.

   There is very little need of being too technical in this unit, so guard against this tendency.
2. Speak in a language the pupils can understand.
3. Use competitive devices throughout this unit.

Objectives of Unit VI

1. To develop an understanding of how a chemist classifies chemical substances in an orderly, definite manner.
2. To develop a familiarity with, and to be able to recognize, acids, bases, and salts.
3. To become aware of the use of many of these compounds in daily living.
4. To learn general methods of preparing the compounds of each of these groups.

Suggested Approach

Let's take a field trip! To introduce this unit on acids, bases, and salts, take the class through one of the neighborhood grocery stores. When this is suggested to the class, there will be remarks to the effect that there are no chemicals in a grocery store. However, instruct each pupil to take paper and pencil, and as the class passes through the store, write down every acid, base, and salt they see in the grocery. Some may not find any but table salt, but others will discover a great many more.

This trip to the store will bring chemistry out of the classroom right into a world that is familiar to every student. This is a good place to keep this study of acids, bases, and salts, -- right before the pupil in his home and in his community.

A problem to introduce this unit would be as follows: Place a beaker of dry salt and one of dry sugar on the demonstration desk along with an evaporating dish, tripod, matches, Bunsen burner, and wire gauze. Ask a student to come forward and determine which is salt and which is sugar without tasting either substance. A discussion of the physical properties of salt would certainly result from this problem.

Unit Analysis

Suggested time: five to six weeks.

Content	Suggested Activities
1. Acids a. Mineral b. Organic c. General properties of acids (1) Taste (2) Effect on indicators (3) Hydrogen ion (4) Effect on metals	1. Make a display of various mineral acids in containers along side of organic acids. Illustrate on the blackboard how some of the common acids ionize in solution. i.e. HCL ionizes $\rightarrow \overset{+}{H} + \overset{-}{CL}$ Have students find as many chemical terms as possible that are used in modern advertising.
2. General preparation of acids	2. The two general methods of preparing acids should be well developed.
3. Common acids and their importance a. Hydrochloric	3. Ask the class to give you some general properties of muriatic acid. Some will not know that hydrochloric acid is used in soldering. The yellow color of muriatic acid is due to organic substances

or a trace of iron. Some tinsmiths call muriatic acid by the very old name of spirit of salt.

b. Nitric acid

Reports on the various uses of nitrogen, explosives, fertilizers, nitrogen fixation, etc..

Investigate ammonia gas as a refrigerant.

Have a student make a chart illustrating the nitrogen cycle.

Ask a student to investigate why nitric acid will turn the skin yellow. It is due to the xanthoproteic reaction, forming xanthoproteic acid.

c. Sulfuric acid

Have a student prepare the various forms of sulfur for a class demonstration.

A report on the Frasch process of mining sulfur.
Try to interest a pupil in making a model illustrating

the process.

Sulfuric acid is the most powerful of the inorganic acids.

Report on the importance of sulfur in industry.

d. Carbonic acid.

An acid all students are familiar with, in soda pop.

e. Acetic acid.

Reports on the use of acetic acid in the textile industry.

Be sure to refer to the field trip to the store from time to time as common acids are mentioned, such as vinegar and citric acid.

Plan a laboratory period that will be free to the student to investigate any problem he may wish to solve or attempt to solve.

4. Bases - Hydroxides
   a. Taste
   b. Effect on indicators

4. Have a display of the common bases in their natural containers, such as lime, ammonia, magnesia, lye, etc.

c. OH ion

d. Effect on fats

e. Neutralization

Ask the class how many of the above bases were on their lists as they went through the store on the first day of this unit.

Reports on the different types of soaps made by the use of NaOH and KOH. NaOH producing the hard s soaps and KOH the soft soaps.

5. Common bases and their importance

   a. Lye

   b. Caustic potash KOH

   c. Ammonium hydroxide

5. Have a report on the use of cocoanut oil in making marine or hard water soaps.

   Prepare a map or maps of chemical industries or products.

   Project: Have a student analyze household ammonia.

6. Salts

   a. Importance

   b. Formation

   c. Naming salts

   d. Properties

      (1) Physical

      (2) Chemical

6. Project: Make a chemical garden using water glass as the solution and add one or two pieces of any of the following salts: copper sulfate, ferric sulfate, cobalt sulfate, calcium nitrate, or nickel sulfate, manganese

sulfate, or aluminum sulfate. For best results the solution should have a specific gravity of 1.1. Ask the pupils to explain how the garden grows.

If iron sulfate was used, the iron sulfate solution reacts with the sodium silicate and forms insoluble iron silicate in the shape of a film or sac. The sac is filled with iron sulfate and then osmosis occurs, and the sac builds up to the top of the solution or until the liquid is exhausted.

Have a student make an ammonia fountain and ask him to explain it to the class.

In order to avoid confusion by the great number of acids, bases, and salts just learned, play many games as a review and for fun. Play the game, "Who am I," where a student stands before the class, calling on various members of the group to define or tell something about the acid, base, or salt that has been written on the blackboard behind the student who is "it." If the person who is "it" can tell from the information given to him from the group, what is written on the board, he may write a chemical term to try and "stump" the next person who is to be "it."

Laboratory Suggestions

The following experiments are recommended for study in Unit VI. These experiments were taken from "Chemistry and You in the Laboratory."

1. Hydrogen Chloride.
2. Acids and Bases.
3. Neutralization.
4. Conductivity of Solutions.
5. Electrolysis.
6. Hydrolysis of Salts.

7. Sulfuric Acids and Metals.
8. Some Reactions of Sulfuric Acid.
9. Nitric Acid.
10. Oxides of Nitrogen.

Make every effort to supervise the experiments as closely as possible. Insist the students know what they are doing before starting an experiment.

Encourage students to set up and develop experiments not found in the laboratory manual.

Evaluation of Unit VI

Take a field trip to the same grocery store to see how many acids, bases, and salts can be recognized now that the students have completed their study of this unit. It will serve as a student check as to the number of new things he will have on his list this time as compared with the first trip.

Make it a point to interview each of your students. Check on their progress in a friendly interested manner. This can be an excellent evaluation procedure if done properly. Under no circumstance must the interview be a direct quiz of the student's knowledge.

Use essay type examinations occasionally to test principles. Use questions such as this: What will happen if acid foods are cooked in aluminum pans?

To test for facts, use completion, multiple,choice, and matching type questions. Evaluate student projects that were completed in the unit.

Materials

Text references:

Living Chemistry. pp. 93-120.

Dynamic Chemistry. pp. 161-205, 234-256.

Chemistry and You. pp. 177-227, 285-300, 363-399.

Other references:

Fabre, Jean-Henri. The Wonder Book of Chemistry. D. Appleton-Century Company, Inc., New York, 1923.

Howe, H. E. Chemistry in Industry. Vol. I. The Chemical Foundation, Inc., New York, 1925.

Slosson, Edwin E. Creative Chemistry. D. Appleton-Century Company, Inc., New York, 1919.

Films: (16 mm.)

Invaluable Ingredient. 20 min. Sound. $0.50. Salt. Corvallis, Oregon.

Refrigeration. 10 min. Sound. $1.00. #222. Berkeley, California.

Sulphur. 18 min. Sound or Silent. $0.50. Corvallis, Oregon.

The Story of Soap. 1 reel. Silent. $0.50. Pullman, Washington.

Free and inexpensive materials:

Electron Theory of Acids and Bases. W. F. Tuder. 39 p. 1940. Northwestern University, 360 Huntington Avenue, Boston, Mass. Free.

History of Salt. 32 p. Morton Salt Company, Chicago, Illinois, Free.

The Miracle of Ice from Heat. Servel Inc., Servel Electrolux Sales Division, 51 East 42nd Street, New York City. 25 p. Free.

The Modern Ice Refrigerator. Eleanor Howe, Household Refrigeration Bureau of the National Association of Ice Industries, 228 N. La Salle St., Chicago, Illinois. 22 p. Free to teachers.

Water Softening Material. The Permulite Company, 330 W. 42nd St., New York City. Free. A glass demonstrator tube along with several bulletins on filters and water softeners is provided. Write for list.

The importance of carbon in industry and in all walks of life will be realized by the student through a study of this unit.

Suggestions to Teachers

1. Encourage your students to devise experiments of their own.
2. Organic compounds are very interesting to most students. Help them to appreciate the many ramifications of this subject.
3. Encourage your students to read and report on the many interesting phases of organic compounds. i.e. The diamond industry, coal tar dyes, etc..
4. Students should be urged to design displays that involve the scientific method of thinking than merely presenting illustrative material.

Objectives of Unit VII

1. To cultivate a general understanding of some of the fundamentals of organic chemistry.
2. To understand the refining of petroleum and the preparation of gasoline and allied products.
3. To develop an appreciation of the number of compounds that illustrate the great variety and valuable uses of carbon and its compounds.

Suggested Approach

Perform the self-inflating balloon demonstration that was suggested as an interest arouser for the first day laboratory period. Ask the group for an explanation. The discussion will introduce acetylene gas, its preparation, and its uses.

A demonstration: Use this to stimulate thinking. It has no real connection to this unit. Place some zinc in the bottom of large cylinder and add a salt solution of dilute hydrochloric acid. Place several moth balls in the solution and they will rise to the surface and sink back down again. This will go on almost indefinitely if the salt solution is slightly less than that of the moth balls.

The zinc releases hydrogen which collects on the balls causing them to rise to the surface where the hydrogen is lost to the air and down come the moth balls. This demonstration is an interest-getter. Students are really curious as to why the balls keep moving. It is better to have the experiment working before class, and let the students call your attention to the strange occurrence.

Pupils can do this trick at home with a quart of water, with four teaspoonsful of crystals of citric acid and four teaspoonsful of ordinary baking soda, added to the water.

Unit Analysis

Suggested time: Three to five weeks.

Content	Suggested Activities
1. Petroleum a. General properties b. Fractional distillation c. Cracking process d. Hydrogenation	1. A week before this unit is presented have several students prepare reports on the more spectacular phases of this subject. Reports on the analyne dyes, Cracking process, carbon black plants, synthetic perfumes, forms of carbon, etc.. Someone in every chemistry class is waiting for this opportunity to test various gasolines and fuel oils. Encourage the pupil to demonstrate his experiments to the rest of the class. An excellent book for this type of experiment is, "Test It Yourself,"(40) by Tuleen - Muehl - Porter. This book is explained in

great detail in the next unit.

2. Gases
   a. Natural
   b. Artificial
      (1) Water gas
      (2) Producer
      (3) Acetylene gas

2. Have a student report on the type of gas used in the laboratory. How it was prepared and its uses.

   Send a pupil to the local welding shop or agriculture shop to report on how acetylene welding works.

   Interest your class in performing experiments on how to get the most heat out of fuels and various heat values of different types of fuel.

   Build a model of a coal gas plant and explain it operation.

3. Hydrocarbons
   a. Structure
   b. Methane series
   c. Ethylene series
   d. Acetylene series

3. Project: Build model molecules from wire and colored balls to represent the various atoms. These are fun to make and help understanding

e. Benzene series

f. Reactions of hydrocarbons

(1) Unsaturated

(2) Saturated

of organic structure.

A demonstration: Boil water in a half-filled litre flask, stopper the flask and invert. After the boiling stops, place a large piece of ice on top of the inverted flask. The liquid boils again. Apply heat to the top and the boiling stops. Why?

4. Alcohols

a. Wood

b. Grain

c. Denatured

d. Structure of

(1) Glycerol

(2) Phenol

e. Uses

(1) Antifreeze

(2) Solvents

4. Have a report on the alcohol plant at Springfield, Oregon.

Reports on alcohol as a solvent.

Reports on the many uses of alcohol in industry and elsewhere.

A 48 page booklet may be had free from the U.S. Industrial Alcohol Company, 110 East 42nd. Street, New York City.

5. Products of Alcohols

a. Formaldehyde

b. Formic acid

c. Acetaldehyde

5. Have a student perform an experiment to determine the amount of acetic acid in vinegar. Use, "Test It

d. Acetic acid

e. Vinegar

6. Organic Acids
   a. Formation
   b. Butyric
   c. Citric
   d. Lactic
   e. Oxalic
   f. Salicylic

7. Esters
   a. Formation
   b. Uses
      (1) Flavoring
      (2) Solvents
      (3) Explosives

8. Fats
   a. Liquid
   b. Solid
      (1) Crisco
      (2) Snowdrift
      (3) Spry
      (4) Oleomargarine
   c. Linseed oil
      (1) Uses
   d. Hydrolysis

Yourself," by Tuleen - Muehl - Porter. (40)

Reports on fermentation.

6. Investigations concerning the organic acids in the form of reports.

7. Correlate this material with the laboratory work on esters.

Don't expect your students to know all the structural formulas of these esters.

8. Perform experiments to determine how water can be softened. What are the characteristics of water softners?

Write to Berry Brothers, 211 Leib Street, Detroit, Michigan, for a free booklet on Varnish, Gums, and

e. Soaps
   (1) Preparation
   (2) Uses

Varnishing.

Along with the laboratory experiments of making soap, perform experiments on the testing of soaps.

9. Carbohydrates
   a. Simple sugars
      (1) Glucose
      (2) Levulose
      (3) Reducing
   b. Double sugars
      (1) Sucrose
      (2) Lactose
   c. Complex carbohydrates
      (1) Starch
      (2) Cellulose

9. Encourage students to investigate how the various sugars are obtained, manufactured, and used.

Material can be obtained free from large sugar refining companies such as, California and Hawaiian Sugar Refining Corporation, San Francisco, California.

10. Cellulose
    a. Paper making
       (1) Parchment
       (2) Cellophane
       (3) Film

10. Many interesting displays and reports may be made concerning cellulose, for example, an exhibit showing the various steps in manufacturing paper.

Laboratory Suggestions

The following experiments are recommended for study in Unit VII. These experiments were taken from "Chemistry and You in the Laboratory."

1. Hydrocarbons: Methand, Acetylene, Benzene.
2. Alcohols and Their Oxidation Products.
3. Esters.
4. Making Soap.
5. Tests for Carbohydrates
6. Transformation of Carbohydrates

Evaluation of Unit VII

A check list on cooperativeness can be prepared like the other check lists presented. Check such items as, close attention to discussion, cleaning up the laboratory desk, helping students, care of room, courtesy to person speaking, and any other that may be desired.

Observational and problem solving test may be made. Set up a generator on the desk with all the equipment for making carbon dioxide. Ask the class to write their reasons why no carbon dioxide is collected in the bottle inverted over the water. No carbon dioxide forms in the container because the thistle tube is placed so it is above the level of the liquid in the generator allowing the gas to escape. Many tests of this type should be used.

Materials

Text references:

Living Chemistry. pp. 131-136, 359-371.

Dynamic Chemistry. pp. 597-666.

Chemistry and You. pp. 460-531.

Other references:

Clarke, Beverly L. Marvels of Modern Chemistry. Harper and Brothers, New York, 1932.

Darrow, F. L. The Story of Chemistry. Blue Ribbon Books, Inc., New York.

Foster, William. The Romance of Chemistry. Appleton-Century Co., New York, 1936.

Holmes, H. N. Out of the Test Tube. Ray Long and Richard R. Smith, New York, 1937.

Howe, H. E. (Editor). Chemistry in Industry. The Chemical Foundation, Inc., New York, 1924-25, 2 vols.

Rogers, Allen. Manual of Industrial Chemistry. D. Van Nostrand Co., New York, 1931, 2 vols.

Slosson, Edwin E. Creative Chemistry. D. Appleton-Century Co., New York, 1930.

Tilden, W. A. Chemical Invention and Discovery in the Twentieth Century. E. P. Dutton and Co., New York, 1936.

Films: (16 mm.)

Fourth Kingdom. 30 min. Sound. $0.50. Plastics. Corvallis, Oregon.

Fuels and Heat. 12 min. Sound. $1.50. #2725. Berkeley, California.

Lubrication. 30 min. Sound. $0.50. Corvallis, Oregon.

Modern Metal Working with Oxy-acetylene Flame. 2 reels. Silent. $0.50. Pullman, Washington.

New Worlds Through Chemistry. 2 reels. Sound. $0.50. Nylon. Pullman, Washington.

Oil From the Earth. 22 min. Sound. $0.50. Corvallis, Oregon.

Oil For Aladdins Lamp. 33 min. Sound. $0.50. Corvallis, Oregon.

Oxwelding in Industrial Production. 2 reels. Silent. $0.50. Pullman, Washington.

Petroleum and Its Uses. 40 min. Sound. $0.50. Corvallis, Oregon.

Romance of Rubber. 2 reels. Silent. $0.50. Pullman, Washington.

Story of the Tire. 2 reels. Silent. $0.50. Pullman, Washington.

Sugar. 2 reels. Sound. $0.50. Pullman, Washington.

Synthetic Rubber. 2 reels. Sound. $0.50. Pullman, Washington.

Willard and You. 30 min. Sound. $0.50. How Storage batteries are made. Corvallis, Oregon.

Free and inexpensive materials:

Cottonseed and Its Products. 34 p. 1941. National Cottonseed Products Association, Inc., 731 Sterick Building, Memphis, Tennessee. Free.

Industrial Alcohol. United States Industrial Alcohol Company, 60 E. 42nd St., New York City. Free.

Oxy-acetylene Welding and Cutting - The Universal Tool of all Industry. Linde Air Products Co., 205 E. 42nd St., New York City. 12 p. Free.

Petroleum. Clara Tutt. Unit Study Book No. 553. 32 p. 1939. American Education Press, 400 South Front Street, Columbus, Ohio. $0.15.

The Preparation of Synthetic Organic Chemicals. Eastman Kodak Company, 343 State Street, Rochester, New York. Free.

The Story of Manufactured and Natural Gas.
American Gas Association, 420 Lexington Avenue, New York City. Free.

The student has now reached the point where he is able to apply his knowledge of chemistry to the world in which he lives.

Suggestions to Teachers

Through a careful study of the preceding units the class has acquired a foundation of chemical knowledge upon which they can build in fields in which they are most interested.

Each student is to prepare a list of their needs which they think can be met through a study of chemistry. These lists are collected and organized by a student committee. They are grouped in such a manner that investigations which are similar in nature are in the same group.

The purpose of grouping the questions is to keep the whole class working on subjects that are somewhat alike. The committee has copies of the investigations placed in the hands of each student. The entire class will start their work in the same general division. For example: In most chemistry classes there will be an assemblage of studies on household chemicals and cleansers. The entire class will then begin their investigation of their particular problem involving household chemicals and cleaners.

If two students have the same problem they may work together or they may work independently, whichever the teacher thinks is best.

Each pupil should be required to keep a record of his research, including a brief review of the preliminary readings, the experiments, the results, and the conclusions.

Since these problems were real to each student, they will have value for the rest of the class. At the completion of their work, each pupil will make an oral report to the class concerning his experiment.

Objectives of Unit VIII

1. To develop and awaken a variety of enduring interests in the field of chemistry.
2. To give to the student a greater appreciation of the contributions of chemistry to life.
3. To cultivate an awareness of the many unsolved problems in chemistry that need a solution.
4. To develop the ability of the student to buy and use consumer goods more intelligently.

Suggested Approach

The approach to this unit has been outlined in the suggestions to teachers. The student interest will be real in this unit, for isn't this the very thing he hoped for in chemistry? To be able to investigate for himself in fields that are of interest to him -- this is what every boy and girl expects from the study of chemistry.

Unit Analysis

Suggested time: Six to fifteen weeks.

A detailed outline of this large unit is impossible since the subject matter will be determined by the interest and needs of the particular chemistry class.

The book, "Living Chemistry," (1) is written for a course of study similar to the one presented here. The first 120 pages deal with the fundamentals of chemistry and the remaining 390 pages are devoted to three sections, Chemistry of the Individual, of the Home, and of the Community. This book along with the laboratory manual would be an excellent source book for Unit VIII of this study. For example, here are some of the unit titles from, "Living Chemistry."

Unit 13 Glands of Internal Secretion.
Unit 15 Chemistry of Drugs and Medicine.
Unit 16 Chemistry of Cosmetics.
Unit 18 Chemistry Hobbies.
Unit 19 Vocations Related to Chemistry.
Unit 21 Chemistry of Cooking Utensils
Unit 23 Chemistry of Fuels and Heating
Unit 26 Chemistry of Materials Used in Modern Home Construction.
Unit 28 Chemistry of Gardening.

Unit 29 Chemistry of Water Purification.

Unit 31 The Chemistry of Food Production and Distribution.

Unit 32 Chemistry in Industry.

"Test It Yourself," (40) by Tuleen, Muehl, and Porter, is a superior book of chemistry experiments with consumer applications. Each experiment is prefaced by a discussion of the problem, giving information that is not found in the usual chemistry textbook.

In the teachers edition there are suggestions to instructors concerning the operation of each experiment. A complete list of chemicals and equipment that will be needed to perform the exercises is included, but most high schools will find their stock rooms will take care of the needs of the manual.

The material in "Test It Yourself," (40) is divided into fourteen units, having from five to seven experiments in each division. The content of the units is as follows:

Unit 1 Measuring.

Unit 2 Household Chemicals.

Unit 3 Cleansers and Softners.

Unit 4. Foods.

Unit 5 Drinks.

Unit 6 Health.

Unit 7 Cosmetics.

Unit 8 Textiles.

Unit 9 Fuels.

Unit 10 Lubricants.

Unit 11 Antifreezes.

Unit 12 Protective Coatings.

Unit 13 Inks, Dyes, and Stains.

Unit 14 Soil.

In farming communities the unit on soil will be most interesting. A soil chart is furnished which will allow students to determine the ph of the soil on their farms.

"Living Chemistry," and "Test It Yourself" are mentioned here only as source books, and not as a text to be followed in the conventional manner. These remaining weeks of the chemistry course are for free experimentation and investigation conducted by the student. The work is suggested and completed by the pupil.

There should be a set of each of the laboratory manuals mentioned above, in the classroom at all times. These books can be used as source books, but most students would prefer to own a copy of a book like, "Test It Yourself." (37) This manual has a great deal of information about each topic as well as laboratory instructions for the completion of the experiments.

For additional reference material use all the available chemistry texts, science reference books, encyclopedias, scientific periodicals, and dictionaries. The reference material should be kept in the chemistry room where the students can use it readily.

Evaluation of Unit VIII

This unit will offer a more direct evaluation of each pupil since they are all working independently. How their problem is handled, the nature and success of their experiments, and how their problem is summed up before the class will give abundant opportunity for evaluation.

Use the check lists for attitudes, creativeness, and cooperation.

Materials

References:

In addition to the following references use all the chemistry texts, encyclopedias, and science periodicals available.

Ahrens, M. R., N. F. Bush, and R. K. Easley. Living Chemistry. Ginn and Company, New York, 1942.

Ahrens, M. R., N. F. Bush, and R. K. Easley. Laboratory Problems for Living Chemistry. Ginn and Company, New York, 1942.

Armstrong, E. F. and L. M. Miall. Raw Materials From The Sea. Chemical Publishing Co., Inc., Brooklin, New York, 1946.

Bennett, H. More for Your Money. Chemical Publishing Co., Inc., New York, 1937.

Consumers Test Manual. Consumers Research Inc., Washington, N. J. 1937. 38 p. $0.50. Tests for common household articles and supplies for use by high school students.

Furnas, C. C. The Storehouse of Civilization. Bureau of Publications, Teachers College, Columbia University, New York.

Howe, H. E. (Editor). Chemistry in Industry. The Chemical Foundation, Inc., New York, 1924-25. 2 vols.

Kallet, Auther and F. J. Schlink. 100,000,000 Guinea Pigs. Vanguard Press, Inc., New York, 1932.

Lynde, C. J. Science Experiences with Home Equipment. International Textbook Company, Scranton, Pa., 1937.

Lynde, C. J. Science Experiences with Inexpensive Equipment. International Textbook Company, Scranton, Pa., 1939.

Lynde, C. J. Science Experiences with Ten-Cent Store Equipment. International Textbook Company, Scranton, Pa., 1941.

Palmer, B. Paying Through the Teeth. Vanguard Press Inc., New York, 1935.

Phillips, M. C. Skin Deep. Vanguard Press Inc., New York, 1934.

Photographic Publications. American Photographic Publishing Co., 353 Newbury St., Boston, Mass. Write for catalog.

Rogers, Allen. Manual of Industrial Chemistry. D. Van Nostrand Co., New York, 1931. 2 vols.

Tavern, A. B. and A. F. Bullock. The Consumer Investigates. H. M. Rowe Company, E. 21st St., Baltimore, Md., 1938. Teachers manual free.

Tuleen, L. F., W. L. Muehl, and G. S. Porter. Test It Yourself. Scott, Foresman and Company, New York, 1941.

Woodring, M. N., M. E. Oakes, and H. E. Brown. Enriched Teaching of Science in the High School. Bureau of Publications, Teachers College, Columbia University, New York, 1941.

Films: (16 mm.)

Alchemist In Hollywood. 28 min. Sound. $1.50. #2990. Chemistry of photography. Berkeley, California.

Alloy Steels. 20 min. Sound. $0.50. Corvallis, Oregon.

Aluminum - Fabricating. 19 min. Sound. $0.50. Corvallis, Oregon.

Aluminum - Mine to Metal. 18 min. Sound. $0.50. Corvallis, Oregon.

Asbestos. 2 reels. Silent. $0.50. Pullman, Washington.

Copper Leaching. 12 min. Silent. $0.50. Corvallis, Oregon.

Copper Mining. 33 min. Silent. $0.50. Corvallis, Oregon.

Copper Refining. 11 min. Silent. $0.50. Corvallis, Oregon.

Copper Smelting. 11 min. Silent. $0.50. Corvallis, Oregon.

Fabrication of Copper. 45 min. Silent. $0.50. Corvallis, Oregon.

Manufactured Abrasives. 24 min. Sound. $0.50. Corvallis, Oregon.

Nickel and Nickel Alloys. 30 min. Sound. $0.50. Corvallis, Oregon.

Nickel - Milling and Smelting. 17 min. Sound. $0.50. Corvallis, Oregon.

Nickel - Refining. 10 min. Sound. $0.50. Corvallis, Oregon.

Rayon. 33 min. Sound. $0.50. Corvallis, Oregon.

Romance of Glass. 22 min. Sound. $0.50. Corvallis, Oregon.

Romance of Radium. MGM 12 min. $1.00. Sound #3021. Berkeley, California.

Romance of Rubber. 22 min. Silent. $0.50. Corvallis, Oregon.

Steel, Raw Materials. 15 min. Silent. $0.50. Corvallis, Oregon.

Steel, Making of. 10 min. Silent. $0.50. Corvallis, Oregon.

Story of Rock Wool Home Insulation. 30 min. Sound. $0.50. Corvallis, Oregon.

Free and inexpensive materials:

Anti-Hydro. Anti-Hydro Waterproofing Company, Newark, N. J., Free. Waterproofing concrete with free samples.

Copper, How It Is Mined and Refined. Anaconda Copper Mining Company, 25 Broadway, New York, Free to Teachers.

Hammer Apparatus. Bulletin #178. Denver Fire Clay Company, 1742 Champa St., Denver, Colorado. Discussion of radioactivity. Free.

Johnson Automatic Temperature and Humidity Control. Johnson Service Co., Milwaukee, Wis., 28 p. Free to teachers.

Minneapolis-Honeywell Regulator Co., 5036 Grand Central Terminal, New York City. Free. A set of catalogs showing details of construction and methods on installation. Also: "This Thing They Call Air Conditioning," and "This Thing Called Automatic Heating and Air Conditioning."

National Modern Welded Pipe, National Tube Co., Pittsburg, Pa. 90 p. Free. Illustrated and details of welding pipe are shown from the ore to the finished product.

Portland Cement - Its Characteristics, Development, and Manufacture. Portland Cement Association, 347 Madison Avenue, New York City. 12 p. $2.20 per hundred. History - manufacture - tests.

School Exhibit on Asbestos. Kearsby and Mattison Co., Ambler, Pa. Free.

Thermite Welding. Metal and Thermite Corporation, 120 Broadway, New York City. 34 p. Free.

Thermostatic Bimetal. W. M. Chase Company, Detroit, Michigan. Free. Temperature control devices.

The Romance of Copper and Its Alloys. 16 p. 1939. Copper and Brass Research Association, 420 Lexington Avenue, New York City. Free.

You Might Like Chemurgy as a Career. 15 p. 1941. Western Personel Service, 30 N. Raymond Avenue, Pasadena, California. $0.25.

CHAPTER V

SUMMARY AND RECOMMENDATIONS

A course of study in high school chemistry that meets the needs, interests, and capacities of individuals has been developed in this study. The course is set up on a unit basis with each unit built around one or more major chemical principles. The first seven units are concerned with the basic fundamentals that pupils need in order to understand and apply their chemical knowledge to the world in which they live.

The remainder of the course consists of a series of independent investigations and research conducted by the pupils. The methods employed in conduction this portion of the course are: the use of committees, individual projects, small group projects, reports, and student leadership. These methods tend to encourage the development of cooperativeness, self-assurance, intelligent self-direction, and wider personal interests.

Each unit consists of the following:

1. Suggestions to teachers.
2. Objectives of the unit.
3. Suggested approach.
4. Unit analysis.
5. Laboratory suggestions.
6. Evaluation of the unit.
7. Materials for the unit.

Many interest-getting devices have been used throughout the course of study, such as, stimulating approaches to each unit, thought-provoking problems, games, many demonstrations, and other instruments that have been proven by modern psychology to be effective teaching methods.

This study is offered to the State of Oregon to be used as a guide in part or as a whole for a course of study for Oregon secondary schools.

On the basis of the material presented, these suggestions are offered with the hope that they may stimulate further thought and investigation for the improvement of instruction in chemistry.

1. This study has indicated a need for new textbooks in chemistry that put less stress on factual material and logical presentation and more stress on the psychological approach to chemistry through students' needs and interests.
2. There is an urgent need for more supplementary material written for the secondary level in plastics, metals, dyes, synthetic products, rubber, glass, lubricants, and allied material.
3. A source book should be prepared for chemistry that would supply information as to where various teaching aids and materials can be found.

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