A Study of the Uses of the Natural Resources of Louisiana in the Teaching of High School Chemistry.

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MANUSCRIPT THESSES

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A STUDY OF THE USES OF THE NATURAL RESOURCES OF LOUISIANA IN THE TEACHING OF HIGH SCHOOL CHEMISTRY

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the Faculty of the Graduate School
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ABSTRACT

This study presents a method by which some of the natural resources of Louisiana may be used in the teaching of high school chemistry. By bringing the materials of the pupils' environment into the study of chemistry, more interest will be created and will bring about an awareness of the development and conservation of these resources.

The problem is limited to the mineral resources of the state of Louisiana in the teaching of high school chemistry. Teaching units have been constructed on the resources, illustrating that the study of these resources can be used in developing the basic principles of chemistry with the twofold objective: (1) to make the study applicable to the present needs of the pupils as well as to their future needs and at the same time (2) to prepare those who wish to continue their chemistry in college.

Research studies have shown that few of the facts learned in chemistry are retained by pupils after two years have elapsed. A small percentage of the pupils who graduate from high school take courses in college chemistry; of these only about two per cent specialize in the fields of science. In order to meet the needs of pupils the content of high school chemistry course must be reorgan-
ised in keeping with the changing needs of society and the organisation and selection of course materials must be made with reference to the objectives of modern education.

A review of the educational objectives in relation to the teaching of high school chemistry shows that in the early part of this century the objectives were centered in the idea of preparation for college, because of the highly selective character of the population of the high school. The increased enrollment, brought about by greater prosperity, compulsory school attendance laws, child labor laws, and increased population, made the school less selective in function. The percentage of pupils going to college decreased; thus it became apparent that the objectives of education should be changed to meet the needs and interest of all the pupils. The purpose of education is to educate all of the children of all the people for a more effective living in a democratic society.

The objectives and criteria for the selection and organization of subject matter for high school chemistry as set up by the Committee for the Forty-Sixth Yearbook of the National Society for the Study of Education in its report, "Science Education in American Schools," Part I, were used as guides in the selection and developing teaching units from the mineral resources of Louisiana for use in high school chemistry. Only in the light of the objectives of education and science can any materials be selected as content in a particular course in science.
The trends of organization of subject matter is toward related units rather than topical units. These related units are based upon generalizations and principles which have their origin in the environment of the pupils. Two teaching units, on Sulphur and Petroleum, are developed in detail to show the method used. The outline of high school chemistry as presented in this study has taken into consideration the necessity of a thorough understanding of principles. The first four units are devoted to the basic fundamental principles of chemistry, and these in turn are focused upon the environment of the pupils when and wherever it is possible to do so.

The method of using more than one textbook and articles from authoritative sources gives pupils practice in gathering data from many sources for solution of their problems. This tends to eliminate page-by-page assignments in a single text. This type of organization will necessitate definite planning on the part of the teacher. Large amounts of material that are overlapping in college and high school chemistry have been kept to a minimum. The increased emphasis on the uses of visual aids is a worth while contribution to the understanding of industrial applications of chemistry. Motion pictures, slides, charts, exhibits, models, and field trips tend to make the abstractions of chemistry more concrete and meaningful to pupils. The more concrete these learning experiences of the pupils, the more functional the subject matter of chemistry will be.
CHAPTER I

INTRODUCTION

THE PROBLEM AND THE BACKGROUND

The professional use of chemistry and physics in industry and in independent research is playing a vital part in the rapid changes of the social, physical, and economic structure of our civilization. Why should not the great majority of our junior and senior boys and girls be interested in studying these sciences? Is the goal of science education in accordance with the opinion of the National Committee on Science Teaching as stated by Ebel,¹ that "the principal job of the public schools is to prepare all of the children for effective living in a democracy"? The writer has set as his goal to find some way to teach high school chemistry so that it will be of some value in each pupil's present daily life as well as in his later life.

According to Anibal and Leighton,² about thirty-five out of every one hundred pupils graduating from high school will enter

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institutions of higher learning. Of these thirty-five, less than ten pupils will indicate a desire to specialize in the professional fields that require chemistry and physics. Of these ten, only two pupils will be graduated in these fields. About 98 per cent of our high school graduates will eventually become non-scientific citizens.

The Biennial Survey of Education\(^3\) gives the following data: In 1915, 21.6 per cent of the high school population in the public high schools were enrolled in chemistry and physics. This had dropped to 13.78 per cent in 1934.

In an attempt to find an answer to this situation the writer has talked to many science teachers as well as to boys' and girls' advisers. Without exception they give the following as reasons offered by the pupils: too many new terms to be learned, too much formal mathematics, and too great difficulty to remember enough of the facts to pass an examination in either chemistry or physics.

When high school and college textbooks in chemistry are compared on the basis of subject matter, the two are found to be almost identical. The college text has more pages than the high school text and devotes more space to the principles, definitions, theories, preparation of compounds, and the properties of these compounds. Glasoe\(^4\) compared eleven of the standard high school texts now in


use and found that they ranged from four hundred to eight hundred pages. He found that some of the college texts ran from five hundred to almost a thousand pages. He concludes from his study that the high school course is in reality a simplified first year college course.

A study of student reaction to the subject matter of high school chemistry has shown that knowledge and skills which the pupils have spent many hours acquiring are practically lost within one or two years.5

The teaching of high school chemistry with the purpose of preparing pupils for college chemistry has been condemned by college professors as a failure. If it is taught as an "abbreviated college chemistry," certainly it will not be functional in everyday activities of the pupils. Glasoe states that failure of the course in high school chemistry is due to two causes:

(1) It is too massive. We smooth all our objective under an avalanche of words, theories, and technical applications. We give the student a book of four hundred to eight hundred pages; in Europe the textbook for the same course is one hundred fifty pages. European students master the subject so that

it can be said that they know the elements of chemistry; our students flounder in a morass of theory, practical application, and a multi-myriad of concrete but unconnected facts. And then, when such a pupil arrives at college he is treated as if he had not had the high-school preparation at all.

(2) It fails in that the course starts out as if it expected to make chemists of all these boys and girls. Very seldom does one of them become a chemist. Taking for granted that the average high-school graduate is the same person we meet upon the average walks of life we shall have to hunt far and long to find many who have retained a great deal about atoms and molecules, atomic and molecular weights, the electron theory, valence and formula writing, molecular composition and equations, ions and ionization, the multitude of nitrogen oxides, the host of halogen derivatives, the Periodic System, the formulas for benzene, carbolic acid, and aspirin, the composition of alloys, cement, and steels; the making of sulfuric acid, nitric acid, and ammonia; the solubilities of all the common salts and the chemistry of the complex ions. Only now and then does one of these facts or phenomena protrude themselves into the uneventful life of the average high school graduate.

Statement of the problem. The problem is to demonstrate how some of the natural resources of Louisiana may be used in the teaching of high school chemistry. Surely by bringing the materials of the pupils' environment into the study of chemistry more interest will be created. Certainly the pupils would understand more about the resources and industries of their own parish and state. Teachers in other states of our nation might use the same methods as developed in this study and apply them to their own state resources, thereby bringing about an awareness of the development and conservation of

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Delimitation. This study is limited to the study of the mineral resources of the State of Louisiana in the teaching of high school chemistry. The important mineral resources are petroleum, natural gas, sulphur, salt, and shells. Teaching units have been developed on the resources of Louisiana, illustrating that the study of these resources can be used in developing the basic principles of chemistry, with the following twofold objective: (1) to make the study applicable to the present needs of the pupils as well as to their future needs and at the same time (2) to prepare those who wish to continue their chemistry in college.

Background for the problem. The history of the teaching of chemistry gives an interesting insight as to the content, aims, and trends of high school chemistry. In the early days, when America was a new country with vast resources to be developed, facts and methods were wanted. There was not time for anything of a cultural nature in chemistry, and it was impossible to stress anything but the immediate useful values of the subject.

Fay suggests that the history of the teaching of high

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school chemistry in the American school be divided into three periods as follows:

The history of the aims, methods of teaching and content of high school chemistry divides roughly into three periods. In general, however, the first period included the first eight or nine decades of the nineteenth century; the second period included the last decade or two of the nineteenth and the first decade or first decade and a half of the twentieth century; the last period included the years since 1910 or 1915.

Chemistry was introduced into the academy during the latter part of the eighteenth century with the intent to further the purpose of the academy in providing for the youth a more liberal and practical education. As early as 1830 chemistry occupied a position of some prominence. Boston High School for Girls in its course of study suggested that chemistry, which was useful in domestic economy, be included. The first public high school to contain a chemistry laboratory was constructed in the year 1854.

A survey of the status of chemistry in America was made by the Bureau of Education in 1878, showing that, of the one hundred and seventy-six schools reporting, one hundred and fifty-four offered some instruction in chemistry. Fifty-six of these schools included


9 Ibid., p. 235.
students' work in the laboratory. Teacher demonstration method was used in seventy-three of the schools. The remainder of the reports did not refer to the laboratory.\textsuperscript{10}

The textbooks of the first part of the first period cited by Fay reveal the nature and content of the courses in chemistry taught at that time. For the most part they were based on question and answer method and were superficial.

High school chemistry was accepted for college entrance in 1872, and with this acceptance came the era of college domination. The benefit accruing from this domination was the establishment of laboratories in the secondary school and the beginning of laboratory procedure. However, along with the memorizing of facts, the performance of a given number of experiments, and the submission of these experiments and records as a requirement for college entrance, the interest and desire of the pupils for further study of chemistry were deadened. Powers\textsuperscript{11} is of the opinion that the method of instruction and the standardization of content resulted from the following causes:

1. The work of influential committees;
2. Smith and Hall textbook;
3. The influence of texts written by college teachers and used in high schools;

\textsuperscript{10} \textit{Ibid.}, p. 240.

\textsuperscript{11} \textit{Ibid.}, p. 242.
(h) Transplanting by teachers of the content and method which they learned in college to the high school.

The most outstanding agencies considering the standardization of the aims, contents, and methods of teaching chemistry were the Committee of Ten, whose chairman was President Charles W. Eliot of Harvard, and the College Entrance Committee. Both of these committees accepted the aim of secondary education as disciplinary and recommended courses in chemistry that were in reality college preparatory courses. They also set up standards of method by which a certain number of experiments and so many hours of laboratory work were required and had to be pursued for an entire year.

College domination of high school chemistry has continued to some extent up to the present time. Between the years of 1910 and the present a reactionary movement has arisen against college domination, standardization, and uniformity. The evidence of this movement has been shown in teachers' meetings and in the many articles that have appeared in the different school journals and scientific magazines. This reactionary movement has been brought about by the increased high school enrollment, in which the pupils have had a greater range of ability and interest. In this period educators began to change their ideas as to the aims of secondary education and to realize that all the pupils could benefit from science instruction whether they attended college or not.
The textbooks of the second period became less superficial and the content more standardized, since most of the textbooks were written by college professors.

With the beginning of the third period there was a swing back to the more practical aspects of chemistry. Several factors were responsible for this trend. World War I placed the emphasis on the discoveries of chemistry and the need for more chemists. The public demanded more knowledge to meet the needs of everyday life.

During this period the Commission on Reorganization of Secondary Education formulated the objectives of education known as the "Seven Cardinal Principles." These objectives deviated from the subject matter practices of the period and stimulated thinking on the problems of education. A special science committee was appointed by the commission for the purpose of reorganization of science in the secondary school to meet the needs of the new conditions following World War I. This was the first report dealing entirely with science and science instruction in the secondary schools. The committee suggested a systematic organization of the different science courses in high school. General science and general biology were placed on a firm basis in the curriculum of secondary schools. The committee gave many practical suggestions on the aims, method, and

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content of general science, biology, chemistry, and physics. Fay\textsuperscript{13} states that this report probably gave the most influential statement of the objectives named. The objectives of mental discipline were replaced with ones more in keeping with the democratic concept of education.

The establishment of the *Journal of Chemical Education* in 1921 for the advancement of teaching high school and college chemistry was evidence of an awakening of teachers to the many problems in the teaching of chemistry. Discontent with the method, organization, and content of high school chemistry was shown in some thirty thousand criticisms and suggestions offered by chemistry teachers throughout the country to the Committee on Chemical Education.\textsuperscript{14} These criticisms and suggestions resulted in the establishment of minimum essentials that should be taught in high school chemistry. This committee listed twenty-eight different topics that should be taught in a year's course in high school chemistry, with supplementary lists of material relating to the environment of the pupils. The content of the minimum essentials harmonizes with the aim of preparation for college. The outline of content and the syllabi of the New York Board of Regents and College Entrance Examination Board were the basis for

\textsuperscript{13} Fay, *op. cit.*, p. 1553.

the writing of textbooks and for instruction in high school chemistry. Teachers throughout the country covered the materials as outlined, but they covered the materials so rapidly that all the pupils did was to try to memorize enough facts so that they could pass an examination for credit. Consequently, the pupils did not comprehend these facts and proceeded to forget them as soon as they had finished their examination. It is not astonishing that college professors condemned high school chemistry as being of no value and preferred in many cases pupils who had had no high school chemistry.

A special committee, appointed by the American Association for the Advancement of Science in 1927, in its report, "On the Place of Science in Education," made the following recommendations: that some organization like the United States Bureau of Education or the National Education Association undertake an intensive study of the tendencies and needs of science instruction; that a field secretary be appointed to operate as a sort of clearing-house agent for the distribution of information on research and to stimulate research in science education; and that a national council of science teachers be formed in order to increase the public appreciation and advance the teaching of science. This report emphasized the awareness of

the importance of the scientific method to the problems of science teachings.

In 1932 the National Society for Education published the Thirty-First Yearbook, "A Program for Science Teaching," Part I. This was a comprehensive program for science instruction in all the grades. This report advocated that the specialized subject of science be organized around broad concepts or generalizations such as the following: "When a chemical change takes place, the substances that are involved are changed in such a way that they no longer behave as they did before this reaction occurred." The report stimulated many investigations, exerted a strong influence on the organization, aims, and content of science courses, and helped to professionalize science education.

To meet the demands of education upon the high school a new committee was appointed to revise and rearrange the list of essentials published in 1921 by the Committee on Chemical Education of that date, the revision to be in keeping with changing methods and thought. The membership of this committee was made up of both high school and college teachers. The scope of high school chemistry was broadened to contain cultural as well as factual information. The committee suggested that the course contain only eleven units as contrasted to

the twenty-eight topics suggested in 1921. These eleven units indicated some important changes, among which was the emphasis placed on the historical development in chemistry in the first unit. The course was arranged in units rather than by topics.17

Hall made a thorough analysis and investigation of the various committee reports relating to the organization of high school chemistry since 1920. The sources of the data used for his study included articles appearing in School Science and Mathematics, Science Education, and Journal of Chemical Education; fifty-eight public school courses of study; and forty-five high school chemistry textbooks; all published since 1920. He grouped the reports into three divisions: those appearing from 1920-1923, first group; 1923-1927, second group; and 1927-1937, third group. His findings may be summarized as follows: During the first period the trend was away from preparation for college and formal discipline and sought organization around the development of practical applications of chemistry. During the second period, the trend was toward correlation of high school and college chemistry. During the third period, the trend was toward development of habits, skills, and attitudes. Emphasis was placed on chemistry in relation to the social and cultural patterns found in the environment of the pupils. The topical


organisation began in the second period and has been replaced by the unit organisation. Another trend was the adoption of the scientific approach to the study of the organization of high school chemistry.

Dunbar\textsuperscript{19} analyzed twenty-five textbooks in high school chemistry that had been published between 1913 and 1937, inclusive, and found that there had been an increasing emphasis upon topics such as atomic and molecular structure, radioactivity, ionization, colloids, and periodic law. The major topics, in most instances, have been increased without eliminating any of the older materials. Recent texts have more practical applications and less technical detail; they retain all the fundamental and basic laws and theories; and they have increased in size. Most of the articles published at this time show that the trend in the content of high school chemistry is toward the practical application of the subject. The Progressive Education Association published in 1938 a report, "Science in General Education," which suggested that science courses should be arranged around the broad ideas of living and the use of reflective thinking.\textsuperscript{20}

\textsuperscript{19} Ralph E. Dunbar, "Changing Conception of Major Topics in High-School Chemistry Textbooks," \textit{Journal of Chemical Education}, 17:394-397, August, 1940.

The formation of a National Committee on Science Teaching in 1939 received its impetus from the reports issued by the Education Policies Commission. The objects of this commission were to see what science could contribute to the program of education that was advocated by this commission. They placed continued emphasis on the personal-social type rather than the subject matter approach in science teaching.21

The trends as set forth in the Forty-Sixth Yearbook of the National Society for the Study of Education, Part I, "Science Education in American Schools," are toward courses in science planned to meet the needs of the everyday users.

Summary. Research studies have shown that few of the facts learned in chemistry are retained by pupils after two years have elapsed. Small percentages of the pupils who graduate from high school take courses in college chemistry; of these only about two per cent specialize in the fields of science. The trend in organization, content, and methods of teaching high school chemistry is away from the purpose of preparation for college, points toward the purpose of generalized nature of utilizing the teaching value of the environment of pupils, and is planned to meet the pupils' needs.

The trend of organization is dispensing with the topical method of organization in which there is very little relationship

between topics or chapters and is directed toward the development of organized units which bear definite relationship with each other. An important trend is the elimination of much of the descriptive material and the study of a large number of metals and chemical processes. More emphasis is being placed upon historical development, the use of visual aids in the teaching of chemistry, and the premise that the subject matter should be taken from the environment of pupils wherever it is possible.

Research studies have shown that in order to meet the needs of pupils the content of the high school chemistry course must be reorganized in keeping with the changing needs of society and that the organization and selection of course materials must be made with reference to the objectives of modern education. Therefore, the writer is proposing an organization of subject matter in high school chemistry by which the resources of Louisiana can be utilized as a starting point in focusing the pupils' awareness of the relationship of chemistry to their environment.
CHAPTER II

A REVIEW OF EDUCATIONAL OBJECTIVES

IN RELATION TO THE TEACHING OF HIGH SCHOOL CHEMISTRY

Trends in teaching objectives of science in secondary education. The educational process is one of continuous change. The task is not to try to attain high levels and then rest, but to keep up with the changes so that our courses in science shall meet the needs of the pupils. Often subject matter has been added to chemistry, has become a fixed part, and has remained long after it has proved useless. The same may be said of teaching techniques. There must be a constant evolution of method, content, and aims in order to meet the needs of a changing civilization. These fundamental concepts center on the question: What is the purpose of secondary education?

The objectives of education which were derived from the needs of the people for a little more than a generation were college preparatory in nature because of the highly selective character of the population of the high schools. The period of increasing growth of population and of the prosperity of the country during and following World War I saw increasing numbers of children enrolled in the high schools. As enrollment increased, the high school became less
selective. The need arose to re-examine the purposes of secondary education. As a result a commission was appointed by the National Education Association which made a report, the "Cardinal Principles of Secondary Education." This was followed by the first comprehensive report on science teaching and the reorganization of science in secondary schools. These reports emphasized the functional values of education and the organization of courses in secondary school science. They also emphasized that science instruction is valuable in the realization of six of the cardinal principles, or objectives, of secondary education, namely: "health, worthy home membership, vocation, citizenship, the worthy use of leisure, and ethical character." They stimulated interest in research in the field of science teaching and formed a background for the further development of objectives in science.

The Thirty-First Yearbook, Part I, of the National Society of Education proposed that the science curriculum be organized about


3 Ibid., p. 12.

broad generalizations which should be used as objectives in teaching of science.

The major generalizations and associated scientific attitudes are seen as of such importance that understandings of them are made the objectives of science teaching. These statements are so far-reaching that they may be said to encompass the fields of science. They touch life in so many ways that their attainment as educational objectives constitutes a large part of the program of life enrichment. The program for their attainment must be considered in relation to the whole program of education. Principles and generalizations of science are objectives. Learning experiences result from activities selected for their contribution to the enlargement of the meaning of these objectives.\[^5\]

Burnett, in his discussion of the objectives of the science teacher, states that these generalizations, if adopted, would force a re-evaluation of the offerings of science in terms of the important laws and concepts. If the science content were organized about the generalizations and if the inductive approach were followed in practice very rigorously, the facts would be knitted together into meaningful experiences and appreciations of laws and natural phenomena. This approach has not been genuinely tried. These generalizations of the phenomena and natural laws have been mere verbalism without support necessary to prove their value to the

\[^5\] Ibid., p. 44.

\[^6\] R. Will Burnett, "The Science Teacher and His Objectives," Teachers College Record, 45:244-245, January, 1944.
pupils or to society. The task has been left to the teachers, most of whom have become bewildered and have never found the problems in which the generalizations received greatest meaning and value. Most of them taught these generalizations as ends in themselves.

Beauchamp made a national survey of instruction in science, and his study was published in 1932. He made an analysis of "58 courses in general science, 45 courses in biology, 27 courses in physics, and 30 courses in chemistry"; and in addition to this he visited 14 city school systems in various parts of the country. He checked the courses of study to find the educational objectives. After a detailed analysis of these objectives, he uncovered a wide variety of aims in which there was a curious mixture of general and specific objectives, in which there was neither "fish, flesh or fowl."

The Progressive Education Association, in its publication of "Science in General Education," discussed the impact of science upon the social and cultural patterns of the lives of individuals. The confusion as to the purposes and methods in the field of science is due to the rapid advances made in the areas of communication and


transportation and in the increase of productive power of the country. The changing concept of how pupils learn has had a profound effect on the objectives of education and has made it imperative that objectives, methods, and functions of science teaching be re-examined in the light of these new changes. The statement of the aim of general education is:

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.9

The basic aspects of living are divided into four areas: personal living, personal-social relationship, social-civic relationship, and economic relationship. The report stresses the importance of understanding the adolescent and the importance of development of reflective thinking. It presents a progressive philosophy of education and shows how science can play an important role in development of basic aspects of living.

The Educational Policies Commission has issued a series of reports which suggest that education must keep abreast of the changing social conditions and satisfy the needs of living in a democracy. The purpose of education, according to the commission, is to aid pupils in the four aspects of living, namely: self-

9 Ibid., p. 23.
Realization, human relationship, economic efficiency, and civic responsibility.  

How can the teaching of high school science contribute to these purposes of education? Will the teaching methods help promote a better understanding of democracy? These and many other questions have been in the minds of science teachers throughout the nation since the reports were published. As an outgrowth from this unrest, the National Committee on Science Teaching was formed. The committee set up different subcommittees, one of which was on Philosophy or Frame of Reference. This subcommittee was to implement the "Purposes of Education in American Democracy," issued by the Educational Policies Commission; and they published a report in 1942 which interpreted and amplified the purposes of education as set forth in the report of the commission.  

The report of the subcommittee on Philosophy or Frame of Reference continued the trends of the personal-social approach rather than the subject matter type of science teaching and suggested that the teaching function should be:


To provide people with sufficient understanding of science and importance to enable those not actually engaged in scientific pursuits to cooperate rationally with those who are and to use intelligently the benefits of science in everyday living. A second purpose which is not entirely distinct from the first, is to give people sufficient understanding of the scientific method to enable them to apply its principles in solving problems of personal and social significance.\(^\text{12}\)

The committee recommended that teachers should encourage and try to develop in their pupils, through contact with everyday problems, those experiences which will help them find their rightful place in society.

The subcommittee on needs, after a thorough inquiry into the needs of pupils from six different levels of instruction in our school system, has identified the requirements in the following areas: "health, safety, recreation, maturing inter-personal relationships, work, consumership, conservation and a maturing philosophy of life." It has furnished a check list of functional outcomes toward which science teaching could contribute at the different levels of instruction.\(^\text{13}\)

The reports of the different subcommittees of the National Committee on Science Teaching are significant in that they represent the efforts of: (1) a large number of science teachers in the public

\(^{12}\) Ibid., p. 31.

schools throughout the nation; (2) a large number of consultants, at least one from each state in the union; and (3) representatives from national organizations of science teachers and scientists. These reports are valuable because they give to the science teachers suggestions by means of which they may contribute their efforts in the areas mentioned. They are helpful because they stimulate thinking and encourage the experimenting with new techniques in teaching of science.

The rapid advance of scientific discoveries in medicine, nuclear physics, biochemistry, and other sciences is affecting the thinking and standard of living of our country and has placed a heavy burden on the science teacher. New movements in science education, such as fused science courses in the senior high school and the establishment of science in the elementary grades, have increased the burden. The need for an analysis and evaluation of the research in science teaching brought forth a request for the publication of a yearbook by the National Society for the Study of Education.\(^1\)

This yearbook set up the following criteria in formulating objectives of science teaching:

(1) The statement should be **practicable** for the classroom teacher.

(2) The statement should be **psychologically** sound.

(3) It should be **possible of attainment** under reasonably favorable circumstances and to a measurable degree.

(4) It should be **universal** in a democratic society.

(5) The statement of the objectives and the explanatory context should indicate, directly or by clear implications, the **relationship of classroom activity to desired changes in human behavior.**

This yearbook committee of the National Society for the Study of Education explained its objectives as "directions of growth," as objectives which can never be completely attained. The idea is to take each pupil as he is and to help him make as much progress as he is capable of making. Using the criteria as set up, the committee proposes the following types of objectives:

A. **Functional information or facts** about such matters as:
   1. Our universe — earth, sun, moon, stars, climate and the weather.

2. The nature of matter -- elements, compounds, mixtures, chemical change, physical change, solids, liquids, gases.

B. Functional concepts such as:
   1. Space is vast.
   2. All matter is probably electrical in structure.

C. Functional understandings of principles, such as:
   1. Changes in seasons and differences in weather and climate depend largely upon the relation of the earth to the sun.
   2. All matter is composed of single elements or combinations of elements.

D. Instrumental skills, such as ability to:
   1. Read science content with understanding and satisfaction.
   2. Perform fundamental operations with reasonable accuracy.
   3. Read maps, graphs, charts and tables and be able to interpret them.
   4. Make accurate measurements, readings, titrations, etc.

E. Problem-solving skills, such as ability to:
   1. Sense a problem.
   2. Define a problem.
   3. Study the situation for all facts and clues
bearing upon the problem.

4. Select and test the most likely hypothesis.
5. Accept or reject the hypothesis and test others.
6. Draw conclusions.

F. **Attitudes**, such as:
   1. Open-mindedness, willingness to consider new facts, suspend judgment, withhold conclusions until all available facts are in.

G. **Appreciations**, such as:
   1. Appreciations of the contributions of scientists.
   2. Basic cause and effect relationship.

H. **Interests**, such as:
   1. Interest in some phase of science, as recreational activity or hobby.
   2. Interest in science as a field for a vocation.

The committee has taken the best thought available and has attempted to form objectives that would help the classroom teacher in relating the activities of the class toward a maximum achievement of these goals.

**Trends in teaching objectives of chemistry in secondary education.** A clear perspective of the trends in the teaching of high school chemistry can be obtained by tracing the evolution of the objectives of high school chemistry begun in 1920, when the Committee

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on the Reorganization of Science in Secondary Schools made its report. Frank summarized all the objectives and aims of high school chemistry from the following sources into seven objectives: instruction, training, inspiration, discipline, power to interpret, exploration and guidance, and recreation:¹⁷

Inglis, "Principles of Secondary Education"
Bagley, "Educational Values"
Eikenberry, "Teaching of General Science"
Bulletin 35, 1918, "Cardinal Principles of Secondary Education"
Bulletin 26, 1920, "Reorganization of Science in Secondary Schools"
Report of Committee on Education of American Chemical Society (1924)
Powers, "A Diagnostic Study of Subject Matter of High School Chemistry"

A brief explanation of the above will show what Frank intended each of these objectives to mean to the teachers of high school chemistry.

**Instruction:** The main task of the teacher is to train the pupils to comprehend ideas and to think of subject matter in terms

of systematic organization and the fusion of laws and principles together into a complete subject.

**Training:** The pupils should develop skills, habits, and abilities in manipulation of apparatus, in reading directions, and in habits of accuracy.

**Inspiration:** Within the pupils' lives should grow an appreciation of the service of chemistry and of the lives of great scientists.

**Discipline:** Chemistry should produce an attitude of stability and willingness as a matter of fair play to hear both sides.

**Power to Interpret:** Chemistry can help free the pupils from fears and superstitions. It should teach the pupils to discriminate between the false and the true.

**Exploration and Guidance:** Chemistry should give to the pupils a desire to explore and a joy in looking to see what is just around the corner.

**Recreation:** The pupils should have developed within their thinking a desire to go further with the subject and an ability to see that there is much of interest all about us.\(^{18}\)

Frank's interpretations of the aims were far afield from the classroom practice of that time. Most of the objectives would be good in our present day teaching of chemistry.

A comprehensive list of thirteen objectives for chemistry teaching was compiled in 1925 from educational literature by S. R. Powers. These objectives show a definite trend away from the emphasis on subject matter toward the interests, the practical applications of chemistry to industry, and the vocational guidance of the pupils. However, this list of objectives is too large, and it would be impossible to accomplish all of them in a year's course in high school chemistry.

The Committee for the Thirty-First Yearbook of the National Society for the Study of Education, Part I, "A Program for Teaching Science," proposed that chemistry should be organized about the broad principles and generalizations of science and that the objectives of chemistry should be as follows:

I. Pupils in high-school chemistry courses should develop better understandings of those fundamental concepts, major ideas, laws or principles of chemistry that will enable them better to interpret natural phenomena, common applications of chemical principles, and industrial applications and uses of the principles of chemistry.

II. Pupils in high-school chemistry classes should learn to use the processes of reflective thinking, problem-solving, and techniques of study that are best adapted to the solution of problems within the field of chemistry, especially those which most often present themselves in daily life.

III. Pupils in senior high-school classes in chemistry should develop those attitudes towards the facts and principles of chemistry and toward the method of investigation employed in the field that will serve as guides in their use of chemical facts and principles and methods of problem-solving.²⁰

The committee gives a list of the major ideas or principles involved in the learning of chemistry and recommends that these generalizations or principles as centers of organizations be used in building teaching units.²¹ This type of organization was a distinct contribution to the teaching of chemistry, and it stimulated the wide-awake teacher to do some experimenting and testing with the organization of chemistry. It acted as a lever for those enthusiastic and energetic teachers to break away from the traditional methods of teaching and to apply the methods of research in order that they might improve their teaching of chemistry. The committee gave thirty-eight generalizations to be used as objectives in science teaching but did not suggest sufficient means by which these might be obtained. As a consequence, a large number of teachers taught


²¹ Ibid., p. 265.
these generalizations as so much factual material to be learned without understanding.

Led by its chairman, Neil E. Gordon, the Chemical Education Section of the American Chemical Society recognized that the list of Essentials of High-School Chemistry published in 1921 needed revising and rearranging so that it might keep abreast of the changing concepts of chemical education. For the first time it recognized that the objectives of high school chemistry should be fundamentally different from those in college chemistry. "They urged teachers in preparatory classes to present courses which are planned to meet the needs and interests of their pupils." The committee recommended the following to aid the teachers in developing the suggested topics:

1. To show the service of chemistry to the home, to health, to medicine, to agriculture, to industry; in a word, to show the service of chemistry to the country.

2. To develop this service in chemistry around certain minimum fundamental topics, and, in doing so, to see that these minimum requirements are so well taught that they may be built upon, if required, as a foundation in college.

3. To train the student in keen observation and exact reasoning, and in the scientific attitude of mind.

4. To develop a careful correlation between recitation and experiment.

5. To encourage students to keep notebooks which shall be an accurate record of laboratory experiments expressed in concise, clear English.

6. To build upon earlier science courses and knit them together wherever possible.

7. To encourage students to use reference books and scientific periodicals, in addition to their textbooks.

8. To help pupils to find themselves — i.e., to discover whether or not they have an aptitude for further study in chemistry or applied science, and if so, to encourage such students to continue their study of science in university or technical school.

9. To stress the general principles involved in the specific cases studied, and to assure the pupils' mastery of each principle.

10. To use well-established principles of psychology as far as they can be applied to students of high-school chemistry.23

This list of objectives shows remarkable similarity to other lists published in the courses of study from the different states. As an example, the guiding principles of the State Board of Minnesota are:

1. A thorough knowledge of elementary chemistry as such knowledge relates itself to good citizenship, social welfare, home and community life, commerce, the trades, and professions.

2. An understanding of the interrelation of all science, thus giving a broader appreciation and understanding of the world in which we live.

23 Ibid., p. 175.
3. Training in scientific observation and thinking, leading to the ability to make impartial comparisons and careful generalizations upon a sound factual basis.

4. Vocational information which will assist a pupil to determine whether chemistry offers him a field for his lifework.

5. Chemical knowledge which will contribute to individual and community health.

6. Interest which may function in a more worthy use of leisure time.

Recognizing the need for a revision of the course in high school, the State of Texas has initiated a curriculum revision. They set up objectives, devised methods, and built a course of study of wide areas of interest and suggested that the local teachers use materials of local interest. The following objectives were taken in part from the State Bulletin No. 383 and in part from R. A. Eads' unpublished manuscript:

1. To reveal the fascinating phenomena of chemistry.

2. To reveal the chemical reactions in a few of our simpler body functions.

3. To reveal the role of chemistry in such important processes as cooking, preserving foods, plant growth, sanitation, health, fires, burns, decay, poisonous medicine, and first aid.

4. To learn how to detect fraudulent and misleading advertisements.

5. To learn to judge properly, or at least question, values, particularly of synthetic foods and drugs.

6. To learn the effect of alcohol, narcotics, and tobacco on the human system.

7. To acquire sufficient vocabulary to be able to read intelligently and to converse with informed people.

8. To reveal the role of chemistry in American industry.25

The objectives from these three widely different sources have a remarkable agreement in placing emphasis upon service or usefulness of chemistry to the home and community, health, trades, and industry in order to meet the needs and interest of the pupils.

An analysis of the articles appearing in the current issues of Science Education and School Science and Mathematics, together with the Report of the National Committee on Science Teaching in 1942, reveals that they emphasized the functional outcomes of chemistry as related to individual and group needs in such areas as health, safety, recreation, work, consumership, conservation, and socio-economic responsibility. The Committee of the Forty-Sixth Yearbook, Part I, in setting up the objectives of chemistry in

"Science Education in American Schools," has incorporated the best thinking from the most important experimental studies and committee reports of national standing and has outlined the major objectives as follows:

A. Providing opportunities for growth in the functional understanding of facts.

B. Providing for the development of functional concepts.

C. Providing for growth in the functional understanding of principles.

D. Providing opportunity for growth in the basic instrumental skills.

E. Providing opportunity for growth of skills in the use of elements of scientific method.

F. Providing for growth in the development of scientific attitudes.

G. Providing for growth in the development of appreciations.

H. Providing for growth in the development of interests.26

An analysis of each objective is essential for the purpose of teaching and evaluation of a course in high school chemistry.

A. Provision for growth in the functional understanding of facts. This provision deals with such matters as the nature of

matter; i.e., elements, compounds, mixtures, physical changes, solids, liquids, and gases. Facts may be specific or general and are necessary for an understanding of a course in chemistry. They should not be taught or acquired by the pupils as an isolated body of materials, but the information learned should result in an altering of the thinking and behavior of those individuals who make up the class in chemistry.27

B. Provision for the development of functional concepts. "All matter is probably electrical in structure. Concepts are syntheses or constellations of ideas or meaning. Thus a number of facts may be combined to produce a concept."28

C. Provision for growth in the functional understanding of principles. The functional understanding of such principles as "all matter is composed of single elements or combinations of elements" is fundamental to an understanding of chemistry. The three above objectives are closely related and interact. One must have a fund of information in order to understand principles or concepts. The foundation upon which functional concepts and principles are based "is understanding." Concepts and principles should be used repeatedly under a variety of conditions. Almost any one can learn or repeat a law in chemistry. To be able to understand or identify

27 Ibid., p. 29.

28 Ibid., p. 30.
it under different circumstances requires far more knowledge and understanding.

D. **Provision for growth in basic instrumental skills.**

This objective requires the use of the essential tools of learning, such as being able to read with understanding, the ability to do computations, the ability to locate and use source materials, interpretation of graphic materials, and the ability to make observations in solving problems.\(^{29}\)

E. **Provision of opportunity for growth of skills in the use of the elements of scientific method.** This has been listed for many years as the outstanding objective of all courses in science, but many teachers have given "lip service" only. Most of the high school chemistry courses have not been productive in their use of this method. There are certain abilities that are fundamental to problem solving, such as being able to recognize a problem, to observe, to reason, to analyze, and to see relationships. An important way to develop these abilities is by the use of good demonstrations. The teacher can open a field of interest and investigation and draw from the pupils' own experiences questions that will be of a problem solving nature. They will not only learn the facts and principles but will begin to realize how the scientific method can be used to achieve results. Very

little has been done to help teachers, especially beginning teachers, develop professional techniques. Certainly the textbooks and laboratory provide little for the development of the abilities needed in scientific method. It is for the individual teacher to devise his own method of developing this technique, but many do not have the time or energy to search for materials to be used in problem solving.\textsuperscript{30}

F. **Provision for growth in the development of scientific attitudes.** The scientist is always looking for new evidence and is glad to give up an idea if the facts do not agree with it. He is open-minded and never forms an opinion until he has all the facts. He has a spirit of curiosity and belief in cause and effect relationship. He is accurate, honest, and persistent in the quest for truth. These are some of the attitudes that a high school course in chemistry should strive to make a part of the everyday thinking of pupils who study it.

G. **Provision for growth in the development of appreciations.** Many appreciations can be developed in chemistry. Appreciations should develop for the contributions of chemistry to medicine, to industry, for conservation of natural resources, and for the many inventions which have helped to raise the standards of living. Appreciation is the outgrowth of understanding, and no pupil can appreciate these

\textsuperscript{30} Ibid., pp. 203-205.
contributions unless he has some understanding of chemistry.

H. **Provision for growth in the development of interests.** Chemistry teaching should try to create an interest not only in chemistry but in other sciences. Whether these interests be vocational, avocational, or recreational, the chemistry teacher is in a position to help guide his pupils along the avenues in which they have special aptitudes. Many happy hours can be spent by boys and girls in pursuit of worthwhile hobbies. Many of these hobbies depend on a knowledge of chemistry, such as growing crystals, testing soils, testing cosmetics, and growing plants without soil with the use of chemicals.\(^{31}\)

**Summary.** The objectives of secondary school science in the early part of this century centered in the idea of preparation for college; but the increased enrollment, brought about by greater prosperity, compulsory school attendance laws, and child labor laws, made the schools less selective in function. The percentage of pupils going to college decreased; thus it became apparent that the objectives of education should be changed to meet the needs and interests of all the pupils. The purpose of education is to educate all the children of all the people for a more effective living in our democratic society. The objectives of secondary school science are being gradually changed in order to meet the needs of a democratic society.

Economic and social changes have forced an evaluation of the purposes of our high school chemistry. The majority of the pupils will become citizens who have had very little contact with the study of science but who still live in a society that has been changed by science. They will meet many everyday experiences that are chemical in nature. The trends of the objectives have been slow in changing; but, with the impact of science upon society, teachers have begun to realize their obligations and are reorganizing their courses to meet the needs of the day. The objectives of high school science should have their beginning in the environment of the pupils in order to show the relationship of chemistry to the home, community, and nation, and to demonstrate the effect it has produced on the economic and social aspects of society.
CHAPTER III

FUNCTIONAL TEACHING UNITS PLANNED TO DEMONSTRATE RELATIONSHIP
OF CHEMISTRY TO ENVIRONMENT OF PUPILS

Introduction. The major part of this chapter is devoted to the development and organization of units investigating the mineral resources of Louisiana as a part of the course in high school chemistry. Research studies have shown that the trend in subject matter and course organization is toward the use of units based upon interpretative generalizations or science principles found in the environment of the pupils. These units are planned to show that chemistry can be made interesting and vital by giving the pupils principles which are necessary for the understanding of their environment. This method of teaching high school chemistry will at the same time prepare the pupils who may wish to continue chemistry in college.

Selection and organization of content. Any material that is selected should meet the minimum requirement, and it should be material which will be of the most value to the greatest number of pupils in that particular group. This material must be changed from year to year to meet the needs of the different groups, as the informational background of each group differs from the preceding one.
At best, only guiding principles can be established upon which to base the selection and organization of these materials.

The Committee for the Forty-Sixth Yearbook of the National Society for the Study of Education, Part I, has proposed the following principles upon which the choice of course material be based:

1. The course content should help to satisfy real needs of the students.

2. The course content should be of a proper degree of difficulty, adequate consideration being given in its selection to the maturity level of the pupils.

3. Economic and social applications should be developed and stressed, particularly those relating to everyday life.

4. The content should include a wealth of materials and activities designed for use in developing the abilities and attitudes associated with the scientific method of problem-solving.

5. Content that appeals to pupil interest is more likely to influence pupil behavior than that which does not.¹

Opinions vary as to the order in which units of subject matter should be used and as to the number of units and principles that should be included in a year's course in high school chemistry.


Society for the Study of Education (discussed in Chapter II of this study) the committee suggested that a functional understanding of the scientific principles be considered as an important objective of science teaching. These principles should be the focal points for the organization of materials of instruction in science. The functional understanding of principles such as "chemical and physical changes are manifestations of energy changes" is basic to an understanding of chemistry and has relationship to the many problems of a social, economic, and technical nature of the world.²

Pruitt,³ after a thorough and careful analysis and evaluation of over 50,000 pages of books on high school and college textbooks in chemistry and other science fields, scientific and non-scientific magazines, newspapers, books on sociology, popular books in chemistry and other science fields, and examinations in chemistry, obtained 135 generalizations and concepts of chemistry which are of the greatest value in interpreting the environment of mankind. This research has been a distinct contribution to the reorganization of chemistry. However, the textbooks and courses of study have been slow in adopting the organization along the environmental situations of the pupils, and the teachers have failed for

² Ibid., p. 31.

the most part in developing an understanding of the basic principles of chemistry as related to everyday living.

The following principles have been suggested for the organizations of the chemistry course by the committee of the Forty-Sixth Yearbook, Part I:

1. The content should be organized into fairly large units, each focused upon some functional understanding or principles.

2. The sequence of units should be planned to proceed from the generally less difficult principles to those of greater difficulty.

3. The organization should stress relationships (between units as well as within units).

4. The organization should stress problem-solving as such with emphasis upon the associated skills and attitudes.

5. The classroom work should be constantly related to the larger life outside.

6. The organization should stress the development of interests and attitudes.¹

With the vast amount of new materials added each year, the increased enrollment of secondary schools, the overlapping of high school and college chemistry, and the changes in our social and

economic order of life, a heavy burden has been placed on the science teacher. It is beyond the fondest hope to cover adequately all the subject matter in the present textbooks of high school chemistry. Most teachers are so burdened with routine and outside activities of the present day high school that they have neither the time nor the physical stamina to reorganize their courses in chemistry.

The writer has attempted to solve some of these problems by organizing the course into seven or eight units, offering the fundamental facts, theories, and principles that every pupil should know, whether or not he intends to enter college. The fundamentals are essential to any course in order that pupils may be able to read books and magazines intelligently and to distinguish between the good and bad advertisements which are tendered under the name of science. If the pupils gain an adequate functional understanding of a few principles which are the fundamentals of any course and if these principles have been taught in relation to the environment of the pupils, an appreciation will be built. Pupils finishing their secondary education will realize the magnitude of the resources of their state and the part that chemistry is playing in the development of these resources. They will have adequate preparation for college chemistry.

Organization of high school chemistry. The following units are planned for a year's course in high school chemistry:
Unit I. Materials that Make Up the World Around Us
(Matter and energy, chemical and physical changes)

Unit II. The Most Important Liquid of Life
(Water, solutions, and the composition of water, oxygen and hydrogen)

Unit III. The Structure of Matter
(Units of matter, atoms, electrons, protons, and neutrons. How atoms combine to form compounds. Equations and simple problems)

Unit IV. The Three Great Classes of Compounds
(Acids, bases, and salts. The theory of ionization)

Unit V. The Most Abundant of the Mineral Resources of Louisiana, Common Salt
(From the composition of salt a study of grouping of elements into families. Sodium and chlorine families. Cheapest source of both. Alkali metals and halogens)

Unit VI. Sulphur, a Cornerstone of Industry
(The barometer of the chemical industries and one of the necessary elements for life. One of the valuable mineral resources of Louisiana)

Unit VII. Petroleum, the Magic Fluid
(The source of greatest revenue obtained from mineral resources of Louisiana. The source of many useful compounds of synthetic chemistry)
It is not the purpose of this study to outline in detail every unit planned to be taught in high school chemistry but to give in detail two of the units using the mineral resources of Louisiana. A brief description of each unit is necessary in order to show the connecting thread of each. All of the units deal with some phase of the environment of the pupils, and the first four serve as a foundation for the study of the mineral resources of the state.

**Unit I. Materials that Make Up the World Around Us**

This unit offers a study of the simple terms and tools which the chemist uses. It poses the question: What is the world made of? The unit invites attention to matter and energy and the changes they undergo and to the common elements and compounds that the pupils come in contact with in everyday life, including water, which is the common constituent of all life.

**Unit II. The Most Important Liquid of Life**

This unit deals with the sources, purification, and distribution of water; it teaches the uses of water as a standard for determining temperature, expressing weight, and calories. The study of water as the universal solvent leads naturally into a study of solutions. The determination of the composition of water leads into the study of oxygen and hydrogen, two important gases, and their properties. A study of the causes of pressure and molecular activity in
relation to these gases offers the connecting thread to the study of the structure of matter.

Unit III. The Structure of Matter

A study of the electron theory leads into a study of valence and formation of compounds and equations and problems involving these equations. The study emphasizes what an equation represents and why certain substances react with other substances, like acids on metals, demonstrating the production of electrical current by this action of acids on different metals. These chemical reactions point to a more detailed study of compounds.

Unit IV. The Three Great Classes of Compounds

(Acids, Bases, and Salts)

This unit teaches the properties of acids and bases and the tests used in identifying these substances. A study is made of the common acids and bases found in the home and of the substances called indicators that are available in the natural environment of the pupils and that can be used to identify the acids and bases. Answers are sought to such questions as the following: What is formed in the neutralization of acids and bases? Why do some substances conduct electric current and others do not? A study of the theories of ionization by which the pupils are familiarized with the preparation and identification of the common salts leads into the study of common salt in Unit V.
Unit V. The Most Abundant of the Mineral Resources of Louisiana, Common Salt

A study is made of the occurrence, formation, and locations of the deposits of common salt and the products derived from the substance. The pupils study briefly the history, geology, and location of the salt mines in Louisiana, and these are located on a map of the state. If possible, a visit is made to some of these mines. A part of this unit focuses attention on the composition of common salt (sodium and chlorine) and on the fact that chemists have grouped these elements into two families. The association of deposits of sulphur in the cap rock of some of these salt domes leads into a study of sulphur in Unit VI.

Unit VI. Sulphur, a Cornerstone of Industry

Louisiana is second in the nation in the production of native sulphur, of which three-fourths is used in the production of sulphuric acid, the "king of chemicals." The answer is sought to the question: Why is it that sulphur cannot be mined like coal and iron ore? The uses of sulphur are discussed in relation to agriculture, health, and industry. A visit to the sulphur mines of Freeport Sulphur Company at Grand Ecaille in Plaquemines Parish gives the pupils an insight into the industrial operations, the living conditions of the employees, and the different geographical sections of their state. A visit to the sulphuric acid plant of
the Consolidated Chemical Industries, Inc., of Baton Rouge, Louisiana, produces many interesting problems for discussion and laboratory exercises. A discussion of the uses of sulphuric acid in refining petroleum is the connecting thread to the study of petroleum in Unit VII.

Unit VII. Petroleum, the Magic Fluid

A study is made of fuels and the comparison of each in the production of energy. The pupils learn that many useful carbon compounds are produced from petroleum. The pupils briefly study the methods of locating and drilling for oil and learn some of the problems of conservation and refining of petroleum. A visit is made to the Standard Oil Refinery in Baton Rouge, Louisiana; and motion pictures of the refining processes are shown. The unit gives an insight into the enormous possibilities of new products being formed from petroleum, the significance of scientists in the development of fuels and chemicals, and the relationship of these products to other industries.
UNIT: SULPHUR, A CORNERSTONE OF INDUSTRY

I. Objectives.

A. Unit objective:

To understand and appreciate the importance of sulphur and its compounds and the role they play in the progress of civilization.

B. Specific objectives:

1. To understand and appreciate the following:
   a. The importance of sulphur as a mineral resource in Louisiana.
   b. The nature and location of the native sulphur deposits of Louisiana.
   c. The many attempts made to mine sulphur in Louisiana before it was successfully obtained.
   d. The importance of the Frasch Process of mining of sulphur and how it helped to break the monopoly of Sicilian sulphur.
   e. The importance of sulphur and its compounds in industry.
   f. The importance of sulphur in health, industry, and agriculture.
   g. That if the sulphur deposits of Louisiana and Texas were exhausted, the United States might have difficulty in obtaining its sulphur.
2. To understand how some of the important compounds of sulphur are prepared and to learn their uses.

3. To learn why sulphuric acid is sometimes called the "king of chemicals."

4. To understand the relative advantages of the different processes in the manufacture of sulphuric acid.

5. To understand the process of the manufacture of sulphuric acid in Baton Rouge, Louisiana.

6. To know some of the important properties of sulphuric acid and to understand these in comparison with the common acids.

II. Introduction and Orientation.

A brief presentation of the important facts should be given in order to create interest in further study of the unit. The element sulphur has a romantic history. From the ancient writings one learns that it was used in bleaching linen. The Egyptians used it to some extent in their painting. The Romans used it in medicine, in the making and casting of statues, and in starting fires. The alchemists used it in trying to change baser metals into gold, but it did not come into prominence until the discovery in 1785 of a process for the manufacture of sulphuric acid. The nations of the world sought to control it, and America was dependent upon the rest of the world for sulphur. Native deposits of sulphur were discovered
in the process of drilling for oil in Calcasieu Parish, Louisiana, in 1865. The pupils should learn of the many attempts to mine these deposits by use of the shaft method. They should learn why these attempts resulted in failure. Herman Frasch in 1903 succeeded in obtaining sulphur on a commercial basis over 99 per cent pure from these deposits by forcing super-heated water and steam into them and pumping the molten sulphur to the surface into barrels and vats.

Sulphur furnishes an excellent sample of how men and women of various vocations can find an interest in chemistry. To the doctor and biologist sulphur is one of a dozen or more elements that are essential for the growth of plants and animals and in the manufacture of "sulfa" drugs. The farmer can appreciate the use of sulphur in the preparation of sprays for his fruit trees and insecticides for plants and in the neutralization of alkaline soils. It is of interest to the chemical engineer in the construction of acid resisting cements which can be used in the manufacture of various chemical products. In the home the housewife learns never to leave her silverware in mustard or products where the yolk of egg is used, because the silver will turn black. In industrial centers the houses that are painted with white lead turn dark and have to be repainted frequently. Sulphur is necessary in the manufacture of rubber and the 32,000 rubber products and in the production of sulphuric acids, paper, rayon, paints, petroleum, steel, and fertilizers. It indirectly touches the life of every individual.
Curves of sulfur sales parallel with remarkable accuracy the ups and downs of business activity. In chemical circles it has long been held a truism that complete sulphuric acid statistics — production, consumption, and stocks — lay out a very perfect pattern for the general indexes and in themselves present the clearest, most accurate picture of the state of trade. And most of our sulfur tonnage is converted into sulphuric acid.5

After this brief introductory talk, a discussion period is carried on with the pupils. The ideas and suggestions made are listed on the blackboard. Booklets such as "4000 Years of Yellow Magic," published by Freeport Sulphur Company at Port Sulphur, Louisiana, and "Sulphur — An Essential to Industry and Agriculture" and "Modern Sulphur Mining," published by Texas Gulf Sulphur Company (New York office), are given to each pupil to take home and read. (Booklets can be obtained free of charge.)

The next day a discussion of the booklets read is carried on, and the pupils begin to realize the importance of this study of sulphur.

III. Assignments and Activities.

Following the discussion, copies of the guide sheet for the unit are given to the pupils. This guide sheet lists the problems, readings, and suggested activities to be pursued in the course of

the study of this unit.

THE GUIDE SHEET OR ASSIGNMENT

Problem 1. Where is sulphur found in Louisiana and why can it not be mined as coal and iron ore? How is it mined?

Read: William Haynes, The Stone That Burns

Chapter I. Sulphur Mine in Louisiana
Chapter II. The Frasch Process
Chapter III. The Sulphur Deposits of the Gulf Coast
Chapter XII. Grand Ecaille, the Latest Dome

After several class periods of reading and class discussions, a list of questions is given each pupil with instructions to read very carefully. The announcement is made that a motion picture, "Mining of Sulphur in the Gulf Coast Region," produced by Freeport Sulphur Company (free), will be shown them. This motion picture will clarify many of the points not clear to the pupils or about which their curiosity is aroused.

In order to prepare the pupils for the motion picture, a list of questions is given each individual a day before the film is shown. This is for them to study and to use as a guide to direct their attention when viewing the film.

The following is a list of the questions to be given to
1. Where is sulphur found in the United States?

2. List other countries that produce sulphur and name the sources from which they obtain their sulphur.

3. What are the other sources from which the United States obtains sulphur?

4. At what points along the Gulf Coast is sulphur mined?

5. How was sulphur discovered in Louisiana?

6. What are the nature and occurrences of the geological formation in which sulphur is mined? What are the associated minerals?

7. What are the characteristics of the sulphur bearing formation?

8. Why can not sulphur be mined as is coal?

9. What process is used to mine sulphur in Louisiana?

10. How does this process operate?

11. Upon what scientific principles does the operation of this process depend?

12. What are the first requisites in mining sulphur in Louisiana and Texas?

13. Water boils at 212°F. How can water be heated to 360°F.?

14. Why is the water treated before going to the boilers?

15. How do they get rid of the excess water in the sulphur
bearing formation?

16. Why do they purify the water before it is released in
   the Gulf waters?

17. What causes the molten sulphur to rise in the four-
   inch pipe?

18. How is the molten sulphur brought to the surface?

19. Why is the relay station such an important part of
   the operation of the sulphur wells?

20. Why is the garden sprinkler arrangement used for the
   discharging of the sulphur in the storage bins?

21. How large are the storage bins?

22. Why is mud sometimes pumped into the sulphur bearing
   formations?

23. What are the important uses of sulphur?

24. What does the company do to take care of its employees?

The film is shown without comment, and then a discussion
period is held. When questions that the pupils do not understand
arise, the film is shown immediately and stopped at the places
where these questions may be answered. Explanations and discussion
on the reshowing of the film are carried on until the pupils under-
stand the problems. This is a fine motivating device. The majority
of the students ask for supplementary materials on the mining of
sulphur.
Demonstration

A demonstration of a working model of the Frasch Process is made for the class with the assistance of several of the pupils.

In order to be able to use glass in the construction of the model, paraffin which has been colored yellow is substituted for sulphur because of the high temperature and pressure necessary to melt the sulphur.

The accompanying diagram shows the apparatus as used. A wide-mouthed bottle (D) filled with lumps of yellow paraffin and small pebbles and sand to represent sulphur deposits. A Liebig condenser (C) with lower rubber connection removed is used as an outer and inner jacket. A cork is fitted to the wide-mouthed bottle (D) and holes are bored to fit the lower end of outer jacket of the Liebig condenser. A tube for the compressed air is passed down the inner tube of the condenser, and it is fitted with a two-hole rubber stopper at the top of the condenser. Through the other hole of the stopper at the top of the condenser a delivery tube is inserted, in order to conduct the molten materials into a glass (Collection Bin) representing a storage vat or bin. The upper inlet of the outer jacket of the condenser is connected to a steam boiler (B) and the lower outlet of the water jacket is closed by means of a screw clamp and rubber tubing.

Steam is sent through the outer jacket and passes into the
bottle (D). The paraffin melts and accumulates in the bottom of the bottle. When enough has melted, compressed air which is furnished by means of a bicycle pump is introduced through tube as shown in the diagram and forces the melted paraffin, water, and air through the intermediate tube to the storage vessel.

This process duplicates the essential features of the Frasch Process for the mining of sulphur. 6

Field Trip

A visit to the Freeport Sulphur Company mines at Port Sulphur 15 miles below the City of New Orleans on the Mississippi River in Plaquemines Parish is made. The necessary arrangements are made by the class. They select a committee to write for permission to visit the mines, to provide the necessary transportation, and to indicate the time and place to assemble, clothes to wear, necessary notebooks, questions to be asked, and places to stop for food. Standards of conduct are listed by the pupils on the blackboard for the trip, and each pupil is provided with a copy of these.

After the trip to the mine the next class period is devoted to an exchange of ideas and a discussion of the experiences of the trips. Reports are given by the pupils, and a summary of the trip is made on the blackboard by the pupils. (An excellent outline for making field trips is given in Modern Methods and Materials for

Delivery Tube

Compressed Air

Collection Bin

Screw Clamp

Rubber Tube

Entry for Steam

AA—GROUND LINE; B—BOILER; C—CONDENSER; D—Bottle Containing Wax (Representing Sulfur)

Courtesy of Journal of Chemical Education, 8:1632, August, 1931.
Experiments

Individual: To learn something of the physical and chemical properties of sulphur.

1. Take a piece of sulphur about the size of a small pea and add 3 or 4 ml. of carbon disulphide. (Caution: be sure no flame or burner is lit as carbon disulphide is very inflammable) and shake.

Filter into a watch glass. In a few minutes examine the crystals under a magnifier, and describe the appearance of these; save these crystals and examine again after a few days. What do you observe?

2. Heat gently 1/2 of a test tube of powdered sulphur until it melts. (Be careful that the sulphur is not heated to the point that it becomes dark. Just melt the sulphur.) Pour this into a folded filter paper in a funnel. When a crust is formed on the surface, gently and quickly spread out the filter paper. Examine the crystals under a magnifier. Describe the shape of these crystals, and after a few days examine again and describe what is observed.
3. Heat about 1/3 of a test tube of sulphur until it boils. Pour this into a beaker of water. Remove and examine the sulphur. Try to pull on it. Describe your observations. Examine this after a few days. Describe your observations.

4. Perform an experiment to see if sulphur is soluble in cold and hot water.

5. Burn a small piece of sulphur and note the odor of the gas. (Be careful not to inhale too much of this gas.)

6. Heat about 1/3 of a test tube of sulphur until it begins to vaporize; insert a thin strip of copper into the tube; and remove the copper strip and examine. Describe your observations.

7. Rub some powdered sulphur on a silver coin and observe what happens after a few minutes. (If nothing happens, heat the coin and sulphur gently.) Describe what happens.

Demonstration: (By the teacher with the pupils at a safe distance.) A little powdered sulphur and an equal amount of powdered zinc are mixed in a pile on an asbestos mat and carefully ignited with a flame from a burner. Describe what happens. Examine the asbestos mat for deposits of materials.
The pupils are to write in their notebooks the purpose and their observations on each experiment. Where a chemical change takes place, they are to write the equations. A part of the assignment is to write a short summary combining these experiments into one paragraph.

Supplementary References


Questions or Problems

1. Why does the gangue material not come up with the molten sulphur in the Frasch Process?

2. What is the importance of sulphur in agriculture, medicine, and industry?

3. What properties of sulphur make it useful in making certain kinds of cement?

4. What are other sources of sulphur in the United States? How is sulphur obtained from these sources?

5. What advantages does the sulphur obtained from Louisiana and Texas have over sulphur obtained from other sources?

6. What economic value is the mining of sulphur to the state of Louisiana?

7. What is meant by the vulcanization of rubber? How has
this affected the social and economic conditions of the country?

8. What scientific facts or principles have you learned in the study of this problem?

Panel Discussion or Forum

Those pupils who have finished all of their work on this problem are organized into a group to plan a forum on the important points and to clear up any problems that are not clear.

Testing

Evaluation is taking place all the time. Short tests are given at varying intervals. The experience of the writer has shown that such tests have a stimulating effect on the pupils. Written reports, exercises, discussion, and other class activities serve also to keep the teacher informed on the work of the class. A progress chart and a record of the number of points made on each test is kept by each pupil.

Essay and objective type tests are used. Throughout the unit the essay type test is used to see how the pupils can use the new information which has been acquired. The unit test is usually of objective nature, using various forms, together with some types of questions requiring reflective thinking. A key is made for each test before it is given. Sometimes pupils and teacher make the key
for the short essay tests after they are given. This is very good for occasional use. The following list of questions illustrates the type of question used during the study of the problem at different intervals.

Test questions used at different intervals in Problem 1:

1. Describe briefly the sulphur deposits of Louisiana.
2. What are the ways in which the sulphur deposits of Louisiana and Texas differ from those of Sicily?
3. What facts did Frasch take into consideration in obtaining sulphur from the deposits in Louisiana?
4. What are the requisites for the successful operation of the Frasch Process?
5. Why is mud pumped into underground formations?
6. What is the purpose of the relay station?
7. What are some of the impurities and why must they be removed from the bleed water before it is discharged into the Gulf?
8. Why does the company not re-use the bleed water in mining sulphur?
9. Briefly summarize the physical and chemical properties of sulphur.
10. Why does silverware in the home tarnish much more rapidly in the winter than in the summer?
11. Describe briefly why sulphur is such an important element.
Problem 2. In attempting to sink a shaft to mine sulphur in Louisiana, the workmen encountered not only quicksand and water, but poisonous gases, mainly hydrogen sulphide. Why is this gas used by chemists in chemical analysis?

Exercise 1: Hydrogen sulphide is very poisonous. One part in two hundred parts of air may prove fatal if breathed for any length of time. What is the action of this gas on the body?

Read: Chemistry and You
A First Book in Chemistry
New Practical Chemistry
Holmes, General Chemistry

Problem: Question No. 5, Chemistry and You, p. 273

"Air containing more than 0.02 per cent by volume of hydrogen sulfide is dangerous. Suppose thirty pupils who are preparing hydrogen sulfide permit four liters of the gas to escape from each flask generator into a laboratory the dimensions of which are 10 x 8 x 5 meters. Assuming that there is no ventilation, calculate the approximate percentage of hydrogen sulfide in the room."7

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Demonstration

The preparation and properties of hydrogen sulphide are performed as a demonstration by the teacher. The demonstration is followed by a general discussion of the precipitation of the metallic sulphides and of the reason that hydrogen sulphide is used in qualitative analysis.

Laboratory Problems

1. To discover why the walls of chemical laboratories are not painted with white lead. If the walls are painted white using a paint made up of compounds of zinc and barium, why do they not turn black? (The pupils write out their procedure and have it checked by the teacher. Then several pupils are selected to demonstrate their experiment. Note: Hydrogen sulphide is very poisonous.)

2. To test to see if the gas that is used for cooking and heating the home contains hydrogen sulphide.
Testing

Test questions used at different intervals in Problem 2:

1. Carbon monoxide and hydrogen sulphide are very poisonous gases. Why is hydrogen sulphide the less dangerous of the two?

2. Paintings and silverware tarnish in the home. Can you give a reason why?

3. How could you prove that a substance is a sulphide?

4. Given the materials iron, hydrochloric acid, and sulphur, devise an experiment to make hydrogen sulphide.

Problem 3. Into what compound is most of the native sulphur of Louisiana and Texas converted before it is used by industries?

Exercise 1: What compound of sulphur is formed when sulphur is burned? Take a small piece of roll sulphur and place it in a deflagrating spoon and ignite it. (Do not inhale too much of this gas.) Note the odor and color of the flame. Place the burning sulphur in a wide-mouth bottle containing some water. Keep the bottle covered as nearly as possible with a piece of card board.
After the sulphur has burned, stopper the bottle and shake. Test this solution for an acid or base.

Burn a piece of roll sulphur in a crucible under a bell jar, which contains moisture and dry rose petals. Describe your observations. Write the purpose and conclusions in your note book.

**Exercise 2:** What are some of the other methods of preparing this compound? What are some of its important properties?

**Read:**
- *Chemistry and You* 282
- *Fundamentals of Chemistry* 198-199
- *New Practical Chemistry* 202
- *Read, Industrial Chemistry*, 3rd edition 157
- *Modern Chemistry* 389

**Read:**
- *Chemistry and You* 279-284
- *New Practical Chemistry* 202-204
- *Modern Chemistry* 389-392
- *Dynamic Chemistry* 297-299
- *Modern-Life Chemistry* 286-289
- *A First Book in Chemistry* 318-323
Experiments

Demonstration: (By the teacher.)

Sulphur dioxide is prepared for the class, using sodium sulphite and dilute sulphuric acid. The gas is collected in wide-mouth bottles by air displacement. The following tests are performed: solubility, density, and determination as to whether the gas would burn or support combustion.

In separate bottles of the gas the following substances are placed: moist and dry paper with ink and pencil marks, moist and dry rose petals, apple peeling, and a piece of an old straw hat that has turned yellow. Allow to stand for few minutes. The apple peeling after the color has been removed is placed in a bottle containing some hydrogen peroxide and allowed to stand until the color reappears. From these observations a class discussion of the bleaching action of sulphur dioxide is carried on. Potassium permanganate in dilute solution is poured into a bottle containing sulphur dioxide. Observe what takes place.

Sulphur dioxide is liquified for the class in a glass tube, using dry ice.
Individual: Heat on a piece of charcoal, using a blowpipe, the following minerals: galena, iron pyrites, and zinc blende. Note the odor. (This is an important source of sulphur dioxide.)

Briefly summarize in your notebook your observations and conclusions of the demonstrations and individual experiments, writing equations where chemical reactions take place.

Test questions used at different intervals in Problem 3:

1. Explain the difference between the action of sulphur dioxide and chlorine as bleaching agents.
2. Why is a straw hat white in the early summer and yellow in the fall?
3. Study the labels from cans and packages of food to see if there is a connection with sulphur dioxide.
4. How many liters of air are necessary to burn 800 grams of sulphur 99.5% pure? (Assume that the air is 20% by volume of oxygen.)

Problem 4: Why is sulphuric acid such an important chemical in the industrial world?

Exercise 1: What are the most important properties of sulphuric acid?
Individual: Before performing any experiment with sulphuric acid, read the first aid chart, in case some is spilled on the skin or clothes. (Be very careful in pouring, heating, or diluting sulphuric acid. Always pour the acid into water, small amounts at the time, stirring the mixture. Never pour water into acid.)

1. Measure 25 ml. of water and pour this into a beaker.

Then dry the graduate cylinder and measure 5 ml. of concentrated sulphuric acid. Pour the acid slowly into the beaker containing the water, and stir the mixture. Feel the bottom of the beaker.

2. Pour about 5 ml. of dilute sulphuric acid into a test tube and add a few small pieces of zinc. Test the gas with a lighted splint. Pour 5 ml. of concentrated sulphuric acid (Handle with care.) into a test tube and add a few small pieces of zinc. Contrast the action
Repeat the experiment, using copper. (Perform this only in the presence of the teacher.) Heat the concentrated acid and copper gently. Note the odor. (Be careful about inhaling any of these fumes.) Test the dilute acid with litmus paper.

3. With a stirring rod put a few drops of concentrated sulphuric acid on a wooden splint. Place a small piece of cotton or cotton cloth in a test tube and pour about 3 ml. of concentrated sulphuric acid into the test tube and observe what happens. In another test tube fill the curved part with granulated sugar and add a few drops of concentrated sulphuric acid. Place this in your test rack and do not stand too close to the tube. Observe.

4. Put 1 gram of each of the following compounds into separate test tubes: sodium chloride and sodium nitrate. (Be careful not to inhale any of the gases given off.) Add 3 ml. of concentrated sulphuric acid and test the gas given off in each case with moistened blue and red litmus. If there is no reaction, heat gently.

5. Pour 2 ml. of dilute sulphuric acid into a test tube and add 2 ml. of barium chloride. After a few minutes add 2 ml. of hydrochloric acid. (This is a test for
sulphates.) Repeat, using sodium sulphate and sodium chloride solutions. What have you learned about the properties of sulphuric acid? Summarize briefly the properties of sulphuric acid in your note book. Write equations where chemical reactions take place.

Exercise 2: What methods are used in the manufacture of sulphuric acid?

Read:  
**Fundamentals of Chemistry** 200-203  
**Chemistry and You** 293-298  
**Chemistry for Our Times** 349-353  
**A First Book of Chemistry** 325-330  
**Modern-Life Chemistry** 292-296  
**Holmes, General Chemistry** 264-271

Field Trip

A visit to the sulphuric acid plant of the Consolidated Chemical Industries, Inc., in Baton Rouge, Louisiana, is made. The same technique for the organization and conducting this trip is used as previously described in the visit to Port Sulphur, Louisiana. In this plant the contact process is used for the manufacture of sulphuric acid. One of the problems that comes out of this visit is that when the pupils see a tank car made of iron being loaded with concentrated acid, they are amazed that this powerful chemical can be shipped in these cars. The next class period they set about trying
to devise an experiment whereby they can learn the answer to this problem.

Demonstration

A working model or demonstration of the contact process is set up for the class. Several of the pupils are given the problem of making a suitable catalyst for the process; some have the problem of supplying and purifying the sulphur dioxide; and others devise ways of proving the product formed is sulphuric acid.

Models

Cross section models of both the chamber and contact processes are constructed by students working in pairs. Only those who wish to do this are encouraged to make these models. Usually those pupils who take woodwork or shop are pupils who elect to do this. (See supplementary references for suggestions on constructions of working models.)

Graphs

Make a graph showing the production of sulphuric acid since 1910.

Exercise 3: What are the most important uses of sulphuric acid?
Make a chart or graph showing the uses of sulphuric acid.

Written Work

Write a paper on "Why Sulphuric Acid is Called the 'King of Chemicals.'"

Supplementary References

5. S. C. Dennis, "A Miniature Contact-Process Sulfuric Acid," Journal of Chemical Education, 6:1781-1783,
Panel Discussion or Forum

On the comparison of the chamber and contact processes for the manufacture of sulphuric acid.

Questions

1. Often brown rings are found on the re-agent shelves where bottles of concentrated sulphuric acid have been standing. How can you account for this?

2. Why is concentrated sulphuric acid used for drying gases? Could this acid be used in drying all gases? If so, explain your answer; if not, give example of a gas that could not be dried with concentrated sulphuric acid.

3. Explain the action of concentrated and dilute sulphuric acid on an active metal; on a metal below hydrogen in the activity series (copper).

4. Why is concentrated sulphuric acid used in the preparation of such acids as hydrochloric and nitric?
5. A laboratory assistant was diluting some concentrated sulphuric acid and left 25 ml. of concentrated acid in a graduated cylinder for several weeks, in the laboratory. Remembering that he had left it, he returned to dilute it. He observed a change in the volume of the acid. Can you give an answer as to what kind of change in volume had taken place and why?

6. Sulphuric acid is used in the manufacture of the following:
   a. Fertilizers (superphosphate)
   b. Refining of petroleum
   c. Sodium sulphate
   d. Storage batteries
   e. Galvanizing iron and steel
   f. Explosives
   g. Dyes
   h. Drugs

Would you use acid made by the chamber or contact process? Explain your answer.

7. Why is it more practical to use vanadium pentoxide as a catalyst than platinum?

Testing

Test questions used at different intervals in Problem 4:

1. List four important properties of sulphuric acid and
2. Barium chloride is added to a dilute solution of sulphuric acid a ________________ which is ________________ in hydrochloric acid.

3. Why is concentrated sulphuric acid shipped in an iron or steel car and dilute acid is not?

4. Number 1 is a problem; read this carefully and check in 2 the correct answer or answers. Check the statements in 2 which give your reasons for the correct answer. Most of the statements are true but may not be the reasons for the correct answer. These should not be checked.

   No. 1
   Sulphuric acid is used in the preparation of explosives and flavors. Why?

   No. 2
   ____ (1) Sulphuric acid has a high boiling point.
   ____ (2) Sulphuric acid is a good oxidizing agent.
   ____ (3) Sulphuric acid is a good dehydrating agent.
   ____ (4) Sulphuric acid has a high specific gravity.

   No. 3
   ____ (1) Sulphuric acid is used in making other acids.
   ____ (2) Sulphuric acid reacts with copper to produce S\textsubscript{O}\textsubscript{2}.
   ____ (3) Barium chloride is used in testing for a sulphate.
Sulphuric acid removes water from substances.

Nitric acid is used in manufacture of explosives.

Esters are produced by the reaction of an acid and alcohol in the presence of concentrated sulphuric acid.

Explosives are unstable compounds.

Many esters have a fruity odor.

Sulphuric acid is used in preparation of ethers.

A chemical reaction will go to completion if one of the products formed is volatile.

IV. Vocabulary: New Terms and Words.

Be able to spell and use these correctly:

1. Vulcanisation
2. Dehydrating agent
3. Gangue
4. Anhydride
5. Rhombic
6. Monoclinic
7. Amorphous
8. Iron pyrites
9. Roasting
10. Sulphides
11. Sulphites
12. Sulphates
13. Oil of vitriol
14. Bisulfites
V. **Special Activities.**

1. Motion picture: Mining of Sulphur on the Gulf Coast, Freeport Sulphur Company (free).
2. Glass lantern slides made by the pupils on the chamber and contact processes and the Frasch Process.
3. Field trip to Port Sulphur where the mines of Freeport Sulphur Company are located.
4. Posters and charts showing the cross section of a typical Gulf Coast salt dome sulphur field.
5. Posters and charts showing the production and uses of sulphur.
6. Models of the Frasch Process and chamber and contact processes constructed by some of the pupils. These are cross sections made of balsa wood mounted on heavy cardboard and painted.
7. Working models constructed and demonstrated to the class of the Frasch Process and contact process.
8. Panel discussions or forums held at different times on important problems that arise in class.
9. Reports on the lives of Herman Frasch and Charles Goodyear made by pupils.
10. Reports on Sicily deposits of sulphur, and other sources of sulphur.
11. Reports on the uses of sulphur and its compounds.
12. Reports on the deposits of native sulphur of Louisiana and Texas.
13. Scrapbooks of articles and pictures relating to sulphur and its compounds.
14. Graphs made on the production, use of sulphur, and sulphuric acid.

VI. Organization.

Here the unit is summarized and the pupils are taught how to outline the unit for the essentials, and how to express these in a clear and concise form. It gives the pupils an overall view and helps the pupils to collect their thoughts and put them into some logical form.

VII. Unit Test.

After the organization and floor talks, the unit test is given. This is an objective type usually, but not always.
BIBLIOGRAPHY FOR UNIT ON SULPHUR

PUPILS' BIBLIOGRAPHY

A. BOOKS


B. TEXTBOOKS


C. PERIODICALS


D. BOOKLETS OR PAMPHLETS

Freeport Sulphur Company, 1804 American Bank Building, New Orleans 5, Louisiana

1. "4000 Years of Yellow Magic" (Free)
2. "Flow Charts and the Uses of Sulphur" (Free)
3. "Brimstone Brevities" (Free)

Texas Gulf Sulphur Company, 75 East 45th Street, New York 17, New York

1. "Sulphur—An Essential to Industry and Agriculture" (Free)
2. "Modern Sulphur Mining" (Free)
3. "Sulphur Mining at Newgulf" (Free)
UNIT: PETROLEUM, THE MAGIC FLUID

I. Objectives.

A. Unit objective:

To understand and appreciate the importance of petroleum and its products and how American ingenuity has produced miracles.

B. Specific objectives:

1. To understand and appreciate the following:
   a. The importance of petroleum as a mineral resource in Louisiana.
   b. The possible formations and nature of formations where oil may be found.
   c. The part that Louisiana plays in the production of petroleum in the United States and the world.
   d. The importance and potentialities of petroleum and natural gas as fuels for the development of other mineral resources and industries in the state.
   e. What the state and nation are doing in the conservation of petroleum and natural gas.
   f. The importance of research in the development of new sources of fuels.

2. To understand the following:
a. Some of the simple basic principles or facts of the refining of petroleum.

b. The nature of the different substances that are used for fuel in the United States.

c. That petroleum and natural gas are sources of many basic compounds of organic chemistry.

d. How it is possible for carbon to form thousands of different compounds, and its position in the periodic table.

e. That many of our useful and important chemicals and commercial products are obtained from petroleum and natural gas.

II. Introduction and Orientation.

A brief history is presented of the discovery of petroleum and the drilling of the first oil well by Colonel E. R. Drake near Titusville, Pennsylvania. The pupils should be interested in knowing how he used an iron pipe and battering ram made of oak to drive the pipe into the ground. At the depth of about 70 feet he reached oil. This is contrasted with our modern way of drilling, to depths occasionally reaching 16,668 feet. A motion picture, "10,000 Feet Deep," produced by the Shell Oil Company of Houston, Texas (free), is a very fine motivating device, giving a brief description of the origin of oil and showing how modern science has replaced superstition. The various tests are made to determine the location and
the depth of the underground anticline rock formations. It shows how the drilling of the deepest wells in the swamps and bayous of Louisiana was accomplished. This is a splendid picture for the introduction of the unit on petroleum, especially since some of the scenes are made of drilling in the bayous of Louisiana. The Petroleum Engineering Department of Louisiana State University has been generous in lending this film for use in the chemistry classes of the University High School.

After the showing of the film, the class is encouraged to discuss the production of petroleum. They are asked to read the booklets, "Petroleum in the World," published by the Standard Oil Company of New Jersey, and "Contribution of Petroleum to Industry, Farm, and Home," published by the Bureau of Educational Services. (Booklets can be obtained free of charge.)

The next class period is given to the discussion of these booklets. They bring to the pupils the realization of the effect on the standards of living of motor driven vehicles fueled by petroleum products and natural gas. They offer the statistical statement that the petroleum products and natural gas furnish 42.6 per cent of the energy produced in this country from all sources. The pupils are made thoughtful at the realization that our transportation system and industries could not function without lubricating oil and that one of the modern sources of hydrogen is obtained from natural gas or methane which can be made to combine with
nitrogen to make fertilizers, sprays, and insecticides for the control of pests and plant diseases for the farmers' use and to make possible the preparation of 2, 4-D weed killer. The contributions of petroleum to medicine and to the home are of particularly keen discussion value.

III. Assignment and Activities.

A guide sheet or assignment guide is given each pupil with a list of the problems, exercises, readings, experiments, and suggested activities to be pursued in the study of the unit.

THE GUIDE SHEET OR ASSIGNMENT

Problem 1. What are petroleum and natural gas, and where are they found? How are they obtained? What are the useful compounds?

Exercise 1: Where are petroleum and natural gas found in Louisiana? How does the state of Louisiana rank in the production of these resources in the United States?


Map: Make a map showing the seven leading states
in the production of crude oil in the United States. Make a map of Louisiana showing the parishes that produce petroleum and natural gas, or both.

Exercise 2: In what kind of formations are petroleum and natural gas likely to be found? How does the scientist locate these possible formations of petroleum and natural gas? How are petroleum and natural gas obtained?

Read:

- Chemistry and Human Affairs 192-197
- Petroleum in the World 6-9, 13-15
- Contribution of Petroleum to Industry-Farm-and-Home 5-6
- Lamp (December, 1943) 4-7
- Lamp (August, 1946) 10-12

Motion Picture: "Prospecting for Petroleum," Shell Oil Company, Houston, Texas (free).

Running time: 23 minutes, size 16 mm. and 35 mm. Sound and Technicolor

Teachers' Manual and wall charts are furnished upon request.

This film gives a brief portrayal of petroleum and its uses. It explains simply
and graphically how oil has been located, from the early days of the "doodlebugs" and the divining rod to the science of modern exploration for oil. It uses animation in portrayal of the structure of the possible formations that might contain oil, and demonstrates the use of the modern scientific instruments employed in mapping these formations.

Questions on the Film

These questions are used to direct the attention of the pupils when viewing the film and to enable them to give an intelligent discussion of the film.

1. Where are oil and natural gas located?
2. Why was the first oil well drilled, and how?
3. What is meant by "doodlebugs"?
4. What methods are used by the scientists in locating the formations that might contain petroleum?
5. How does the scientist map these formations without leaving the surface of the earth?
6. Upon what principles does the seismograph operate in locating possible formations containing petroleum?
7. What methods are used in drilling for petroleum and natural gas?
Exercise 3: Of what are petroleum and natural gas composed?

Read: Chemistry and Human Affairs 501-505
Chemistry and You 161-163
Dynamic Chemistry 600-604

Questions on Problem 1:

1. Describe briefly the production of petroleum and natural gas in Louisiana.

2. Describe briefly the possible formations where petroleum and natural gas are most likely to be found.

3. What causes the petroleum to flow from the ground?

4. What is the composition of petroleum and natural gas?

5. How does the composition of petroleum change with the source? Explain.

6. What is the difference between proved reserves and resources?

7. Why is mud used in drilling for petroleum and natural gas?

8. What are some of the conservation measures used in the petroleum and natural gas industry?

9. What is the difference between the paraffin base, asphalt base, and mixed base?

10. What is a hydrocarbon? Write the structural formula for
the first five hydrocarbons in the paraffin series.

11. What are some of the impurities found in petroleum?

12. Why should sulphur compounds be removed from petroleum?

Problem 2. How is petroleum refined?

Exercise 1: What are the first steps in the refining of petroleum or crude oil?

Read: Chemistry and You 462-467
Fundamentals of Chemistry 481-484
Lamp (June, 1946) 12
Petroleum in the World 19

Motion Picture: "Refining of Crude Oil," Eastman Teaching Film. Running time: 15 minutes, size 16 mm. Silent. (University Laboratory Film Library.)

This film is a series of laboratory demonstrations, photographs and animations. It shows the steps, in animation, of the fractional distillation and the uses of many of its products.

Exercise 2: What is the most important product of petroleum, and how has modern science improved and increased the yield of this product?
Panel Discussion on Modern Motor Fuels

In this discussion reports are made on the following topics and are discussed: thermal cracking, (fluid) catalytic cracking, polymerization, alkylation, and octane rating. (Sometimes this is carried on over several class periods.)

Supplementary Readings


Exercise 3: What are some of the other products produced in the refining of petroleum?

Read: *Dynamic Chemistry* 604-609
Motion Picture

"Refining of Crude Oil" is shown for the second time for the pupils to see how products other than gasoline are obtained.

Models, Charts, and Posters

Charts and posters are made of the products obtained from petroleum. Cross section models of balsa wood are made to illustrate the flow chart of petroleum.

Demonstration (by the teacher)

An apparatus consisting of an electric heater, distilling flask, Liebig condenser, and a fractionating column is set up to demonstrate the refining of crude oil. Some crude oil obtained from the University Oil Field is used for the experiment. Dry ice is used to chill some of the distillate so as to determine if any wax or paraffin is present.

Reports:  1. Kerosene
          2. Diesel fuels
          3. Lubricating oils
4. Greases
5. Paraffin wax
6. Petrolatum and mineral oil
7. Asphalt
8. Gases

Field Trip: A visit through the refinery of the Standard Oil Company of New Jersey at Baton Rouge, Louisiana. This trip enables the students to get a good conception of modern industry. The huge catalytic cracking units and rubber plant are explored and observed.

Questions on Problem 2:

1. Why can petroleum be separated into different products?
2. What changes have taken place in the production of gasoline and kerosene since 1900?
3. What is fractional distillation, and how is this carried out in a refinery?
4. What is the difference between thermal cracking and catalytic cracking?
5. What is meant by the terms polymerization, and alkylation?
6. What is meant by "octane rating"? How can this be changed?
7. What is meant by synthetic gasoline? Name two processes that the Germans used to produce synthetic gasoline.

8. Recently the Standard Oil Company of New Jersey built a pilot plant at Baton Rouge, Louisiana, for the purpose of testing their process of making synthetic gasoline. What is the main material used to produce gasoline?

9. Why is lubricating oil so important in our modern civilization?

10. Assuming that gasoline has a composition of $C_7H_{16}$, calculate the volume of air needed for the complete combustion of 1000 grams of this gasoline.

11. Describe what comes from 100 gallons of crude oil.

12. Why is Louisiana such an important state in the petroleum industry?

13. How is sulphuric acid used in the refining of petroleum?

14. Assume that in the distant future we will not have any natural oil. What are possible sources of liquid fuels?

Problem 3. What is the chemical nature of petroleum and natural gas?

Exercise 1: What is the composition of natural gas?
Demonstration

Preparation of Methane: Use several grams of fused sodium acetate and about 6 grams of soda lime. Grind these in a mortar. Place the mixture in a hard glass test tube provided with a rubber stopper and a delivery tube. Support the test tube by means of a clamp to a ring stand with the end of test tube containing the stopper slightly lower than the other end. Heat the tube gently and collect several bottles of the gas over water. Place a lighted splint into a bottle of the gas. Describe your observation. Add a dilute solution of potassium permanganate solution to a bottle of the gas and shake. Allow to stand a few minutes. Repeat, using bromine.

Collect several bottles of natural gas from the laboratory outlet and perform the same tests with this gas as stated above.
Describe in notebooks observations and conclusions. Write an equation for the preparation of methane from sodium acetate using sodium hydroxide in place of soda lime.

Questions

1. Methane is a hydrocarbon, and natural gas is composed for the most part of methane. What are some of the other members of this series?

2. What is meant by saturated hydrocarbon?

3. Why are there so many compounds containing carbon and hydrogen?

4. How many hydrogen atoms would a compound containing 60 carbon atoms contain?

5. What is meant by isomers? Write the structural formula for isomers of pentane.

6. What synthetic chemical industries have been built up in the last few years using natural gas as the raw material?

7. What is carbona? Write the structural formula for this compound.

Exercise 2: Primarily petroleum is regarded as a source of fuel, but recently it has become the
source of a large number of chemical compounds. What is the composition of petroleum? What are some of the compounds derived from petroleum in the thermal and catalytic cracking and other processes of refining?

Read: Read's Industrial Chemistry 368-370
Petroleum in the World 20–25
Modern Chemistry 686–690
Rubber from Oil 1–2h

Demonstration

Preparation of Acetylene: Place a few small pieces of calcium carbide in a flask supported to a ring stand by means of a clamp. Fit a two-hole rubber stopper to the flask containing a dropping funnel and a delivery tube. Put some water in the dropping funnel and let the water fall very slowly, drop by drop onto the calcium carbide in the flask. Collect several bottles of the gas over water. Collect a test tube of the gas over water. Ignite the test tube of gas. Add to a bottle of the gas a few drops of
bromine. Cover and shake. (Do not inhale any of this gas, as it is poisonous.)

Compare the action of bromine with methane and this gas. Describe your observation and conclusion. Also compare this gas with methane. Write an equation for the preparation of acetylene. Compare the structural formulas of methane and acetylene. How do you think ethylene would react with bromine?

Questions

1. What is meant by unsaturated compounds?

2. What are some of the unsaturated compounds obtained in the refining of petroleum?

3. How could you prove that a substance is a saturated or unsaturated hydrocarbon?

4. Why is ethylene such an important compound? What are some of its uses?

5. What are propylene and butylene? What useful substances are made from these compounds?

6. What was the source of our toluene for the manufacture of TNT during the war?

7. Why were we able to produce synthetic rubber?
so quickly after our supply of natural rubber was cut off during the war?

8. What are some of the different kinds of synthetic rubber?

9. Compare synthetic rubber with natural rubber.

Exercise 3: During the war a considerable amount of our ethyl alcohol and other alcohols for industrial purposes were made from the refinery gases. What are the sources of these compounds and their uses?

Read:

Chemistry and You 488-491
Fundamentals of Chemistry 501-504
New Practical Chemistry 442-447
New World of Chemistry 583-589
Read's Industrial Chemistry 369-370

Experiments

Individual:

1. Place a small amount of salicylic acid and methyl alcohol in a test tube and add a few drops of concentrated sulphuric acid. Warm gently and note the odor. This is a crude test for methyl alcohol.

2. Add a few drops of ethyl alcohol to about 1 ml. of
dilute sodium hydroxide. Add to this drop by drop a solution of iodine in potassium iodide until a yellow color appears after it has been shaken. Heat gently and note the odor and appearance of the precipitate. This is a test for ethyl alcohol.

(Caution: Tests based on odors are not reliable for positive or absolute identification of substances. Derivatives must be prepared which have definite melting points. Other substances give the odor of iodoform when tested in this manner.)

3. Pour 2 ml. of amyl alcohol and an equal amount of acetic acid in a test tube and add a few drops of concentrated sulphuric acid. Heat gently and note the odor. (Caution: Do not inhale too much of the vapors.)

4. Add 2 ml. of ethyl alcohol and 1 ml. of butyric acid and a few drops of concentrated sulphuric acid. Heat gently and note the odor.

The compounds prepared are known as esters. Write the structural formula for amyl alcohol and acetic acid. Then write the structural formula for amyl acetate.

Read: Holmes's General Chemistry: Alcohols from petroleum 419-421
1. Why is petroleum an important source of organic compounds?

2. Anti-freeze compound under the trade name of Prestone is sold to the public. Suggest the class of organic compounds that this belongs in.

3. Why is concentrated sulphuric acid used in the preparation of esters and ether?

4. Discuss briefly the possibility of the manufacture of soaps and detergents from petroleum.

5. What are some of the important uses of acetone?

6. Why are esters important?
7. What is used in bakelite? Can these products be obtained from petroleum?

8. What compounds derived from petroleum can be used as anesthetics?

9. What substance obtained from petroleum is used as a base for medicinal salve?

Panel Discussion

Petroleum as a source of important raw materials for chemical industries.

IV. Vocabulary: New Terms and Words.

1. Hydrocarbon
2. Anticline
3. Fault
4. Seismograph
5. Fractional distillation
6. Pipe still
7. Aldehyde
8. Ester
9. Ketone
10. Unsaturated hydrocarbon
11. Saturated hydrocarbon
12. Thermal cracking
13. Catalytic cracking
14. Polymerization
15. Alkylation
16. Agitator
17. Viscosity
18. Octane rating

V. Special Activities.

Laboratory Experiments and Models:

1. Preparation of bakelite and other synthetic resins.
2. Preparation of salves and cosmetics.

3. Collection of samples of petroleum products.

4. Construction of cross section models of the flow charts of the refining of petroleum.

5. Construction of a miniature oil derrick and cross section of the underground structure of an oil trap.


Reports:

1. Products that are obtained from a barrel of petroleum

2. Motor fuels

3. Synthetic rubber

4. Synthetic alcohol

5. Synthetic gasoline from natural gas

6. History and discovery of petroleum and natural gas in Louisiana

7. Preparation of oil from shale

8. Cosmetics

9. Lubricating oils
Charts and Graphs

1. Comparison of energy from oil and other fuels.
2. Consumption of gasoline in the United States since 1940.
3. Production of crude oil in United States since 1940.
4. Production of natural gas.
5. The products obtained from natural gas.

VI. Organization.

The same procedure is used in this unit as was outlined in the unit on sulphur.

VII. Unit Test.
BIBLIOGRAPHY FOR UNIT ON PETROLEUM

PUPILS' BIBLIOGRAPHY

A. BOOKS


B. TEXTBOOKS


C. PERIODICALS


"Cat Cracker," September, 1946.

"Gas from the Earth," November, 1946.

"Looking for Oil," November, 1946.

"Gasoline Tailored to Fit," November, 1946.

"Oil from Shale Demonstrated," August, 1947.


D. BOOKLETS OR PAMPHLETS

The following booklets or pamphlets can be obtained from the Standard Oil Company (New Jersey), Room 1626, 30 Rockefeller Plaza, New York 20, New York (free):

1. "America's Real Resource"
2. "Conservation: Making the Most of our Oil"
3. "Looking Forward in Oil"
4. "Insecticide"
5. "An Introduction to Standard Oil Company (New Jersey)"
6. "Petroleum in the World"
7. "From Oil to You (Flow Chart of Petroleum and its Products)"
8. The Lamp (Published in January, March, June, September, November)
9. "Rubber from Oil"

The following booklets or pamphlets can be obtained from the American Petroleum Institute, 50 West 50th Street, New York 20, New York (free or for a very small fee):


3. "Sunshine in the Rockies"

4. "Oklahoma." The State that Oil Built

5. "Spindletop." A Texas Titan

6. "Great Grow the Oasis"

7. Excellent charts:
   (1) Petroleum Discovery and Production
   (2) Petroleum Products


The following booklet can be obtained from the General Motors Corporation, Research Laboratories Section, Technical Data Department, Detroit, Michigan (free):

"Chemistry and Wheels." The Automobile a Chemical Factory on Wheels

The following booklet can be obtained from the Firestone Tire & Rubber Co., Akron, Ohio (free):

"Rubber"
For the past eight years the writer has used the functional method discussed in this study in teaching high school chemistry. He has made modifications and changes from year to year so as to adjust his organization of subject matter to the needs of each particular group of pupils. He has had many conferences with pupils who have continued their chemistry in college and with those who have not. Without exception they express opinions that the most enjoyable and enlightening part of their high school chemistry course was the study of the resources of Louisiana. Those former pupils who completed their high school chemistry course as long as eight years ago can today intelligently discuss the mining of sulphur and salt or the refining of petroleum. They realize the contribution that Louisiana has made by means of her resources to the wealth and the welfare of the nation.

The selection and organization of subject matter in high school chemistry are dependent upon the aims of education and their applications to chemistry. Only in the light of the objectives of education and of science can any materials be selected as content in a particular course in science. A survey of the history of the
teaching of high school chemistry in the United States shows that the aims of science education are pointed away from teaching with the sole purpose of preparation for college and definitely emphasize the broader aims of education in which the social, economic, and cultural significance of science and chemistry are based upon life situations. The trend of organization of subject matter is toward related units rather than topical units. These related units are based upon generalizations and principles which have their origin in the environment of the pupils.

A review of recent scientific investigations and committee reports on the teaching of science has shown that the objectives of science courses must be focused on the social and economic aspects of the pupils' environment. The committee for the Forty-Sixth Yearbook of the National Society for the Study of Education in its report, "Science Education in American Schools," surveyed the scientific research and reports of the most influential and important committees of national standing and incorporated the best thinking into eight major types of outcomes of learning as objectives of courses in science. This report is an "attempt to formulate objectives that will bridge the gap between the classroom activities and the social desirable type of human behavior."¹ The principles

and criteria as set up in this report have been taken as bases for the selection and organization of courses in high school chemistry.

The writer is convinced that any one who tries to read the popular scientific articles published in newspapers and magazines and who seeks to enjoy and interpret these articles with any kind of understanding must know certain fundamental facts. Certainly, fundamentals are basic for any course in chemistry whether pupils wish to pursue chemistry in college or not. The outline of high school chemistry as presented in this study has taken into consideration the necessity of a thorough understanding of principles. The first four units of high school chemistry are devoted to the basic fundamental principles of chemistry, and these in turn are focused upon the environment of the pupils when and wherever it is possible to do so.

The method of using more than one textbook and articles from authoritative sources gives the pupils practice in gathering data from many sources for the solution of their problems. This technique will tend to eliminate the covering of page-by-page assignments in a single text. This type of organization will necessitate definite planning on the part of the teacher. To be sure, any plan must be flexible to meet the needs of a particular group of pupils. Large amounts of material that are overlapping in high school and college chemistry have been kept to a minimum or have been eliminated. Too often good high school pupils will
develop an indifferent attitude to a particular topic or to part of the subject matter of college chemistry because they think they know it all from having studied that particular material in high school. They lose interest because they do not find the thrill of something new.

The increased emphasis on the use of visual aids is justified as a worthwhile contribution to the understanding of industrial applications of chemistry. To many of the pupils a visit to an industrial plant reveals only a mass of pipes, towers, machines, or furnaces which can have little or no meaning. A good film with animated drawings of the process, shown and discussed with the pupils before the visit to the industrial plant, will add much to the understanding of the practical application. A visit to a petroleum refinery or a first-hand view of the Frasch Process for the mining of sulphur will have little or no meaning unless a good film or scaled models of the processes have been thoroughly studied before the trip is made. Visual aids tend to make the abstractions of chemistry more concrete and meaningful to pupils. The more concrete these learning experiences of the pupil, the more functional the subject matter of chemistry will be.

The selection and organization of content of high school chemistry may be excellent from the standpoint of objectives and content but may or may not be functional. This depends entirely upon the individual teacher. Unless the individual teacher understands
the laws of learning, is interested in boys and girls, is thoroughly
grounded in the subject matter, and is fired with enthusiasm, no
organization or method—however fine it may be—will ever be
functional in effect. The writer is not saying that his is the
best method or the only solution to the problem found in teaching
high school chemistry, but he does submit it as a teaching method
which has proved inspirational to pupils by increasing their desire
to learn more about their state and more about the application of
chemical principles. It is one way of motivating and making
chemistry worthwhile in the lives of pupils studying high school
chemistry.
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A. BOOKS


B. PERIODICAL ARTICLES


Bradbury, G. M., "What Shall We Teach in Chemistry?" School Science and Mathematics, 35:368-373, April, 1935.


Glasoe, Paul Maurice, "Residue of High-School Knowledge Utilizable in College Chemistry," Journal of Chemical Education, 10: 571-574, September, 1933.


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Tildsley, John L., "Teaching Science as a 'Way of Life',' Journal of Chemical Education, 8:670-678, April, 1931.


Wray, Robert P., "The Relative Importance of Items of Chemical Information for General Education," The Journal of Experimen- 
tental Education, 1:341-389, June, 1933.

C. BULLETINS


**D. PUBLICATIONS OF LEARNED ORGANIZATIONS**


APPENDIX
PETROLEUM

Petroleum is the source of our gasoline, kerosene, fuel oil, lubricants, and many other products necessary for maintaining our high standards of living. Crude petroleum is an oily liquid varying from black to amber in color. It is a complex mixture of hydrocarbons with varying amounts of organic compounds of sulphur, nitrogen, and oxygen. Three types of bases are found in the crude oil produced in America, the paraffin base, the asphalt base, and the mixed base, depending upon the amount of each that is in the crude oil.

Crude petroleum is found in certain locations in porous strata of rock, usually associated with gas and salt water beneath the surface of the earth at varying depths. The collecting places of crude petroleum are usually known as "traps." There are three kinds of traps. The first is known as anticline and is formed by the upward folding of the rock strata. Figure 1 illustrates this type of trap. It shows how the oil and gas have been trapped at the top of these dome-like structures, with an impervious strata of rock above and below. Salt water prevents the seepage of oil.
The anticline is, in its simplest form, a dome caused by upfolding of rock strata. Oil and gas are trapped in porous structures at the tops of these domes, with impervious strata above and below the porous rock layer. In most reservoirs, the oil floats on salt water, which prevents dispersion of the oil downward. The anticline exists in many varied forms, but all are the result of folding.

* Courtesy, American Petroleum Institute*
downward. The second type is that in which the strata of rocks has slipped up or down and the strata on either side does not match. In faulting, the porous strata is placed against an impervious one and forms a trap for the oil. Oil may be found on either side of the fault at varying depths, as is shown in Figure 2. The third type is known as the stratigraphic type, in which the porous rock tapers off more or less like a wedge, ending between layers of impervious rock. Figure 3 illustrates this type of trap.¹

Drilling for crude oil is a very expensive operation; therefore, it is necessary that before a well is to be bored, a thorough exploration should be made by the best available scientific methods. At best these methods can only indicate the formations that may or may not contain oil or gas. Some of these methods are (1) measuring gravity, (2) measuring magnetic forces, (3) seismograph, and (4) electrical methods.²

Figure No. 4 illustrates the gravity meter being used in locating the different kinds of oil traps. Briefly, the force of gravity is not the same in all places, and a delicate instrument can detect the slightest variation in the force of gravity.

² Ibid., p. 15.
Faults result from a break or slip in the earth's rock crust. When a fault places a porous stratum against an impervious one, a natural petroleum trap is formed. Oil may be found on either or both sides of a fault at varying depths. 

Figure 2

Courtesy, American Petroleum Institute
Most difficult of all oil-bearing structures to locate is the stratigraphic trap. No pronounced up and down folds of rock strata are present, the trap being formed by changes in the porosity of the formation. Thus, none of the scientific devices now in use to search for potential oil structures gives a clear clue to the existence of a stratigraphic trap. They are located only by exhaustive geological study, using every particle of information that can be gleaned about the area under consideration. The great East Texas field, largest in the United States, is a stratigraphic trap. 

Figure 3

Courtesy, American Petroleum Institute
Geological structures such as those shown above cause slight variations in the force of gravity. The Gravity Meter detects these minute variations and therefore discloses the presence of possible oil-bearing structures. The latest models can detect variations as small as one one-hundredth-millionth of the total force of gravity. While the principle of the Gravity Meter is well understood, the actual mechanism is an expensive maze of delicate parts and jewel bearings. The salt dome, shown at left, is a prolific source of oil accumulation along the Gulf Coast of Texas and Louisiana.

Figure 4
Courtesy, American Petroleum Institute
The magnetometer is used to measure the variation in the magnetic field of the earth in various places.³

The seismograph is the foremost instrument used in locating the possible formations containing oil. A hole is bored in the ground for a short distance, and a charge of dynamite is placed in this hole. At different intervals detectors are arranged in order to detect the reflected waves from the formations in the earth after the charge of dynamite has been set off. These reflected waves are recorded on a tape or film, and from this recording the geologist can indicate the structure of the underlying rock. See Figure 5.

The electrical method is the lowering of a metal electrode into a well while it is being drilled, another electrode being grounded in the surface of the earth. A current is supplied and the earth acts as a conductor. The electrode in the well is drawn up at a constant rate, and as the current meets with different resistances depending upon the nature of the formation it passes, an electric log is recorded on a tape. This record gives clues as to the nature and content of the strata of rock in the underlying earth.⁴

There are two methods of drilling for oil, cable tool and

³ Loc. cit., p. 15.
⁴ Loc. cit., p. 15.
The Seismograph is the foremost scientific instrument now in use for the location of hidden structures which may contain oil or natural gas. Since its adoption in the mid-1920's, millions of acres of land in the United States have been mapped from its findings. The seismograph was originally devised to record earthquakes. In oil prospecting, a dynamite blast is set off which sends energy waves down into the earth. As they strike rock formations, the waves are reflected back to sensitive detectors. Soft formations reflect weakly on the recording film and hard formations make larger jogs. The elapsed time between the blast and the return of the shock waves to detectors measures depth. Figure 5

Courtesy, American Petroleum Institute
rotary drilling. More than 90 per cent of all the wells are drilled by the rotary method. After the oil sands have been reached, a two or two and one-half inch pipe is lowered into the well and cemented to the casing. At the surface of the earth a series of valves and dials are connected to the tubing, which regulates the flow of oil. This is called the "Christmas tree." 5

The crude oil from the wells usually contains sand, water, and gas. It is run to a storage tank where the water and sand may be separated and thence into separators to remove the gas from the oil. It is measured and passed into the storage tanks in the oil field. It is transported either by barges, tankers, or tank cars; but usually it is pumped through pipe lines to the refineries, where it is separated into the many commercial products of everyday use.

The United States produces 65 per cent of the total world production, and Venezuela, 12 per cent. "The U.S.S.R. furnished 6 per cent of the world's total, so far as incomplete statistics would indicate." The United States produced 1,711 million barrels in 1945. 6

5 Ibid., pp. 16-17.

Louisiana ranked third among the states producing oil and second in the production of natural gas during the period of 1944-1945. Louisiana's production of crude oil and gas condensate for the biennium of 1944-1945 was 275.6 million barrels or about 8.1 per cent of total production in the United States for 1944 and about 12.3 per cent for 1945.

Forty-eight parishes out of a total of sixty-four produce oil and gas; five produce gas; and fifty-three produce either oil or gas or both. The accompanying map of Louisiana from the Department of Conservation shows the parishes that produced oil and gas in 1945. Large quantities of the oil and gas that are produced in Louisiana are obtained from state-owned lands. The state owns vast tracts of marsh lands and water bottoms, which may yield more oil than the remainder of the state has yet produced. During the biennium of 1944-1945 forty-five new fields, which included three re-discoveries, were found in Louisiana. Of these forty-five the most important discoveries were Delhi in the northeast, Good Hope in the southeast, and West Tepetate in the southwest part of the state.

8 Ibid., p. 15.
9 Loc. cit., p. 15.
LOUISIANA
SHOWING
PARISHES PRODUCING
OIL AND GAS
1945

OIL AND GAS
OIL
GAS

Courtesy of Department of Conservation and Louisiana Geological Survey.
The estimated proved reserves in Louisiana were 1,690 million barrels in 1946.10

NATURAL GAS

Natural Gas has had a very rapid development and has been one of the outstanding industrial features of the state in the past twenty to twenty-five years. With the Monroe Field in the northeast part of the state commercial production of natural gas began in 1916, and since that time North Louisiana has produced six trillion cubic feet of natural gas. According to the Department of Conservation of the State of Louisiana the natural gas reserves constitute 69 per cent of the total fuel reserves of Louisiana, and oil the remainder. The total reserves of natural gas are estimated to be 17 trillion cubic feet. In 1945 Louisiana produced and delivered to consumers 534,683 million cubic feet and received from other states 9,520 million cubic feet, making a total supply and demand of 544,208 million cubic feet. Of this total 310,127 million cubic feet was consumed within the State, and 234,081 million cubic feet was delivered to other states.11

Natural gas is not only used as fuel for domestic and industrial purposes but is used to produce carbon black. In 1945


11 Ibid., p. 1177.
Louisiana produced 168,229,000 pounds of carbon black from 23,209,000 thousand cubic feet of natural gas. This was an average yield of 7.25 pounds per thousand cubic feet. Carbon black is used in the manufacture of rubber, ink, carbon paper, paints, and varnishes. The state ranks second in the production of carbon black in the nation.\(^\text{12}\) During World War II several plants were producing ammonia from natural gas, and one plans to convert its ammonia plant to chemical production.

Louisiana produced 192,659,000 gallons of natural gasoline from natural gas in 1944, using three different methods, compression, adsorption, and cycling.\(^\text{13}\) At the present there are four cycling plants in operation. Figure 6 illustrates recycling method of recovering gasoline from natural gas.

Conservation measures, based upon the gas pressure and the depth of the well, have been passed to prevent too much waste of gas and oil. The two main sources of energy to push the oil to the surface are gas and water. Figure 1 on page 133 of the anticline trap shows the gas above the oil and shows the oil floating on salt water which is under pressure. Laws have been passed to regulate the flow of gas so that the pressure may be maintained evenly in the oil field. If the oil is drawn off gradually, the gas cap will

\(^{12}\) Ibid., p. 1205.

\(^{13}\) Ibid., p. 1195.
Gas Recycling MEANS MORE OIL!

Figure 6—Courtesy, American Petroleum Institute
expand and help force the oil to the surface. Gas may be injected into the cap to help maintain the pressure if the pressure begins to get too low. The real delight for an oil man is to find a water driven field where a large quantity of water is compressed under the oil. As the oil is withdrawn, the water expands and fills in the gap left by the oil and tends to keep the pressure even. Properly operated gas and water-driven wells may recover as high as 80 per cent of oil from the field.¹¹

SULPHUR

Deposits of sulphur were discovered in Calcasieu Parish, Louisiana, in 1865, when prospectors were seeking for oil. This led to numerous attempts to sink a shaft to the strata bearing the sulphur, but all attempts failed because of the overlying formation of quicksand and poisonous gases. The deposits of native sulphur of commercial value for Louisiana and Texas are found beneath the surface along the coast of the Gulf of Mexico. The deposit of sulphur occurs in the cap rock of salt domes which lie beneath a mass of unconsolidated materials consisting usually of gumbo, sand, silt and some gravel. Some two hundred or more domes have been located in Louisiana and Texas, and from only nine of these has sul-

¹¹ The Lamp, Standard Oil Company of New Jersey, 28:3, April, 1946.
phur been mined.15

The salt domes are usually thought of as salt plugs which have intruded the unconsolidated sediments from a great depth. They are usually, but not always, overlaid with cap rock, consisting of limestone, calcite, gypsum, and anhydrite. Usually they are round or circular with sloping or steep dipping flanks; some are rather flat on top, and others exhibit slight depressions and domes. Figure 7 shows typical cross sections of sulphur-bearing cap rock on some of the salt domes.16 Figure 8 shows by a theoretical cross section of part of Louisiana Gulf Coast how these salt plugs have intruded through the sediments of different geological ages. The exact thickness of these salt plugs has not been determined accurately; some have been penetrated to a distance of a mile or more without reaching the bottom.17 The basic formation of these plugs is the mineral halite, a dry compact crystalline substance which is exceptionally pure.

The cap rock of these salt domes varies in thickness from less than 50 feet to more than 1000 feet.18 Cavities are found in


16 Ibid., p. 848.


18 Wilson T. Lundy, op. cit., p. 847.
Figure 7: Courtesy of Freeport Sulphur Co. (Sulphur and Pyrites Reprint from Industrial Minerals and Rocks, 1931)
THEORETICAL CROSS SECTION OF PART OF LOUISIANA GULF COAST.

Showing depth to basement complex and types of salt plugs that may have affected various formations above 25,000 ft. (Oil Weekly, Jan. 20, 1936.)

Figure 8 Courtesy of Freeport Sulphur Co. (Sulphur and Pyrites Reprint from Industrial Minerals and Rocks, 1931)
the cap rock. Some are very large and form channels in which water circulates. At Lake Washington in Plaquemines Parish, Louisiana, water which was pumped into one of the wells of the Freeport Sulphur Company was returned in a well over a quarter of a mile away almost immediately. Usually hydrogen sulphide and other sulphides accompany the flow of water from the cap rock. These are poisonous and make the drilling hazardous.19

The commercial deposits of sulphur are found in only a very few of the known domes. In Louisiana it has been developed in three salt domes: Sulphur in Calcasieu Parish, Jefferson Island in Iberia Parish, and in Plaquemines Parish at Grand Ecaille or Lake Washington, the latter at the present time being the only active producer in Louisiana. The deposits occur usually in the lower part of the limestone and extend in some instances to the gypsum.

Figure 9 illustrates a typical cross section of a Gulf Coast salt dome sulphur field, showing the unconsolidated formation with its quicksand, barren limestone, sulphur bearing limestone with the cavities, and the barren anhydrite which caps the salt dome, and the depth of each. The unconsolidated formation, which is of a quicksand nature, and the poisonous gases encountered from the

TYPICAL SECTION
GULF COAST SALT DOME SULPHUR FIELD

Fig 9
Courtesy of Freeport Sulphur Co.
waters of the cap rock make it impossible to mine sulphur by the shaft method.

Sulphur is mined by the Frasch process, and it depends upon two properties of sulphur: (1) the low melting point of sulphur, 240° Fahrenheit, and (2) the fact that sulphur is twice as heavy as water. Frasch produced the first sulphur by his process in 1892, but it was not until the year 1903 that this process was made a commercial success.

Figure 10 shows a cross section of a typical sulphur well. At Grand Ecaille in Plaquemines Parish wells are located ten miles from the Mississippi River and approximately 15 miles south of New Orleans in the tidal marsh. For the first 80 feet a 15\(\frac{3}{4}\)-inch surface casing is set; then a 13-3/4 inch hole is drilled, which is usually to a depth of about 1,250 feet, where a ten-inch casing is set and cemented in the cap rock. An eight-inch pipe perforated with holes extending usually to twenty feet is sunk through the cap rock to the bottom of the sulphur-bearing materials. A four-inch pipe is placed inside of the eight inch pipe and extends to within a few feet of the bottom of the well. A one and one-quarter inch pipe extends to within 200 feet of the bottom.

Superheated water at about 335° Fahrenheit is forced down

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SULPHUR AND PYRITES

Figure 10 Courtesy of Freeport Sulphur Co.
between the eight-inch and four-inch pipes. This superheated water melts the sulphur, which sinks to the bottom of the well and is forced by the water pressure up the four-inch pipe. Then compressed air is forced down the one and one-quarter inch pipe to lift the sulphur to the surface, where it is discharged into vats, from which it passes through a meter in order to register the amount of sulphur. Then it is pumped into storage bins. The purity averages about 99.5 per cent or better.\textsuperscript{21}

This process requires an enormous amount of pure water each day, an adequate supply of cheap fuel, and mud for filling the natural cavities in the cap rock. The waste water removed by bleed wells must be treated before it can be disposed of.

Texas furnished a little over 79 per cent and Louisiana nearly 21 per cent of the native sulphur mined in the United States in 1945. The table on the following page shows the sulphur produced in the United States, 1944-45.\textsuperscript{22} The price of sulphur quoted f.o.b. mines by trade journals was $16 per long ton.\textsuperscript{23}

Sulphur is used by a large number of industries. Of the


\textsuperscript{23} Ibid., p. 1380.
AMOUNT OF SULPHUR PRODUCED IN THE UNITED STATES, 1944-45

<table>
<thead>
<tr>
<th>YEAR</th>
<th>Produced (Long Tons)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Texas</td>
<td>Louisiana</td>
<td>Other States</td>
<td>Total</td>
</tr>
<tr>
<td>1941</td>
<td>2,596,731</td>
<td>533,620</td>
<td>8,902</td>
<td>3,139,253</td>
</tr>
<tr>
<td>1942</td>
<td>2,885,621</td>
<td>570,345</td>
<td>4,720</td>
<td>3,460,686</td>
</tr>
<tr>
<td>1943</td>
<td>1,908,581</td>
<td>630,205</td>
<td>-</td>
<td>2,538,786</td>
</tr>
<tr>
<td>1944</td>
<td>2,582,238</td>
<td>635,920</td>
<td>-</td>
<td>3,218,158</td>
</tr>
<tr>
<td>1945</td>
<td>2,969,778</td>
<td>783,410</td>
<td>-</td>
<td>3,753,188</td>
</tr>
</tbody>
</table>

2,961,000 long tons consumed in the United States in 1945, chemicals used 1,605,000; fertilizer and insecticides, 600,000; pulp and paper, 297,000; explosives, 90,000; dyes and coal-tar products, 75,000; rubber, 58,000; paint and varnish, 94,000; food products, 7,000; miscellaneous, 135,000. The greatest use of sulphur is in the preparation of sulphuric acid, of which about three-fourths of the total sulphur produced is used. The major industries which use sulphuric acid are those making products such as fertilizer, petroleum, chemicals, paper, rubber, iron, steel, rayon and cellulose film. The industries can use just as much in peace time as in war. (See chart on page 156.)

2\[\text{Ibid.}, \text{p. 1380-1381.}\]
SULPHUR
PRODUCTION AND USES

PYRITES 53.9%
NATIVE SULPHUR
OTHER 8.0%
MANUFACTURED
GASES 1.7%
PETROLEUM
GASES 0.3%
FRASCH PROCESS 27.8%

CHEMICALS 44.0%
PULP & RAYON
15.9%
EXPLOSIVES 4.6%
INSECTICIDES 4.5%
RUBBER 26%
FOOD PRODUCTS 0.5%
DYE & COAL TAR PRODUCTS 36%
MISCELLANEOUS 4.3%

WORLD PRODUCTION
8,600,000 Long Tons

UNITED STATES USES
1,100,000 Long Tons

Courtesy of Freeport Sulphur Co.
SALT

One of the most abundant natural resources in Louisiana is salt. The state ranks fourth in the nation in the production of salt. The amount of Louisiana salt sold or used by producers was 1,867,689 short tons, valued at $4,465,643 in 1945. This was 12 per cent of the total salt produced for the United States.25

The deposits of salt are usually found in formations known as salt domes. The shape of these salt domes or plugs is usually shown in the cross section diagrams as truncated cones with steep sides, usually with a flat top; but this is not always the case as has been shown in the drilling of wells on the edges of some domes where the well has passed through salt and back into the sedimentary material. This flattening of the top of salt plugs in which the top edges extend over the steep sides is referred to as "over hanging."26 These domes may be from less than a mile to two miles in diameter and many thousands of feet deep. Figure 11 illustrates the shape and height of a typical salt dome in Iberia Parish. It also gives the geological age and name of the sedimentary deposits that the salt plug has intruded.27


27 Ibid., p. 90.
Ideal cross-section of a typical Iberia Parish salt dome.

Figure 11  Courtesy of Department of Conservation and Louisiana Geological Survey
or less agreement among those who have studied the origin of salt that it is of a sedimentary origin. Howe and Moresi have given detailed information concerning the origin of salt and the theory of the salt dome in their study of the geology of Iberia Parish.\textsuperscript{28}

The reserves of salt are almost inexhaustible. R. A. Steinmayer\textsuperscript{29} estimated that there are 2,000,000,000 tons of salt underlying Avery Island. Only six of the 75 known salt domes in the state are producing salt, and these vast deposits have scarcely been touched. In case of an emergency these domes could supply the entire world with salt for many years.\textsuperscript{30}

Four of these domes are mined for rock salt, and none of these is over 1,000 feet deep. Three of the mines are located in Iberia Parish and are a part of the famous Five Islands which have occupied a prominent position in the literature of salt domes. Rock salt was first discovered on Avery Island. It was here and on other of the Five Islands that Lucas, from the cores of the wells drilled under his supervision into the salt domes, gave to the geologist an insight into the interior of salt domes. The salt mines of South Louisiana are located on Avery, Jefferson, and Weeks Islands.

\begin{itemize}
\item[28] Ibid., pp. 102-114.
\end{itemize}
In the North Central part of the state in Winn Parish near Winnfield is located the Carey Salt Company mine. Two other domes, Choctaw in Iberville Parish and West Hackberry in Cameron Parish produce salt brine. The brine from the Choctaw dome is produced from wells sunk into salt and is piped some 14 miles to the Solvay Process Company in Baton Rouge, where it is used to produce soda ash, caustic soda, and liquid chlorine. The brine from the wells of West Hackberry dome is piped some 15 miles to Lake Charles, Louisiana, to the Mathieson Alkali Works, Inc., where they produce liquid, solid, and flake caustic and light, dense soda ash, and salt cake.

In the mining of salt a shaft is sunk into the rock for some distance. The workmen and supplies are lowered into the mine by means of a cage. The skip or conveyors are used to carry the salt.

Tunnels or shafts are driven into salt at right angles to the entrance shaft; then large rooms from 60 to 80 feet in height and 40 to 50 feet wide are opened by removing the salt, leaving large pillars of salt for support.

The first step in the process of mining is the undercutting of the walls at the level of the floor to a depth of about eight or nine feet. Holes are drilled into the wall, and a charge of dynamite is placed in each and exploded. The salt is loaded into cars and carried to the entrance of the mine where the skip or conveyors carry it to the top of the mill. There it flows by gravity to the
crushers and is screened, then ground, after which it is ready for packing. The salt as it is mined is very pure and does not need to be refined.

Beside the use of salt for the table and other household uses, approximately half the salt produced is used in making chemicals such as chlorine, chlorates, hydrochloric acid, soda ash, caustic soda, bleaches, metallic sodium, and salt cake. It is used in textiles, in tanning and curing of hides, in soaps, in refrigeration; in the manufacture of glass, paper, dentrifices, D.D.T., and rubber; and for meat packing, water treatment, and elimination of highway and railroad dust, and ice control. Bay Chemical Company is producing hydrochloric acid and salt cake from their mine at Weeks Island.

LIMESTONE

There are only two locations in the state where limestone has been quarried to any extent. The quarry at Pine Prairie has been abandoned, and only the Winnfield quarry of the Solvay Process Company located near Winnfield is in operation at the present time.

At the Winnfield quarry the Solvay Process Company is using the open-pit method of mining. The overburden of approximately 20 or 30 feet of clay is removed by a drag line. Then the limestone is broken up by using charges of explosives. After the blast it is loaded into trucks and carried a short distance to crushers where it is crushed, washed, and screened. Then it is loaded on cars and
shipped to the Solvay Plant in Baton Rouge, where it is used in making soda ash. The smaller fragments are used in railroad ballast and road metal. A total of 834,140 tons were produced during the biennium of 1943-45.31

Limestone deposits are limited, and considerable testing has been carried on in the state in the last several years. A deposit in Bienville Parish at the Prother dome has been examined by the State Geological Survey, and from the data obtained indications are that the deposit is of considerable size.32

SHELLS

Shell deposits consisting mainly of oyster and clam are located in beds and reefs along the Gulf Coast of Louisiana. During the year 1945, 1,425,112 tons were dredged from these deposits. The shell deposits are the real sources of lime which is used in making soda ash and cement, in agriculture, and in the sugar industry. "Although it appears that Louisiana has a considerable reserve of such shell material, no definite information concerning the occurrence, availability, and quality of such deposits is available."33 There are extensive reefs in Cameron Parish and they are used in the manufacture of chemicals, cement, and road building. Shells

32 Ibid., p. 66.
33 Ibid., p. 64.
are composed of nearly pure calcium carbonate, which makes them a good source of lime.

OTHER MINERALS

Clays. The relatively small value of the clay deposits has been due to the lack of exploration. Surveys have been made of some of the deposits, and indications are that these deposits are an excellent source of materials in the manufacture of brick and tile. Good deposits of clay occur in North Louisiana as well as in the Florida Parishes. With the availability of cheap fuel and abundance of salt, together with research along the lines of ceramics, the clay deposits may attain a place of importance in the mineral resources of the state.

Fuller's Earth. Deposits of Fuller's earth occur in the Florida Parishes, and it is being mined near Bogalusa. Fuller's earth is a type of clay which has a high absorbent power and differs from common clay in the high percentage of combined water. Fuller's earth as mined in Louisiana is used in the making of cosmetics and for drilling mud. The chief uses of Fuller's earth are in the clarifying or filtering of oils, greases, and fats.

Deposits of bentonitic clay, which is used as a drilling mud, are being worked at Hornbeck in Vernon Parish. The physical properties have been tested by the petroleum engineering laboratory at Louisiana State University, and they show that it has a "low gel
characteristic, high filtrate loss, high cake thickness, and low recovery in barrels per ton of clay used.\textsuperscript{34}

**Sand and Gravel.** Louisiana produced 3,825,086 short tons of sand and gravel during the year 1945. This was an increase over the year 1944, but a considerable decrease over the pre-war years. The largest amount of the sand and gravel produced was used in construction; and the rest was used for railroad ballast, filter sands, and engine sands. There are possibilities of the use of the quartz sands in the manufacture of inexpensive glass, even though it has a rather high iron content. Louisiana has large reserves of these substances. \textit{Geological Bulletin No. 19, "The Sand and Gravel Deposits of Louisiana,"} gives detailed information on the locations, geology, chemical and physical properties and specifications of the different uses.

**Lignite.** Lignite is found in considerable amounts in DeSoto and Sabine Parishes and in some of the northern parishes. It is the second step in the coal formation. It varies from a yellowish to a brown color and has a woody texture. This substance usually contains a large amount of moisture. The production of oil

from which gasoline or motor fuel can be obtained is possible from this low grade coal. With the large production of petroleum in this country this process could not compete in price with motor fuel made from petroleum.

Summary. Louisiana has a unique place in the reserves and production of petroleum and natural gas in the United States, ranking third in the production of oil, second in natural gas, second in native sulphur, and fourth in the production of salt.

According to the Department of Conservation of Louisiana, approximately 89 per cent of the mineral wealth for the biennium 1940-41 was derived from petroleum and natural gas, 6 per cent from sulphur, a little more than 2 per cent from salt, and the greater part of the remainder from shells, sand, and gravel. Limestone clays and other minerals account for less than one per cent.

Salt is the only mineral present in the state that is practically inexhaustible, although some of the mineral resources cannot last indefinitely. Each individual has a responsibility to do what he can in the conservation and development of new mineral resources, looking into the future to the time when oil and gas will not be so abundant. Much has been done in the way of conservation, and more will be done; but it is the duty of the schools to give the children a knowledge of the mineral resources so that they may become intelligent citizens and avoid useless waste of the non-replaceable minerals.
With more scientific research in the development of such minerals as clays, shells, sand, peat, and lignite, considerable income could be derived from these materials.
VITA

Lee Moncrief Harrison, the eldest son of Wesley and Lila Pitts Harrison, was born near the town of Bluffton, Georgia, November 9, 1897. After graduating from Bluffton High School, he attended Shenandoah Collegiate Institute in Dayton, Virginia, where he graduated in 1916. He attended Emory University in Oxford, Georgia, in 1916-1917. He served in the Engineering Department of Maryland Pressed Steel Company in 1918-1919. He entered Washington and Lee University in 1919 and received the Bachelor of Arts degree in 1923. His graduate work was done at Louisiana State University and at Washington and Lee University with the exception of one semester and summer session in Columbia University, New York, New York, and one summer in the University of North Carolina, Chapel Hill, North Carolina. He received his Master of Arts degree in Chemistry and Geology from Washington and Lee University in 1927.

The writer began his teaching experience in Bluffton High School in 1921. In 1923 he was an instructor in chemistry and physics in South Georgia College, McRae, Georgia, and in 1924 was made registrar and instructor in science. From 1925 to 1927 he was an instructor in geology in Washington and Lee University, Lexington, Virginia. From 1927 to 1938 he was Instructor and Head of the
Science Department of Woodlawn High School in Birmingham, Alabama. He resigned this position in May, 1938, to become a member of the Louisiana State University Laboratory School staff as Supervisor of the Teaching of Science, which position he now holds.
EXAMINATION AND THESIS REPORT

Candidate:  L. M. Harrison

Major Field:  Education

Title of Thesis:  A Study of the Uses of the Natural Resources of Louisiana in the Teaching of High School Chemistry

Approved:

[Signatures]

Major Professor and Chairman

[Signatures]

Dean of the Graduate School

EXAMINING COMMITTEE:

[Signatures]

Date of Examination:

May 3, 1948